State of California
THE RESOURCES AGENCY
Department of Water Resources

BULLETIN No. 86

UPPER PIT RIVER INVESTIGATION

SEPTEMBER 1964

HUGO FISHER
Administrator
The Resources Agency

EDMUND G. BROWN
Governor
State of California

WILLIAM E. WARNE
Director
Department of Water Resources

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STATE OF CALIFORNIA—RESOURCES AGENCY
WILLIAM E. WARNE, *Director*

DEPARTMENT OF WATER RESOURCES
P.O. BOX 388
SACRAMENTO

August 26, 1964

Honorable Edmund G. Brown, Governor
and Members of the Legislature
of the State of California

Gentlemen:

I have the honor to transmit herewith the final edition of Bulletin No. 86, "Upper Pit River Investigation." This investigation was initiated from funds authorized by the Legislature in Item 263, Budget Act of 1957.

Bulletin No. 86, first published in preliminary form in November 1960, concludes that agricultural and economic development in Big Valley, located in Modoc and Lassen Counties, is limited by climate, inadequate water supply, frequent flooding of the valley lands, and inadequate drainage. The construction of water conservation facilities would alleviate, in large part, these conditions by providing the basis for a higher type agriculture, and enhancing the recreational potential of the area.

The bulletin presents plans for the development of local water conservation projects that would achieve optimum use of limited available water supplies to the Big Valley area. Emphasis was placed on the engineering analysis of the Allen Camp Project on Pit River and the Round Valley Project on Ash Creek. Our analysis indicates that the Allen Camp Project is economically justified, and the department recommends that local interests continue efforts to obtain funds from either federal or state sources to implement the project as the initial stage in a plan of water development for Big Valley.

While the Round Valley Project is not economically justified at this time, the department further recommends that the overall plan for water development in Big Valley include this project and other smaller projects, when future conditions are such as to warrant economic justification.

Information and data developed by the investigation were used during the period 1962 to 1964 by the U. S. Bureau of Reclamation in preparing a feasibility report on construction of the Allen Camp Project as a feature of the Central Valley Project to provide a firm water supply for Big Valley.

Sincerely yours,

William E. Warne

Director

Enclosure

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

EDMUND G. BROWN, Governor
HUGO FISHER, Administrator, The Resources Agency
WILLIAM E. WARNE, Director, Department of Water Resources
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by

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NOTE

The Upper Pit River Investigation was conducted from 1958 to 1960, at which time Harvey O. Banks was the Director of the Department of Water Resources. William E. Warne succeeded Mr. Banks who resigned from the department to enter private consulting business on January 1, 1961. This investigation was carried out under the general direction of William L. Berry who is in charge of the Division of Resources Planning.

ORGANIZATION

CALIFORNIA WATER COMMISSION

ACKNOWLEDGMENT

Valuable assistance and data used in this investigation were contributed by agencies of the State and Federal Governments, Lassen and Modoc Counties, public districts, and by private companies and individuals. This cooperation is gratefully acknowledged.

Special mention is also made of the helpful cooperation of the following:

Forest Service, United States Department of Agriculture
Soil Conservation Service, United States Department of Agriculture
Bureau of Reclamation, United States Department of the Interior
Geological Survey, United States Department of the Interior
Corps of Engineers, United States Army
California Department of Fish and Game
California Division of Beaches and Parks
California Division of Highways
University of California
Lassen County Board of Supervisors
Modoc County Board of Supervisors
Big Valley Irrigation District
Pit Soil Conservation District
Pacific Gas and Electric Company

PUBLIC COMMENTS ON PRELIMINARY EDITION

Bulletin No. 86 was published in preliminary edition in November 1960 and was released for public distribution in May 1961. All agencies, groups, and individuals receiving copies of the report were invited to submit written comments to the department.

In order to conform with the water code, a public hearing on the preliminary edition was proposed during fiscal year 1963-64. However, the Big Valley Irrigation District suggested that a hearing might be confused with the investigation of the Allen Camp Project to be reported on by the Bureau of Reclamation in the fall of 1964. A joint public hearing relative to the Allen Camp Dam and Reservoir, and other aspects of the Upper Pit River Investigation, was held in October 1959, pursuant to Assembly Concurrent Resolution No. 104, Chapter 212, statutes of 1959. With publication of the preliminary edition, a meeting was held in Bieber, California, on June 6, 1961, to discuss Bulletin No. 86. It was concluded that another hearing on the bulletin in 1964 was not necessary. Instead, persons receiving the preliminary edition of the report were requested to submit written comments to the department for review in preparing the final edition of the report.

Written comments were received from the following agencies:

Big Valley Irrigation District, Bieber, California
U. S. Forest Service, Modoc National Forest, Alturas, California
U. S. Bureau of Reclamation, Regional Office, Region 2, Sacramento, California
Department of Public Works, Division of Highways

The Big Valley Irrigation District indicated that it, along with Modoc and Lassen Counties, had participated financially in a study by the Bureau of Reclamation which is aimed at developing a project in the Big Valley area, primarily for a supplemental water supply. The district anticipates that such a project would be integrated with the federal Central Valley Project. Additionally, the alternative programs for financing the project as shown in Bulletin No. 86 were not found to be feasible and the district concluded that the best opportunity for construction of a project to serve the Big Valley area would be to proceed as part of the federal Central Valley Project.

The Bureau of Reclamation stated that it has been investigating the Allen Camp Unit for the past year and a half, at the request of Big Valley Irrigation District and Lassen and Modoc Counties, and that its report will be similar to Bulletin No. 86 except for a possible National Wildlife Refuge on Ash Creek included in our plan.

The Big Valley Irrigation District submitted additional comments that the Bureau of Reclamation in March 1964, requested partial assignment of State Application No. 5643 and assignment of State Application No. 20532 in its entirety, so as to assure a water supply for the Allen Camp Project. In the event that construction of the project is not authorized by January 1, 1970, the requested assignments would be reassigned by the Bureau back to the State of California.

The U. S. Forest Service stated that it has prepared a report on a detailed multiple use survey of the proposed Allen Camp Reservoir Project to provide for recreation development in the Modoc National Forest.

The Division of Highways stated that cost estimates in Bulletin No. 86 for highway relocation in the Round Valley and Allen Camp Reservoirs are adequate, but that the cost for relocating utilities and roads for Allen Camp Dam, should be increased if the maximum water elevation is to exceed 4,286 feet. The division's estimate for maximum water elevation at 4,286 feet is only slightly higher than the department's estimate, when engineering and contingencies are included.

After reviewing the comments received, it was found that no technical changes were necessary to complete the report. However, recommendations were changed to reflect developments occurring after the preliminary edition was released.

CHAPTER I. INTRODUCTION

The economic development of Big Valley, the largest agricultural area in the Upper Pit River watershed, is hampered by severe water problems. Agricultural production, the mainstay of the local economy, is impeded by frequent floods in the spring and an inadequate water supply in the late summer and early fall. The once active lumber industry has declined in recent years because most of the mature timber has been logged. Since local conditions are not conducive to extensive industrial development, any future economic growth of the area will depend upon increased agricultural productivity and the establishment of a stable recreational industry.

In order to increase agricultural production in Big Valley, flood protection and water conservation for the irrigation of crops are required. A considerable portion of the valley is flooded in most years. Flooding of valley lands along the Pit River and Ash Creek precludes a higher type of land use than presently exists over much of the valley floor. Conservation of water by reservoir storage would convert the damaging flood flows of Ash Creek and the Pit River into regulated water supplies for irrigation in the summer and fall.

The establishment of a stable recreational industry will depend to a large degree upon features that will draw tourists and recreationists into the area throughout the summer season. The operators of private motels and other facilities in the area cannot justify expansion under present conditions even though their facilities are overcrowded during the popular, but short, duck and deer hunting seasons. Large reservoirs coupled with well planned shore-line facilities could attract visitors during the entire summer season, and aid in achieving fulfillment of the recreational potential of the Big Valley area.

Authorization for Investigation

In May 1957, the Department of Water Resources published Bulletin No. 3, entitled "The California Water Plan". The California Water Plan is a master plan to guide and coordinate the planning and construction of all future water development in California. The plan has been designed to provide for the fullest practicable measure of conservation, protection, control, distribution, and utilization of the State's water resources in order to meet the present and future needs for all beneficial purposes in all areas of the State.

The California Water Plan includes Allen Camp and Round Valley Reservoirs which could provide flood protection and irrigation water for Big Valley. These reservoirs could also be used for recreation and fish and wildlife purposes.

Recognizing the need for flood protection of Big Valley and the demand for more complete conservation of the water resources of the Pit River and Ash Creek, the Legislature, by the Budget Act of 1957, provided:

> "Item 263. For conducting water resource investigations, surveys and studies, preparing plans and estimates, making reports thereon, and otherwise performing all work and doing all things relative thereto, Department of Water Resources, in accordance with the following schedule . . . (e) Upper Pit River Investigation".

Objective of the Investigation

The objective of the Upper Pit River Investigation was to develop a plan for water development that would achieve optimum conservation of the limited water supply available to Big Valley. Emphasis was placed on the determination of the engineering feasibility and economic justification of the Allen Camp Project on the Pit River and the Round Valley Project on Ash Creek. In order to accomplish this objective, it was necessary to obtain engineering and geological data, determine the types and extent of the benefits to be obtained from each project, and develop the most economical plan for each project. Full consideration was given to economical development of the conservation, flood control, power development, and recreational aspects of each project.

Scope of Investigation

The investigation comprised those studies necessary to accomplish the stated objective. Data developed in previous investigations, particularly the State-Wide Water Resources Investigation and the Northeastern Counties Investigation, were utilized in evaluating the projects. Work on two other concurrent investigations, namely, the Inventory of Water Resources and Water Requirements and the Northeastern Counties Ground Water Investigation, was coordinated with the Upper Pit River Investigation to provide common data which could be utilized in each of the investigations.

Hydrologic studies were made to determine the amount of water available for storage in each reservoir and the extent, duration, and frequency of floods which may occur in the area.

Geologic exploration of foundation conditions at each dam site was conducted. In addition, samples were obtained from potential borrow areas and tested to determine their suitability as construction materials.

Engineering designs and cost estimates were prepared for a suitable range of reservoir storage capacities at each site.

Economic studies were made to determine the benefits which would accrue from the regulation of the waters of Ash Creek and the Pit River.

These studies included consideration of irrigated agriculture, the flood hazard, the value of hydroelectric energy, and the recreational potential of the area.

Detailed operation studies were made to evaluate the accomplishments of various sizes of each reservoir. Each reservoir was sized accordingly, to provide maximum net benefits.

Finally, costs were allocated among the project purposes and related to the benefits to determine economic feasibility.

Related Investigations and Reports

Several prior investigations and reports were reviewed in connection with this investigation. Of major importance are four recent investigations of the Department of Water Resources. The following is a brief summary of these investigations.

The State-Wide Water Resources Investigation was initiated in 1947 and completed in 1957. Three bulletins were published containing the results of this investigation. Bulletin No. 1, "Water Resources of California", published in 1951, contains a compilation of data concerning precipitation, unimpaired stream runoff, flood flows and frequencies, and quality of water throughout the State. Bulletin No. 2, "Water Utilization and Requirements of California", published in June 1955, includes determination of the present use of water throughout the State for all consumptive purposes and presents forecasts of probable ultimate water requirements. The third and concluding phase of the investigation was reported in Bulletin No. 3, "The California Water Plan", published in May 1957. This bulletin presents a master plan to guide and coordinate the activities of all agencies in the planning, construction, and operation of works required for the control, development, protection, conservation, distribution, and utilization of California's water resources for the benefit of all areas of the State and for all beneficial purposes.

The Northeastern Counties Investigation was conducted during the period 1954 through 1957. A preliminary edition of Bulletin No. 58, "Northeastern Counties Investigation", was distributed in December 1957, and the final edition published in June 1960. This bulletin presents results of a comprehensive analysis of present and probable ultimate water needs of 15 northeastern counties of California: Butte, Colusa, Glenn, Lake, Lassen, Modoc, Plumas, Shasta, Sierra, Siskiyou, Sutter, Tehama, Trinity, Yolo, and Yuba.

The Northeastern Counties Ground Water Investigation was initiated in July 1957, for the purpose of determining the ground water potential of 10 major valley fill areas in the mountainous areas of northeastern California. Initially, work was concentrated in Big Valley to develop data pertinent to the Upper Pit River Investigation.

An investigation designated Inventory of Water Resources and Requirements was started in July 1956, to develop data on land and water use, water supply, and water requirements in order to determine the surplus or deficiency of water supplies in areas of origin. Work in the water supply phase of this investigation in the Upper Pit River Basin was rescheduled for coordination with studies undertaken for the Upper Pit River Investigation and the Northeastern Counties Ground Water Investigation.

In addition to the four investigations described, information obtained through watermaster service in Big Valley was utilized. Annual reports on this service, which contain detailed information on the operation of the stream system in Big Valley, have been published since 1934.

Additional reports reviewed in connection with this investigation are as follows:

United States Reclamation Service, "Work on Pit River Basin", April 1915.

California State Department of Public Works, Division of Water Resources, "Pit River Investigation", Bulletin 41, 1933.

California Division of Water Resources, "Report on Investigation of Water Projects to Postwar Planning Committees of Modoc and Lassen Counties", March 1945.

The Pit Soil Conservation District, "The Coordinated Land and Water Use Conservation Program". The U. S. Soil Conservation Service, et al, March 1953.

California State Department of Public Works, Division of Water Resources, "Report on Water Supply and Use of Water on Pit River Stream System in Big Valley", May 1956.

California State Water Rights Board, "Pit River and Big Valley Adjudication, Order of Determination", December 4, 1958.

Area of Investigation

The area under intensive consideration in this investigation comprises the major portion of the agricultural lands in Big Valley. Big Valley is located in Northern California in southwestern Modoc County and northwestern Lassen County. The valley is a broad plain about 15 miles long from north to south, and 15 miles wide from east to west. The elevation of the valley floor is approximately 4,150 feet above mean sea level. The location of Big Valley is shown on Plate 1, entitled "Location of Big Valley and Existing Water Agencies".

The Pit River traverses the westerly portion of Big Valley in a shallow meandering channel. Important tributary streams including Ash, Willow, Butte, Juniper, Taylor, and Widow Creeks drain an area of approximately 890 square miles and join the Pit River in Big Valley. A number of sloughs break out from the main streams, roughly parallel the main channels, and re-unite in the lower regions of the valley. Flat topography, combined with tule and sedge growth in the sloughs and tributary stream channels, cause serious drainage problems in the valley. As a result, winter and spring flood flows frequently inundate a large portion of the better agricultural lands. Another consequence of poor drainage is the large mosquito population, which constitutes a health hazard to residents of Big Valley.

Pit River Basin

As considered herein, the Pit River Basin comprises the entire drainage area of the Pit River system above the gaging station on Pit River near Montgomery Creek, exclusive of Goose Lake Basin. Goose Lake overflowed to the Pit River in 1869 and has contributed minor quantities of water to the river twice since 1869, once in 1881, and again in 1898. There are no surface indications that the waters of Goose Lake Basin are tributary to the Pit River other than by direct discharge over the rim of the lake. Increased irrigation and storage development have caused a progressive lowering of the lake, and future spill into the Pit River system appears highly improbable. The basin is delineated on Plate 2, entitled "Water Resources of the Pit River Basin". A hydrologic study of this extensive basin was necessary in order to estimate the water supply available to Big Valley and to estimate the water supply available to satisfy the downstream water rights of the Pacific Gas and Electric Company.

Mt. Lassen is located at the southern limit of the Pit River Basin. From this point, the basin extends northwesterly to Shasta Lake and thence almost due north to Grizzly Peak on the Siskiyou-Shasta county line. From Mt. Lassen, the basin extends northeasterly to the southern terminus of the

Warner Range, thence northerly along the crest of this range to a point near the south end of Goose Lake. The northern boundary extends from Grizzly Peak on the west to the Warner Range on the east.

The Pit River Basin above the Montgomery Creek gaging station, exclusive of the Goose Lake Basin, has an area of approximately 4,900 square miles. Approximately 2,900 square miles of this area comprise mountains and foothills, and 2,000 square miles comprise valley and mesa lands.

Climate

The climate of Big Valley is characterized by moderately severe winters and warm dry summers. However, localized summer thunderstorms of heavy intensity but short duration are common. About three-quarters of the seasonal precipitation occurs during the winter months. Growing season precipitation averages only about 4 inches of depth so that irrigation is required for most crops. Table 1 contains a summary of pertinent climatological data in the Pit River Basin.

TABLE 1

CLIMATOLOGICAL DATA AT SELECTED STATIONS IN THE PIT RIVER BASIN

Station	Elevation, in feet	Temperature, in degrees Fahrenheit					Mean seasonal precipitation, in inches of depth
		Maximum of record	Minimum of record	Average maximum	Average minimum	Annual average	
Jess Valley	5,290	92	-19	59.3	31.2	45.3	16.49
Alturas Ranger Station	4,365	106	-32	63.2	30.1	46.6	12.16
Adin Ranger Station	4,193	103	-18	63.5	31.9	47.7	14.47
Bieber	4,130	104	-31	61.9	30.3	46.1	16.79

The growing season in Big Valley is restricted by freezing temperatures occurring late in the spring and early in the fall. The growing season, based on a period free of temperatures of 28°F or lower, is approximately 120 days. The duration between the average spring and fall occurrences of minimum temperatures of 32°F is only 60 days, based on 27 years of temperature data recorded at Bieber. These climatological conditions limit the crops that can be grown in Big Valley to those that can tolerate short periods of below freezing temperatures.

Geology

Big Valley lies within the boundaries of Modoc Plateau geomorphic province of northeastern California. Structurally, many parts of this area are similar to the Basin-Ranges province which lies to the east.

Big Valley is a faulted structural basin near the edge of the Modoc Plateau lava beds. The valley is bounded on all sides by volcanic rocks such as lava flows and pyroclastics which were erupted at diverse times from about 40 million to less than 1 million years ago. These volcanic rocks are exposed in the tilted fault block ridges on the east and west margins of the valley, in the complex faulted, mountainous terrain south of the valley, and in the faulted lava plateau north of the valley.

The lava plateau area surrounding Big Valley is typified by wide-spread, rough-surfaced flats which are the topographic expressions of the more recent flows. Dissection of these flats by streams of the area began in relatively recent geologic time. Some of the sharp, steep slopes in the area are erosional scarps; others are fault line scarps.

The Big Valley Basin is filled to a depth of over 2,000 feet by lake sediments. These sediments include well-bedded, tuffaceous and diatomaceous silts and clays with interbedded thin sand lenses. The lake sediments are overlain by Pleistocene and Recent stream deposited silt, sand, and gravel, which blanket most of the floor of the valley. The alluvial sediments near the margins of the valley are, in general, somewhat coarser than the sediments near the center. Recent flood-plain deposits are widespread along the present meandering courses of the Pit River and Ash Creek.

Although the most prominent fault system in the region trends more or less northwesterly, strong cross-faulting is apparent in places. There is some suggestion that the fill of Big Valley has undergone considerable faulting as evidenced by the presence of several isolated, lava-capped hills on the valley floor, poor correlation of deposits from inspection of well logs, and the presence of hot water from wells and springs in portions of the valley.

Soils

The soils in Big Valley may be arranged in three general groupings: recent alluvial soils, residual soils, and old valley filling soils. They have been derived almost entirely from volcanic types of parent rock.

Recent alluvial soils are found in and bordering the active stream channels of the valley. These soils consist of water-deposited material that has not been altered or modified by weathering processes. Normally, the soil profiles are without layers of cementation or compaction but frequently exhibit a large amount of stratification. This stratification can cause a wide variability in soil texture. Recent alluvial soils are considered to be the most valuable for irrigated agriculture due to their loose and friable nature, rapid internal drainage, and deep rooting zone. At present, however, they are frequently subjected to severe stream erosion. Works designed to decrease the erosional hazard would greatly increase the crop adaptability of these soils.

Residual soils have been formed in place by the weathering and decomposition of the parent rock material. These soils are prevailingly shallow and/or stony. Residual soils are generally found on the more broken, sloping or rolling lands around the margin of the valley. The areal extent of these lands is not large. Also, because of their limited adaptability they are of minor importance to irrigated agriculture.

Old valley-filling soils include those which have been transported and deposited by water, and weathered and altered in place subsequent to deposition. Soil drainage and rooting depth are generally restricted by the presence of clay or hardpan layers. These soils generally exhibit a hummocky or broken relief. Most of the lands found in the valley belong to this grouping.

Most of the lands in Big Valley may be classed as moderately good agricultural lands. The depth of soil varies from less than 1 foot on the adjacent hill lands to 10 feet or more in the center of the valley.

In general, the marginal lands support native vegetation consisting of sagebrush, sheep grass, and other low yielding types of forage, and are used primarily for early spring and late fall grazing. At present the livestock carrying capacity on these dry range lands is undependable. However, under irrigation and proper management, these lands are capable of supporting a dependable yield of forage and other crops.

Lands presently irrigated in Big Valley are utilized primarily for the production of meadow hay and pasture. The crop adaptability of these lands could be greatly improved by the establishment of adequate drainage facilities and improved cultural and irrigation practices. The production of hay and pasture could be more than doubled if native meadow lands were drained, leveled, fertilized, and properly irrigated.

Present Development

Settlers were attracted to Big Valley by the abundant growth of grasses in the natural meadows adjacent to the water courses. These natural meadows, coupled with surrounding mountain grazing land, made stock raising the dominant industry from the beginning. Irrigation by the still prevalent method of wild flooding began almost simultaneously with settlement. Wild flooding is accomplished by use of diversion dams and dikes across water courses of low areas which results in the flooding of adjacent lands. By 1890, available stream flows were fully utilized in this manner with a generally adequate supply of water in the spring months but with acute shortages occurring about the middle of June. Numerous small water storage projects have been constructed since 1900, primarily to provide supplemental stock and irrigation water during the summer drought.

The principal economic activity in Big Valley has remained agriculture. Approximately 24,000 acres are currently irrigated during early spring with the water supply that is available from the unregulated or partially regulated streams. Agricultural development is hampered by the frequent flooding of large areas adjacent to the valley streams. Farmers on the flood plain of Big Valley are justifiably unwilling to plow their lands to plant improved pastures or cultivated crops because of the severe erosion that might easily then occur. Consequently, a large part of the valley floor is limited to noncultivated crops that are tolerant to annual inundation and a prolonged high water table. In contrast to the spring flooding, most of the land has an inadequate water supply during the late summer and early fall months. As a result of these factors, low yield meadow hay and pasture land account for approximately 20,000 acres of the land irrigated, and 4,000 acres are devoted to alfalfa, hay, and grain. These forage and grain crops are utilized primarily in livestock enterprises, which consist of cow-breeding herds from which yearlings are sold. there is a substantial portion of national forest and other range land available around the valley floor for utilization as supplemental livestock feed.

Another major resource in the area is timber. There are productive stands of timber on the slopes of the Cascade Range, and the Warner, Big Valley, and Adin Mountains. In recent years, however, the lumber industry has shown a considerable decline in activity as evidenced by the closing of several local lumber mills. This decline is due to the fact that a large portion of the mature timber has been logged at a rate exceeding the natural growth. Recently, forest conservation practices have been adopted to preserve this renewable resource. Although the development of new lumber by-products may to some extent offset the adjustments necessary to place the harvest and annual sustained yield in balance, it is likely that there will be little or no growth in the logging or lumber industry in the foreseeable future.

The valley marshlands and the large forest areas of the Modoc National Forest have for many years attracted large numbers of hunters and campers from all over the State. To some extent, the increase in recreational activity has offset the decline in the lumber industry. This increase, however, has resulted in overcrowding of the existing recreational facilities during the hunting seasons. The improvement of recreational features in the area would attract visitors during the summer season and would aid in the economic growth of the area.

Development of the power potential of the Pit River below Fall River Valley has been undertaken by the Pacific Gas and Electric Company. This development has been under construction in stages for many years, and there are now three major installations with a total installed capacity of 290,900 kilowatts that utilize Pit River water for power purposes. Another plant, with an installed capacity of 56,000 kilowatts, diverts water from Fall River at Fall River Mills and returns the water to the Pit River below the power plant. The Pit River power plants, although not in the project area, were necessarily considered in order to ascertain the net effect on their water supply from operation of the upstream projects considered in this investigation.

The Department of Finance of the State of California has estimated the 1959 population of Lassen County at 13,600, and Modoc County at 9,100. The 1950 populations of the two counties were 18,474 and 9,678, respectively. Available information indicates the major reason for the recent declining population has been the curtailment of the lumber industry in the area. The 1959 population estimates of the four communities in Big Valley are Adin, 400; Bieber, 300; Nubieber, 150; and Lookout, 125.

U. S. Highway Route 299 traverses the central portion of Big Valley from east to west. This route is a paved road adequate to serve the area in all weather farm-to-market capacity, and to provide access for recreational purposes. The county roads in the area are adequate as supplementary transportation links.

Big Valley is also served by the Great Northern Railroad and the Western Pacific Railroad, which join at Nubieber. This joint terminal, which accounted for the establishment of Nubieber, was constructed in the early 1930's. Minimum facilities are maintained in Nubieber at the present time, although the potential is available for adequate rail service should increased economic activity warrant it.

CHAPTER II. WATER SUPPLY

This chapter contains a discussion of the characteristics of precipitation and runoff in the Pit River Basin. Hydrologic criteria and methods of analysis are described. There is a brief discussion of regional ground water characteristics and the ground water potential of Big Valley. Information on water quality standards and a description of the quality of the surface and ground water supply to Big Valley are included.

The major sources of water within the Pit River Basin are direct precipitation on lands within its topographic boundary and large perennial springs which feed tributary streams in the lower Pit River reaches. Depth of seasonal precipitation varies from over 75 inches on the mountainous areas to less than 9 inches on the plains. The large springs which draw on significant ground water resources have undefined recharge areas which may or may not lie within the topographic boundary of the basin.

The Pit River Basin is described in Chapter I and is delineated on Plate 2. For convenience in subsequent chapters, the basin was divided into the Upper Pit River Basin and the Lower Pit Basin. The Upper Pit River Basin includes that portion of the drainage area lying above the gaging station known as Pit River near Bieber, which is located at the head of Muck Valley. This area, covering 2,440 square miles, includes Big Valley and its contributing watershed. The Lower Pit River Basin, covering 2,460 square miles, includes the remaining downstream drainage area from the gaging station at the head of Muck Valley to the Pit River gaging station near Montgomery Creek.

Precipitation

Precipitation over the Pit River Basin, in common with that throughout the State, is characterized by a wet and a dry season. Precipitation occurs as a combination of snow and rain, principally during the winter and spring months, from October through April.

The storms occurring over the region have an erratic pattern of distribution, and it is not uncommon for a series of storms to result in above average precipitation along some narrow path, while a few miles away below average conditions exist during the same period. Generally, precipitation increases rapidly with abrupt increases in elevation, but since significant differences are found in the amounts of precipitation in topographically similar areas, it is apparent that factors other than elevation are involved. Some of the factors influencing the quantity of precipitation on a given area are the topographic features the moist air must cross to reach the area, the slope of the area, the distance from foothills to summit, and the bearing of the slope with respect to the prevailing storm path.

Precipitation Stations and Records

The mean seasonal depth of precipitation on the Pit River Basin was computed for each of 28 precipitation stations in or near the basin. Of these, 23 stations have records of 10 years or longer, and five have records of less than 10 years. The location, elevation, period of record, source of record, and values of mean, maximum, and minimum seasonal precipitation for selected stations are shown in Table 2.

TABLE 2

SELECTED PRECIPITATION STATIONS IN OR NEAR THE PIT RIVER BASIN

Station	County	Latitude N. and longitude W.	Elevation, in feet	Period of record	Source 1/	Seasonal depth of precipitation: Mean 1905-55, in inches	Maximum and minimum: Season	Maximum and minimum: Inches
Bieber	Lassen	41°07' 121°08'	4,130	1930 to date	DWR	16.79	1937-38 1938-39	28.24 8.69
Alturas Ranger Station	Modoc	41°29' 120°32'	4,365	1906 to date 2/	USWB	12.16	1951-52 1930-31	21.09 6.44
Jess Valley	Modoc	41°16' 120°18'	5,290	1929 to date	USWB	16.49	1937-38 1930-31	24.44 9.56
Adin Ranger Station	Modoc	41°12' 120°57'	4,193	1944 to date	USWB	14.47	1955-56 1954-55	21.31 10.62
Canby Ranger Station	Modoc	41°27' 120°52'	4,312	1944 to date 2/	USWB	13.33	1955-56 1954-55	19.20 7.97
Cedarville	Modoc	41°32' 120°10'	4,675	1894 to date	USWB	12.12	1937-38 1932-33	21.17 7.04
Big Bend	Shasta	41°01' 121°55'	1,710	1927 to 1939	Private	60.98 3/	1937-38 1930-31	101.39 36.14
Fall River Mills Intake	Shasta	41°01' 121°28'	3,340	1923 to date	USWB	15.82	1937-38 1938-39	30.08 10.42
Burney	Shasta	40°53' 121°40'	3,127	1943 to date	USWB	27.84	1955-56 1943-44	42.33 15.26
Pit No. 5 Powerhouse	Shasta	40°59' 121°59'	1,458	1945 to date	USWB	75.37	1955-56 1948-49	121.02 47.10

1/ USWB - United States Weather Bureau, DWR - Department of Water Resources.
2/ Broken record.
3/ Average for period of record only.

The water content of snow on April 1 is measured at 12 snow courses in the Pit River Basin, four of which are in or above Big Valley. These latter courses are Cedar Pass, Eagle Peak, Blue Lake Ranch, and Adin Mountain. The Adin Mountain snow course, located on the eastern edge of the Big Valley Basin at an elevation of 6,350 feet, is considered most representative of snow conditions in the mountainous areas surrounding Big Valley. In Table 3 are listed the 13 snow courses with respective locations, elevations, and periods of record. In addition, average maximum and minimum water content of snow on April 1, for the period 1930 through 1959, are shown for each station. These data were furnished by California Cooperative Snow Surveys, whose reference numbers of the courses are shown in the left column.

Precipitation stations, snow course locations, lines of equal mean seasonal precipitation, and the boundary of the Pit River Basin are presented on Plate 2.

Precipitation Characteristics

In the Upper Pit River Basin the prevailing southwest approach of storms causes the heaviest precipitation on the abrupt southern and western slopes of the Adin and Warner Ranges. The low-lying plateaus and valleys, east and northeast of the mountainous ranges, suffer from a deficiency of precipitation to the extent that these areas are naturally productive of only scattered juniper trees and sagebrush.

Precipitation in the form of snow generally occurs during the period from December to March, with occasional snowfall in April. In the area above Big Valley, approximately 65 percent of the total precipitation in the winter and spring months occurs as snow; therefore, there is little

TABLE 3

SNOW SURVEY COURSES IN OR NEAR THE PIT RIVER BASIN

Ref. no. 1/	Snow course	County	Latitude N. and longitude W.	Elevation, in feet	Period of record	Water content of snow on April 1: Average 1930-59, in inches	Maximum and minimum: Season	Maximum and minimum: Inches
28	Blue Lake Ranch	Lassen	41°9.4' 120°15.7'	7,300	1940 to date	11.3	1958 1947	14.0 5.0
29	Eagle Peak	Modoc	41°15.5' 120°14.0'	7,200	1930 to date	16.2	1952 1934	32.1 2.9
30	Cedar Pass	Modoc	41°35.2' 120°18.0'	7,100	1930 to date	17.0	1952 1934	33.6 1.0
32	Medicine Lake	Siskiyou	41°35.2' 121°36.8'	6,700	1938 to date	30.5	1958 1944	60.0 19.7
31	Blacks Mountain	Lassen	40°45.7' 121°11.5'	6,650	1945 to date	8.0	1952 1947	22.9 0.0
33	Thousand Lakes	Shasta	40°41.7' 121°34.5'	6,500	1946 to date	38.0	1952 1947	71.4 20.9
35	Adin Mountain	Modoc	41°14.0' 120°47.0'	6,350	1930 to date	14.0	1952 1934	32.1 0.0
34	Snow Mountain	Shasta	40°46.0' 121°47.5'	6,200	1930-58	32.7	1952 1931	68.1 3.9
36	Manzanita Lake	Shasta	40°31.6' 121°33.7'	5,900	1936-55	10.2	1938, 39 1940, 41	31.9 0.0
343	New Manzanita Lake	Shasta	40°31.6' 121°33.0'	5,900	1950 to date	6.7	1952 1957-59	24.0 0.0

TABLE 3 (Continued)

SNOW SURVEY COURSES IN OR NEAR THE PIT RIVER BASIN

Ref. no. 1/	Snow course	County	Latitude N. and longitude W.	Elevation, in feet	Period of record	Water content of snow on April 1: Average 1930-59, in inches	Maximum and minimum: Season	Inches
39	Halls Flat	Shasta	40°45.0' 121°16.0'	5,600	1945-57	3.1	1952-55 1947, 51, 53, 54, 57	12.6 0.0
37	McElroy Pass	Shasta	40°41.7' 121°28.8'	5,000	1939 to date	2.6	1952 1939, 40 41, 47, 54, 55, 57, 59	18.0 0.0
41	Burney Springs	Shasta	40°46.8' 121°37.0'	4,800	1945 to date	3.1	1952 1951, 54, 55, 57, 59	20.3 0.0

1/ Designated by California Cooperative Snow Surveys.

or no direct relationship between precipitation and runoff during these months. Aggravated flood runoff conditions are created if a rain occurs simultaneously with late winter or early spring thaws. During April and May the precipitation is usually in the form of rain and produces immediate runoff in the streams.

The occurrence of thunder showers accounts for a large percentage of the summer season precipitation. Although the precipitation during the summer season is high in comparison with that in the Central Valley Area, it is not adequate to sustain high yield crops without supplemental water.

The mean monthly distribution of precipitation at selected stations in or near the Pit River Basin is shown in Table 4.

Quantity of Precipitation

Mean seasonal depth of precipitation over that portion of the Upper Pit River Basin situated below an elevation of 6,000 feet varies from 12 to 17 inches. In general, all the valley areas within the upper basin lie below the 6,000-foot elevation. At the Alturas station the mean seasonal depth of precipitation is approximately 12 inches, about 75 percent of which falls during the season from November through May. At the Bieber station, data from which represents the precipitation pattern in Big Valley, mean seasonal depth of precipitation is 16.79 inches. The highest recorded value (28.24 inches) at the Bieber station occurred during the 1937-38 season, while the lowest value of record (8.69 inches) occurred the following season. The recorded seasonal precipitation at Bieber for the period 1929-30 through 1958-59 is given in Table 5.

TABLE 4

MEAN MONTHLY DISTRIBUTION OF PRECIPITATION AT
SELECTED STATIONS IN OR NEAR THE PIT RIVER BASIN

(In inches of depth)

Name of station	Seasonal total	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
Alturas Ranger Station	12.16	.34	.25	.51	.96	1.28	1.49	1.62	1.37	1.32	1.02	1.11	.89
Bieber	16.79	.22	.15	.58	1.31	1.90	2.33	2.52	2.21	1.92	1.38	1.37	.90
Cedarville	12.12	.22	.14	.47	.99	1.36	1.56	1.84	1.43	1.32	.97	.99	.83
Fall River Mills Intake	15.82	.14	.13	.40	1.00	1.82	2.36	2.72	2.50	2.00	1.22	.98	.55
Hat Creek Powerhouse No. 1	17.99	.16	.15	.43	1.07	1.94	2.76	3.21	2.96	2.18	1.34	1.11	.68
Jess Valley	16.49	.29	.23	.72	1.20	1.77	1.96	2.21	1.94	1.80	1.45	1.63	1.29
Pit No. 5 Powerhouse	75.37	.38	.44	1.63	4.37	8.38	12.78	14.23	12.09	9.53	5.44	3.83	2.27

TABLE 5

SUMMARY OF RECORDED SEASONAL DEPTH OF PRECIPITATION AT BIEBER

Season	Precipitation, in inches	Season	Precipitation, in inches
1929-30	15.02	1944-45	18.76
1930-31	9.28	1945-46	16.51
1931-32	14.98	1946-47	14.26
1932-33	13.73	1947-48	22.77
1933-34	10.74	1948-49	13.86
1934-35	18.96	1949-50	15.65
1935-36	17.36	1950-51	17.30
1936-37	14.33	1951-52	23.99
1937-38	28.24	1952-53	19.13
1938-39	8.69	1953-54	14.69
1939-40	20.70	1954-55	12.08
1940-41	21.73	1955-56	25.50
1941-42	20.38	1956-57	17.04
1942-43	22.35	1957-58	24.95
1943-44	12.73	1958-59	14.75

The total mean seasonal quantity of precipitation that falls on the Pit River Basin is estimated at 6,710,000 acre-feet. Of this total, about 35 percent falls on the Upper Pit River Basin, and about 65 percent falls on the Lower Pit River Basin.

Runoff

The cyclic characteristic of runoff which prevails throughout California also is typical of the runoff of the Pit River and its tributaries. This pattern of heavy winter and light summer runoff, however, is modified to some extent by the existence of large perennial springs which feed tributary streams in the lower reaches of the river.

