NORTHERN CALIFORNIA STREAMS INVESTIGATION

RUSSIAN RIVER BASIN STUDY

FINAL REPORT

MARCH 1982

U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
211 MAIN STREET
SAN FRANCISCO, CALIFORNIA

SPDPD-P (Mar 82) 1st Ind
SUBJECT: Final Report for Russian River Basin Study, Northern California Streams Investigation

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SYNOPSIS

The Russian River Basin Study was initiated by the U.S. Army Corps of Engineers in September of 1973. The study was initiated in response to a resolution adopted by the U.S. House of Representatives Committee on Public Works in October 1972. This resolution directed the Corps of Engineers to review reports on previous Corps studies dealing with the Russian River, and to determine whether the results of these studies were still valid or if they should be re-assessed in light of new information, problems or conditions in the Russian River basin. In particular, the House resolution directed the Corps to address several problems and issues related to preserving and enhancing the water and other environmental resources of the river.

Previous Corps studies concerning the Russian River basin date back to the late 1930's. These studies mainly addressed the basin's need for protection from devastating floods and the provision of adequate water supplies, and resulted in several large-scale water resource development projects. These projects, developed jointly by the Corps and local governments, include Coyote and Warm Springs dams and channel improvement and bank protection measures along the Russian River. The House Resolution authorizing the Russian River Basin Study, however, mandated study of several water quality and environmental issues of local concern for which structural solutions are not always applicable. These included:

- preservation of free passage at the mouth of the Russian River;
- the small summer recreational dams established annually on the river;
- the operation of existing structures on the river;
- preservation and enhancement of the basin's fisheries;
- sediment influx and movement in the river system;
- gravel mining in the river flood plain;
- land use related to flood plain management;
- water quality releases from Coyote and Warm Springs dams; and
- the effects of channel improvement and bank stabilization measures constructed in the basin.

The Corps San Francisco District has addressed these issues through public involvement activities, coordination with other government agencies, and basic research and data collection. The results of these efforts are presented and discussed in this report.

Based on research concerning the effects of summer dams on the Russian River fisheries, several alternative methods for managing the dams were developed during the course of the Russian River Basin Study. Since the Federal government is not presently authorized to participate in the management of such dams other than through its existing permit program, these alternatives are presented for local interests and governments to consider in any dam management plans they may undertake.

Alternative schemes for managing Coyote and Warm Springs dams were evaluated as part of the Basin Study. The goal of this effort was to examine the opportunities for improving fish habitat and migration success in the basin through modified flow release schedules, without sacrificing the operation of these facilities for their authorized purposes. Since the operation of these facilities for fisheries enhancement is established through negotiation between the projects' local sponsors and the State of California, the alternative management schemes presented by the Corps are intended for consideration during such negotiations. The Corps is only responsible for operation of the flood control and recreation features of these projects, and thus is not authorized to implement alternative release schemes for fisheries enhancement.

Detailed land use data for critical Russian River flood plain areas were developed as part of the Basin Study. These data were collected through extensive aerial photography and surveys. Computer-assisted photographic interpretation techniques were used to develop detailed land use and flood plain maps of areas adjacent to the Russian River. These data were provided to local interests during the course of the study.

Questions regarding sediment movement, erosion, gravel mining, channel stabilization and providing free passage at the mouth of the river were examined during the Basin Study. The San Francisco District also provided local interests with assistance in developing their own plans for regulating gravel mining in the basin. The San Francisco District Engineer recognizes the need for additional detailed study of sediment movement, erosion and associated problems, and channel improvement and stabilization in the basin. Congress in 1980 provided funds under the Russian River Basin Study authorization for the District to conduct a special study of sediment movement in the Dry Creek basin. This study was initiated in late 1980.

Further in-depth study of erosion and bank stabilization along the Russian River is supported by several Federal, State and local agencies, and a number of individuals. However, any such effort would require specific authorization and funding from the U. S. Congress. Therefore, no further Corps study of these issues is presently warranted under the current Russian River Basin Study authorization.

In conclusion, the District Engineer believes the problems and issues voiced by the public regarding the water and related resources of the Russian River, and those outlined in the House Resolution authorizing the Russian River Basin Study, have for the most part been adequately addressed during the course of the study. Some issues on Dry Creek requiring further investigation are being addressed in a special Corps study initiated in late 1980. Additional study of several issues on the Russian River will require specific authorization from Congress. Therefore, the District Engineer recommends that no further water resource development studies or projects be conducted by the Corps under the current Russian River Basin Study authorization.

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I. INTRODUCTION

The Russian River basin, located in northern California, is a unique and valuable natural and economic resource. It affords a livelihood to many who reside within the basin and provides an area for relaxation to those who visit it each year. Its waters provide much of the agricultural and municipal water supply for both the basin and the surrounding area. Apart from this, human misery and property damage often result from winter rains and resulting high flows in the river and its tributaries. To preserve, protect, maintain and enhance the basin's environment and the residents' standard of living, controlled and proper use of its natural resources is required. This can only be achieved through acquisition of data on these resources and development of proper management programs. The Russian River Basin Study has helped to accomplish some of these tasks.

A. AUTHORIZATION

This report is in response to the following resolution of the Committee on Public Works of the U.S. House of Representatives adopted 12 October 1972:

> "Resolved by the Committee on Public Works of the House of Representatives, United States, that the Board of Engineers for Rivers and Harbors be, and is hereby, requested to review the reports on the Russian River, California, published in House Document No. 547, 87th Congress, and previous reports, with a view to determining whether any modifications are necessary for water quality and protection and enhancement of the environment, including, but not limited to, preserving free passage at the mouth of the river, summer and recreational-type dams, operation of existing structures on the river, preservation and enhancement of the fishery, sediment influx and transport, gravel mining in the flood plain, land use related to flood plain management, water quality releases from Coyote and Warm Springs Dams, and effects of channel improvement and stabilization."

This report is also partially in response to Section 209 of Public Law 87-874, the Flood Control Act of 1962, which reads:

> "The Secretary of the Army is hereby authorized and directed to cause surveys for flood control and allied purposes, including channel and major drainage improvements, and floods aggravated by or due to wind or tidal effects, to be made under the direction of the Chief of Engineers, in drainage areas of the United States and its territorial possessions, which include the following named localities: ...Sacramento River Basin and streams in northern California draining into the Pacific Ocean for the purposes of developing, where feasible, multiple-purpose water resource projects, particularly those which would be eligible under the provisions of title III of Public Law 85-500."

B. SCOPE OF THE STUDY

The study of the Russian River basin is a Level C implementation study which encompasses the entire 1,485 square mile Russian River basin, including all tributary watersheds. Level C studies, including most Corps of Engineers studies, are generally intended to recommend authorization or initiation of plans to solve local resource problems.

C. STUDY PARTICIPANTS

The Russian River Basin Study has involved many individuals and agencies. During the initial formulation stages, an interagency task force involving representatives from the U.S. Department of the Interior, the State of California Resources Agency and the Corps of Engineers was instrumental in establishing, reviewing and commenting on study procedures and the Plan of Study (POS).

Sonoma and Mendocino Counties have been providing local sponsorship for the Russian River Basin Study. The Mendocino County Planning Department and Sonoma County Water Agency have been serving as local agency coordinators.

D. CORPS OF ENGINEERS STUDIES AND PROJECTS

The Corps of Engineers has been actively involved in the management of the water and related land resources of the Russian River basin since the late 1930's. The Flood Control Act of 1937 authorized the Corps to study the Russian River basin for the need for Federal involvement in managing the basin's water resources for flood control and other related purposes. The Corps San Francisco District conducted a preliminary examination and two surveys, which resulted in a report to Congress in 1950 (House Document 585, 81st Congress, 9 May 1950). This report recommended the Federal government adopt a comprehensive plan for water resources development in the Russian River basin. This plan included construction of: (1) a multiple-purpose reservoir on the East Fork of the Russian River at Coyote Valley, (2) channel stabilization works along the Russian River and the lower reaches of its principal tributaries, and (3) a multiple-purpose reservoir on Dry Creek. The report also recommended that the first stage of the plan, the Coyote Valley project and the channel stabilization measures, be authorized for construction.

These works were authorized by the Flood Control Act of 1950. Coyote Dam was completed in 1959. The dam and its resulting reservoir, Lake Mendocino, provide flood control, water supply, and streamflow augmentation, and include extensive recreational facilities. The channel stabilization measures were constructed from 1956 to 1972, and included channel clearing and excavation and the installation of extensive bank protection works.

A resolution adopted by the House of Representatives Committee on Public Works in July 1958 authorized the Corps to re-examine its previous surveys of the Russian River basin, particularly with regard to providing flood control measures on some of the tributaries to the river. This resolution was inspired by hydrologic, economic and other changes that had taken place in the basin since the Corps report of 1950. The Corps San Francisco District completed an interim report under this authorization in October of 1961. This report became House Document 547, 87th Congress, 12 September 1962, and recommended construction of a multi-purpose reservoir on Dry Creek to provide flood control, water supply and recreational benefits, as well as mitigation for any fish and wildlife losses incurred through development of the project. The interim report also recommended provision of channel improvements along Dry Creek below the dam site. Construction of the Dry Creek project (later renamed Warm Springs Dam and Lake Sonoma) was authorized by the Flood Control Act of 1962, and actually began in 1967. The project is scheduled to be completed in 1984. Construction of the Dry Creek channel improvements began in 1981 and is scheduled for completion by 1984.

Following completion of the interim report, a final report was prepared by the Corps San Francisco District under the authority of the July 1958 House Resolution. This report was completed in early 1964 and later became House Document 518, 89th Congress, 10 October 1966. It recommended development of a multiple-purpose reservoir in Knights Valley with the damming of Franz and Maacama Creeks, to provide flood control, water supply and recreational benefits. In addition, the report recommended adoption of a plan for future water resources development in the Russian River basin, including the provision of diversion works on the Russian River mainstem. The Knights Valley project was authorized by Congress for construction with the passage of the 1966 Flood Control Act. However, due to a decline in local support for the project, it was recommended for deauthorization in 1976. The project was formally deauth-orized in 1977 under the provisions of Section 12 of the 1974 Water Resources Development Act.

The July 1958 House Resolution served as authority for one additional review report, completed in 1973, investigating the need and opportunities for flood control and related projects in the Russian River basin. This report, also prepared by the Corps San Francisco District, was initiated mainly because of renewed local interest in some of the proposals contained in the previous final report (House Document 518, 1966). These proposals were reviewed in light of the changes in costs, interest rates and economic conditions that had taken place in the basin between the mid-1960's and 1972. The results of this review were that no single-purpose flood control or dual-purpose flood control/recreation projects were shown to be economically feasible, and that there was little local interest in any other multi-purpose projects. Thus the report recommended that no further Corps water resource development projects for flood control and other allied purposes be undertaken, and that no further studies be conducted under the authority of the 1958 House Resolution.

The 1973 review report documented the last major Corps study of the Russian River basin for flood control and related purposes, prior to the present

Russian River Basin Study. The Corps San Francisco District did conduct two small flood control studies in the basin; one on Mill and McClure Creeks in Mendocino County (August 1974), and the other on Robinson Creek in Mendocino County (November 1974). Neither of these studies recommended further Federal involvement in flood control at these sites. The San Francisco District also conducted two flood insurance studies in the Russian River basin; one for the Guerneville area in Sonoma County (1970), and the other for the rest of the Sonoma County portion of the Russian River (1971). These studies were up-dated in 1978. These studies provided floodplain depths and flood frequency information for use by the Federal Insurance Administration in setting rates for these areas for the Federally-subsidized Flood Insurance Program. The Corps San Francisco District has also cooperated with other Federal agencies, and State and local interests, in joint studies concerning the Russian River basin. The District was involved with the U.S. Geological Survey in a 1971 cooperative study of turbidity sources and suspended-sediment transport in the basin. In 1974 the San Francisco District also participated in a joint Federal-State-local streamflow augmentation study of the Eel and Russian Rivers, examining the effects of modifying the diversions of Eel River water to the Russian River basin via the Potter Valley powerhouse.

The Corps has also been involved in navigation studies of the Russian River. The River and Harbor Act of 1946 authorized the Corps to survey the northern California coast for suitable sites for recreational harbors and harbors of refuge for light-draft vessels. The Corps San Francisco District initiated the study in 1949, but due to the Korean War and funding difficulties, it was not completed until 1969. The Corps report on this study suggested several plans for providing an entrance channel and a small craft harbor at the mouth of the Russian River near the community of Jenner. Most of the benefits of the proposed projects would have accrued to commercial mining interests engaged in dredging sand and gravel from the Russian River estuary. However, stringent water quality requirements imposed by the State on such mining operations and local efforts to preserve the environment of the lower Russian River effectively prohibited any mining operations in the Russian River estu-ary. This eliminated the major benefits of the Corps proposals, which led the Corps to terminate its study.

Thus much of the Russian River basin has been studied by the Corps of Engi-neers regarding the need and opportunities for major water resource develop-ment projects, prior to initiation of the Russian River Basin Study. The Basin Study was the first Corps attempt to provide meaningful alternatives for managing the basin's water resource problems using a 'software' approach; that is, by directing studies towards administrative management measures rather than structural solutions. For this reason Executive directives such as those mandating consideration of floodplain management in the Federal water resource planning process are applicable to this study. However, other directives, including consideration of water and energy conservation measures and non-structural alternatives, were not directly applicable to the Basin Study. These directives deal with problems and project alternatives addressed in previous Corps studies of the basin.

Three separate documents concerning the Russian River Basin Study have been released by the Corps San Francisco District prior to this Final Report. The Plan of Study was released in April 1975, identifying initial basin problems and needs and possible approaches to their solution. It also outlined the objectives of the study, discussed methodologies and put forth a strategy for public involvement. The second document prepared as part of the Basin Study was the Phase I Study Report, completed in December 1976. This report further defined the problems and needs of the basin, presented criteria for evaluating potential solutions, and recommended which problem areas should be addressed in more detailed studies. As part of its detailed investigations for the final study report, in 1977 and 1978 the San Francisco District conducted surveys and evaluations of fish habitats and structures affecting fish migration along the Russian River. The results of these efforts were documented in a report titled "Evaluation of Fish Habitat and Barriers to Fish Migration, Russian River Mainstem and Lower Dry Creek", released by the District in October of 1978. This was the last report released by the Corps under the Russian River Basin Study prior to this final study report.

E. STUDIES OF OTHERS

A number of other pertinent reports and projects served as the basis for much of the information in this report. The following is a summary of relevant studies.

Brown, W. M. III and L.E. Jackson, Jr. <u>Sediment Source and Deposition Sites and Erosional and Depositional Provinces, Marin and Sonoma Counties, California.</u> U.S. Geological Survey Miscellaneous Field Studies Map MF-625. 1974. Two sheets and pamphlet, 32 pp. Describes what sediment is, how sediment transport is measured, and how sediment-transport data and denudation rates are used to help understand land-surface processes in Marin and Sonoma Counties. Principal places where sediment is eroded and the principal sites where sediment is deposited are mapped on a scale of 1:125,000.

California Department of Fish and Game. <u>Eel-Russian River Streamflow Augmentation Study: Reconnaissance Fisheries Evaluation.</u> By Dennis P. Lee and Phillip H. Baker. 1975. Evaluated ways to improve flow conditions in the Eel River. Six project operation alternatives were studied, all of which would involve the existing Potter Valley Hydroelectric Project. Enlargement of Lake Mendocino was contained in all of the three alternatives recommended for further study.

Creative Planning and Management, Inc. <u>Parks and Recreation Master Plan: Russian River Recreation and Park District.</u> December, 1974. Reviewed and analyzed existing recreation facilities for adequacy to meet the needs of the District's residents. Recommended consideration of day-use fees to offset operational costs and recommended against a major land acquisition program which would be difficult to develop and maintain.

Kramer, Chin and Mayo, Inc. Site, Process and Concept Study of the Fish Hatchery and Related Facilities, Warm Springs Dam and Lake Sonoma Project, Sonoma County, Calif. Prepared for the U.S. Army Corps of Engineers, San Francisco District. 1974. Presents proposed design, capacities and production levels for a fish hatchery and appurtenant structures on Dry Creek, California, downstream of Warm Springs Dam. The hatchery is intended to mitigate damages to anadromous fish spawning habitats caused by the dam.

Office of the Chief of Engineers, Department of the Army. Final Environmental Impact Statement - Warm Springs Dam and Lake Sonoma Project. November 1973. Documented impacts of project features including the earthfill dam, recreation facilities, fish hatchery, and downstream channel improvements. Presented and discussed alternatives to the project.

Sonoma County Regional Parks Department. Russian River Recreation Study. Summer 1976. Existing data on recreation on the Russian River was inventoried and summarized. An inventory of recreation elements on the river was compiled from visitor guides, by personal contact and from field reconnaissance.

F. REPORT AND STUDY PROCESS

1. General Description

During most of the period the Russian River Basin Study was underway, the Corps of Engineers used a three-part conceptual framework to perform its planning activities. This process was undergoing revision while this final report was being prepared, and subsequent Corps water resources planning may follow different guidelines. Nevertheless, it would be helpful for the reader to understand the planning process used by the Corps in the Russian River Basin Study before going into specific study details. Briefly, plans to meet study objectives were developed in three stages. During the initial stage (Stage I), the plan of study is formulated to guide subsequent planning. During the intermediate stage (Stage II), a broad range of plans is developed and analyzed. In the final stage (Stage III), plans are screened to identify those which should be developed in detail to furnish a basis for selection and recommendation. During each stage, four functional planning tasks (problem identification, formulation of alternatives, impact assessment, and evaluation) are accomplished.

2. Plan Development Stages

a. Development of Plan of Study

The initial planning stage defines the scope and character of the study and provides a guide for subsequent planning by carrying out all four planning tasks at a preliminary level. Identification of issues related to resource management in the study area is emphasized. Broad planning objectives are defined, possible alternative measures for achieving the objectives are formulated, and tentative impacts are assessed and evaluated.

b. Preliminary Planning

This stage is characterized by developing a range of alternatives to achieve the planning objectives without concentrating on detailed engineering or design considerations. Potential impacts of these alternative plans are assessed and evaluated, concentrating on their significant consequences. Data are sufficient to set forth and analyze alternative concepts for resource management and provide initial choices between the different viable resource management options available in the study area.

c. Final Report

During this final stage, alternatives are modified and reduced in number to produce an array of feasible plans for potential recommendation. Detailed design, assessment, and evaluation necessitate specific data and well-defined study assumptions. The plans are in sufficient detail to facilitate effective choices and possible plan implementation. Nonstructural and structural measures are described and the means of implementing and managing them are specified. A specific plan satisfying the planning objectives is usually selected as the recommended plan with appropriate technical and institutional measures to accomplish efficient resource management.

d. Public Involvement Program

The Corps of Engineers conducted a public involvement program during the development of the Plan of Study and the preliminary planning stage. This program began with distribution of the Notice of Study Initiation in September, 1973. Three initial public meetings to review the Plan of Study were held on June 5th and 25th, 1974 in Guerneville, Santa Rosa and Ukiah. Meeting summaries and other pertinent information were distributed to the public following the meetings.

A Citizens Advisory Committee was formed in February, 1976 after invitations to participate on the committee were distributed to 50 individuals and organizations. The committee met every two to three weeks until the Phase I (preliminary planning) Study Report was completed in December, 1976 (the term "Phase I Study Report" refers to terminology in use prior to implementation of the three-stage plan development process). The Citizens Advisory Committee issued findings and recommendations which are discussed in that report. Further public information activities included presentations before various interest groups within the Russian River basin and a variety of news releases.

II. PROBLEM IDENTIFICATION

The purpose of the Russian River Basin Study is to develop information and plans providing solutions to identified basin-wide water and related resource problems and needs. Through completion of the initial stages of the study, development of the Plan of Study and the Phase I (preliminary planning) Study Report, several problems and needs were identified. The objective of this section is to specify these problems and needs and to identify and quantify them in more detail than was possible during earlier reporting stages.

A. OBJECTIVES

1. National Objectives

The "Principles and Standards for Planning Water and Related Land Resources" (P&S), promulgated by the Water Resources Council in 1973 and revised in 1979 and 1980, dictated the conduct of the Russian River Basin Study. These rules required that Federal and Federally-assisted water and related land activities be planned toward achievement of National Economic Development (NED) and Environmental Quality (EQ) as co-equal national objectives. At some stage in the planning process, an alternative plan must be formulated which makes optimum contributions to the NED objective. Similarly, at least one alternative plan must be formulated which emphasizes contributions to the EQ objective.

A plan contributing to the NED objective increases the value of the nation's output of goods and services or improves national economic efficiency. An increase in national income may be accomplished through the development of water and related land resources.

Contributions to the EQ objective are achieved by management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems. The preservation and enhancement of the nation's environmental resources is essential to insure their availability for future use.

2. Planning Objectives

As authorized, the overall broad planning objective and goal of the Russian River Basin Study is protection and enhancement of the environment. This is clearly consistent and closely parallel to the national policy objective of enhancement of Environmental Quality (EQ). While the structure of the study and planning process involve development of plans addressing both national policy objectives, the unique nature of the Russian River Basin Study authorization and direction suggest that any plan which might ultimately be recommended may be relatively EQ-oriented.

Input from public involvement activities conducted at the outset of the Russian River Basin Study reaffirmed the overall authorized goal of the study as being protection and enhancement of the basin environment. In addition, this program helped identify specific areas of public concern regarding the basin environment, most of which were also recognized in the authorizing resolution. This information, along with that gathered from other studies conducted in the basin by Federal agencies and other interested parties, allowed the formulation of three broad planning objectives to help guide early study efforts. These objectives were:

a. To preserve or enhance the fishery resources of the Russian River basin for the present and future benefit of the public.

b. To achieve or maintain acceptable water quality in the Russian River and its tributaries for present and future municipal, industrial, agricultural and recreational use by the public and for the present and future benefit of the basin's fish and wildlife resources.

c. To provide data on floodplain usage and other land applications in the Russian River basin for use by government officials, planners and other interested parties in future land use planning and floodplain management.

Definition of some of the problems, needs and opportunities associated with these planning objectives resulted from preliminary environmental evaluations and inventories, and from citizen and interagency advisory activities conducted during the early stages of the Basin Study. With this information the study planning objectives were refined to address specific issues. Evaluation of these issues was considered essential to achieving the overall study goal of protecting and enhancing the basin environment. These refined planning objectives were:

a. To provide data on the effect of gravel mining on the total Russian River system and the role it plays in increased erosion, loss of fishery habitat, water quality, aesthetics and other problems, for use in future programs for managing the basin's sand and gravel resources.

b. To provide data on the environmental, economic and social impacts of small summer recreational dams established annually on the Russian River mainstem and tributaries, for use in future programs for managing these dams.

c. To provide data on the effectiveness and environmental impact of existing channel improvement and stabilization measures along the Russian River mainstem and tributaries, and the need for any new measures, for use in determining future Federal and non-Federal involvement in channel improvement.

d. To provide information on the feasibility and environmental and economic impacts of maintaining free passage at the mouth of the Russian River, for use in determining future Federal and non-Federal involvement in providing facilities for maintaining free passage.

e. To provide data on the sources and movement of sediments in the Russian River basin for possible future use in sediment influx and transport and river mouth investigations.

f. To provide information regarding the operation of existing structures on the Russian River mainstem and tributaries, so that any future Federal and/or non-Federal plans for managing these structures can include provisions for maintaining optimum flows and water quantities in the basin for water quality, recreation, and fishery enhancement and/or mitigation, consistent with basin requirements for flood control and water supplies and consistent with the authorized purposes of these structures.

As in the case of the national policy objectives, the overall planning objective of protection and enhancement of the environment is extremely broad and general. This generality resulted in the objective not being useful for specific planning purposes. To realistically address the objective within the constraints of study authority, time, and money, it was necessary to identify specific environmental needs and existing problems in the basin and to establish appropriate limitations on the scope of the study. These needs and problems were outlined in the six refined planning objectives. Thus, while the planning objective of protection and enhancement of the environment was not directly applicable, it was addressed through consideration and development of plans for resolution of the specific environmental needs and existing conditions within the basin identified in the refined planning objectives.

Subsequent efforts further defined the planning objectives and existing conditions, and evaluations of resource capabilities and expected conditions in the absence of any plans were initiated. The purpose of the following sections is to describe existing conditions in the Russian River basin and problems identified during the early stages of the Basin Study. These conditions and problems served as the basis for the planning objectives and for alternate plans addressing the objectives formulated in the later study stages.

B. STUDY AREA DESCRIPTION

1. Environmental Setting and Natural Resources

a. Background

The Russian River drains a basin of 1,485 square miles in Sonoma and Mendocino Counties. The drainage basin, lying between adjoining ridges of the Coast Range Mountains, is about 80 miles long and from 10 to 30 miles wide, with its major axis roughly parallel to the coast of California. The total length of the river, from its source about 16 miles north of Ukiah to its mouth at Jenner, where it empties into the Pacific Ocean, is about 110 miles (Figure 1).

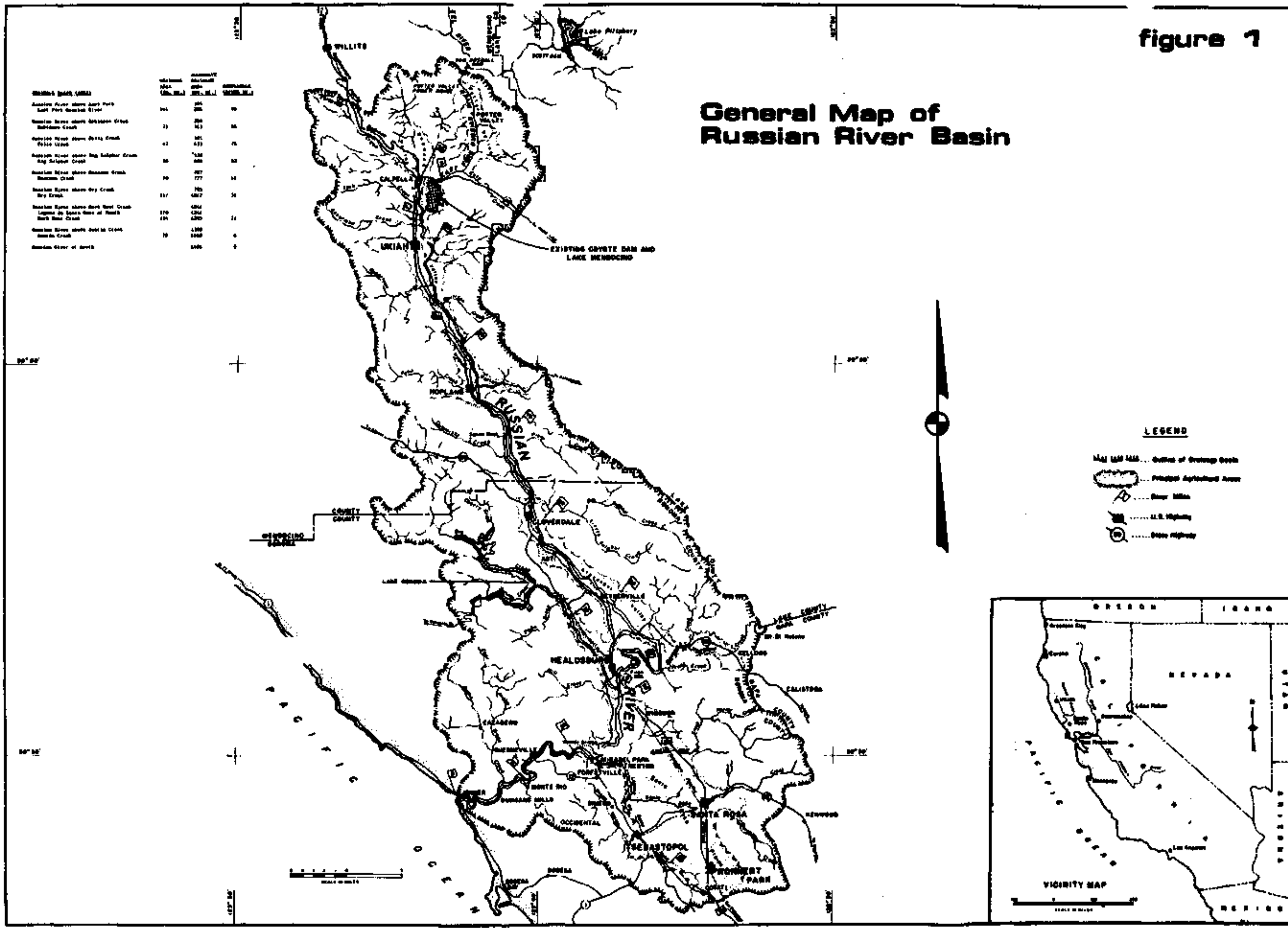
The principal tributaries of the Russian River are Dry Creek and Mark West Creek. Dry Creek drains an area of 217 square miles situated in the west-central portion of the drainage basin. Its confluence with the Russian River is about two miles south of Healdsburg. Warm Springs Dam is currently under construction on Dry Creek. The Corps facility is located approximately 14 miles upstream of the confluence with the Russian River and has a contributory watershed of 130 square miles. Warm Springs Dam-Lake Sonoma is a multi-purpose project providing flood control, water supply and recreational benefits. The dam will be 319 feet in height and will have the capacity to store 381,000 acre-feet of water. Lake Sonoma will have a surface area of 2,700 acres. Besides flood control and water supply benefits, the project will provide additional recreation opportunities in the area including fishing, boating, hiking, biking, horseback riding, camping and picnicking. Below the dam is a fish hatchery constructed by the Corps and being managed by the California Department of Fish and Game. About 2,500,000 king salmon, silver salmon and steelhead trout eggs will be propagated in the hatchery each year.

Mark West Creek drains an area of 254 square miles located in the south-eastern portion of the drainage basin, and joins the main stream at Mirabel Park. Other major tributaries of the Russian River include its East Fork, Robinson Creek, Feliz Creek, Big Sulphur Creek, Maacama Creek, and Austin Creek. A regulated supply of water from the Eel River drainage basin, which adjoins the Russian River to the north, is diverted into the East Fork of the Russian River at Potter Valley. This diversion, augmented by natural flows of the East Fork, is further regulated by the Coyote Dam Project completed by the Corps of Engineers in June 1959.

Coyote Dam is 160 feet in height, has a contributory watershed of 105 square miles, and has the capacity to store 122,000 acre-feet of water. The Coyote Dam-Lake Mendocino Project provides flood control and water supply benefits, and provides extensive recreational opportunities, including fishing, boating, camping, picnicking, and hiking. Lake Mendocino has a maximum surface area of approximately 1,810 acres.

figure 1

General Map of Russian River Basin



Currently, Warm Springs Dam is under construction and is expected to be fully operational in the mid-1980's. This investigation assumes that both Coyote and Warm Springs dams are in place and operational. Thus, reduced flood flows on Dry Creek and on the Russian River downstream of Dry Creek due to the operation of Warm Springs Dam are part of the baseline conditions. These conditions also include the joint operation of both reservoirs to supply water for agricultural, municipal and industrial uses along the Russian River mainstem and in portions of southern Sonoma County and northern Marin County. The principal diversion for non-agricultural uses will continue to be the Ranney collector wells in the mainstem near the Wohler Bridge, downstream of the Dry Creek confluence. The operation of Coyote and Warm Springs dams for water supply releases and the operation of the Ranney wells will continue to be under the jurisdiction of the Sonoma County Water Agency (SCWA).

A fish hatchery has been constructed as part of the Warm Springs Dam project. The existence of this hatchery is considered part of the baseline conditions. The hatchery provides for the production of king salmon, steelhead and silver salmon. In conjunction with water supply releases from Lake Sonoma, the hatchery provides for enhancement of the fisheries resources along Dry Creek and the lower Russian River to offset the impacts of Warm Springs Dam.

b. Natural Land Features

The Santa Rosa Plains, Alexander Valley, Hopland Valley, Ukiah Valley, Redwood Valley, Potter Valley and other smaller valleys are level areas comprising about 15 percent of the Russian River drainage basin. The remainder of the area is hilly or mountainous with approximately 45 percent at elevations in excess of 1,000 feet above mean sea level. The highest point on the divide outlining the basin is on a ridge near Cobb Mountain, with an elevation of 4,500 feet. Elsewhere the elevation of the divide varies from 3,000 to 4,000 feet along the east side of the basin and from 1,400 to 3,000 feet along the west side. Near Cotati, at the southern end of the drainage basin, the divide is only about 120 feet above mean sea level and is not easily discernible. Connecting the several valleys referred to above are mountainous gorge reaches through which the Russian River flows. Most notable of these is the reach between Mirabel Park and the mouth of the river at Jenner and the reach between the communities of Hopland and Cloverdale.

Mountainous and hilly portions of the basin are moderately to heavily wooded. The north slopes and deep ravines are more heavily wooded than areas where conditions are less favorable to the retention of water within the root zone. The principal species of trees are California redwood, Douglas fir and live oak. There are also extensive growths of manzanita and chaparral. Considerable forest and dense chaparral areas have been burned over in the relatively recent past, with much intentional burning to convert additional areas to vegetation suitable for grazing.

c. General Geology

The topography of the Russian River basin consists of a series of northwest-trending fault-block ridges and inter-mountain valleys that were formed by folding and faulting beginning in the Miocene and Pliocene epochs and continuing spasmodically into recent time. Generally the ridges and valleys parallel the coastline and the San Andreas Fault zone which occupies a trench along the coast in this area. The drainage pattern is principally barbed or trellis, indicating that the stream courses are controlled by the regional structure, but in some areas it is markedly traverse. The Russian River flows southeastward through a series of fairly wide alluvial valleys and narrow rock gorges for about 50 miles, then turns abruptly westward near Healdsburg incising through the regional trend and coastal ridges to the ocean.

The rocks that underlie the Russian River drainage basin have been grouped into three units for simplicity and because of their similarity and intimate lithic relationships. The formations consist of the Franciscan-Knoxville of Jurassic-Cretaceous Age, late Tertiary (Pliocene) Sonoma Volcanics and Merced formation, and the Quaternary Pleistocene and Recent alluvial deposits. The Franciscan-Knoxville formation comprises a complex sequence of graywacke (sandstone), shale, conglomerate, chert, and glaucophane schist that have been intruded by numerous igneous rocks. Areas underlain by Franciscan-Knoxville rocks are characteristically pockmarked by slumps and landslide scars due to the deep weathering of the highly fractured rocks and thick residual soils. Tertiary rocks of the Sonoma Volcanics and Merced formation crop out only in the extreme southern portion of the basin. The Merced is chiefly marine sandstones and is overlain by the Sonoma Volcanics groups which is mainly extrusive volcanics with minor amounts of tuff, tuffaceous sandstone, and agglomerate. A thick accumulation of alluvial deposits overlie the Tertiary rocks, but are restricted to the valleys of the Russian River. The alluvium is composed of varying mixtures of clay, silt, sand, and gravel and attains a thickness of over 1,000 feet.

d. Climatology

The climate of the Russian River basin is tempered by the proximity of the Pacific Ocean. In common with much of the California coastal area, the year is divided into wet and dry seasons. Ninety-three percent of the annual precipitation normally falls during the wet season, October to May, with a large percentage of the rainfall occurring during three to four major winter storms. Winters are cool but below-freezing temperatures are seldom experienced. Snow falls infrequently over the higher elevations and rarely attains an appreciable depth. Summers are warm and the frost-free season is fairly long, varying from 224 days at Santa Rosa to 265 days at Cloverdale.