Although maximum runoff in the Pit River Basin occurs during the snowmelt period, a large base flow exists in the lower reaches of the river throughout the year due to the sustaining runoff from such tributaries as

Fall River and Hat Creek. These streams are fed by large springs which draw upon ground water supplies. Runoff in the Upper Pit River Basin is not supported by substantial base flows and, therefore, is dependent to a large extent upon climatological conditions.

Stream Gaging Stations and Records

Many stream gaging stations have been operated for various periods of time in the Pit River Basin. Stations either have been, or are being, maintained by the United States Geological Survey, the Pacific Gas and Electric Company, and the California Department of Water Resources. Most of the records of gaging stations in and above Big Valley are of short duration, or are measurements of intermittent summer flows obtained under State Watermaster Service.

The analysis of tributary runoff on a seasonal basis was hampered by lack of stream flow records. Since precipitation patterns generally reflect the amount of runoff that can be expected from ungaged drainage areas, the monthly distribution of precipitation and seasonal totals were used to check the estimated runoff from small ungaged tributaries. Recently, however, 15 new or reactivated stream gaging stations have been placed in operation on a year-around basis, and records from these stations should prove valuable in future years for substantiating or modifying estimates of runoff made during this investigation.

Table 6 lists selected stations whose records were utilized in this study. The table indicates the drainage area, period of record, and source of record for the selected stations. The newly installed gaging stations are listed in Table 7.

TABLE 6

SELECTED STREAM GAGING STATIONS IN THE PIT RIVER BASIN

Reference number on Plate 2	Stream	Station	Drainage area, in square miles 1/	Period of record	Source 2/ of record
1	North Fork Pit River	At Alturas	231	1928-31 1941 to date	USGS-1 DWR-1
2	South Fork Pit River	Near Likely	248	1928 to date	USGS
3	Pine Creek	Near Alturas	31	1918-31 1931 to date	USGS DWR-1
4	Pit River	Near Canby	1,430	1904-05 1929 to date	USGS USGS
5	Ash Creek	At Adin	249	1904-05 1928-32	USGS USGS
6	Pit River	Near Bieber	2,440	1904-08 1913-14 1921-26 1928-31 1951 to date	USGS USGS USGS USGS USGS
7	Pit River	At Fall River Mills	3,880	1921-51	USGS
8	Pit River	Below Pit No. 4 Dam	4,590	1927 to date	USGS
9	Pit River	At Big Bend	4,650	1910 to date	USGS
10	Pit River	Near Montgomery Creek	4,900	1944 to date	USGS

1/ Goose Lake Basin excluded.
2/ USGS - United States Geological Survey, USGS-1 - Intermittent record, DWR-1 - Department of Water Resources, intermittent record.

TABLE 7

NEW OR REACTIVATED STREAM GAGING STATIONS
IN THE PIT RIVER BASIN

(Continuous recorders installed after 1956 by the California Department of Water Resources, except as noted.)

Stream	Station	Date installed	Location, referenced to MDB&M		
			Section	Township	Range
Ash Creek 1/	At Adin	9-12-57	21	39N	9E
Big Sage Reservoir	Near Alturas	10-11-57	7	43N	12E
Burney Creek	Near Burney	4-21-58	19	35N	3E
Butte Creek	Near Adin	11-20-57	24	38N	9E
Fall River	Near Dana	11-19-57	30	38N	4E
Hat Creek	Near Cassel	9-18-58	18	36N	4E
Pine Creek	Near Alturas	11-20-57	35	42N	13E
Pit River	Below Alturas	10-12-57	13	42N	11E
Rush Creek	Near Adin	11-19-57	36	40N	9E
South Fork Pit River	Near Jess Valley	10-12-57	16	39N	14E
South Fork Pit River Diversion	To West Valley Reservoir	10-12-57	16	39N	14E
West Valley Reservoir 2/	Near Likely	12- -57	19	39N	14E
Turner Creek	Near Canby	4-30-58	35	42N	8E
Willow Creek 3/	Near Adin	9-16-57	35	38N	9E
Pit River 4/	Near Lookout	8-17-58	11	40N	7E

1/ Reference number 11 on Plate 2.
2/ Staff gage only.
3/ Reference number 12 on Plate 2.
4/ Reactivated by United States Geological Survey.

The gaging station on the Pit River near Canby is located about 14 miles upstream from the Allen Camp Dam site, and was the key station in estimating the water supply available for storage in the proposed Allen Camp Reservoir. The station is operated by the United States Geological Survey and has continuous records dating from 1931.

Estimates of inflow to the Round Valley Reservoir site were based on data obtained from a gaging station located on Ash Creek at Adin. Records are available for four complete years and 16 irrigation seasons at this station.

On September 12, 1957, the station was reactivated as a year-round continuous recording station by the Department of Water Resources. This station records the runoff of 249 square miles of drainage area. The available data were expanded and modified in order to estimate the water supply available for storage at the Round Valley Reservoir site.

The runoff from approximately 58 square miles of drainage area on Willow Creek, 27 square miles on Butte Creek, and 14 square miles on unnamed tributaries could be collected, conveyed, and stored in Round Valley Reservoir by construction of a 9-mile feeder canal. In order to estimate the runoff available for diversion to the Round Valley Reservoir site, the sparse records available from the "Willow Creek near Knudson Ranch" gaging station were utilized. A year-around gaging station, equipped with a continuous recorder, was installed a short distance upstream from this station on September 16, 1957, by the department. The station is known as "Willow Creek near Adin". Correlation of runoff at Willow Creek near Adin with runoff at Ash Creek near Adin was made to estimate the water supply available for diversion to the Round Valley Reservoir site. Stream flow records for Butte Creek are available only from December 1957, to April 1958. Flows during this period indicate that the runoff of Butte Creek is proportional to that of Willow Creek. The ratio of the drainage areas of Butte and Willow Creeks above the diversion sites, therefore, was used to estimate the total amount of water available for diversion to the Round Valley Reservoir site. Two small unnamed and ungaged tributaries to Ash Creek also have a portion of their drainage areas located above the proposed feeder canal route. The flows of these tributaries were also estimated by the ratio of drainage areas.

Runoff Characteristics

Most of the uncontrolled runoff from winter and spring precipitation and snowmelt from the Pit River watershed above Big Valley occurs prior to April 15. The most reliable sources of water in the upper basin during the summer are the perennial springs which contribute a combined flow of about 15 second-feet in the vicinity of Likely, and about 17 second-feet in the vicinity of Ash Valley. In the lower reaches of the Pit River the sustained flow from springs is credited for the stable base flow of the river. The total effluent flow from ground water storage to the Pit River above Shasta Lake has been estimated by the United States Bureau of Reclamation to be about 2,500 second-feet, with Fall River being the principal contributor.

Despite an abundant water supply for the Pit River Basin as a whole, the upper basin (shown on Plate 2) where most of the irrigable land is situated, is an area of limited supply. Certain areas in this upper basin produce virtually no surface runoff. A portion of the Modoc lava beds tributary to Big Valley is particularly significant in this respect. This area encompasses several hundred square miles north and west of Big Valley, but produces virtually no surface runoff due to the topographic and geologic characteristics of the lava formations.

The seasonal variations in runoff in the Upper Pit River Basin are similar to those encountered on the other stream systems on the western slope of the Sierra Nevada. The general drought, prevalent in northern California during the period from 1928 through 1934, is reflected in the records of runoff on the Pit River system. A graphical presentation of runoff during this critical drought period, and long-term trends of water supply are illustrated on Plate 5, entitled "Accumulated Departure from Estimated Average Seasonal Project Impaired Runoff of the Pit River at Allen Camp Dam Site".

Quantity of Runoff

Available records of stream flow, including those obtained from measurements made in connection with this investigation, were sufficient to estimate the runoff of the Pit River and its major tributaries at strategic points in the basin. Two important objectives of the hydrologic study of the Pit River Basin were to develop reliable inflow information for operation and sizing studies for the proposed Allen Camp and Round Valley Reservoirs, and to determine the water supply historically available to the Pacific Gas and Electric Company so that the effect of operation of the proposed reservoirs on downstream power plants could be evaluated.

Runoff above the Allen Camp Reservoir site has been impaired by irrigation and the construction of many reservoirs and stock watering ponds. Assuming that present conditions of this upstream development had prevailed throughout the 37-year base period of study, 1919-20 to 1955-56, the impairments would have averaged about 40 percent of the unimpaired seasonal flow of the Pit River. Runoff varies from season to season due to differences in seasonal precipitation, upstream storage, and the number of acres irrigated in the watershed above the Allen Camp Dam site. The period from 1952 through 1956 was utilized to determine present conditions of impairment. Plate 3, entitled "Estimated Seasonal Historical Runoff of the Pit River at the Allen Camp Dam Site", is a graphical representation of the quantity of water that has passed the Allen Camp Dam site from 1919-20 through 1955-56.

Estimates of project impaired runoff at the Allen Camp Dam site were obtained by modifying estimates of unimpaired runoff to account for present upstream development and for differences in stream flow depletion caused by inundation of approximately 800 acres of agricultural bottom lands in the Allen Camp Reservoir area.

Plate 4, entitled "The Estimated Seasonal Historical Runoff of Ash Creek at Adin", shows the quantity of water that has passed the gaging station at Adin. The historical runoff represents the water supply available at the Round Valley Dam site. Project impaired runoff at the Round Valley Dam site was obtained by a process similar to the one described for Allen Camp Dam site. Hydrologic studies and economic sizing studies of the proposed Willow Creek Canal were made to determine the amount of water supply that could be made available from Willow and Butte Creeks. This additional imported supply was added to the project impaired flow at the Round Valley Dam site to obtain the total project impaired flow. Plate 6, entitled "Accumulated Departure from Estimated Average Seasonal Project Impaired Runoff of Ash Creek at Round Valley Dam Site", indicates long-term trends of water supply conditions and includes inflows from the Willow Creek Canal.

The estimated seasonal unimpaired and project impaired runoff at the Allen Camp and Round Valley Dam sites are tabulated in Table 8. Estimates of the effects that construction of several upstream projects would have on the runoff at the Allen Camp Dam site are discussed in Chapter IV.

TABLE 8

ESTIMATED SEASONAL UNIMPAIRED AND PROJECT IMPAIRED RUNOFF AT THE ALLEN CAMP AND ROUND VALLEY DAM SITES

(In acre-feet)

Season	Allen Camp Dam site: Unimpaired runoff	Allen Camp Dam site: Project impaired runoff	Round Valley Dam site: Unimpaired runoff of Ash Creek	Round Valley Dam site: Project impaired runoff including Willow Creek Canal
1919-20	168,400	69,200	37,700	38,500
21	343,300	201,100	58,200	64,800
22	316,700	200,100	54,400	58,900
23	153,700	83,600	34,300	33,500
24	130,900	57,300	32,000	33,800
1924-25	198,900	81,500	41,100	42,100
26	143,200	59,700	34,000	35,000
27	350,200	214,200	58,900	65,000
28	233,900	126,500	45,500	48,400
29	144,900	68,700	32,600	31,700
1929-30	182,300	86,800	39,300	40,300
31	62,700	29,000	23,600	22,200
32	278,400	152,800	46,800	48,700
33	120,300	42,400	32,500	32,600
34	72,700	24,100	26,100	24,800
1934-35	229,100	112,200	45,200	48,100
36	311,000	190,800	55,300	60,900
37	174,500	88,800	35,900	37,500
38	654,900	487,200	92,400	104,200
39	139,800	63,300	31,800	31,300
1939-40	247,200	135,500	44,400	47,400
41	271,400	149,200	47,300	50,500
42	401,900	270,200	62,600	69,200
43	462,900	321,900	69,800	77,400
44	199,200	103,400	38,800	40,300
1944-45	318,400	205,900	52,800	57,200
46	261,900	156,600	49,400	53,200
47	146,600	68,000	35,500	36,300
48	276,900	168,500	47,900	51,500
49	311,800	199,500	52,000	56,200
1949-50	228,600	125,400	42,200	43,400
51	262,200	163,300	46,200	50,100
52	634,700	489,900	90,000	98,900
53	389,400	275,600	61,200	68,000
54	233,900	138,300	42,900	44,300

TABLE 8 (Continued)

ESTIMATED SEASONAL UNIMPAIRED AND PROJECT IMPAIRED RUNOFF AT THE ALLEN CAMP AND ROUND VALLEY DAM SITES

(In acre-feet)

Season	Allen Camp Dam site		Round Valley Dam site	
	Unimpaired runoff	Project impaired runoff	Unimpaired runoff of Ash Creek	Project impaired runoff including Willow Creek Canal
1954-55	185,800	88,100	37,200	38,100
56	608,200	422,400	86,900	98,000
TOTALS	9,850,800	5,921,000	1,764,700	1,882,300
37-year average	266,200	160,000	47,700	50,900

As previously stated, in order to plan efficient operation of the Allen Camp Project and in order to evaluate the effect of project operation on the water rights of the Pacific Gas and Electric Company, it was necessary to estimate the historical runoff available to the company's power plants from the entire Pit River Basin, and to estimate the runoff available to the plants from sources located downstream from the Allen Camp Dam site.

The three power plants of the Pacific Gas and Electric Company are located on the Pit River between the gaging station at Fall River Mills and the gaging station near Montgomery Creek just above Shasta Lake, as shown on Plate 2. The runoff attributable to the drainage area between these two stations was isolated by subtracting the flows of the Pit River at Fall River Mills and of the Fall River from the flow at the gaging station near Montgomery Creek. The flow of Fall River was corrected to account for the historical diversion of water through the Pit No. 1 Power Plant. The total runoff available to each plant was derived by distributing the incremental flow between the gaging stations at Fall River Mills and near Montgomery Creek in proportion to their respective drainage areas and adding the present impaired flows of the Pit River at Fall River Mills and of the Fall River. The runoff available to each plant from sources below the Allen Camp Dam site was derived by subtracting the present impaired runoff at the dam site from the total runoff available to the plants. Estimates of the present impaired runoff available to the Pit No. 3 Power Plant on a seasonal basis from the entire basin and from sources below the Allen Camp Dam site are contained in Table 9.

The average present impaired seasonal runoff for the 37-year period of analysis at the Allen Camp Dam site amounts to about 14.2 percent of the runoff of the Pit River below its confluence with Fall River, and averages about 6.3 percent of the runoff at the gaging station on the Pit River near Montgomery Creek.

TABLE 9

ESTIMATED PRESENT IMPAIRED SEASONAL RUNOFF OF THE PIT RIVER AT PIT NO. 3 POWER PLANT DIVERSION

(In acre-feet)

Season	Runoff at Pit No. 3 diversion from	
	Entire Pit River Basin	Sources below Allen Camp Dam site
1919-20	1,608,700	1,540,800
21	2,418,400	2,218,500
22	2,228,500	2,029,700
23	1,642,500	1,560,100
24	1,578,800	1,522,800
1924-25	1,767,700	1,687,500
26	1,805,300	1,746,900
27	2,629,400	2,416,500
28	2,118,100	1,992,400
29	1,811,300	1,743,800

TABLE 9 (Continued)

ESTIMATED PRESENT IMPAIRED SEASONAL RUNOFF OF THE PIT RIVER AT PIT NO. 3 POWER PLANT DIVERSION

(In acre-feet)

Season	Runoff at Pit No. 3 diversion from	
	Entire Pit River Basin	Sources below Allen Camp Dam site
1929-30	1,955,400	1,869,900
31	1,582,900	1,555,200
32	2,042,400	1,890,900
33	1,690,200	1,649,100
34	1,513,900	1,491,000
1934-35	2,147,500	2,036,500
36	2,221,100	2,031,600
37	1,816,200	1,728,700
38	3,617,300	3,131,400
39	1,732,200	1,670,200
1939-40	2,434,200	2,299,900
41	2,546,300	2,398,400
42	2,826,400	2,557,400
43	2,998,400	2,677,700
44	1,943,800	1,841,500
1944-45	1,889,900	1,685,100
46	2,075,700	1,920,400
47	1,511,800	1,445,100
48	2,001,200	1,833,700
49	1,637,300	1,439,100
1949-50	1,707,200	1,583,100
51	2,098,500	1,936,400
52	2,932,600	2,443,800
53	2,408,500	2,134,000
54	2,171,600	2,034,600
1954-55	1,607,500	1,520,700
56	3,235,600	2,814,400
TOTALS	77,954,300	72,078,800
37-year average	2,106,900	1,948,100

Ground Water

The Northeastern Counties Ground Water Investigation, initiated in July 1957, includes a study of the ground water potential in Big Valley. In Department of Water Resources Bulletin No. 3, entitled "The California Water Plan", it was pointed out that if it should be found feasible in the future to operate the Allen Camp and Round Valley Reservoirs in conjunction with possible, but not assured, ground water storage capacity in Big Valley, the combined yield might exceed the full ultimate water requirements of Big Valley. The investigation of ground water resources in Big Valley, insofar as possible, was planned so that data obtained could be used to evaluate the possibility of conjunctive operation with the surface supply. Ground water resources in Big Valley are discussed in the following sections.

Ground Water Geology

Big Valley is a faulted structural basin near the edge of the Modoc Plateau lava beds. The valley is bounded on all sides by volcanic rocks, such as lava flows and pyroclastics, which were erupted at diverse times during the past 40 million years. These volcanic rocks are exposed in the tilted fault block ridges on the east and west margins of the valley, in the complexly faulted mountainous terrain south of the valley, and in the faulted lava plateau north of the valley.

Fine-grained lake sediments comprise the bulk of the sedimentary deposits which fill Big Valley. These sediments include well-bedded tuffaceous and diatomaceous silts and clays with interbedded thin sand and gravel lenses. The lake sediments are overlain by Pleistocene and Recent stream-deposited silt, sand, and gravel which blanket most of the floor of Big Valley.

The lithologic units in Big Valley may be placed in three categories relative to the occurrence of ground water. These are the volcanic rocks of the margins, the lake sediments, and the alluvial sediments.

The volcanic rocks in the immediate vicinity of Big Valley apparently yield only a relatively small volume of ground water to springs and wells, and appear to be water-bearing only to a limited extent. Some recharge to the deeper aquifers in Big Valley probably occurs through the volcanics.

The lake sediments, which are over 2,000 feet thick in the Big Valley area, contain thin beds and stringers of sand which yield limited quantities of ground water to wells. Lacking evidence to the contrary, it is presumed that recharge to the thin permeable zones within the lake sediments is limited. Recharge probably occurs from pervious zones in the contiguous volcanics.

The recent alluvial deposits show a wide variation in thickness, distribution, and grading. The thickness varies from a thin veneer having but little significance as a source of ground water up to possibly 150 feet of alluvial sediments which are potentially an important source of ground water. The variations in thickness are due to both the irregular topography, caused by faulting and erosion of the ancient land surface on which the alluvial sediments were deposited, and to the erosion of the alluvial sediments after deposition. The alluvial cover is highly permeable near the margins of the valley, but both soil grain size and permeability decrease toward the center of the valley.

From ground water level measurements, the following generalization may be made relative to ground water movement. Free ground water in the alluvial sediments moves slowly downslope from the valley margins toward the outlet at the lower end of the valley. Some subsurface inflow and outflow through the volcanic is probable, but the volume of both may be low.

Ground Water Exploration in Big Valley, March 12, 1958

Recharge to the free, but semi-perched, ground water body in the alluvial sediments is derived principally from seepage of streams, with smaller contributions from rainfall and a minor amount of irrigation seepage. Data currently available are insufficient to delimit specific recharge areas.

Present Ground Water Development

There are little data available from which to evaluate the present and ultimate potential of the ground water supply in the Big Valley. Prior to the initiation of the Northeastern Counties Ground Water Investigation in July 1957, essentially no data were available on ground water use, ground water fluctuations, or recharge to the ground water basin.

Water level measurements obtained during the fall of 1957 indicate that the ground water table is less than 10 feet below the ground surface over the major portion of the valley floor. The water table is at a greater depth in the vicinity of Bieber and along the valley margin, particularly in the vicinity of Butte and Willow Creeks. Subsequent measurements indicate that the average change of level of the ground water table from spring to fall is approximately 2 feet.

Over 400 water wells have been located in Big Valley. Most of these wells are situated within a three-mile wide strip between Bieber and Adin, and are primarily used for domestic and stockwatering purposes. Of the wells located, only six were being used for irrigation purposes during 1958. In comparison with the amount of irrigation water supplied by surface diversion, these six wells provide only a negligible amount of irrigation water.

The majority of wells in Big Valley vary in depth from 25 to 250 feet. A few are over 700 feet in depth. The deeper wells probably produce ground water from thin sand lenses in the lake sediments.

Potential Ground Water Development

Available data indicate that the practical and economic development of water from the lake sediments underlying Big Valley would be limited by several factors. The specific capacity of wells producing from such sediments is usually too low to permit use of the wells for irrigation purposes. While no pump test data are available to support this contention, landowner's statements would appear to bear it out. It may be possible to increase the capacity by employing interconnected well clusters or similar type of development. Since recharge to the lake sediments is believed to be from the contiguous volcanics, and may be relatively low, it would tend to limit the safe yield of water from these sediments to a fairly low value.

Generally, the alluvial sediments have higher specific yield than the lake sediments. Development of ground water appears to be generally limited by the availability of the alluvial sediments. Since the ground water table is close to the surface over a large portion of the valley, it may be possible to develop a limited amount of water for irrigation by constructing large sumps which would extend below the free ground water table. Yield of ground water from the sumps would be determined by the area exposed to water-bearing sediments, permeability of sediments, and by the recharge rate to the sediments from perennial streams in the area.

Water Quality

A study was conducted to evaluate the present quality of ground and surface water resources of Big Valley, and to ascertain the suitability of these waters for present and anticipated beneficial uses. Primary consideration was given to the mineral quality of these waters as related to domestic, irrigation, and recreational uses, and to the preservation of fish and wildlife.

Field work was commenced in 1957 and water samples were subsequently obtained from the major surface streams and from ground water. Possible sources of degradation were investigated. Standard mineral analyses were made on all water samples, and those waters suspected of containing excessive mineral constituents were tested for heavy metals.

Water Quality Criteria

Determination of those characteristics of a water which affects its use for beneficial purposes is made by means of a water quality analysis. A comprehensive analysis of water quality consists of three parts: mineral, involving a determination of the inorganic constituents of the water; physical, including measurement of temperature, color, odor, and turbidity; and sanitary, made up of biochemical, bacteriological, and biological examinations. For the purpose of this bulletin, only mineral and physical characteristics were considered. Following are listed the water quality criteria for domestic, irrigation, recreation, and fish and wildlife uses, which are commonly employed by the Department of Water Resources.

Domestic and Municipal Water Supply. The limiting concentrations of mineral constituents for drinking water, as proposed by the United States Public Health Service in 1946, and subsequently adopted by the State of California, are presented in Table 10.

TABLE 10

UNITED STATES PUBLIC HEALTH SERVICE
DRINKING WATER STANDARDS
1946

Mineral constituent	Concentration, in parts per million
	Mandatory limit
Lead (Pb)	0.1
Fluoride (F)	1.5
Arsenic (As)	0.05
Selenium (Se)	0.05
Hexavalent chromium (Cr^{+6})	0.05
	Nonmandatory, but recommended limit
Copper (Cu)	3.0
Iron (Fe) and manganese (Mn) together	0.3
Magnesium (Mg)	125
Zinc (Zn)	15
Chloride (Cl)	250
Sulfate (SO_4)	250
Phenolic compounds, in terms of phenol	0.001
Total solids - desirable	500
Total solids - permitted	1,000

Interim standards for certain mineral constituents have recently been adopted by the California State Board of Public Health. Based on these standards, temporary permits may be issued for drinking water supplies failing to meet the United States Public Health Service Drinking Water Standards, provided the mineral constituents in Table 11 are not exceeded.

TABLE 11

MAXIMUM CONCENTRATIONS OF TOTAL SOLIDS AND SELECTED MINERAL IN DRINKING WATER AS DELIVERED TO THE CONSUMER

(In parts per million)

Constituent	Permit	Temporary permit
Total solids	500 (1,000)1/	1,500
Sulfates (SO_4)	250 (500)1/	600
Chlorides (Cl)	250 (500)1/	600
Magnesium (Mg)	125 (125)	150

1/ Numbers in parenthesis are maximum permissible, to be used only where no other more suitable waters are available in sufficient quantity for use in the system.

The California State Board of Public Health recently has defined the maximum safe amounts of fluoride ion in drinking water in relation to mean annual temperature as tabulated below:

Mean annual temperature	Mean monthly fluoride ion concentration
50°F	1.5 ppm
60°F	1.0 ppm
70°F - above	0.7 ppm

While hardness of water is not included as part of the United States Public Health Service Drinking Water Standards, it is of importance in domestic and industrial uses. Excessive hardness in water used for domestic purposes cause increased consumption of soap, formation of scale in pipes and fixtures, and other difficulties. The degrees of hardness, expressed in calcium carbonate in parts per million, suggested by the United States Geological Survey, are listed in the following tabulation.

Range of hardness, in parts per million	Relative classification
0 - 55	Soft
56 - 100	Slightly hard
101 - 200	Moderately hard
greater than 200	Very hard

It should be emphasized that the foregoing recommended limits are merely guides to appraisal of water quality. A water which exceeds one or more of these limiting values need not be eliminated from consideration as a source of supply. However, other possible sources of better quality water should be investigated.

Irrigation Water. Criteria for mineral quality of irrigation water used by the Department of Water Resources are those developed at the University of California at Davis, and at the Rubidoux and Regional Salinity Laboratories of the United States Department of Agriculture. Because of the diverse climatological conditions, and the variation in crops and soils in California, only general limits of quality for irrigation waters can be suggested.

The properties or constituents taken into account in the classification of irrigation waters and their prescribed limits are shown in Table 12.

TABLE 12

CLASSIFICATION OF IRRIGATION WATERS

Chemical properties	Class 1, excellent to good	Class 2, good to injurious	Class 3, injurious to unsatisfactory
Total dissolved solids:			
In parts per million	Less than 700	700 - 2,000	More than 2,000
In conductance, micromhos/cm at 25°C	Less than 1,000	1,000 - 3,000	More than 3,000
Chloride, in parts per million	Less than 175	175 - 350	More than 350
Sodium, in percent of base constituents	Less than 60	60 - 75	More than 75
Boron, in parts per million	Less than 0.5	0.5 - 2.0	More than 2.0

Class 1 irrigation water is suitable under most conditions for most crops. Under certain conditions, Class 2 irrigation water is of doubtful suitability for crops of low salt tolerance, such as deciduous fruit, some vegetables, and most clover grasses. Class 3 water is ordinarily unsatisfactory for all except the more tolerant plants, such as sugar beets, and salt-tolerant forage grasses.

Proper evaluation of quality of irrigation water must include other factors, in addition to the aforementioned criteria, such as soil permeability, drainage, temperature, humidity, rainfall, etc. Thus, there are instances in which water considered of poor quality by standards defined herein, is being used satisfactorily because of other factors.

Recreational, Fish, and Wildlife Uses. Since the mineral content of water used for recreational purposes rarely presents a problem, there are at present no generally accepted criteria governing the quality of waters used for such purposes. Sanitary and aesthetic factors are, however, of major importance in the development of water resources for recreational uses.

Studies by various state and federal agencies show that there are many mineral and organic substances harmful to fish and aquatic life, in relatively low concentrations. Water quality criteria for the maintenance of fresh water fish life, suggested by the California Department of Fish and Game, are as follows:

1. Dissolved oxygen content not less than 85 percent of saturation or 5 parts per million.

2. Hydrogen-ion concentration (pH) ranging between 7.0 and 8.5.

3. Conductivity between 150 and 500 micromhos/cm at 25°C and, in general, not exceeding 1,000 micromhos/cm.

Fish and aquatic life are particularly susceptible to:

1. Mineral salts of high toxicity, such as those of mercury, copper, lead, zinc, cadmium, aluminum, nickel, trivalent and hexavalent chromium, and iron.

2. Detergents, poisons, and insecticides employed in agriculture.

3. Unusual temperature conditions. Normal range of water temperature for cold water fish lies between 32° and 65°F. For warm water species, a temperature range from 45° to 85°F, with an absolute maximum of 91°F is generally considered acceptable.

4. Waste discharges containing more than 15 parts per million of ether soluble material.

Quality of Surface Water

Discussed herein is the quality of surface water which constitutes the supply to, and drainage from, Big Valley. For discussion and study purposes the stream system was divided into three units: Upper Pit River above Big Valley, Round Valley stream system, and Big Valley. In general, these three units have good to excellent quality water suitable for most beneficial uses.

Upper Pit River Above Big Valley. Water supplies to Allen Camp Reservoir would include the Pit River, and small streams and springs within the reservoir site. The small streams are intermittent and would contribute only a minor portion of the water supply to the reservoir.

To evaluate the quality of surface waters in this area, the Pit River was sampled at three points along the reach of the Allen Camp Reservoir site. These samples show a turbid, slightly hard, calcium-sodium bicarbonate-type water suitable for most uses. The analyses show only moderate concentrations of mineral constituents, with total dissolved solids ranging from 130 to 180 parts per million. During the time samples were being collected, minor streams tributary to the Pit River within the reservoir site were not flowing.

Monthly samples collected from the Pit River near the northeast end of the reservoir site at Canby Bridge, during the period from April 1951 to December 1957, showed a range in turbidity from 9 to 140 parts per million, with an average of 45 parts per million. Turbidity in this section of the Pit River is generally attributed to erosion of very fine particles, probably lava, in the upper reaches of the stream.

Round Valley Stream System. Ash and Rush Creeks comprise most of the surface waters that flow into Round Valley. Water in the upper reaches of Ash Creek above Round Valley is of a soft, sodium-magnesium bicarbonate-type, while Rush Creek, the major tributary to Ash Creek in Round Valley, is predominantly a slightly hard, calcium-magnesium bicarbonate water. These creeks contain excellent quality water, suitable for most beneficial uses. Butte and Willow Creeks, which would supplement this supply, were sampled during low flow conditions. Analyses of these samples indicate a soft to slightly hard, excellent quality, sodium bicarbonate-type water.

<u>Big Valley</u>. Principle surface water inflows to Big Valley during the late summer months are from the Pit River, Ash Creek, Willow Creek, and releases from Lower Roberts Reservoir.

Irrigation return flows from Big Valley have entered the Pit River by the time it flows past the gaging station located at the head of Muck Valley, near the lower end of Big Valley. At this point, Pit River water is a slightly hard, sodium-calcium bicarbonate-type of excellent quality.

Water from Ash Creek was sampled near the gaging station at Adin. At the time of sampling, overflow from the sawmill log pond, located just upstream, was negligible. The mineral constituents present in the water sample were of low to moderate concentrations, and the water sampled was excellent in quality.

Willow Creek was sampled near the bridge on U. S. Highway 299. The water sampled was slightly hard with concentrations of total dissolved solids ranging up to 187 parts per million, and was suitable for most beneficial purposes.

Water from Lower Roberts Reservoir, which provides supplemental water for irrigation in the fall, was sampled at the reservoir outlet. Analyses of samples indicate water of excellent quality, with total dissolved solids of 98 parts per million.

Turbidity, which is very apparent in the Pit River above Big Valley, is noticeably absent in the lower end of Big Valley. Turbidity in the Pit River ranges from 25 parts per million at the Allen Camp Dam site to five parts per million at the lower end of Big Valley.

Table 13 contains the results of mineral analyses of selected surface water samples from the Pit River, Ash and Rush Creeks, and at various other locations in Big Valley.

TABLE 13

COMPLETE MINERAL ANALYSES OF SELECTED WATER SAMPLES FROM THE UPPER PIT RIVER BASIN 1/

Source	Location number	Date sampled	Discharge, in second-feet	Temperature in °F	Specific conductance (micromhos at 25°C)	pH	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Total 2/ dissolved solids, in ppm	Per cent sodium	Hardness as $CaCO_3$ Total in ppm	Hardness as $CaCO_3$ N.C. in ppm	Remarks
							Mineral constituents in parts per million / equivalents per million																
ALLEN CAMP RESERVOIR SITE																							
Pit River near Canby	41N/9E-9R	5/9/56	772	54	174	7.0	15 / 0.75	5.5 / 0.45	15 / 0.65	3.0 / 0.07	0.0 / 0.00	100 / 1.64	9.0 / 0.19	2.5 / 0.07	0.6 / 0.01	0.2 / 0.01	0.02	30	130	34	60	0	3/
Pit River at Stone Coal Valley Road Bridge	41N/8E-27B	9/18/57	100 4/	62	248	8.1	19 / 0.95	7.7 / 0.63	22 / 0.96	5.7 / 0.15	0.0 / 0.00	136 / 2.23	20 / 0.42	18 / 0.05	0.4 / 0.01	0.6 / 0.03	0.10	36	180	36	79	0	
Pit River at Allen Camp dam site	41N/7E-35M	9/17/57	100 4/	66	254	7.9	16 / 0.80	11 / 0.92	22 / 0.96	5.6 / 0.14	0.0 / 0.00	144 / 2.36	18 / 0.37	3.4 / 0.10	0.4 / 0.01	0.8 / 0.04	0.07	34	182	34	86	0	
ROUND VALLEY RESERVOIR SITE																							
Rush Creek at Highway 299 Bridge	40N/9E-36M	9/18/57	15 4/	56	156	7.6	13 / 0.65	6.2 / 0.51	9.0 / 0.39	3.4 / 0.09	0.0 / 0.00	100 / 1.64	0.0 / 0.00	0.2 / 0.01	0.0 / 0.00	0.0 / 0.00	0.00	41	122	23	58	0	
Ash Creek at Round Valley dam site	39N/9E-21Q	9/18/57	12	58	191	6.5	9.8 / 0.49	7.4 / 0.61	17 / 0.74	6.4 / 0.16	0.0 / 0.00	113 / 1.85	2.9 / 0.06	0.0 / 0.00	0.3 / 0.00	0.6 / 0.03	0.01	38	138	37	55	0	
Butte Creek at diversion dam site	38N/9E-14M	9/17/57	0.2 4/	62	206	7.4	13 / 0.65	6.2 / 0.51	20 / 0.87	5.6 / 0.14	0.0 / 0.00	125 / 2.05	1.9 / 0.04	0.5 / 0.01	0.0 / 0.00	0.4 / 0.02	0.04	52	162	40	58	0	
Willow Creek at diversion dam site	38N/9E-27K	9/17/57	12 4/	62	176	7.2	10 / 0.50	4.6 / 0.38	21 / 0.91	5.6 / 0.14	0.0 / 0.00	108 / 1.77	7.7 / 0.16	0.0 / 0.00	0.1 / 0.00	0.2 / 0.01	0.05	51	153	47	44	0	
BIG VALLEY																							
Lower Roberts Reservoir below dam	39N/7E-11P	9/18/57	0.5 4/	65	112	7.2	9.2 / 0.46	7.1 / 0.58	6.1 / 0.27	2.3 / 0.06	0.0 / 0.00	64 / 1.05	12 / 0.25	0.0 / 0.00	0.3 / 0.00	0.6 / 0.03	0.04	28	98	20	52	0	
Willow Creek at Highway 299 Bridge	39N/9E-31P	9/19/57	1 4/	55	233	7.3	15 / 0.75	6.0 / 0.49	25 / 1.09	7.9 / 0.20	0.0 / 0.00	141 / 2.31	13 / 0.27	0.0 / 0.00	0.2 / 0.00	0.2 / 0.01	0.16	51	187	43	62	0	
Ash Creek at Adin gaging station	39N/9E-21P	9/19/57	17	60	193	7.1	12 / 0.60	6.3 / 0.52	18 / 0.78	5.4 / 0.14	0.0 / 0.00	114 / 1.87	7.7 / 0.16	0.2 / 0.01	0.0 / 0.00	0.6 / 0.03	0.09	40	146	38	56	0	5/
Pit River at Muck Valley gaging station	37N/7E-27L	9/19/57	54	57	303	7.0	21 / 1.05	10 / 0.84	27 / 1.17	6.8 / 0.17	0.0 / 0.00	167 / 2.77	15 / 0.31	3.3 / 0.09	0.3 / 0.00	0.8 / 0.04	0.07	39	206	36	94	0	

1/ Analyses by U. S. Geological Survey, Quality of Water Branch, Sacramento Laboratory, unless otherwise noted.
2/ Calculated from analyzed constituents.
3/ Other constituents include iron (Fe) 0.14, aluminum (Al) 0.15, chromium (Cr^{+6}) 0.01, manganese (Mn) 0.00, lead (Pb) 0.00, zinc (Zn) 0.00, arsenic (As) 0.00, phosphate (PO_4) 0.00, and copper (Cu) 0.00.
4/ Estimated.
5/ Analysis by Department of Water Resources, Bryte Laboratory.

Quality of Ground Water

For purposes of discussion of the quality of ground water herein, the Upper Pit River Basin was divided into the same three units discussed under surface water quality. It was found that ground water available to the area generally is of excellent quality.

Upper Pit River Above Big Valley. Samples were collected from a spring and a flowing well which would contribute directly to the Allen Camp Reservoir site. The spring, used for stockwatering and wildlife, shows a slightly hard, calcium-magnesium bicarbonate water of excellent quality. The flowing well, 300 feet deep, is located in the upper reaches of the reservoir site and has a calcium-sodium bicarbonate-type water. Total dissolved solids were less than 200 parts per million in samples collected from the spring and well.

Round Valley Stream System. Springs contributing to the flow of Ash Creek generally yield a slightly hard calcium-magnesium or calcium-sodium bicarbonate water of excellent quality. Flows from these springs are the major contributors of surface waters during the summer months. A spring and well along Rush Creek show excellent quality water, similar to that in the creek. The well is shallow in depth and is probably recharged by Rush Creek. However, a spring on upper Ash Creek yields calcium-magnesium bicarbonate water, while the creek itself is sodium-magnesium bicarbonate in mineral character.

Ground water in the lower end of Round Valley is generally a calcium-sodium bicarbonate-type. Total dissolved solids in ground water samples collected within Round Valley ranged from 116 to 196 parts per million.

<u>Big Valley</u>. In Big Valley, pumped wells and flowing springs are used as sources of water supply. These springs occur on the valley floor, as well as along the valley slopes. Depth of wells sampled during this investigation varied from 12 to 600 feet. Well casings, which generally extend only 40 to 60 feet below land surface, permit commingling of free and confined ground waters in deeper wells. The few wells cased below 60 feet are usually perforated at a depth of 70 to 120 feet in order to utilize the unconfined ground water. Because of this, ground water obtained from the deeper wells usually contains a mixture of water from both the unconfined and the various confined aquifers.

In general, ground water in Big Valley is suitable for most beneficial uses and is a soft to slightly hard, sodium bicarbonate-type of excellent quality. However, there are several active hot springs in the central portion of the valley just east of Bieber, with significantly different characteristics. Samples from two of these springs, and a nearby well which yields hot water, show a predominantly sodium, sulfate water with excessive concentrations of sulfate, fluoride, boron, arsenic, and a high percentage of sodium. A cold-water domestic well, 80 feet deep, located southeast of Bieber, also yields magnesium-sodium sulfate water. Water in this well showed 525 parts per million sulfate, 1,200 parts per million total dissolved solids, 507 parts per million noncarbonate hardness, and 580 parts per million total hardness. This poor-quality water may result from a mixture of fresh ground water with juvenile waters rising to the surface from the series of faults which traverse the central portion of Big Valley.

A domestic well and irrigation spring, located approximately four miles west of Bieber, yield calcium-magnesium bicarbonate-type water, while two miles east, several domestic wells show a sodium-magnesium bicarbonate water. This change in cation balance indicates the influence of sodium-type water issuing from the fault zone. However, ground water from these two sources is of excellent quality. A similar condition exists in the northern section of the valley. Here the dominant cation in the ground water changes from calcium within Allen Camp Reservoir site to sodium in an area five to seven miles below the dam site. However, in the foothills to the southeast of Big Valley, a spring tributary to Butte Creek in its upper reaches, as well as Lower McBride Warm Springs, the major contributor to the headwaters of Willow Creek, show a soft sodium bicarbonate-type water similar to that within Big Valley. Total dissolved solids were less than 150 parts per million in samples collected at these springs. Ground water inflows from Round Valley generally appear to be a sodium-calcium bicarbonate-type, of excellent quality, similar to the major streams which are the source of recharge. Total dissolved solids in the ground water range from 154 to 233 parts per million.

Table 14 contains the mineral analyses of selected ground water samples at various locations in the area.

TABLE 14

COMPLETE MINERAL ANALYSES OF SELECTED GROUND WATER SAMPLES FROM THE UPPER PIT RIVER BASIN 1/

Source	Well number	Date sampled	Temperature, in °F	Specific conductance (micromhos at 25 C)	pH	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents	Total dissolved solids, in ppm	Per cent sodium	Hardness as $CaCO_3$ Total, in ppm	Hardness as $CaCO_3$ N. C., in ppm	Remarks
						Mineral constituents in parts per million / equivalents per million																	
B. Gravier, flowing stock and irrigation well	41N/8E-34C1	11/19/55	62	253	7.5	24 1.20	5.9 0.48	18 0.78	6.6 0.17	0.0 0.00	154 2.52	2.0 0.04	1.0 0.03	3.3 0.05	0.0 0.00	0.05	49		186	30	84	0	Depth 330' +
U. S. Forest Service, game watering spring	41N/8E-29H1	9/18/57	61	238	7.0	21 1.05	11 0.91	11 0.48	3.9 0.10	0.0 0.00	145 2.38	6.7 0.14	0.2 0.01	0.0 0.00	0.0 0.00	0.00	63		188	19	98	0	
M. E. Kresge, domestic well	39N/9E-2P1	7/23/56	--	268	6.8	24 1.20	12 0.98	12 0.52	5.7 0.15	0.0 0.00	162 2.66	3.8 0.08	0.2 0.01	5.6 0.09	0.2 0.01	0.00	53		196	18	109	0	Depth 12' hand dug
Edgerton Sawmill Ind., warm spring	39N/9E-21Q1	9/18/57	70	180	7.8	13 0.65	6.9 0.57	14 0.61	5.5 0.14	0.0 0.00	113 1.85	1.9 0.04	2.1 0.06	0.4 0.01	0.1 0.01	0.00	56	Cu 0.01 3/ Zn 0.02	156	31	61	0	
H. Hayes, domestic well	39N/7E-26M1	9/19/57	55	279	7.3	19 0.95	12 0.96	24 1.04	2.9 0.07	0.0 0.00	176 2.88	5.8 0.12	4.5 0.13	0.1 0.01	0.0 0.00	0.00	58		213	34	95	0	Depth 45' cased 40'
H. Simer, domestic hot springs	38N/8E-14P1	9/18/57	150-170	1,290	8.6	31 1.55	0.0 0.00	241 10.48	7.2 0.18	10 0.33	18 0.30	403 8.39	117 3.30	0.0 0.00	2.8 0.15	3.1	87	Fe 0.06 Al 0.15 Cu 0.01 Zn 0.01 As 0.12 3/	911	86	78	47	Depth 60'
City of Bieber, municipal well	38N/7E-23D1	1951-53	--	---	7.7	20 1.00	10 0.82	15 0.65	---	0.0 0.00	152 2.49	0.0 0.00	10 0.28	1.5 0.02	0.0 0.00	---	--		182 4/	--	91	--	Depth 451' 5/ Perf. 73-93+
E. O. Babcock, irrigation well	38N/7E-34J1	5/31/56	48	693	7.3	58 2.89	36 2.98	45 1.96	3.7 0.09	0.0 0.00	362 5.93	46 0.96	29 0.82	0.0 0.00	0.1 0.01	0.10	49	Fe (total) 1.8 Fe 0.01	445	25	293	0	Depth 606' Perf. 80'

1/ Analyses by U. S. Geological Survey, Quality of Water Branch, Sacramento Laboratory, unless other noted.
2/ Calculated from analyzed constituents.
3/ Analysis was made for iron (Fe), aluminum (Al), manganese (Mn), copper (Cu), lead (Pb), zinc (Zn), arsenic (As), and chromium (Cr); the results were 0.0/0.00 except as noted.
4/ Electrometric determination.
5/ Analysis by State Department of Public Health.

CHAPTER III. WATER UTILIZATION AND WATER REQUIREMENTS

Prior to the times when the first immigrants entered California and made the first employments of water, the land patterns of the river basins, as well as the regimen of stream flows, were in a state commonly termed "natural conditions". The time period of the first settlement provides a convenient beginning from which to consider later changes in the quantity, quality, and regimen of stream flow caused by water development.

Changes in natural conditions occur when man stores water in a reservoir, irrigates land to produce crops, diverts stream flow for municipal or industrial purposes, conveys water to a hydroelectric plant to generate power, or otherwise develops the land and water resources. By such uses, he either changes the amount of water available in the stream for other purposes or imposes a change on the natural characteristics of stream flow. A general expression for such employments of water is the term "water utilization".

The nature and extent of land use and water utilization in Big Valley, both at the present time and under conditions of full development, are considered in this chapter.

Water Utilization

Use of water from the Pit River stream system in Big Valley began with initial settlement of the area in about 1871. The land subject to irrigation by direct diversion from the Pit River or its tributaries was gradually developed in the years following, with a usually ample water supply available during the spring months but with acute shortages occurring after about the middle of June.

The water resources available to Big Walley have been developed largely by individual effort. Irrigation, which creates the principal consumptive use of water in the area, has not increased appreciably during the last quarter-century, and no irrigation projects of valley-wide significance have been constructed. There remains a significant amount of unregulated water susceptible to development for agricultural, domestic, municipal, recreational, and other beneficial uses.

Present Water Supply Development

Controversies over the use of the limited summer supply of water in the Pit River Basin have resulted in various degrees of agreement between water users. In 1928, the former Division of Water Resources, in cooperation with Modoc and Lassen Counties, undertook a comprehensive survey of conditions and factors involved in the conservation of flood waters of the Pit River and its tributaries.

Farmers who diverted water from the Pit River in Big Valley availed themselves of the services of the Division of Water Resources during this survey to assist them in working out an agreement whereby the State could distribute the available water. The Division of Water Resources thereafter in 1930, 1931, 1932, and 1933 distributed the waters of the Pit River in Big Valley in accordance with annual agreements.

At the end of the 1933 season, the water users entered into a permanent agreement entitled, "Agreement Determining Rights to Water and to the Use Thereof From Pit River in Big Valley in Modoc and Lassen Counties, California", dated October 10, 1933. This agreement, which was designed to make maximum beneficial use of the available water supply on lands irrigated at that time, was signed by all major users of water from the Pit River in Big Valley. The Department of Water Resources and its predecessor has, since 1934, provided watermaster service under this agreement.

In the period between 1933 and 1954, various changes in water supply and water use conditions occurred with the result that the agreement of 1933 was no longer adequate to serve the purposes for which it was intended. Four of the most significant changes are described in the following paragraphs. The locations of the major existing water conservation facilities are shown on Plate 2.

First, improved water supply conditions during the low flow months occurred because of the construction in 1936 of West Valley Reservoir on West Valley Creek, a headwaters tributary of the Pit River, to store 17,700 acre-feet of water for use in South Fork Valley between Likely and Alturas. About the same time, the storage capacity of Dorris Reservoir near Alturas, which is utilized by diverting water from Pine Creek and Parker Creek, was enlarged to 11,100 acre-feet. In 1943, Big Sage Reservoir on Rattlesnake Creek filled to its capacity of 77,000 acre-feet for the first time since its completion in 1921. Development of the additional storage capacity, and the availability of ample water in Big Sage Reservoir made possible more liberal application of waters in the areas served by the various reservoirs during the summer months. As a result, downstream flows increased markedly during June, July, August, and September.

Secondly, Roberts Reservoir, originally utilized to store water for use on the ranch of H. M. Roberts, was purchased by the Big Valley Mutual Water Company about 1942. The reservoir was enlarged to a storage capacity of 5,500 acre-feet and runoff diverted into the reservoir from a portion of the Whalen Creek and Last Chance Creek watersheds. With this enlargement, the shareholders of the company had water available to supplement their supply from the Pit River during periods of low flow.

The third change occurred when owners of lands contiguous to the Pit River who were not parties to the 1933 agreement began to pump water from the river to irrigate approximately 3,000 acres of land. In order to properly distribute the water of the Pit River it was necessary that the water rights of these parties be defined.

The fourth and last significant change involved reconstruction of diversion dams to eliminate leakage. Water is diverted from the Pit River in ditches and sloughs, and by overflow of river banks by means of 11 dams which raise the water level of the river from 4 to 12 feet. At the time the 1933 agreement was signed, all but one of the dams then existing was of timber construction and excessive leakage occurred at higher levels of storage. As a result, large heads of water were necessary in the river to supply diversion requirements. Subsequent to 1933, the diversion dams were rebuilt with concrete abutments and floors, thus eliminating leakage. Thereafter, with the rebuilt dams, less flow was needed to permit diversions from the river.

As a result of these four changes in water supply and water use conditions, new problems were created which the water users believed could only be solved by a comprehensive determination of all water rights within the area. On December 24, 1954, the Division of Water Resources received a petition from 17 water users requesting a determination of the rights of the various claimants to the water of the Pit River stream system between the Canby gaging station at the lower end of Hot Springs Valley and the Pit River near Bieber gaging station at the outlet of Big Valley. Ash Creek was excluded from the Pit River stream system study since rights to water on Ash Creek had already been determined.

The division initiated an investigation of the Pit River stream system on April 1, 1955. On July 5, 1956, the State Water Rights Board assumed jurisdiction of the determination of the rights to water of the Pit River. In December 1958, the board completed its Order of Determination on the rights of the various claimants to the water of the Pit River stream system and filed its findings with the California Superior Court in Modoc County. On February 17, 1959, the court affirmed the Order of Determination, as modified, and decreed that the water rights in question are as set forth therein.

Pertinent Water Rights in the Pit River Basin

For convenience in presentation herein, a discussion of the pertinent water rights in the Pit River Basin are divided into those rights held upstream from Big Valley, in Big Valley, and downstream from Big Valley.

Upstream Rights. The use of water for irrigation purposes within the Pit River watershed upstream from the proposed Allen Camp Reservoir is of considerable magnitude. Table 15 lists the major water rights of record on the Pit River and its tributaries upstream from Big Valley. The most important storage rights are those permitting storage of water in West Valley Reservoir and Big Sage Reservoir. Numerous other storage rights held by individuals are not included in this tabulation.

In addition to the adjudicated, contractual, and major storage rights upstream from Big Valley there are numerous minor direct diversion rights which total a small amount of water, and also a number of minor storage rights.

Big Valley Water Rights. Use of water in Big Valley began with the settlement of the area about 1871. Nearly all of the water rights were acquired shortly after that date, and before the Water Commission Act of 1914

TABLE 15

MAJOR WATER RIGHTS OF RECORD UPSTREAM FROM BIG VALLEY

Location and description	Flow, in second-feet	Storage, in acre-feet
South Fork Pit River		
W. E. Armstrong vs. Frank McArthur, et al, Judgment and Decree No. 3273, Superior Court of Modoc County, October 30, 1954	227.19	---
Pine Creek Agreement of 1934	60.00	---
South Fork Irrigation District license on water rights Application No. 7860 (for storage in West Valley Reservoir)	---	17,000
North Fork Pit River		
North Fork Pit River Statutory Adjudication resulting in Decree No. 4074, Superior Court of Modoc County, December 14, 1939	110.55	---
Franklin Creek Adjudication by Court Reference Procedure, Crowder, et al, vs. Indart, et al, resulting in Decree No. 3118, Superior Court of Modoc County, September 8, 1933	11.65	---
Pit River in Hot Springs Valley		
Agreement of November 7, 1934	102.00	---
Hot Springs Valley Irrigation District permit on water right Application No. 3353 (for storage in Big Sage Reservoir)	---	50,000

which required that appropriative rights be initiated by filing an application with the State. Consequently, the only Big Valley water rights of importance on file with the State Water Rights Board are those for reservoir storage which were initiated after 1914. At the present time, most of the rights to water in the Pit River watershed between Canby Bridge (near the town of Canby) and the lower end of Big Valley have been determined by adjudication proceedings. Table 16 lists the major water rights in Big Valley.

TABLE 16

MAJOR WATER RIGHTS OF RECORD IN BIG VALLEY

Location and description	Flow, in second-feet	Storage, in acre-feet
Pit River Statutory Adjudication, Decree No. 6395 of the Superior Court of Modoc County, February 17, 1959	714.05[1/]	167,766[1/]
Ash Creek Adjudication by Court Reference Procedure, Charles A. Gerig vs. C. W. Clarke Co., et al, resulting in Decree No. 3670, Superior Court of Modoc County, October 27, 1947	152.80	---

1/ These amounts include applications for the Allen Camp Reservoir.

The season of use for all irrigation rights, except storage rights, is from April 1 to September 30. The season of use for storage rights varies, but the storage rights generally allow collection of water during the winter runoff season of each year. The period of use for domestic and stock watering rights extends from January 1 through December 31.

Downstream Rights. The State of California is authorized (Section 10500 of the Water Code) to file an application for any unappropriated water which in its judgment may be required in the development and the completion of the whole or any part of a general or coordinated plan looking toward the utilization and conservation of the State's water resources. The State is also authorized to assign its applications to an agency which undertakes the construction of a project which is substantially in conformance with that set forth in the state application.

State applications were made in connection with the development of the Sacramento River at Shasta Dam and were subsequently assigned to the United States. The following condition is contained in the assignment of Applications Nos. 5625, 5626, 9364 and 9365:

> ". . .subject to depletion of the stream flow above Shasta (formerly Kennett) Dam by the exercise of lawful rights to the use of water for the purpose of development of the counties in which such water originates, whether such rights have been heretofore or may be hereafter initiated or acquired, such depletion not to exceed in the aggregate four million five hundred thousand (4,500,000) acre-feet of water in any consecutive ten-year period, and not to exceed a maximum depletion in any one year in excess of seven hundred thousand (700,000) acre-feet."

The water rights held by the Pacific Gas and Electric Company for operation of its power plants downstream from Big Valley consitute a major item in the evaluation and planning of water projects for Big Valley. For many years the company has been developing the power resources of the Pit River below Fall River Valley. The company's plan for complete development calls for seven power plants. Construction has proceeded by stages, and there are now three major installations utilizing Pit River water, with a total installed name plate rating of 290,900 kilowatts. Water rights on file with the State Water Rights Board in support of the existing and proposed developments of the company are shown in Table 17.

TABLE 17

PIT RIVER WATER RIGHTS HELD BY
PACIFIC GAS AND ELECTRIC COMPANY

Application number	Date filed	Place of use	Amount, in second-feet	Status
1891	July 2, 1920	Pit No. 3	3,000	License
1892	July 2, 1920	Pit No. 4	3,000	Permit
14743	April 7, 1952	Pit No. 6	4,500 (40,000 acre-feet)	Permit
14928	July 28, 1952	Pit No. 4	500	Permit
15407	July 9, 1953	Pit No. 7	4,850	Permit

Water is diverted from Fall River for power generation at Pit No. 1 Power Plant. Use of water at the Pit No. 5 Power Plant is under a claim of riparian rights. The Pit Power Plants Nos. 6 and 7 have not been constructed. The nature and extent of the water rights for these projects must be considered in connection with planning for upstream development.

Water Rights for or Affecting the Allen Camp and Round Valley Projects

Specific water rights for or affecting the Allen Camp and Round Valley Projects are discussed in the following sections.

Water Rights for Allen Camp Reservoir. Two water rights applications have been filed for the Allen Camp Project in Big Valley. They cover a total of 156,000 acre-feet, substantially the storage rights required for the entire project.

Unassigned State Application No. 5643 includes 80,000 acre-feet of water for Allen Camp Reservoir. It was filed on July 30, 1927, pursuant to Section 10500 of the Water Code. That section now exempts state applications from the requirements of diligence. As long as the exemption is continued and the State retains custody of this application, its priority is assured. The usual requirements of diligence will apply, however, upon assignment of the application for construction purposes or upon a failure by the Legislature to extend the exemption in the future.

Application No. 14602 was filed on December 13, 1951, by the Pit Soil Conservation District as trustee for the Big Valley Irrigation District. It seeks to appropriate 76,000 acre-feet from the Pit River, to be collected each season between October 1 and April 30, and to be used for irrigation purposes on a net area of 35,166 acres within a gross area of 39,772 acres within the boundaries of the Big Valley Irrigation District. It proposes a project similar to the Allen Camp Project proposed in State Application No. 5643.

Application No. 14602 is complete, but has been protested by the Pacific Gas and Electric Company. Before the necessary permit may be issued, the protest must either be considered at a hearing before the State Water Rights Board or be settled by negotiation. On December 19, 1957, the board granted Pit Soil Conservation District an extension of time until December 1, 1958, to continue negotiations with the Pacific Gas and Electric Company. No further action has been taken by the board to the present date (October 1960).

Water Rights for Round Valley Reservoir. No applications have been filed to support the proposed storage project at the Round Valley site on Ash Creek, or for the diversion of water from Willow Creek and Butte Creek for off-stream storage at the Round Valley site. These developments are not covered by State Application No. 5643.

The County Board of Supervisors or the Big Valley Irrigation District could request the Department of Water Resources to file additional state applications to appropriate water for them. Such applications could be assigned to the constructing agency just prior to construction of the projects. An alternative, of course, would be for the agency itself to file applications when project construction becomes imminent. State applications could be filed earlier, however, and could retain their priority, since they would be exempt from the requirements of diligence. Finally, it might be possible to amend Application No. 5643 to permit diversion to storage at the Round Valley site. This would involve a transfer of a portion of that application downstream.

Pacific Gas and Electric Company Downstream Rights. The first of the Pacific Gas and Electric Company power plants to be affected by water development for Big Valley would be Pit No. 3, which is located on the main stem of the Pit River about 70 miles downstream from the proposed project. Pit No. 3 is operated under Application No. 1891, filed on July 2, 1920, and a license subsequently issued on May 6, 1927, for 3,000 second-feet year-around diversion.

Other Pacific Gas and Electric Company appropriative rights on the main stem of the Pit River are evidenced by permits for Pit No. 4, Pit No. 6, and Pit No. 7. The latter two plants are not yet constructed. The major part of the Pit No. 4 diversion, 3,000 second-feet, is covered by Application No. 1892 filed in 1920.

Applications Nos. 1891 and 1892 for the Pit No. 3 and Pit No. 4 plants, respectively, predate State Application No. 5643, which was filed to appropriate water for the Upper Pit River watershed including Allen Camp Reservoir. As a senior appropriation, the company could probably assert its priority against the projects under consideration.

The Pit No. 5 Power Plant, located near Iron Canyon Creek, is unique in that it operates under claim of riparian rights. Pit No. 5 has an installed name plate rating capacity of 128,000 kilowatts. The company lists the peak output from this plant at 152,000 kilowatts, with a corresponding peak flow of 3,500 second-feet.

Since the generation of power is a proper riparian use, the company could probably assert these rights with respect to upstream appropriation, to the extent that it can establish its status as a riparian owner.

Other Downstream Rights. Use of the waters of the Pit River under riparian rights for irrigation in Fall River Valley constitutes the major consumptive use of water between Big Valley and Shasta Reservoir. This use is effected by several diversions from the river near McArthur for irrigation on a narrow strip of land bordering the river. These rights to the use of Pit River water are not on record with the State Water Rights Board but could be asserted against the projects under consideration in this bulletin.

Water Districts and Agencies

The Big Valley Irrigation District was organized for the purpose of constructing and operating water projects for the benefit of farmers in Big Valley. The district was formed on October 12, 1925, after two previous efforts to organize had failed.

The gross area of the new district was 12,430 acres, of which 11,000 were irrigable. The plan, as then proposed, was to store water in a reservoir in Jess Valley east of Likely, in cooperation with other interests. Negotiations failed, and the district remained inactive until 1933.

In 1933, a new plan was proposed by the district involving the storage of 15,000 acre-feet of water at a reservoir site on the Pit River about 12 miles above Lookout. An application for a loan of $206,400 was filed with the Federal Public Works Administration for funds with which to finance the proposed project, but the funds did not materialize and the plan was dropped.

In 1951, the National Association of Soil Conservation Districts established a pilot district program for the purpose of developing a comprehensive plan for proper conservation of all lands within one soil conservation district in each state. Subsequently, the Pit Soil Conservation District, which includes that portion of Big Valley which lies within Lassen County, was selected as the pilot district for California.

The Adin-Lookout Soil Conservation District operates in that portion of Big Valley which lies within Modoc County. The interests of Big Valley Irrigation District and the two soil conservation districts are closely allied.

The Big Valley Mutual Company was formed in 1942 for the purpose of acquiring Lower Roberts Reservoir. The company has obtained water from this reservoir as a supplemental supply for use on lands of its shareholders along the Pit River in Big Valley. Other organizations, such as the Big Valley Water Council, have been formed to promote interest in the development of water resources.

The Lassen-Modoc County Flood Control and Water Conservation District was created by an act of the 1959 Legislature (Chapter 2127, Statutes of 1959). The new district comprises all of the County of Lassen and that portion of Modoc County situated within the drainage area of the Pit River.

Land Use

Determination of water requirements in Big Valley for this investigation began with a study of the nature and extent of land use prevailing during the period between 1954 and 1958. Future land use, as related to water utilization, was forecast on the basis of land classification survey data which segregated lands of the area in accordance with their suitability for irrigated agriculture. Lands for urban and recreational uses are expected to constitute a minor portion of the total lands in Big Valley and, therefore, will not be covered in detail in this bulletin.

Although extensive land and water utilization data were collected in all of the agriculturally significant valleys in the Pit River Basin and used in developing estimates of the total water supply available to Big Valley, only the data pertinent to Big Valley proper are presented in this chapter.

Land Classification. An extensive land classification survey was conducted during the period from 1954 to 1956 as part of the Northeastern Counties Investigation. The results of this survey are included in Bulletin No. 58. The extent and location of the irrigable lands in the Big Valley hydrographic unit were determined by field surveys which grouped all lands into their appropriate classifications of irrigability and crop adaptability.

The suitability of land for irrigated agriculture is influenced by many factors. The physical characteristics of the land, are the inherent conditions of the soil itself, directly affect the adaptability of the land for irrigation development. Further, the location of the land with respect to the available water supply and the selection of crops suitable for the climatic conditions affect the degree of possible development through irrigation. For this investigation all pertinent factors were considered in evaluating future requirements for water.

Lands classified as suitable for irrigation development were segregated into three broad topographic groups: (1) smooth lying valley lands, (2) slightly sloping and undulating lands, and (3) steeper and more rolling lands. Where other conditions limited the suitability of the lands to produce climatically adapted crops, the three broad classes were further subdivided in accordance with the nature of the limitations. Such limiting conditions included shallow soil depth, rockiness, high-water tables, coarse soil textures with low moisture-holding capacities, very fine soil textures limiting the effective depth, and the presence of saline and alkaline salts.

Table 18 comprises a description of the land classes with respect to irrigability and crop adaptability.

TABLE 18

LAND CLASSIFICATION STANDARDS

Land class	Characteristics
	Irrigable Valley Lands
V	Smooth lying valley lands with slopes up to six percent in general gradient, reasonably large-sized bodies sloping in the same plane; or slightly undulating lands which are less than four percent in general gradient. The soils have medium to deep effective root zones, are permeable throughout, and free of salinity, alkalinity, rock or other conditions limiting crop adaptability of the land. These lands are suitable for all climatically adapted crops.
Vw	Similar in all respects to Class V, except for the present condition of a high-water table, which in effect limits the crop adaptability of these lands to pasture crops. Drainage and a change in irrigation practice would be required to affect the crop adaptability.

TABLE 18 (Continued)

LAND CLASSIFICATION STANDARDS

Land class	Characteristics
Vs	Similar in all respects to Class V, except for the presence of saline and alkaline salts, which limits the present adaptability of these lands to crops tolerant to such conditions. The presence of salts within the soil generally indicates poor drainage and a medium to high-water table. Reclamation of these lands will involve drainage and the application of additional water over and above crop requirements in order to leach out the harmful salts.
Vh	Similar in all respects to Class V, except for having very heavy textures, which makes these lands best suited for the production of shallow-rooted crops such as pasture.
Vl	Similar in all respects to Class V, except for having fairly coarse textures and low moisture-holding capacities, which in general make these lands unsuited for the production of shallow-rooted crops because of the frequency of irrigations required to supply the water needs of such crops.
Vp	Similar in all respects to Class V, except for depth of the effective root zone, which limits use of these lands to shallow-rooted crops, such as irrigated grain and pasture.
Vr	Similar in all respects to Class V, except for the presence of rock on the surface or within the plow zone in sufficient quantity to prevent use of the land for cultivated crops. These lands are suitable for irrigated pasture crops.
Vhs	Similar in all respects to Class V, except for the limitations set forth for Classes Vh and Vs, which make these lands best suited for the production of shallow-rooted, salt-tolerant crops.
Vls	Similar in all respects to Class V, except for the limitations set forth for Classes Vl and Vs, which make these lands best suited for the production of deep-rooted, salt-tolerant crops.
Vps	Similar in all respects to Class V, except for the limitations set forth for Classes Vp and Vs, which restrict the crop adaptability of these lands to shallow-rooted, salt-tolerant crops.
Vpr	Similar in all respects to Class V, except for the limitations set forth for classes Vp and Vr, which restrict the crop adaptability of these lands to irrigated pasture.

TABLE 18 (Continued)

LAND CLASSIFICATION STANDARDS

Land class	Characteristics
	Irrigable Hill Lands
H	Rolling and undulating lands with slopes up to a maximum of 20 percent for rolling large-sized bodies sloping in the same plane; and grading down to a maximum slope of less than 12 percent for undulating lands. The soils are permeable, with medium to deep effective root zones, and are suitable for the production of all climatically adapted crops. The only limitation is that imposed by topographic conditions, which affect the ease of irrigation and the amount of these lands that may ultimately be developed for irrigation.
Hl	Similar in all respects to Class H, except for having fairly coarse textures and low moisture-holding capacities, which in general make these lands unsuited for the production of shallow-rooted crops because of the frequency of irrigation required to supply the water needs of such crops.
Hp	Similar in all respects to Class H, except for depth of the effective root zone, which limits use of these lands to shallow-rooted crops.
Hr	Similar in all respects to Class H, except for the presence of rock on the surface or within the plow zone in sufficient quantity to restrict use of the land to noncultivated crops.
Hpr	Similar in all respects to Class H, except for depth of the effective root zone and the presence of rock on the surface or within the root zone in sufficient quantity to restrict use of these lands to noncultivated crops.
Ht	Similar in all respects to Class H, except for topographic limitations. These lands have smooth slopes up to 30 percent in general gradient for large-sized bodies sloping in the same plane, and slopes up to 12 percent for rougher and more undulating topography. These lands will probably never become as highly developed as other "H" classes of land, and are best suited only for irrigated pasture.
Htl	Similar in all respects to Class Ht, except for having fairly coarse textures and low moisture-holding capacities which in general make these lands unsuited for the production of shallow-rooted crops and presents a great erosion hazard.
Htp	Similar in all respects to Class Ht, except for depth of the effective root zone, which limits use of these lands to shallow-rooted crops.
Htr	Similar in all respects to Class Ht, except for the presence of rock on the surface or within the plow zone in sufficient quantity to restrict use of these lands to noncultivated crops.

TABLE 18 (Continued)

LAND CLASSIFICATION STANDARDS

Land class	Characteristics
Htpr	Similar in all respects to Class Ht, except for depth of the effective root zone and the presence of rock on the surface or within the root zone, which limit use of these lands to noncultivated shallow-rooted crops.
	Other Lands
F	Presently forested lands, or lands subject to forest management, which meet the requirements for irrigable land but which, because of climatic conditions and physiographic position, are better suited for timber production or some type of forest management program rather than for irrigated agriculture.
U	Urban lands presently used for residential, commercial, resort, and industrial purposes.
N	Includes all lands which fail to meet the requirements of the above classes.

As a result of the land classification survey in Big Valley, approximately 94,300 acres of land have been classed as irrigable. An additional 300 acres are classified as urban. Approximately 67,000 acres, or 71 percent of the irrigable lands, are valley lands. The remaining irrigable lands are hill lands. Table 19 presents the results of the land classification survey in Big Valley.

Present Patterns of Land Use. All farmed lands in Big Valley are located on the flat valley floor or on the gently sloping bordering foothills. Low lands bordering the Pit River and the main tributaries constitute nearly all the irrigated lands in the valley. The variety of crops presently grown in Big Valley is limited not only by climate and land suitability but also by frequent flooding of large areas adjacent to the

TABLE 19

CLASSIFICATION OF LANDS WITHIN BIG VALLEY

Land class	Area, in acres
Irrigable Valley Land	
V	30,400
Vw	12,150
Vs	3,850
Vp	20,550
Vpr	50
Subtotal	67,000
Irrigable Hill Land	
H	3,950
Hp	20,250
Hr	500
Ht	650
Htp	1,650
Hpr	300
Subtotal	27,300
Other Lands	
U	300
TOTAL	94,600

valley streams. This flooding, which occurs each spring, precludes using a large portion of the valley floor for other than noncultivated crops that are tolerant to annual inundation and a prolonged period of high-water table conditions. As a result, native pasture and meadow hay are the principal crops grown on the valley floor.

Native meadow hay grows in areas of naturally occurring high-water table conditions such as depressions where water collects, or on unleveled land near the river where wild flooding practices result in an excess of water saturating the soil for long periods of time. The meadow grasses vary in quality from coarse water grass found on saturated land to the improved grasses growing where water is applied intermittently. After meadow hay is harvested, usually during early July, the land is irrigated for fall pasture if water is available.

Irrigated lands situated at higher elevations have better drainage and are cropped mostly to alfalfa. The first crop of alfalfa is usually cut between June 15 and July 15. Alfalfa that receives adequate irrigation will mature a second crop by the latter part of August. The uncultivated portion of the Big Valley area, consisting of sage brush hills and timbered mountains, is used to pasture cattle during the spring and summer. This range land is largely public land within the Modoc National Forest, or public land administered by the United States Bureau of Land Management.

Results of the land use survey made in 1958 indicate that over three-fourths of the lands presently irrigated in Big Valley are farmed to either pasture or meadow hay lands. The remaining irrigated lands are devoted to alfalfa, hay, or grain.

A summary of the results of the land use survey within Big Valley is presented in Table 20. Irrigated land areas are gross delineations that include all agricultural lands to which water is or could be applied, as well as roads, farmsteads, canals, or other rights of way.

Probable Future Pattern of Land Use in Big Valley. Since irrigated agriculture is now and will probably continue to have the most significant future water requirement in Big Valley, considerable emphasis was placed on the classification of lands suitable for irrigated agriculture and the projection of a future crop pattern. The anticipated future crop pattern for Big Valley was projected with due regard for land irrigability, crop adaptability, and present irrigated agricultural development. Local farmers, farm

TABLE 20

PRESENT AND FUTURE PATTERN OF LAND
USE IN BIG VALLEY

Land Use	Area, in acres	
	Present	Future
Irrigated lands		
Alfalfa	2,400	25,100
Improved pasture	0	16,900
Meadow pasture	0	1,200
Hay and grain	1,740	9,200
Native pasture and meadow hay	19,950	0
Truck crops	0	1,800
Field crops	0	1,200
Subtotals	24,130	55,400
Urban area	300	2,500
Miscellaneous	70,170	36,700
TOTALS	94,600	94,600

groups, and agricultural leaders familiar with the area furnished valuable information which aided in the forecast of future agricultural development.

Only 55,400 acres of the 94,300 acres classed as irrigable in Big Valley were forecast for eventual irrigation development, because of practical limitations on the availability of water supply. The 38,900 acres not forecast for irrigated agriculture consist primarily of rolling hill lands with shallow and sometimes rocky soil cover. In addition, some of the shallower and saline irrigable valley lands were not forecast for future irrigation development.

As the agricultural economy approaches full development, it is anticipated that proportionately more of the irrigated acreage will be devoted to alfalfa. Much of the land cropped to meadow hay will be replaced by improved pasture. Grain and grain hay will become much more important in the area, and there will be a significant amount of field and truck crops grown. The crop pattern projected for full irrigation development in Big Valley is presented in Table 20.

Unit Use of Water

In general, the amounts of water consumptively used by irrigated crops in Big Valley were estimated by applying appropriate unit values of water use to the present land-use pattern as determined from field survey data. The appropriate unit values were determined by a method originally developed at the University of California at Davis, modified in accordance with the results of department studies.

It has been found that unit values of consumptive use of water by crops in a given locality can be estimated from evaporation data obtained in the locality from black and white atmometers, and from consumptive use coefficients for the crops derived elsewhere by actual measurement of evapotranspiration. Agroclimatic stations were established in 1955 in Fall River Valley, Big Valley, and near Alturas for the purpose of obtaining evaporation and other significant data which would reflect the varying local climatic and operational influences. Empirical coefficients of consumptive use for alfalfa and pasture in Big Valley were derived by this method. The coefficients for hay, grain, truck, and field crops were established on the basis of judgment and available information with respect to irrigation of these crops. Monthly unit values of consumptive use for the irrigated crops were estimated on the assumption that the water supply would be adequate to produce optimum crop yields. Unit consumptive use values were adjusted by subtracting effective precipitation that occurs during the growing season, and soil moisture stored at the start of the growing

Agroclimatic Station in Big Valley

season and consumed by the plants by the end of the season. From this analysis estimates of unit values of monthly and seasonal consumptive use of applied water were made for selected crops in Big Valley. These values are presented in Table 21.

TABLE 21

ESTIMATED SEASONAL UNIT VALUES OF CONSUMPTIVE USE
OF APPLIED WATER FOR SELECTED
CROPS IN BIG VALLEY

(In feet of depth)

Crop	May	June	July	August	September	Seasonal totals
Alfalfa	0.33	0.49	0.60	0.25	0.08	1.75
Pasture	0.33	0.49	0.60	0.38	0.18	1.98
Hay and grain	0.16	0.28	0.28	0	0	0.72
Truck crops	0.10	0.31	0.40	0.18	0	0.99
Field crops	0.10	0.31	0.40	0.08	0	0.89
Alfalfa seed	0.33	0.49	0.24	0	0	1.06

The coefficients used for the determination of consumptive use in Big Valley reflect the best available information. However, advances in methods of measuring evapotranspiration by means of evapotranspirometers and advances in methods of measuring soil moisture by use of radioactive devices are currently under study. These continuing field studies may yield water-use data which may modify the values presented herein.