The normal annual precipitation over the Russian River basin is 41 inches, ranging from about 22 inches over the southern portion of the

Santa Rosa Plains to over 80 inches near Cazadero and Mount Saint Helena. The quantity of rainfall increases with elevation and the centers of greatest precipitation occur over the highest ridges. Annual precipitation is quite variable. For example, although the normal annual precipitation in Santa Rosa from 1921 to 1978 is approximately 29 inches, a total of 52 inches was recorded in 1941 and only 12 inches was recorded in 1977.

Runoff in the Russian River basin, like precipitation, is highly variable. Records from the U.S. Geological Survey streamgage station on the Russian River near Healdsburg show that since 1940, the year the gage was installed, the maximum instantaneous discharge was 71,300 cfs in December 1964. The year with the smallest instantaneous peak discharge was 1977 with 17 cfs.

Major droughts have occurred in the basin in 1924, 1931, 1934, 1939, 1976, and 1977. The 1976-1977 drought was particularly severe having two extremely dry years in sequence. Since 1940, major flood events have occurred in the basin in December 1940, January 1943, January 1954, December 1955, February 1958, December 1964, January 1970 and January 1974.

e. Land Use

At the present time, the Russian River drainage basin is primarily an agricultural area with the greatest emphasis placed on orchard crops and vineyards. Besides agricultural pursuits, there is a growing trend toward light industry and commercial development, with the major urban center being Santa Rosa and its vicinity. Also, there is considerable activity in cattle and sheep raising in the hilly areas surrounding the valleys. There are a significant number of summer homes and resorts along the river reaches adjacent to Healdsburg and between Mirabel Park and Duncans Mills. Major orchard crops consist of prunes, pears and apples, with some production of other crops such as cherries and walnuts taking place. The Russian River basin is one of the most important wine-grape producing centers of the United States, with vineyards located along all of the river valleys and some of the major tributaries. Over the past several years wine-grape prices have been high, encouraging the planting of new vineyards in Sonoma and Mendocino counties, as well as in other places in the State. Many prune orchards and some pear orchards have been taken out to make room for the new vineyards. A large percentage of the new vineyard plantings are on what previously was referred to as low-density agricultural land; generally defined as native pasture, wood- and brushland, and improved pastureland.

The basin was once important in the production of hops, but this crop has virtually disappeared and the hopyards have been converted to orchards, vineyards, or truck crops. The basin contains both dry and irrigated pasture, and both hay and grains are grown. Industrial activities in the basin include lumber production and the processing of timber products, wine production, facilities for the processing of agricultural and animal products, gravel removal and processing, a minor amount of mining, and miscellaneous light manufacturing operations. Commercial activities are largely in the fields of distribution and services to supply the needs of those engaged in the agricultural, industrial and recreational activities mentioned above.

f. Natural Resources

The fertile soils of the river valleys are well suited to the agricultural activities taking place. The predominant soil association in the valleys of Sonoma County is the Yolo-Cortina-Pleasanton. These soils are generally well drained and are in capability Class I, indicating that there are few limitations that restrict their use. The predominant soil types along the Russian River in Mendocino County are the Maywood and Esparto types, which are in soil capability Classes 1 and 2 respectively.

Portions of the basin contain stands of commercially harvestable timber but most timber that is processed in the Russian River basin is imported from Pacific Coastal areas west of the basin. Minerals are produced commercially but not in such quantity as to be of major importance. The processing of river sand and gravels throughout much of the length of the Russian River and the downstream reaches of some of its tributaries accounts for about 70 percent of the total mineral production. Commercial use is also made of natural geyser steam in an area east of Cloverdale, where it is used to generate electrical power.

The quality of the Russian River water is good to excellent. The chemical character of the water is moderately hard. Dissolved oxygen and temperature levels of the river water are, in general, adequate to support fish life. This is a significant improvement over previous conditions. In previous years secondary-treated domestic sewage was being discharged into the Russian River during the summer months, creating several major water quality problems in the basin. This practice was stopped in 1977.

The Russian River is important as a spawning ground for anadromous fish of which the principal varieties are steelhead trout and silver (or coho) salmon. Other fish inhabiting the basin include king (or chinook) salmon, small-mouth bass, American shad, striped bass and white catfish.

The Russian River basin supports a wide range of wildlife species including a substantial population of blacktailed deer, bandtailed pigeons, and pheasants. Several species of small mammals associated with agricultural uses, i.e. rats, mice and rabbits are also found in the area. The Russian River basin supports a variety of resident and non-resident waterfowl who utilize the river habitat for nesting and refuge.

Fish and wildlife resources in the basin have been and are being adversely impacted in some cases because of inadequate legal protection and management policies, poor land use practices, instream barriers, inferior water quality, and other resource conditions. Despite concerted efforts by local, State and Federal agencies to correct some of these problems, with definite improvements realized in areas such as water quality, additional improvements are needed.

The Russian River basin is characterized by warm, dry summers and cool, wet winters. The air quality of this predominantly rural region is classified as good to excellent. The scenic surroundings and mild climate of the basin, coupled with a wide variety of natural resources and close proximity to the large population of the San Francisco Bay area, make the Russian River basin a valuable recreational and open space resource.

g. Cultural and Historic Values

The Russian River basin historically was occupied by several groups of native California Indians. These included the Southwestern, Southern, Central and Northern Pomo as well as the Wappo and the Huchnom. Archival research indicates that the Russian River drainage area was once one of the most densely populated areas in the State of California. The demography of the area was principally riverine oriented. Riverine locations were highly desirable because of their central location within the various ecological zones. People located along the river could take advantage of both riverine and foothill environments.

The fisheries of the Russian River basin were exploited through use of nets, traps, dams, weirs and poisons. Large animals and birds (especially water fowl) associated with the basin were also taken. Plants associated with the river and its tributaries were utilized. Acorns, buckeye and various seed crops were harvested; basket materials such as willows, sedges, wild grape and pepperwood were collected and building materials such as grasses and tule were obtained in quantity.

Pomo aboriginal use patterns were modified around 1831 with the entry of the Wappo into the Russian River Valley. The Spanish moved into the area in 1834 with the establishment of the Sonoma Mission. The Russians established Fort Ross on the Sonoma coast in 1812 and made occasional visits to the interior. American settlers arrived on the "Sonoma Frontier" in the 1840's. After the American occupation of the Russian River area, Pomo use of the river continued for another generation, but traditional use patterns were disrupted. Thereafter the Indians fell victim to the abuses of the settlers occupying the area. They were often used as forced labor to cultivate the lands which once provided their livelihood.

In the early 1900's the U. S. Government embarked upon a program to acquire land for the Indians. By the 1940's thirteen rancherias or reservations had been established in the Russian River area. Subsequently, nine have been terminated.

Thus the Russian River basin is known to be of significant historic and cultural interest and to contain valuable archaeological remains. With the exception of the Warm Springs Dam-Lake Sonoma Project area, the majority of the basin has not been subject to intense archaeological or cultural investigation to date. The early cultural resource studies done as part of the Warm Springs project identified 65 archaeological sites having pre-historic cultural value in the flood control and reservoir area. Plans have been implemented to properly study, collect, preserve and protect the significant sites to the maximum extent possible, as part of the Warm Springs Dam-Lake Sonoma Project. It is reasonable to assume that many other areas of the Russian River basin which have not been subject to such intense study may contain an equal or greater number of valuable archaeological resources.

There are no cultural or historical resources listed in the National Register of Historic Places or the State Historic Preservation Officer's files for the Russian River basin. However, according to several published sources there are a number of significant landmarks and legends unique to the area. The city of Hopland, situated on the Russian River and originating in 1860, was once a famous hops growing center. This agricultural use has since been replaced by the pear industry. Located six miles south of Hopland, on the scenic Redwood Highway, is Squaw Rock, also call "Lovers Leap". The legend of Squaw Rock originates from Pomo Indian history which identifies the rock as the one from which an Indian maiden took her life because of a faithless lover.

The Russian River basin contains several active mineral springs. Vichy Springs, located three miles east of Ukiah, was originally an area settled by the Pomo Indians before the arrival of the white man. The springs of the area are similar to the Vichy waters of France, and were commercially sold until a fire in the early 1900's destroyed the operation. Commercial production of these waters has started again in recent years. Another point of interest near the Russian River basin is a huge rock located near Willits. The boulder is known as Black Bart Rock, and is said to have been the hide-out of Black Bart the bandit. Black Bart successfully robbed the mail stage in the Russian River basin for over thirteen years between 1875 and 1888.

2. <u>Human Resources</u>

a. Background

The population of the Russian River basin is generally located along the river corridor. This includes several rural communities, one medium-sized urban center and extensive river oriented rural agricultural areas. The principal communities in the basin are Ukiah, Cloverdale, Healdsburg, Sebastopol, Santa Rosa, Rohnert Park and the urban recreational complex stretching from Mirabel Park to the Russian River mouth. The latter area contains the recreational centers of Rio Nido, Guerneville, Monte Rio, Duncans Mills and Jenner.

United States Bureau of the Census reports indicate recent population changes in the general study area. These are shown in Table 1.

Table 1

RUSSIAN RIVER STUDY AREA
POPULATION CHANGES

Locality	Population by Year: 1950	1960	1970	1975	1980(3)
Mendocino County (entire)	41,000	51,000	51,000	57,000 (1)	66,700
Sonoma County (entire)	103,000	147,000	205,000	247,100 (2)	299,800
Russian River Basin (estimated)	65,000	118,000	181,000	N/A	N/A
Communities:					
Ukiah	6,100	9,900	10,000	N/A	12,000
Cloverdale	1,300	2,800	3,200	3,600 (2)	4,000
Healdsburg	3,300	4,800	5,400	6,200 (2)	7,200
Sebastopol	2,600	2,700	3,800	4,600 (2)	5,600
Santa Rosa	18,000	31,000	48,500	65,600 (2)	83,200
Rohnert Park	N/A	N/A	6,100	12,900 (2)	23,000

(1) California Department of Finance E-150 projection
(2) 1975 Sonoma County Special Census
(3) U.S. Bureau of the Census preliminary data

b. Population Projections

1) DOF - The most current and widely used population projections for California are those prepared by the State of California Department of Finance (DOF). The projections are prepared in five series, D-100, E-0, D-150, C-150, and E-150. The letter prefix refers to the Department of Commerce standard birth rate, which represents the average number of children a woman will have during her lifetime. The letters B, C, D and E represent 3.1, 2.8, 2.5, and 2.1 respectively. The number suffix indicates the average net immigration, in thousands, that the projection estimates California as a whole will experience over the projection period. The E-150 series is considered the basic or "baseline" projection, while the others provide lower and upper boundaries. DOF projections are available for the entire study area.

2) ABAG - Population projections have been prepared for the nine counties around San Francisco Bay by the Association of Bay Area Governments (ABAG) in cooperation with the Metropolitan Transportation

Commission (MTC). The most recent projections available are from Projections 79, published January 1980. These projections cover only the Sonoma County portion of the study area.

3) BASS - The Center for Real Estate and Urban Economics at the University of California has developed a set of Bay Area county population projections with a model known as the Bay Area Simulation Study (BASS). Two of the projections, BASS Medium and BASS Low, cover the Sonoma County portion of the Russian River study area.

Table 2 presents a compilation of the preceding population estimates for Sonoma and Mendocino Counties.

Table 2

POPULATION PROJECTIONS
SONOMA COUNTY / MENDOCINO COUNTY (1)
(1,000's Population)

	1970	1980	1990	2000
(E-150) (Revised 1980)	205/51	279/65 284/68	355/81	428/96
DOF (E-0)	205	287	335	374
DOF (D-100)	205	300	395	478
DOF (D-150)	205	301	420	541
DOF (C-150)	205	304	431	564
ABAG	205	289(2)	354(2)	425(2)
BASS (Low)	217(3)	304	404	521
BASS (Med)	219(3)	311	427	569

(1) Where two numbers are shown, the first represents Sonoma County.
(2) Projections 79, ABAG, January 1980.
(3) Projections made before 1970.

The State of California Department of Water Resources (DWR), in conjunction with a water demand study of the Russian River Service Area, has extrapolated E-150 series projections for the Russian River basin. Utilizing selected DWR subunits, it is possible to obtain E-150 series projections for the Russian River Basin Study area to the Year 2000. These projections will be used for this study and are shown in Table 3.

Table 3

RUSSIAN RIVER BASIN STUDY AREA
DOF E-150 POPULATION PROJECTIONS
(Population in 1,000's)

SUBUNIT	1975	1980	1990	2000
Forsythe	2.4	3.7	4.6	5.8
Coyote	2.3	2.7	3.4	4.1
Upper Russian	23.0	26.7	33.1	38.2
Middle Russian	7.0	8.3	10.8	11.5
Lower Russian	13.4	14.6	20.0	22.7
Dry Creek	11.7	12.6	17.9	20.5
Austin	0.5	0.6	0.9	1.0
Santa Rosa	137.2	146.6	196.4	242.3
TOTAL	197.5	215.8	287.1	346.1

3. Development and Economy

The development of the Russian River basin has generally been river oriented. The economy rests principally upon three industries: extractive, manufacturing and recreational. Extractive industries include lumbering, livestock production, mining (including river sands and gravel), and extensive agricultural development. Manufacturing historically consisted of processing indigenous agricultural products, and more recently the addition of durable goods manufacturing in the southern portion of the basin has taken place. Recreational usage ranges from extensive day use by out-of-basin visitors, to established second home and river front communities along the lower river area. U.S. Highway 101 extends from the major urban centers south of the basin to important scenic attractions north of the basin. Clustered service facilities are located the length of the basin, particularly adjacent to Highway 101.

One of the principal economic and recreational activities in the Russian River during the summer is canoeing or river touring. This industry accounts for 10 to 20 percent of the total recreation use-days in the basin. Most canoeing takes place in the 70-mile reach between Cloverdale and Jenner on the coast. Generally, canoeing is limited to the lower-flow period between April and October when the river's Class I designation makes it particularly suitable for novice and recreational canoeists. In dry years, the canoeing season may begin as early as March and/or continue into November. Because of its relatively mild and safe boating conditions and abundant put-in and take-out points, as many as 120,000 to 150,000 people canoe on the Russian River each year. While residents of the San Francisco Bay area and the rest of northern California account for most of this use, the Russian River attracts canoeists from all over the United States, as well as many foreign countries. Roughly 100,000 of the people who canoe on the Russian River each year take advantage of commercial canoe rentals, with 60-70 percent of the use being in organized trips (usually one day to a week), and the rest in hourly rentals. The remaining 20,000 to 50,000 canoeists are visitors or residents of the Russian River basin who use privately-owned canoes. While people of all ages canoe on the Russian River, most are between the ages of 12 and 40.

Traditionally the basin has been rural in nature and agriculturally oriented. Within the past decade, however, with the ever expanding impact of the San Francisco Bay area and the desirability of nearby recreation, the Russian River basin has been increasingly influenced by urban pressures. The City of Santa Rosa, for example, is now considered within the general Bay Area and commute buses run regularly to and from San Francisco. Even Mendocino County, which presently retains its rural character, has been influenced by numbers of former urban or city dwellers who have relocated and created a form of counterculture in the region.

Perhaps the most significant recent economic change in the basin has been the extensive development of the grape industry. The basin offers a unique and valuable climate conducive to the growth of premium wine grapes. The recent high prices for this product have encouraged the removal of existing prune orchards to make room for new vineyards in many cases. A significant number of the new vineyard plantings are on what previously were referred to as low-density agricultural land; meaning native pasture, wood- and brushland, and improved pasture land. This conversion to vineyards has had profound effects upon the basin in terms of water demands, employment and investment capital. Much of the initial capital for new plantings has come from large companies outside the local community. Although the trend to grape production has lessened recently, it is expected to stabilize and pick up slightly due to growing demand and the building of additional barrel and tank storage facilities.

C. PROBLEMS, NEEDS AND OPPORTUNITIES

1. Gravel Mining and Sediment Influx

a. Existing Conditions

The Russian River, although perennial, is characterized by large variations in flow. In the summer the low flows are clear of sediment; however, during winter floods, a sizable sediment load, including a large portion of gravels and sands, is carried downstream. These sands and gravels support a sizable aggregate mining industry along the Russian River, particularly in Sonoma County. For the purpose of this study, gravels are those materials in the river bed which are between 3 inches and 0.25 inch in diameter. Sands are less than 0.25 of an inch in diameter, but greater than 0.005 inch in diameter. Aggregate is the combination of sands and gravels as they naturally occur in any location along the bed of a watercourse.

Plates 1 through 4 show the locations of gravel mines which have recently operated or are currently operating along the Russian River. Several mining methods have been used to remove the gravel deposits:

1) the shallow excavation of the river channel to remove gravel deposited by winter floods;

2) the excavation of deep in-channel ponds which then trap and collect gravel transported by floods;

3) the mining of exposed gravel bars;

4) the excavation of large pits separated from the river by dikes;

5) the excavation of gravel in quarries away from the river.

Along the river reach below Healdsburg, two companies have excavated large pits. These mines accounted for about 67% of Sonoma County's sand and gravel production and about 50% of the County's aggregate production in 1978. Alexander Valley in-channel mining supplies about 33% of the County's sand and gravel production and about 25% of the County's total aggregate production.

Downstream of Healdsburg, the gravel companies mined inside the summer channel as late as the early 1970's, but this reach of the river is almost "mined out." The companies have therefore removed vegetation and top soil from nearby land and excavated large pits as deep as 60 feet, leaving dikes between the pits and the river. These pits are known as "terrace" mines because they are located in the river terraces. Draglines are used to remove gravel, and sedimentation ponds are used to trap fine sediments from wet processing of the gravel. Figure 2 shows a profile of a typical terrace mine.

In the Alexander Valley, miners scrape the exposed gravel bars down to the summer water surface elevation as allowed by their County gravel extraction use-permits. The sites are then smoothed to prevent fish entrapment and abandoned to the winter floods. The floods replenish some of the gravel removed so that mining can resume the next spring.

In gravel-bar mining, the gravel is excavated with front-end loaders, scrapers, or paddle skimmers and hauled to a processing site either on the gravel bar or just above the winter-flow channel, or outside the immediate area. In the latter case, the gravel may be processed year-round. Processing includes screening and crushing and may be either "dry" or "wet," with "wet" processing requiring sediment holding ponds to trap fine sediments. At least one operator yearly removes the accumulated fine sediments from the ponds and adds them to farmland. In other cases, the ponds are abandoned to the winter floods. Gravels over 1-1/2 inches and cobbles are sometimes used to armor nearby river banks.

b. Problems and Opportunities

Several bank and channel erosion problems exist in the Russian River basin which may be caused in part by gravel extraction. In the last four years, bank erosion and loss of farmland has occurred along the outside of a bend just upstream of Geyserville Bridge. A pilot channel was cut in early 1978 in an attempt to train the river back into its previous configuration. Some landowners in the area expect erosion to continue, however, and feel that a nearby road will be threatened by the next sizable flood. The area has also experienced a four-foot drop in its water table over the last three years. The Corps of Engineers investigated these problems under Section 14 of the 1946 Flood Control Act. Section 14 authorizes the Secretary of the Army to construct, where advisable, emergency stream bank protection works to prevent flood damage to public works and services. However, construction of such works in the area of Geyserville Bridge was determined not to be economically feasible.

Severe widening of the lower 3 miles and in the vicinity of mile 8 of Dry Creek has occurred in the last twenty years with a resulting loss of approximately 74 acres of farmland. This has been accompanied by severe enough degradation of the streambed of the downstream portion of the creek to require extensive renovations to the Westside Bridge. Tied pilings installed by the U.S. Department of Agriculture Soil Conservation Service (SCS) in an attempt to halt erosion have mostly failed. The water table in the Dry Creek area has also fallen significantly.

Several areas in Mendocino County are also experiencing erosion problems which may be attributable to gravel mining. Much of the Forsythe Creek streambed is undergoing increased meandering which is eroding significant areas of farmland and may threaten some private pumping facilities. This meandering is possibly due to removal of armoring material by gravel mining in the areas. While Mendocino County officials are attempting to manage County gravel extraction on a sustained yield basis, this has not yet been achieved. Consequently mining in Forsythe Creek has progressed to a point where very little gravel is left. Gravel production in the area is declining and the creek now flows through clay substrate material in some areas which originally underlain the gravel. The wells of some landowners along the creek have reportedly gone dry. This is possibly due to the removal of gravel infiltration beds which were tapped by these wells or the silting in of remaining beds with fine clay materials.

An area near the California Department of Transportation bridge south of Hopland, where State Highway 101 crosses the Russian River, has also experienced gravel depletion. The riverbed beneath the bridge formerly afforded a prime pool and riffle habitat for salmonids. A gravel-bottomed pool was formed underneath the bridge by gravel deposits in the bed south of the bridge. Commercial gravel removal upstream and downstream of the bridge apparently caused the streambed below the bridge to degrade, washing away the gravel and eliminating the pool and riffle. The riverbed below the bridge has eroded down to bedrock and is devoid of gravel.

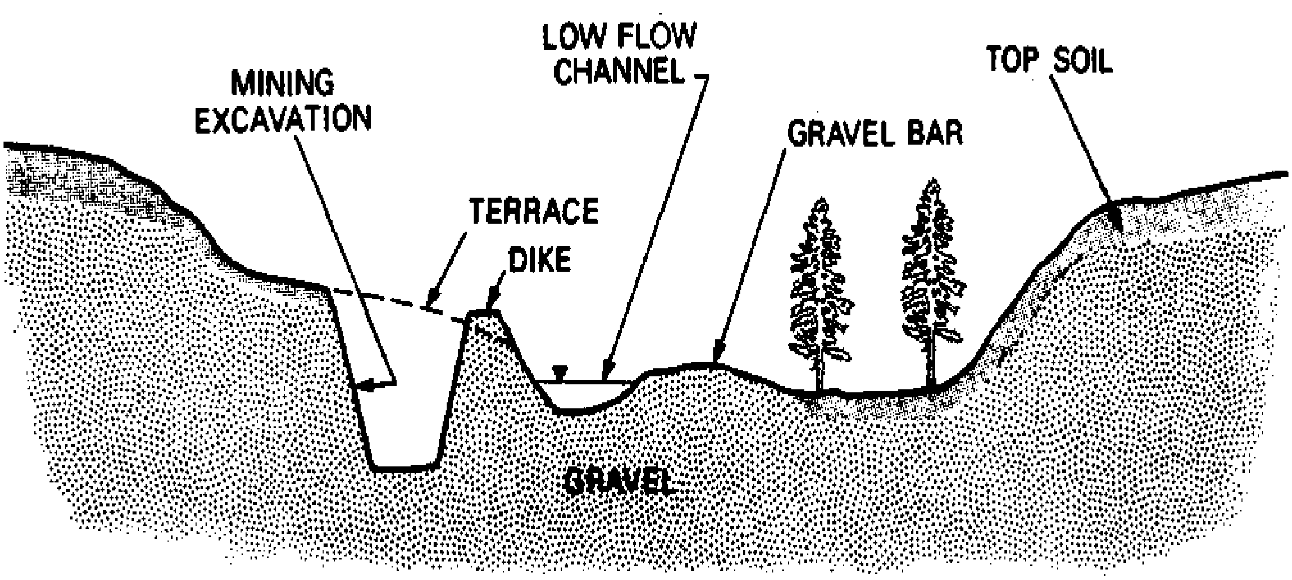
Similar streambed degradation has occurred on the Russian River between roughly Calpella and the confluence of the Russian River and Forsythe Creek. The streambed downstream of a mining operation in this area is devoid of gravel, exposing the underlying hard substrate material.

Streambed degradation is also occurring below the State Highway 20 bridge across Cold Creek. This bridge is located just upstream of the confluence of the creek and the east fork of the Russian River above Lake Mendocino. The bridge employs a concrete box culvert through which the creek flows, creating a hydraulic jump downstream of the bridge and consequent erosion. The California Department of Transportation has placed heavy riprap downstream of the bridge in an effort to reduce this degradation. Gravel mining has taken place in Cold Creek both upstream and downstream of the bridge.

Gravel mining and loss of riparian growth can result in negative visual impacts and negative impacts on water quality, fish and wildlife habitat, and local transportation networks. Mining operations can degrade stream habitat for fish by increasing turbidity, accelerating sediment transport, creating deep pools and removing spawning gravels. The loss of riparian vegetation can encourage bank erosion. Mining can also adversely affect water quality through the discharge of untreated wash water into the river, grease and oil spills, and excessive turbidity caused by the operation of heavy equipment in or near the streambed. Heavy trucks used to transport mined materials can affect local traffic patterns, noise levels, air quality, road and bridge stability, and the safety of travelers and residents. A more detailed description of gravel mining in the Russian River basin is contained in Appendix A.

figure 2

Typical Cross Section at a Terrace Mining Operation



If planners considered only the stated objective of minimizing the negative impacts of gravel mining, the obvious solution to the problem would be to halt mining along the river. However, constraints exist which would most likely lead to a different solution. These constraints include social, economic, and environmental factors associated with gravel mining:

1) The demand for gravel. Gravel is needed for construction both in and outside of Sonoma County. The effect of this constraint on the problem will depend on how much gravel is available from sources away from the river, such as quarries. The cost and quality of gravel from various sources should also be considered.

2) Possible effects of mining on floods. Degradation often results in an increased flow capacity of the channel. A marked reduction of mining activity could cause aggradation of the river bed and increases in overbank flooding.

3) The economic effects of mining in Sonoma County. A change in overall mining activity would affect both employment and taxes. Indirect impacts on the local economy, such as changes in commercial activity, should also be considered.

c. Further Study

The California "Surface Mining and Reclamation Act" was passed in 1975. The act requires counties to enact ordinances regulating surface mining. It allows counties to require that all operations started after January 1, 1976, operate according to local mining standards. It also requires all mining operations to prepare reclamation plans. In response to the act, both Sonoma and Mendocino Counties have passed Surface Mining Ordinances. Each ordinance sets up a mining permit procedure to be used to regulate aggregate mining.

The Corps has been assisting Sonoma County in preparing a plan for the regulation of gravel mining by:

1) reviewing existing information and preparing a report outlining planning objectives and constraints, mining methods, and the hydrologic history of the river;

2) selecting and describing a computer bedload model to help evaluate the effects on the river system of different regulation alternatives. A report was prepared including a description of the model, its limitations, data requirements, and role in defining potential erosion. A sample run was also included. A portion of the report to Sonoma County is contained in Appendix A.

Sonoma County has completed a study of the effects of gravel mining on the environmental characteristics of the Russian River in Sonoma County, and has proposed an aggregate resources management plan for the County. The plan calls for phasing-out of terrace mining, a reduction in the amount of sand and gravel supplied by in-channel extraction, and increasing development and reliance upon hard-rock sources of aggregate. The County hopes to eventually implement the bedload model provided by the Corps of Engineers for the purpose of evaluating the effects of mining on sediment transport mechanisms in the river. The County also supported Congressional funding for additional Corps studies of bedload movement and erosion along Dry Creek and the Russian River mainstem.

Mendocino County is currently obtaining cross-sections from the mining operations as part of their use-permit program. The County has also begun the development of a comprehensive data base to be used for purposes of predicting the environmental effects of in-stream mining operations. In this regard the County has contracted with the California State Department of Water Resources for a cooperative study of erosion and gravel movement in the upper Russian River.

As both Counties have become involved in managing the sand and gravel resources of the Russian River basin, and as Sonoma County has expressed the desire for additional Federal involvement in evaluating these resources, further Federal study of gravel mining, sediment influx and related problems in the Russian River basin is warranted at this time. This topic is being partially addressed in a special Corps study of the Dry Creek basin initiated in late 1980.

2. Channel Improvements and Stabilization

a. Existing Conditions

Extensive soil losses associated with both natural and man-induced erosion occur along the banks and channel of the Russian River and its tributaries each year. Several methods of bank stabilization and channel improvement have been utilized on the Russian River in attempts to reduce or prevent such damages.

Federal construction of some channel improvements along the Russian River and the lower reaches of its principal tributaries was authorized in conjunction with the Corps of Engineers Coyote Dam Project. These improvements, completed in 1972, consisted of two channel and pilot channel excavations, 33 miles of channel clearing, and the installation of bank protection works at 99 individual sites, including flexible fencing, steel jacks and riprap.

The Corps is currently constructing other improvements for existing eroded areas along Dry Creek, under the Warm Springs Dam-Lake Sonoma project authorization. By November 1981, three erosion control sills and a section of low flow channel had been constructed along the creek, and rip-rap placed at one site. Planned future work includes additional rip-rapping, willow planting and possibly construction of several groins.

The Sonoma County Water Agency maintains about 4 miles of low flow drainage channel along the Laguna de Santa Rosa, a tributary of the Russian River. The Agency also collaborated with the Soil Conservation Service (SCS) in the construction of flood control improvements as part of the Central Sonoma Watershed Project. These improvements included 34 miles of channel works along Santa Rosa Creek from its confluence with the Laguna de Santa Rosa to beyond the City of Santa Rosa Civic Center complex. Also included were channel improvements on certain tributaries of Santa Rosa Creek: Piner Creek, Paulin Creek, Brush Creek and its tributaries, Spring Creek and Matanzas Creek. The project further involved flood detention reservoirs on Paulin Creek, Brush Creek, Matanzas Creek and one off-stream reservoir for Santa Rosa and Spring creeks.

Under a Federal cost-sharing program administered by the SCS many property owners installed bank protection works along the mainstem of the Russian River, particularly in the Ukiah and Hopland Valleys. These usually consisted of wire mesh fencing attached to driven timber piling which, due to its rigidity, often collapsed as river flows undermined the pilings and caved the river banks. In some places collapsed works have been replaced by more reliable flexible-type works, such as those employed by the Corps in its bank stabilization projects.

Besides bank stabilization works, local entities constructed flood control levees in the upper end of Alexander Valley near Cloverdale, along Dry Creek and at scattered sites in other portions of the basin. On the average, these levees were intended to provide protection against floods of a magnitude likely to occur once every ten years. Most of these levees were constructed with native river gravels, and in most cases were not provided with erosion protection on the riverward side. Consequently, some of these levees failed, due either to erosion or overtopping by floodflows. Some of these have been replaced and strengthened since the mid-1950's in accordance with emergency authorities available to the Corps of Engineers.

With the exception of SCS and privately sponsored projects, responsibility for operation and maintenance of the remaining works discussed above, including Corps projects, rests with the appropriate counties. The adequacy of county maintenance programs for Corps channel projects on the Russian River is monitored by the Corps San Francisco District office. Updating of the Operation and Maintenance Manuals prepared by the Corps for use by the counties in their maintenance programs is conducted periodically.

Extensive monitoring of the Dry Creek channel, a tributary of the Russian River, is being conducted by the Corps in conjunction with the Warm Springs Dam project. The goal of this effort is to document channel conditions prior to completion of the project. Monitoring will probably continue for three to five years following completion, and should new areas of serious erosion develop, construction of bank stabilization and/or channel improvements will be considered on a case-by-case basis.

b. Problems and Opportunities

Currently, certain reaches of the Russian River and its tributaries are suffering renewed bank erosion and meandering of the stream channel, which is threatening private riparian property as well as a number of publicly-owned structures. Additionally, since completion of channel improvements along the Russian River and portions of its tributaries by the Corps in 1972, certain of the structures have degraded significantly. Related channel works constructed by the Sonoma County Water Agency have sustained similar damages.

In the Russian River mainstem, serious bank erosion just upstream of the Jimtown Bridge is a continuing problem. Upstream of the Geyserville Bridge, meandering of the River is threatening to sever River Lane, with State Route 128 possibly threatened during a major flood. Major Corps bank stabilization works constructed near Geyserville have been completely destroyed, and 600 feet of heavy stone rip-rap placed along the river by the Sonoma County Water Agency to prevent further erosion may soon be undercut by the meander. While such use of heavy stone by Sonoma County has been effective in preventing erosion in some cases, in the alluvial reaches of the Alexander Valley flanking or undermining of heavily rip-rapped sites has occurred.

Significant damage has also been sustained by flexible bank stabilization works installed by the Corps of Engineers along the Russian River mainstem. Long periods of high flows during the winter of 1978 undermined the anchorages of several jacklines and allowed the structures to wash away. Loose jacks and broken or dislocated upstream ends of jacklines have created hazards for boaters and proven difficult to repair. Heavy riprapping used by Sonoma County in lieu of repair of the flexible works has in some cases failed to halt erosion.

The Dry Creek channel below the Warm Springs dam site has also experienced severe bank erosion and channel degradation. The lower portion of the channel has widened considerably over the past twenty years, eliminating approximately 74 acres of farmland and requiring renovation of Westside Bridge. Tied pilings installed in this area by the Soil Conservation Service have mostly failed. Severe erosion has occurred in the vicinity of Pine Ridge Creek and near property used by the Sonoma County Department of Public Works. The worst recent single case of erosion in Dry Creek occurred about eight miles upstream of the mouth, where lateral movement of the stream channel increased the channel width from 150 feet to nearly 600 feet, washing out nine acres of potentially arable land.

Much of the bank and channel erosion and damage to bank stabilization and channel improvement works along the Russian River and its tributaries may be attributable to the unpredictable and rigorous nature of flows along the Russian River. However, another major cause may be gravel mining in the streambed.

In-stream gravel mining has often been mentioned in discussion of erosion problems in the Russian River basin. Some riparian landowners believe commercial removal of sand and gravel from the bed of the Russian River mainstem and its tributaries alters the erosion potential in certain reaches, resulting in excessive bank and channel erosion and meandering of the stream channel, with consequent loss of valuable agricultural, residential and commercial lands. The Sonoma County Planning Department, in an effort to evaluate this situation and supplement its existing gravel mining permit system, hopes to eventually utilize the computer-based bedload model provided to the County by the Corps of Engineers as part of this study. It is planned that the model will aid the County in determining the most beneficial locations and quantities for future mining operations, with a view towards minimizing any associated streambank and channel erosion problems.

Timely inspections and prompt maintenance of existing stream channel and bank improvement works are essential to their continued effectiveness. The Sonoma County Water Agency, under enacted assurances of local cooperation, is required to inspect and maintain Federally-constructed bank stabilization and channel improvement works along the Russian River and its tributaries. However, the Agency has had problems maintaining Corps erosion-prevention works, particularly where jacklines were involved. In addition, a number of Agency proposals for Federally-funded repair of damaged areas and structures under Public Law 84-99 were determined by the Corps of Engineers not to be economically feasible.

c. Further Study

In addition to damage to some bank stabilization and erosion protection structures along the Russian River and its tributaries, various unprotected reaches have sustained significant erosion damage. While repair and reconstruction of these sites may in certain instances be economically justifiable given the damage caused by erosion, study of more comprehensive river improvement, stabilization and flood management plans would be required to properly address the problem on a basin-wide level and to develop long-term solutions. This study could address topics such as the construction of improved bank stabilization and channel improvement works and the assurance of adequate future maintenance, the use of non-structural improvement measures such as revegetation, the effectiveness of local erosion prevention efforts, the various beneficial and detrimental effects associated with the movement and accumulation of sand and gravel deposits along the Russian River and its tributaries, and the economic issues relating to channel improvement and bank stabilization.

Both Sonoma and Mendocino County have become involved in managing the sand and gravel resources of the Russian River basin, including evaluation of such often related problems as bank erosion and channel degradation. Sonoma and Mendocino County, as well as the U.S. Fish and Wildlife Service and the Resources Agency of California have expressed the desire for additional Federal involvement in evaluating these resources and problems. In light of these developments, further Federal study of erosion and associated problems and channel improvements and stabilization in the Russian River basin appears warranted at this time.

3. <u>Summer and Recreational Type Dams</u>

a. Existing Conditions

1) Definition

Summer and recreational-type dams are temporary structures placed across a watercourse to provide deep, slow-moving bodies of water. These dams are emplaced for a variety of purposes including recreational enhancement and water supply. The summer dams on the mainstem of the Russian River are of a variety of types including an inflatable dam at the Wohler intake, sheet piling and flash board structures with gravel embankments, and a flash board structure on a permanent concrete sill. The dams are installed in late spring, generally just prior to Memorial Day if flow conditions in the river permit. The dams are generally removed at the end of the recreational season; i.e., just after Admission Day - September 9. The dams on the mainstem of the Russian River are owned and operated by a number of public agencies including recreational districts, Sonoma County and the Sonoma County Water Agency.

Annually, up to two hundred summer and recreational type dams are constructed on the Russian River and its tributaries. The dams range from small gravel dams on the tributary streams to large-scale, semi-permanent structures on the Russian River itself. The principal use of the dams and impoundments is recreation, although some peripheral uses such as water supply for agriculture, livestock and firefighting are also common. Specific data on the numbers and locations of summer dams placed each year are limited. The major dams constructed annually on the main river by local governmental agencies are well documented, but the majority of the small tributary dams are not.

Concern on the part of both residents and visitors has been expressed regarding alleged water quality problems caused or aggravated by the summer and recreational-type dams. Certain of these problems may result from the activities of and lack of proper sanitation facilities for the recreationists themselves. In response to these concerns, the North Coast Regional Water Quality Control Board (NCRWQCB) has recommended comparisons of basic water quality conditions, algal biomass and productivity upstream and downstream of the dams both before and after their construction. A program for such monitoring was contained within the comprehensive water quality monitoring element discussed in the Russian River Basin Study Phase I Study Report, but was found infeasible.

Establishment of summer dams on the mainstem of the Russian River and its tributary streams poses a threat to the fishery. The California Department of Fish and Game (CDFG) has expressed concern over the loss of fishery access to spawning habitat in the upper reaches of the tributaries. The question of possible increases in water temperature due to heating up of slack water behind the impoundments, which may be harmful to the fishery, has also been raised by the Department.

In keeping with these concerns and cognizant of the limitations of study funding and duration, it was deemed appropriate to restrict the primary study of this topic to summer dams on the Russian River main stream.

2) Operation

Beginning in the 1930's, temporary flashboard recreation dams have been regularly installed on the lower Russian River during the summer recreation season. The dams, which are currently located at Vacation Beach, Johnson's Beach, Healdsburg and Del Rio Woods (Plates 5 through 8), are normally installed by Memorial Day at the end of May and removed by the week after Admission Day, September 9. The Vacation Beach and Johnson's Beach dams are installed by the Russian River Parks and Recreations District. The Sonoma County Water Agency installs the Healdsburg Dam, and the Del Rio Woods Homeowners Association installs the Del Rio Woods Dam.

The Sonoma County Water Agency operates Wohler Dam, a semi-permanent inflatable structure, for water diversion on the lower Russian River. The inflatable dam was constructed in 1976 and impounds water to increase percolation to Ranney wells in the river gravels, supplying water to the City of Santa Rosa as well as portions of Sonoma and Marin Counties. This dam is deflated in the fall or winter when stream discharges exceed approximately 1,000 cfs and if stream flows are sufficient, remains deflated until the stream discharge drops below 1,000 cfs in the spring. The Willow County Diversion Dam is a permanent instream structure located on the river near the City of Ukiah and is maintained by the Willow County Water District for municipal water supply.

A detailed description of the operation of summer recreation and water diversion dams on the Russian River is provided in Appendix F.

Fourteen different recreational area/facilities are directly affected by the summer dams. These areas contain a total of approximately 23 acres of beach devoted primarily to water-oriented recreation. An inventory of the areas can be found in Appendix C. These areas/ facilities range from highly developed to virtually undeveloped. Five of the 14 recreation areas are maintained by private owners/

operators. Four areas are maintained by public agencies, one is operated by a boat club, and the rest are undeveloped or not expressly maintained for recreational purposes. Facilities at Healdsburg Memorial Beach and Johnson's Beach are the most highly developed recreation facilities. The area in the vicinity of Wohler Dam and Wohler Bridge, on the other hand, is undeveloped.

In general, the recreational areas are relatively small in size and minimally developed. None of the facilities have much more than local "drawing power". In other words, the recreation use at the areas is generated primarily because of the attraction of the Russian River, and not the development of its recreation facilities. The fact that public access to the river is limited has contributed to these areas being places of concentrated recreation activity.

3) Water Quality

The principal water quality problems of the Russian River have historically been high turbidity during the winter and spring months due to high runoff and erosion, persistent turbidity caused by diversions from the Eel River basin, and high summer nutrient loading in the lower river due primarily to the high discharge of domestic sewage effluent.

While concern does exist regarding persistent turbidity problems in the Russian River due to the inflow of highly turbid Eel River water, this concern will not be addressed in this report. This problem has been recognized in previous studies conducted by several public entities, including the Corps of Engineers, the Federal Power Commission (FPC), the Federal Energy Regulatory Commission (FERC) and the California Department of Water Resources. Also, the effects of installing a multiple outlet structure at Coyote Dam to reduce turbid water discharges will be considered in any Coyote Dam enlargement study conducted by the Corps.

A water quality investigation, conducted by the California Department of Water Resources in 1968, identified the discharge of sewage effluent into the Russian River and its tributaries during the summer months as the major water quality problem within the basin. At that time the cities of Ukiah, Cloverdale, Healdsburg, and Sebastopol discharged secondary-treated domestic sewage into the Russian River only during the winter and spring high stream flow periods, and practiced land disposal during the summer low flow months.

However, the City of Santa Rosa discharged secondary-treated effluent all year into the Laguna de Santa Rosa, which then flowed into the Russian River. The investigation concluded that summer discharge from the Laguna de Santa Rosa resulted in high coliform counts and high nutrient concentrations (mostly nitrates and phosphates) which stimulated excessive growths of attached and floating algae in the warm waters of the lower Russian River.

Since the discharge of sewage effluent into the Russian River during the summer months was stopped in 1977, the major water quality problems associated with nutrient loading in the lower river have been significantly reduced. However, gradual downstream degradation of water quality still continues due to erosion, runoff from agricultural and urban areas, leaking septic tanks and high natural mineral levels in some of the tributaries of the lower river. Summer sampling of water quality in the Russian River by the North Coast Regional Water Quality Control Board has continued since 1973-1974 in order to monitor these trends. Some of the major water quality parameters included in the monitoring program are water temperature, dissolved oxygen, pH, turbidity, specific conductance, and nitrate and phosphate levels. The monitoring has shown that some sporadic violations of water quality standards still occur and that seasonal turbidity from storm runoff and nonpoint source nutrient loading are the major remaining water quality problems.

4) Fisheries Resources

The fisheries resources of the Russian River, excluding the marine species that may inhabit the brackish water lagoon at Jenner (Table 4), consist of an estimated 34 species (Table 5). Both resident freshwater species which spend their entire life cycle in the river, as well as anadromous species, are present. Anadromous fish species hatch and develop to the juvenile stage in fresh water, then migrate to the ocean where they mature. They return as adults to spawn in fresh water, completing their reproductive cycle. The anadromous species of steelhead, silver salmon, king salmon and American shad are the primary species considered by this report, because they have the highest sport fishing value in the Russian River basin.

The Russian River and its tributaries support one of the most important salmonid fisheries along the central coast of California. The basin ranks third in the State in steelhead production and supports a sizable run of silver salmon. An estimated 57,000 steelhead trout and 5,500 silver and king salmon use the Russian River drainage annually as a spawning area. The Russian River and its tributaries provide about 682 miles of stream habitat, about 110

Table 4

MARINE FISHES FOUND IN NORTH COAST STREAMS OF CALIFORNIA

Common Name	Scientific Name
Pacific herring	*Clupia harenguis* - 0
Surf smelt	*Hypomesus pretiosus* - 0
Longfin smelt	*Spirinchus thaleichthys* - N
Topsmelt	*Athernop affinis* - 0
Bay pipefish	*Syngnathus leptorhynchus* - N
Shiner perch	*Cymatogastu aggregata* - 0
Tidewater goby	*Eucyclogobius newberryi* - N
Yellowfin goby	*Acanthogobius flavimanus* - I
Arrow goby	*Clevelandia ios* - 0
Penpoint gunnel	*Apodichthys flavidus* - 0
Saddleback gunnel	*Pholis ornata* - 0
Sharpnosed sculpin	*Clinocottus acuticeps* - 0
Staghorn sculpin	*Leptocottus armatus* - N
Coastrange sculpin	*Cottus aleuticus* - N
Starry flounder	*Platichthys stillatus* - 0

0 = Occasional marine visitor
N = Native
I = Introduced

Source: Moyle, P. B. *Inland Fishes of California*. University of California Press. 1976.

Table 5

FISHES OF THE RUSSIAN RIVER DRAINAGE

Common Name	Scientific Name
Pacific lamprey	Entosphenus tridentatus
Brook lamprey	Lampetra planeri
White sturgeon	Acipenser transmontanus
Green sturgeon	Acipenser medirostris
American shad	Alosa sapidissima
Fink salmon	Oncorhynchus gorbuscha
Silver salmon	Oncorhynchus kisutch
King salmon	Oncorhynchus tshawytscha
Brown trout	Salmo-trutta
Steelhead trout	Salmo gairdnerii
Western sucker	Catostomus occidentalis
Carp	Cyprinus carpio
Greaser blackfish	Orthodon microlepidotus
Hardhead	Mylopharodon conocephalus
Hitch	Lavinia exilicauda
Sacramento squawfish	Ptychocheilus grandis
Splittail	Pogonichthys macrolepidotus
Venus roach	Hesperoleucus venustus
White catfish	Ictalurus catus
Mosquitofish	Gambusia affinis
Striped bass	Roccus saxatilis
Smallmouth bass	Micropterus dolomieu
Largemouth bass	Micropterus salmoides
Green sunfish	Lepomis cyanellus
Bluegill	Lepomis macrochirus
Sacramento perch	Archoplites interruptus
Black crappie	Pomoxis nigromaculatus
Tule perch	Hysterocarpus traskii
Riffle sculpin	Cottus gulosus
Prickly sculpin	Cottus asper
Aleutian sculpin	Cottus aleuticus
Three-spined stickleback	Gasterosteus aculeatus
Channel catfish	Ictalurus punctatus
Brown bullhead	Ictalurus nebulosus

Source: Report to the Federal Power Commission on the Fish and Wildlife Aspects of the Relicensing of the Potter Valley Hydroelectric Project (F.P.C. Project #77) Lake and Mendocino Counties, California by K.R. Anderson. California Department of Fish and Game. Region 3. March 1972.

miles (16 percent) of which is in the mainstem of the Russian River. The California Department of Fish and Game indicates that about 448 miles of the Russian River and its tributaries are used by steelhead, 132 miles by silver salmon and 101 miles by king salmon for passage, spawning, egg development and juvenile rearing (Table 6).

Sampling of the fish population of the Russian River and its tributaries during the summer months from 1952 to 1955 revealed that the population of the mainstem consisted of 90 percent rough fish, 8 percent warmwater game fish and only 2 percent resident trout and juvenile steelhead. Most salmonids in the drainage, the majority of which were juvenile steelhead, were found in the headwater areas of the tributary streams.

Yearling (juvenile) steelhead trout caught in the tributary streams make up a large part of the summer fishing in the Russian River, and stocking of fish in the river and its tributaries has consisted mainly of juvenile steelhead rescued from dewatered or intermittent tributary streams during the summer low flow months. In some years this salvage effort has involved as many as 350,000 fish.

A significant American shad population estimated at between 11,000 and 22,000 adult fish is present during the spring and summer in the lower Russian River and provides an important sport fishery for the area. Shad migrate from the ocean up the river mainly from April through July. Peak migration occurs from late May to early June. Even though the entrance channel is partially blocked by a sandbar during part of this time, significant numbers of shad are able to negotiate the mouth of the river and migrate to the upper reaches. Total closure of the mouth usually does not take place until late fall.

A generalized description of the life history characteristics of steelhead, silver salmon, king salmon and American shad in the Russian River is presented in Appendix B. The life history descriptions are supplemented by "Environmental Criteria Guidelines" which represent the critical resource needs of the species. The guidelines incorporate criteria in fisheries literature and input from California Department of Fish and Game fishery biologists. After initial formulation, the criteria were informally reviewed by the CDFG and the NCRWQCB, and appropriate adjustments made to more closely reflect the needs of the respective fish species within the Russian River drainage.

As a result of climatic conditions, stream flows have historically been high during the winter rainy season with periodic flooding, shifting of stream channels and cleaning of channel gravel areas used as spawning and nursing areas by steelhead and salmon. During the spring and summer, stream flows have normally decreased progressively, with the upper part of the river and the lower reaches of

Table 6

MILES OF STREAM CHANNEL IN RUSSIAN RIVER DRAINAGE USED BY SALMONIDS

	Total Available Stream Channel Habitat	Used by King Salmon	Used by Silver Salmon	Used by Steelhead
Russian River (mainstream)	109.5	100.5	31.5	109.5
Dry Creek	50.5	-	11.0	50.5
Other Tributaries*	522.0	1.0	89.5	288.5
Total	682.0	101.5	132.0	448.5

*Tributaries to both Russian River and Dry Creek.

Source: Report to the Federal Power Commission on the Fish and Wildlife Aspects of the Relicensing of the Potter Valley Hydroelectric Project (F.P.C. Project #77) Lake and Mendocino Counties, California by K. R. Anderson. California Department of Fish and Game. Region 3. March 1972.

the tributaries becoming intermittent or dry in summers of dry years. Since 1908, water from the Eel River has been diverted into the East Fork of the Russian River through the Potter Valley powerhouse, maintaining a minimum summer flow of 100-150 cfs in the mainstem of the river except during certain dry years.

The pre-1908 natural flow regime exhibited more variation in the mainstem of the river. Under these conditions, spawning and nursery areas for salmonids existed in most of the tributary streams and in the main forks of the Russian River upstream from Ukiah. The mainstem of the river below Ukiah historically became too warm during the late spring and summer months to provide nursery or spawning habitat for salmonids. With the start of the Eel River diversions, it is likely more spawning and nursery habitat was made available in the east fork of the Russian River and the Russian River mainstem downstream of the confluence.

During wet years prior to 1908, most steelhead and salmon spawning and rearing took place in the upper reaches of the river and in the tributary streams. In dry years, spawning and rearing habitat was limited to the mainstem of the river since access to the tributary streams was unavailable to adult salmonids migrating upstream. The utilization of the tributary streams as spawning and nursery habitat during years of high and moderate rainfall was a key adaption in the success of the salmonid fishery in fluctuating climatic conditions. Below Ukiah the river served mainly as an inmigration route for adults during the winter and spring, and as an out-migration route during the late spring and summer months since this area then became too warm to provide suitable nursery or spawning habitat.

As agricultural and urban development and related land use activities intensified in the Russian River basin over the past 40 to 50 years, progressive degradation and loss of anadromous salmonid spawning and nursery habitat occurred. Although inventory data on anadromous fishes in the basin is insufficient to show actual trends, indications are that extensive losses of habitat, particularly steelhead habitat, occurred subsequent to 1962. A factor contributing to this loss has been the establishment of numerous seasonal recreational and water diversion dams on the tributary streams. The tributary streams, compared to the mainstem, are more sensitive to hydrologic changes induced by various land and water uses.

While specific information on total spawning and rearing habitat in the tributaries of the Russian River basin is not available, indications are that these habitats are very important to the basin's anadromous fisheries. California Department of Fish and Game data (Table 6) indicate that 84% of the basin's available habitat is in the tributaries. The seasonal dams on the tributaries of the Russian River, while small in size, can change the seasonal temperature regimes of many of the streams during the summer low-flow months. By reducing the summer streamflow early in the season, they restrict juvenile salmonid nursery habitat to shaded areas in isolated pools and spring seeps where water temperatures remain suitable. Higher stream temperatures associated with the lower flows also encourage the growth of nongame fish populations such as roach, suckers and squawfish which are serious competitors with game fish.

Moreover, the numerous recreation and water diversion dams on the tributary streams may also act as barriers to migration (upstream movement of salmonids during spawning runs) and cause increases in stream turbidity and the silting of the stream beds, resulting in the destruction of fish and fish habitat. These impacts may occur both during dam construction in the spring or summer and when the gravel fill used to form most of the summer dams on the tributaries is washed downstream during high flows in the fall and winter months.

Land use changes have also adversely affected the habitat of tributaries through vegetation removal, channelization and siltation. Logging in stream headwater areas, overgrazing, and the building of roads along streams have resulted in silting of stream beds during the rainy season, eliminating both spawning and nursery habitat. Sand and gravel mining in the Russian River and some tributaries has resulted in similar destruction of habitat due to increased turbidity, silting and removal of spawning gravels. Channelization of streams for flood control purposes has also reduced the amount of salmonid habitat.

With the completion of Coyote Dam and Lake Mendocino on the East Fork of the Russian River in 1959, approximately 35 miles of anadromous salmonid spawning and nursery habitat were eliminated. However, the cold water releases from Lake Mendocino shifted the natural warming trend in the river downstream, making a previously unsuitable portion of the mainstem available for spawning and nursery habitat along the 19 miles between Hopland and the dam. Thus, the extent of the mainstem historically used for migration only has probably been reduced. The reach of the mainstem downstream of Hopland remains unfit for juvenile rearing due to high water temperatures during the summer. Altogether, the 109 miles of the Russian River mainstem contain only about 53 miles of habitat suitable for salmonid spawning, egg development and juvenile reading. Of course, the relative importance of the mainstem to anadromous fishes varies according to hydrologic conditions.

The habitat loss resulting from all of the above-mentioned activities of man is the primary factor limiting the success of the anadromous salmonid fisheries in the Russian River drainage.

b. Problems and Opportunities

1) Water Quality

Based on existing data the summer recreational dams on the Russian River itself have little clearly identifiable effect on river water quality while they are in place. Although studies to date have not been designed to thoroughly evaluate water quality changes relative to the dams, no significant water quality problems have developed that have been related to the existence of the dams, with the exception of increases in turbidity during installation and removal of the dams. Questions still remain as to the long-term cumulative impacts of these dams particularly with regard to water temperature. Much more data is needed to definitively assess these impacts. Existing data concerning the effects of the recreational dam operations on the water quality of the Russian River are described below.

The California Department of Fish and Game, Region 3, collected water temperature data during a study of American shad in 1971. However, these data only include samples taken upstream and downstream of the Johnson's Beach (Guerneville) and Vacation Beach (Hatcher's) summer dams from mid-May through July.

The North Coast Regional Water Quality Control Board conducted a similar 1-day daytime study in August 1973. This study included temperature, dissolved oxygen, pH and alkalinity samples taken upstream and downstream of the Johnson's Beach dam.

As part of this Russian River Basin Study limited water quality data was collected on the mainstem during the evaluation of fish habitat and fish migration barriers (Appendix F). The information included water temperature, dissolved oxygen and turbidity levels both upstream and downstream of each recreational dam as well as within the impoundments.

The only clearly identified impact of summer dams on water quality is in regard to their installation and removal which cause temporary increases in stream turbidity. To reduce or eliminate these increases, agencies installing and removing the dams are presently required to comply with the North Coast Regional Water Quality Control Board's waste discharge requirements, which stipulate allowable turbidity levels and methods of operation within the stream channel.

On the basis of data and information currently available, the summer recreation dams, while in place, appear to have little effect on the water quality of the river during the low flow summer months.

2) Fisheries Resources

The following evaluation of the impacts of summer recreation dam operations on steelhead trout, silver salmon, king salmon and American shad in the Russian River mainstem is based on the "Environmental Criteria Guidelines" outlined in Appendix B. The guidelines were used to identify critical periods during which recreation dam operations on the lower Russian River may affect the environmental needs of the fish species of concern, and to define the specific nature of these effects.

The outmigration of juvenile salmonids will be adversely affected to the extent that smolts are present when the dams are in place. While most juvenile salmonids leave the river in March, April and May, some stay until June. Placement of the dams in late May makes it more difficult for the remaining fish to swim downstream.

The summer recreation dam operations also affect the inmigration of occasional early-running king salmon in August and early September. While the normal run occurs in September, October and November, early-running king salmon have been observed in the river in August. If current efforts to rear a strain of late-running king salmon in the Warm Springs fish hatchery on Dry Creek are successful, the dams will not be barriers to passage by this species. The late-running king salmon are expected to run in late November and early December when the summer dams are not in place. Winter conditions at some dam sites may also cause salmonid passage problems during adult inmigration due to debris build-up around permanent piers.

In early 1980 the California Department of Fish and Game began planting a strain of summer steelhead in the Russian River. Native strains of summer steelhead exist in the Eel and Mad River basins north of the Russian River basin. The first plants in the Russian River amounted to approximately 150,000 yearling smolts expected to migrate to the ocean soon after planting. Approximately 5% of these plants are estimated to return as adult fish to spawn in the river in one to three years. The mature steelhead will return to the river between April and early July. They are expected to spend the summer in cool, deep pools in the upper river and spawn late in the following winter and early spring. Plants were made in March 1981 and will be made again in 1982. The first fish from the 1980 planting are expected to return to the basin in mid-1982. The summer dams may inhibit the upstream migration of these summer steelhead and prevent their establishment in the Russian River basin.

The summer recreation dams on the lower Russian River have historically created barriers to the upstream migration of adult shad during the early summer. Summer dams affect shad more severely than the other anadromous species, primarily due to their limited ability to negotiate barriers and their method of egg incubation. The summer recreation dams, in general, create the fewest problems for the silver salmon. This is because these salmonids use habitat afforded by the mainstem and about twenty tributaries in the lower section of the basin downstream from Healdsburg Dam.

Prior to the construction of Healdsburg Dam in 1952, shad migrated to the middle and upper parts of the Russian River; as far up as Ukiah in some years. However, since construction of the dam, shad have been confined to 32 miles of the mainstem downstream of Healdsburg. This is roughly 29 percent of the mainstem habitat available to migrating shad before construction of the dam. The habitat now available to shad is probably less suitable for reproduction due to increased predation, sedimentation and human activity, and decreased streamflow, cover and food supply.

In 1973, Denil-type fishways were installed at Vacation Beach and Johnson's Beach dams to reduce passage problems. These fishways were subsequently modified in 1975 to improve conditions for shad passage. Observations of fish using the Vacation Beach Dam (Hatcher's) fishway were made from the time the dam was installed on June 2, 1973 until August 6, 1973. During that time, 11 shad were observed moving upstream and 8 shad were seen moving downstream. This indicates that individual shad can pass through the fishway; however, due to late placement of the dam in 1973, most of the spawning run had probably already occurred.

The two modified Denil-type fishways at Wohler Dam were included in construction of that facility and have the same design characteristics as those located at Vacation Beach and Johnson's Beach dams.

In the mid-1970's, a plan was developed to add a fish passage structure to Healdsburg Dam. However, this plan was never implemented due to difficulties encountered by the Sonoma County Water Agency and the California Department of Fish and Game in assuring sufficient construction funds.

The study of barriers to fish migration in the Russian River (Appendix F) included both summer and winter evaluations of Vacation Beach, Johnson's Beach, Healdsburg, and Del Rio Woods summer recreation dam sites on the lower river as well as the Wohler water diversion dam. The evaluations focused primarily on adult inmigration.

Evaluation of summer conditions at Vacation Beach, Johnson's Beach and Wohler dams indicated that, due to the presence of modified Denil fishways at each dam, upstream movement of both American shad and king salmon was possible. Winter conditions at both the Vacation Beach and Wohler Dam sites presented no passage problems for upstream movement of adult salmonids; however, the concrete and steel piers which remain in the river at the Johnson's Beach site often catch debris which may limit fish passage.

Evaluation of summer conditions at Healdsburg and Del Rio Woods dams indicated critical fish passage problems at both locations, neither of which contain fishways. Healdsburg Dam, involving a 15-foot high freefall under the spillway when in place, eliminates any possibility of significant shad, king salmon or summer steelhead migration up the river. Summer conditions at Del Rio Woods Dam would prevent shad passage and inhibit passage of early run king salmon and summer steelhead if passage over Healdsburg Dam were accomplished. Water velocities of 7 fps over the spillway are near the upper limit of salmonid passage capabilities (8 fps). Turbulence and a water depth of only 0.5 feet over most of the spillway were also judged to constitute potential upstream passage barriers for king salmon and shad. In addition, besides having to negotiate the fishways in the lower river, early-running king salmon must hold up at the Healdsburg Dam until the flashboards are removed after Labor Day. The combined stress of negotiating summer dams and fishways, and holding up in warm water, can accelerate the natural physiological decline of migrating fish and reduce spawning success.

An evaluation of winter conditions at Healdsburg Dam revealed a number of fish passage problems for upstream migrating salmonids. The permanent concrete sill of the dam creates a 5-foot high barrier across the entire river. While the sill was originally constructed at grade, subsequent erosion downstream of the sill has lowered the streambed approximately 18 feet. In the late 1960's the Sonoma County Water Agency placed heavy riprap downstream of the sill in an effort to retard further degradation. Some of this material has since eroded away leaving a 5-foot drop below the sill. At the winter flow observed (estimated at 1,800 cfs), a spillway velocity of 8.7 fps was recorded which is above the normal limit of 8 fps for salmonids. Such flows could create a velocity barrier to the upstream movement of salmonids; flows lower than those observed would reduce water depth over the barrier and reduce the resting habitat and take-off areas below the dam. The riprap placed in the river below the dam also creates turbulent conditions which increase the difficulty of upstream passage.

Before entering the salt water environment, juvenile salmonids must undergo a physiological change called smoltification. Most smolting and outmigration of juvenile salmonids occurs from March through May, though some outmigration may occur all year if flows and temperatures are adequate. The placement of the recreation dams in late May adversely affects this outmigration in a number of ways. The downstream movement rate of salmonids is related to stream flow velocities, and the migration time through large impoundments may be three times longer than that for the natural run of a river (this is approximately equal to the difference in water velocity). Any increase in the travel time of salmonid smolts through the lower Russian River impoundments would result in longer exposure to high water temperatures and predation from birds and warmwater fish such as black bass and crappie. Smoltification cannot be completed nor can the smolt condition be maintained at water temperatures above 15 degrees C. Therefore, delay of smolt movement through the lower river during May or June, when average monthly temperatures range from 18 to 24 degrees C, may cause desmoltification and prevent successful outmigration. Juvenile steelhead are particularly susceptible to these pressures. Unlike salmon the majority of these fish remain in the streams where they hatched for two, and occasionally three, years before smolting.

Changes in water depth and flow velocity patterns of the lower Russian River which are caused by installation of recreation dams may also result in ecological changes in the aquatic community and adversely affect shad production as well as salmonid smolt passage through the area. Elimination of fast water riffle areas or "runs" by the impoundments and the siltation of channel gravels may cause a decline in the aquatic invertebrate community on which young shad feed. The change from a stream to a lake-like environment is also likely to change the predator-prey relationships of the various fish species inhabiting the area, favoring large carnivorous fish such as large and smallmouth bass which feed on small fish such as juvenile shad and salmon. In the tributaries juvenile salmonids can be trapped between the summer dams, making them especially vulnerable to angling pressure.

Since shad currently spawn throughout the lower part of the Russian River in riffle or "run" areas at the lower end of naturally occurring pools, the placement of the summer recreation dams adversely affects spawning success by flooding the riffle areas and reducing current flows. Placement of the dams reduces flow velocities to almost negligible levels and causes siltation of the impoundment bottoms. In the absence of any current, shad eggs laid within or drifting into the impoundments would settle to the bottom and may be smothered by the silt, thus jeopardizing their hatching success.

Although the existing modified Denil-type fishways on the lower Russian River are individually passable by shad, the necessity for shad to pass through a number of fishways is believed to have an adverse effect on upstream migration. Even if fishways were present at both Healdsburg and Del Rio Woods Dams, a reticence to use the fishways and resultant delays in migration may prevent shad from reaching appropriate spawning areas in the middle reaches of the Russian River, thus preventing full use of the river for shad production.

Installation and removal of the recreation dams also creates a fish passage problem due to temporarily increased stream turbidities which may result in fish suffocation or inhibition of upstream movement. Siltation resulting from increased turbidities may also cause a loss in benthic invertebrates which are a major food source for salmon and shad. Sedimentation following dam removal may also smother shad eggs.

The timing of the shad run and outmigration of smolting salmonids is dependent on climatic conditions which vary from year to year. Both migrations may occur later during high water years with lower water temperatures. Thus, the impacts of the recreation dams on shad and salmonid reproduction will vary from year to year.

In summary, the summer dams presently create some fish passage problems, particularly with respect to the inmigration of American shad, early run king salmon and summer steelhead at Healdsburg Dam where no fishway structure exists. The Del Rio Woods summer dam, upstream of Healdsburg, also prevents fish passage when it is in place. The other dams on the mainstem include fishways.

Outmigration of juvenile salmonids is adversely affected to the extent that smolts are present when the dams are in place. The impoundments make it more difficult for the fish to swim downstream, and they are exposed to increased predation in the slower, deeper impoundments. Successful outmigration may also be prevented by increased water temperatures in the impoundments.

Shad spawning, egg incubation, fry emergence and rearing may be adversely affected by the impoundments. The eggs, which must drift in moving water, may come to rest on the bottom of the pool behind the dams and be smothered by sediment.

Installation and removal of the dams increases stream turbidities, increasing the threat of fish suffocation and loss of benthic invertebrates, an important source of food for salmon and shad.

c. Further Study

While there are currently no studies underway of summer and recreational-type dams on the Russian River or its tributaries, a number of Federal and local agencies have regulatory authority over the summer dams.

The Corps of Engineers has authority under Section 10 of the Rivers and Harbors Act of 1899 to regulate all activities involving structural works in the nation's navigable waterways. The navigable portion of the Russian River extends from the ocean to Vacation Beach. The Corps also has permit authority under Section 404 of Public Law 92-500 (the Federal Water Pollution Control Act Amendment of 1972 and supplemental amendments) to control activities in the nation's waterways to protect the quality of our water resources. For purposes of this investigation, the Corps Section 404 authority involves control of the disposal of dredge or fill material into the nation's waters.

The Corps Section 404 permit authority encompasses the entire length of the Russian River and the tributaries of Austin, Mark West, Maacama, Big Sulphur, and Forsythe Creeks, and the East Fork of the Russian River. After Warm Springs Dam is completed, Dry Creek will be included under the Section 404 authority as releases from the dam will provide sufficient flow in the creek for it to fall into the category of "waterway" specified in the regulations.

As Section 404 permit authority is applicable to the discharge of dredge or fill materials into a waterway, many small dams on the designated tributaries of the Russian River require a Section 404 permit as their construction involves a discharge to the watercourse. Also, any summer dam on the Russian River would require a permit if dredge spoils from construction were to be discharged to the river.

The Corps, as part of its permit procedures, coordinates with other agencies who have either permit authority or an interest in the proposed project. For example, the Corps usually does not issue a Section 404 permit until the California Department of Fish and Game has completed its review procedures to provide for maintenance of or mitigation of damages to the fisheries resources in the vicinity of the project.

The California Department of Fish and Game, through its 1600-series regulations, has the authority to require any party desiring to initiate construction or other work between the banks of any water body in California to apply for a Department permit. The Department reviews the permit application and evaluates the potential impacts of the proposed project on the fish and wildlife resources associated with the project site. The Department then specifies which changes, if any, should be made in the project plan, construction methods, or operation so as to eliminate or reduce any adverse impacts the project may have on these resources. The Department applies its 1600-series regulations to existing summer recreational dams on the river and would have similar authority over any proposed new dams. Similarly, it has authority in all tributaries to the Russian River.

The North Coast Regional Water Quality Control Board requires that owners and operators of summer dams on the Russian River obtain waste discharge permits. This permit requirement is authorized by Public Law 92-500. The dams are considered non-point sources of pollution and permits are required for the installation and removal of the structures. The owner of a dam must notify the Board prior to installation and removal, and must obtain a permit to do so. The owner must then monitor turbidity during dam construction.

Sonoma County, through the Sonoma County Water Agency, exercises permit authority to control increases in turbidity due to construction activities in the river. The County also has jurisdiction over new summer dam construction through land use and grading permit requirements, zoning ordinances and enforcement of the California Environmental Quality Act (CEQA).

These regulatory agencies have the authority to control adverse effects of man's activities on water quality and fisheries resources. Much has already been done by these agencies. The North Coast Regional Water Quality Control Board has, through its basin plan, reversed the trend of degrading water quality in the river. Further, the Board is regulating the implacement of summer dams and road crossings on the river to reduce turbidity.

As previously described, based on current data, summer dams on the main-stem of the river minimally affect water quality. Therefore, no further Federal action by the Corps of Engineers in this area is warranted under the current Russian River Basin Study authorization.