Present Consumptive Use of Applied Water

The amount of applied water that would be consumptively used on presently irrigated lands, if a full water supply were available, was determined by multiplying the acreage of each crop by its respective unit value of consumptive use of applied water. Based on assumed availability of a full water supply, the present seasonal consumptive use of applied water in Big Valley amounts to an estimated 45,000 acre-feet.

Under existing conditions, however, adequate water supplies are not available each season. For example, water supply shortages during the 1954-58 irrigation seasons caused decreases in the average monthly total of irrigated acreage. Table 22 presents the averages of acreage irrigated by months during this period.

TABLE 22

AVERAGE IRRIGATED ACREAGE IN BIG VALLEY
DURING THE PERIOD 1954-58

(In acres)

Crop	Total acreages	May	June	July	August	September
Alfalfa	2,440	2,440	2,260	2,010	1,750	1,160
Native pasture and meadow hay	19,950	19,950	13,120	7,120	6,040	7,940
Hay and grain	1,740	1,740	1,540	1,270	420	0
TOTALS	24,130	24,130	16,920	10,400	8,210	9,100

If the unit values of consumptive use are multiplied to the acreages shown in Table 22, the resulting estimate of present seasonal consumptive use of applied water in Big Valley is approximately 25,800 acre-feet. However, the total consumptive use of water in Big Valley is higher than this amount by an estimated 6,000 acre-feet seasonally, due to the use of available soil moisture by plants on lands on which water is not regularly applied.

Future Consumptive Use of Applied Water

The probable magnitude of consumptive use of applied irrigation water in Big Valley under full irrigation development is presented in Table 23. These values were obtained as products of the anticipated future crop acreages, as shown in Table 20, and the seasonal unit values of consumptive use of applied water presented in Table 21.

TABLE 23

ESTIMATED FUTURE SEASONAL CONSUMPTIVE USE OF APPLIED WATER IN BIG VALLEY

Crop	Acres	Consumptive use, in acre-feet					
		May	June	July	August	September	Totals
Alfalfa	25,050	8,260	12,250	15,020	6,230	2,020	43,780
Improved pasture	16,920	5,570	8,280	10,180	6,410	3,070	33,510
Meadow pasture	1,210	400	590	730	450	210	2,380
Hay and grain	9,160	1,460	2,560	2,560	0	0	6,580
Truck crops	1,850	190	570	740	150	0	1,650
Alfalfa seed	1,250	410	610	300	0	0	1,320
TOTALS	55,440	16,290	24,860	29,530	13,240	5,300	89,220

Monthly Demands for Irrigation Water

As indicated in Table 21, the consumptive use of applied water in Big Valley occurs primarily during the months of May through September. Seasonal variations in precipitation, however, may alter the pattern of growth and make irrigation necessary as early as March, or retard the beginning of the irrigation season until late in May. Also, when subnormal precipitation occurs in September and October, irrigation is continued on pastures when water is available.

For purposes of estimating the average monthly distribution of demand for irrigation water for various crops in Big Valley, the consumptive use pattern presented in Table 21 was used. Table 24 shows the distribution of demand in percent of seasonal total for selected crops in Big Valley.

TABLE 24

ESTIMATED AVERAGE MONTHLY DISTRIBUTION OF SEASONAL DEMAND FOR IRRIGATION WATER FOR SELECTED CROPS IN BIG VALLEY

(In percent)

Crop	May	June	July	August	September	Totals
Alfalfa	19	28	34	14	5	100
Pasture	17	25	30	19	9	100
Hay and grain	22	39	39	0	C	100
Truck crops	10	31	41	18	0	100
Field crops	11	35	45	9	0	100
Alfalfa seed	31	46	23	0	0	100

Water Requirements

Estimates of the use of irrigation water under present conditions, and irrigation water requirements under future anticipated conditions, are discussed in the following paragraphs. In addition, nonconsumptive water requirements are briefly discussed.

Present Use of Irrigation Water

Estimates of the present use of irrigation water in Big Valley were based on the unit consumptive use values previously discussed and tabulated in Table 21, and on appropriate irrigation efficiency factors. Irrigation efficiencies in Big Valley are highly variable both in respect to place and time. During May and June, for instance, when the water supply is generally adequate and the basin is nearly saturated from winter precipitation and runoff, the efficiency associated with the application of irrigation water is extremely low. On the other hand, during the latter part of July, and during August and September when the water supply is generally short, irrigation efficiency in Big Valley is high. Application of irrigation efficiency factors (ranging from 50 percent to 90 percent) to consumptive use estimates for the irrigated acreages tabulated in Table 22, resulted in an estimated average use of irrigation water in Big Valley during the 1954-58 irrigation seasons of about 39,000 acre-feet, as shown in Table 25.

TABLE 25

ESTIMATED AVERAGE USE OF IRRIGATION WATER
IN BIG VALLEY DURING THE 1954-58 IRRIGATION SEASONS

Crop	Irrigation requirement, in acre-feet					
	May	June	July	August	September	Totals
Alfalfa	1,300	1,400	1,300	500	200	4,700
Estimated efficiency, in percent	70	80	90	90	90	
Native pasture and meadow hay	13,100	10,700	4,800	2,600	1,600	32,800
Estimated efficiency, in percent	50	60	90	90	90	
Grain and grain-hay	500	600	400	-----	-----	1,500
Estimated efficiency, in percent	60	70	90			
TOTALS	14,900	12,700	6,500	3,100	1,800	39,000

Future Irrigation Water Requirements

The estimated future irrigation requirement for Big Valley was derived by modifying future seasonal consumptive use as given in Table 23 by appropriate irrigation efficiency factors. Irrigation efficiencies for the respective crops were selected on the basis of present knowledge of irrigation practices, modified by improvements expected to occur under future conditions of development. Monthly and seasonal future irrigation requirements for Big Valley are shown in Table 26.

TABLE 26

ESTIMATED FUTURE MONTHLY AND SEASONAL IRRIGATION WATER REQUIREMENTS IN BIG VALLEY

Crop	Acres	Estimated irrigation efficiency, in percent	Irrigation requirement, in acre-feet: May	June	July	August	September	Totals
Alfalfa	25,050	75	11,000	16,300	20,000	8,300	2,700	58,300
Improved pasture	16,920	70	8,000	11,800	14,500	9,200	4,400	47,900
Meadow pasture	1,210	65	600	900	1,100	700	300	3,600
Hay and grain	9,160	80	1,800	3,200	3,200	0	0	8,200
Truck crops	1,850	60	300	1,000	1,200	300	0	2,800
Alfalfa seed	1,250	80	500	800	400	0	0	1,700
TOTALS	55,440		22,200	34,000	40,400	18,500	7,400	122,500

Nonconsumptive Water Requirements

Water requirements associated with nonconsumptive uses refer to employment of water for any beneficial use which does not significantly impair the quality or quantity of water. Such use may be for hydroelectric power generation, recreation, or fish and wildlife. Although such requirements usually constitute a fundamental consideration in the development and distribution of water, they generally do not result in consumption of significant quantities of water or in excessive depletion of runoff. As a result, most nonconsumptive water requirements, as they presently exist or as they may develop in the future, are not readily susceptible to evaluation, except as they relate to actual water development projects.

At the present time, nonconsumptive uses of water in Big Valley are limited to fish, wildlife, and recreation. A small fishery exists in the Pit River for warm water fish such as brown bullhead, largemouth black bass, and bluegill. Angling is considered relatively good in Rush and Ash Creeks, which support a trout fishery. The major game resource found in the Big Valley area is the migrating herds of Rocky Mountain mule deer. As a result, deer hunting constitutes an important outdoor recreational activity. A substantial number of ducks, geese, and other waterfowl are found in Big Valley. Since the valley is located on the Pacific flyway, migrating waterfowl, especially Canadian geese, utilize it as a resting area. The hunting of deer and fowl constitutes the major recreational use of land in the Big Valley area. Inasmuch as hunting is permitted only for limited periods in the fall, existing recreational facilities are underdeveloped and overcrowded when in use. Only minor recreational use is attributable to camping, picnicking, and fishing. The present annual recreational use in the area is estimated at about 54,000 visitor-days, 58 percent of which may be ascribed to hunting activities.

In general, the future water requirements for fish and wildlife in the area will be essentially nonconsumptive in nature. A report by the California Department of Fish and Game (Appendix B) on the problems and aspects of fish and wildlife of the Big Valley area indicates that the 15 second-foot flow required for stockwater is adequate for purposes of maintaining the limited warm water fishery that exists in the Pit River in Big Valley.

Future water development for the generation of hydroelectric energy in the area is not anticipated. Under present conditions, all available water from natural stream flows is being diverted during the growing season to irrigate lands adjacent to stream channels. The streams are subject to extremely low summer flows, and many of the streams in the area become dry during the summer months. Consequently, no water supply development for the generation of hydroelectric energy has occured, nor is any such development likely to occur in the future.

CHAPTER IV. PLANS FOR WATER DEVELOPMENT

Consideration is given in this chapter only to the major features of a general plan of water development for Big Valley. Thus, primary attention is focused on development of the Allen Camp and Round Valley Reservoir Projects. However, in Chapter III, it was shown that more than adequate land resources exist in Big Valley to use the entire water yield of these reservoirs. Even if the two large projects were constructed, there would still be the need for small water developments on other streams tributary to the valley. Since local public agencies exist in Big Valley with capacity to accomplish the planning of such small projects, planning of this type was not undertaken as part of this investigation, even though recognized as essential and a part of the overall plan for water development.

Plans Previously Proposed

During the period from 1903 to 1915, a series of investigations was made which covered the area under consideration, either in whole or in part. These early investigations were primarily for the purposes of determining the feasibility of constructing storage for conservation and for flood control to protect the Sacramento Valley, and of evaluating hydroelectric power development possibilities.

In 1914 and 1915 an investigation was conducted and a report was prepared by the United States Reclamation Service in cooperation with the State of California. This report was published by the state under the title, "Report on Pit River Basin, April 1915". Of interest is the following observation made in the report which has been confirmed during the course of the investigation:

> "Above the junction with Fall River the Pit is usually dry during the summer months, all supplies from tributary streams being used for irrigation. All storage that can be obtained at a reasonable cost will also be needed to irrigate local lands. As a result, hydroelectric development will probably be confined to small perennial streams on which no favorable storage sites exist, and at no time will the development of power in this region be of a large amount."

The April 1915 report also included the following conclusion:

> "[It is concluded] that irrigation development in the Pit River Basin will not seriously interfere with future power development in or below the basin."

This conclusion still appears valid, as the amount of flow originating in the Upper Pit River Basin constitutes a relatively small amount of the supply used for hydroelectric purposes below Fall River.

Following the dry period from 1923 to 1927, which resulted in shortages of natural irrigation supplies during the peak of the growing season, the people of Modoc and Lassen Counties requested a hydrographic investigation by the (then) State Division of Water Rights. In the subsequent investigation, the results of which were published in Bulletin No. 41, "The Pit River Investigation", dated 1933, it was proposed to develop the Allen Camp Reservoir for irrigation of lands in Big Valley. The dam site as proposed in Bulletin No. 41 is located about 12 miles north of Lookout and about 3 miles northeast of the presently proposed site. It did not appear economically feasible at that time to develop any projects which contemplated the irrigation of any considerable amount of new acreage, and storage works proposed were confined to projects mainly for the purpose of providing supplemental water supplies for already irrigated lands. Accordingly, a reservoir storage capacity of 15,000 acre-feet was proposed for Allen Camp Reservoir to provide a supplemental water supply for about 12,000 acres of Big Valley land and to irrigate some 300 acres of new land. The Round Valley Reservoir site was also mentioned in the 1933 report, but the cost of relocation of U. S. Highway 299 then, as now, was sufficient to render the project infeasible.

The Ash Valley Reservoir site on Ash Creek approximately 14 miles upstream from the Round Valley Dam site, was also considered in the 1933 report. Further investigation of the site during the course of studies for Bulletin No. 3, "The California Water Plan", indicated that the development was not practical due to the limited water supply available. Another reservoir site on Ash Creek, near the Ryan Place, was considered during the current studies. However, the relatively high dam required for a small amount of storage capacity makes a project at this site infeasible.

In March 1945, the (then) State Division of Water Resources published a short report, entitled "Report on Investigation of Water Projects to Post War Planning Committees of Modoc and Lassen Counties". This report indicated projects worthy of development that could provide employment during the period following the close of the war. Studies made for this report were very preliminary in nature. The Allen Camp Project, much the same as proposed in Bulletin No. 41, was mentioned and, in addition, a 14.5-mile canal to convey water from Allen Camp Reservoir for use on lands in the Ash Creek swamp area was proposed.

Following the selection in 1951 of the Pit Soil Conservation District as the Pilot District for California by the Public Lands Committee of the California Association of Soil Conservation Districts, an investigation of the district was undertaken. The results were published in March 1953, in a report entitled "A Coordinated Land and Water Conservation Program". With regard to Allen Camp Reservoir, it was proposed that a reservoir with a storage capacity of about 76,000 acre-feet be provided to develop water for supplemental irrigation on partially irrigated lands and to provide water supplies for new lands. Also, many other smaller reservoir sites were proposed as worthy of further consideration.

Plan for Water Development

The plan considered herein for water development in Big Valley would achieve optimum utilization of the limited water supply available, would provide adequate flood control, and would enhance the recreational potential of the area. The plan would rely primarily upon the Allen Camp and Round Valley Projects to accomplish these objectives, but an important aspect of the plan would involve the coordinated efforts of individuals in soil and water conservation practices.

The principal features of the plan for water development would comprise Allen Camp Dam and Reservoir, Round Valley Dam and Reservoir, Willow Creek Canal, Pit River and Ash Creek channel improvements, a distribution system, recreational facilities located around the reservoirs, and small local water conservation developments as needed to meet future requirements. The principal features are shown on Plate 8, "Plans for Water Development".

Allen Camp Dam would be located on the Pit River, and would create a reservoir with a storage capacity of 155,000 acre-feet at the spillway crest elevation of 4,275 feet. The reservoir would be operated for both flood control and water conservation.

The Round Valley Dam would be located on Ash Creek near Adin, and would create a reservoir with a storage capacity of 72,000 acre-feet at the spillway crest elevation of 4,268 feet. The Willow Creek Canal would divert from the Willow Creek and Butte Creek watersheds and convey the water to Round Valley Reservoir for storage. Flood protection on Ash Creek would be provided for the most part by storage in Round Valley Reservoir.

Operation studies for the 37-year period from 1919-20 through 1955-56 indicate that the combined firm seasonal yield of the two reservoirs would be approximately 94,600 acre-feet. This amount of water would be sufficient to provide a full water supply for approximately 42,800 acres. Presently developed water supplies and other future projects on streams tributary to the Pit River in Big Valley should eventually increase the available firm water supply to approximately 122,000 acre-feet seasonally. This amount of water would be sufficient to irrigate 53,600 acres, included in the Big Valley service area considered in this investigation, as well as 1,800 acres presently irrigated outside the service area. The Big Valley service area comprises most of the irrigable valley lands and a substantial portion of the irrigable hill lands. The combined yield of the Allen Camp and Round Valley Reservoirs, as proposed herein, would provide approximately 80 percent of the water requirement for the Big Valley service area.

Channel improvements on the Pit River and Ash Creek would enhance drainage, and as designed would provide capacity for passing the once-in-20-year flood without damage. The Pit River channel improvement program would widen, deepen, and realign the river from a point near the Pit River-Ash Creek confluence to the lower end of the valley. The Ash Creek improvement would channelize the creek and prevent the flooding of the Ash Creek swamp area. Development of a large portion of the irrigable valley lands is not feasible under present conditions of flooding. The control of flooding is imperative if expanded and diversified agricultural productivity is to be achieved.

A distribution system would encompass the 53,600 acres of irrigable land which comprises the Big Valley service area, and would be capable of delivering water by gravity from Allen Camp and Round Valley Reservoirs to these lands. The system could also deliver other waters developed by existing and future small local reservoirs such as Lower Roberts or Silva Flat (see Plate 2). The cost of the distribution system has been included as a part of the cost of the Allen Camp and Round Valley Projects, since it is likely that acreage to be served from these projects would be located throughout the proposed service area.

Lands susceptible to development for camping, picnicking, boating and summer home sites were selected near each reservoir. The plans include access roads, boat launching sites, picnic tables and camp units, and the necessary sanitation and water supply facilities to support recreational use attributable to the reservoirs.

It was concluded that practical and economic considerations would preclude the simultaneous development of both the Allen Camp and Round Valley Reservoir sites. Accordingly, a plan of staged development was formulated to achieve development of the works. The plan consists of two major stages. The first stage would involve construction of Allen Camp Dam and appurtenant features, channel improvements along the Pit River and along a portion of Ash Creek, the recreational facilities associated with Allen Camp Reservoir, and that portion of the distribution system designed to supply water from the reservoir. The location of these features is shown on Plate 9.

Following the development of lands served by water from Allen Camp Reservoir to full productivity, and at the time when economic conditions are such that the second stage of development is economically justified, Round Valley Dam and the remainder of the channel improvements on Ash Creek would be constructed. Under the second stage, the Willow Creek Canal would be constructed along with necessary diversion structures. The remaining portion of the distribution system would be constructed, and both reservoirs would be operated coordinately to most efficiently serve all lands within the combined service area without regard to source of water supply. Recreational facilities would be added as required. No definite time has been determined for the second stage of water development for Big Valley, since future re-evaluation of the economic situation to ascertain economic justification and financial feasibility will be required.

In addition to the Allen Camp and Round Valley Projects, small water conservation projects would be developed as fast as economic considerations permit and the demand warrants, and would be integrated into the general plan for Big Valley. It is estimated that Lower Roberts Reservoir (shown on Plate 8) would have a firm seasonal yield of 3,200 acre-feet, if operated with a small amount of carry-over storage. Also the combined firm seasonal yield of Taylor Creek Reservoir and Silva Flat Reservoir, estimated at 2,400 acre-feet, would aid in meeting future requirements.

The Allen Camp Project

The Allen Camp Project constitutes the initial stage in a plan of development necessary for optimum utilization of the limited water resources of Big Valley.

Service Area

The proposed Allen Camp service area, delineated on Plate 9, includes 31,100 acres of irrigable land. All of the irrigable valley floor lands are included, as well as a small portion of the irrigable hill lands around the margin of the valley. An estimated 27,100 acres of these lands could be served from the yield of Allen Camp Reservoir. Table 27 shows the crop pattern expected on lands to be irrigated from Allen Camp Reservoir in the initial project years, and the crop pattern and water requirement anticipated under conditions of full project development.

TABLE 27

ESTIMATED CROP PATTERN AND WATER REQUIREMENT IN THE PROPOSED ALLEN CAMP PROJECT SERVICE AREA

Crop	Initial development, in acres	Full project development			
		Acres	Estimated irrigation efficiency, in percent	Water requirement	
				Acre-feet per acre	In acre-feet
Alfalfa	1,790	14,920	75	2.35	35,050
Improved pasture	0	4,740	70	2.80	13,250
Meadow hay and pasture	12,850	830	65	3.05	2,550
Hay and grain	1,400	4,350	80	0.90	3,900
Truck crops	10	1,520	60	1.60	2,400
Alfalfa seed	0	740	80	1.30	950
TOTALS	16,050	27,100			58,100

Project Features

The four main elements of the Allen Camp Project are: (1) the dam and appurtenant structures, (2) the channel improvement program for the Pit River in Big Valley, (3) the distribution system to convey project water to areas of use, and (4) recreational facilities located near Allen Camp Reservoir.

Dam and Appurtenant Structures. Allen Camp Dam would be a rockfill structure with a central impervious earth core. The availability of excellent quarry sites and limited amounts of impervious fill in the immediate vicinity were the primary reasons for choosing this type of dam. The dam would have a height of 129 feet above stream bed and a crest length of 1,510 feet. The upstream and downstream faces were designed with slopes of 2 to 1 and 1.8 to 1, respectively. The upstream and downstream core slopes were fixed at 0.6 to 1 and

0.4 to 1, respectively. Properly graded filters would be provided on each slope of the core.

It will probably be necessary to strip the alluvium in the channel under the impervious section of the dam and under most of the pervious fill section. Results of drilling operations indicated that maximum stripping depth in the channel would be approximately 40 feet.

Because of the possibility of leakage of water through the right abutment of the dam, features were incorporated into the design to reduce such losses and to protect the foundation of the dam. A grout curtain would extend approximately 600 feet across the flat located on the right abutment. In addition, a horizontal filter would be installed over the volcanic sediments (which underlie the basalt flow on the right abutment) just downstream from the impervious section. This filter, as well as gravel-packed relief wells, would be provided to prevent piping of the foundation material should leakage be excessive in the underlying sediments. It is estimated that leakage through the right abutment with the prescribed treatment would be less than 30 acre-feet per year.

The dam would create a reservoir with a storage capacity of 155,000 acre-feet at spillway crest elevation and an active storage capacity of 149,600 acre-feet. The water surface area at spillway crest elevation would be 3,680 acres. Of the 149,600 acre-feet of active storage capacity, 36,000 acre-feet would be reserved for flood control purposes from October through April, and 10,000 acre-feet through May. Water surface areas and storage capacities of the Allen Camp Reservoir at various stages of water surface elevation are shown in Table 28.

The spillway would be located on the right abutment. The foundation for the entire spillway is the basalt cap on the right abutment.

The spillway was designed to pass a flow of 53,600 second-feet. The design was based on the estimated once-in-100-year flood followed in three days by the once-in-1,000-year flood. Although the peak inflow for a flood of this frequency would be about 77,200 second-feet, the peak outflow from the reservoir would be reduced to 53,600 second-feet. The maximum flood of record, which took place in 1907 before much of the present upstream development occurred, had an estimated peak flow of approximately 20,000 second-feet.

The spillway would have an uncontrolled overflow weir, with a crest length of 300 feet and a crest elevation of 4,275 feet. A concrete-lined converging chute section, which would terminate in a flip-bucket energy dissipator, would convey the flood waters across the basalt cap of the right abutment. A grout curtain would extend the full length of the weir. Adequate drainage would be provided under the entire spillway slab to prevent uplift.

TABLE 28

AREAS AND CAPACITIES OF THE ALLEN CAMP RESERVOIR

Depth of water at dam, in feet	Water surface elevation, in feet U.S.G.S. datum	Water surface area, in acres	Storage capacity, in acre-feet
0	4,165	0	0
5	4,170	50	130
15	4,180	250	1,650
25	4,190	440	5,120
35	4,200	700	10,850
45	4,210	1,000	19,360
55	4,220	1,250	30,590
65	4,230	1,540	44,570
75	4,240	1,870	61,620
85	4,250	2,200	81,950
95	4,260	2,670	106,300
105	4,270	3,290	136,100
110	4,275	3,680	155,000
115	4,280	4,280	173,900
125	4,290	5,660	220,600
135	4,300	7,640	287,100

Allen Camp Dam Site as Viewed from the Reservoir Area

The outlet works would provide for both irrigation and flood control releases. The main conduit of the outlet works would consist of 108-inch diameter, precast, reinforced-concrete, cylinder pipe located in sound rock along the base of the left abutment and bedded in field-placed concrete. The intake would have clear openings of 2 feet and a net intake area of about 1,450 square feet. At the gate chamber, located just upstream from the axis of the dam, the irrigation release would be diverted to a 60-inch diameter, reinforced-concrete, cylinder pipe which would parallel the flood release conduit. A trash-rack would be located in the gate chamber to protect the irrigation control valve from debris. Two pairs of high-pressure slide gates, 4 feet by 6 feet in size, would regulate flood control releases. Access to the gate chamber would be provided by means of a 9-foot diameter shaft which would daylight into a control house near the crest. At the downstream end, a transition section would discharge flood releases into a sloping, apron-type stilling basin 65 feet in length. A 3-foot thick rock blanket would extend downstream another 100 feet from the end of the stilling basin.

The irrigation outlet system would be capable of discharging 350 second-feet under a 20-foot head. The flood control release capacity would be 3,300 second-feet under a 95-foot head.

The Division of Highways is currently completing plans for the relocation and improvement of Highway 299 near Canby. The new grade line, with one exception just south of Canby Bridge, will be above an elevation of 4,287 feet which is above the high-water elevation of Allen Camp Reservoir. Approximately 2,200 feet of highway immediately south of Canby Bridge would require vertical relocation when construction begins on the Allen Camp Dam. Cooperation between the Department of Water Resources and the Division of Highways has resulted in placing the proposed Canby Bridge above the high-water level proposed in Allen Camp Reservoir, in accordance with highway design criteria.

The muddy or turbid appearance of the Pit River near Canby is due to the erosion of very fine lava particles which form a colloidal solution. Monthly water samples collected from the Pit River at the Canby Bridge, during the period from April 1951 through November 1957, show a range in turbidity from 9 to 140 parts per million with an average of 45 parts per million. From studies it was concluded that the solids which cause the muddy appearance of the Pit River would not cause a significant loss of storage space in Allen Camp Reservoir during the economic life of the project.

A dead storage space of 5,400 acre-feet was established to accommodate sediment and provide a minimum recreational pool in the Allen Camp Reservoir.

A plan view of Allen Camp Dam and appurtenances, a section of the dam, and a profile of the dam are shown on Plate 11, entitled "Allen Camp Dam on the Pit River".

Pertinent data with respect to general features of Allen Camp Dam are presented in Table 29.

Channel Improvements. The surface runoff of the Pit River in Big Valley originates in the 1,550 square-mile drainage area above the Allen Camp Dam site, and in the 800 square-mile drainage area tributary to the valley below the dam site. A frequency study of the inflow between the dam site and the southerly edge of the valley indicates that approximately one-half of the flood inflows to Big Valley originate in watersheds that would not be controlled by Allen Camp Reservoir.

Conferences with the United States Corps of Engineers led to establishment of the criterion that protection against a once-in-20-year flood is the least that should be considered in Big Valley if federal financial participation is desired. The maximum rate of inflow to the reservoir from the one-in-20-year

TABLE 29

GENERAL FEATURES OF ALLEN CAMP DAM AND APPURTENANCES

General Data	
Location	SW 1/4, Sec. 35, T41N, R7E, MDB&M
Drainage area, in square miles	1,550
Embankment	
Type	Rockfill
Crest elevation, in feet above mean sea level	4,294
Crest length, in feet	1,510
Crest width, in feet	30
Slopes	
Upstream face	2:1
Downstream face	1.8:1
Upstream core	0.6:1
Downstream core	0.4:1
Maximum height above stream bed, in feet	129
Maximum structural height, in feet	169
Quantity of materials, in cubic yards	
Dumped rock	909,000
Impervious core	447,000
Filters	194,000
TOTAL	1,550,000
Spillway	
Spillway crest elevation, in feet above mean sea level	4,275
Spillway crest height above stream bed, in feet	110
Weir crest length, in feet	300
Maximum surcharge head, in feet	13
Residual freeboard, in feet	6
Design flood peak inflow, in second-feet	77,200
Design flood peak outflow, in second-feet	53,600
Outlet Works	
Flood control release capacity, in second-feet	3,300
Irrigation release capacity, in second-feet	350
Reservoir	
Surface area at spillway crest elevation, in acres	3,680
Storage capacity at spillway crest elevation, in acre-feet	155,000
Surface area at minimum pool, in acres	470
Storage capacity at minimum pool, in acre-feet	5,400
Surface area at maximum pool, in acres	5,400
Storage capacity at maximum pool, in acre-feet	210,000
Surcharge storage capacity, in acre-feet	55,000

flood is estimated to be 9,200 second-feet, and the corresponding rate of flow from the flood at the lower end of Big Valley is estimated to be 18,500 second-feet.

The proposed channel improvement program, coupled with a maximum flood control storage reservation of 36,000 acre-feet at Allen Camp Reservoir, would be adequate to prevent damages from the once-in-20-year flood. The program would involve increasing the capacity of the Pit River in the service area by widening, deepening, and realigning the existing channel. This increased capacity would be sufficient to contain the maximum flood control release of 3,300 second-feet from Allen Camp Reservoir and all downstream tributary drainage from the once-in-20-year flood. In addition, the improved channel would act as a master drain, thereby alleviating serious drainage problems on low-lying lands.

The channel improvements would begin just upstream from the confluence of the Pit River and Ash Creek. The capacity of the Pit River from this location to Bieber would be increased from its present value of 3,300 second-feet to 10,100 second-feet. Ash Creek would be channelized for about one mile, and its capacity increased to 5,500 second-feet, in order to provide drainage for lands which lie in the service area proposed for Allen Camp Reservoir. From Bieber to the southerly edge of the valley, the channel capacity of the Pit River would be increased to 11,100 second-feet, as compared with the present value of 2,200 second-feet. A total of 2,827,000 cubic yards of material would be excavated in connection with these channel improvements. The general alignment of the proposed channel improvement program is shown on Plate 9.

It was assumed that additional minor channel improvements on Taylor and Widow Creeks would enable the flood flows of these streams to discharge into the improved Pit River channel near the confluence of the Pit River and

Ash Creek. Furthermore, it was assumed that the abandoned Pit River channel below Juniper Creek would be left to handle flood flows from Juniper Creek and local drainage from the lower east side of the valley.

Distribution System. As stated before, the Allen Camp Project service area, shown on Plate 9, contains approximately 31,100 acres of irrigable land. Of the 31,100 irrigable acres, approximately 27,100 would be irrigated from yield developed by the Allen Camp Reservoir, and the remainder of the area would be supplied eventually from Roberts, Taylor Creek, Silver Flat and other smaller reservoirs.

The tentative distribution system shown on Plate 9 was laid out principally to indicate the cost of distributing project water to irrigable land. The system selected would initially irrigate a large portion of the better quality lands. Design of this distribution system was necessarily accomplished without benefit of detailed topographic maps or comprehensive field surveys. The Big Valley Irrigation District is in the process of mapping the valley floor. Following completion of this mapping, the district will be better able to determine a more accurate service area and distribution system.

As shown on Plate 9, the diversion dam at Lookout would divert water from the Pit River channel into two canals. The first canal would extend along the easterly edge of the Allen Camp service area and terminate at the lower end of Big Valley. This canal would provide water for about 9,200 acres of land and would have a maximum capacity of 105 second-feet. About two miles from the Lookout Diversion Dam, a branch of the main canal would enable the irrigation of an additional 5,200 acres of land north of Bieber and east of the Pit River. The second main canal would begin at the Lookout Diversion Dam and extend southerly parallel to the Pit River, cross U. S. Highway 299, and then continue northeasterly to the Pit River near Bieber. This canal would have a maximum capacity of 112 second-feet and would be used to deliver water to about 9,100 acres of land. Return flows would discharge to the main channel of the Pit River, which would act as a master drain during the irrigation season.

At Bieber, another diversion dam would divert water into two canals for irrigation of the southern end of the valley. These canals would serve about 7,600 acres of land. Construction of all but the most easterly canal would enable the delivery of water to approximately 22,000 acres of farm land, the major portion of which is already under partial irrigation. Construction of the easterly canal could be deferred until individual farm development progressed to the point where operation of the canal would prove economical.

The lateral canal system was designed to serve 320-acre parcels. An average slope of 2.5 feet per mile was assumed in design of the laterals.

Recreational Facilities. Recreational facilities would be provided for picnicking, camping, and boating in the more attractive areas around Allen Camp Reservoir. Proposed recreational areas include the Turner Creek area, located near the junction of Turner Creek and the Pit River, and the Rose Canyon area, located just northwest of the dam site. Sufficient favorable terrain and forest cover exist in these areas to support recreational activities.

Under the plan, recreational development would proceed by stages, with new facilities installed at the beginning of each decade to keep abreast of the anticipated use. There are presently insufficient recreational facilities available in the area to accommodate existing demands. However, the cost of facilities necessary to meet present recreation deficiencies, as well as development of other sites were not included as a project cost. It is expected that recreational use at Allen Camp Reservoir would be 80 percent for camping and 20 percent for picnicking. The estimated number of camp and picnic units required for the project on a decade-by-decade basis is shown in Table 30.

TABLE 30

ESTIMATED RECREATIONAL FACILITIES REQUIRED
FOR THE ALLEN CAMP PROJECT

Decade beginning	Camp units	Picnic units
1960	61	8
1970	38	4
1980	32	4
1990	28	4
2000	16	2
TOTALS	175	22

Because most of the day-use is expected to be from the Alturas area, the initial picnic development would be located in the Turner Creek area. Both Turner Creek and Rose Canyon areas would have boat launching ramps, roads, parking areas, and water and sanitary facilities necessary to accommodate the predicted initial level of use.

Both the southern margin of Stone Coal Valley, and the area directly southeast of Turner Creek across the Pit River, exhibit qualities of terrain and cover adaptable for summer home sites. Plate 9 indicates the areas selected for recreational development near the Allen Camp Reservoir site.

Geology of the Allen Camp site

The land forms at the Allen Camp Dam site are determined by two prominent fault systems and by recent volcanic flows. The major fault system is located southeast of the dam site. It bears approximately N60°W and defines the northeastern boundary of Big Valley. A very pronounced system of cross faults is located normal to the major fault trend and is parallel to the course of the Pit River above the dam site. There is striking topographic alignment along both fault trends. Although earthquakes have not been recorded in historic times in this area, the apparent recency of fault movement suggests high seismicity.

The upper portion of the right abutment of the dam site is formed by flat-lying recent flows of olivine basalt which terminate in a precipitous slope. The rock is relatively unweathered, moderately fractured, and locally highly vesicular in zones separating distinct basalt flows. An inspection of the rock cores from four drill holes which penetrated the basalt flows capping the right abutment indicated that the average total thickness of the flows is about 70 feet. No lava tubes were observed in the basalt during this investigation, although these features are often associated with this type of formation. The flow is underlain by an older series of tilted sediments which probably was deposited during the Miocene age. This series consists mainly of volcanic sandstones, mudstones, or siltstones and conglomerates striking about N50°W to N20°W and dipping 30°-50° to the west. A large talus deposit of basaltic blocks conceals the underlying sediments of the right abutment.

Leakage through the basalt flow and the basalt-sediment contact is expected to be high as evidenced by water pressure tests run in the core holes on the right abutment. Adequate cutoff by grouting would reduce the leakage through the basalt and the contact to an allowable amount, although the grout take is expected to be high. Leakage through the sedimentary portion of the right abutment should not be excessively high, but if losses are estimated to be excessive during the course of the construction exploration, a chemical or bituminous grout cutoff curtain should be provided prior to filling the reservoir.

Allen Camp Dam Site as Viewed from the Top of the Right Abutment

Water table measurements taken during the spring and summer of 1958 indicate that there is no clearly defined water table in the right abutment. Water was found standing high in the basalt in one hole, while in another hole only a few hundred feet away, water was standing below the flow-sediment contact. This condition existed for several months. Permeability in the basaltic flow is highly variable from place to place. Although no widely accepted method exists for the accurate field determination of permeability, quantitative estimates of permeability were attempted from the water pressure test data. The methods utilized were derived for laminar flow from a well located in an unsaturated medium. Assuming laminar flow, these estimates indicate an average coefficient of permeability of approximately 150 feet per year for the basalt which caps the right abutment.

The channel section of the Allen Camp Dam site is approximately 750 feet wide, including the flat surface of the Pit River flood plain. Bedrock in the channel section changes from volcanic sediments, similar to those which underlie the basalt cap on the right abutment, to the nonvesicular basalt of the left abutment. A downdropped block of basalt, similar in thickness and lithology to that which caps the right abutment, was located by a core hole at the base of the right abutment. Depth to bedrock varied from 15 to 40 feet in the four core holes which penetrated the stream deposits. The depth to water in borrow holes in the channel section was about 10 feet during the spring of 1958.

The cores obtained in the channel section show that the greater part of the width of the channel section is underlain by a strongly sheared fault zone. However, this condition does not appear to create serious cutoff or foundation problems. Although the bedrock which underlies channel deposits is sheared into small fragments, these are tightly interlocked in their natural conditions. Abundant alteration products of rocks tend to seal any open fractures.

The rock of the left abutment is a hard, dark-colored, nonvesicular basalt, which is older than and quite different from the vesicular basalt of the right abutment. A fault concealed under the channel section is the contact between the two rock units. Outcrops of the rock in the left abutment display closely spaced, parallel joints which tend to heal at depth. Water pressure tests conducted on the left abutment showed negligible water losses.

Plate 10, entitled "Geology of the Allen Camp Dam Site", illustrates the rock types encountered during the foundation exploration of the dam site. Detailed logs of all exploration borings are on file in the Department of Water Resources.

Cost Estimates

Capital costs of the project features were derived by applying recently bid unit prices on similar items to quantities estimated from design data, and generally are representative of prices prevailing during late 1958 and early 1959. The designs were not in sufficient detail for purposes of construction, but rather were made for the purpose of indicating the types of structures necessary for safe and efficient operation of the project, and for the purpose of determining the magnitude of costs.

The costs of lands, easements, rights of way, and relocation of utilities were estimated from field appraisals of the real property, of the improvements that would be acquired, and of the damages that would occur. Highway relocation cost estimates were obtained in part from the State Division of Highways. The appraisals do not include the value of lands in federal ownership nor the value of subsurface minerals, gas, or oil rights.

Table 31 summarizes cost estimates derived for the major features associated with Allen Camp Dam and appurtenances. The estimated total capital cost of Allen Camp Dam and appurtenances is $6,922,000.