Adverse effects of summer dams on the fisheries resources of the Russian River have been reduced by installation of fish passage structures at the Vacation Beach and Johnson's Beach summer dams by the Russian River Recreation and Park District. The California Department of Fish and Game designed these ladders. The Department is also involved in a plan to introduce a late-running strain of king salmon and a summer steelhead strain into the river. Late-running salmon would encounter only minor passage problems involving the summer dams while the steelhead would encounter significant obstacles during inmigration.

The absence of fish passage facilities at both the Healdsburg and Del Rio Woods Dam sites adversely affects fish passage, particularly shad, early-run king salmon and summer steelhead passage. Construction of such facilities would reduce these effects. The California Department of Fish and Game has indicated that it will continue to pursue installation of these structures.

Usually, steelhead smolt passage take place during the months of March, April and May before the dams are in place. Passage of any remaining smolts in late May and in June may be impeded by the dams.

The adverse impacts the summer dams have on the water quality and/or fisheries resources of the Russian River consist of: increased sedimentation and turbidity levels in the river during construction and removal of the dams; reduction of habitat availability and food supplies; increased predation and migration stress; creation of passage problems for late outmigrating smolting salmonids, early inmigrating king salmon and summer steelhead; and creation of passage problems for salmonids at Healdsburg Dam and for American shad at both Healdsburg and Del Rio Woods dams. While the actual adverse effects these factors may have on the basin's fish populations are difficult to determine, several parties, including the California Department of Fish and Game and the U.S. Fish and Wildlife Service, believe these effects to be significant. In particular, the mainstem of the Russian River is important during dry years when salmonids have no access to the tributaries. In this situation the mainstem serves as a safety valve, providing nursery and rearing habitat in place of the tributaries.

Because of the importance of summer dams on the Russian River to the basin's recreation industry, and the possible impacts of the dams on the river's fisheries, alternative dam management plans were developed as part of the Russian River Basin Study. These plans were developed for consideration for implementation by local interests. Descriptions and evaluation of these alternative plans are presented in Section III - Formulation of Plans. It is hoped that these alternatives will be useful in any consideration of changes in the operations of the summer dams. Local agencies are encouraged to continue their data collection efforts on the water quality and fisheries resources of the Russian River basin. The data collected and assembled during the Russian River Basin Study are available upon request.

4. Mouth of the River

a. Existing Conditions

High winter rainfall and streamflows in the Russian River drainage basin, combined with naturally erodable alluvial soils in the basin's low-lands, annually cause erosion along the river and its banks. Since the settlement of the basin in the mid-1800's, activities such as logging, agriculture, livestock grazing, and other human activities have, in combination with heavy winter storms, also caused significant soil and streambank erosion in some areas. This eroded material contributes to heavy suspended sediment and bedloads in the mainstem of the Russian River and its tributaries. On-going recreational home and commercial development in the Russian River basin and an expected 100% increase in the populations of Sonoma and Mendocino Counties over the next 40 years point toward continued conversion of agricultural land to residential and commercial uses, with consequent erosion and sedimentation problems.

While many streams and rivers with significant sediment loads remain free flowing at their ocean discharge point, depositing their sediment loads considerable distances offshore, others such as the Russian River deposit their loads at the channel entrance. This often creates sandbars or shoaling areas and can restrict upstream and downstream passage of vessels and fish. Why the mouths of certain rivers remain clear year around while others are blocked by sand and bedload deposits is not completely understood but may depend upon complex interactions between wind, waves, tides, streamflows and offshore currents. The subsurface movement of sand and sediment along the coast by ocean processes may particularly affect the mouth of the Russian River, since it has been observed that the channel entrance becomes blocked even during low flow years when little sediment is transported by the river.

b. Problems and Opportunities

Almost since the settlement of the Russian River basin, the mouth of the river has been the object of much attention and controversy. In particular, many attempts have been made to maintain year-round free passage through the mouth of the river for economic development, commercial operations, recreational boating, flood prevention, and fishery access. Historically, navigation between the Russian River and the Ocean has been difficult or impossible due to: 1) formation of a sandbar at the river's mouth during periods of low streamflows; 2) lack of protection from high waves at the channel entrance; and 3) lack of navigational aids to guide vessels through offshore rock formations.

The first attempts at improving navigation through the mouth of the Russian River took place in the late 1920's when local interests and the State of California constructed a jetty extending from the south shore of the mouth of the river out to sea. The original purpose of the 400-foot long structure was to maintain a navigable channel entrance so that natural sands and gravels mined in the estuarine portion of the river could be moved out of the area by barge; however, it never succeeded in providing a navigable inlet for ocean-going vessels.

The River and Harbor Act of 1946 included authorization for the Corps of Engineers to survey the northern California coast for suitable sites for harbors serving shallow-draft vessels. The San Francisco District initiated this study in 1949, including study of a proposed harbor near the community of Jenner at the mouth of the Russian River. A similar proposal was developed by the Sonoma County Planning Commission during preparation of its "Master Plan of Small Craft Harbors for Sonoma County, California," published in 1957. Sonoma County's plans, however, made no provisions for maintaining a safe entrance to the river, which would be required for ocean-going vessels to reach the proposed harbor.

Besides the boating and recreational potential of the downstream reaches of the Russian River, much attention has been given to extracting the sand and gravel carried down by the river and deposited annually in the estuary. These deposits play an important role in local and regional construction activities. In the early 1960's, several mining firms attempted to dredge the mouth of the river to allow material mined in the estuary to be transported by barge to markets near San Francisco. However, due to constant deposition of sediments near the mouth, it was impossible to keep the mouth open. This forced the temporary abandonment of mining operations in the estuary.

In 1969, another proposal was made to dredge the mouth of the Russian River and mine sand and gravel in the estuary. This aroused public concern over preservation of the Russian River basin environment which soon developed into organized opposition to the dredging operations. Following the enactment of stringent waste discharge requirements by the State Water Resource Control Board in 1970, mining of the Russian River estuary was no longer economically viable, and the dredging proposals were dropped.

While the controversy over dredging of the Russian River estuary was taking place, the Corps of Engineers completed its survey on Jenner Harbor in October of 1969. Based on previously expressed public support, and on the potential for mining and resort development in the lower Russian River valley, the Corps presented plans for providing a small craft harbor at the mouth of the river. However, most of the benefits expected from such a project would accrue to mining interests engaged in dredging sand and gravel from the estuary. The emigration of mining interests from the Jenner area eliminated this source of project benefits. The remaining recreational benefits alone could not justify the project. Following this determination, the Corps discontinued its study.

In 1972, the Sonoma County Board of Supervisors requested that the Corps of Engineers conduct a new study on opening the mouth of the Russian River and creating a harbor of refuge near Jenner. The Corps responded that without the commercial navigation benefits derived from the mining operations previously proposed —but never successfully undertaken—in the Russian River estuary, such a study could not produce an economically feasible project proposal.

c. Further Study

In the past, construction of structural improvements by the Corps of Engineers providing year around safe passage through the mouth of the Russian River has not proven to be in the Federal interest. First, such improvements could only be justified economically if commercial sand and gravel mining in the Russian River estuary were to take place. Today any such mining operations would have to meet many stringent State and Federal water quality and waste discharge requirements, as well as deal with public concerns over preservation of the lower Russian River valley environment. Secondly, the magnitudes of other benefits attributable to maintaining a channel through the mouth of the Russian River are in question. It is believed that maintenance of free passage would have limited flood control benefits since the first major winter floodflows normally open the channel. Maintenance of an open channel entrance for fish passage would probably somewhat improve the fishery through improved inmigration of anadromous adults and outmigration of smolts. The productivity of the fishery has declined in recent years, however, apparently in response to factors independent of conditions at the river mouth, such as decreases in suitable habitat in tributary streams. Therefore, no further Corps of Engineers studies of maintaining year around free passage through the mouth of the Russian River are necessary at this time.

5. Land Use Related to Flood Plain Management

a. Existing Conditions

The Russian River drainage basin covers 1,485 square miles. The basin is primarily agricultural with the greatest emphasis on orchard crops and vineyards. The major orchard crops are prunes, pears and apples with some production of cherries and walnuts. The Russian River basin is one of the most important wine-grape producing centers in the United States, with vineyards located all along the river valley and some of the major tributaries. Since 1970, wine-grape prices have been high, encouraging the planting of new vineyards in Sonoma and Mendocino Counties as well as other areas throughout the United States. Many prune and some pear orchards have been replaced by vineyards. A large percentage of these new vineyards have been planted on low-density agricultural land: native pasture, wood and brushland, and improved pasture land.

In addition to agricultural uses, there is a growing trend toward light industrial and commercial development in the Russian River basin, with the major urban center being Santa Rosa and its vicinity. Industrial activities in the basin include lumbering and the processing of timber products, wine production, processing of agricultural and animal products, gravel removal and processing, some mining, and miscellaneous light manufacturing operations. Commercial activities are principally related to distribution and other services supplying the needs of those parties engaged in agricultural, industrial, and recreational activities.

Cattle and sheep are raised in the basin hills and are fed by hay and grain grown on valley pastureland. A significant number of summer homes and resorts are located along the river in the vicinity of Healdsburg and between Mirabel Park and Duncans Mills. The provision of services to these vacation resort areas comprises another important economic activity in the basin.

b. Problems and Opportunities

Development in the Russian River basin ranges from intense urbanization to near wilderness conditions in the more mountainous areas. Increasing development and urbanization pressures, particularly in the south, present visible threats to the existing environment. Both development and more intense agricultural use of portions of the Russian River flood plain increase the potential for flood damage.

Land use planning and flood plain management may allow the region to grow without endangering the quality of life. Planning objectives related to land use and flood plain management should involve the following activities to help resolve existing problems and enhance the quality of life in the Russian River basin:

1) determination of existing general land use patterns and trends and their effects on the river basin environment;

2) development of flood plain management plans compatible and in coordination with the National Flood Insurance Program conducted by the Federal Emergency Management Agency (FEMA) in accordance with the 1968 Flood Insurance Act, as amended, and the Flood Disaster Protection Act of 1973, PL 93-234;

3) consideration of the effects of urbanization of the lands draining into the Laguna de Santa Rosa on flood levels and frequencies in the lower Russian River.

Several contributions toward achieving these objectives were made during the course of the Russian River Basin Study. A digital land use data bank was established through the use of color infrared aerial photography and computer-assisted interpretation techniques. Additional details regarding current land use with particular reference to the Russian River flood plain are available through both high and low level aerial photography obtained in conjunction with the Basin Study. The color and color infrared photography provided total coverage of the river basin, with specific emphasis upon the Russian River mainstem and principal tributaries. Together, these data provide a valuable tool for land use and environmental planning in the Russian River basin. Maps showing 1975 land uses and the 100-year flood plain are included in Appendix E.

Flood plain maps are also contained in the Corps San Francisco District Review Report for Flood Control and Allied Purposes, Russian River, California. High water mark data and flood delineations for the January flood are available in another published District report titled "High Water Mark Data for Russian River Flood of January 1974". The Flood Insurance Study for Sonoma County, December 1977, which was conducted by the Corps for FEMA, contains updated floodway and floodplain maps. Consequently, communities have the tools to develop flood plain management measures. All incorporated and unincorporated areas of both Sonoma and Mendocino counties participate in the National Flood Insurance Program. As such they individually must adopt appropriate flood plain management ordinances. These ordinances specify proper construction methods in identified flood hazard areas.

c. Further Study

The extent of available flood plain data and maps and the level of current efforts with respect to flood plain delineation in the Russian River basin, along with the existing data bank of land use, is considered sufficient to meet the current needs of local interests. No further Federal action by the Corps of Engineers appears warranted at this time. However, conditions and land use in the flood plain should be constantly surveyed by local interests to detect any significant changes.

6. Operation of Existing Structures on the River and Tributaries

a. Existing Conditions

Two structures mentioned in the study authorization as needing more intensive investigation were Warm Springs and Coyote dams. The existing conditions for this investigation are predicated on the assumption that both dams are in place, even though Warm Springs Dam is currently under construction.

Coyote Dam has been operational since 1959. Located on the East Fork of the Russian River near Ukiah, the dam forms Lake Mendocino. The facility provides flood control, water supply and streamflow augmentation benefits, and includes extensive recreation facilities. The dam retards flood flows from the contributing 105 square mile watershed, thus reducing peak flood flows and related damages on the Russian River downstream of the confluence of the mainstem and the east fork of the river. The dam also impounds water diverted from the Eel River via the Potter Valley Diversion. This supply along with the yield from the contributing watershed is released to satisfy demands for water along the river including agricultural and municipal water supplies and instream uses. The major municipal diversion is located at the Wohler and Mirabel intakes in Sonoma County. It is likely there are also a number of unregistered, unmetered agricultural water diversions on the Russian River mainstem and its tributaries. These diversions have been difficult to inventory and assess and may have significant but as yet undetermined effects on salmonids, particularly in the tributaries. The releases from Coyote Dam for in-stream uses provide benefits to the fisheries resources and recreational activities on the mainstem of the river.

Warm Springs Dam is expected to be operational by late 1982. Located on Dry Creek, the dam will create Lake Sonoma. The Warm Springs Dam Project will provide multi-use benefits for: flood damage prevention for Dry Creek and the lower Russian River, water supply for municipal-industrial uses in portions of Sonoma and Marin Counties, recreation on Lake Sonoma, and fisheries enhancement.

A variety of recreational benefits will be available to the general public at Lake Sonoma, including fishing, boating, hiking, biking, horseback riding, camping and picnicking. Much of the 17,000 acres to be included within the project boundary will be open to the public. Some 4,000 acres of it and most of the reservoir surface will be set aside for recreation. About 1,400 acres will be devoted to over-looks, picnic sites, camp-grounds, boat-launching ramps, and swimming beaches. There will be parking, sanitary and drinking water facilities.

The Warm Springs Dam/Lake Sonoma Project will also include a fenced area of some 3,200 acres in its natural state. This area on the northeast side of the lake will be set aside as a wildlife management area to be managed in cooperation with the California Department of Fish and Game.

Dry Creek is a spawning and rearing habitat for steelhead trout, with an estimated average annual run of 8,000 adults. Although much of the streambed is dry during summer months, pools in the headwater reaches fed by seepage through streambed gravels are adequate to permit survival of immature fish during the dry period. Approximately 300 silver salmon also spawn in Dry Creek.

Construction of the Warm Springs Dam Project will dam Dry Creek, create Lake Sonoma, and change downstream flow conditions. It is estimated that 6,000 of the 8,000 total steelhead trout that have annually returned to Dry Creek in recent years spawn upstream of the dam site. These fish will be permanently cut-off from their natural spawning grounds as will approximately 100 of the 300 total annual silver salmon run. The fishery for young steelhead trout and silver salmon presently located on the site of Lake Sonoma will be lost. Improvement of downstream flow conditions below the dam is expected to lead to an improved fish environment and an improved fishery in that portion of Dry Creek. However, the question of public access to Dry Creek for fishing, boating and other activities has yet to be settled. This will play a major role in determining whether a salmon and steelhead fishery will become established in Dry Creek.

In addition to providing mitigative measures for an annual fish run of 6,000 steelhead trout and 100 silver salmon, the project will provide for annual fish run enhancement of 1,000 silver salmon and 1,750 king salmon. To produce this run, an additional 100,000 silver yearlings and 1,000,000 king fingerlings will be released each year from a fish hatchery below Warm Springs Dam.

The operation of the fish hatchery constructed in 1980 as part of the Warm Springs Dam Project is geared to raising steelhead trout yearlings, silver salmon yearlings, and king salmon fingerlings. The hatchery expects to harvest more than 470,000 steelhead trout eggs, 171,000 silver salmon eggs and 1,370,000 king salmon eggs annually. From this harvest, 300,000 steelhead trout yearlings, 110,000 silver salmon yearlings and 1,000,000 king salmon fingerlings will be reared. To enhance fishing downstream of the dam should a fishery be established, after the required number of steelhead trout eggs have been taken, surplus adult steelhead may be transported back to the mouth of Dry Creek for another run up the creek.

The Warm Springs fish hatchery contains some accommodations for increasing fish production by about 50%. These include room in the hatchery building for additional start tanks, incubators, filters and ultra-violet units. Over-sized piping has been installed to handle the water requirements of additional rearing ponds.

Consideration of expansion of the hatchery is mandated by Section 95 of Public Law 93-251 dated March 7, 1974. This law authorized the Corps of Engineers to compensate for anadromous fish losses on the Russian River which may be attributed to the construction of Coyote Dam, which was completed in 1959. While Coyote Dam on the East Fork of the Russian River prevents access to some 35 miles of upstream tributary habitat once used by salmonids, releases from Lake Mendocino created new rearing habitat below Coyote Dam where low summer flows had once prevailed. Although the relative importance of the lost habitat is a subject of debate, observations of steelhead jumping near the base of the dam during early project years suggest that several hundred fish used the upstream tributaries.

The multiple-level outlet capability of Warm Springs Dam will provide for a high degree of control over the temperature of water released. This will help maintain and enhance the fisheries below the Dam in the lower reaches of Dry Creek and the Russian River downstream from the Dry Creek confluence.

Based upon detailed water supply and flood control criteria developed during project formulation for both Coyote and Warm Springs dams, the operating procedures for the two projects are well established. Existing agreements and water supply commitments place limits upon possible optional release schedules. Water supply storage in the reservoirs is owned by the participating local agencies by virtue of financial commitments and purchase costs which were a part of project formulation and construction as required under the 1958 Water Supply Act. In the case of Warm Springs Dam, all of the water supply pool in Lake Sonoma is owned by the Sonoma County Water Agency (SCWA). For Coyote Dam and Lake Mendocino, the Water Agency owns approximately 89 percent of the water supply pool, with Mendocino County owning the remaining 11 percent. Release schedules for these water supplies are determined by the Water Agency and Mendocino County based upon their water demand criteria. Operating procedures have been established by the SCWA and Mendocino County in cooperation with the State and the Corps, which retains the responsibility for physical operation of the reservoirs. Maintenance of the flood control pool and release of flood waters remains the responsibility of the Corps.

The California Department of Water Resources is currently studying the joint operation of Lake Mendocino, Lake Sonoma and the Lake Pillsbury reservoir on the Eel River. The general goal of the study is to examine opportunities for optimizing the operation of the three reservoirs to meet projected Year 2000 water demands in both the Russian and Eel River basins.

The California State Water Resources Control Board also exercises a role in regulating the diversion and use of water in the Russian River and in Lake Mendocino and Lake Sonoma. Any diversion or use of water that does not conform to the terms and conditions of existing permits or licenses, or which constitutes a new diversion or use of water, is subject to the Board's review and approval.

b. Problems and Opportunities

Flow releases from Coyote and Warm Springs dams affect the Russian River discharge (Figures 3 and 4) and thus can influence the basin's water quality and fisheries resources. Potential problem areas are addressed below.

1) Water Quality

The water quality of the Russian River changes in response to variations in flow volumes. While many natural and man-influenced factors affect water quality, the most pronounced quality changes correlate well with flow volume. Most quality parameters, with the notable exception of turbidity, are at their optimum levels relative to water quality objectives during the wet months from December through April. Turbidity normally increases with flow and is highest following extreme flood periods.

An evaluation of the physical and chemical characteristics of surface water in the Russian River and its tributaries by the California Department of Water Resources (DWR) revealed that the mineral content of the water, as indicated by its specific conductance, was highest during the low-flow summer months and declined during periods of high winter and spring flows. Water temperatures in the river followed the same trend. Dissolved oxygen, pH and turbidity were all at their lowest levels during the low-flow summer months and increased with stream flow.

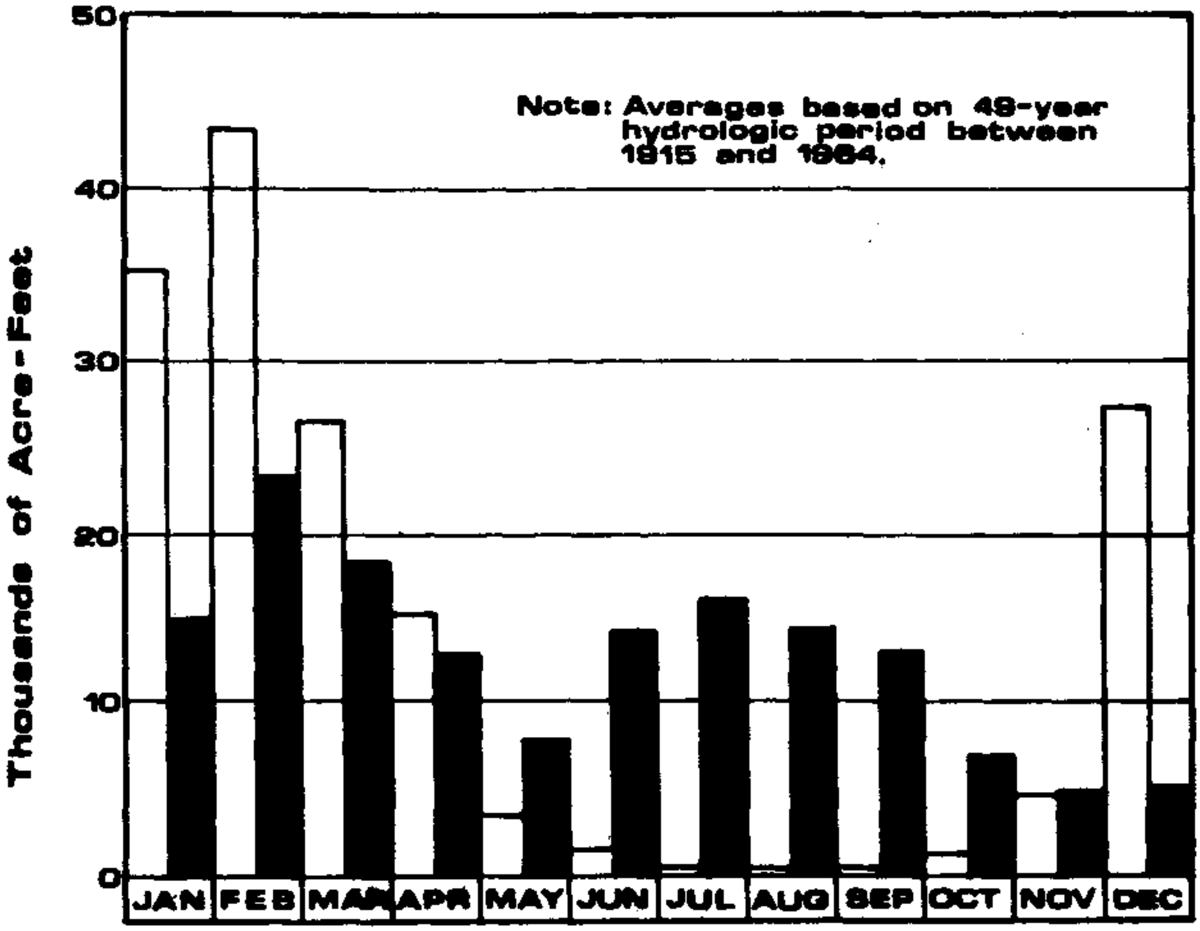
The relationship between stream flow and water quality in the Russian River revealed by the DWR study indicates that the most critical period with regards to water quality is during the summer months when flows are low and water use for agricultural, municipal and recreational purposes is high. The importance of this period is reflected in the water quality monitoring program conducted by the North Coast Regional Water Quality Control Board which has been limited to the low-flow summer months. The water quality data collected from the middle and lower Russian River during the summer of 1977 indicate that even during the summer low-flow months of a drought year such as 1977, water quality conditions, with few exceptions, meet the objectives established in the SWRCB North Coastal Basin Water Quality Control Plan to protect and preserve the beneficial water uses within the basin.

2) Fisheries Resources

Minimum releases for fisheries from the Coyote Project are subject to a 1959 agreement between the Sonoma County Water Agency (SCWA) and the California Department of Fish and Game (CDFG). The agreement specifies that the SCWA release enough water to maintain a flow of 150 cfs at the junction of the east fork and mainstem of the Russian

figure 3

Effect: of Warm Springs Project on Average Monthly Runoff of Dry Creek at Damsite



Month

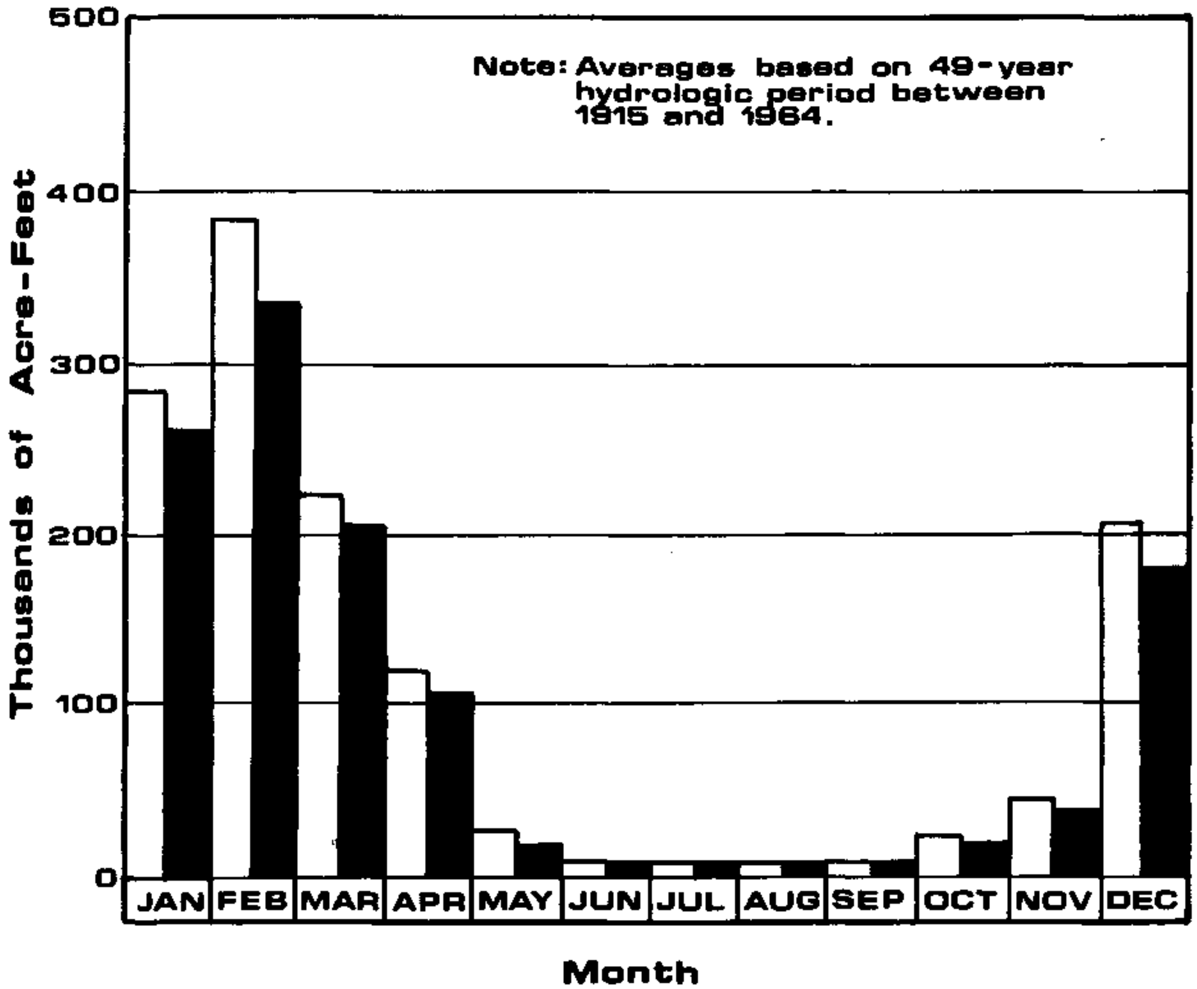
Legend

- ☐ **Without Warm Springs Project**
- ■ **With Warm Springs Project Under Ultimate Use.**

Source: Final Environmental Impact Statement, Warm Springs Dam and Lake Sonoma Project

figure 4

Effect of Warm Springs Project on Average Monthly Runoff of Russian River at Guerneville



Legend

☐ Without Warm Springs Project

■ With Warm Springs Project Under Ultimate Use

Source: Final Environmental Impact Statement, Warm Springs Dam and Lake Sonoma Project

River, or release water at a rate equivalent to the inflow to Lake Mendocino, whichever is less, while maintaining a minimum release from the dam of 25 cfs. The agreement also mandates that a flow of 125 cfs be maintained in the mainstem at the Guerneville gauging station. In 1970, the CDFG and the SCWA entered into an agreement for releases from Warm Springs Dam for fishery protection and enhancement. A supplemental agreement is now being negotiated but has yet to be finally approved by the two agencies.

The 1970 Warm Springs agreement was incorporated into Appropriative Water Right Permit 16596 issued July 9, 1973 by the State Water Resources Control Board. The release schedule in that agreement calls for a minimum release of 25 cfs from April through November, and a release of 50 to 75 cfs from December through March, depending on the amount of water stored in the reservoir the previous spring.

As a result of negotiations now being conducted between the SCWA and CDFG, a supplemental operational agreement for Warm Springs Dam and Coyote Dam has been formulated (Appendix D). This supplemental agreement is only tentative; however, as discussions are taking place between the agencies, this agreement will be discussed here. In addition to the flows outlined in the 1970 agreement, during years when sufficient storage exists within Lake Sonoma additional flows would be released from Warm Springs Dam to enhance the fishery potential of Dry Creek, particularly with respect to king salmon released from the Warm Springs hatchery. When sufficient storage is available a minimum of 80 cfs would be released into Dry Creek from May through October, 105 cfs from November through December, and 75 cfs from January through April. In addition to these releases, an amount of water equal to 5,000 acre-feet (equivalent to 84 cfs for one month) would be released at the rates and time requested by the CDFG between May 1 and April 15 for beneficial fishery uses.

During the initial filling of Lake Sonoma, and in the absence of a drought emergency, releases from Warm Springs Dam would be made at the higher rates defined in the proposed supplemental operational agreement. When excess water is available during the early years of project operation, greater release rates may be experimented with to obtain additional data about the flow needs of the downstream fishery. These greater releases would only be allowed for short periods. It is presently stipulated in the proposed supplemental agreement that the August 1959 Coyote Valley Project agreement between the SCWA and CDFG would remain in effect. According to this agreement, the Coyote Valley Project is to provide 150 cfs or the inflow to Lake Mendocino, whichever is less, in the Russian River at the confluence with the east fork. A minimum flow of 125 cfs in the Russian River at the Guerneville gauging station is also required.

Studies have been conducted to determine the instream flow requirements of salmonids in the mainstem of the Russian River and lower Dry Creek by both CDFG and as a part of this present study as shown in Appendix F. Both studies used methods involving cross-sectional measurements of stream width, depth, velocity and substrate composition to determine flow needs.

Field studies were carried out by CDFG during the winter of 1975-76 to determine whether the flow releases from Warm Springs Dam stipulated in the 1970 agreement were adequate to protect the fisheries resources of Dry Creek and to allow successful operation of the fish hatchery below Warm Springs Dam. Instream flow requirements were determined for steelhead, silver salmon and king salmon. Flow requirements for adult passage, spawning, and nursery habitat were determined for each species.

Minimum flows necessary to insure adequate upstream passage of adults at five riffles in Dry Creek were found to average approximately 70 cfs for steelhead and silver salmon and 102 cfs for king salmon. Flows recommended to ensure passage were approximately 105 cfs for king salmon and 75 cfs for both steelhead and silver salmon.

An assessment of flows necessary to provide optimum spawning habitat in Dry Creek indicated that available habitat increased with flow for all three species and exceeded 200 cfs. Optimum flows were assumed to be closer to 480 cfs.

Available nursery habitat was also found to increase with flow, and the greatest amount of nursery habitat available with the least flow occurred at a flow of 80 cfs. A reduction in flow below 80 cfs resulted in a relatively rapid decline in availability of nursery habitat.

The indepth study of salmonid habitat flow requirements in lower Dry Creek and the mainstem of the Russian River completed under the current Corps authorization was based on field surveys made during the winter and summer of 1978. The evaluation of fish passage requirements in Dry Creek indicated that during upstream migration of spawning salmonids, the mean stream flow in Dry Creek is sufficient to provide adequate fish passage. The study also concluded that it was necessary to maintain stream flows above an average of 100 cfs to ensure successful fish passage at critical riffle sites.

Stream flow requirements for optimal salmonid spawning conditions were determined in the Corps study to be 400 cfs for Dry Creek below Warm Springs Dam, 200 cfs on the Russian River upstream of approximately Cloverdale, 700 cfs from upstream of the Dry Creek confluence to approximately Cloverdale, and 1,000 cfs downstream of the Dry Creek confluence. Optimum nursery resting habitat was found to occur at 20 cfs on both Dry Creek and the entire length of the Russian River. This discharge would result in optimum nursery habitat in terms of resting space only. This streamflow appears to be well below the flow necessary to satisfy water temperature requirements for nursery habitat, particularly during the summer months when air temperatures are high. For this reason, the optimum flow for nursery habitat was taken to be 80 cfs, as determined by the CDFG.

A comparison of the minimum release schedule from the proposed Warm Springs supplemental operational agreement with the instream flow recommendations reveals the following for Dry Creek: during years with sufficient water, adequate flows will be available from Warm Springs Dam for passage of king salmon (105 cfs), steelhead and silver salmon (75 cfs) during their fall and winter migrations, and for nursery habitat requirements (80 cfs) during the spring, summer and early fall. A minimum flow of 80 cfs during the spring and summer may also provide spawning habitat for shad in lower Dry Creek.

Releases in the proposed supplemental operational agreement, while satisfying the suggested minimum salmonid passage requirements, would not satisfy optimum spawning habitat requirements. However, in most years, releases from Warm Springs Dam during winter and spring will be greater than those minima specified in the proposed agreement because of releases necessary to maintain required flood storage capacity in Lake Sonoma. An analysis of average monthly flow rates at the Dry Creek streamgage near Geyserville, located downstream of Warm Springs Dam, reveals that from 1960 to 1978 (the entire period of record) optimum spawning flows (i.e. sustained flows which satisfy optimum spawning habitat requirements) were equaled or exceeded: during November, only twice out of 19 years; while the flows from December through March had reached or exceeded optimum spawning flows during approximately 12 years out of the 19. Thus, optimum spawning conditions were not always present in Dry Creek prior to the construction of Warm Springs Dam.

c. Further Study

Based on current data, water quality problems on the Russian River are not of major concern and further Corps study into the effects of releases from Coyote and Warm Springs dams on water quality are not warranted.