TABLE 31

ESTIMATED CAPITAL COSTS OF ALLEN CAMP DAM AND APPURTENANCES

Item	Cost
Embankment	$ 3,000,000
Spillway	652,000
Outlet works	750,000
Land and improvements	552,000
Relocation of utilities and roads	315,000
Reservoir clearing	56,000
Subtotal	$ 5,325,000
Engineering and administration, 10 percent	532,000
Contingencies, 15 percent	799,000
Interest during construction	266,000
TOTAL	$ 6,922,000

Table 32 summarizes the estimates of costs of providing adequate channel capacity in Big Valley. The estimated total capital cost of the channel improvements is $1,474,000. No costs are included for the rights of way for the new channel.

TABLE 32

ESTIMATED CAPITAL COSTS OF CHANNEL IMPROVEMENTS FOR THE ALLEN CAMP PROJECT

Item	Cost
Diversion and care of stream	$ 30,000
Clearing and grubbing	4,000
Mobilization and demobilization	50,000
Concrete removal	4,000
Excavation	1,046,000
Subtotal	$ 1,134,000
Engineering and administration, 10 percent	113,000
Contingencies, 15 percent	170,000
Interest during construction	57,000
TOTAL	$ 1,474,000

Table 33 summarizes the costs for the distribution system, including main and lateral canals, as estimated without benefit of topographic maps and surveys and without regard for existing boundaries of the Big Valley Irrigation District. The estimated total capital cost of the distribution system is $541,000.

TABLE 33

ESTIMATED CAPITAL COSTS OF THE DISTRIBUTION SYSTEM
FOR THE ALLEN CAMP PROJECT

Item	Cost
Excavation	$ 112,000
Highway and farm bridges	170,000
Diversion dams	88,000
Turnouts	2,000
Parshall flumes	3,000
Lands, easements, and rights of way	41,000
Subtotal	$ 416,000
Engineering and administration, 10 percent	42,000
Contingencies, 15 percent	62,000
Interest during construction	21,000
TOTAL	$ 541,000

Table 34 shows the estimated capital necessary to provide recreational facilities for the Allen Camp Project on a decade-by-decade basis.

Major park facilities were assumed to have a useful life of 50 years. However, it was considered necessary to replace all tables, stoves and food cupboards at 10-year intervals at an average estimated cost of $150 per recreational unit.

TABLE 34

ESTIMATED CAPITAL COSTS OF RECREATIONAL FACILITIES
FOR THE ALLEN CAMP PROJECT

Decade beginning	Camp units	Picnic units	Capital cost	Replacement cost	Total cost
1960	61	8	$ 121,000	$ 0	$ 121,000
1970	38	4	74,000	10,000	84,000
1980	32	4	63,000	17,000	80,000
1990	28	4	56,000	22,000	78,000
2000	16	2	31,000	27,000	58,000
TOTAL					$ 421,000

In addition to the costs shown in Table 34, the cost of surfacing the road from U. S. Highway 299 to the Turner Creek area was considered an essential part of the recreational facilities. This cost was estimated to be $156,000. The investment required for the initial decade to make recreation an integral part of the project would total $277,000. The present worth of the estimated expenditures necessary for recreational facilities and road surfacing, discounted at an interest rate of 4 percent, amounts to $406,000.

Table 35 summarizes all capital costs for the Allen Camp Project. The estimated total capital cost is $9,514,000. The estimated present worth of these expenditures amounts to $9,343,000, if costs for the recreational facilities are discounted to present worth.

TABLE 35

SUMMARY OF ALLEN CAMP PROJECT CAPITAL COSTS

Item	Estimated cost
Dam and appurtenances	$ 6,922,000
Channel improvements	1,474,000
Distribution system	541,000
Recreational facilities	577,000
TOTAL	$ 9,514,000

The sum of all estimated annual costs for the Allen Camp Project is $543,900, as shown in Table 36. Annual costs include amortization of the capital investment at 4 percent per annum, operation, maintenance, replacement, and general expense. The present worth of these annual costs amounts to $11,684,000.

Project Operation

The Allen Camp Reservoir was sized to provide maximum net project benefits. It was determined that maximum net benefits would be achieved, under the adopted operating conditions, with normal reservoir storage capacity of 155,000 acre-feet.

Operation of the Allen Camp Reservoir was based on the following criteria:

1. Estimates of monthly runoff during the 37-year base period from 1919-20 through 1955-56.
2. Reservoir storage capacity, at spillway crest elevation of 4,275 feet, of 155,000 acre-feet.

TABLE 36

SUMMARY OF ANNUAL COSTS OF THE ALLEN CAMP PROJECT

Item	Estimated cost
Amortization and interest	
Dam and appurtenances	$ 322,200
Channel improvements	68,600
Distribution system	25,200
Recreational facilities	18,900
Subtotal	$ 434,900
Operation, maintenance, replacement, and general expense	
Dam and appurtenances	38,000
Channel improvements	12,000
Distribution system	35,000
Recreational facilities	24,000
Subtotal	$ 109,000
TOTAL	$ 543,900

3. Minimum pool with a storage capacity of 5,400 acre-feet.
4. Minimum stock and fish release of 15 second-feet from the reservoir, maintained at all times.
5. Flood control storage reservation of 36,000 acre-feet maintained in the reservoir from October through April, reduced to 10,000 acre-feet during May, with a maximum flood control release capacity of 3,300 second-feet.
6. Downstream prior rights of the Pacific Gas and Electic Company recognized, with consideration given to the licensed water right at the company's Pit No. 3 Power Plant from October through April, and all presently held water rights to Pit River water in

Big Valley reregulated in accordance with the irrigation demand schedule.

7. Reservoir demand schedule for irrigation assumed as follows: May, 18 percent; June, 28 percent; July, 33 percent; August, 15 percent; and September, 6 percent.

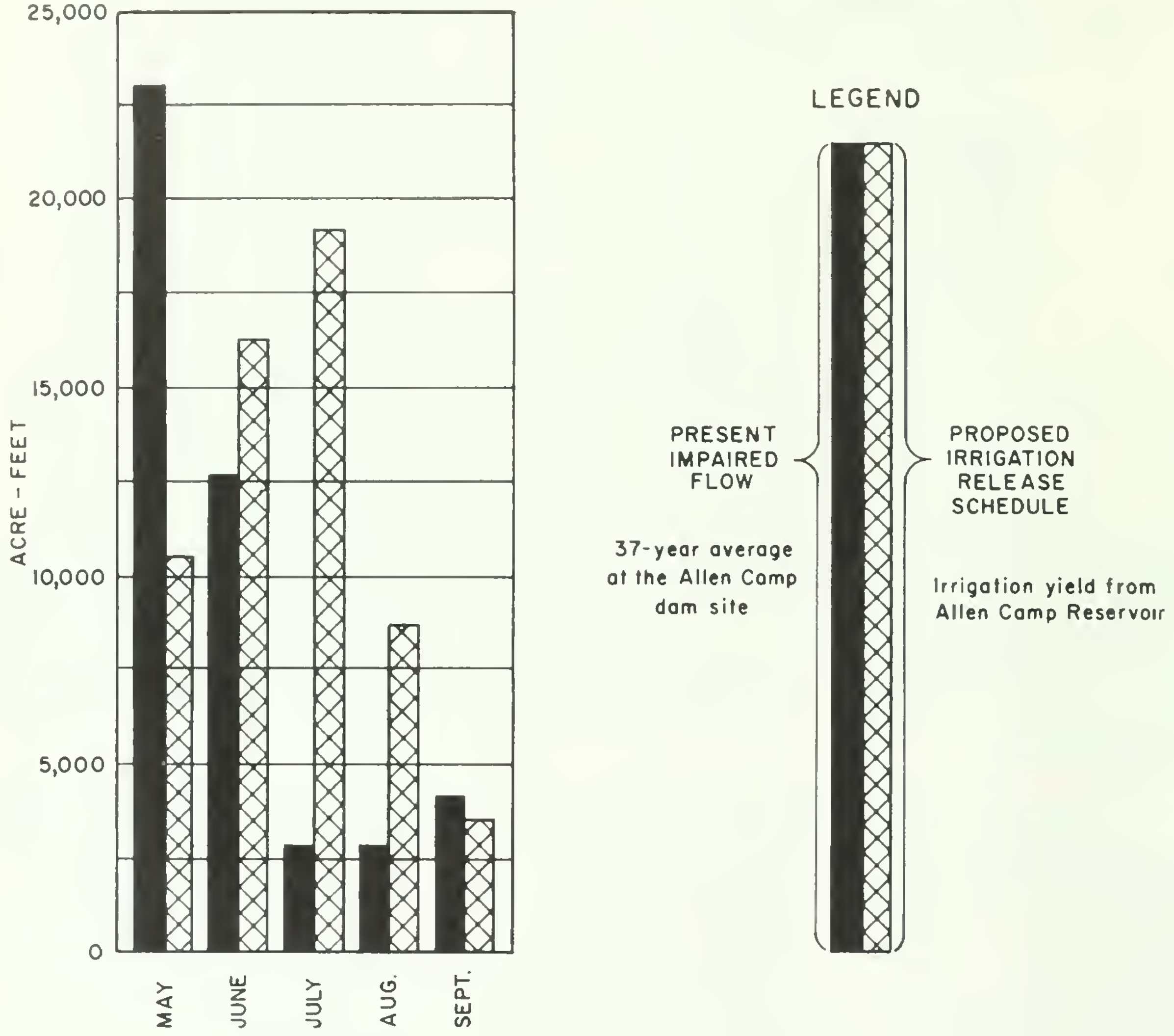
8. Depth of net evaporation losses from the reservoir water surface estimated as follows: October, 0.19 feet; November through March, 0; April, 0.15 feet; May, 0.31 feet; June, 0.44 feet; July, 0.66 feet; August 0.58 feet; and September, 0.39 feet.

9. A 30 percent deficiency in irrigation yield allowed in the most critical season (1925-26) during the 37-year base period.

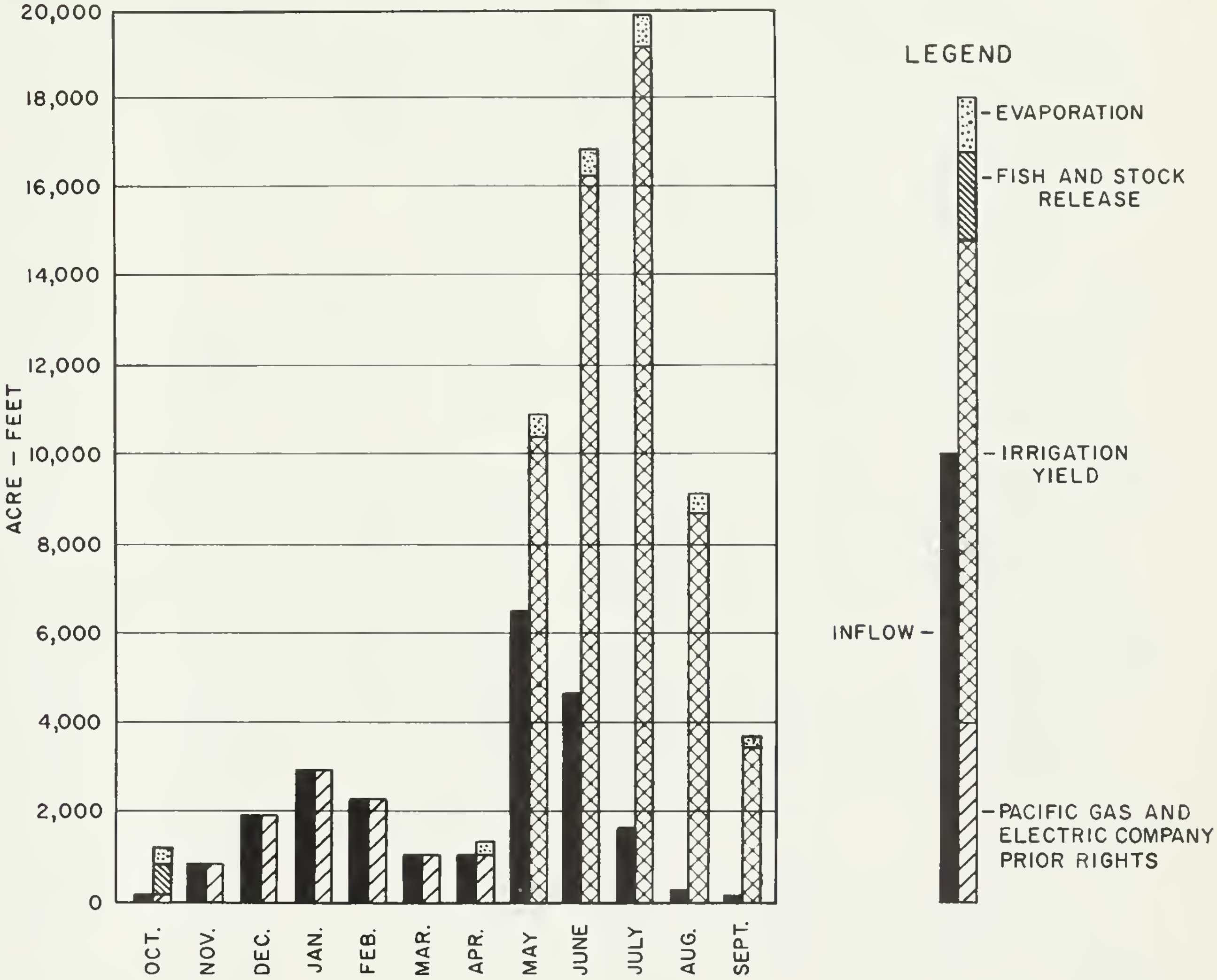
Operation of Allen Camp Reservoir under the foregoing conditions resulted in a firm seasonal yield of 58,100 acre-feet for the 37-year period from 1919-20 through 1955-56. The operation study was performed on a monthly basis. Table 37 presents a seasonal summary of the reservoir operation study for that period.

From records of watermasters, it was estimated that a seasonal average of about 25,600 acre-feet of water is diverted for irrigation in Big Valley under present conditions. Under project conditions, approximately 58,100 acre-feet per season would be available on an irrigation demand schedule. Thus, on the average, 25,600 acre-feet per season would be reregulated water, and 32,500 acre-feet would be new water.

Figure 1 illustrates the effect that the Allen Camp Project would have on the regimen of the Pit River during an average irrigation season. Figure 2 shows water supply conditions during the season of minimum runoff, 1933-34, and the project operation release schedule. Note the large quantity of water available in May and the rapid reduction in this supply during the



PRESENT AND PROJECT PIT RIVER WATER SUPPLY CONDITIONS IN BIG VALLEY DURING AN AVERAGE IRRIGATION SEASON



MONTHLY SUMMARY OF PROPOSED ALLEN CAMP RESERVOIR OPERATION DURING SEASON OF MINIMUM RUNOFF 1933 - 1934

DEPARTMENT OF WATER RESOURCES 1959

TABLE 37

SEASONAL SUMMARY OF ALLEN CAMP RESERVOIR OPERATION

(In acre-feet)

Season	Inflow	Release to satisfy PG&E rights	Yield	Evaporation	Stock and fish release	Flood Control release and/or spill	Storage at end of season
1919-20	69,200	25,200	58,061	4,997	1,000	0	51,330
21	201,100	11,000	58,061	8,599	1,800	50,267	122,703
22	200,100	43,500	58,061	8,254	0	105,398	107,590
23	83,600	44,400	58,061	6,856	0	0	81,873
24	57,300	37,900	58,061	4,791	0	0	38,421
1924-25	81,500	28,700	58,061	3,980	900	0	28,280
26	59,700	22,300	29,029	3,795	900	0	31,956
27	214,200	6,100	58,061	8,126	2,400	58,369	113,100
28	126,500	21,100	58,061	7,072	600	71,809	80,958
29	68,700	25,100	58,061	5,843	900	0	59,754
1929-30	86,800	15,400	58,061	5,906	2,700	0	64,487
31	29,000	22,900	58,061	3,478	0	0	9,048
32	152,800	8,800	58,061	6,652	3,100	0	85,235
33	42,400	5,600	58,061	5,787	2,500	0	55,687
34	24,100	10,700	58,061	3,295	700	0	7,031
1934-35	112,200	5,700	58,061	4,764	3,900	0	46,806
36	190,800	4,300	58,061	7,064	1,700	82,162	84,319
37	88,800	6,900	58,061	6,621	500	29,134	71,903
38	487,200	4,300	58,061	8,642	300	364,487	123,313
39	63,300	19,800	58,061	6,627	0	35,682	66,443
1939-40	135,500	5,900	58,061	6,746	1,800	55,122	74,314
41	149,200	10,500	58,061	7,564	1,800	48,664	96,925
42	270,200	9,200	58,061	8,870	900	162,316	127,778
43	321,900	8,500	58,061	9,000	0	247,829	126,288
44	103,400	27,600	58,061	7,632	0	40,445	95,950
1944-45	205,900	60,200	58,061	8,980	0	39,948	134,661
46	156,600	25,300	58,061	7,571	0	110,886	89,443
47	68,000	38,000	58,061	5,786	900	0	54,696
48	168,500	28,700	58,061	8,406	900	0	127,129
49	199,500	26,300	58,061	8,554	0	118,607	115,107
1949-50	125,400	23,100	58,061	7,555	0	60,408	91,383
51	163,300	11,500	58,061	8,172	1,800	65,395	109,755
52	489,900	10,500	58,061	9,341	0	372,398	149,355
53	275,600	20,900	58,061	9,328	0	195,147	141,519
54	138,300	23,900	58,061	7,542	0	100,518	89,798
1954-55	88,100	51,000	58,061	5,995	0	0	62,842
56	422,400	9,000	58,061	8,761	0	276,259	133,161
Averages	160,027	20,535	57,276	6,945	865	72,736	

following months under present conditions. Reregulation provided under project conditions would enable the month of peak use to be shifted from May to July.

Operation of the proposed flood control system was checked by routing the once-in-20-year flood through the reservoir. Storage capacity of 23,900 acre-feet would be required to prevent damage from the once-in-20-year flood if the reservoir was at maximum conservation storage, 119,000 acre-feet, at the beginning of the flood. A constant release of flood waters of 3,300 second-feet would continue for about 7-1/2 days commencing at the time of encroachment on the flood control reservation space.

The March 27-April 14, 1952 flood was similarly routed through the reservoir. On the fifth day of the flood, the 36,000 acre-foot flood control storage reservation would have been filled, even though the flood control gates had been passing the maximum flood control release of 3,300 second-feet since the beginning of encroachment on the flood reservation. Assuming the occurrence of flood flows of comparable frequency from the streams tributary to Big Valley downstream from the Allen Camp site at this time, water would have overflowed the banks of the downstream channel. The damaging flow, however, would have been decreased considerably by operation of the project.

Although intensive studies of future upstream development were not undertaken, the effects of several potential upstream water conservation projects on the Allen Camp Reservoir were analyzed. These projects were proposed in Bulletin No. 3, "The California Water Plan". The four projects considered comprise Parker Reservoir on Parker Creek, Jess Valley Reservoir on the South Fork of Pit River, enlarged Bayley Reservoir in Crooks Canyon, and Sears Flat Reservoir in Stones Canyon. The aggregate new average seasonal yield from these projects would be about 16,400 acre-feet. Operation of these reservoirs in a manner similar to operation of the existing West Valley Reservoir indicated that the average seasonal depletion of the Pit River at Allen Camp Dam site would be about 13,700 acre-feet. The firm seasonal yield of Allen Camp Reservoir would be thereby reduced approximately 2,000 acre-feet, or 3.4 percent.

The effect of project operation on the vested water rights at downstream power plants of the Pacific Gas and Electric Company was studied in some detail. It was determined that if the water right at the Pit No. 3 Power Plant could be satisfied, the rights at downstream plants would not be adversely affected to any significant degree. Therefore, the analysis centered on the net effect of the project on the licensed water right at Pit No. 3. Operation studies were conducted on a monthly basis.

Table 38 summarizes the average monthly and the average seasonal net effect of Allen Camp Project operation on the water supply at Pit No. 3 Power Plant for the 32-year period from 1924-25 through 1955-56. The positive and negative signs indicate enhancement and depletion, respectively, of the water supply to the power plant.

In general, the project operation would be adverse to the licensed water right at Pit No. 3 Power Plant during the months of May and September, and favorable during July, August, and October. The largest adverse effect, occurring in May, would average approximately 2 percent. The total net result would constitute an average seasonal enhancement of approximately 3,000 acre-feet. However, the regulation imposed by the Allen Camp Project might necessitate a slight change in operation of the Pit River power plants.

Project Benefits

The benefits that would accrue to the proposed Allen Camp Project would be derived principally from the three purposes of the project; namely, irrigation, flood control, and recreation.

TABLE 38

AVERAGE MONTHLY NET EFFECT OF ALLEN CAMP PROJECT OPERATION ON THE PIT NO. 3 POWER PLANT
32-YEAR PERIOD, 1924-25 THROUGH 1955-56

Month	Net effect, in acre-feet	Percent of licensed water right at power plant
October	+1,200	+0.7
November	+300	+0.2
December	0	0
January	-200	-0.1
February	-100	-0.1
March	0	0
April	-100	-0.1
May	-4,100	-2.2
June	+400	+0.2
July	+4,400	+2.4
August	+2,300	+1.2
September	-1,100	-0.6
AVERAGE SEASONAL NET EFFECT	+3,000	+1.6

Irrigation benefits would accrue to irrigated lands from reregulated and new water developed by the Allen Camp Reservoir. It is anticipated that alfalfa, improved pastures, and small grains will dominate the crop pattern during the economic life of the project. This crop pattern would represent a continuation of the present pattern on those lands where a relatively good supply of water is available and flooding is not a problem. Although some acreages of seed, potatoes, or similar crops will undoubtedly be grown within the project area, it is believed the present forage-livestock enterprise will continue on a somewhat more intensified basis after project development.

Under project conditions, it was assumed that most of the land presently in meadow hay and pasture would be converted to alfalfa, improved pasture, and field crops. The deeper soils would be used primarily for alfalfa and field crops. Some of the shallow soils are best adapted to improved pasture and would be used almost entirely for that crop.

The only meadow pasture expected to remain under project conditions would be on a limited amount of land, not easily drained or not economically feasible to drain. It is expected, however, that net returns for meadow hay and pasture would remain about the same under both pre-project and project conditions, since added costs under project conditions for water charges would probably offset the value of increased yields.

Small grains presently dominate and are expected to continue to dominate the field crops irrigated in the Big Valley area. Their suitability to the more shallow lands utilized in livestock enterprises, and their usefulness as rotation crops make them a popular choice for farmers of the area.

Presently there are no cash crops, such as potatoes or seed crops, being commercially produced in Big Valley, as have been predicted under project conditions. The projected seed crops will be mainly clover and alfalfa seed. It is believed that as land values increase these crops will become important. Also, it is expected that the acreage suited to potatoes and seed crops will be augmented as meadow lands are leveled and drained.

Most of the forage and grain crops produced in Big Valley will be utilized in livestock enterprises within or adjacent to the project area. At present the predominant livestock enterprise consists of selling yearling feeders from cow-breeding herds. Under present and anticipated future agricultural conditions and crop prices, a financially successful breeding cattle enterprise must have available a large amount of low-cost, natural grazing land. It is believed that under project conditions the breeding cattle enterprises would continue at a sufficiently high level to utilize available national forest and other range lands for grazing.

The additional forage and grain produced under project conditions would be fed to livestock. Such operation would probably involve purchasing weaner calves and selling them a year later as slaughter animals. The cattle would utilize improved pasture, supplemented by grain and alfalfa hay.

In nearly all instances a higher monetary return will result from utilization of forage and grain crops in efficient livestock enterprises, rather than from the direct sale of these crops. The additional returns, however, are attributed more to additional labor, investment, and risk than to water. For this reason, the estimates of agricultural benefits from project irrigation were based on crop budgets.

The estimated gross income per acre for the selected crops is the product of the prices and yields expected to prevail during the economic life of the project, plus after-harvest grazing benefits that would accrue to various crops.

The average market value of various crops in Big Valley was determined from prices that prevailed in the area during the decade, 1947-56. These were alfalfa, $25.00 per ton; meadow hay, $22.80 per ton; barley, $2.55 per hundred pounds; potatoes, $2.60 per hundred pounds; and alfalfa seed, $0.29 per pound.

Crop yields in Big Valley were estimated primarily from data obtained from offices of the Agricultural Commissioner and Farm Advisor in Modoc and Lassen Counties, and the Soil Conservation Service office in Bieber, as well as from comparison of the area with other areas growing crops under conditions similar to those of Big Valley. The projected crop yields per acre for Big Valley, adjusted to reflect a full supply of irrigation water, were as follows: alfalfa, 4.25 tons; meadow hay, 1.1 tons; barley, 3,000 pounds; potatoes, 17,000 pounds; and alfalfa seed, 350 pounds. It was estimated that improved pasture would yield 9 animal-unit months annually per acre.

The gross agricultural returns were computed from the prices, yields, and projected crop patterns. In order to determine gross agricultural benefits, it was necessary to compute and subtract all production costs, including return to management, but excluding water charges and interest on lands, from gross returns. The return to management was estimated for each crop, as shown in Table 39.

TABLE 39

ESTIMATED RETURN TO MANAGEMENT FOR SELECTED CROPS IN BIG VALLEY

Crop	Estimated size of unit, in acres	Estimated farm family income requirement	Labor costs contributed by operator	Return on farm investment	Return to management to meet income requirement	Return to management on per acre basis
Alfalfa	180	$6,000	$1,600	$1,585	$2,815	$15.64
Improved pasture	200	6,000	1,600	1,225	3,175	15.88
Barley	240	6,000	1,100	1,900	2,920	12.17
Alfalfa seed	180	6,000	1,500	1,585	2,915	16.19
Potatoes	80	6,000	1,600	886	3,514	43.92
Meadow pasture	500	6,000	300	1,888	3,812	7.62
Meadow hay	500	6,000	1,050	1,990	2,960	5.92

Crop production costs were derived from labor and material inputs reported in extension service crop enterprise studies, from interviews with local farm advisors and farmers, and from other sources. Input costs were adjusted to reflect the 1947-56 average, by use of indexes of prices paid by farmers for various items as published by the U. S. Department of Agriculture. Estimated total production costs per acre for the selected crops are shown in Table 40.

TABLE 40

ESTIMATED PRODUCTION COSTS FOR SELECTED CROPS IN BIG VALLEY

(per acre)

Item	Alfalfa	Improved pasture	Barley	Alfalfa seed	Potatoes	Meadow pasture	Meadow hay
Cultural cost	$19.32	$19.24	$19.60	$37.52	$149.75	$0.60	$0.60
Harvest cost	18.68	0	10.50	19.15	154.20	0	10.53
Cash overhead cost	10.30	6.39	7.97	11.62	29.93	2.06	2.67
Interest[1/] and depreciation	12.15	9.78	4.00	12.15	14.75	0.35	0.71
Management	15.64	15.88	12.17	16.19	43.92	7.62	5.92
TOTAL COST	$76.09	$51.29	$54.24	$96.63	$392.55	$10.63	$20.43

1/ Excludes interest on investment in land

Table 41 shows the estimated gross income and crop production costs, excluding interest on the investment in land. The difference between these two items is the total agricultural benefit for the selected crops. Gross average annual equivalent benefits were estimated as the product of the crop benefits, as shown in Table 41, and the number of acres projected for that crop. The analyses presuppose control of floods of a 20-year frequency, and the availability of a full supply of water.

Following the determination of gross annual benefits forecast for Big Valley under project conditions, net agricultural benefits attributable to the Allen Camp Project were estimated. Consideration was given to the extent of land that could be irrigated from project yield, and to the benefits from present agricultural operations on those lands.

TABLE 41

ESTIMATED AGRICULTURAL BENEFITS FOR SELECTED CROPS IN BIG VALLEY
(per acre)

Item	Alfalfa	Improved pasture	Barley	Alfalfa seed	Potatoes	Meadow pasture	Meadow hay
Gross income[1/]	$108.25	$74.25	$77.50	$128.50	$442.00	$17.22	$27.08
Crop production costs	76.09	51.29	54.24	96.63	392.55	10.63	20.43
Difference: Agricultural benefit	32.16	22.96	23.26	31.87	49.45	6.59	6.65

1/ Gross income includes the following additional credits: alfalfa, $2.00 for aftermath grazing; barley, $1.00 for aftermath grazing; alfalfa seed, $2.00 for aftermath grazing, plus $25.00 for one ton of hay; and meadow hay, $2.00 for aftermath grazing.

Irrigation benefits constitute that portion of the net agricultural benefits that would accrue to the service area from development of a firm water supply. The estimates of irrigation benefits were derived from the total agricultural benefits as follows. It had been estimated from available flood damage data that with adequate flood protection 10,000 acres in the Allen Camp service area could be adapted to a higher land use. The net agricultural benefits accruing to the 10,000 acres could not be obtained without a full irrigation water supply and adequate flood protection. Since flood control and irrigation water were considered to contribute equally to the improved agricultural conditions, the benefits were assigned equally between flood control and irrigation water for the area. Total irrigation benefits were thus estimated as the sum of one-half of the net agricultural benefits from lands that lie in the flood plain, and all of the net agricultural benefits from lands served outside the flood plain.

It was estimated that a total of approximately 27,100 acres would be served from the yield of Allen Camp Reservoir. Allowing a 15-year period for development of the area following construction of the project works, the net irrigation benefit that would accrue to the project from the service area was estimated to be $8,230,000 on a present-worth basis. The estimated annual equivalent net irrigation benefit is $383,100.

The total flood control benefit that would accrue to the project would result from higher land use afforded to the previously mentioned 10,000 acres of land that currently lie in the flood plain and are subject to frequent inundation, and from the reduction of flood damages incurred under preproject conditions. One-half of the net agricultural benefits that would accrue to the flood plain area were assigned to the flood control function, and to this amount was added the amount of flood damage reduction attributable to the project under conditions of present development. From the estimated 10,000 acres that would be provided with flood protection adequate to induce a change to the improved crop pattern, the benefits credited to flood control would have an estimated present worth of $1,859,000, or an annual equivalent worth of $86,500. In addition to the flood control benefit due to the improvement of agricultural conditions for those lands lying within the flood plain, there would be flood control benefits due to the reduction of flood damage to presently existing operations and other improvements. These latter benefits would have an estimated present worth of $866,000, or an annual equivalent of $40,300. Thus, the total flood control benefits attributable to the flood control features of the Allen Camp Project would be an estimated $2,725,000 on a present-worth basis, or $126,800 on an equivalent annual basis.

Recreational benefits would accrue to the project from increased opportunities for outdoor recreation. The recreational study involved field surveys and extensive analysis of factors affecting growth of the recreational potential of the area, with and without the project, in order to estimate the recreational benefits attributable to it. The analysis proceeded in two general steps: first, recreational use in visitor-days resulting from development of the project was estimated; and second, the estimated recreational use in visitor-days was converted to a monetary value.

The recreational use in visitor-days forecast for each decade for the Allen Camp Project is summarized in Table 42.

TABLE 42

FORECAST OF RECREATIONAL USE OF ALLEN CAMP PROJECT IN VISITOR-DAYS

Use	Decade					
	1960	1970	1980	1990	2000	2010
Nonlocal	4,380	35,000	56,700	75,400	91,100	100,800
Local	7,010	4,680	7,570	10,000	12,200	13,500
TOTALS	11,390	39,680	64,270	85,400	103,300	114,300

The willingness of persons utilizing any given recreational area to incur travel expenses that are above the average was assumed to be a measure of the recreational value of the area and hence a measure of benefits. A figure of $2.00 per visitor-day was selected as being conservative and in line with benefit figures currently in use by federal agencies. The $2.00 per visitor-day value was applied to the predicted number of visitor-days and discounted to present worth to estimate total recreational benefits.

The benefits estimated in this manner amounted to $2,352,000 on a present-worth basis, or $109,500 on an equivalent annual basis.

Table 43 summarizes the net primary project benefits expected to accrue to the Allen Camp Project.

TABLE 43

ESTIMATED PRIMARY PROJECT BENEFITS ATTRIBUTABLE TO THE ALLEN CAMP PROJECT

Item	Benefits	
	Present-worth	Annual equivalent at 4 percent
Net irrigation benefit	$ 8,230,000	$383,100
Flood control benefits		
Higher land use	1,859,000	86,500
Damage reduction	866,000	40,300
Recreational benefits	2,352,000	109,500
TOTALS	$13,307,000	$ 619,400

In addition to the primary project benefits expected to accrue to the Allen Camp Project, certain secondary benefits are expected to result. Although not accounted for in monetary terms for project justification, these benefits should be given qualitative consideration.

Resource development projects of the type discussed herein provide expansion of the market in sparsely populated or low income areas, thereby enabling more efficient operation of the area as a whole. This type of benefit may accrue in the form of a more extensive division of labor and fuller use of existing public services and facilities such as schools, roads, utilities, police, and fire protection. The result is a lower per capita cost for these services and facilities.

In addition, this type of resource development provides more employment in industry and agriculture which is necessary to accommodate the rapidly expanding population of California. Regional and state economies are strengthened.

A secondary benefit accruing to the drainage and flood control features of the Allen Camp Project would be abatement of the severe local mosquito problem. In addition to the health hazard to residents of Big Valley, the large mosquito population accounts for an economic loss due to efforts of the livestock to escape swarms of mosquitoes. The consequence is a considerable loss of weight in livestock. Elimination of large mosquito breeding areas would reduce the mosquito population significantly.

Benefit-cost Analysis

Benefit-cost analyses were made for reservoir storage capacities at the Allen Camp site ranging from 77,000 to 190,000 acre-feet. From these analyses, it was determined that maximum net benefits would accrue to the Allen Camp Project if the storage capacity at spillway crest elevation were 155,000 acre-feet.

The benefit-cost ratio for the selected level of the development was calculated by dividing the primary project benefits by all project costs, including operation, maintenance, and replacement, either on a present-worth basis or equivalent annual basis. Utilizing an interest rate of 4 percent and a repayment period of 50 years, the estimated total net project benefits on a present-worth basis amount to $13,307,000, and the estimated total project costs amount to $11,684,000. The estimated annual equivalent net project benefits amount to $619,400 and the annual equivalent project costs amount to $543,900. The resultant benefit-cost ratio is 1.14 to 1, which indicates that the project is economically justified, but only marginally so, under present economic conditions.

Allocation of Project Costs

The separable costs-remaining benefits method was used to allocate project costs among the purposes served. The costs of lands, easements, rights of way, and relocation of public utilities were included. It was assumed that agreement could be reached on the settlement of internal water rights problems in Big Valley which would not involve any capital outlay.

The method of cost allocation utilized enables an equitable distribution of costs of the project among the purposes served. All investment costs, as well as operation, maintenance, replacement, and general expense costs were included in the analysis on a present-worth basis. The interest rate used was 4 percent, and the period of analysis used was 50 years. Table 44 presents pertinent data relating to the cost allocation for the Allen Camp Project. The annual equivalent costs allocated to each purpose are included.

TABLE 44

COST ALLOCATION ON PRESENT-WORTH BASIS FOR ALLEN CAMP PROJECT

Item	Project purpose			Total
	Irrigation	Flood control	Recreation	
Benefits	$8,230,000	$2,725,000	$2,352,000	$13,307,000
Alternative costs	9,643,000	3,200,000	4,908,000	17,750,000
Benefits, limited by alternative costs	8,230,000	2,725,000	2,352,000	13,307,000
Separable costs	2,454,000	2,121,000 1/	993,000	5,568,000
Remaining benefits	5,776,000	604,000	1,359,000	7,739,000
Percent of unallocated joint costs	74.6	7.8	17.6	100.0
Allocated joint costs	4,563,000	477,000	1,076,000	6,116,000
Total allocation	7,017,000	2,598,000	2,069,000	11,684,000
Annual equivalent allocation	326,600	121,000	96,300	543,900
Percent of project cost	60.1	22.2	17.7	100.0

1/ Specific cost

It was assumed that the annual cost for operation and maintenance associated with recreation would be paid by the users of the recreational facilities. This amount, $24,000, was allocated directly to the recreational function. The remaining $85,500 for operation, maintenance, replacement, and general expense was allocated between the irrigation and flood control functions. The annual cost allocated to irrigation was $62,100 and that to flood control $22,900.

Payment Capacity

Payment capacity is that portion of gross income which remains after all farm expenses, except water costs, have been deducted. Payment capacity, therefore, is a measure of the maximum amount available for the payment of water costs, and has a direct bearing on the ability of an area to support a project. The payment capacity per acre for representative crops in the proposed Allen Camp service area was determined by an analysis of the agricultural conditions expected to prevail during the life of the project.

The estimated gross income per acre, based on expected prices and yields for selected crops, is shown in Table 45. Total production costs, including cultural costs, harvest costs, overhead, interest on equity and land, depreciation and return to management, were subtracted from the gross income. The payment capacity per acre is the difference between the gross income and total production costs, excluding the cost of water. These per acre payment capacities are further reduced to an acre-foot basis after consideration of the estimated farm delivery demand of water. Pertinent information on determination of payment capacity is shown in Table 45.

Estimated payment capacities range from a high of $34.45 per acre for potatoes to no payment capacity for meadow pasture. The weighted average payment capacity for the proposed service area is approximately $7.20 per acre-foot. A 15-year development period was considered in this determination.