Further study of development of alternative flow release schedules for Coyote and Warm Springs dams may be warranted in the following cases: 1) if the California Department of Fish and Game requires additional flow releases from Warm Springs Dam to successfully operate the Warm Springs fish hatchery; 2) if the Corps and local interests wish to optimize operation of Coyote and Warm Springs dams to provide flows for the SCWA custom- customers while optimizing recreation along the river, and/or preserving and enhancing the fishery along Dry Creek, while at the same time preventing excessive drawdown of Lake Mendocino.

Further discussion of fisheries resources affected by Coyote and Warm Springs dams and the operational criteria at the two projects is warranted. This discussion is presented in Section III - Formulation of Plans.

III. FORMULATION OF PLANS

A. PRELIMINARY PLANS: SUMMER AND RECREATIONAL TYPE DAMS

The Corps is limited under its present Russian River Basin Study authority and can only provide assistance and advice in the management of summer dams. The alternatives described in this section are put forth for consideration by local interests and governments. It will be their decision which management measures, if any, they should employ to achieve their recreational, fishery management and other goals associated with the summer dams.

1. Management Measures

Currently, management of summer dams on the Russian River is principally in the form of regulations adopted and enforced by various Federal and local agencies. These regulations cover broad areas of environmental protection and are not specifically confined to the issue of the summer dams. There is no existing comprehensive plan that specifically addresses the placement, operation and removal of the summer recreational dams on the Russian River or its tributaries.

To illustrate a range of management schemes which could be used to regulate summer dams on the Russian River, six alternative management plans were initially formulated for this study:

Alternative A. - Status Quo Management: Continuation of present management practices and operating schedules (May 20-September 15) without addition of fishway structures at Healdsburg or Del Rio Woods summer dams.

Alternative B - Status Quo Management with Addition of Fishways: Continuation of present management practices and operating schedules (May 20-September 15) and addition of fishway structures at Healdsburg and Del Rio Woods dams. Fishways would be added to the two dams to provide up- and downstream fish passage when the recreation dams are in place. Stream channel modifications and/or low level fish passage facilities would also be provided from the foundation sill of Healdsburg Dam to the downstream river channel, to reduce fish passage problems during low flow periods when the recreational dam is not in place.

Alternative C - Variable Dam Installation and Removal Dates: The installation and removal dates would be established on short notice each year, depending on hydraulic conditions, timing of the spring shad run, the summer steelhead run and the fall king salmon run, opening of the river mouth, and other environmental factors. An agency infrastructure would be established to determine the installation and removal dates based on day-to-day or week-to-week assessment of these controlling factors. A bracket of dates for both installation and removal of the summer dams may also be recommended to provide a defined time period within which dam installation or removal may be regulated.

Alternative D - No Summer Recreation Dams: The installation and operation of summer recreation dams on the lower Russian River would be eliminated.

Alternative E - Dual Level Dam Installation with Second Level Fishway: The summer dams would be installed to one-half their full height during the first month of operation (following present operations schedules May 20-September 15) and increased to their full height thereafter. The addition of a second fishway or modification of the existing fishway at each dam would provide fish passage facilities during the entire period when dams are in place. This alternative also includes the addition of fishway facilities at Healdsburg and Del Rio Woods dams as outlined in Alternative B.

Alternative F - Revised Dam Installation and Removal Dates: The summer dams would be installed to full height and removed at dates differing from present practices. One possibility would be installation June 20 rather than May 20. This alternative also includes the addition of fishway facilities as outlined in Alternative B.

2. Plan Formulation Rationale

a. Regulatory Structure

Currently the Corps of Engineers, the California Department of Fish and Game, the North Coast Regional Water Quality Control Board, the Sonoma County Water Agency, and Sonoma and Mendocino Counties have differing regulatory authorities over various aspects of the installation, removal and operation of summer dams. Specific authorities are described in Section II.C.3.c of this report.

b. Environmental Effects of Dams

1) Water Quality Effects

As previously noted, based on existing data, the summer dams have no identifiable effects on Russian River water quality with the exception of increased turbidity levels during installation and removal. Both local and Federal agencies should continue to collect water quality data and if possible increase these efforts. Of particular importance are data on water temperature, dissolved oxygen, pH, turbidity, specific conductance, and nitrate and phosphate concentrations.

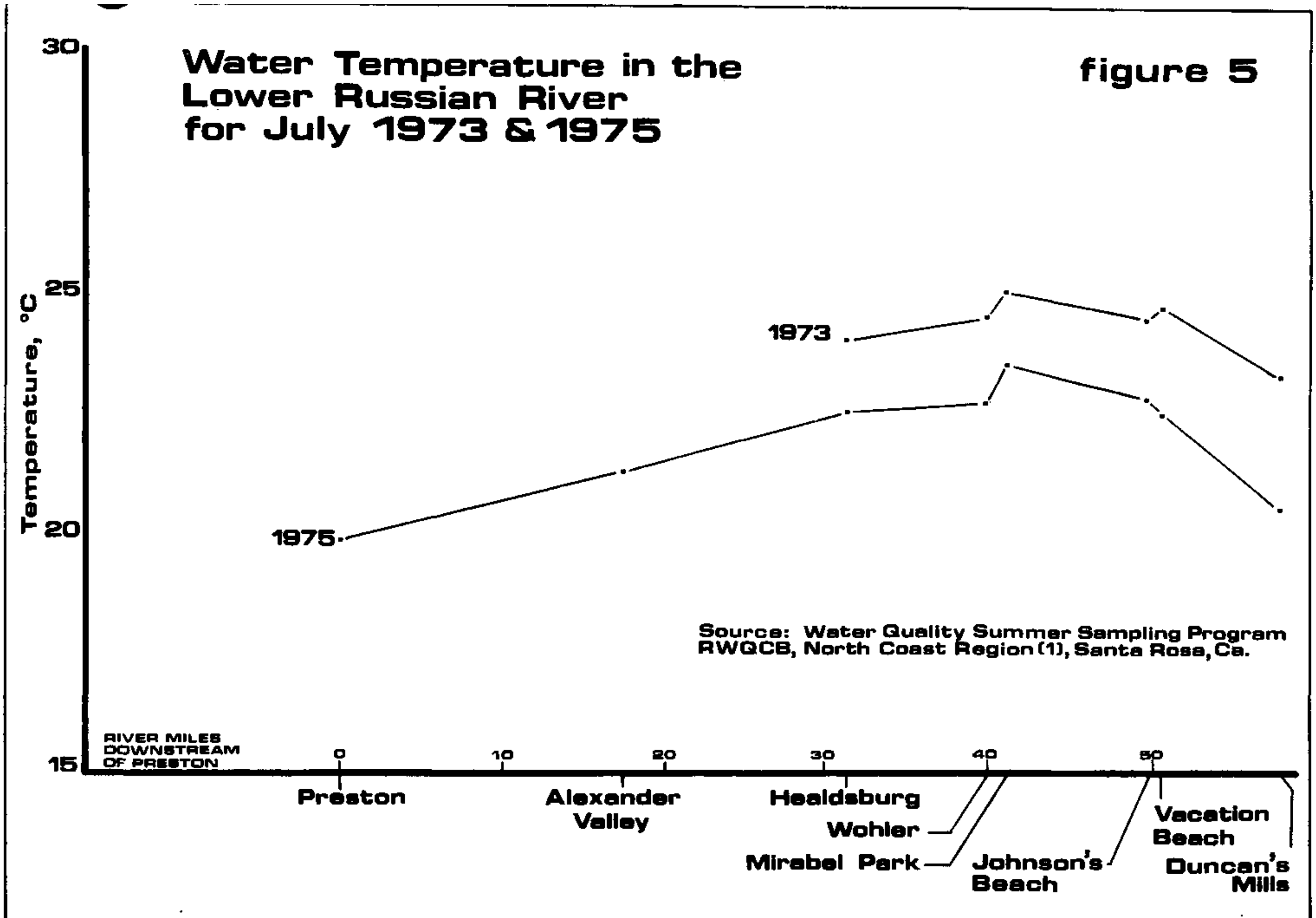
A synopsis of available data on water quality in the Russian River is presented below. As new data is accumulated, any effects which the summer dams may have on water quality could become more definitive, and appropriate management measures could then be taken to address problem areas.

Water Temperature. Water temperatures in streams may vary with seasonal climatic changes, time of day, volume of flow, water depth, and distance from the stream source, as well as immediate climatic conditions determined by vegetative cover along the stream channel. Changes in water temperature in turn may effect changes in the chemical and physical properties of natural waters including dissolved oxygen, pH, turbidity and conductivity. The water temperature regime of a stream also affects, either directly or indirectly, the distribution and survival of plants and animals which live in the stream. Due to its broad effects on the chemical, physical and biological characteristics of aquatic environments, temperature is a key indicator of water quality in natural streams.

During the summer, the Russian River experiences a downstream warming trend beginning as far up as Preston (near Cloverdale) and peaking in the area of Mirabel Park on the lower river as seen in Figure 5. The average monthly water temperatures for May through August 1977 from Preston to below Vacation Beach Dam, as shown in Table 7, reveal both a seasonal increase in temperature from May to August and a downstream increase in temperature which is present in May, even before the recreation dams are installed. Although in May the increase in temperature continues down past Vacation Beach, in June it peaks between the Healdsburg and Wohler dams, in July it peaks at Mirabel Park, and in August it peaks above Wohler Dam. This shift in downstream heating and cooling of the waters of the lower Russian River may be due to the appearance of the summer coastal fog belt.

The relationship between water temperature in the Russian River and ambient air temperature is also indicated by water and air temperatures during a wet year (1973) and a relatively dry year (1975) as seen in Figure 6. At Mirabel Park, although river flows were much higher in 1973, water temperatures were also higher, corresponding to higher ambient air temperature in 1973 than in 1975. Downstream warming and cooling trends for July 1973 and 1975 as shown in Figure 5 reveal a similar effect, with 1973 water temperatures consistently higher than 1975 values from Healdsburg to Vacation Beach. Although during both of these years water temperatures decreased overall in the reach from Mirabel Park to Duncan's Mills, in 1973 temperatures increased slightly between Johnson's Beach and Vacation Beach.

The results of the evaluation of fish habitat and barriers to fish migration on the Russian River mainstem and lower Dry Creek conducted as part of the Russian River Basin Study (Appendix F) indicate that summer dam impoundments had little or no significant effect on water temperature. However, these results were based on limited


Water Temperature in the Lower Russian River for July 1973 & 1975
figure 5
Temperature, °C
30
25
20
15
1973
1975
Source: Water Quality Summer Sampling Program RWQCB, North Coast Region (1), Santa Rosa, Ca.
RIVER MILES DOWNSTREAM OF PRESTON
0
10
20
30
40
50
Preston
Alexander Valley
Healdsburg
Wohler
Mirabel Park
Johnson's Beach
Vacation Beach
Duncan's Mills

Water Temperature and Ambient Air Temperatures for the Russian River at Mirabel Park from May to August 1973 & 1975 figure 6

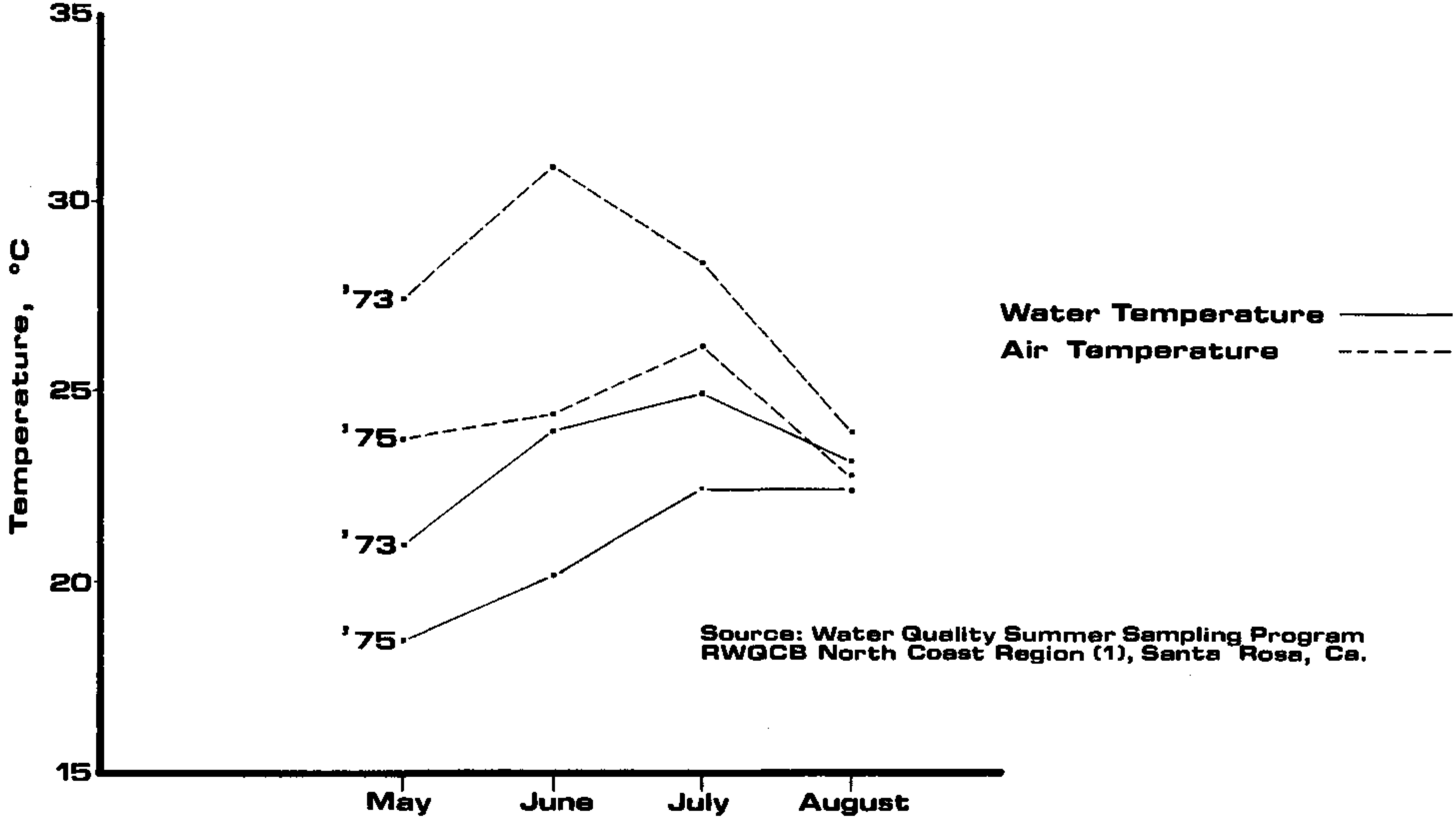


Table 7

AVERAGE MONTHLY VALUES FOR WATER QUALITY IN THE RUSSIAN RIVER FROM PRESTON TO VACATION BEACH - MAY TO AUGUST 1977

	Water Quality Parameters						
Station	Temp. (C)	DO (ppm)	pH	Turb. (JTU)	Specific Cond. (Micromohs)	Nitrate (mg/1)	Phosphate (mg/1)*
MAY							
Preston	15.75	10.1	8.46	2.57	271.75	-	<1
Alexander Valley	16.50	9.5	8.2	1.0	309.25	<.1	<1
Healdsburg	18.0	9.5	8.5	1.85	317.5	<.1	1.6
Wohler Bridge	18.5	9.9	8.47	2.72	328.25	<.1	<1
Mirabel Park	18.88	12.8	8.67	11.57	390.75	<.1	<1
Johnson's Beach	19.1	9.7	8.74	6.88	348.6	.14	1.55
Vacation Beach	19.7	10.02	8.70	7.72	341.5	<.1	2.05
JUNE							
Preston	21.0	9.16	8.36	2.86	248.6	.06	<1
Alexander Valley	22.1	8.94	8.2	1.74	294.2	.03	<1
Healdsburg	23.8	8.5	8.46	1.5	309.6	<.1	<1
Wohler Bridge	23.7	8.82	8.4	3.38	314.2	<.1	<1
Mirabel Park	22.70	7.92	8.38	2.65	302.6	<.1	<1
Johnson's Beach	22.38	6.75	7.75	1.9	317.75	.05	<1
Vacation Beach	21.75	7.5	8.0	3.5	311.5	<.1	<1
JULY							
Preston	21.5	8.85	8.32	2.4	250.75	.02	-
Alexander Valley	23.0	9.1	8.20	1.25	284.25	.02	-
Healdsburg	24.13	8.25	8.23	1.55	295.25	.00	-
Wohler Bridge	24.63	9.1	8.4	2.37	294.25	.00	-
Mirabel Park	24.75	8.45	8.25	1.78	297.75	.00	-
Johnson's Beach	23.88	8.35	8.15	1.5	295.	.015	-
Vacation Beach	23.00	7.7	8.0	2.07	297.	.00	-
AUGUST							
Preston	23.25	8.52	8.32	1.7	241.75	.02	-
Alexander Valley	21.6	7.98	8.1	1.18	279.2	.01	-
Healdsburg	24.0	8.06	8.34	1.56	293.0	.01	-
Wohler Bridge	25.7	9.32	8.58	1.44	290.8	.003	-
Mirabel Park	24.2	8.32	8.18	1.76	296.6	.00	-
Johnson's Beach	23.5	8.36	8.18	1.1	290.6	.003	-
Vacation Beach	22.7	8.06	8.12	2.04	294.6	.00	-
Water Quality Objectives**	-	7	6.5-8.5	5***	375	2	0.4

Footnotes:

*Minimum result is "<1 mg/1" due to sensitivity of analysis.

**Water Quality Control Plan Report, North Coastal Basin (1B), State Water Resources Control Board, August 1974.

***Maximum turbidity for municipal water use.

Source: Water Quality Summer Sampling Program. Regional Water Quality Control Board, North Coast Region. Santa Rosa, California. 1977.

spot temperature measurements taken in the summer dam impoundments and in the Russian River channel below the dams. Even if the impoundments formed by the dams have an effect on water temperature, the direction and magnitude of that effect may be masked by or dependent upon the prevailing climatic conditions both on a monthly and yearly basis.

Dissolved Oxygen. Dissolved oxygen (DO) levels in natural waters are dependent on the physical, chemical and biochemical activities prevailing in the water and may be used as a key indicator of water pollution levels due to organic waste discharges. Oxygen is produced as a by-product of the photosynthetic activity of aquatic plants and is consumed by the respiratory activities of plants and animals, and the breakdown of organic matter by bacterial action. Diurnal fluctuations in the oxygen content of streams may result from daily variations in temperature but are also associated with pollution which encourages algal growth during the day time and high respiratory demands at night. Low dissolved oxygen levels adversely affect fish and aquatic invertebrates, and the depletion of dissolved oxygen will lead to the development of anaerobic conditions with associated odor and aesthetic problems. Ideal DO levels for fish range from 7 to 9 milligrams per liter (mg/1), with critical levels ranging from 3 to 6 mg/1.

Monthly average dissolved oxygen levels in the lower Russian River during the summer of 1977 (Table 7) were all above the minimum of 7.0 ppm as stipulated in the State Water Resources Control Board water quality objectives for the North Coast Basin, except for the station below Johnson's Beach Dam in June with a value of 6.75. Values for Cloverdale, Alexander Valley and Healdsburg all show a seasonal decrease in dissolved oxygen levels corresponding to seasonal temperature increases and reduced stream flows. No consistent downstream trend in dissolved oxygen levels is shown either before or after the dams were installed at the end of May. A possible exception to this is the month of June, in which there is a general, although not consistent, drop in dissolved oxygen between Cloverdale and Vacation Beach. In general, these limited data do not indicate any specific impacts of summer dam operations on dissolved oxygen levels in the lower Russian River. This conclusion is in agreement with the findings of the evaluation of fish habitat and barriers to fish migration (Appendix F), which indicated that no significant differences in upstream and downstream dissolved oxygen levels resulted from operation of the summer recreation dams.

pH. The pH of a solution is a measure of its hydrogen ion activity, with the values of most natural waters ranging from 4 to 9, indicating acidic or alkaline conditions, respectively. A neutral solution (neither predominantly acidic nor alkaline) has a pH of 7.0. The majority of waters are slightly alkaline (greater than 7.0) because of the presence of carbonates and bicarbonates in solution.

Extremes of pH levels, either acidic or alkaline, due to the pollution of waters with domestic or industrial wastes may adversely affect aquatic plants and animals.

In slow-flowing streams or impoundments where water temperatures and nutrient levels are high, algal blooms cause increases in pH levels due to the consumption of large amounts of carbon dioxide. Since summer domestic sewage effluent discharges to the Russian River ceased in 1977, pH levels during the months the summer dams are in operation have generally remained within the limits of 6.5 to 8.5 set in the State Water Resources Control Board water quality objectives. In contrast to this, during the month of May 1977, before the dams were in operation, average pH levels at Mirabel Park, Johnson's Beach and Vacation Beach were all in excess of 8.5. It appears from these data that the operation of the summer dams has no identifiable effect on pH levels in the lower Russian River. However, these limited data may be insufficient to determine actual effects of the summer dams on pH values. In their 1973 study of the Johnson's Beach impoundment, the NCRWQCB found no differences in pH values within or below the impoundment.

Turbidity. Turbidity is a measure of the cloudiness of water, or the extent to which light passing through water is reduced due to suspended materials. It may be caused by the presence of suspended matter such as clay, silt, sand, finely divided organic and inorganic matter, plankton, or algae. Turbidity may also affect aquatic life as well as fishing success and aesthetics. High turbidities may suffocate fish and other stream animals, and exclude sunlight, thereby restricting the growth of both benthic and planktonic algae which are important to the aquatic food chain.

The main cause of turbidity in the Russian River is runoff and erosion during the rainy season from December to April. During late spring and through the summer as flows decrease, downstream turbidity due to erosion decreases although it may persist at moderate levels as long as turbid water is transported from the Eel River through the Potter Valley powerhouse and Lake Mendocino.

In its 1971 study, the U. S. Geological Survey concluded that persistent turbidity in the mainstem of the Russian River is due to water diverted from the Eel River at Lake Pillsbury into the East Fork of the Russian River above Lake Mendocino. During large winter rain storms, the water flowing into Lake Pillsbury is highly turbid due to the mudslides and erosion of fine clay soils in the Eel River watershed, which remain in suspension for long periods. Therefore, even during periods of little or no rain in the Russian River watershed, stream flows in the river may remain turbid due to Eel River water passing through Lake Mendocino. However, if the release of water from Lake Mendocino is small, and if algal blooms or sand and gravel mining operations in the river do not increase turbidity, the Russian River becomes clear due to the diluting effects of the waters contributed by the tributary streams.

Turbid waters in the Russian River, especially during the winter steelhead migration from December through March, have been blamed for a decline in successful sport fishing and an associated loss of trade in the Guerneville resort area. The main target of these accusations has been the operation of Coyote Dam on the East Fork of the Russian River. In order to reduce turbidity levels on peak angling weekends during the steelhead fishing season, a "yo~yo" flow release schedule was implemented in the early 1970's which involved short periods of high discharge during the week followed by periods of low discharge on the weekends. This practice was discontinued during the drought of 1975-1977 and was partially reinstated in March of 1980. Use of this practice is expected to decline as demands for water supply releases from Lake Mendocino increase.

During low summer flows, turbidity may also increase due to algal blooms in the river. Since nutrient loading of the lower river due to sewage effluent discharge no longer occurs during the summer, associated algal blooms have been greatly reduced, in turn reducing the major source of summertime turbidity in the lower Russian River. Some short periods of higher turbidity in the lower river may occur due to road construction and gravel mining operations; however, the main cause of persistent low levels of turbidity during the summer is water transferred from the Eel River.

Examination of the turbidity values in Table 7 for the lower Russian River during the months of May through August 1977 reveals a general decrease in turbidity over the summer, with values greater than 5 Jackson Turbidity Units occurring only during the month of May, before or while the summer dams are being installed.

These data agree with the findings shown in Appendix F which concluded that the turbidity problems caused by summer dam operations were limited to their installation and removal periods. High turbidity values for the month of May at Johnson's Beach and Vacation Beach (Table 7) may represent the effects of dam installation which is done over a period of 2 or 3 days to a week during the latter part of the month. Grading of the riverbed and the use of gravel fill in construction of the dams is a potential source of downstream turbidity. Healdsburg Dam was identified as a possible sediment trap, accumulating sediment deposits that would wash out each fall when the structure is removed, causing temporary increases in downstream turbidity. The other impoundments on the lower river may also act as sediment traps, creating temporary turbidity problems after their removal in September.

The primary concern of the North Coast Regional Water Quality Control Board regarding summer dam operations is the impacts on water quality due to installation and removal methods, which contribute to increases in turbidity. To control resultant stream turbidities, dam installation and removal must be conducted according to waste discharge requirements established by the Board which stipulate standards for stream turbidity levels and operations within the streambed. The Department of Fish and Game, Region 3, also regulates dam installation and removal procedures through the issuance of stream channel modification permits, which stipulate dates and locations of work to be done and methods to be used.

The available data on stream turbidity in the lower Russian River during the time the dams are in place are insufficient to determine the effects of the dams on turbidity due to factors such as nutrient retention and resultant algal blooms. However, the installation and removal of the dams is clearly a source of turbidity.

Specific Conductance. The specific conductance of a solution is a measure of its capacity to convey an electric current due to the presence of ionized substances, and is directly related to substances dissolved in the water. Thus, specific conductance may be used as an indicator of the degree of mineralization of water, or its "total dissolved solids". This information is useful for assessing the effects of ions on chemical equilibria or for evaluating the physiological effects of ions on plants and animals.

The State Department of Water Resources' 1968 study of water quality in the Russian River watershed indicated that the river is similar to other natural water courses, with mineral content, as indicated by specific conductance, increasing in a downstream direction. This is due to leaching of minerals from the riverbed and seepage of highly mineralized groundwater.

Specific conductance values in Table 7 reveal that the mineral content of the river water was generally higher during May than the following three months. This may be due to two factors: 1) higher flows from tributary streams with a high mineral content, such as Big Sulphur Creek, during the month of May; and 2) winter-spring sewage discharges to the river, which continue until May 15, and effluent discharged to the Laguna de Santa Rosa, which may take up to 2 additional weeks to reach the main river. As tributary stream flows decrease and sewage effluent releases to the river are halted, mineral content, and therefore specific conductance of the river water, may be expected to decrease as is seen in Table 7. Although overall specific conductance levels decrease during the summer months, the downstream trend of increasing specific conductance in the river is shown throughout the year due to leaching and groundwater seepage.

Although the limited data available are not sufficient to detail such effects, the summer impoundments may cause an increase in specific conductance levels due to increased river bank contact, increased leaching of minerals from the streambed, and an increase in total dissolved solids due to evaporation from the impoundments. Recreational use of the impoundment waters may also contribute to similar increases in specific conductance.

Nitrates and Phosphates. Nitrates and phosphates are two of the primary nutrients utilized by aquatic plants. The natural sources of these nutrients in streams is rainfall, surface runoff and bank erosion. Drainage from agricultural lands also contains large amounts of nitrates and phosphates, as does domestic sewage effluent, which is a major cause of nutrient loading in streams in many urban areas. Nutrient loading of streams causes excessive algal growth, which in turn may effect a reduction in dissolved oxygen levels, increases in pH values and other conditions which adversely affect fish and aquatic invertebrates.

Nutrient loading of the lower Russian River is due chiefly to agricultural runoff and domestic sewage effluent containing nitrates and phosphates. During the months of June, July and August (Table 7), nutrient loads are kept well below the stated water quality objectives. However, during May when effluent releases to the river are still permitted, phosphate levels in excess of 0.4 mg/1 may occur. The data for the summer months do not indicate that summer dam operations affect nutrient buildup in the lower river, although recreational use of the impoundments may be expected to contribute to such a buildup.

2) Fisheries Resources Effects

The indepth study of barriers to fish migration on the Russian River contained in Appendix F includes an evaluation of both summer and winter conditions at Vacation Beach, Johnson's Beach, Healdsburg and Del Rio Woods summer dams, as well as the Wohler water diversion dam. As previously indicated, the summer dams presently create few fish problems except at Healdsburg and Del Rio Woods dams where there are no fishway structures. All other summer and recreational dams provide fishways.

Of the four fish species considered in this study, the American shad would be the most affected by dam operations. Shad spawning, egg incubation, and fry emergence usually take place from April through July.

The effects of summer recreation dam operations on the three salmonid species are limited to occasional late smolting and outmigration of juveniles during May and June, the inmigration of summer steelhead between April and July, and the inmigration of occasional early-running adult king salmon in August and September. Wintertime conditions at some dam sites may also cause salmonid passage problems during adult inmigration.

The timing of the shad run and the outmigration of smolting salmonids is dependent on climatic conditions which vary from year to year, and both migrations may occur later during high water years with lower water temperatures. Thus the impacts of the recreation dams on shad and salmonid reproduction will vary from year to year.

In addition to fish passage problems related to installation and operation of the summer recreation dams, summer road crossings and other water impoundment dams can cause fish passage problems.

Summer Road Crossings. The Basalt summer road crossing located at the mouth of Dry Creek was the only road crossing evaluated during the study of fish habitat and barriers to migration (Appendix F) that was shown to inhibit upstream fish passage. During the summer when the road crossing is installed, the flow of Dry Creek is restricted to six culverts. When stream flows are high in Dry Creek at the beginning of summer, the average velocity of water flowing through the culverts is potentially restrictive to the upstream movement of fish (including salmonids). The position of the culvert outlets (2.5 feet above the downstream water surface) essentially prevents shad passage into Dry Creek.

Water Diversion Dams. The Willow County water diversion dam located on the Russian River near Ukiah is composed of rocks and broken concrete slabs placed in the river to impound water for diversion to municipal and agricultural wells in the area. Insufficient flow will cause the water to flow through voids in the rock and slab structure, instead of over it, completely preventing fish passage. Higher winter and spring flows may create a velocity barrier to upstream movement.

The construction and removal of the summer dams and summer road crossings also have some impact on local riparian vegetation. The heavy equipment used prevents vegetation from becoming established in the construction and staging areas. This can lower the quality of salmonid habitat in the river system by eliminating shaded areas and increasing water temperatures.

The passage problems associated with summer road crossings and the Willow County diversion dam can affect fish migration in the Russian River basin. However, the Basalt summer road crossing on Dry Creek presently only affects American shad migration in the early summer before the lower end of the creek goes dry. These impacts may become more significant following completion of Warm Springs Dam, and if a summer steelhead population is established in the basin. Completion of the dam will provide year-around flows in Dry Creek and the possibility of establishing a summer fishery in the creek. Such a fishery may be adversely affected by the crossing. The Willow County diversion dam is located 88 miles above the mouth of the Russian River and provides marginal passage for steelhead. These problems were considered to be of lesser importance at the time of this study than the passage problems associated with summer recreation type dams in the lower river. Passage problems at the summer road crossings and the Willow County diversion dam were therefore deleted from further consideration in the Basin Study. This of course does not preclude consideration of these barriers in future studies, particularly since they would probably hinder improvement of the fishery in the Russian River basin.

c. Recreational Analyses

1) Benefits of Small Dams

The summer dams on the Russian River are usually emplaced for the summer recreational season, extending from Memorial Day through Labor Day weekend. Within this period are about 153 days, including 15 weekends. In general, higher recreational use in the study area occurs on the weekends than on weekdays. Peak use periods are the Memorial, Independence, and Labor Day weekends. Recreation use increases during the time when school is out for summer recess (June 15 to Labor Day). As with any water-oriented recreation area, recreation use in the study area fluctuates greatly with the number of clear, sunny and hot days.

Recreation use engaged in throughout the study area includes sightseeing, camping, swimming and sunbathing, boating (canoeing), fishing, picnicking, hunting, horseback riding and hiking. The activities that are primarily water-oriented include swimming and sunbathing, boating and fishing.

Monthly recreation use estimates for the summer recreation season (Memorial Day through Labor Day) at the 14 recreational areas impacted by the dams are shown in Table 8. Appendix C contains details on the method used for deriving these estimates. These use estimates apply to the 1978 recreation season under conditions existing at that time. Total 1978 recreation use for these areas was estimated to be 216,600 visitor-days (persons).

The amount of recreational use attributable solely to the summer dams is difficult to determine. No data or surveys are available to indicate the recreation use that would go on at the sites if just the dams were removed. Some activities such as sunbathing, camping, fishing, picnicking, hunting, horseback riding and hiking would probably continue without the dams. The method used in this study was to limit the analysis to only those areas of concentrated recreation activity directly impacted by the dams.

Table 8

ESTIMATES OF SUMMER SEASON RECREATION USE
AND SMALL DAM SITE BENEFITS

	Recreation Use (Visitor Days)	Benefits (Dollars)
May	11,600	$ 21,460
June	48,600	89,910
July	74,000	136,900
August	67,000	123,950
September	15,400	28,490
	216,600	$400,710

Source: Williams-Kuebelbeck and Associates, Inc., 1978; Recreation Analysis and Method of Estimating Recreation Use/Benefits at the Small Dam Site Recreation Areas. (See Appendix C for full text.)

Under these assumptions, all 216,600 total visitor-(recreation) days could be attributed to the summer dams. In other words, if the dams were not installed, a loss of 216,600 visitors could occur.

The major recreational benefits of the dams in terms of enhancing recreation are that they 1) create unobstructed boating areas much wider than the natural width of the river without the dams in place (the dams do somewhat inhibit downstream float-trip boating in that these boaters must portage around them); 2) increase the number and size of swimming areas and provide access to the river; and 3) enhance the recreational environment by empounding large, slow-moving bodies of water which provide a park-like setting for recreationists.

Table 8 shows estimated recreational benefits of the small dam sites, using a recreational-day value of $1.85 (see Appendix C for details). Total recreational benefits of the dam sites are estimated to be $400,710.

2) Fishery Benefits

The Russian River supports a substantial sport fishery that comprises a distinct economic resource. As a Class I premium fishery waterway, close to the population centers of the San Francisco Bay area, the river draws a large number of fishermen.

The economic value of this fishery is difficult to estimate accurately. There is no legitimate market for sport fish, and thus no identifiable market value per fish, as there is for commercially-caught fish. The commercial market price does not give an accurate estimate of the value of the sport fish catch. Commercial fishermen catch fish in much larger numbers with a higher catch per unit time. Equipment investments and personal time values are also significantly different between sport and commercial fishermen.

The methodology used in this study involves estimating the total angler-days devoted to the Russian River by type of fish, estimating sport and commercial catches, applying standard benefit values to angler-days of sport fishing (as defined by the Principles and Standards of the Water Resources Council in effect during the last stages of the study), and applying wholesale prices to commercial catches. While these values may not include all peripheral costs and benefits associated with these resources, they provide a basis for comparison of alternative resource management plans in the Russian River basin. As such, these values should not be considered definitive or inclusive of all costs and benefits associated with these resources.

The principal fisheries that provide the greatest economic benefits on the Russian River are the anadromous fisheries. Silver salmon, king salmon, American shad and steelhead all return to the Russian

River annually to spawn. During the annual runs, sport fishermen abound along the Russian River in pursuit of these fish.

This study did not estimate the impacts of the establishment of a summer steelhead fishery in the Russian River basin. The reason for this is that initial plantings of summer steelhead in the basin were made by the California Department of Fish and Game in 1980. Enough time has not elapsed between then and the issuance of this report to determine the viability or success of this population in the Russian River basin. However, should a summer steelhead fishery become established, the overall fishery recreation use of the Russian River could increase significantly.

Steelhead. The Russian River ranks third in California in steelhead production. As such, it provides an important fishery for the State. Economic benefits apply only to inland sport fishing since in California there is no commercial steelhead fishery. Table 9 shows the estimated annual catch of 5,062 fish and an estimated 53,151 angler-days for the 1971-1972 season. The maximum net fishing value of $10.40 per angler-day used by the Corps of Engineers (under guidelines issued by the Water Resources Council during the later stages of the study) was assigned to steelhead angling.

Multiplying this value by the total angler-days produced an estimated annual net value of $552,770. It should be noted that the number of angler-days expended to harvest the steelhead in 1971-1972 is exceedingly high, which may be an indication of poor census results or an unusually poor season for steelhead. An angler-day in this study was assumed to be 2.55 hours, which could be considered a low figure.

Angler success for steelhead in the 1971-1972 season was only 0.037 fish per hour. The California Department of Fish and Game 1965 Fish and Wildlife Plan estimate for steelhead angler success is 0.2 fish per hour, which would lower the economic value of each fish considerably. However, in various steelhead census surveys conducted throughout California from 1967-76, angler success ranged from 0.020-0.060 fish per hour.

Angling success and the size of the steelhead runs have reportedly declined during the last few years. This is possibly due to degradation of steelhead habitat through dam construction, water diversion, channelization and changing land use. The estimated catch in 1965 was 12,000 per 60,000 angler-days.

Silver Salmon. Silver salmon constitute both an important commercial and sport fishery for the Russian River, with substantial benefits accruing to marine sport and commercial fisheries. Again, a figure of $10.40 per angler-day was used for inland sport fishing (see Table 10). The value for marine sport fishing was taken as $30.00 per angler-day, almost triple the unit value for the freshwater

Table 9

ESTIMATED ANNUAL STEELHEAD ANGLING VALUE

1971-72

Total Catch = 5,062

	Fresh Water Sport Fishery	Marine Sport Fishery	Marine Commercial
Catch	5,062	0	0
Angler-Day Per Fish	10.5	-	-
Total Angler-Days	53,151	-	-
Value Per Angler-Day	$10.40	-	-
Annual Value	$552,770	$0	$0
Total Annual Value		$552,770	

Source: Lee, Dennis. 1972. Angler Use, Harvest & Population Estimates for Russian River Winter Steelhead (Salmo gairdneri), California Department of Fish and Game, Region 3, File Report.

Table 10
ESTIMATED ANNUAL SILVER SALMON ANGLING VALUE

1971-72

Total Catch = 12,500

	Fresh Water Sport Fishery	Marine Sport Fishery	Marine Commercial
Catch	2,000 (2)	2,100 (3)	8,400 (3)
Angler-Day Per Fish	5.0 (2)	0.95 (4)	—
Total Angler-Days	10,000 (2)	1,995	-
Value Per Angler-Day	$10.40	$30.00	-
Annual Value	$104,000	$59,850	$189,000 (1)
Total Annual Value		$352,850	

(1) At 10 pounds average per fish, and at $2.25 per pound.

(2) Values from 1965 study as republished in Eel-Russian Rivers Streamflow Augmentation Studies. California Department of Water Resources. Bulletin No. 105-5. February 1976.

(3) Jones & Stokes Associates estimate based on the assumption that the total marine catch is three times the freshwater population of 3,500 (taken as one-half of a 1965 estimate of 7,000 [see footnote 2 above]). The marine sport catch is assumed to be 25 percent of the marine commercial catch. These assumptions are based on evaluations of the existing fishery data and represent Jones & Stokes Associates best estimate of the 1971-72 silver salmon angling value.

(4) Value calculated from San Francisco port angler use data from California Marine Fish Landings for 1971. California Department of Fish and Game. Fish Bulletin 159. 1973.

fishery due primarily to the use of sport fishing vessels. The total annual inland sport fishery approximates $104,000 and the total marine sport fishery about $59,850. The annual commercial value is estimated to be about $189,000 using a market value of $2.25 per pound.

King Salmon. At the present time king salmon are not considered a viable sport fishery resource in the Russian River basin. Near the end of the 1960's, strains of late-summer and early-fall spawning salmon were planted in the basin in attempts to establish a self-sustaining population. These attempts failed to produce lasting results, primarily because returning fish encountered water temperatures too high for successful development of eggs and juveniles. A new effort is being made to establish a significant king salmon run in the basin through operation of the fish hatchery at Warm Springs Dam. A strain of late running (i.e., late November through early December) salmon is being used so that adults will return to the river after temperatures drop in the fall. Once this run is fully established, king salmon may become an important fishery resource in the basin.

American Shad. The Russian River shad population supports a substantial sport fishery. The sport fishery has increased since inland commercial fishing was made illegal. The data on shad are based on the Russian River American shad creel census of 1970 by CDFG and are considered to be a minimum estimate since the census did not start until angler effort and catch for the season were already high. The annual catch is estimated at 2,000 fish and total angler-days at 1,040 as shown in Table 11.

Estimation of net value per angler-day for shad was taken as equal to the value for salmon, although some may consider it of less value when considering relative fish size, type of tackle, limited run time, and difficulty of cleaning and preparing shad.

The game fish constituting the warm water fishery in the Russian River are striped bass, channel catfish, largemouth bass, bluegill and black crappie. It has been estimated from the CDFG's 1969 creel census that a total of 131,650 angler-days were expended in the basin in fishing for these species. Assigning an upper range value of $2.50 per angler-day for these fisheries puts the annual value at $329,100.

These estimates of the Russian River fisheries represent broad estimates based on data that are often incomplete. At best, the above values represent minimum estimates for the Russian River, based on data that are about 10 years old. Taking this into account, the total estimated value of the anadromous fishery is about $916,400. Including the warmwater fishery at $2.50 per angler-day, the annual value of the total Russian River fishery would be about $1,245,500.

Table 11

ESTIMATED ANNUAL AMERICAN SHAD ANGLING VALUE

1970

Total Catch = 2,000

	Fresh Water Sport Fishery	Marine Sport Fishery	Marine Commercial
Catch	2,000	0	0
Angler-Day Per Fish	0.52	-	-
Total Angler-Days	1,040	-	-
Value Per Angler-Day	$10.40	-	-
Annual Value	$10,816	0	0
Total Annual Value		$10,816	

Source: California Department of Fish and Game. 1978. Russian River American Shad Creel Census (1970), Region 3, File Report.

These values include the effects *of* the small summer recreational dams, at which some fishing takes place.

3. Review of Previous Plans

Currently, there is no comprehensive plan for the management and operation of the summer dams on the Russian River. However, a variety of agencies, Federal, State and local, are applying their regulatory powers to preserve and enhance both water quality and the fisheries resources in the river.

While summer dams have been placed in the river since the 1930's, it was not until the early 1970's that fish passage structures were added to the dams at Vacation Beach and Johnson's Beach. Fish passage facilities were included in the construction of the inflatable Wohler Dam in 1975.

A review of existing information and contacts with Federal, State and local agencies has pointed out a deficiency in the quantity and extent of water quality and fisheries resource data on the Russian River, particularly that which can be related to the effects of summer dams. Even with the scarcity of data, however, the addition of fish passage facilities to both the Healdsburg and Del Rio Woods dams was felt to offer the potential of enhancing the fisheries resources in the river upstream of Healdsburg.

Healdsburg Dam

Since its construction in 1952, Healdsburg Dam has eliminated the upstream movement of shad and king salmon during the summer recreation season and inhibited the passage of steelhead and salmon during winter low flow periods. The dam would also inhibit the migration of summer steelhead.

In 1975, the CDFG, Region 3, submitted plans and specifications to the SCWA for the construction of a modified Denil fishway on the west abutment of Healdsburg Dam to permit fish passage while the recreation dam is installed during summer months, and when the dam is removed and the foundation sill obstructs fish passage at low flows. By an agreement dated June 9, 1975, the CDFG and Sonoma County each agreed to contribute one-half of the cost of the fishway, not to exceed $30,000 each, comprising a construction fund of $60,000. The cost of the recommended fishway design was, however, estimated to be closer to $100,000, and the fishway was never advertised for construction bids. The SCWA also concluded that a fishway placed on the west abutment would receive a great deal of battering during flood flows, resulting in high maintenance and repair costs.

Another less expensive alternative suggested by the SCWA was to place additional large rocks below the dam to allow for fish passage over the dam foundation sill during winter low flow periods, and the construction of a permanent or portable fishway on the east abutment of the dam to allow for fish passage when the flashboards of the dam are installed. In 1966 and 1968, the SCWA added rocks retained by iron rails to stabilize the streambed below the dam. This work resulted in the formation of stepped pools leading up to the dam foundation sill, which allowed for salmonid passage during the winter months when flows were low. Much of the material has since eroded away, leaving a 5-foot drop below the sill.

Due to cost considerations, there are currently no plans for provision of a fishway at Healdsburg Dam to solve the problem of fish passage during the recreation season when the dam is in place or during periods of low winter flows. However, support for such an effort has been recently voiced by Salmon Unlimited, the Mendocino County Board of Supervisors, and the Eel-Russian River Commission.

The installation of a removable, modified Denil-type fishway on the dam's east abutment during the recreation season, similar to those used at Vacation and Johnson's Beach dams, would involve no major structural problems. The fishway could be installed yearly on concrete footings and removed at the end of the recreation season. The fishway would require a rise of about 16.5 feet at a construction cost of approximately $6,500 per foot. For low flow passage, a concrete fishway protected by iron grating could be constructed in the river channel to a low point in the foundation sill, accomplishing a rise of 5 feet at a similar cost per foot of rise. This structure would not interfere with the recreation dam.

Del Rio Woods Dam

Although the CDFG has expressed concern over the problem of fish passage at Del Rio Woods Dam during the summer months, they have made no definite recommendations for incorporation of a fishway into the dam since summer fish passage is not possible at Healdsburg Dam downstream. Fish passage facilities could be provided at Del Rio Woods Dam by the installation of a removable modified Denil fishway similar to those placed on the Johnson's Beach and Vacation Beach dams. Installation of the fishway would involve no major structural problems. The structure could be installed yearly on concrete footings and could be removed when the dam is dismantled each year. The fishway would require a rise of about 12 feet to permit passage and construction would cost approximately $78,000.

4. Conclusions

Four of the six alternative summer dam management plans conceptualized as part of this study were selected for further consideration. Alternative F -Revised Installation and Removal Dates - was discarded as it was considered to be an option available under Alternative C - Variable Installation and Removal Dates. Alternative E - Dual Level Dam Installation with Second Level Fishway - was dropped from further consideration because Alternative C appeared to offer similar flexibility in the trade-off between fisheries and recreational needs. The dual level installation would have a much higher first cost than Alternative C while the additional environmental benefits would be marginal.

B. ASSESSMENT AND EVALUATION OF DETAILED PLANS: SUMMER AND RECREATIONAL TYPE DAMS

1. Alternative A

a. Management Plan Description

Alternative A is Status Quo Management. This plan would retain the installation and removal dates of the summer dams as they are now: installation just prior to Memorial Day and removal just after Labor Day. No additional fishways would be installed.

b. Impact Assessment

1) Environmental

The water quality effects of status quo management of the summer dams would be identical to present conditions, with no identifiable effects on water quality while the dams are in place, based on existing data. Installation and removal of the dams will continue to cause temporary increases in stream turbidity.

Status quo management will continue to have some adverse effect on the anadromous fisheries of the Russian River. The dams, even with fishway structures, inhibit upstream migration of shad, early upstream migration of king salmon, late downstream migration of juvenile salmonids, and will probably inhibit migration of summer steelhead. The pools formed behind the summer dams reduce the quality and quantity of shad spawning and nursery habitat in the lower Russian River.

The turbidity caused by installation and removal of summer recreation dams adversely affects fish by silting channel gravels, reducing the availability of benthic organisms as a food source, and by increasing fish mortality through suffocation. For example, in June 1972, significant kills of both steelhead and silver salmon were observed by the CDFG in sediment-laden waters below areas where summer dams were under construction in the Austin Creek drainage basin. Austin Creek is a tributary of the Russian River. Bioassays were conducted by the CDFG of water having a turbidity of 1350 Jackson Turbidity Units (JTU's), taken from below the construction site of one of the summer dams. One hundred percent (100Z) of the juvenile steelhead placed in the water were killed. Results of laboratory tests published in 1961 by D. W. Herbert and J. C. Merkens indicated that trout mortality due to turbidity is caused by direct damage to the gills by the sediment particles, or by gill damage which makes the fish more susceptible to disease.

2) Economics

This plan would result in the same recreational impacts currently associated with summer dams (see Section II.C.3.a).

3) Social Impacts

Under this alternative, the current social impacts of summer dams would continue. Noise brought about by construction and removal of summer dams would remain. This noise is primarily from bulldozers and small earth-moving equipment. People using the dams will heighten the noise level during the summer season. Temporary noise from their vehicles will also interfere with the usual background noise level.

Leisure opportunities for people visiting the river will continue with the availability of the summer dams. The community structure in and around the dams will remain basically the same with very little anticipated growth. Cultural opportunities include experiencing lifestyles of a rural or outdoor nature and meeting people of diverse backgrounds and occupations. These opportunities for people visiting the river area will be maintained, as will aesthetic opportunities related to enjoyment of certain of the river's features and environment.

c. Evaluation and Trade-Off Analysis

Status quo management would allow the present operation of the summer dams on the river to continue with all the recreational and economic benefits now enjoyed. Regarding adverse impacts of the dams, shad would not be able to migrate past the Healdsburg Dam, which would affect the future of the river's upstream fishery. An unknown percentage of fish will continue to be affected by the presence of the summer dams, as well as their installation and removal. This would include early inmigrating king salmon, summer steelhead, and outmigrating juvenile salmonids.

d. Mitigation Requirements

There are no mitigation measures required by the implementation of Plan A.

e. Implementation Responsibilities

No new implementation responsibilities need be identified.

2. <u>Alternative B</u>

a. Management Plan Description

Alternative B is the Status Quo Management Plan with the addition of fishways at Healdsburg and Del Rio Woods dams. This alternative would maintain the existing installation and removal schedule for the summer dams, which is variable but generally involves installation just prior to Memorial Day and removal just after Labor Day. Fishways would be added to the two summer dams upstream of the Dry Creek confluence. These fish passage devices would be temporary structures and would enhance up- and downstream movement of fish when the dams are in place for summer use. Also at the Healdsburg summer dam, a permanent fish passage device for the concrete sill should be constructed to reduce the fish passage problems during low flow periods when the recreational dam is not in place.

b. Impact Assessment 1)

Environmental

On the basis of information currently available, it appears that the summer recreation dams as they are now operated have little effect on the water quality of the lower Russian River when they are in place. The only clearly identified impact of these dams on water quality is caused by their installation and removal which results in temporary increases in stream turbidity. The installation of fishways at both Healdsburg and Del Rio Woods dams should have no effect on water quality.

Under current management techniques, the summer recreation dams have some adverse effects on the anadromous fisheries of the Russian River. The presence of the dams, even with fishway structures, inhibits both upstream migration of shad and king salmon, and downstream migration of juvenile salmonids. The dams may also inhibit or prevent the establishment of a summer steelhead population in the river. Operation of the dams may also reduce the quality and quantity of shad spawning and nursery habitat in the lower Russian River. Although the addition of fishways at Healdsburg and Del Rio Woods dams may permit the passage of shad, early run king salmon and summer steelhead into the upper river during the recreation season, the success of shad passage through any of the existing or proposed fishways has not been evaluated. The possible reluctance of shad to use the fishways, and the necessity of using five fishways to reach the upper river, could reduce the shad run to fewer fish than would successfully complete their migration if no dams were installed on the river.

The addition of a low-flow fishway at Healdsburg Dam will improve the upstream passage of salmon and steelhead following removal of the recreational dam and prior to the occurrence of higher flows in the fall. During this period, the concrete foundation for the dam now forms a barrier to fish.

2) Economic

The costs associated with the addition of two fish passage devices at Healdsburg Dam and one such structure at Del Rio Woods Dam include the construction cost plus additional costs for engineering, contingencies and construction inspection. These additional costs are estimated to be 40 percent of the construction cost. Therefore, the total cost for installation of fish passage structures at Healdsburg Dam would be $200,000 while the total cost for a fish passage structure at the Del Rio Woods Dam would be $110,000. Annual maintenance costs would be approximately $10,000 for the two Healdsburg fishways and approximately $6,000 for the Del Rio Woods fishway.

This plan would be of limited benefit to the recreational uses associated with sport fishing, neglecting for the moment potential benefits associated with establishment of a summer steelhead fishery in the basin. Only modest increases in the population of steelhead or king salmon would be expected as a result of installation of the fish passage structures. It is estimated that at best only a one percent increase in fish and thus angler-days could be expected. For American shad, the estimated increase in the number of fish and thus angler-days is again felt to be rather modest and on the order of ten percent. This alternative could significantly affect the establishment of a summer steelhead population in the basin although the magnitude of these effects cannot be determined at the present time.

3) Social Impacts

The social impacts of Alternative B will essentially be the same as Alternative A. With more fish able to go upstream, the upstream area will become more attractive for anglers. This will have some additional impact on the upper reaches of the Russian River where fishing is expected to increase. Noise will be higher during fishing season because of more cars. There should be no additional community growth nor should community cohesion be disrupted.

c. Evaluation and Trade-Off Analysis

Alternative management plan B would allow the present operation of the summer dams on the river to continue. The dates of erection and removal would continue to be variable but would generally be shortly before Memorial Day and shortly after Labor Day.

The addition of fish passage structures to Healdsburg and Del Rio Woods dams would have total first costs estimated to be $200,000 and $110,000, respectively. Annual operation and maintenance costs are estimated at $10,000 and $6,000 respectively. The addition of these structures has the potential to provide improved fish passage during the later stages of the American shad run and would help some fish reach the middle reaches of the river. The number of fish these structures would pass cannot be accurately predicted. In terms of percentage of the total shad run, the numbers are thought to be rather small. Nevertheless, the installation of these structures will remove an impediment to shad migration and thus enhance the fisheries resources of the river.

The fish passage structures would also enhance migration of summer steelhead and fall run king salmon. The number of runs which would be enhanced and the number of fish involved is difficult to quantify. The very existence of these structures would, however, provide a better opportunity for passage than now exists.

This alternative would have no adverse effects on recreational benefits in the Russian River basin and could improve the overall recreational resources of the basin. Improved fish passage at Healdsburg and Del Rio Woods dams has the potential to improve the fishery resources of the basin, which would allow more recreational days to be spent in the basin by anglers. However, any such improvement is expected to result in modest increases in use of the river system by anglers. This does not include the effect of this alternative on summer steelhead. The provision of fish passage facilities at Healdsburg and Del Rio Woods summer dams could play a significant role in the establishment of a viable population of this strain in the Russian River basin.

Plan B therefore will result in, at best, modest enhancement of the environment and modest increases in recreation benefits, neglecting the possible beneficial impacts on summer steelhead. The total first cost would be approximately $310,000. Annual operations and maintenance costs would be approximately $16,000.

d. Mitigation Requirements

There are no mitigation measures required by Plan B.

e. Implementation Responsibilities

The only elements of Plan B which differ from existing summer dam management practices are the addition of fish passage structures at Healdsburg and Del Rio Woods dams. The Healdsburg Dam fishway would have to be installed prior to that at Del Rio Woods for without passage at Healdsburg Dam, the upstream fishway would serve little purpose.

The responsibility for installing these structures rests with local agencies. The California Department of Fish and Game and Sonoma County, through the Sonoma County Water Agency, would be responsible for installation of the fishway at the Healdsburg Dam. At the Del Rio Woods Dam, the California Department of Fish and Game and either the Del Rio Woods Homeowners Association or Sonoma County would have implementation authority.

Operation and maintenance costs would be the responsibility of the owner of the dam. In this case, Sonoma County and the Del Rio Woods Homeowners Association would be responsible.

There is no Federal involvement under Alternative B, other than the usual regulatory responsibilities regarding activities in the nation's waterways. This includes the Corps Section 404 authority (Public Law 92-500) involving the disposal of dredge or fill material in waterways. Local agencies would be relied upon exclusively to formulate, design and implement the fisheries enhancement provisions contained in this plan.

3. Alternative C

a. Management Plan Description

Under Alternative C, the times at which the summer dams will be installed and removed would be determined by an appropriate agency, based on day-today or week-to-week assessments of certain environmental factors. These factors would include temperature and hydraulic conditions in the river, opening of the river mouth, and the timing of the spring shad, summer steelhead and fall king salmon runs. Brackets of dates would be established to provide defined periods during which the responsible agency could regulate the timing of recreation dam installation and removal. As part of this plan, an administrative structure involving existing agencies would need to be established and authorized to implement the plan.

Plan C also includes addition of fish passage structures to both Healdsburg and Del Rio Woods summer dams. The discussion of this aspect of Plan B would also apply to Plan C.

b. Impact Assessment

1) Environmental

The effects of summer recreation dam operations on water quality in the Russian River under this management alternative would be similar to those identified for Alternatives A and B. Turbidity would still occur during dam installation and removal, although the time at which this would occur would vary with the installation/removal dates selected by the responsible agency.

This management alternative would have a beneficial effect on the salmonid and shad fisheries of the Russian River. Dam installation and removal would be timed, within limits, to allow for greater unobstructed upstream migration of shad, summer steelhead and king salmon, downstream drift of shad eggs, and outmigration of juvenile salmonids.

During certain years, later installation of summer dams could allow a larger percentage of the returning adult shad to successfully reach upstream spawning areas, would provide more fast water riffle areas for shad spawning, and would provide required stream areas for the downstream drift of shad eggs. Later installation would also reduce interference with inmigrating summer steelhead and outmigrating juvenile salmonids and would reduce the effects of predation on these juveniles by other species.

Earlier removal would benefit the remaining early king salmon run when other conditions existed allowing the run to occur, including opening of the sandbar at Jenner. Relatively high temperatures in the lower river during the early king salmon run may make removal of obstructions, including summer dams, necessary to minimize exposure of the fish to these higher temperatures as they seek the colder waters of Dry Creek and other tributaries.

However, if current plans to rear a strain of late-running king salmon in the Warm Springs fish hatchery are successful, the existence or non-existence of the summer dams in the month of September will become less of an environmental factor. The late-running king salmon are expected to run in November and December and spawn in December and January when the summer dams are not in place.

2) Economic

Impacts of this plan on recreation use cannot be precisely determined *a priori.* Installation of the dams prior to their current installation time would theoretically increase recreational use. However, if the dams are installed later, a loss of recreation benefits would result. Obviously installation of the dams by Memorial Day, in line with the current schedule, would not change the recreation benefits estimated under existing conditions. Similarly, extending the time the dams remain in place (up to September 30th) would increase recreation benefits, while removing the dams earlier than at present would cause a decrease in recreation benefits.

During the Memorial Day weekend, the small dam recreational facilities operate at full capacity. If the dams were not installed until just after this long weekend, an estimated minimum of $21,500 in recreation benefits would be lost. For each day in May the dams are in place before Memorial Day, use of the recreation facilities was estimated to be roughly 30% of the daily Memorial Day weekend use. Thus, an estimated $2,150 in additional recreational benefits is generated for each extra day the dams are in place in May. For more information on these estimates, see Appendix C.

For every day the installation of the dams is delayed beyond the Memorial Day weekend, an average of $3,000 in recreation benefits would be lost. For example, if the dams were not installed until June 20th, the total loss of recreation benefits would be $81,500 ($21,500 + (20 days x $3,000)).

The small dam recreation areas also operate at full capacity on Labor Day weekend. If the dams were removed prior to this weekend, a minimum of $21,500 in recreation benefits might be lost.

Average daily recreational benefits in September (not including Labor Day weekend) are estimated to be 30% of the daily Labor Day weekend benefits, or $2,150. Therefore, the average daily recreation benefits accruing by leaving the dams up after the Labor Day weekend is $2,150. For more information on these estimates, see Appendix C.

It is estimated that when compared on an average annual basis, Alternative Management Plan C would provide the same localized recreational benefits as those currently provided by the summer dams. There would, however, be an increase in recreational benefits accruing to other parts of the basin since this alternative would increase the numbers of fish in the river, which would result in an increase in the number of angler-days expended. Increases in the number of steelhead and king and silver salmon are expected to be greater than those expected under Alternative B and may be as much as a two percent increase over present populations, excluding the possible establishment of a summer steelhead fishery. Similarly, the numbers of American shad may be increased by as much as 15 percent over the present population. These increases could be expected to be converted to similar increases in the number of angler-days expended in the pursuit of these sport fish.

The implementation of this alternative is not expected to significantly change average annual recreation benefits due to other uses of the river such as float trips. The total first cost for the addition of a fishway at Healdsburg Dam is estimated to be $200,000, and the cost for such a structure at Del Rio Woods Dam is estimated to be $110,000. Annual operations and maintenance costs for these fishways are estimated to be $16,000. These are the same estimates used for Alternative B.

Besides these costs, there is a possibility that summer dam placement and removal costs would be different than under the status quo mode of operation. Any such cost differential, however, is not considered to be significant. The structures would still be constructed in the manner presently used. • While occasionally stream flows may be lower than at present with consequently lower installation costs, the average annual cost is not expected to change significantly.

This alternative also has costs associated with collection of fisheries data, prediction of the start and duration of the runs and coordination of efforts to permit installation or dictate removal. On an annual basis, these costs are expected to be modest and would be in the range of $5,000-$8,000. This alternative would also require relatively high initial administrative costs to achieve appropriate agreements between the various agencies involved in this alternative management plan and would involve extensive coordination between public and private interests.

3) Social Impacts

The main social impact of this alternative would be the uncertainty regarding when the dams will be put in each year. This could disrupt community cohesion by causing conflict between the agency specifying the dates of installation and removal and those parties making their livelihood from the dams. These latter parties may be unwilling to accept a schedule that does not permit Memorial Day and Labor Day operations from one year to the next. Noise would increase or decrease during the summer period depending on when the dams are installed and removed. If installed earlier, there could be more people utilizing the facilities over a longer period of time. This would bring about additional vehicular traffic earlier in the year.

This alternative is not expected to affect existing community growth patterns in the study area, nor to displace persons impacted by the alternative.

c. Evaluation and Trade-Off Analysis

Alternative C involves a trade-off between certain recreational uses of the Russian River. The benefits to the fisheries resources due to later installation and/or earlier removal of the summer dams are difficult to quantify as are the benefits due to installation of fish passage structures at Healdsburg and Del Rio Woods summer dams. There are indications that these actions will enhance the fisheries resources, but there is no evidence available to indicate the magnitude of this enhancement.

Due to the uncertainty of how often and for how long the summer dam recreation season will be impacted, the cost of Alternative C associated with loss of recreation benefits cannot be precisely quantified. However, it is expected that there will be little if any change in the average annual recreation benefits directly attributable to the summer dams.

The cost of the installation of the two fish passage structures would be approximately $310,000. Annual operation and maintenance costs would be approximately $16,000.

Alternative C is expected to provide a net gain in recreation benefits, while incurring costs for installation of fish passage structures, and for administering and monitoring the implementation of this management plan. This alternative is supported by the U.S. Fish and Wildlife Service.

d. Mitigation Requirements

There are no mitigation measures required for Plan C.

e. Implementation Responsibilities

Alternative C is essentially real-time operation of the summer dams, particularly with respect to the installation and removal dates. The basic input required to determine whether the dams are impeding the fish runs is data on the occurrence of such a run. These data must be developed by a person or persons with fisheries experience who are able to identify the start and finish of the shad, summer steelhead and king salmon runs. These data, with an estimate of the magnitude and duration of the runs, would be required to assess the dams' impact on the runs. The California Department of Fish and Game could supply this information during the critical late spring and early fall months. The U.S. Fish and Wildlife Service and the National Marine Fisheries Service could also be involved in developing these fish run data.

The Corps of Engineers and/or the U.S. Geological Survey could be responsible for supplying hydrologic data on projected stream flows and water supplies available in the river basin. This information may be required to help predict the start, duration, and finish of the fish runs.

Sonoma County, through the Sonoma County Water Agency, could provide the local component of the summer dam management structure. Under a dam permit system, the Agency could condition permits based on stream flows and fisheries requirements. The Water Agency could also provide a local view of recreation requirements, with assistance from the Sonoma County Regional Parks Department.

A regulatory program involving these agencies would then account for all the variables involved in the real-time control of summer dam installation and removal as postulated in Alternative C. The Federal role would be to provide hydrologic data and possibly information on the fish runs for the control mechanism. The California Department of Fish and Game would likewise provide critical input in the form of real-time fisheries data.

Through this program, the changing needs of the fisheries resources in the river could be addressed, and appropriate summer dam operational modifications made in a timely fashion.

A similar management program, though it has not yet been implemented, currently exists as part of a proposed fisheries agreement regarding Warm Springs Dam. This agreement is being negotiated between the Sonoma County Water Agency and the California Department of Fish and Game, and concerns water releases from Warm Springs for fisheries enhancement. Like the proposed management program for the summer dams, it involves the Corps of Engineers. This program could be extended beyond Warm Springs to cover the operations of the summer dams.

The program for summer dams, as proposed, would not eliminate requirements for summer dam-related permits currently issued by various Federal and local governmental agencies. The management plan would have to be fully coordinated with those agencies having permit authority. This coordination would allow permit-granting agencies to incorporate their concerns into the management plan, would provide a smooth permit process and uniform compliance, and would illustrate the need for and benefits derivable from the proposed plan.

The costs of implementing and administering the management plan would be borne by the SCWA and CDFG, and the Corps of Engineers. Each would be responsible for costs for its specific input.

The costs of installing fish passage structures would be left to the local entities involved, i.e. Sonoma County through the Sonoma County Water Agency, the California Department of Fish and Game and the Del Rio Woods Homeowners Association. Operation and maintenance costs would be the responsibility of the owner of the dam.

As with Alternative B, Alternative C involves no predominant Federal involvement either in terms of expenditures or increased regulatory responsibility. The bulk of the responsibility for implementation of the plan rests with local agencies.

4. Alternative D

a. Management Plan Description

Under this plan installation and operation of summer recreation dams on the lower Russian River would be eliminated. No temporary dams would be allowed to be built. The Wohler water supply dam is excluded from this alternative because it is equipped with a fish ladder and can be raised and lowered to meet many streamflow requirements.

b. Impact Assessment

1) Environmental

The removal of summer recreation dams would minimize any water quality changes associated with the impounding of water during the summer at the summer dam sites. Based on existing data, no substantial or consistent quality changes have been documented under the current management program. Therefore, the benefits to water quality from elimination of the recreational summer dams would likewise not be substantial.

The removal of summer recreation dams would benefit fisheries by allowing virtually unobstructed passage of migrating steelhead, salmon and shad. Greater spawning areas would be available to shad, and interruption of the downstream drift of shad eggs prior to hatching would be minimized. Late out-migrating juvenile salmonids would no longer need to travel through the large number of impoundments behind summer dams, which cause them to be subject to delays, increased predation and rising water temperatures. An early king salmon run up the river would be facilitated since the fish would no longer have to negotiate several fishways on the lower river. Establishment of a summer steelhead population would also be enhanced by this alternative. There would be fewer barriers affecting the migration of these fish up the river in search of suitable summer holding areas.

Removal of the concrete dam foundation sill at Healdsburg as part of this operation plan would open the upper river to shad, summer steelhead and early king salmon by eliminating an existing barrier to their migration. However, removal of this sill would probably cause significant erosion damages in the Healdsburg area as there is currently heavy erosion occurring below the dam. This erosion could be expected to move upstream upon removal of the sill.

This management plan has the potential for the most significant improvement in the productivity of the Russian River fishery among the summer dam plans evaluated. However, it is not clear that the interference with movement of anadromous fish associated with present operation of the summer dams is the main factor presently limiting success of the basin fishery.

2) Economic

Recreational benefits directly attributable to the numerous summer-type dams along the river (over 216,600 visitor-days) would be lost under Alternative D. Applying a value of $1.85 per recreational day, a total of $400,700 would be lost in annual recreational benefits. This adverse effect will extend to small commercial recreation-related businesses (boat and raft rentals, overnight facilities, gasoline stations, etc.). However, these impacts could possibly be somewhat offset by provision of similar services to other increased recreational pursuits such as fishing and float trips. These uses of the Russian River could be expected to increase as a result of this alternative management plan.

Alternative D would benefit the fisheries resources of the basin and is expected to increase the numbers of fish throughout the basin. This would result in similar increases in the number of angler-days expended each year. Thus certain recreation benefits would increase due to removal of the summer dams. While it is difficult to quantify increases in the numbers of steelhead, king salmon, silver salmon and American shad, it is expected that this alternative would provide the largest increase of all alternatives investigated. It is estimated that steelhead and salmon could increase in population by as much as four to five percent over present numbers and American shad could increase by as much as one third. This alternative would greatly increase the possibility of successful establishment of a summer steelhead population in the Russian River basin. However, the benefits associated with the establishment of this fishery cannot be determined at the present time.

The U.S. Fish and Wildlife Service has indicated that implementtation of Alternative D might easily foster even greater increases in salmon and shad numbers, with concomitant increases in recreational fishery benefits. In particular, the Service believes the establishment of a sizeable shad fishery in the Russian River basin could result in considerable local recreation benefits since the potential of American shad to support angling has not been reached on the West Coast. Angling for shad is an important activity on East Coast streams in early spring, and can offer a significant sport fishing challenge on West Coast streams when salmon and steelhead are not running. The Service also indicated that removal of migration barriers would, following the introduction of suitable genetic strains, probably facilitate the establishment of a king salmon fishery in the basin.

3) Social Impacts

Besides actual monetary loss, the impact of this plan on people whose livelihood depends on recreational use of the summer dams would be tremendous. Smaller over-night lodging facilities would suffer from a loss of customers, leaving their owners looking for new markets. There could be some displacement of people as recreational facilities fall into disuse and their proprietors are required to move elsewhere in search of new incomes.