Under project conditions it is anticipated that very little meadow hay or meadow pasture will remain, nor are extensive seed or potato acreages predicted. The repayment revenues from alfalfa and improved pastures will be the important factor in the ability of the project lands to meet project costs, due to the probable large acreages which will be devoted to these crops.

TABLE 45

ESTIMATED PAYMENT CAPACITY FOR SELECTED CROPS IN BIG VALLEY

Crop	Gross income[1/] per acre	Total production costs[2/] per acre	Payment capacity	
			Per acre	Per acre-foot
Alfalfa	$108.25	$91.09	$17.16	$7.46
Improved pasture	74.25	61.29	12.96	4.63
Barley	77.50	69.24	8.26	7.51
Alfalfa seed	128.50	111.63	16.87	12.98
Potatoes	442.00	407.55	34.45	21.53
Meadow pasture	17.22	18.13	none	none
Meadow hay	27.08	27.93	none	none

1/ Gross income includes the following additional credits: alfalfa, $2.00 for aftermath grazing; barley, $1.00 for aftermath grazing; alfalfa seed, $2.00 for aftermath grazing plus $25.00 for one ton of hay and meadow hay; $2.00 for aftermath grazing.

2/ Total production costs include interest on investment in land.

Project Financing

Repayment of costs of the Allen Camp Project for each project function and possible sources of funds for financing the project are discussed in this section. Included in the discussion is an estimate of the cost of water based on one possible method of financing the project. This discussion must be studied in the light in which it is written, as a guide for possibilities for financing that appear at this time. Comparative analyses must be undertaken with changing conditions, interest rates, or opportunities for financing.

Repayment of Allocation to Irrigation. The portion of the total estimated cost of the Allen Camp Project allocated to the irrigation function is $7,017,000. Of this amount, $1,334,000 is the present worth of annual costs for operation, maintenance, and replacement, leaving a project first cost of $5,683,000. For purposes of discussion, it can be assumed that the constructing agency would make an application for a loan under the Small Reclamation Projects Act (Public Law 984). The amount of money available under the act would total approximately $2,446,000, after the maximum required amount ($1,250,000) for lands, easements, and rights of way, and the assumed federal contribution for flood control ($1,304,000) are deducted from the maximum allowable loan, under the act of $5,000,000. The portion of the $2,446,000 loan which would bear interest is dependent upon the extent of lands receiving water in the service area that are held in excess of the federal acreage limitation. Assuming that interest payments for land in excess holdings will average 25 percent of the loan over the economic life of the project, interest would be paid on 25 percent of $2,446,000 or on $612,000. This would amount to $28,500 annually. Assuming that the balance of the loan, or $1,834,000 would be interest free, the annual payment would be $36,700. Thus, total annual funds necessary to repay the federal loan would average about $65,200.

It may be possible to obtain a state loan of $3,237,000 under terms of the Davis-Grunsky Act to raise the funds necessary to meet the remaining cost allocated to irrigation. Assuming a 4 percent loan, the annual cost of amortization would be approximately $150,700.

The sum of the annual amounts necessary to repay the foregoing federal and state loans for the Allen Camp Project, plus annual operation, maintenance, replacement, and general expense was estimated to be $278,000. If this amount were to be raised solely by the sale of project yield of water, the cost of water would be approximately $4.78 per acre-foot.

Public Law 984 requires that the repayment period of loans not exceed 50 years. However, it is possible to arrange the repayment schedule to provide for lower payments in early years, with higher payments during later years. This would be a subject for negotiation between the constructing agency and the United States Bureau of Reclamation which administers these loans, and is not considered herein. The Davis-Grunsky Act permits a maximum repayment period of 50 years, plus a limited development period. The development period was not utilized for purposes of the analysis discussed herein.

The Pacific Gas and Electric Company has indicated that a contract for the purchase of water not needed for irrigation in Big Valley during the development period might be negotiated, on the basis of the value of stored water to the company for development of hydroelectric power at the company's Pit River power plants. In order to evaluate this proposal, it was necessary to estimate the value of an acre-foot of water to the company. The estimate was based on the assumption that no additional dependable power capacity could be realized at the existing Pit River power plants, as the total installed capacity is now reported dependable by the company. It was also assumed that there would be insufficient new water available to justify the construction of additional power capacity and thereby realize an increase in dependable capacity. Therefore, the estimate of value of water to the company was based on the energy component only. The value of water for hydroelectric power production was derived from current fuel costs. It was assumed that the company would request delivery of water from Allen Camp Reservoir on a schedule which would permit the power plants to operate under optimum conditions. It was further assumed that Pit Power Plants Nos. 6 and 7 would be in operation in 1971, thereby increasing the value of water to the Pacific Gas and Electric Company at that time. The estimated values derived were $3.20 per acre-foot through 1970 and $4.10 per acre-foot after 1970. Thus, some income for the Allen Camp Project might be derived from water not required for irrigation purposes in Big Valley during the initial years of the project.

Another source of income available to the agency operating the Allen Camp Project, for repayment of the cost allocated to irrigation or flood control, would be income from lands in Allen Camp Reservoir leased to local farmers for pasture in the Hot Springs area near Canby. It was estimated that approximately 1,325 acres that would be acquired to accommodate the reservoir between the Canby Bridge and Canby could be leased for pasture. This land is presently subject to inundation in the early spring during the normal course of snowmelt runoff. Although this flooding could be increased occasionally due to high water in Allen Camp Reservoir, the productivity of these lands would not be seriously affected. It was estimated that this land could be leased for pasture at a net average rent of $6.00 per acre per year. Thus, approximately $8,000 per year could be derived from this source. If this income were used to defray costs allocated to irrigation, the average cost of water would be reduced to $4.63 per acre-foot.

Repayment of Allocation to Flood Control. It may be assumed that the costs allocated to flood control for the Allen Camp Project would be borne by the Federal Government, and would be nonreimbursable except for that portion of the costs required to be paid by local interests under provisions of the 1936 Flood Control Act. This act established the policy that local interests should share in the costs of projects to the extent of (a) providing lands, easements, and rights of way, (b) holding and saving the United States free of damages due to construction of the works, and (c) maintaining and operating all the works after completion. In addition, Section 17c of the United States Bureau of the Budget Circular A-47 provides, in part, that projects which will result in more intensive use of land will be reviewed in accordance with the criterion that there will be a nonfederal contribution toward construction costs, equal to at least 50 percent of an amount determined by applying to the total project first cost the ratio of the higher land-use benefits and the total monetary primary benefits. Although this concept has been applied to local flood control and drainage projects by the Corps of Engineers, no experience is available within the Sacramento District Office of the Corps in applying it to a multipurpose reservoir project such as Allen Camp. The assumption was made that this policy would apply to the flood control features of the Allen Camp Project.

The total estimated cost allocated to flood control amounts to $2,598,000. Of this amount, $492,000 is the present worth of operation and maintenance costs and would be borne by local interests. Of the remaining $2,106,000, some $262,000 would be borne by local interests as the cost of lands, easements, and rights of way attributable to flood control. Further they probably would be required to pay a portion of the construction costs amounting to $540,000. The estimated present worth of all costs to local interests would be $1,294,000. The annual equivalent of this value is $60,200. In accordance with the assumption that the Federal Government will share in the cost of flood control facilities, an estimated $1,304,000 would be provided by a federal grant.

The estimated annual costs to local interests for flood control, $60,200, could be raised by an assessment on all or part of the district lands.

If the entire service area shares equally in the cost, the necessary annual assessment would amount to an estimated $2.22 per acre.

Repayment of Allocation to Recreation. The remainder of Allen Camp Project costs, an estimated $2,069,000, was allocated to recreation. Of this amount, $516,000 is the present worth of operation and maintenance of the recreational facilities. It was assumed that the users would contribute this amount to the cost of the project. Included in the cost allocated to recreation is $129,000, the present worth of expenditures to be made in the future for recreation. An estimated $1,424,000 would, therefore, be required for initial project financing, $277,000 of which would be utilized for initial recreational facilities.

Under terms of the Davis-Grunsky Act, a recreation grant toward construction of a dam and reservoir in any amount over $300,000 requires specific approval of the Legislature. A state grant in the amount of $1,147,000 would, therefore, require legislative approval. Local interests would be required to finance initial and future expenditures for recreational facilities and guarantee suitable operation and maintenance. The initial investment required would be $277,000.

Summary of Unit Costs. Estimated unit costs on an average annual basis, as summarized in this section, are included to give the reader a general idea of the cost of implementing the Allen Camp Project under the plan and assumptions described herein. Possible postponement of project costs in the initial years of development to later years was not given consideration, although such scheduling of repayment is common practice.

It is evident that any comprehensive development of the Pit River must financially involve those individuals and entities that currently use Pit River water for irrigation. In fact, without the support of present water users, such development is not possible. Hence, no attempt was made to differentiate between the value of new water as opposed to reregulated water. The establishment of equitable rates for water and flood control among individual project beneficiaries in the Allen Camp service area was not considered in this study.

Project costs allocated to irrigation could be repayed by charging an average of about $4.65 per acre-foot for the entire seasonal yield of 58,100 acre-feet from Allen Camp Reservoir. The costs allocated to flood control could be repaid by an assessment of $2.20 per acre on the 27,100 acres of project lands.

Possible Method of Financing. The preceding discussion on the repayment of allocated costs to each project function was based on the procurement of federal funds under the Small Reclamation Projects Act of 1956 (Public Law 984) and of state funds under the Davis-Grunsky Act of 1959. Table 46 summarizes a possible method of financing the Allen Camp Project. It was assumed that a federal loan of $2,446,000 and a grant of $1,304,000 could be obtained under the Small Reclamation Projects Act of 1956. It was further assumed that the State would make a recreational grant of $1,147,000, local interests would contribute $277,000 for initial recreational facilities, and that the remaining $4,039,000 necessary for construction could be borrowed from the State. Under these circumstances, the state loan would total over $4,000,000 and specific legislative approval would be required.

TABLE 46

A POSSIBLE METHOD OF FINANCING THE ALLEN CAMP PROJECT

Item	Purpose		
	Irrigation	Flood control	Recreation
Present worth of allocated costs	$7,117,000	$2,598,000	$2,069,000
Present worth of operation, maintenance, and replacement, etc.	1,334,000	492,000	645,000
FIRST COST	$5,683,000	$2,106,000	$1,424,000
Source of Funds			
Federal loan under Public Law 984[1]	$2,446,000		
Federal grant[1]		$1,304,000	
State loan at 4 percent[2]	3,237,000	802,000	
State grant[2]			1,147,000
Initial local contribution			277,000
TOTAL	$5,683,000	$2,106,000	$1,424,000

1/ Federal approval required

2/ State of California legislative approval required

The Round Valley Project

At an appropriate time in the future, when economic circumstances warrant, the second stage of development of the comprehensive water plan for Big Valley would be undertaken. This second stage would comprise the Round Valley Project.

Service Area

The service area included under the distribution system of the Round Valley Project contains 22,500 acres of irrigable land. This area may be visualized by excluding the Allen Camp service area, delineated on Plate 9, from the total service area delineated on Plate 8. Some irrigable hill land is included along the margins of the Round Valley Project service area, but the majority is flat valley floor lands. Of the 22,500 acres included under the distribution system, only 15,700 acres could be irrigated from yield developed at Round Valley Reservoir. The remaining 6,800 acres would have to be irrigated from other potential local sources of water. Table 47 shows the crop pattern expected to prevail in the initial project years, and the crop pattern and irrigation water requirement expected under conditions of full project development.

Project Features

The features associated with the Round Valley Project are the dam and appurtenant structures, the Willow Creek Canal, the Ash Creek channel improvement program, the distribution system, and recreational facilities. These features are discussed in the following paragraphs.

Dam and Appurtenant Structures. Round Valley Dam would be a rockfill structure with a central impervious core. This type of dam would result in the lease expensive structure which could be constructed from material located in the vicinity of the site. Basalt for the shell sections of the dam could be obtained from locations immediately adjacent to the site and from salvage from spillway excavation. Properly graded filters would be provided between the rolled earth core and the rock sections. The dam would have a maximum height of 88 feet above stream bed and a crest length of 845 feet.

TABLE 47

ESTIMATED CROP PATTERN WATER REQUIREMENT
IN THE ROUND VALLEY PROJECT SERVICE AREA

Crop	Initial project development, in acres	Full project development			
		Acres	Estimated irrigation efficiency	Water requirement	
				Acre-feet per acre	Acre-feet
Alfalfa	480	4,930	75	2.3	11,300
Improved pasture	0	7,750	70	2.8	21,700
Meadow hay and pasture	5,500	180	65	3.0	540
Hay and grain	290	2,490	80	1.0	2,490
Truck crops	---	70	60	1.6	110
Alfalfa seed	---	280	80	1.3	360
TOTALS	6,270	15,700			36,500

Stripping depths under the dam would average approximately 40 feet in the channel, 6 feet on the left abutment, and 5 feet on the right abutment.

Round Valley Reservoir Site as It Appears from the Proposed Dam Site

The slopes adopted for the dam were as follows: upstream and downstream faces 2.25 to 1; upstream and downstream core faces 0.5 to 1.

Leakage through the dam foundation is not expected to be a serious problem. However, the basalt in the channel is moderately to intensely fractured, and grouting would be required to insure proper cutoff.

The dam would create a reservoir with a storage capacity of 72,000 acre-feet at spillway crest elevation and active storage capacity of 69,000 acre-feet. Maximum flood surcharge storage for the spillway design flood would be approximately 15,000 acre-feet. The water surface area of the reservoir at spillway crest elevation would be approximately 2,970 acres. The water surface area at minimum pool would be 320 acres. Storage capacities of the Round Valley Reservoir at various stages of water surface elevation are shown in Table 48.

A concrete-lined, side-channel spillway with a crest length of 200 feet would convey flood flows past the dam. The spillway would terminate in a flip bucket, and discharge flood flows into the stream channel about 300 feet downstream from the toe of the dam. The spillway was designed to pass the once-in-100-year flood followed in three days by the once-in-1,000-year flood (maximum instantaneous inflow would be about 16,500 second-feet), with an estimated maximum outflow of 8,100 second-feet. Grouting would be accomplished along the full length of the spillway and adjacent to the wing wall which would run from the weir to the crest of the dam. Subdrainage beneath the spillway would be provided by open-joint tile drain lines.

The outlet works would serve the threefold purpose of providing irrigation releases, flood control releases, and stream diversion during construction of the dam. Although operation of the project for flood control is not

TABLE 48

AREAS AND CAPACITIES
OF ROUND VALLEY RESERVOIR

Depth of water at dam, in feet	Water surface elevation, in feet U.S.G.S. datum	Water surface area, in acres	Storage capacity, in acre-feet
0	4,190	0	0
10	4,200	13	20
20	4,210	180	960
30	4,220	420	3,950
40	4,230	640	9,300
50	4,240	1,030	17,600
60	4,250	1,570	30,700
70	4,260	2,410	50,600
78	4,268	2,970	72,000
80	4,270	3,130	78,300
90	4,280	3,090	113,300
100	4,290	4,530	155,400
110	4,300	5,130	203,700
120	4,310	5,680	257,800
130	4,320	6,190	317,200
140	4,330	6,690	381,500
150	4,340	7,150	450,700
160	4,350	7,550	524,200
170	4,360	7,980	601,900

planned, release capacity of 600 second-feet would be built into the outlet works to enable reservoir drawdown during intense storms, if the reservoir happened to be full. The main conduit of the outlet works would be a 66-inch welded steel pipe encased in reinforced concrete and placed in a trench along the base of the left abutment. Two emergency gate valves enclosed in a reinforced concrete structure would be located at the upstream end and operated hydraulically from the crest of the dam. Control of discharge would be accomplished by a 54-inch, Howell-Bunger-type valve located at the downstream end of the outlet conduit. A rocklined channel would return releases to the stream bed.

Construction of the Round Valley Dam would necessitate a major relocation of U. S. Highway 299. Approximately four miles of the existing highway would be inundated. The relocation would involve the construction of 6.3 miles of roadway, including construction of a 600-foot bridge and a 4,400-foot causeway.

A plan view of the dam and spillway, a section along the dam axis, and maximum section of the dam are shown on Plate 12, "Round Valley Dam on Ash Creek". Pertinent data with respect to the general features of the Round Valley Dam and appurtenances are presented in Table 49.

Willow Creek Canal. The Willow Creek Canal would divert water from Willow and Butte Creeks to Round Valley Reservoir for the purpose of increasing the irrigation yield from the reservoir, as suitable sites are not available on either Willow or Butte Creeks for conservation storage. It was estimated that the proposed canal would be capable of delivering an average of approximately 6,000 acre-feet of water per season to Round Valley Reservoir. The canal would have a slope of 1 foot per 1,000 feet, a bottom width of 2 feet, and side slopes of 2 to 1. The canal would flow at a depth of 2.5 feet at the design capacity of 35 second-feet.

The canal would start at the Willow Creek diversion dam, located just upstream from the Armstrong Ranch, and extend in a northerly direction for approximately nine miles to the Round Valley Reservoir site. A small feeder canal from Butte Creek would intersect the main canal upstream from the flume section which would span Butte Creek. The route of the canal is shown on Plate 13, entitled "Willow Creek Canal".

Preliminary geologic reconnaissance indicates that materials along the canal route consist largely of tuffs and tuffaceous sediments. A mile of

TABLE 49

GENERAL FEATURES OF ROUND VALLEY DAM AND APPURTENANCES

General Data	
Location	SE 1/4, Sec. 21, T39N, R9E, MDB&M
Drainage area (excluding Butte and Willow Creeks), in square miles	249
Embankment	
Type	rockfill
Crest elevation, in feet above mean sea level	4,278
Crest length, in feet	845
Crest width, in feet	25
Maximum height above stream bed, in feet	88
Quantity of materials, in cubic yards	
Pervious	355,000
Impervious	112,500
TOTAL	467,500
Spillway	
Spillway crest elevation, in feet above mean sea level	4,268
Spillway crest height above stream bed, in feet	78
Weir crest length, in feet	200
Maximum surcharge head, in feet	5
Residual freeboard, in feet	5
Design flood peak inflow, in second-feet	16,500
Design flood peak outflow, in second-feet	8,100
Outlet Works	
Release capacity at normal pool, in second-feet	600
Release capacity at minimum pool, in second-feet	250
Reservoir	
Surface area at spillway crest elevation, in acres	2,970
Storage capacity at spillway crest pool elevation, in acre-feet	72,000
Surface area at minimum pool, in acres	320
Storage capacity at minimum pool, in acre-feet	3,000
Surface area at maximum pool, in acres	3,330
Storage capacity at maximum pool, in acre-feet	87,000
Surcharge storage capacity, in acre-feet	15,000

canal near the Willow Creek diversion dam would cross unconsolidated sand, gravel, and silt. The canal would pass through two saddles which would require cuts of about 30 feet in depth. The first mile of the canal would be lined, in order to prevent excessive seepage losses.

Flumes, culverts, and siphons would be located to provide for underdrainage and facilitate crossing, as shown on Plate 13. Flume sections would be utilized to cross Butte Creek and another draw near the existing Myers Reservoir. A flume, extending from high water to slightly below normal pool, would be provided for spilling the canal water into Round Valley Reservoir.

Culverts would be installed to pass local drainage where necessary. A total of seven inverted siphons would be used for road crossings. In all, 1,500 feet of flume, 1,100 feet of various size culverts, and seven inverted siphons would be required to complete the canal.

The Willow Creek diversion structure would be an earthfill dam with a central concrete overpour section 10 feet in height and 100 feet in length. The estimated 50-acre-feet of storage capacity created by the dam would be utilized to diminish fluctuation of the natural flow and would divert as much flow as possible into the canal. An automatic hydraulically actuated gate would maintain a constant release for prior downstream rights, and divert the remaining flow up to a maximum of 35 second-feet into the canal. Water in excess of the required downstream release and the canal capacity would either be temporarily stored or spilled over the central overpour section.

Ash Creek Channel Improvements. Ash Creek presently meanders through the Big Valley service area from east to west, and water from the creek is used for irrigation on meadow, hay, and pasture lands. Present channel capacity of Ash Creek below the confluence of Ash Creek and Willow Creek was estimated to be about 700 second-feet. The slope of the Ash Creek channel increases from Willow Creek to the Round Valley Dam site, and the estimated present capacity in this reach is 900 second-feet. Since the maximum estimated spill from the Round Valley Reservoir for the once-in-20-year flood is approximately 900 second-feet, with incidental operation of the outlet works for flood control purposes, only the Ash Creek channel below the confluence of Ash Creek and Willow Creek would require improvement. The improved section would have a length of approximately 44,400 feet, and would connect with the improved Ash Creek channel provided under the initial stage of development. The capacity in this reach would be increased to 3,600 second-feet, which would be adequate to handle side drainage from tributary areas for the once-in-20-year flood. Excavation of approximately 755,000 cubic yards of material would be required. The bridge, located about one mile upstream from the confluence of Pit River and Ash Creek, would require replacement at the time of this second stage of development.

Distribution System. The distribution system necessary to complete development of the Big Valley service area as suggested herein would be capable of serving about 22,500 acres of irrigable land. Two new diversion dams would be required; one on Ash Creek and the other on the Pit River above Gould Bridge. Water from Allen Camp Reservoir would be diverted above Gould Bridge to irrigate new lands lying below the elevation of the northernmost canal shown on Plate 8. In turn, water from Round Valley Reservoir would be utilized in southern portions of the service area. Such an exchange of water would enable more efficient operation of the distribution system as a whole. It is again emphasized that the main canal system, as delineated on Plate 8, was laid out without benefit of detailed topography and is intended only to illustrate in a general manner the lands that could be served under the projects.

Recreational Facilities. Round Valley Reservoir is not expected to greatly enhance the recreational potential of the area, because of the character of the surrounding terrain and cover, and the large seasonal fluctuation of the reservoir water surface. Seasonal lowering of the water surface in the reservoir would cause large mud flats to form around a major portion of the perimeter. Furthermore, natural cover is lacking or relatively unattractive around a large portion of the reservoir. Nevertheless, a limited number of recreational facilities were included in the plans for development.

Terrain, cover, and access to the water surface at low pool combine to favor the Barber Canyon area as the choice for development of public recreational facilities. Boat launching ramps and picnic areas were planned just northwest of the dam site, but camping would have to be developed about one-half mile from the high water surface up Barber Canyon due to the lack of suitable cover near the water surface.

The long ridge south of the Ash Creek arm of the reservoir is generally flat topped, with relatively good pine and hardwood cover. The area appears well adapted to summer home use.

It is anticipated that some 50 camp sites and 20 picnic units would be required in the vicinity of Round Valley Reservoir by the year 2010. Of this number, 11 camp units, and 2 picnic units were included as features of the Round Valley Project. At the present time, there is an estimated deficiency of 20 camp units and 7 picnic units in the Round Valley area.

Geology

The Round Valley Dam site is located on Ash Creek where the creek passes through the main ridge which separates Big Valley and Round Valley. The ridge is composed of a more or less conformably bedded series of volcanic and sedimentary rock units which dip northeasterly at angles varying from 15° and 40°. Cross faulting has caused an apparent lateral offset between the beds on the left and right abutments. However, the major movement along this fault was probably vertical.

A flow-brecciated or auto-brecciated basalt is exposed in numerous outcrops on both abutments. The intense fracturing in this rock is not ascribed to fault shearing, but occurred during late movement of the partly congealed flow as it cooled. Further cooling of the basalt resulted in healing of most of the fractures at the time the last remaining fluid basalt solidified. This basalt unit extends across the channel section.

The right abutment at the site consists of hard, dark, non-vesicular basalt structurally capable of supporting the proposed works. The surface of the right abutment is covered with weathered fragments of basalt derived from the underlying rock, but sound rock is encountered from 1 to 6 feet beneath the surface. The basalt is fractured but most of the fractures have been sealed with clay and other minerals.

The channel section at the site is covered with alluvial flood plain deposits to a depth of approximately 35 feet. The underlying bedrock consists of fractured basalt which extends to considerable depth. The existence of a warm spring located about 200 feet upstream from the axis, and artesian flow from the channel core holes, coupled with the fractured nature of the bedrock, indicate that care should be taken to achieve an adequate and effective cutoff.

On the left abutment, the auto-brecciated basalt is overlain by 2 feet of soil. The basalt is highly fractured, but minerals filling the breaks have made the rock tight and nearly impervious. The basalt appears to be the same as that cored on the right abutment. However, the rocks on the left abutment are somewhat more brecciated.

Round Valley Dam Site as It Appears from the Right Abutment

It does not appear that leakage from the reservoir will be a problem. The older volcanic series which surrounds the reservoir appears to have a low coefficient of permeability. In addition, the attitude of the beds along the southwest margin of the reservoir, would tend to reduce leakage.

Investigation for impervious borrow material was confined to Round Valley. The material encountered consisted primarily of a brown clay overlain by 1 to 2 feet of organic overburden. Depth to water table averaged about 5 feet on the east side of the valley and about 10 feet on the west side.

Rock for the pervious zones is plentiful in the immediate vicinity of the site, but the prevalence of closely spaced fractures would make the quarrying of large blocks difficult. Gravel has been processed from a pit in Round Valley, about 3 miles from the site. The gravels occur in a conglomeratic hardpan and processing would be fairly expensive. Andesite, contained in the material, may be reactive and thus render the aggregate not suitable for concrete. It may also be possible to obtain sand from this pit if a gravel plant is set up. There does not appear to be any large sources of unconsolidated sand or gravel in the Round Valley area.

Cost Estimates

Capital costs of the project features associated with the Round Valley Project, the second stage of development for Big Valley, were derived from planning designs and office studies and generally are representative of prices prevailing during late 1958 and early 1959. The costs of lands, easements, rights of way and public utility relocations were estimated by a field appraisal of real property, improvements, and severance damages that would be sustained. A summary of the detailed cost estimate derived for the Round Valley Dam and appurtenant structures is shown in Table 50. The estimated capital cost includes engineering contingencies and interest during construction, calculated at 4 percent for one-half of the estimated 2-year construction period.

TABLE 50

ESTIMATED CAPITAL COSTS OF ROUND VALLEY
DAM AND APPURTENANCES

Item	Cost
Embankment	$ 992,000
Spillway	372,000
Outlet works	158,000
Land, improvements, and severance damages	732,000
Relocation of public utilities	26,000
Highway relocation and right of way	3,420,000
Subtotal	$5,630,000
Engineering and administration	563,000
Contingencies	845,000
Interest during construction	282,000
TOTAL	$7,320,000

The estimated capital costs of the Willow Creek Canal are shown in Table 51.

TABLE 51

ESTIMATED CAPITAL COSTS OF THE WILLOW CREEK CANAL

Item	Cost
Diversion dam and control gates	$ 81,000
Canal and accessories	131,000
Right of way	11,000
Subtotal	$223,000
Engineering and administration	22,000
Contingencies	33,000
Interest during construction	11,000
TOTAL	$289,000

The estimated capital cost of recreational facilities planned for Round Valley Reservoir amounts to $28,000. This amount would be expended on a decade-by-decade basis to meet the demand for facilities. The present worth of these expenditures at an interest rate of 4 percent is approximately $17,200.

A summary of the estimated Round Valley Project capital costs, associated with the second stage of development for Big Valley, is shown in Table 52.

TABLE 52

SUMMARY OF ESTIMATED CAPITAL COSTS OF ROUND VALLEY PROJECT

Item	Cost
Dam and appurtenances	$7,320,000
Willow Creek Canal	289,000
Channel improvements	460,000
Distribution system	494,000
Recreational facilities	28,000
TOTAL	$8,591,000

The estimated annual costs include amortization of the capital investment, operation, maintenance, replacement, and general expense. Operation, maintenance, replacement and general expense costs were estimated at $20,300 for the dam and appurtenances, $2,900 for the Willow Creek Canal, $2,600 for the Ash Creek channel improvements, $27,700 for the distribution system, and $1,600 for the recreational facilities. The annual amount necessary to amortize the project first costs at 4 percent interest over a 50-year period would be $399,900. Thus, the estimated total annual cost of the Round Valley Project would be $455,000.

Project Operation

Storage development curves were utilized for sizing the Round Valley Reservoir. The curves were developed for inflow conditions with and without the Willow Creek Canal in operation. It was determined that an increase in seasonal yield of approximately 5,000 acre-feet could be realized with the canal in operation. An economic analysis indicated that a reservoir with a storage capacity of 72,000 acre-feet would be most feasible.

Flood routing of the once-in-20-year flood through the Round Valley Reservoir indicated that maximum spill would reach a rate of only 900 second-feet at the end of the third day of flooding, with only incidental flood control operation of the outlet works. Since this discharge would be non-damaging, no flood control reservation would be required in Round Valley Reservoir to afford protection from the 20-year flood to Adin and downstream lands. Maximum surcharge storage in the reservoir during the once-in-20-year flood would be about 3,500 acre-feet.

The final operation study of the Round Valley Reservoir was based on the following criteria:

1. Runoff during the base period from 1919-20 through 1955-56.
2. Reservoir storage capacity, at spillway crest elevation of 4,268 feet, of 72,000 acre-feet.
3. Minimum pool with a capacity of 3,000 acre-feet.
4. Minimum stock and fish release of 5 second-feet from the reservoir, maintained at all times.
5. Prior water rights on Willow Creek subtracted from the water available for diversion to Round Valley.
6. Downstream prior rights of the Pacific Gas and Electric Company on the Pit River considered to be unaffected by this development. (It may be noted that seasonal average present impaired flow at the Round Valley Dam site constitutes only 2 percent of the flow at the Pit No. 3 diversion.)
7. No reservation of storage space for flood control in the reservoir.
8. Evaporation and irrigation requirements based on the standard project schedule developed for the Allen Camp Project.

9. A 50 percent deficiency in yield in the most critical season (1933-34) during the base period.

The results of the reservoir operation study indicate that a firm seasonal yield of 36,500 acre-feet could be developed from the proposed reservoir. The critical period for the operation would have extended from April 1922 to March 1938. The reservoir would have reached its lowest stage (3,000 acre-feet of storage) in September 1933. The greatest volume of spill would have occurred during the April 1952 flood, and it is probable that channel capacities would have been exceeded during this period had the project been in operation. However, the frequency analysis of this flood indicates a mean recurrence interval of 27 years, which is beyond the 20-year protection afforded by the project. Detailed analysis of the effect of the Round Valley Reservoir on this flood was not possible due to the lack of recorded data. Table 53 presents a seasonal summary of the operation study for the period studied.

Impairment of runoff at the Round Valley Dam site by future upstream water supply development is expected to be negligible. However, water supply estimates at the site may require revision in the future when more recorded run-off data are available from the gaging station near Adin.

<u>Project Benefits</u>

Primary project benefits from the Round Valley Project would be derived from the firm water supply provided, from the prevention of flooding and erosion, and from recreation. The net agricultural benefit that would accrue to the project from the service area has an estimated annual equivalent value of $261,700. Flood damage reduction would result in an estimated annual savings of approximately $23,700. The estimated recreational benefits, derived from assigning a

TABLE 53

SEASONAL SUMMARY OF MONTHLY OPERATION STUDY
ROUND VALLEY RESERVOIR
(In acre-feet)

Season	Inflow	Yield	Evaporation	Stock and fish release	Spill	Storage at end of season
1919-20	38,500	36,500	6,000	2,100	0	31,900
20-21	64,800	36,500	6,600	1,800	8,300	43,500
21-22	58,900	36,500	6,500	1,800	15,400	42,200
22-23	33,500	36,500	5,600	2,100	0	31,500
23-24	33,800	36,500	4,700	2,100	0	22,000
1924-25	42,100	36,500	4,200	2,100	0	21,300
25-26	35,000	36,500	3,600	2,100	0	14,100
26-27	65,000	36,500	5,300	2,100	0	35,200
27-28	48,400	36,500	6,100	2,100	0	38,900
28-29	31,700	36,500	5,100	2,100	0	26,900
1929-30	40,300	36,500	4,900	2,100	0	23,700
30-31	22,200	36,500	2,600	2,100	0	4,700
31-32	48,700	36,500	3,400	2,100	0	11,400
32-33	32,600	36,500	2,400	2,100	0	3,000
33-34	24,800	18,200	1,700	2,100	0	5,800
1934-35	48,100	36,500	3,400	2,100	0	11,900
35-36	60,900	36,500	5,100	2,100	0	29,100
36-37	37,500	36,500	4,800	2,100	0	23,200
37-38	104,200	36,500	6,600	1,500	37,100	45,700
38-39	31,300	36,500	5,900	2,100	0	32,500
1939-40	47,400	36,500	6,000	2,100	0	35,300
40-41	50,500	36,500	6,300	1,800	1,300	39,900
41-42	69,200	36,500	6,700	1,500	19,100	45,300
42-43	77,400	36,500	6,800	1,500	33,600	44,300
43-44	40,300	36,500	6,400	2,100	0	39,600
1944-45	57,200	36,500	6,600	1,500	7,600	44,600
45-46	53,200	36,500	6,400	1,500	11,100	42,300
46-47	36,300	36,500	5,800	2,100	0	34,200
47-48	51,500	36,500	5,300	2,100	0	41,800
48-49	56,200	36,500	6,800	1,800	10,300	42,600
1949-50	43,400	36,500	6,400	2,100	0	41,000
50-51	50,100	36,500	6,400	1,800	5,000	41,400
51-52	98,900	36,500	6,700	1,500	50,300	45,300
52-53	68,000	36,500	6,700	900	26,500	42,700
53-54	44,300	36,500	6,400	1,800	3,500	38,800
1954-55	38,100	36,500	5,700	2,100	0	32,600
55-56	98,000	36,500	6,700	900	44,200	42,300
Averages	50,900	36,000	5,500	1,900	7,400	

value of $2.00 per visitor-day to the number of visitor-days attributable to Round Valley Reservoir, would have an annual equivalent value of $7,700. Estimated annual benefits attributable to the Round Valley Project total $293,100.

Benefit-cost Analysis

The benefit-cost analysis of the Round Valley Project was accomplished for reservoir storage capacities ranging from 43,000 to 120,000 acre-feet. From this analysis it was determined that costs exceeded benefits for all reservoir capacities. The level of development at which total costs exceeded total benefits by the minimum amount was for a reservoir storage capacity of 72,000 acre-feet. For this capacity, it was estimated that primary annual project benefits and costs would be approximately $293,100 and $455,000, respectively. The benefit-cost ratio would be 0.64 to 1. Since the project is not economically justified at this time, no further consideration was given to other financial aspects of the Round Valley Project.

It is evident that because of the significant magnitude of costs involved in the relocation of United States Highway 299, it is and will remain the major deterrent to development of the Round Valley Project. At such time as major reconstruction or enlargement of the present highway appears necessary, careful consideration should be given to an alternative route which would relocate the highway out of the reservoir area.

CHAPTER V. CONCLUSIONS AND RECOMMENDATIONS

As a result of field surveys and analysis of the data developed for the Upper Pit River Investigation, the following conclusions have been reached:

Conclusions

1. The agricultural and economic development of Big Valley is limited by the climate, inadequacies in water supply both with respect to time and quantity, frequent flooding of the valley lands, and inadequate drainage.

    a. A major portion of the runoff from winter and spring precipitation and snowmelt occurs prior to the season of greatest water need and is unregulated.

    b. Agricultural activity on the approximately 24,000 acres of presently irrigated lands in Big Valley is limited to low yield native meadow hay and meadow pasture. The frequent inundation of these presently irrigated lands precludes a change to an improved crop pattern.

    c. Land resources in Big Valley capable of irrigation development are in excess of the irrigable acreage for which a water supply may be reasonably and practicably developed. Although there are 94,300 acres of hill and valley lands classes as irrigable, it is estimated that the water supply susceptible to practical development is sufficient for about 55,400 acres.

2. The construction of water conservation facilities would alleviate, in large part, these adverse conditions by providing Big Valley with the basis for increased agricultural productivity and enhancement of the recreational potential.

3. The Allen Camp Project, with reservoir storage capacity of 155,000 acre-feet, would provide maximum net benefits and constitute the initial stage of the overall plan of development for the water resources available to Big Valley.

4. Allen Camp Reservoir could provide water adequate in quantity and quality to serve 27,100 acres. Approximately 25,600 acre-feet of the 58,100 acre-feet of firm seasonal yield of Allen Camp Reservoir is presently utilized in the valley, but would be reregulated under project operation. Thus, about 32,500 acre-feet seasonally would be new yield attributable to Allen Camp Reservoir.

5. Recognition of the water rights held by the Pacific Gas and Electric Company limits the seasonal yield available from Allen Camp Reservoir to 58,100 acre-feet. In addition, presently held adjudicated water rights in Big Valley must be integrated with those to be acquired by the operating agency for successful project operation.

6. Water rights applications presently on file for storage at the Allen Camp site cover a total of 156,000 acre-feet, substantially the quantity of water required for the project.

7. Flood protection to low-lying lands along the Pit River could be accomplished most economically by combining 36,000 acre-feet of flood control storage at the Allen Camp Reservoir with channel improvements on the Pit River and Ash Creek.

8. The total estimated first cost of the Allen Camp Project is approximately $9,214,000. Annual operation, maintenance, and replacement costs, associated with irrigation, flood control, and recreation, amount to about $62,100, $22,900, and $24,000, respectively.