Community cohesion would be disrupted and community growth in the areas closely associated with the summer dams would probably be reduced. Certain leisure opportunities along the Russian River would not be as readily available if no dams were installed. Noise would lessen as fewer people used the river for recreation.

c. Evaluation and Trade-Off Analysis

Elimination of summer dams on the mainstem of the Russian River would result in the loss of recreational benefits directly attributable to those dams. However, this would be offset somewhat by increases in benefits from other recreation pursuits on the river, principally in the area of sport fishing. While it is difficult to accurately quantify these gains and losses, it is estimated that the net effect would be a reduction in total recreational benefits along the Russian River. As mentioned previously, this does not consider the benefits associated with a viable summer steelhead fishery in the Russian River basin. To this net loss in recreational benefits must be added the costs associated with damages from erosion expected to occur upstream of the Healdsburg Dam should the dam sill be removed.

On the other hand, of all the alternatives considered, this one provides the maximum potential for enhancing the basin environment through improving its fisheries resources.

Alternative D, therefore, would result in an increase in the fisheries resources of the Russian River basin and a probable loss in overall recreation benefits.

d. Mitigation Requirements

A mitigation measure which would be required by this alternative would be the placement of appropriate bank and channel stabilization structures upstream of Healdsburg Dam. Also, some thought should be given to the economic effect this plan would have on people directly engaged in the recreation dam business. Phasing out the dams over a specific number of years would help minimize the eventual impact. However, it would in no way compensate for the loss of revenue to these business people.

e. Implementation Responsibilities

Responsibility for elimination of the recreational dams would belong to local agencies; either the California Department of Fish and Game or the County of Sonoma.

5. Comparison of Detailed Management Plans

a. Comparison of Plans

Four alternative management plans for summer dams on the Russian River were considered for adoption and implementation by local agencies. Alternative A - Status Quo Management - represents the no action alternative and is the baseline used for comparing the plans. The three other alternative plans, B, C and D suggest various management measures (and related administrative structures) for the summer dams. The degree of change from existing conditions increases as one proceeds from Alternative B to Alternative D.

In terms of total project cost, Alternative D is the most expensive for it must include mitigation measures to provide for bank and channel stabilization measures upstream of Healdsburg Dam. Conversely, Alternative B is the alternative with the lowest cost for it only includes addition of fish passage structures at Healdsburg Dam and Del Rio Woods Dam.

The alternative plans also provide for a greater level of environmental enhancement as one proceeds from B to D. The elimination of all summer dams on the mainstem of the Russian River (Alternative D) provides the maximum potential for environmental enhancement through improved fisheries resources.

The plans present a wide range of management measures with an associated wide range of costs and environmental benefits.

b. Rationale for Designating the NED Plan

The alternative management plan which would contribute the most to national economic development would be Alternative B, status quo management with the addition of fish passage structures at Healdsburg and Del Rio Woods dams. This plan would increase the value of the nation's output of goods and services and improve national economic efficiency.

The plan preserves existing recreational benefits and would enhance fishing benefits in the Russian River basin. These benefits could eventually outweigh the costs of the fishways. Greater recreational benefits would occur upstream of Healdsburg, thus enhancing or creating new recreational facilities which would add *to* the local economy and increase the value of the nation's output of goods and services.

c. Rationale for Designating the EQ Plan

The alternative management plan contributing the most to improvement of natural and ecological systems is Alternative D: no summer dams. This plan would achieve maximum preservation and enhancement of fisheries resources in the Russian River basin by minimizing barriers fish have to overcome in order to spawn upstream. In addition, their eggs would be less likely to be caught or smothered in pools behind the dams. Interference from the recreational activities of people would also be less likely.

6. Conclusions

The alternative plans for management and operation of the summer and recreation-type dams on the mainstem of the Russian River were formulated and evaluated with the intent of providing alternatives for consideration for implementation by local agencies. Based on the results of this study there is no basis for additional Corps of Engineers involvement in management of the summer dams in the Russian River basin other than through the existing Corps regulatory permit program. Thus, no further studies under the Russian River Basin Study authorization should be conducted by the Corps of Engineers. However, non-Federal interests can be provided the information generated during this study to assist them in their own decision-making processes.

The major shortcoming encountered during this investigation was the limited extent of specific data concerning the effects of the summer dams on the water quality of the Russian River and its fisheries resources. Any further investigations would benefit by incorporation of a substantial data collection program. Such data could provide more insight into the specific relationships between the operations of the dams and the environment.

While the fisheries resources of the Russian River have declined over the last 50 years, it is not known if interference with the passage of fish caused by summer dams is the primary factor contributing to this decline. While this interference indeed has had an effect on the fisheries, other factors are also thought to be influential and are considered by some to be more important than the effects of summer dams. The loss of habitat in the tributary streams is considered by many fisheries experts to likely be the major impediment to a thriving fishery in the Russian River basin.

C. PRELIMINARY PLANS: OPERATION OF EXISTING STRUCTURES ON THE RIVER AND TRIBUTARIES

1. Management Measures

Coyote and Warm Springs dams in the Russian River basin are Corps of Engineers facilities. The Corps operates the dams and has jurisdiction over operational criteria for water which is stored in the flood control pool of each reservoir. For water in the water supply pool the Corps operates the gates for release, but a local agency, the Sonoma County Water Agency, has jurisdiction over operation criteria. It is the Water Agency's responsibility to schedule releases to meet demands for water and it is the Corps' responsibility to operate the dams to reduce flood hazards within the limits of the projects' capabilities.

Coyote Dam became operational in 1959. Warm Springs Dam is under construction and is expected to be operational by late 1982. Investigations carried out under the Russian River Basin Study were based on the assumption that Warm Springs Dam is in place and operational.

As part of the Warm Springs Dam Project, a fish hatchery, located immediately downstream of the dam, has been constructed. This hatchery will provide mitigation and enhancement to the fishery resources of the Russian River Basin. The hatchery will produce an annual harvest of 300,000 steelhead yearlings, 110,000 silver salmon yearlings and 1,000,000 king salmon fingerlings.

The existence of the two dams and their operation for water supply, flood damage mitigation, recreation and fisheries mitigation and enhancement has altered the basin's hydrologic characteristics inasmuch as large winter and spring discharges are reduced and summer and autumn flows are increased. These operations and resultant alterations of discharges in Dry Creek and the Russian River affect the basin's environment. However, the water quality of the Russian River is generally considered to be very good. Measurements performed by the NCRWQCB in the summer of 1977, a drought year, indicated that the quality of the water in the river generally met the basin standards established by that agency.

The problem of turbidity in the releases from Lake Mendocino is one of long standing concern. The turbidity problem is related to diversion of water from the Eel River basin via the Potter Valley powerhouse. The high erosion hazard in much of the Eel River basin above Lake Pillsbury contributes to *a* very heavy concentration of suspended sediments in the river during the winter and spring. Other contributors may include poor land use practices above Lake Pillsbury and possibly a number of site-specific erosion problems.

In particularly wet years the Eel remains heavily laden with silt through the first part of summer. Some of this sediment is diverted from the Eel to the East Fork of the Russian River via the Van Arsdale diversion dam and the Potter Valley powerhouse. This sediment subsequently travels through Lake Mendocino and into the Russian River mainstem below Coyote Dam, and sometimes adversely affects the fishery resources of both the lake and river. This problem has been recognized in studies conducted by several public entities, including the Corps of Engineers, the Federal Power Commission, the Federal Energy Regulatory Commission, and the California Department of Water Resources.

This problem was not addressed in the Corps' Russian River Basin Study since several local interests have been studying the related issue of Eel-Russian River diversions as part of the FERC re-licensing of the Potter Valley powerhouse. These parties include the Pacific Gas and Electric Company which is studying the effects of various flows on the Eel River fisheries, and Sonoma County which is studying the effects of changing diversions on the resources of the Russian River basin. Also, the effects of installing a multiple outlet structure to reduce turbid water discharges will be considered in any Coyote Dam enlargement study conducted by the Corps.

The temperature of the water in the Russian River is a water quality parameter which has important ramifications regarding the fisheries resources of the basin. Water released from Lake Mendocino increases in temperature as it travels downstream until about the Wohler diversion downstream of the Dry Creek confluence. Downstream of the Wohler diversion, temperatures in the river decrease due to colder water contributions from Dry Creek and other tributaries. The increase in temperature is sufficient to prevent much of the river itself from being used by salmonids as nursery and rearing habitat. The increase in temperature reflects the effects of the ambient air temperature in the Russian River basin on water released from Lake Mendocino. The temperature rise is most dramatic during the summer months when air temperatures are high and releases from the lake constitute the majority of the flow in the river.

Water temperatures in the Russian River drainage typically increase to above 68 degrees F, the upper tolerance limits for salmonids (Kubicek and Price, 1976), during the summer low flow period and decrease as cooler weather conditions and higher stream flows develop in the fall and winter. High water temperatures in the late spring, summer and early fall have been identified as the major factor limiting salmonid habitat suitability in the Russian River mainstem and lower Dry Creek. Much of the mainstem, especially below Cloverdale, is unsuitable as nursery habitat during the summer due to high water temperatures. Dry Creek prior to the construction of Warm Springs Dam provided only marginal summer nursery habitat for the same reason. The only water temperatures suitable for summer nursery habitat in the mainstem of the Russian River were found in its upper reaches from Coyote Dam to near Hopland due to the release of cold water from Lake Mendocino. Elevated summer temperatures may also reduce the suitability of the stream for the growth of aquatic insects which serve as a major food source for juvenile salmonids.

High water temperatures in the Russian River during the late summer and early fall have also contributed to preventing the establishment of a self-sustaining king salmon population. King salmon require temperatures below 13 degrees C (56 degrees F) during migration for proper egg development and availability of eggs within the female. Although adult king salmon have been seen in the river as early as August and most inmigration occurs during September, October and November, temperatures in the lower Russian River at Guerneville usually do not fall below 13 degrees C until mid-November.

Elevated water temperatures may also have a limiting effect on the outmigration of juvenile salmonids during periods of low flow in the Russian River. Temperatures below 15 degrees C (59 degrees F) are required for the process of smoltification prior to outmigration, and fish held in water with temperatures higher than this may lose smolt characteristics rapidly. Since water temperatures in the lower Russian River usually exceed 15 degrees C by the middle of April, outmigration of smolting juveniles, which usually lasts through May or June, may be curtailed due to elevated water temperatures.

Any flow releases made from Coyote or Warm Springs dams to provide suitable summer nursery habitat should consider the magnitude of flows necessary to reduce temperatures to acceptable levels. Any adverse impacts of these releases on other uses of the water such as recreation and water supply should be assessed and balanced against benefits derived from these releases for temperature control. Unlike Coyote Dam, Warm Springs Dam has a multi-level outlet structure. This provides the capability to control the temperature of releases less than approximately 300 cfs. This control is necessary to ensure optimum fish habitat conditions. The water released will increase in temperature as it interacts with the warm air of the Dry Creek Valley on its way to its confluence with the Russian River.

A generalized investigation was conducted to estimate the effects of Warm Springs releases on water temperature in the Russian River. It was estimated that during the summer months water released from Warm Springs Dam would increase by 10 degrees F on its way to the Russian River. The temperature of water released during an average year was based on model studies of temperature stratification in Lake Sonoma. Releases through each of the multi-level outlets were evaluated so that a proper water temperature range would be present below the Warm Springs hatchery. The increase in water temperature along Dry Creek to the Russian River was estimated from water temperature data collected as part of this study and presented in Appendix F. The estimated rise of 10 degrees F was used during all of the spring, summer and autumn months. Discharges and water temperatures of the Russian River at the Healdsburg stream gage were taken from 1975 records as this year was considered typical. The results of this generalized analysis are shown in

Table 12. Releases from Warm Springs Dam could lower the temperature of water in the Russian River particularly during the summer months. The lowering of the temperature, however, is rather modest and is not sufficient to convert the river into a salmonid habitat area. Neither do the temperature decreases appear sufficient to adversely affect American shad habitat in the river. Shad require higher water temperatures than salmonids as part of their environment.

The fisheries resources in the basin will be affected by releases from the dams if these releases are not adequate to meet their requirements during critical times in their life cycles. The releases for fisheries maintenance and enhancement are an important aspect of this investigation. A discussion of these releases is presented in the following section.

2. Plan Formulation

Release schedules and operations of Coyote and Warm Springs dams have an effect on the fisheries resources of the Russian River basin. These schedules and operations are discussed in this section in reference to meeting the needs of the basin's fishery.

a. Operation in the Flood Control Pool

The uppermost parts of both Lake Mendocino and Lake Sonoma are reserved for control of flood waters to provide downstream flood damage prevention. Flow releases and storage for this purpose have top priority and safety cannot be sacrificed. However, the flood control pool in Lake Mendocino is available for additional storage of water for other purposes beginning in April, at the end of the flood season. Storage in the flood control pool must be drawn down beginning in late September and the flood control pool must be evacuated by October 15. This limited encroachment into the flood control pool was accounted for in the design and operation program for Lake Mendocino. Given the current optimized operation plans for the flood control pools for both projects, it is not possible to provide additional water storage or releases for fishery enhancement without sacrificing some flood control benefits.

b. Water Delivery Criteria

A 1980 report on the Russian River service area by the California Department of Water Resources (DWR) estimated the annual demand for water to be 183,000 acre-feet in 1975. An annual demand of 193,000 acre-feet was projected for 1980, climbing to 242,000 acre-feet in the year 2000. These projections were based on the E-150 population forecasts prepared by the California Department of Finance. Also included in the water demand projections, which were for a normal year as opposed to a dry year, were estimated savings due to expected wide-spread use of water conservation practices. For example, without these conservation measures, a total demand of 260,000 acre-feet was projected for the year 2000. Demand during dry years is expected to be 23 percent higher than a normal year, to make up for

Table 12

EFFECTS OF DRY CREEK FLOWS ON WATER

TEMPERATURE IN THE RUSSIAN RIVER

	Dry Creek at the Russian River		Russian River at Healdsburg		Russian River Below Dry Creek		
Month	Disch. (cfs)	Temp. (F)	Disch. (cfs)	Temp. (F)	Disch. (cfs)	Temp. (F)	Change in Temp. (F)
April	96	63	2260	56	2356	56	0
May	50	62	304	66	354	65	—1
June	157	64	178	70	335	67	-3
July	213	63	176	73	389	68	-5
August	196	64	169	73	365	68	-5
September	174	64	207	68	381	66	-2
October	124	64	258	62	382	63	+1

deficiencies in urban and agricultural water supplies created by reduced rainfall amounts.

Water use in the service area includes both agricultural as well as urban-type demands. Agricultural uses account for approximately 45 percent of the total water demand both in 1975 and as projected to 2000. Both agricultural and urban water demands are estimated to increase by 32 percent from 1975 to 2000. Without water conservation measures, however, urban demands would increase by approximately 50 percent during that period.

According to DWR, approximately three-quarters of the urban water demand occurs from April through October and almost 40 percent of the total annual demand occurs in June, July and August.

Agricultural water use depends on the type of crop and rainfall during the winter and spring. For example, almost all the irrigation water required annually by vineyards is generally needed during April, May, June and July. Most crops require irrigation from May to August. High urban and agricultural demands for water occur from late spring to midsummer, when flows are normally low.

Releases from Lake Mendocino and Lake Sonoma will be used to satisfy a large portion of the municipal water demands. Other local surface supplies will also be relied upon. The scheduling of releases for water supply is the responsibility of the Sonoma County Water Agency (SCWA). This agency in cooperation with the Corps of Engineers will determine the optimum mix of releases from both dams to satisfy the water demands of their customers subject to constraints of existing agreements for fisheries mitigation and low flow supplemental releases.

When Warm Springs Dam becomes operational in the mid-1980's, the additional water supply provided will be more than sufficient to meet municipal water demands in the service area. However, as demands increase over the years, the water supply from the two projects will be increasingly in demand. Demands are expected to equal supply shortly after the turn of the century.

The Russian River basin is an area of limited water resources. As the demand for water grows, there will be greater competition for this scarce resource. Eventually it will not be possible to provide optimum supplies for all competing water uses.

c. Minimum Releases for Fisheries Resources

As part of the operational agreements between the responsible agencies, and according to stipulations of the various permits required for diverting, procuring, and delivering surface waters from both the Coyote and Warm Springs projects, agreements concerning minimum flow releases to satisfy downstream fisheries resources needs have been developed. These minimum releases generally provide sufficient flows in drier than normal years to ensure that the fishery will be preserved. In normal or wetter than normal years, releases from the reservoirs and natural runoff will provide flows far in excess of the minimum releases.

Minimum releases for fisheries from the Coyote Project are subject to a 1959 agreement between the SCWA and the California Department of Fish and Game (CDFG). The agreement specifies that the SCWA release enough water to maintain a flow of 25 cfs in the east fork of the Russian River and 150 cfs at the junction of the east fork and mainstem of the Russian River, or release water at a rate equivalent *to* the inflow to Lake Mendocino, whichever is less. The agreement also mandates that a flow of 125 cfs be maintained in the mainstem at the Guerneville gauging station.

In 1970, the CDFG and the SCWA entered into an agreement for minimum releases from Warm Springs dam. That release schedule calls for a minimum release of 25 cfs from April through November, and 50 to 75 cfs from December through March, depending on the amount of water stored in the reservoir the previous spring.

Studies have been conducted to determine the instream flow requirements of salmonids in the mainstem of the Russian River and lower Dry Creek by both CDFG and as a part of this present study as documented in Appendix F. Field studies were carried out by CDFG during the winter of 1975-76 to determine whether the flow releases from Warm Springs Dam as stipulated in the 1970 agreement were adequate to protect the fisheries resources of Dry Creek and to allow proper operation of the fish hatchery below Warm Springs Dam. Instream flow requirements were determined for steelhead, silver salmon and king salmon. Flow requirements for adult passage, spawning, and nursery habitat were determined for each species.

Minimum flows necessary to provide adequate upstream passage of adults at five riffles in Dry Creek were found to average approximately 70 cfs for steelhead and silver salmon and 102 cfs for king salmon. Flows recommended to ensure passage were approximately 105 cfs for king salmon and 75 cfs for both steelhead and silver salmon.

The in-depth study of salmonid habitat flow requirements in lower Dry Creek and the Russian River mainstem done as part of the basin study was based on field surveys made during the winter and summer of 1978. Evaluation of fish passage requirements in Dry Creek indicated that during upstream migration of spawning salmonids, mean stream flow in Dry Creek is sufficient to provide adequate fish passage. The study also concluded that it was necessary to maintain stream flows above an average value of 100 cfs to ensure successful fish passage at critical riffle sites.

As a result of the CDFG investigation, negotiations are now being conducted between the SCWA and CDFG regarding flow releases for fisheries enhancement. A supplemental operational agreement for Warm Springs Dam and Coyote Dam has been formulated (Appendix D). This supplemental agreement is only tentative and may never be formally implemented. However, as discussions are taking place between the agencies, the tentative agreement will be discussed here. In addition to the flows outlined in the 1970 agreement, during years when sufficient storage exists within Lake Sonoma, additional flows would be released from Warm Springs Dam to enhance the fishery potential of Dry Creek, particularly with respect to king salmon released from the Warm Springs hatchery. When sufficient storage is available a minimum of 80 cfs would be released into Dry Creek from May through October, 105 cfs from November through December, and 75 cfs from January through April. In addition to these releases, an amount of water equal to 5,000 acre-feet (equivalent to 84 cfs for one month) would be released at rates and times requested by the CDFG prior to 15 May for maintenance of spawning areas below the dam and/or transportation of juvenile fish downstream.

During the initial filling of Lake Sonoma, and in the absence of a drought emergency, releases from Warm Springs Dam would be made at the higher rates defined in the proposed supplemental operational agreement. When excess water is available during the early years of the Warm Springs Project, greater release rates may be experimented with to obtain additional data about the flow needs of the downstream fishery. These greater releases would only be allowed for short term periods. It is presently stipulated in the proposed supplemental agreement that the August 1959 Coyote Valley Project agreement between the SCWA and CDFG would remain in effect. According to this agreement, the Coyote Valley Project is to provide 25 cfs in the east fork of the Russian River, and 150 cfs or the inflow to Lake Mendocino, whichever is less, in the Russian River mainstem at the confluence with the east fork. A minimum flow of 125 cfs in the Russian River at the Guerneville gauging station would also be maintained.

During dry years when the minimum fisheries releases would be relied upon, the 1970 agreement would not provide for minimum passage requirements as determined by the CDFG 1975-76 study. However, the minimum flows in the proposed agreement would provide for these requirements, during those dry years when sufficient storage was available in Lake Sonoma. During most years, releases to maintain the flood control pool and/or to supply water demands would be far in excess of the minimum releases mandated in the 1970 agreement.

d. Optimum Releases for Fisheries Resources

Optimum flow releases, in contrast to minimum releases, are those that would provide the most benefit to the fisheries resources in the watercourses below the dams.

As part of the 1975-76 CDFG investigation on Dry Creek, an assessment of flows necessary to provide optimum spawning habitat in Dry Creek indicated that these flows exceeded 200 cfs, and that available habitat increased with flow for all three species. Optimum flows were assumed to be close to 480 cfs. Available nursery habitat was also found to increase with flow, and the greatest amount of nursery habitat available with the least flow occurred at 80 cfs. A reduction in flow below 80 cfs was found to result in relatively rapid decline of available nursery habitat.

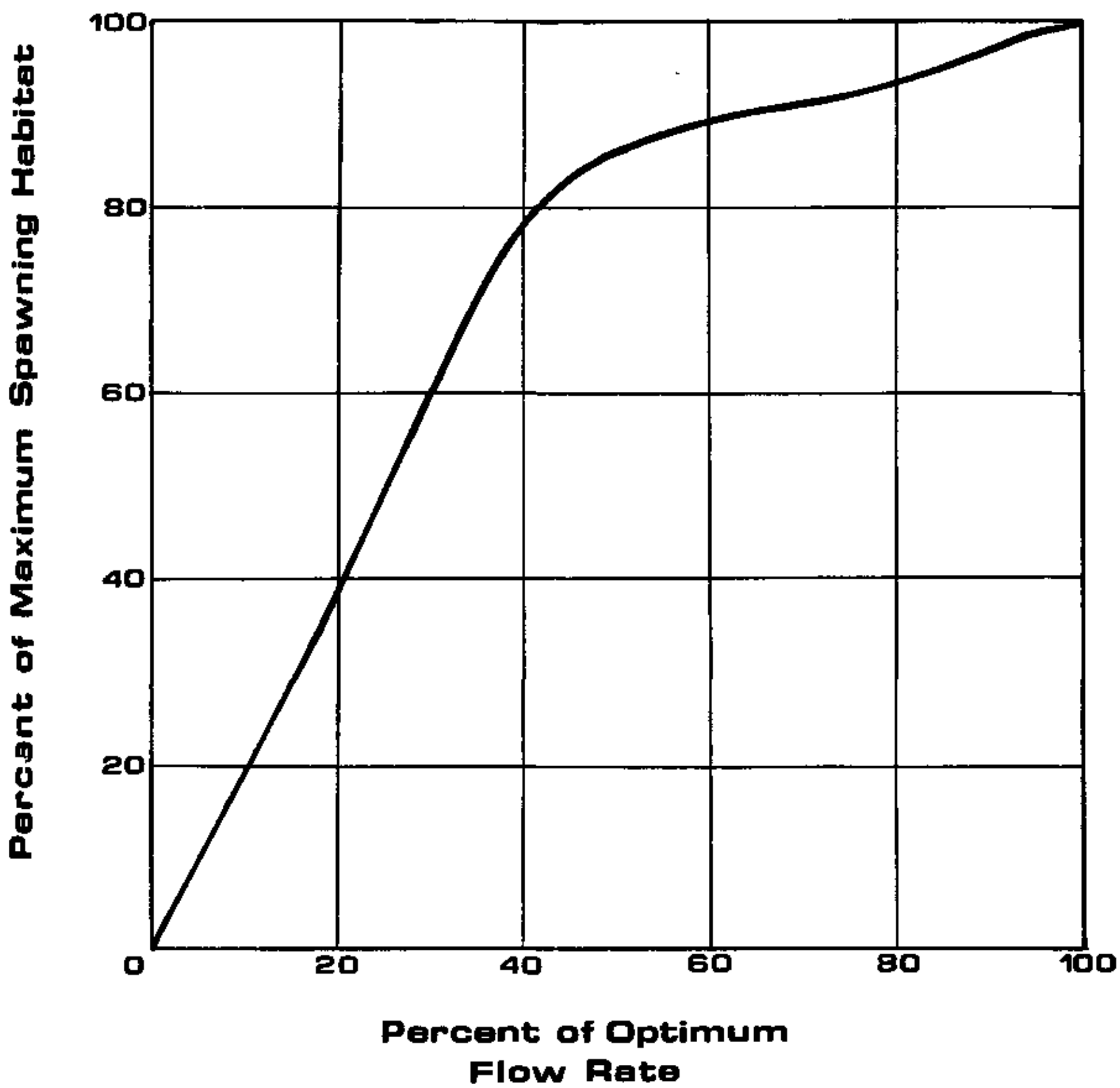
The indepth study of fish habitat and barriers to fish migration completed as part of the Russian River Basin Study also developed some recommendations for optimum flows for salmonids. Stream flow requirements for optimal salmonid spawning conditions were determined to be 400 cfs for Dry Creek below Warm Springs Dam, 200 cfs on the Russian River upstream of approximately Cloverdale, 700 cfs from upstream of the Dry Creek confluence to approximately Cloverdale, and 1,000 cfs downstream of the Dry Creek confluence. Optimum nursery habitat maintenance, in terms of resting space only, was found to occur at 20 cfs on both Dry Creek and the entire length of the Russian River. This streamflow appears to be well below the flow necessary to satisfy water temperature requirements for nursery habitat, particularly during the summer months when air temperatures are high. For this reason, the optimum flow for nursery habitat was taken to be 80 cfs, as determined by the CDFG.

Figures VI-1 to VI-8 in Appendix F provide a graphic illustration of these optimum flows and show the relationship between flow and the length of spawning and nursery habitat available for salmonids. Figure 7 shows the relationship of flow to length of suitable spawning habitat for Dry Creek taken from Figure VI-1 in Appendix F. Note that Figure 7 is non-dimensional and that there is no consideration of flow rates in excess of the optimum flow. While Figure VI-1 in Appendix F shows a decline in spawning habitat for flows in excess of the optimum, such a decline is not universally agreed upon by fisheries biologists as spawning habits of the salmonids are expected to change to accommodate some increase in flow rate over optimum.

One important aspect of Figure 7 is the nature of the curve. From zero to approximately 40 percent of the optimum flow rate, the percentage of maximum habitat length increases much more rapidly than the percentage of optimum flow. For example, at 40 percent of optimum flow, 80 percent of the maximum spawning habitat length is achieved. However, a doubling of the flow to 80 percent of optimum only increases the percent of available habitat to 92 percent.

figure 7

Influence of Flow Rate on Length of Salmonid Spawning Habitat on Lower Dry Creek



Source: Figure VI-1 in Appendix F.

The spawning period for the three salmonids considered in this investigation - steelhead, silver salmon and king salmon - generally takes place from November through March. A comparison of the number of times the optimum flow for salmonid spawning has been equaled or exceeded during the period of stream gauge records is shown in Table 13. From the Table, it can be seen that Coyote Dam has not appreciably reduced the occurrence of optimum flows for salmonid spawning in the Russian River. Natural, unobstructed flows on Dry Creek show a lower incidence of meeting or exceeding optimum spawning flows than flows on the Russian River.

As optimum spawning flows are generally present on the Russian River, and as the minimum releases specified in the 1959 agreement between the SCWA and the CDFG are greater than the flows required to provide optimum nursery habitat, proposal of alternative release schedules from Lake Mendocino is currently not justified. However, should future studies be initiated to investigate alternative release schedules for joint operation of both dams in the basin, these studies should consider the effects such altered release schedules would have on the basin's fisheries resources.

Figure 3 in Section II.C.6.b. shows the approximate effects Warm Springs Dam will have on the long term average flow rate in Dry Creek at the dam site. Generally, flows will decrease in the winter and early spring and increase in the summer and autumn. This alteration in the hydrologic regime of the creek will impact the spawning habitat of salmonids which use Dry Creek. Although the Warm Springs hatchery serves as a mitigation and enhancement measure for the fishery, provision of optimum flows on Dry Creek would allow even greater fisheries enhancement.

A proposed alternative release schedule is shown in Table 14. This schedule would provide optimum salmonid spawning flows of 400 cfs during December, January, February and March. It would also provide 100 cfs for nursery habitat and maintenance of water temperature from May through November and would provide 230 cfs during April to support the end of the spawning season and smolt outmigration period and provide a transition into the nursery period. This alternative release schedule is based on fishery needs alone with the trade-off being possible disruption of water supply deliveries. This alternative would adversely impact the project's water supply purpose. However, until demands for Warm Springs project water increase beyond the 100 cfs level in July, August and September, this may be a viable alternative that could be considered as part of the tentative agreement between the SCWA and the CDFG as an experimental release schedule during which additional fisheries data can be collected and analyzed.

Table 13

EXISTENCE OF OPTIMUM SALMONID SPAWNING FLOWS IN THE RUSSIAN RIVER BASIN

Stream Gage	Optimum Flow (cfs)	Years of Record	No. of years with avg. flow greater or equal to optimum				
			Nov.	Dec.	Jan.	Feb.	Mar.
Russian River at Hopland	200	19 pre Dam*	17	18	19	19	19
		20 post Dam	17	18	18	19	19
Russian River at Healdsburg	700	19 pre Dam*	6	14	18	19	18
		20 post Dam	7	15	17	18	19
Russian River at Guerneville	1,000	19 pre Dam*	4	13	18	18	18
		20 post Dam	7	14	18	18	16
Dry Creek near Geyserville	400	19 pre Dam**	2	10	12	13	12

*Prior to and after construction of Coyote Dam

**Prior to construction of Warm Springs Dam

Table 14

ALTERNATIVE SCHEDULE FOR FISHERY RELEASES FROM WARM SPRINGS DAM

Flows - 1,000 AF and (cfs)

Month	Average Flows on Dry Creek Without Warm Springs Dam	Expected Average Flows on Dry Creek With Warm Springs Dam(1)	Flow Release Schedule for Predicted Optimum Fishery Benefits
January	35.3 (590)	14.8 (250)	24.0 (400)
February	43.5 (730)	23.5 (390)	24.0 (400)
March	26.6 (450)	18.2 (310)	24.0 (400)
April	15.2 (260)	12.8 (220)	13.3 (230)
May	3.6 (60)	8.0 (130)	6.0 (100)
June	1.4 (24)	14.1 (240)	6.0 (100)
July	0.4 (7)	16.0 (270)	6.0 (100)
August	0.3 (5)	14.7 (250)	6.0 (100)
September	0.2 (3)	12.8 (220)	6.0 (100)
October	1.1 (18)	6.7 (110)	6.0 (100)
November	4.6 (77)	4.7 (79)	6.0 (100)
December	27.3 (460)	5.0 (84)	24.0 (400)
TOTAL	159.4	151.3	151.3

(1) Proposed ultimate operations schedule including SCWA water supply releases, developed from Figure 5, Warm Springs Project EIS.

While the flow rates are substantially different under the three conditions shown in Table 14, the effects of these flows on the length of available habitat are not quite as dramatic. Using the flow-habitat relationship shown in Figure 7, the average flows were converted to percent of maximum habitat. Table 15 shows the results during the spawning season from November through March. The months of November and December appear to have the largest deficit with respect to optimum spawning conditions after Warm Springs dam is operational. The proposed alternative schedule will eliminate the December deficit and ease the November deficit.

The flows shown in Table 15 are those at the dam site. There is an 87 square mile drainage basin between the dam and the Russian River. This watershed will contribute flow to Dry Creek, increasing flow in the creek on its course to the Russian River. For example, while the average December flow release from Warm Springs Dam will only provide 36 percent of optimum spawning habitat, this value increases to 81 percent at the Yoakim Bridge stream gauge, and further increases to 89 percent just upstream of the Mill Creek confluence and to 95 percent at the Russian River. Thus, even though the releases are sub-optimal, local inflow along Dry Creek would augment these flows and provide a better habitat downstream.

The alternative flow release schedule proposed should be considered by the SCWA and the CDFG as part of their future investigations into release schedules and fisheries resource needs along Dry Creek.

3. Conclusions

The water resources in the Russian River basin are not sufficient to optimally satisfy all competing water needs. During the time that water supply demands from the Warm Springs project are below project yield, there is an opportunity to test alternative release schedules to determine more precisely the fisheries resources needs.

The SCWA and the CDFG should continue to work together to attempt to satisfy as many of the competing needs as possible. As this process is an ongoing one, it is not prudent for the Corps of Engineers to pursue any further study of the operations of the two dams under the current Russian River Basin Study authorization. However, the Corps could investigate the range of flow releases available from Warm Springs dam as part of the Warm Springs Operation and Maintenance Program or as part of further negotiations and experiments involving the CDFG and the SCWA. Also, the Corps must remain involved in the management of Coyote and Warm Springs dams to the extent that the integrity of the projects' flood control and recreation capabilities are protected.

Table 15

EFFECTS OF DRY CREEK FLOWS
ON
SALMONID SPAWNING HABITAT

Month	Without Warm Springs Dam		With Warm Springs Dam(1)		Flow Release Schedule For Predicted Optimum Fishery Benefits	
	Average Flow (cfs)	% Max. Habitat	Expected Average Flow (cfs)	% Max. Habitat	Flow (cfs)	% Max. Habitat
November	77	34	79	35	100	47
December	460	100	84	36	400	100
January	590	100	250	88	400	100
February	730	100	390	100	400	100
March	450	100	310	91	400	100

(1) Proposed ultimate operation schedule including SCWA water supply releases, developed from Figure 5, Warm Springs Project EIS.

IV. ENVIRONMENTAL ANALYSIS

A. SUMMER AND RECREATIONAL TYPE DAMS

1. Plan A

This management alternative consists of continuation of the present recreational dam installation and removal schedule on the Russian River. This schedule mandates installation and removal on or about May 20 and September 10 respectively. No new fish passage structures would be installed.

a. Environmental Impacts

The water quality effects of status quo management would be identical to present conditions, with no substantial effects on water quality while the dams are in place, based on existing data. Installation and removal of the dams would continue to cause temporary increases in stream turbidity.

Status quo management would continue to have some adverse impacts on the anadromous fisheries of the Russian River. The presence of the dams, even with fishway structures, inhibits both upstream migration of shad and king salmon and downstream migration of juvenile salmonids. The pools formed behind the summer dams reduces the quality and quantity of shad spawning and nursery habitat in the lower Russian River. The dams may also inhibit establishment of a summer steelhead population in the Russian River basin.

Turbidity caused by installation and removal of summer recreation dams adversely affects fish by silting channel spawning gravels, reducing the availability of benthic organisms used as a food source, and by increasing fish mortality through suffocation.

b. Economic Impacts

This plan would result in the same recreational benefits as currently present.

c. Social Impacts

This plan would not produce changes in the social composition of the area.