9. The primary benefits that would accrue to the three purposes served by the Allen Camp Project total about $13,307,000 and are as follows: irrigation, $8,230,000; flood control, $2,725,000; and recreation, $2,352,000.

10. Analyzed under the assumptions stated herein, the Allen Camp Project is economically justified, having a benefit-cost ratio of 1.14 to 1.

11. Estimated payment capacities for water in the Allen Camp service area, under full project development, would range from zero for meadow hay to a high of $34.45 per acre for potatoes. The estimated weighted average payment capacity of the lands to be served from the Allen Camp Project is $7.20 per acre-foot.

12. The Round Valley Project would have a benefit-cost ratio of 0.64 to 1 and is not economically justified under present conditions.

13. Full development of the water resources available to Big Valley would necessitate the later construction of the Round Valley Project, as well as several small local projects, when economic conditions warrant. Smaller, less extensive development on tributary streams would also be necessary for full utilization of the water resources available to Big Valley.

Recommendations

It was recommended in the preliminary edition of Bulletin No. 86, that local interests give consideration to Allen Camp Project as the initial stage in a plan of water development for the Big Valley area, and that they explore as possible sources of financial assistance to construct the project, either the federal government Small Reclamation Projects Act of 1956 (Public Law 984 as amended by Public Law 85-47), or a state grant and loan under provisions of the Davis-Grunsky Act (Section 12880 of the Water Code). Local interests investigated the possibility of obtaining financial assistance from the above sources but found that financing the project by either of the two sources was not feasible.

Subsequent to release of the preliminary edition of this report, the Big Valley Irrigation District and Modoc and Lassen Counties requested the Bureau of Reclamation to make a feasibility study of the Allen Camp Project. During 1963 and 1964, the Bureau investigated the Allen Camp unit. Their study will be completed in the fall of 1964. If the Bureau's report shows economic justification and financial feasibility, it is the intent of local interests to request early authorization of a federally financed project for the Big Valley area as an integral part of the Central Valley Project.

In view of the foregoing, it is recommended that:

1. Local interests continue efforts to obtain funds from either federal or state sources in order to implement the Allen Camp Project as the initial stage in a plan of development for Big Valley.

2. The overall plan for development of water resources for Big Valley includes construction of Round Valley Project, and other smaller projects, when future conditions are such as to warrant economic justification.

APPENDIX A

DEFINITION OF TERMS

DEFINITION OF TERMS

Animal-unit month--Equivalent to the average amount of feed necessary for normal growth which would be consumed per month by one mature animal.

Annual--The 12-month period from January 1 of a given year through December 31 of the same year, sometimes termed the "calendar year".

Applications, permits, and licenses to appropriate water--Prior to 1914, an appropriative right could be acquired in California by merely constructing works and applying the water to beneficial use, providing notice had been posted and a copy of the notice recorded with the county recorder. Since the Water Commission Act of 1914, however, any appropriation of water in surface streams and other surface bodies of water and in subterranean streams flowing in known and definite channels must be initiated by the filing of an application to appropriate water with a designated state agency. The agency now administering these applications is the State Water Rights Board, established by the Legislature in 1956.

The date of filing establishes the priority of any right which may thereafter be acquired under the application. If surplus or unappropriated water is available in the stream, a permit is issued by the board allowing the applicant to divert or store and apply to beneficial use a designated quantity of that unused water and to construct necessary works accordingly. If there are protests to the application, a hearing will be held by the board prior to issuance of a permit. The permit sets forth the conditions under which actual use of unappropriated water will vest the right to continue that use. Diligent application of the water to beneficial use, to the full extent contemplated in the permit, creates a right by appropriation which is confirmed by the issuance of a license.

Applied water--The water delivered to a farmer's headgate in the case of irrigation use or to an individual's meter, or its equivalent, in the case of urban use. It does not include direct precipitation.

Appropriative rights--The appropriation doctrine contemplates the acouisition of rights to the use of water by diverting water and applying it to reasonable beneficial use in accordance with procedures and under limitations specified by constitutional or statutory law or acknowledged by the courts. The water may be used on or in connection with land away from streams, as well as land contiguous to streams. The first appropriator from a particular water course in point of time has the prior exclusive right to the use of the water to the extent of his appropriation without dimunition in quantity or substantial deterioration in quality whenever the water is available. Each later appropriator has a like priority with the respect to all those who are later in time. The appropriative right applies to a specific amount of water and is good as long as the right is exercised.

Assignment of state applications--In general, an assignment of a state application is made pursuant to a request by an agency contemplating a water development project on the same stream system on which a state application has been made. Such assignment is authorized by Water Code Section 10504 and is made in the case where the constructing agency proposes to construct the project essentially as set forth in the state application.

Associated costs--The value of the goods and services needed, over and above those included in project costs, to make the immediate products or services of the project available for use or sale.

Average--The arithmetical average of quantities occurring during other than mean periods.

Base period--A period of years suitable for detailed hydrologic analysis. The base period should include a series of wet years and a series of dry years, but the controlling factor is the availability of sufficient hydrologic data in the area of investigation. The 37-year period from 1919-20 through 1955-56 was selected as the period best fulfilling these requirements in the Pit River Basin.

Consumptive use of water--The water consumed by vegetative growth in transpiration and building of plant tissue, and water evaporated from adjacent soil, from water surfaces, and from foliage. It also refers to water consumed by urban and nonvegetative types of land use.

Effective precipitation--That portion of the direct precipitation which is consumptively used. Effective precipitation does not include runoff or percolation to ground water.

Exemption from diligence--Pursuant to Section 10500 of the Water Code, unassigned applications filed by the State are exempt from the requirements of diligence. This has never been made a permanent exemption, however, and it is subject to periodic renewal by the Legislature. The present exemption was extended by the 1959 Legislature and expires on October 1, 1963. If at any time the Legislature should fail to extend the exemption, the priority of unassigned state applications may ultimately be lost under the normal rules of diligence, and such applications will be subject to cancellation by the State Water Rights Board.

Factors of water demand--Those factors pertaining to rates, times, and places of water delivery, imposed by the control, development, and use of water for any and all beneficial purposes.

Firm seasonal yield--The quantity of water that could be delivered from the project each year, but with a deficiency of 50 percent in 1 out of 37 years.

Historical runoff (flow)--The flow of a stream as it has occurred and was or would have been recorded by measuring devices .

Irrigation efficiency--The ratio of the amount of consumptively used irrigation water to the total amount of such applied water. It is commonly expressed as a percentage.

Mean--The arithmetical average of quantities occurring during the mean period.

Mean period--A period chosen to represent conditions of water supply and climate over a long period of years. The mean precipitation period currently in use by the department is 1905-06 through 1954-55. The mean runoff period currently in use by the department is 1907-08 through 1956-57.

Precipitation season--The 12-month period from July 1 of a given year through June 30 of the following year.

Present--Used generally in reference to the period from 1954 through 1958.

Present impaired runoff (flow)--The flow of a stream as it would have been if the present development had existed throughout the period of study.

Primary project benefits--Primary benefits attributable to a project are the value of products or services directly resulting from the project, over and above associated costs.

Project costs--The market value of the goods and services (land, labor, and materials) necessary for the establishment, maintenance, and operation of the project together with the net value of any induced adverse effects.

Project impaired runoff (flow)--The flow of a stream as it would occur at any point if specified pertinent projects were constructed.

Release from priority of state applications--Under Water Code Section 10504, the State is authorized to release from priority any portion of a state application in favor of applications of a junior priority. In general, a release from priority is made to an agency contemplating a water development project on a stream on which a state application has been filed, but which envisions either a purpose or use, a service area, or a project not covered by the state application.

Requirements of diligence--Any applications (except state applications which have not been assigned) and permits and licenses that have been issued pursuant to approved applications are subject to the requirements of diligence as set forth in Part 2 of Division 2 of the Water Code and the rules and regulations of the State Water Rights Board. Diligence requires the applicant diligently to complete an application on file with the State Water Rights Board, the permittee diligently to complete construction of the physical works required to apply the water sought to beneficial use, and the licensee to continuously apply the water to the uses in accordance with the terms and conditions of the license. Failure to comply with the requirements of diligence will result in the cancellation of an application or the revocation of a permit or license by the board and in a loss of priority as against subsequent appropriators.

Riparian rights--There is no California statute specifically defining riparian rights, but a modification of the common law doctrine of riparian rights has been established in this State by court decision. The doctrine was further modified by an amendment to the State Constitution adopted in 1928. Generally speaking, the riparian doctrine accords to the owner of land contiguous to a watercourse the rights to use the water on that land. Under California law, the use of water must be reasonable in relation to the reasonable requirement of all other owners of land riparian to the same source of supply. Now--although not before the 1928 constitutional amendment--the use must be reasonable likewise with respect to appropriative rights on the same stream.

Riparian rights are not based upon use, and in the absence of prescription (adverse use for a period of five years), they are not lost by disuse. No riparian owner acquires priority over other riparian owners by reason of the time he began his use of the water. The riparian right is proportionate, not exclusive. It is not measured by a specific quantity of water, except when there is an apportionment by a court decree adjudicating the rights of riparian owners among themselves or except in an adjudication of riparian rights as against appropriators of surplus water.

Runoff season--The 12-month period from October 1 of a given year through September 30 of the following year.

Safe seasonal yield--The quantity of water that could be delivered from a project each season of the period under study without a deficiency.

Seasonal--Any 12-month period other than the calendar year.

Secondary project benefits--The benefits attributable to a project which are over and above the value of primary benefits after taking account of expected conditions throughout the economy with and without the project. A dollar value was not placed on secondary benefits for purposes of economic justification, but qualitative consideration was given in the economic analysis.

State applications--A state application is filed by the Department of Water Resources pursuant to Water Code Section 10500. This section authorizes the department to file an application for any water which in its judgment may be required in the development and the completion of the whole or any part of a general or coordinated plan looking toward the development, utilization, and conservation of the state's water resources. Such applications have been filed periodically since 1927 for projects which involve the waters of major streams of the State of California, both for export projects and local development. The effect of the state applications is to hold water in public trust for future use.

Unimpaired runoff (flow)--The flow of a stream as it would have been if unaltered by upstream diversion, storage, import, export, or change in upstream consumptive use caused by man-made development. Unimpaired runoff is reconstructed from historical runoff by allowing for the quantitative effect of alterations in stream flow above the point where the flow is measured.

Water requirement--The amount of water needed for all beneficial uses of water and for irrecoverable losses incidental to such uses.

Water utilization--All employments of water by nature or man, whether consumptive or nonconsumptive, as well as irrecoverable losses of water incidental to such employment. This term is synonymous with the term "water use".

APPENDIX B

UPPER PIT RIVER: EFFECTS OF ALLEN CAMP AND ROUND VALLEY PROJECTS ON FISH AND GAME RESOURCES

EDMUND G. BROWN
GOVERNOR

SETH GORDON
DIRECTOR

STATE OF CALIFORNIA

Department of Fish and Game

722 Capitol Avenue
Sacramento 14, California

February 3, 1959

Honorable Harvey O. Banks, Director
Department of Water Resources
P. O. Box 388
Sacramento, California

Dear Mr. Banks:

Transmitted herewith is a report entitled "Upper Pit River: Effects of Allen Camp and Round Valley Projects on Fish and Game Resources". This report summarizes an investigation carried on cooperatively by the Department of Fish and Game and the Department of Water Resources in the drainage area of the Pit River in southern Modoc County. The study indicates that the projects would provide benefits for fish and wildlife resources.

There is a small warm-water stream fishery for black bass and catfish in the Allen Camp area at present, but water conditions for fish are poor because of suspended solids in the stream. Based on the planned operation and maintenance of a normal minimum pool the reservoir would improve conditions for these fishes, and increase the area available for angling.

In the Round Valley area, Rush and Ash Creeks support small good trout fisheries. The project would replace these stream fisheries with a reservoir fishery.

The Department of Water Resources has estimated the total recreational use to be expected at the reservoirs. We feel that about one-third of this use will be by anglers. This angling use would be greatly in excess of that experienced at present in the river.

The service area of the project extends south along the Pit River to a point near the Muck Valley Station, about six miles south of the town of Bieber. In this reach, flow in the Pit River would be maintained during non-irrigation seasons by a 15 cfs stock water release. This would maintain flow levels superior to present conditions. During the irrigation period, the flow in the stream would be much larger than at present.

Channelization, as proposed in this project, would eliminate cover along the stream. This condition, combined with cattle wading in the stream, will contribute to erosion of the channel. The consequent muddying of the water will limit fish production and reduce esthetic values. These conditions do not represent detriment to fisheries because there is practically none in this stream at present, but no enhancement should be claimed for flow maintenance.

In the event that channelization were not undertaken, and that cattle were excluded from the stream bed, conditions for fish would be significantly improved and benefits could be claimed for enhancement due to stream flow maintenance.

The two projects would have a small over-all benefit for waterfowl, resulting from a somewhat greater gain than loss. The loss would be in nesting areas in drained marshes. The gain would be in resting areas at both reservoirs and in moulting grounds at the Allen Camp Reservoir.

We appreciate the opportunity that this type of study offers us to include consideration of fish, wildlife, and recreational resources in the early stages of water project planning.

Sincerely,

Seth Gordon

Seth Gordon
Director

UPPER PIT RIVER: EFFECTS OF ALLEN CAMP AND ROUND VALLEY PROJECTS ON FISH AND GAME RESOURCES

INTRODUCTION

The Department of Water Resources in December, 1957, published Bulletin No. 58 entitled "Northeastern Counties Investigation". In July, 1957, the Department published Appendix A to Bulletin No. 58 entitled "Future Population, Economic and Recreation Development of California's Northeastern Counties". Further engineering investigation has indicated that the possible Allen Camp project on the Upper Pit River and the possible Round Valley project on Ash Creek, both in southern Modoc County, are the two projects probably most worthy of further consideration for water development in the extreme northeastern portion of the State. At the request of the Department of Water Resources the Department of Fish and Game has estimated the effects of these two projects on the resources of fish and game, and during the course of the investigation, has made recommendations for the maintenance or enhancement of these resources in connection with the two projects.

CHAPTER I. PROJECT AREA AND DESCRIPTION

A. Allen Camp Project

Allen Camp Dam and Reservoir are proposed for construction on the Pit River in the southern portion of Modoc County. The dam would be located in Section 35, T 41 N, R 7 E, MDB&M, nine miles north of the town of Lookout and about thirty-two miles southwest of the town of Alturas. The Pit River upstream from the proposed dam drains approximately 1,430 square miles, and the mean annual runoff is about 160,000 acre-feet. The project is intended to impound waters of the Pit River for irrigation in the service area, which is Big Valley, to an area about six miles south of the town of Bieber. The reservoir would be operated for carry-over storage, and would spill about two years out of ten, while during a critically dry period it would begin each summer season only partially full. Normal annual drawdown would be about thirty-five feet, reducing the surface acres from 3,600 in May to about 1,500 acres in October.

The dam would be about 130 feet high at elevation 4,295 feet above sea level. Gross storage capacity would be about 186,000 acre-feet and dead storage capacity would be about 5,000 acre-feet.

The Allen Camp project would be operated for irrigation, releasing a flow of approximately two hundred cubic feet per second during the height of the irrigation season, about the middle of August. The irrigation season would begin about the first of July and would continue with varying flows until about the first or the middle of September. Existing rights for stock water would require a release of fifteen cubic feet per second at all times.

A channelization program might be carried out in the stream bed below Allen Camp site in order to minimize the effects of floods during years of heavy runoff, and to assist in local drainage and lowering of the water table. This channelization would provide a stream bed of approximately eighty feet across the bottom and would result in the removal of all vegetative cover which now exists. Irrigation diversion would be accomplished by the construction of weirs at intervals along the stream and would result in formation of pools behind these weirs. This would be done either with or without the channelization program.

The reservoir would be long, narrow, and steep-sided, following the Pit River about 15 miles upstream from the dam site to a point near the Canby crossing on Highway U. S. 299. There would be a major bay or arm to the south in Stone Coal Valley and a minor arm extending to the north into a stream area near the dam site.

The canyon floor is covered partially by annual and perennial grasses mixed with sage and scattered junipers. This combination grades gently into an area of mixed conifer forests on north-facing slopes and scrub juniper forests on the south-facing slopes.

The bottom of the reservoir site is composed of rocky alluvial soil for the most part, interspersed with meadow and pasture land. The upper edges of the hills along the sides of the canyon are largely volcanic or caprock of basaltic nature. The valley walls drop off steeply from the lands surrounding the reservoir area, and then break to the valley bottom to the area in meadow and pasture. The topography is generally rugged but not spectacular, and this ruggedness would be a detriment to recreational development and use.

The river bed along the reach in Big Valley is composed mainly of consolidated mud. This condition, together with the practice of watering cattle in the stream, muddies the water. Irrigation return flows the upstream areas bring in organic material, which is augmented by the return flows from irrigation in Big Valley. Water temperatures in summer are above tolerance levels for trout. The whole pattern of water quality, then, is of warm turbid water, unsuitable for angling, low in fish production, and esthetically unattractive.

B. Round Valley Project

Round Valley Dam and Reservoir would be located on Ash Creek in the southern portion of Modoc County with the dam located in Section 21, T 39 N, R 9 E, MDB&M about one-half mile north of the town of Adin. The drainage area of Ash Creek upstream from the dam site is about 249 square miles, and the mean annual runoff is about 53,000 acre-feet. The reservoir would be operated to impound the waters of Ash Creek and its tributaries for irrigation in Big Valley. It would be operated for carry-over storage and would spill about four years out of ten, while in about one year in three it would begin the summer season with considerably less than full storage. Annual drawdown would be about 20 feet from a full reservoir, reducing the surface area from 3,260 acres in May to less than 1,900 acres in October.

The dam would be about 85 feet in height at elevation 4,290 feet above sea level. The reservoir would store about 85,000 acre-feet of water when full and about 2,000 acre-feet at dead storage or minimum pool. The reservoir would inundate about four miles of Ash Creek and about three miles of Rush Creek, both of which are good small trout streams.

Round Valley is actually an irregularly shaped meadow with a length of about six miles. The valley floor breaks off sharply from surrounding hills, which are of volcanic origin and extremely rocky. Rush Creek traverses the valley from the north, joining Ash Creek in the flat of the valley. The valley floor is gently sloping and is farmed extensively, producing excellent hay and good grazing. The water courses are marked by clumps of willows and alders.

Sage and bitter brush invade the grass on the thin rocky soils of the valley's edge and scattered junipers begin to appear there. Leaving the valley and going up the slope of the surrounding hills the junipers become larger and are joined by groups of ponderosa pine. Along the ridge top around the valley are black oak and incense cedar.

Water quality in both Rush and Ash Creeks is good in the upper reaches. In the flat of Round Valley, irrigation and cattle tend to lower the water quality, and temperatures rise somewhat.

C. Climate

The climate of both project areas can be called severe. The winters are quite cold with a relatively small amount of precipitation. At Bieber the precipitation is about 16.77 inches, with about 75 percent of this occurring between the months of October and March. The majority of this precipitation occurs as snow. The temperature goes as low as 30 degrees below zero, and freezing temperatures may occur in any month of the year. Summers are generally warm and dry with occasional thunder showers. The growing season is approximately 120 days. Average summer maximum air temperatures are in the 80's and 90's but daily temperatures may exceed 100 degrees in any of the summer months. In general, low precipitation, wide range of temperature, and abundance of sunshine, and low humidity are characteristics of the two project areas.

CHAPTER II. EXISTING FISH AND GAME RESOURCES

Game Resources

The major resources of fish and game in this area is in the deer herds. Rocky Mountain mule deer live in the higher lands during the warmer seasons, and move into valleys and meadows at lower elevations during the winter. The migration pattern of the herds in this area is not so ingrained as that exhibited by herds which move longer distances, as the Devil's Garden herd for instance. Instead, the herds near Allen Camp and Round Valley are somewhat flexible in habit, and would probably shift their winter range use to areas not inundated nor blocked by water project development.

Deer hunting is evidently the major single outdoor recreational pursuit in this area, attracting about 58 percent of recreational visitor-days on Modoc National Forest.

Another big game resource is in the presence of a number of prong-horn antelope, which visit the Allen Camp Reservoir area in winter.

Waterfowl constitute a second major resource. About 100 pair of Canada geese nest in Big Valley, ordinarily bringing off about 300 young annually. About 250 pair of ducks, primarily mallards, pintails, and cinnamon teal, produce about 1,000 young annually. Another bird, not on the game list but of interest to naturalists and bird watchers, is the sandhill crane, of which there are about 12 pair. These birds maintain their flock by producing about 12 young annually. All these species nest in places which are generally near water or wet lands, but above flood level. It is of interest that about one-half of the Canada geese that appear in California are hatched within the state boundaries, and the Upper Pit River area is a small part of the nesting area.

Big Valley is important to waterfowl, especially geese, migrating to and from Tule Lake, Lower Klamath, and Goose Lake along the Pacific Flyway.

Fisheries Resources

The Pit River in the proposed reservoir area and service area is not of great significance as a fisheries resource. Water quality is low because of solids in the water and because of excessively high summer temperatures. Neither coldwater nor warmwater fishes thrive, and angling is not attractive.

There is a small fishery for such warmwater fishes as brown bullhead, largemouth black bass, and bluegill.

Rush and Ash Creeks support good trout populations, particularly in the reaches above the floor of Round Valley. Angling is not heavy, and angler success is relatively good.

CHAPTER III. EFFECTS OF PROJECT ON FISH AND GAME

A. Allen Camp Project

Effects on Fisheries Resources. The Allen Camp Reservoir, inundating a stream of questionable value to fish, would provide rather substantial increase in the water area available to fish production. The water in the reservoir would undoubtedly become more clear and certainly in deeper water, would provide greater area and volume of cool water for trout production than exists there at present. In the shallower parts of the reservoir warmwater fishes would find suitable habitat.

Downstream from the dam, the variations in flow would limit the amount of fish food available by continually flooding and drying out the stream bed.

At times of irrigation peaks, water will flow fast enough to erode the mud of the stream bed, either with or without channelization, and will be muddy during the ordinary summer recreation season. The erosion would further hinder fish food production in the stream.

On the other hand, there is at present only a very minor fishery in the stream, and conditions under project operation would not harm this resource. Rather, the increase in summer flow, and the maintenance of 15 cubic feet per second winter flow would improve conditions for fish. This improvement can be described as changing a "very poor" to a "poor" fishery.

Effects on Game. The Allen Camp Reservoir would inundate an insignificant area of winter range now utilized by deer from the Ash Mountain herd. In addition, a local migration pattern would be disrupted by the presence of the reservoir. A resident population of waterfowl would be displaced, but the benefit to be derived from resting area might partially compensate for this loss.

In the area downstream, habitat for fur bearers would be lost due to the radical fluctuation of the stream in seasonal irrigation release of water.

B. Round Valley

Round Valley Reservoir, inundating Ash Creek and Rush Creek, would change the nature of the fisheries from a stream trout fishery to a reservoir trout fishery with a subsidiary warmwater fishery supported in a fringe area of the reservoir. The gross available angling would be greater than at present.

The rather substantial resident population of waterfowl in Round Valley would be displaced and the value of resting area available for migratory waterfowl should compensate for this loss.

Round Valley is not important in migration of deer to winter range but is important as winter range itself. However, the loss of winter range here might be compensated for by increase in winter range due to increased irrigated agriculture below Round Valley and Big Valley.

LEGEND

BIG VALLEY

BIG VALLEY MUTUAL WATER COMPANY

BIG VALLEY IRRIGATION DISTRICT

ADIN-LOOKOUT SOIL CONSERVATION DISTRICT BOUNDARY

PIT SOIL CONSERVATION DISTRICT BOUNDARY

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
UPPER PIT RIVER INVESTIGATION

LOCATION OF BIG VALLEY AND EXISTING WATER AGENCIES

1959

SCALE OF MILES

4 0 4 8

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PLATE I

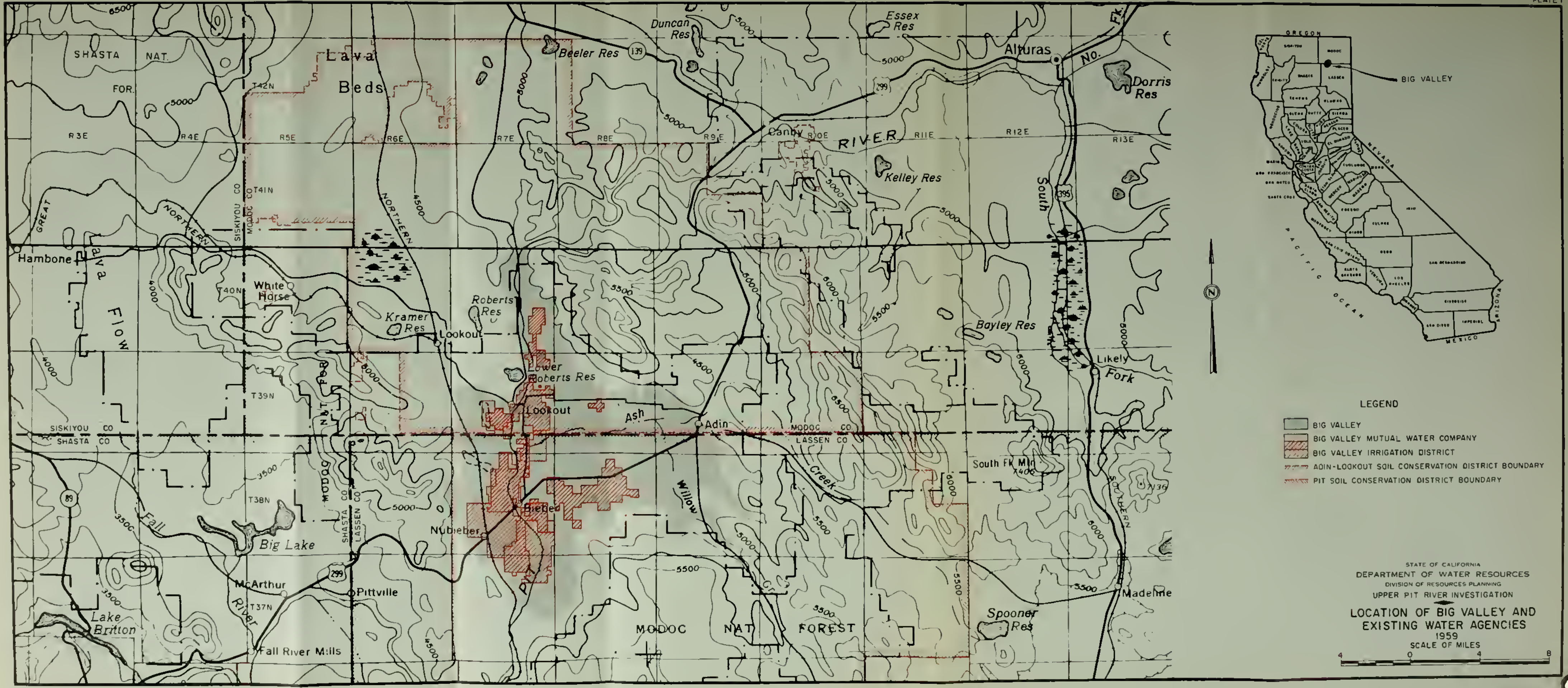
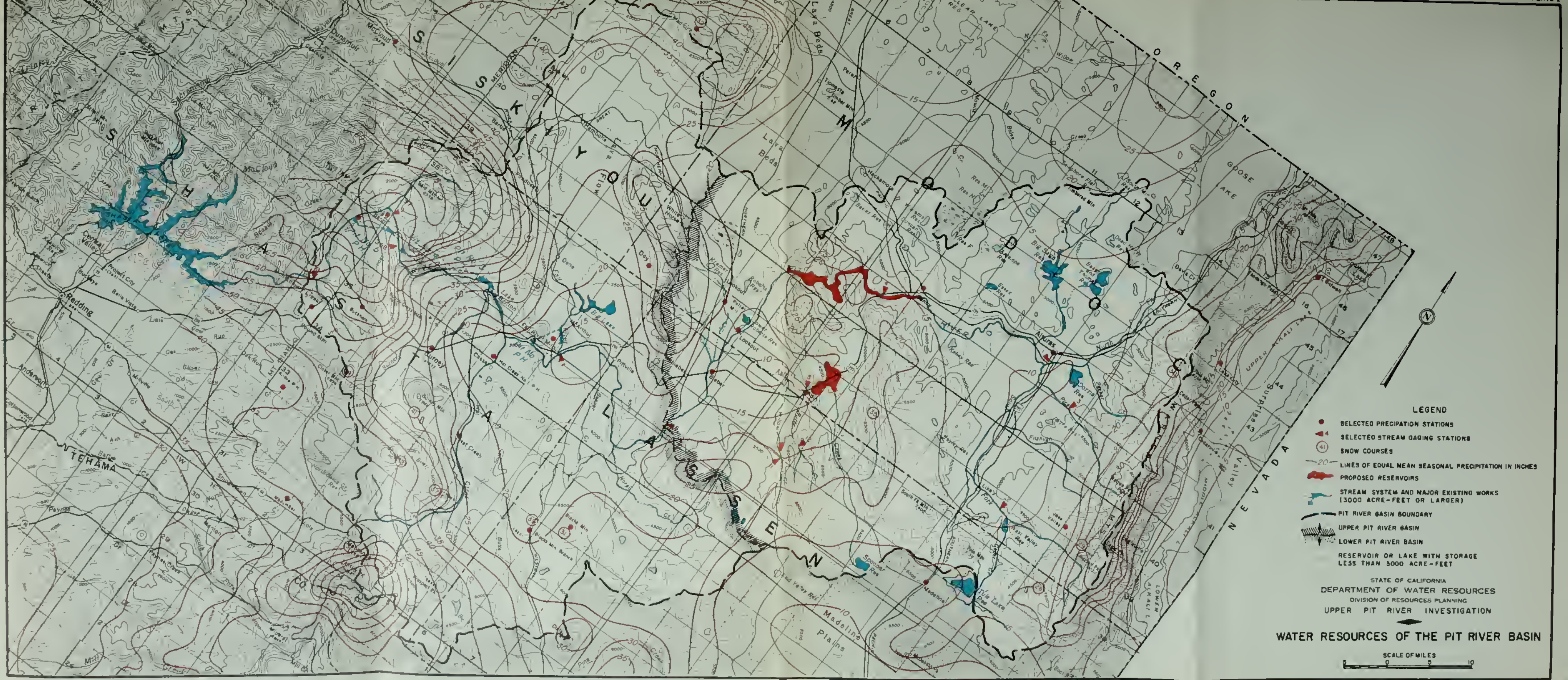
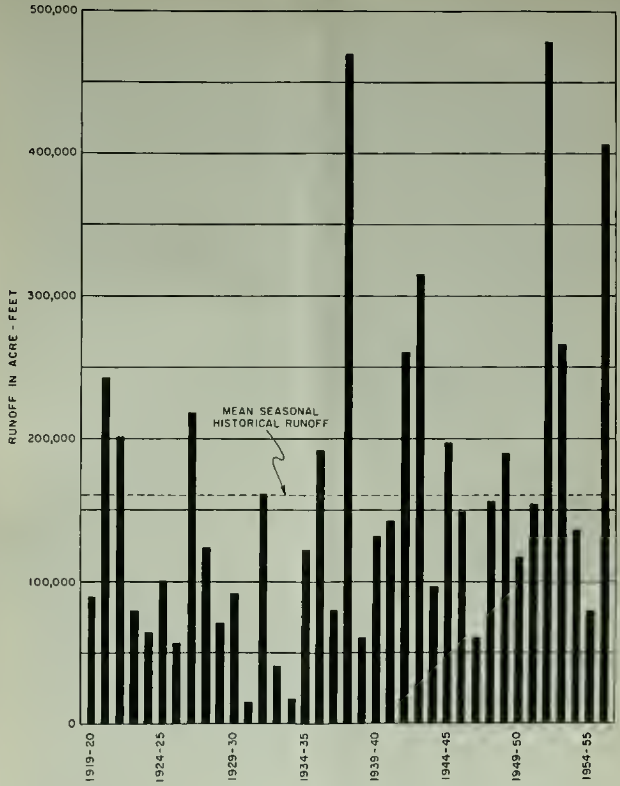

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
UPPER PIT RIVER INVESTIGATION
LOCATION OF BIG VALLEY AND EXISTING WATER AGENCIES
1959
SCALE OF MILES
4 0 4 8
LEGEND
BIG VALLEY
BIG VALLEY MUTUAL WATER COMPANY
BIG VALLEY IRRIGATION DISTRICT
ADIN-LOOKOUT SOIL CONSERVATION DISTRICT BOUNDARY
PIT SOIL CONSERVATION DISTRICT BOUNDARY
OREGON
NEVADA
ARIZONA
MEXICO
PACIFIC OCEAN
BIG VALLEY
SHASTA NAT. FOR.
Lava Beds
Duncan Res
Essex Res
Beeler Res
Alturas
Dorris Res
Canby
RIVER
Kelley Res
Hambone
Lava Flow
White Horse
Kramer Res
Lookout
Roberts Res
Lower Roberts Res
Bayley Res
Likely
Fork
South Fork
Ash
Adin
Willow
Creek
South Fk Mtn
SISKIYOU CO
SHASTA CO
MODOC CO
LASSEN CO
Bieber
Nubieber
Big Lake
Fall
McArthur
Pittville
River
Lake Britton
Fall River Mills
MODOC NAT FOREST
Spooner Res
Madeline
R3E
R4E
R5E
R6E
R7E
R8E
R9E
R10E
R11E
R12E
R13E
T42N
T41N
T40N
T39N
T38N
T37N

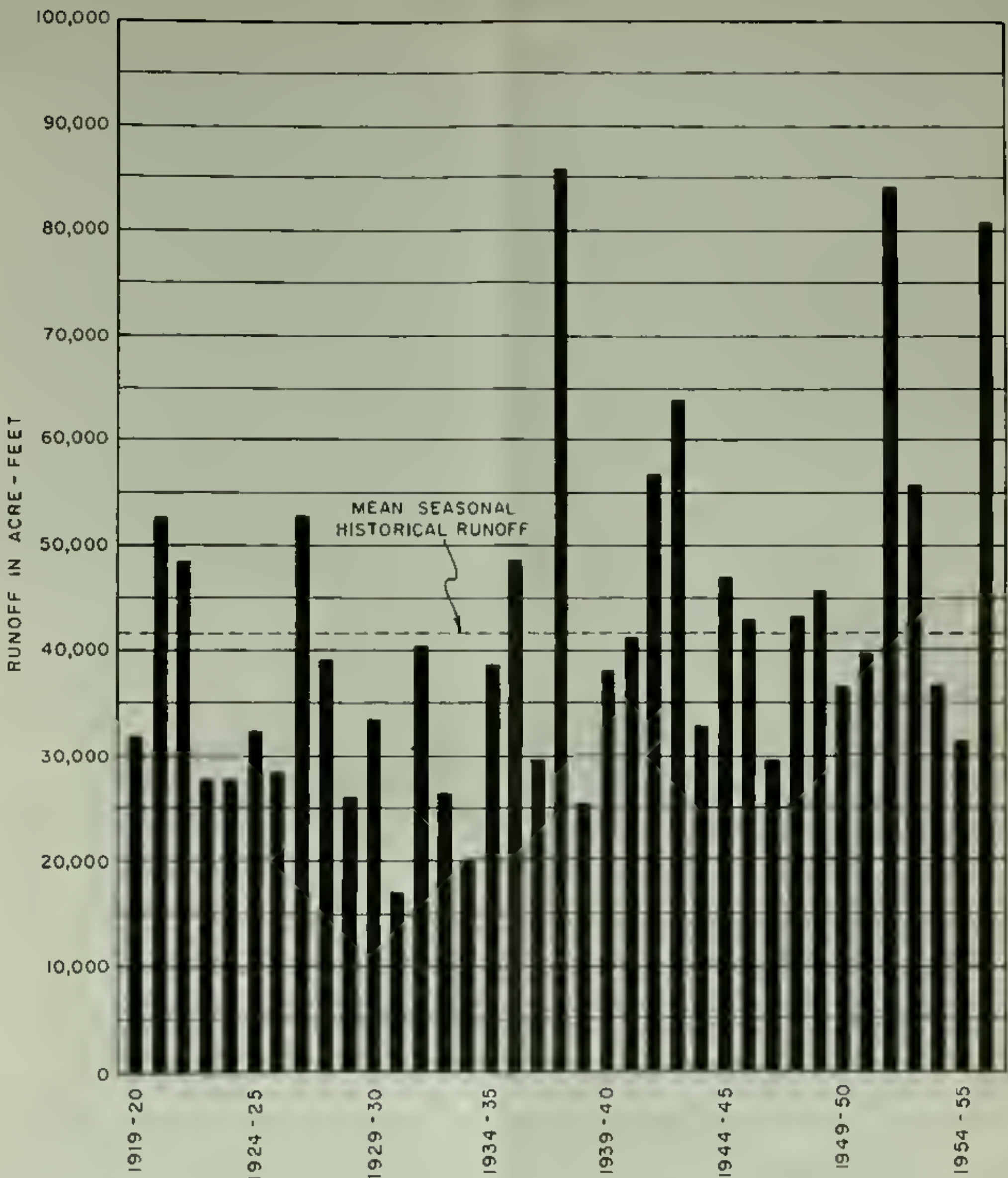
PLATE 2



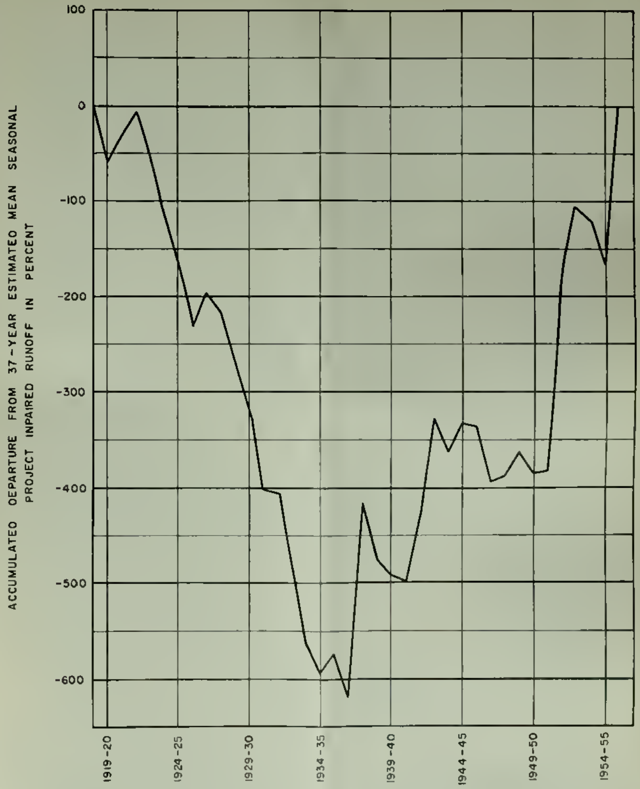
DEPARTMENT OF WATER RESOURCES 1960



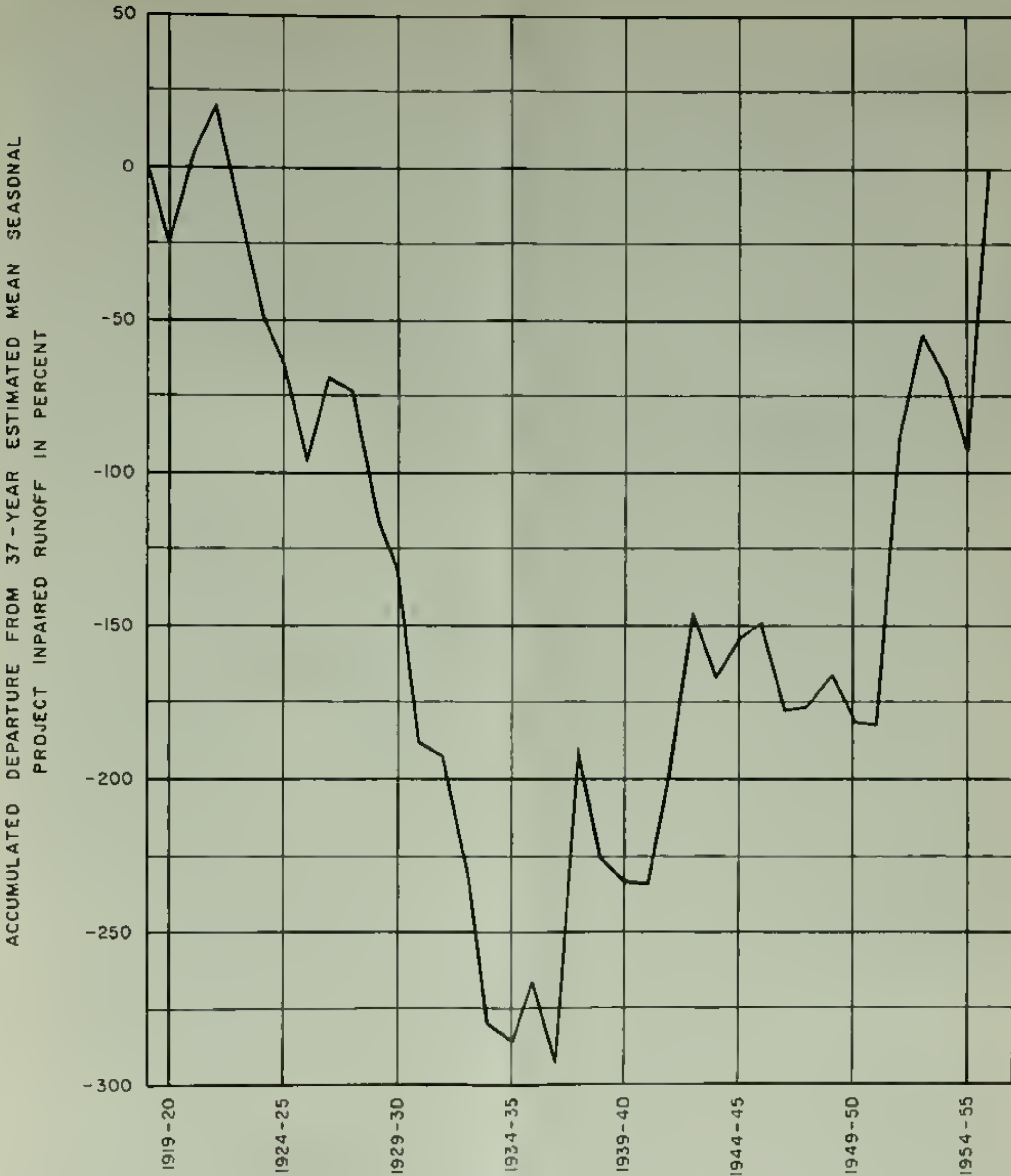
ESTIMATED SEASONAL HISTORICAL RUNOFF
OF
PIT RIVER AT ALLEN CAMP DAM SITE



ESTIMATED SEASONAL HISTORICAL RUNOFF
OF
ASH CREEK AT ADIN

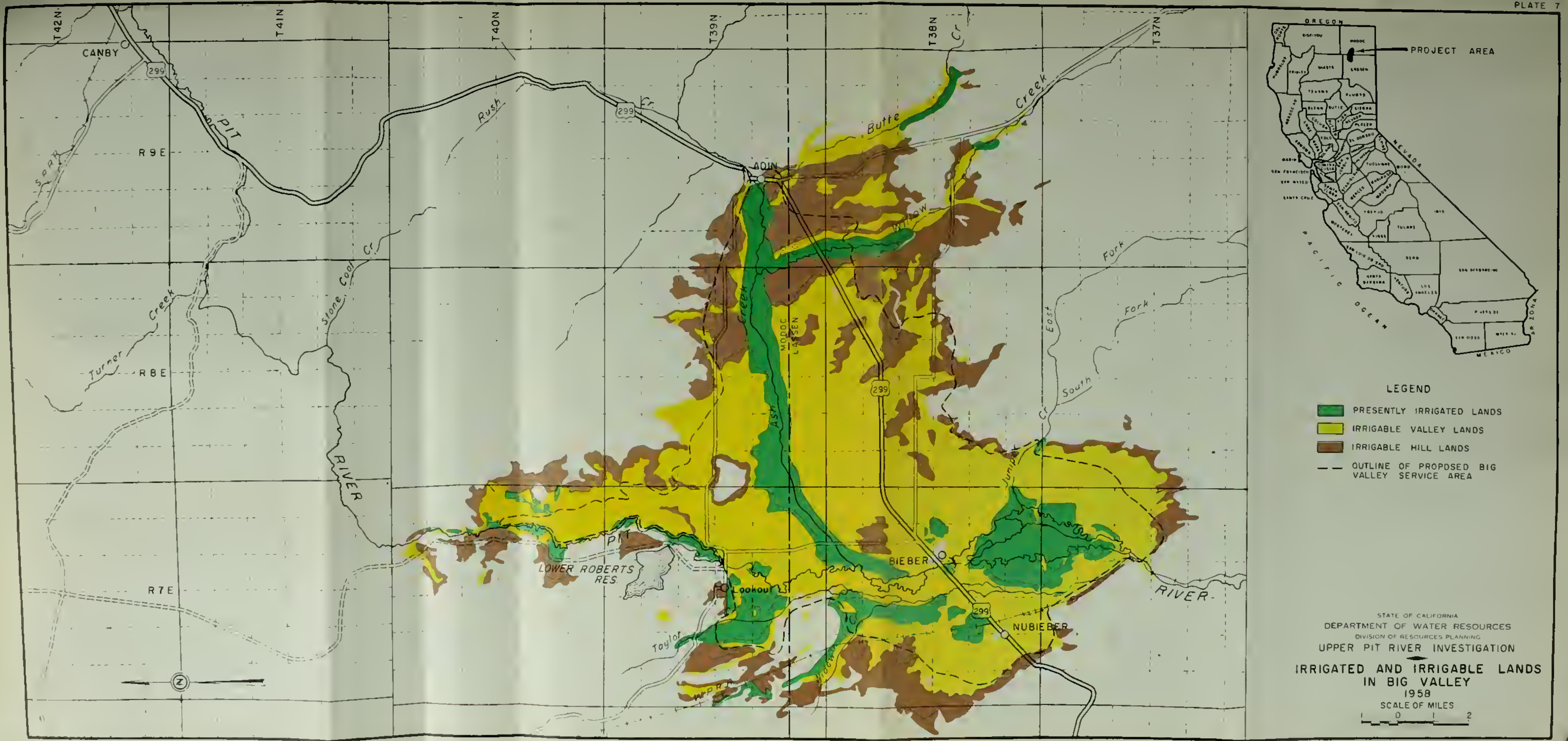


ACCUMULATED DEPARTURE FROM
ESTIMATED MEAN SEASONAL PROJECT IMPAIRED RUNOFF
OF
PIT RIVER AT ALLEN CAMP DAM SITE



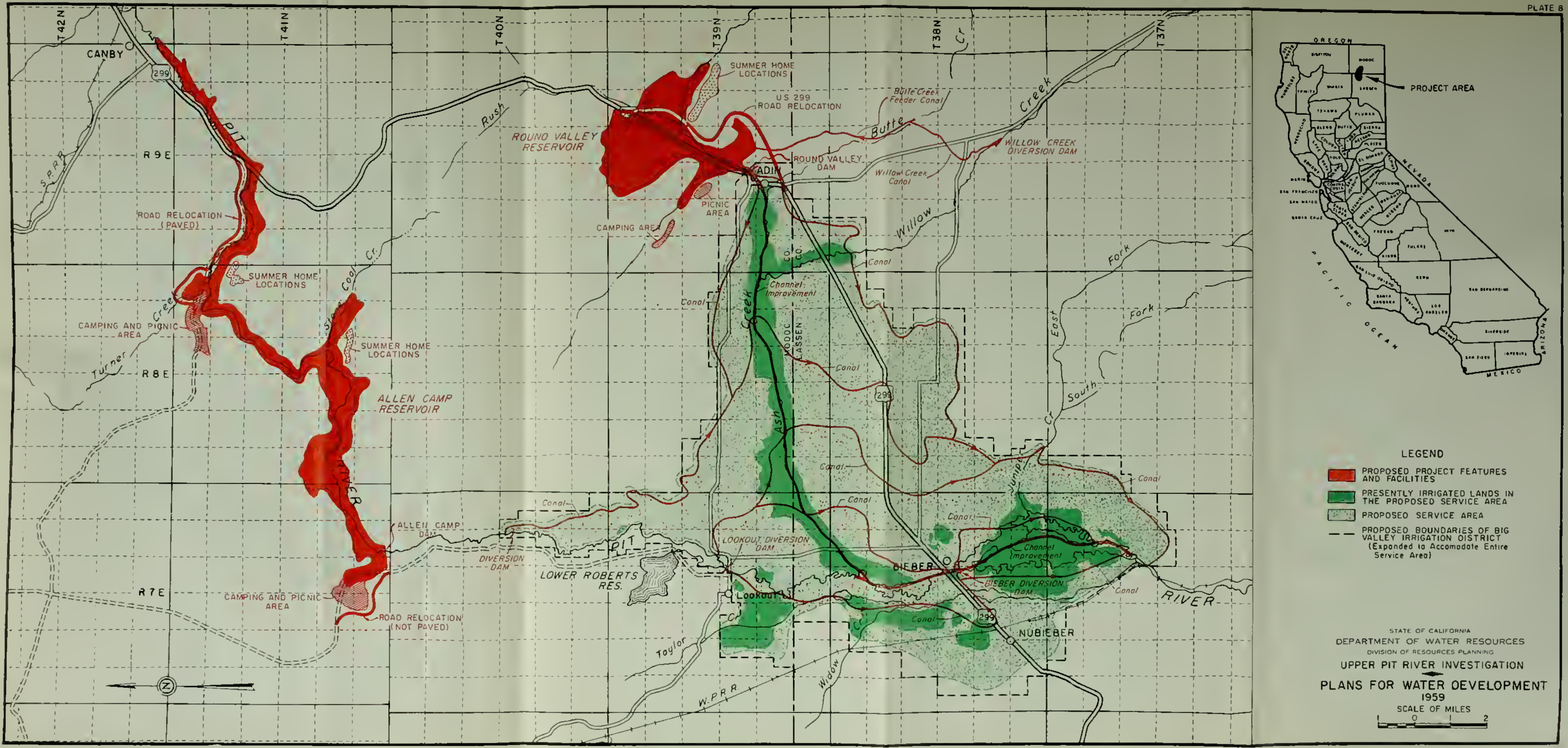
ACCUMULATED DEPARTURE FROM
ESTIMATED MEAN SEASONAL PROJECT IMPAIRED RUNOFF
OF
ASH CREEK AT ROUND VALLEY DAM SITE
INCLUDING FLOWS FROM WILLOW CREEK DIVERSION CANAL

PLATE 7

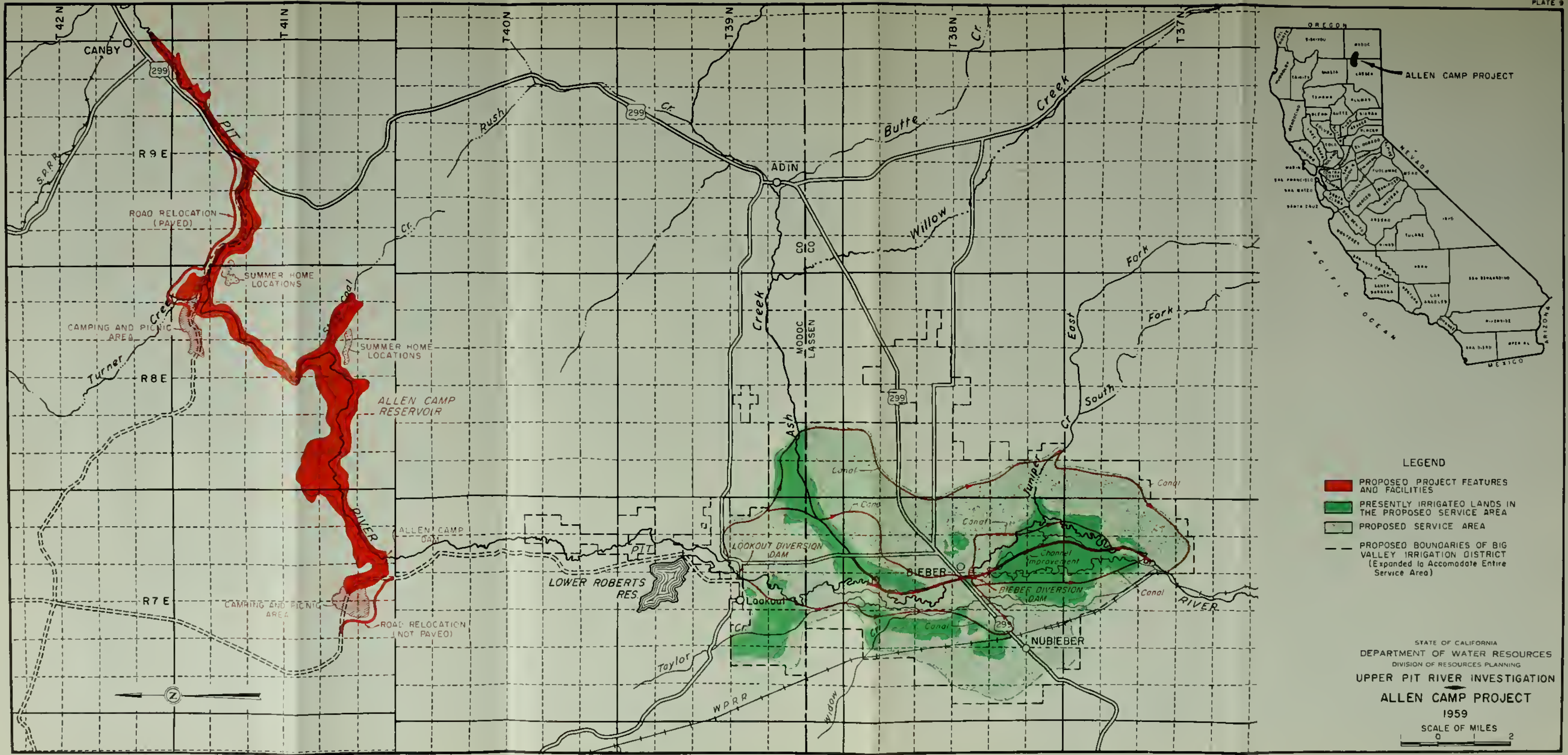


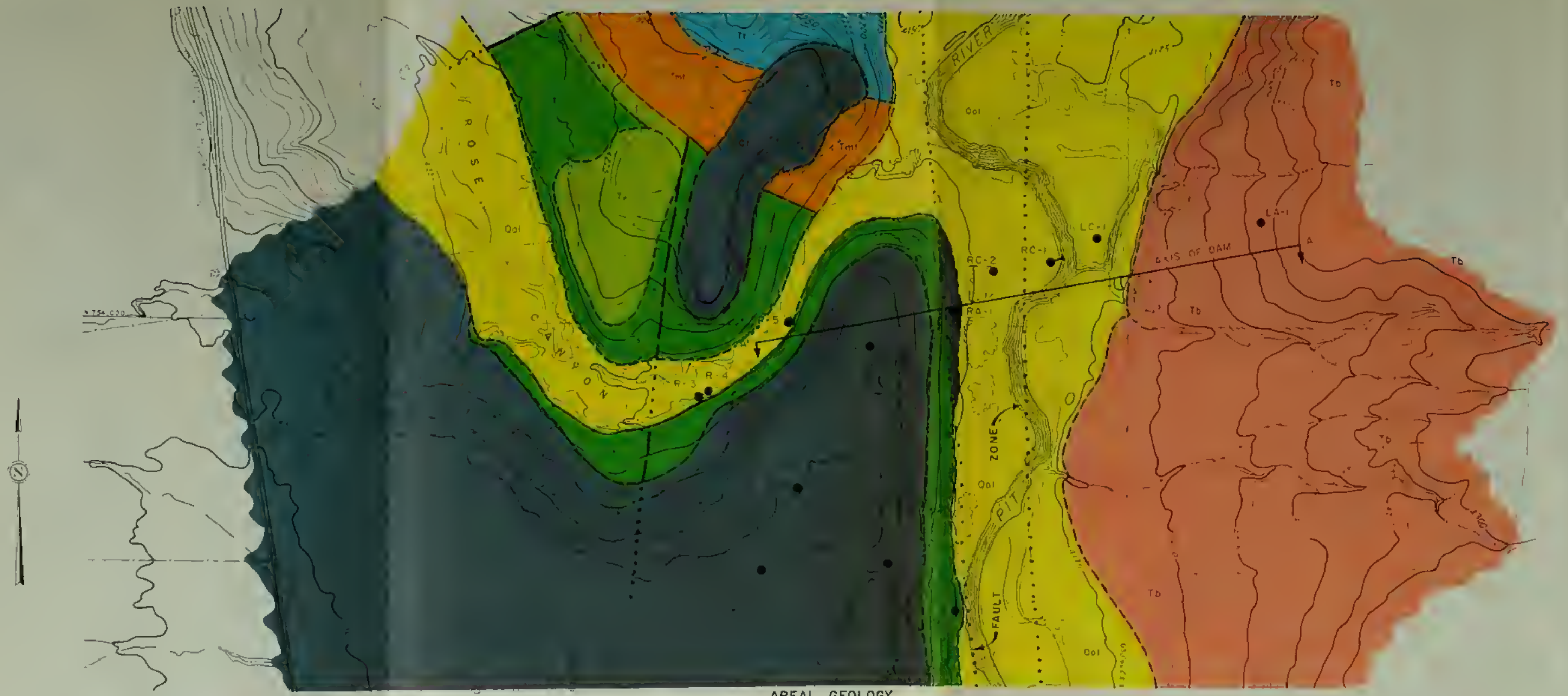
DEPARTMENT OF WATER RESOURCES 1959

PLATE 8



LEGEND
PROPOSED PROJECT FEATURES AND FACILITIES
PRESENTLY IRRIGATED LANDS IN THE PROPOSED SERVICE AREA
PROPOSED SERVICE AREA
PROPOSED BOUNDARIES OF BIG VALLEY IRRIGATION DISTRICT (Expanded to Accomodate Entire Service Area)
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
UPPER PIT RIVER INVESTIGATION
PLANS FOR WATER DEVELOPMENT
1959
SCALE OF MILES
0
2
OREGON
NEVADA
PACIFIC OCEAN
MEXICO
PROJECT AREA
T42N
T41N
T40N
T39N
T38N
T37N
R9E
R8E
R7E
CANBY
299
PIT
RIVER
ROAD RELOCATION (PAVED)
SUMMER HOME LOCATIONS
CAMPING AND PICNIC AREA
Turner
Creek
Coal Cr.
ALLEN CAMP RESERVOIR
ALLEN CAMP DAM
ROAD RELOCATION (NOT PAVED)
DIVERSION DAM
LOWER ROBERTS RES.
Rush
ROUND VALLEY RESERVOIR
SUMMER HOME LOCATIONS
US 299 ROAD RELOCATION
Butte Creek Feeder Canal
Butte
Creek
ROUND VALLEY DAM
ADIN
PICNIC AREA
CAMPING AREA
Willow Creek Canal
WILLOW CREEK DIVERSION DAM
Willow
Canal
Channel Improvement
MODOC CO.
LASSEN CO.
Ash
Creek
Fork
East
South
Juniper
LOOKOUT DIVERSION DAM
BIEBER
BIEBER DIVERSION DAM
Lookout
NUBIEBER
Taylor
Widow
W.P.R.R.
S.P.R.R.

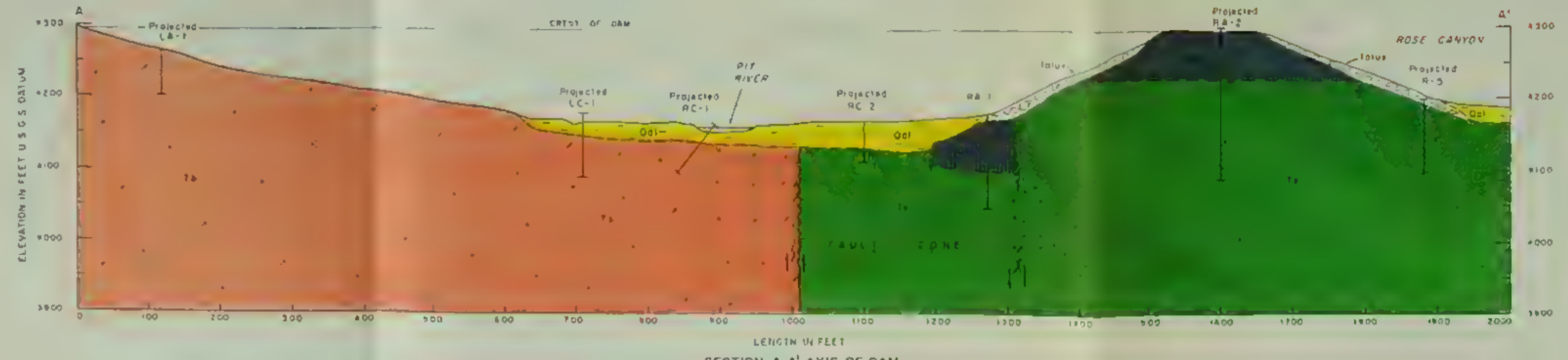

CANBY
ADIN
BIEBER
NUBIEBER
Lookout
PIT RIVER
ROAD RELOCATION (PAVED)
SUMMER HOME LOCATIONS
CAMPING AND PICNIC AREA
ALLEN CAMP RESERVOIR
ALLEN CAMP DAM
LOWER ROBERTS RES.
LOOKOUT DIVERSION DAM
BIEBER DIVERSION DAM
Channel improvement
ROAD RELOCATION (NOT PAVED)
Canal
MODOC
LASSEN
T 42 N
T 41 N
T 40 N
T 39 N
T 38 N
T 37 N
R 9 E
R 8 E
R 7 E
WPRR
S.P.R.R.
ALLEN CAMP PROJECT
OREGON
NEVADA
PACIFIC OCEAN
MEXICO
ARIZONA
LEGEND
PROPOSED PROJECT FEATURES AND FACILITIES
PRESENTLY IRRIGATED LANDS IN THE PROPOSED SERVICE AREA
PROPOSED SERVICE AREA
PROPOSED BOUNDARIES OF BIG VALLEY IRRIGATION DISTRICT (Expanded to Accomodate Entire Service Area)
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
UPPER PIT RIVER INVESTIGATION
ALLEN CAMP PROJECT
1959
SCALE OF MILES
0 1 2



AREAL GEOLOGY

SCALE OF FEET

0 200 400 600 800



SECTION A-A' AXIS OF DAM

LEGEND

Qal — ALLUVIUM
Unconsolidated clay, silt, sand, and gravel. Channel, floodplain and terrace deposits.

BASALT
Fairly recent flat lying basalt flows which cap the right abutment. Gray to greenish gray, vesicular, slightly to intensely fractured and weathered. Blocky jointing. Occasional glassy zones. Locally pervious.

Tv — BASALT AND RELATED SEDIMENTS
Tilted basalt flows with interbedded volcanic sediments. Basalt is gray, fine grained, and appears similar to the Tb basalt. Interbedded sediments are predominantly volcanic sandstone.

Ts — VOLCANIC SEDIMENTS
Tilted interbedded conglomerate, sandstone, mudstone, and shale. Moderately to well indurated.

Tss — Thick sandstone bed at base

Tmf — MUDFLOW
Unsorted volcanic boulders in a clayey silty sand matrix. Slightly consolidated.

Tt — TUFF
Weakly cemented volcanic ash

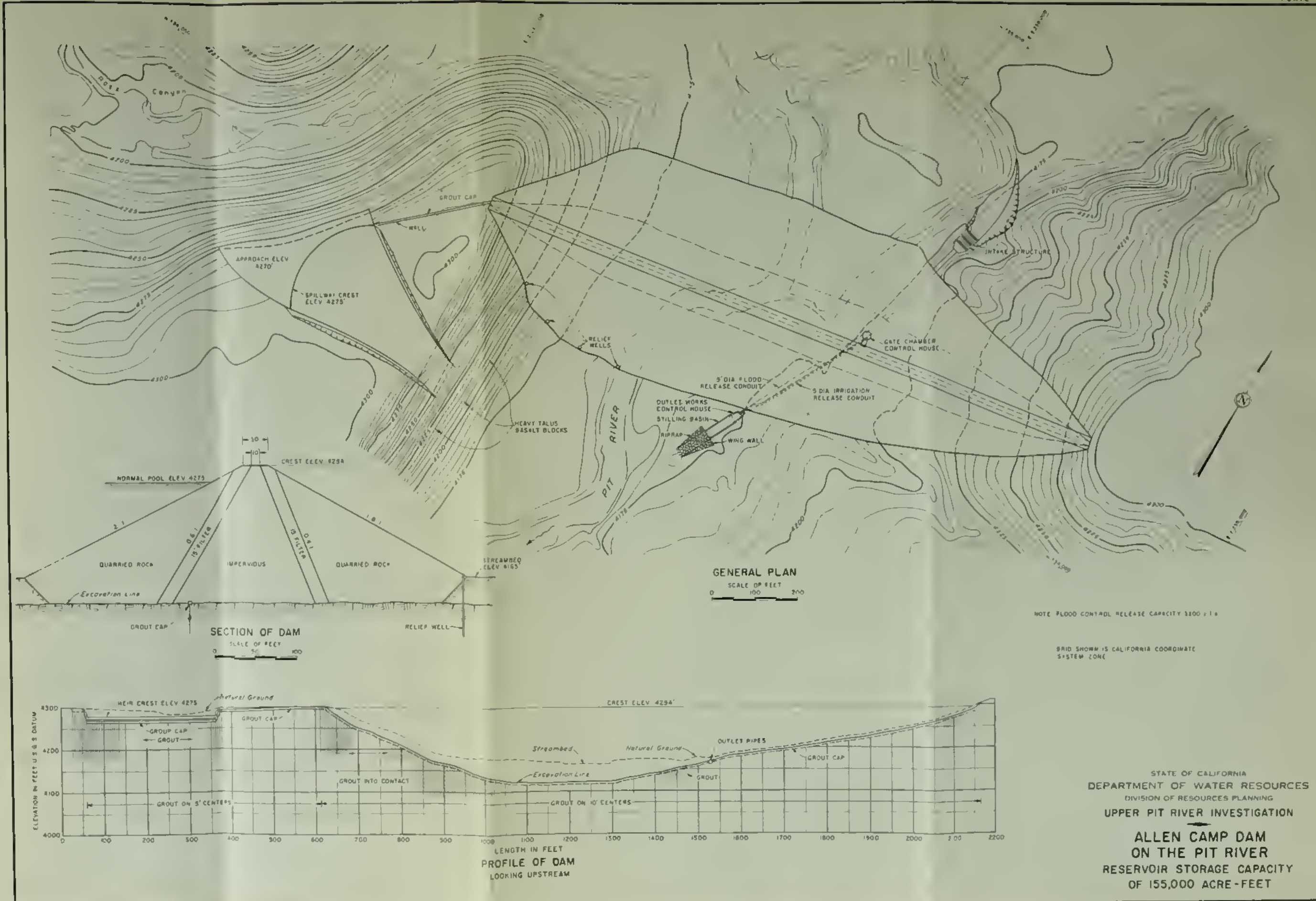
Tb — BASALT
Tilted basalt flows. Gray to black, very fine grained, non vesicular, intensely jointed and fractured. Characterized by tight flow cleavage joints healed by secondary silicate minerals. Impervious.

SYMBOLS

CONTACT
FAULT
LC-1 ● DRILL HOLE
GEOLOGIC SECTION
SHEAR ZONE
STRIKE AND DIP OF BEDS

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
UPPER PIT RIVER INVESTIGATION

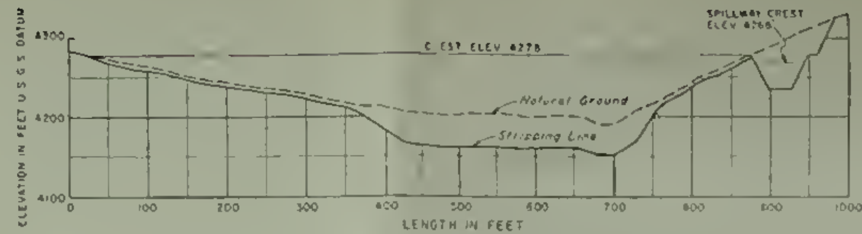
GEOLOGY OF THE
ALLEN CAMP DAM SITE


Rose Canyon
GROUT CAP
WELL
APPROACH ELEV 4270'
SPILLWAY CREST ELEV 4275'
RELIEF WELLS
HEAVY TALUS BASALT BLOCKS
PIT RIVER
INTAKE STRUCTURE
GATE CHAMBER CONTROL HOUSE
5' DIA FLOOD RELEASE CONDUIT
5' DIA IRRIGATION RELEASE CONDUIT
OUTLET WORKS CONTROL HOUSE
STILLING BASIN
RIPRAP
WING WALL
GENERAL PLAN
SCALE OF FEET
NOTE FLOOD CONTROL RELEASE CAPACITY 3200 c.f.s.
GRID SHOWN IS CALIFORNIA COORDINATE SYSTEM ZONE
CREST ELEV 4294
NORMAL POOL ELEV 4275
QUARRIED ROCK
IMPERVIOUS
15' FILTER
STREAMBED ELEV 4165
Excavation Line
GROUT CAP
RELIEF WELL
SECTION OF DAM
SCALE OF FEET
WEIR CREST ELEV 4275
Natural Ground
CREST ELEV 4294'
GROUT CAP
GROUT
Streambed
OUTLET PIPES
GROUT INTO CONTACT
Excavation Line
GROUT ON 5' CENTERS
GROUT ON 10' CENTERS
ELEVATION IN FEET U.S.G.S. DATUM
LENGTH IN FEET
PROFILE OF DAM
LOOKING UPSTREAM
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
UPPER PIT RIVER INVESTIGATION
ALLEN CAMP DAM
ON THE PIT RIVER
RESERVOIR STORAGE CAPACITY
OF 155,000 ACRE-FEET

GENERAL PLAN

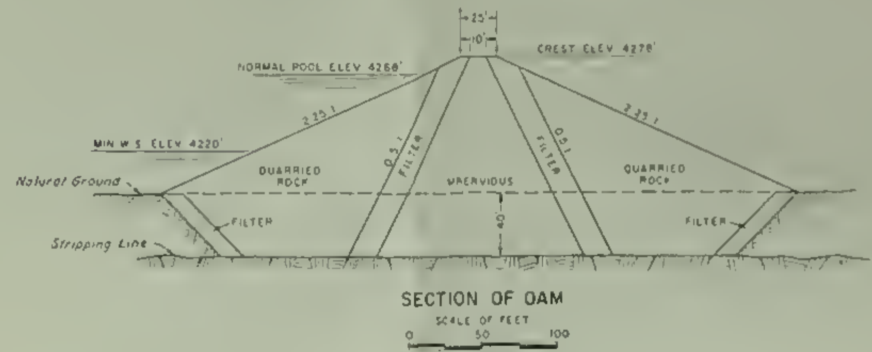
SCALE OF FEET

0 100 200



PROFILE OF DAM

LOOKING UPSTREAM



SECTION OF DAM

SCALE OF FEET

0 50 100

NOTE GRID SHOWN IS CALIFORNIA COORDINATE SYSTEM ZONE I

STATE OF CALIFORNIA

DEPARTMENT OF WATER RESOURCES

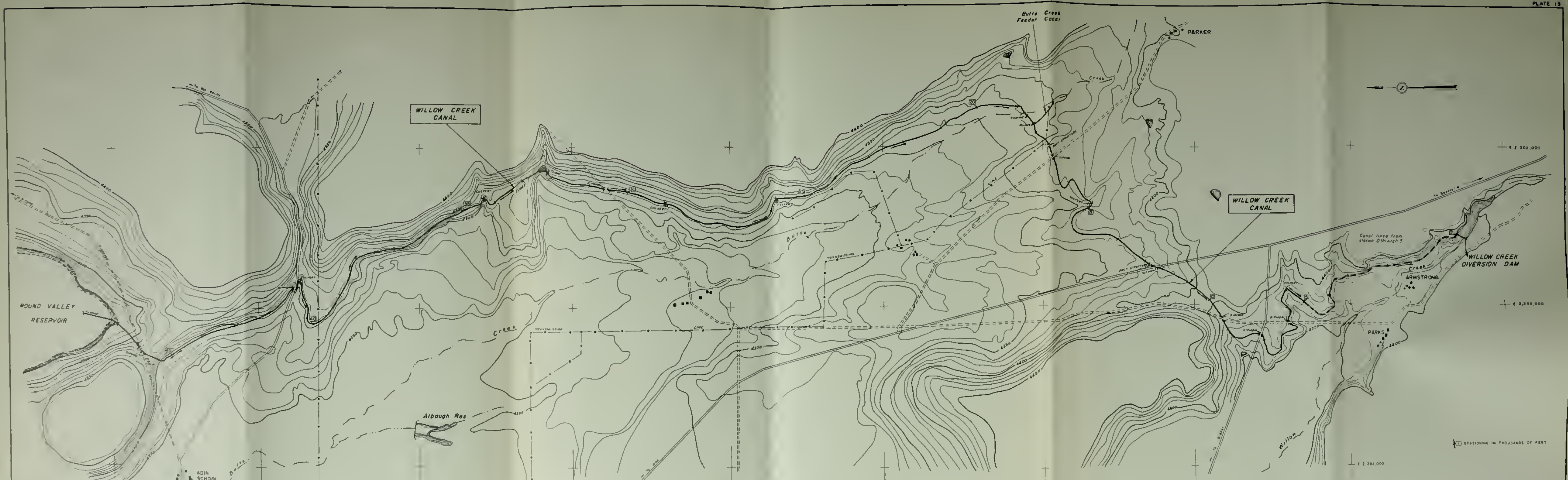
DIVISION OF RESOURCES PLANNING

UPPER PIT RIVER INVESTIGATION

ROUND VALLEY DAM
ON ASH CREEK

RESERVOIR STORAGE CAPACITY
OF 72,000 ACRE-FEET

DEPARTMENT OF WATER RESOURCES 1959



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
UPPER PIT RIVER INVESTIGATION

WILLOW CREEK CANAL
MARCH, 1959
SCALE OF FEET

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