2. Plan B

This management alternative consists of continuation of the present recreational dam installation and removal schedule of approximately May 20 and September 10, respectively, and the construction of fishways at Healdsburg and Del Rio Woods summer recreation dams.

a. Environmental Impacts

The installation of fishways at both Healdsburg and Del Rio Woods dams should have no effect on water quality.

The addition of a low-flow fishway at Healdsburg Dam will improve the upstream passage of salmon and steelhead following removal of the recreational dam at the end of each summer and prior to the occurrence of higher flows in the late fall. Presently, during this period, the concrete foundation for the summer dam forms a barrier to fish.

The addition of fishways at Healdsburg and Del Rio Woods dams may permit the passage of shad, summer steelhead and early run king salmon into the upper river during the recreation season. However, the possible reluctance of shad to use the fishways, and the necessity of using five fishways to reach the upper river, may reduce the shad run to fewer fish than would successfully complete the run if no dams were installed.

b. Economic Impacts

The total first cost to install fish passage structures at Healdsburg and Del Rio Woods Dams would be $310,000. Annual operations and maintenance costs would be $16,000. There could be as much as a ten percent increase in the recreation benefits due to angler-days spent fishing for American shad, but probably only a one percent increase in steelhead and salmon fishing benefits. This estimate neglects the potential benefits associated with the establishment of a summer steelhead fishery in the Russian River basin.

c. Social Impacts

This alternative would not produce significant social impacts beyond those due to a modest increase in angler-days spent along the river, neglecting the impacts of the possible establishment of a summer steelhead population.

3. Plan C

Under this management alternative, the times at which the dams will be installed and removed would be determined by an appropriate agency, based on day-to-day or week-to-week assessments of environmental factors. These factors would include temperature and hydraulic conditions in the river, opening of the river mouth, and the timing of the spring shad, summer steelhead and fall king salmon runs. Brackets of dates would be established to provide defined periods during which the responsible agency could regulate the timing of recreation dam installation and removal. This alternative also includes the addition of fishways at Healdsburg and Del Rio Woods dams.

a. Environmental Impacts

This management alternative would have a beneficial effect on the salmonid and shad fisheries of the Russian River. Dam installation and removal would be timed, within limits, to allow for greater unobstructed upstream migration of shad, summer steelhead and king salmon, the downstream drift of shad eggs, and outmigration of juvenile salmonids.

b. Economic Impacts

The total first cost to install the fish passage structures at Healdsburg and Del Rio Woods dams would be $310,000. In addition, there would be an annual cost of $16,000 to operate and maintain these structures. There would also be an annual cost of $5,000-$8,000 for the collection of fisheries data, projections as to future conditions, and notification of dam operators. There would be a net increase in recreational benefits due to increased angler-days in response to the increased fishery population. It is estimated that steelhead and salmon populations may increase by two percent while the American shad population may increase by as much as 15 percent. This neglects the benefits associated with the establishment of a summer steelhead fishery in the Russian River basin.

c. Social Impacts

The uncertainty of not knowing precisely when the summer dams would be installed or removed, even though the recreation demand was present, is expected to produce a detrimental impact on community cohesion.

4. Plan D

This management plan would allow no dam obstructions at any time in the lower Russian River, other than the Wohler water supply dam. The Wohler dam is excluded from this alternative because it is equipped with a fish ladder and can be raised and lowered to meet many streamflow requirements.

a. Environmental Impacts

The removal of summer recreation dams would benefit fisheries by allowing virtually unobstructed access for migrating summer steelhead, salmon and shad. Greater spawning areas would be available to shad, and impoundments would no longer interrupt the downstream drift of shad eggs prior to hatching. Late out-migrating juvenile salmonids would no longer need to travel through the impoundments, which cause them to be subject to delays, increased predation and rising water temperatures. Early-migrating salmon running up the river would benefit from this plan by no longer having to negotiate fishways on the lower river. Establishment of a summer steelhead population would also be enhanced by this alternative as there would be fewer barriers affecting these fish as they migrate upstream in search of adequate summer holding areas.

Removal of the concrete dam foundation sill at Healdsburg as part of this management plan would open the upper river to shad and early king salmon by eliminating an existing barrier to their migration.

b. Economic Impacts

There would be substantial costs to prevent erosion upstream of Healdsburg Dam when the concrete sill was removed. There would likely be a net loss in recreation benefits when increased benefits due to increased angler-days were compared to decreases due to loss of recreation activities associated with the summer dams. This alternative would probably facilitate the establishment of a summer steelhead fishery in the river, although the associated benefits cannot be determined at the present time.

c. Social Impacts

There would be disruption in the lives of people whose livelihood depends on the summer dams. Community cohesion would also suffer and community growth could be reduced somewhat.

V. STUDY CONCLUSIONS

A. GRAVEL MINING AND SEDIMENT INFLUX

The Corps of Engineers has offered assistance to both Mendocino and Sonoma Counties in their efforts to develop local plans for monitoring and controlling gravel mining in stream channels. As an integral part of this investigation, the Corps provided a variety of inputs to Sonoma County which the County felt would offer them the maximum benefit in their own gravel mining planning process. These included a review of existing literature on gravel mining and a generalized description of the hydrologic history of the Russian River basin. It was felt that these would form a solid base for Sonoma County to build their own management plan. Also provided to the County was a description of a bedload computer model. This computer program was used to model a small section of the Russian River as a training aide for Sonoma County personnel. The input necessary to run the model and descriptions of the output and limitations of the program were conveyed to Sonoma County. The County Planning Department hopes to eventually make this model an integral part of their gravel resource planning and mining regulatory program.

Sonoma County also supported Congressional funding for additional Corps studies of bedload movement and sediment influx along Dry Creek and the Russian River mainstem. Funds were appropriated for these studies in the Dry Creek area in late 1980. The studies were initiated in December 1980.

Mendocino County is currently obtaining data from gravel mining operations in the county as part of their gravel mining use-permit program. The County is also developing a comprehensive data base for predicting the environmental impacts of in-stream mining operations. In this regard the County has contracted with the California State Department of Water Resources for a cooperative study of erosion and gravel movement in the upper Russian River.

Both counties have become involved in managing the sand and gravel resources of the Russian River basin. Also, the Corps of Engineers has initiated a new study of these resources in the Dry Creek area. Some of the results of this study may be applicable to the Russian River. Therefore, no further study of gravel mining, sediment influx and related problems in the Russian River basin is presently warranted under the Corps of Engineers Northern California Streams Investigation - Russian River Basin Study authorization.

B. CHANNEL IMPROVEMENTS AND STABILIZATION

Certain reaches of the Russian River and Dry Creek are experiencing severe bank erosion and degradation and meandering of the stream channel which is threatening private riparian property as well as a number of public structures. Previously installed bank stabilization measures have mostly prevented further damage at particular sites. However, the violent and unpredictable nature of flows along the Russian River and meandering of the channel have destroyed some bank protection works and caused significant damage at unprotected sites.

An in-depth examination of this situation is needed to provide appropriate solutions for specific problems. Such an investigation has been supported by several Federal, state and local agencies. However, any such effort would require specific authorization and funding from the U.S. Congress. Therefore, no further study of erosion and associated problems and channel improvements and stabilization is presently warranted under the Corps of Engineers Northern California Streams Investigation-Russian River Basin Study authorization.

C. SUMMER AND RECREATIONAL TYPE DAMS

The summer dams on the mainstem of the Russian River may have adverse effects on the fisheries resources of the basin. A major problem in the mainstem is shad passage at Healdsburg and Del Rio Woods dams. Other adverse effects may be attributable to the loss of spawning and nursery habitat in the tributary streams.

Since the management of the habitat areas and assurance of adequate fish passage is not a Federal responsibility under the current Northern California Streams Investigation - Russian River Basin Study authority, there is no further Federal interest in the management of summer dams. However, several alternatives for managing the dams were developed as part of the Russian River Basin Study and provided to local interests for consideration for implementation at their level. Local interests should pursue their desires to improve the fisheries resources by continuing efforts to provide fish passage at the summer dams. The Corps of Engineers will continue to exercise its regulatory authority over the installation and removal of these dams as delegated by Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of Public Law 92-500.

D. MOUTH OF THE RIVER

Construction of structural improvements providing year around safe passage through the mouth of the Russian River has not proven to be in the Federal interest. Improving fish passage through the preservation of an open channel entrance would have little or no effect on the Russian River fishery. Therefore, no further Corps of Engineers studies of maintaining year around free passage through the mouth of the river are necessary at this time.

E. LAND USE RELATED TO FLOOD PLAIN MANAGEMENT

Maps were prepared to a scale of 1 to 24,000 (1"=2000') which graphically show the land uses that lie within and adjacent to the 100-year flood plain of the Russian River. These maps reflect flood plain conditions after construction of Warm Springs Dam and are based on data also utilized by the Federal Insurance Administration in preparing its Flood Plain Boundary Maps. Land use statistics and mapping quadrangles covering the area are available in graphic,tabular and magnetic tape form. The land uses were derived from a digital land use data bank, which was developed using color infrared aerial photographs and computer-assisted interpretation techniques. The land use and flood plain maps have been used by several agencies at both the local and Federal level.

The extent of this available flood plain and land use data and maps, and the level of current efforts with respect to flood plain delineation in the Russian River basin, are presently considered sufficient to satisfy the related objectives of the Basin Study. Therefore, no further involvement by the Corps of Engineers in this area is warranted at the present time.

F. OPERATION OF EXISTING STRUCTURES ON THE RUSSIAN RIVER AND TRIBUTARIES

Based on current data, water quality problems on the Russian River are minor and further Corps of Engineers study into the effects of releases on water quality is not warranted.

Flow releases which support the fishery resources in the Russian River basin vary from year to year and depend on both rainfall and runoff and the operations of the reservoirs in the basin. Minimum releases from both Coyote and Warm Springs dams for fishery maintenance are specified in existing agreements between the Sonoma County Water Agency (SCWA) and the California Department of Fish and Game (CDFG). In most years, releases for flood control and/or water supply will be much greater than these minimum releases.

Currently, the SCWA and the CDFG are negotiating a supplemental release schedule which would provide for flows in Dry Creek higher than the existing minimum releases. These higher flows would insure that adequate fish passage would be provided for salmonids migrating to the Warm Springs fish hatchery. This supplemental release schedule, however, has not yet been agreed to by both agencies.

The predicted optimum flows represent the upper end of a range of possible flow releases intended to benefit the basin's fishery resources. These flows would provide the most favorable conditions for the passage and spawning of salmonids. While flows on the Russian River generally are greater than or equal to these predicted optimum flows, the proposed long-term average releases from Warm Springs Dam to Dry Creek are sub-optimal.

An alternative release schedule which would provide optimum flows for salmonid spawning has been proposed as part of this Russian River Basin Study. This release schedule, however, would not provide sufficient water supply releases during the summer and fall to meet the projected ultimate demand from the Lake Sonoma and Lake Mendocino projects. While water supply demands are less than ultimate project yield, this alternative release schedule should be considered by the SCWA. It could be incorporated into the proposed supplemental release schedule currently under negotiation by the SCWA and the CDFG.

Under the current Russian River Basin Study authorization, it is not considered prudent for the Corps of Engineers to continue investigation into alternative release schedules for fishery resources. The Corps could investigate this topic as part of future Warm Springs operations.

G. USE OF STUDY DATA AND FUTURE DATA REQUIREMENTS

The Russian River Basin Study has resulted in the collection and development of *a* wealth of data which could be of use to local interests in their continuing efforts to protect and enhance the basin's environment.

Data developed concerning gravel mining and sediment influx include a literature review, a generalized hydrologic history of the basin and a computer bedload model. These data have been turned over to the Sonoma County Planning Department. The bedload model provided to the County is a Corps of Engineers model readily available to the public from the Corps Hydrologic Engineering Center in Davis, California for a nominal charge.

Floodplain land use data have been developed as part of the Basin Study. Maps included in Appendix E present the basic graphical information. The data are available to planning departments of both Sonoma and Mendocino counties as well as cities and other local agencies. The data also exist in digital and tabular form should local agencies need basic data for computer-assisted analyses. Local agencies could use these data in preparing local floodplain management ordinances mandated by Federal Flood Insurance Program. Future land use changes could be readily documented using recent land use data as a base.

Data concerning the operation of summer and recreational-type dams on the Russian River include a definition of currently recognized fish passage problems, a collection of currently available water quality data and a preliminary assessment of alternative plans for the management of the operation of these dams. These data could be beneficial to County planning departments, the Sonoma County Water Agency and local recreation districts. These data could provide these agencies with the bases for future actions to modify the operation of the summer dams to improve the basin's fisheries resources.

Basic data developed for the operation of existing structures in the Russian River basin included flow estimates for providing optimum fish spawning habitat on both the Russian River and Dry Creek. Operations studies on releases from Warm Springs Dam were compared to estimates of optimum spawning flows. An interim release schedule was developed for consideration by the Sonoma County Water Agency (SCWA). The SCWA could simulate revised release schedules and evaluate the consequences to both water supply and fishery resources.

Much data were collected and developed during the Basin Study. However, during the course of the investigation, it became clear that serious data deficiencies existed. These data deficiencies concern several important resource problems in the Russian River basin and include:

1. A detailed assessment of the effectiveness for all anadromous species of fish passage facilities along the Russian River mainstem.

2. A determination of instream flow requirements in the Russian River mainstem and principal tributaries, and study of operational guidelines for Coyote and Warm Springs dams that would maximize benefits to the anadromous fishery consistent with water requirements for other uses.

3. A comprehensive inventory of fishery resources to assess the status of populations in the Russian River mainstem and principal tributaries.

4. An assessment of the impacts of land use, instream structures, and water diversions on fishery resources in the Russian River mainstem and principal tributaries.

5. An assessment of the impact of instream gravel mining on fish habitat, and on bank and channel stability.

6. An assessment of the possibility of using alternatives to the installation of summer dams along the Russian River and its tributaries for recreation, such as offstream ponding areas.

These deficiencies could be eliminated through coordinated data-gathering efforts of local, State and Federal agencies. Local interests may also obtain certain technical-type assistance from the Corps of Engineers. This could include hydrologic, hydraulic, design and land use data developed by the Corps during its studies of the Russian River basin. The District can also provide operational information on Coyote and Warm Springs dams. Section 55 of Public Law 93-251 authorizes the Corps of Engineers to provide technical and engineering assistance to non-Federal public interests in developing structural and non-structural methods of preventing damages attributable to shore and streambank erosion. This can include inspection of problem areas, advice on methods for erosion control, review of plans and specifications, and inspection of construction.

VI. RECOMMENDATIONS

The research and survey efforts conducted during the Russian River Basin Study are considered to have met the requirements of the authorizing resolution, and to have adequately addressed the specific areas of public concern regarding the protection and enhancement of the basin environment. Taking into account the results of these efforts, it is recommended that no further Federal study of water resource problems and issues in the Russian River basin be conducted under this study authorization.

During the later stages of the Russian River Basin Study, local interests in the basin expressed the desire for additional Federal involvement in detailed study of several specific topics. These topics include the basin's sand and gravel resources, instream mining, bank erosion, channel degradation, and bank and channel stabilization. The topic of sediment influx and movement in the Dry Creek basin is being addressed in a special Corps study initiated in late 1980.

Further in-depth study of erosion and bank stabilization along the Russian River is supported by several Federal, state and local agencies, and a number of individuals. However, any such effort would require specific authorization and funding from the U.S. Congress. Therefore, no further study of these issues is presently warranted under the current Northern California Streams Investigation - Russian River Basin Study authorization.

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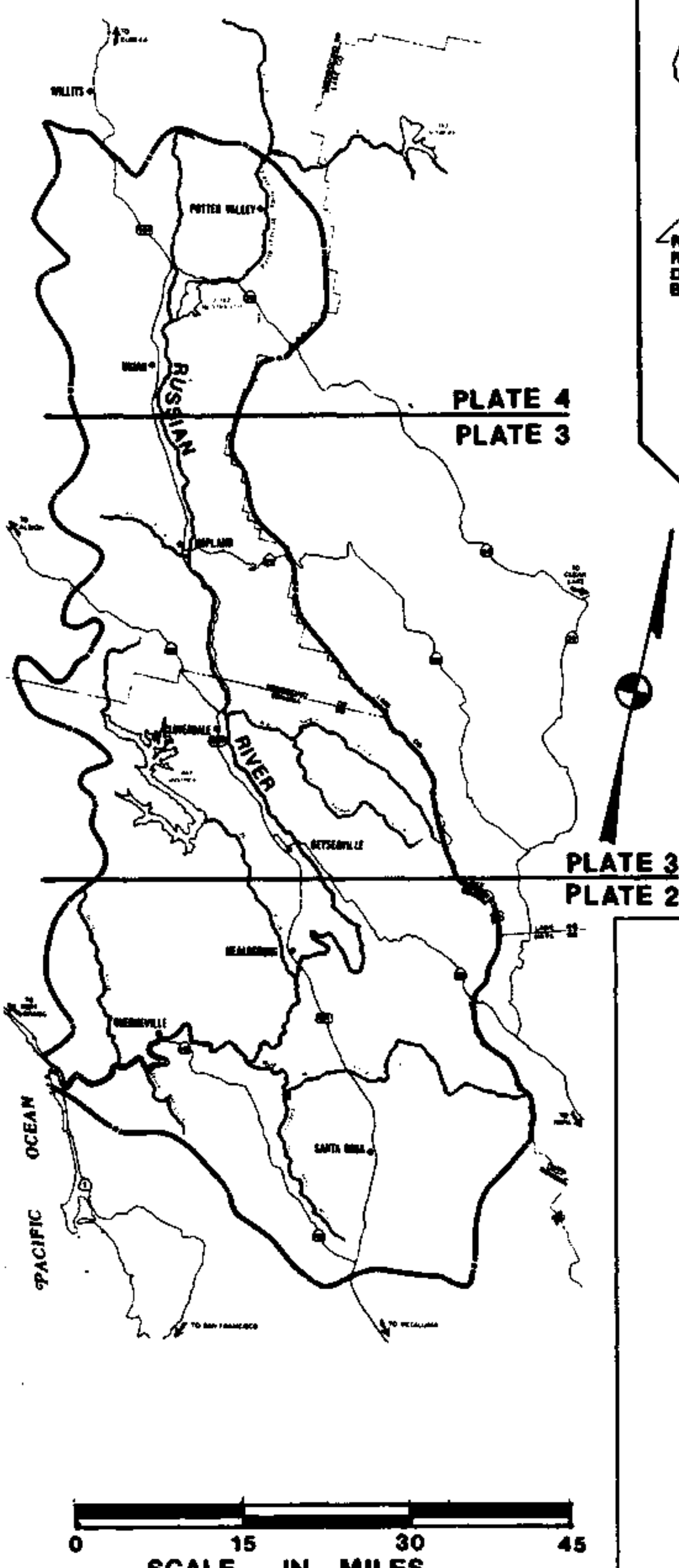
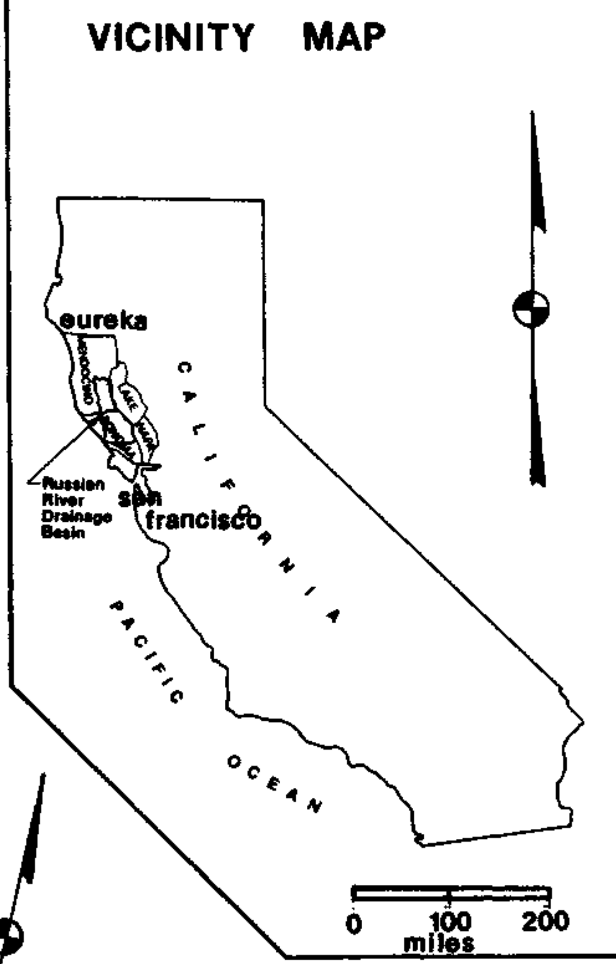




RUSSIAN RIVER
BASIN STUDY

MAP INDEX

LOCATION OF SAND AND GRAVEL OPERATIONS

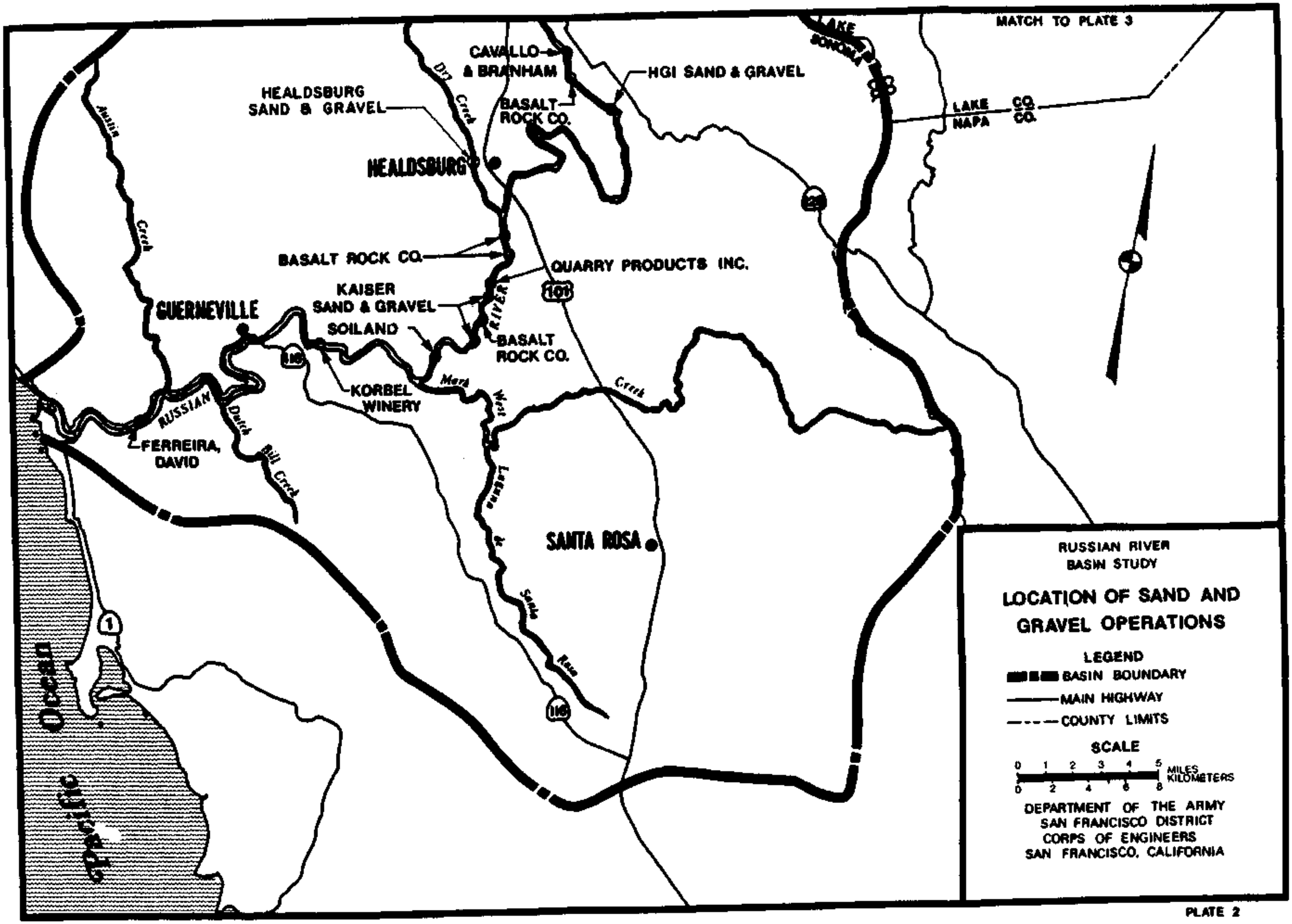
LEGEND

BASIN BOUNDARY

MAIN HIGHWAY

COUNTY LIMITS

DEPARTMENT OF THE ARMY
SAN FRANCISCO DISTRICT
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA



MATCH TO PLATE 3
CAVALLO & BRANHAM
HGI SAND & GRAVEL
HEALDSBURG SAND & GRAVEL
BASALT ROCK CO.
HEALDSBURG
BASALT ROCK CO.
QUARRY PRODUCTS INC.
KAISER SAND & GRAVEL
SOILAND
BASALT ROCK CO.
GUERNEVILLE
KORBEL WINERY
FERREIRA, DAVID
RUSSIAN
RIVER
SANTA ROSA
LAKE SONOMA CO.
LAKE CO.
NAPA CO.
Dry Creek
Austin Creek
Dutch Bill Creek
Mark West Creek
Laguna de Santa Rosa
Pacific Ocean
101
128
116
1
RUSSIAN RIVER BASIN STUDY
LOCATION OF SAND AND GRAVEL OPERATIONS
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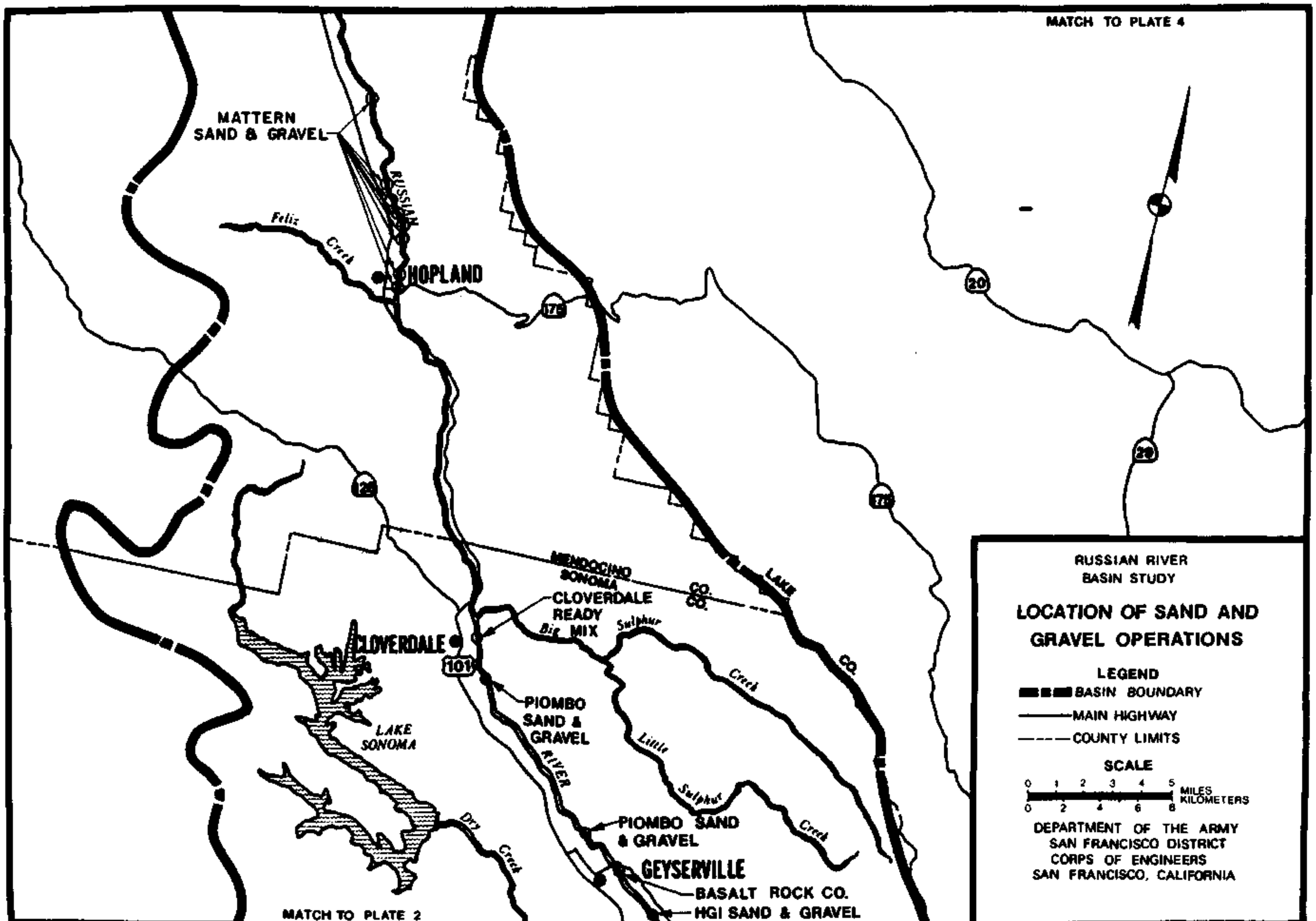
MAIN HIGHWAY
COUNTY LIMITS
SCALE
0 1 2 3 4 5 MILES
0 2 4 6 8 KILOMETERS
DEPARTMENT OF THE ARMY
SAN FRANCISCO DISTRICT
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

PLATE 2



MATCH TO PLATE 4
MATTERN
SAND & GRAVEL
RUSSIAN
Feliz Creek
HOPLAND
175
20
29
128
MENDOCINO CO.
SONOMA CO.
LAKE CO.
CLOVERDALE
READY
MIX
Big Sulphur Creek
CLOVERDALE
101
PIOMBO
SAND &
GRAVEL
LAKE
SONOMA
RIVER
Little Sulphur Creek
Dry Creek
PIOMBO SAND
& GRAVEL
GEYSERVILLE
BASALT ROCK CO.
HGI SAND & GRAVEL
MATCH TO PLATE 2
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0 2 4 6 8 KILOMETERS
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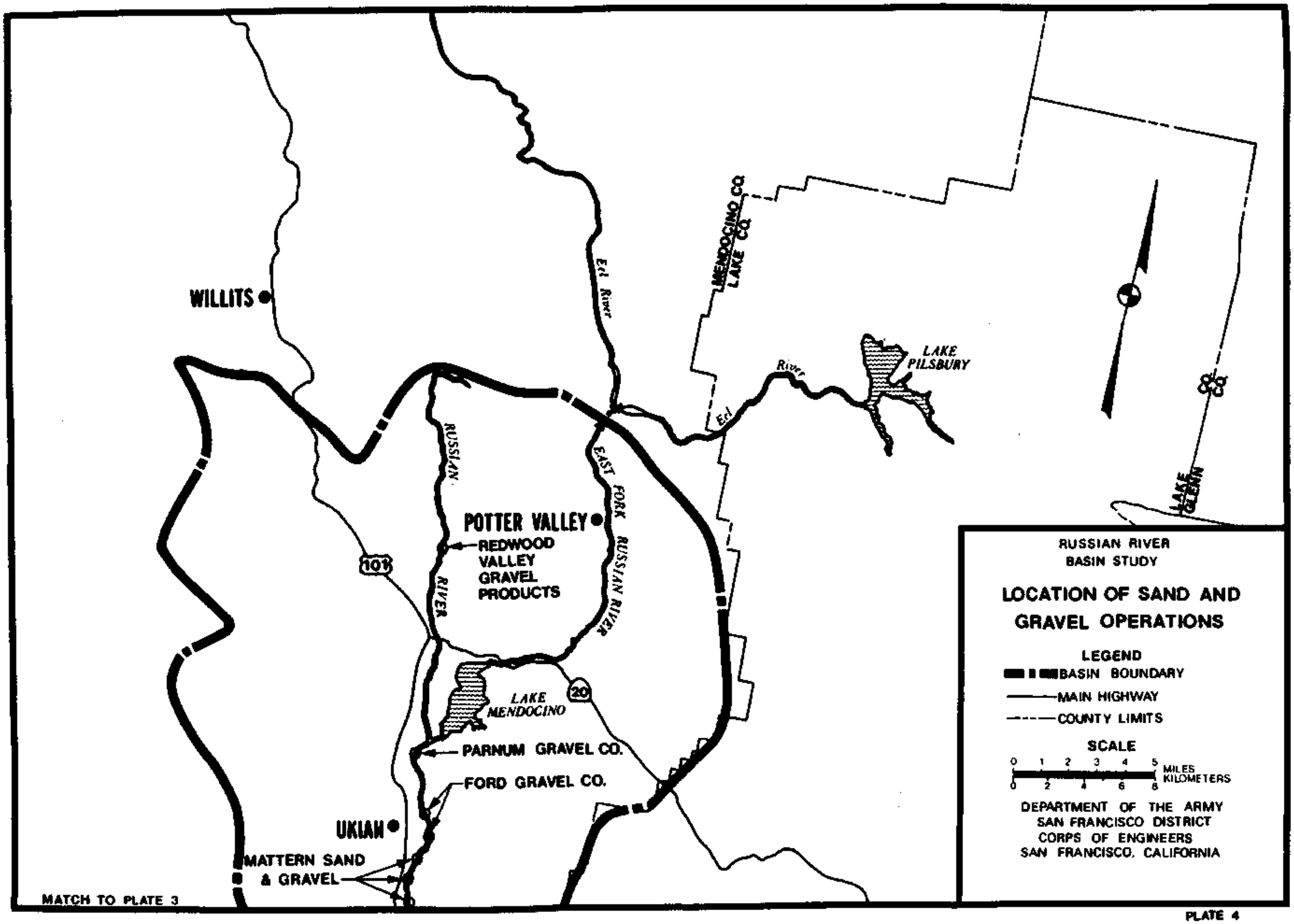
PLATE 3


WILLITS
Eel River
MENDOCINO CO.
LAKE CO.
LAKE PILSBURY
Eel River
RUSSIAN RIVER
EAST FORK RUSSIAN RIVER
POTTER VALLEY
REDWOOD VALLEY GRAVEL PRODUCTS
101
LAKE MENDOCINO
20
PARNUM GRAVEL CO.
FORD GRAVEL CO.
UKIAH
MATTERN SAND & GRAVEL
MATCH TO PLATE 3
LAKE GLENN
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0 2 4 6 8 KILOMETERS
DEPARTMENT OF THE ARMY
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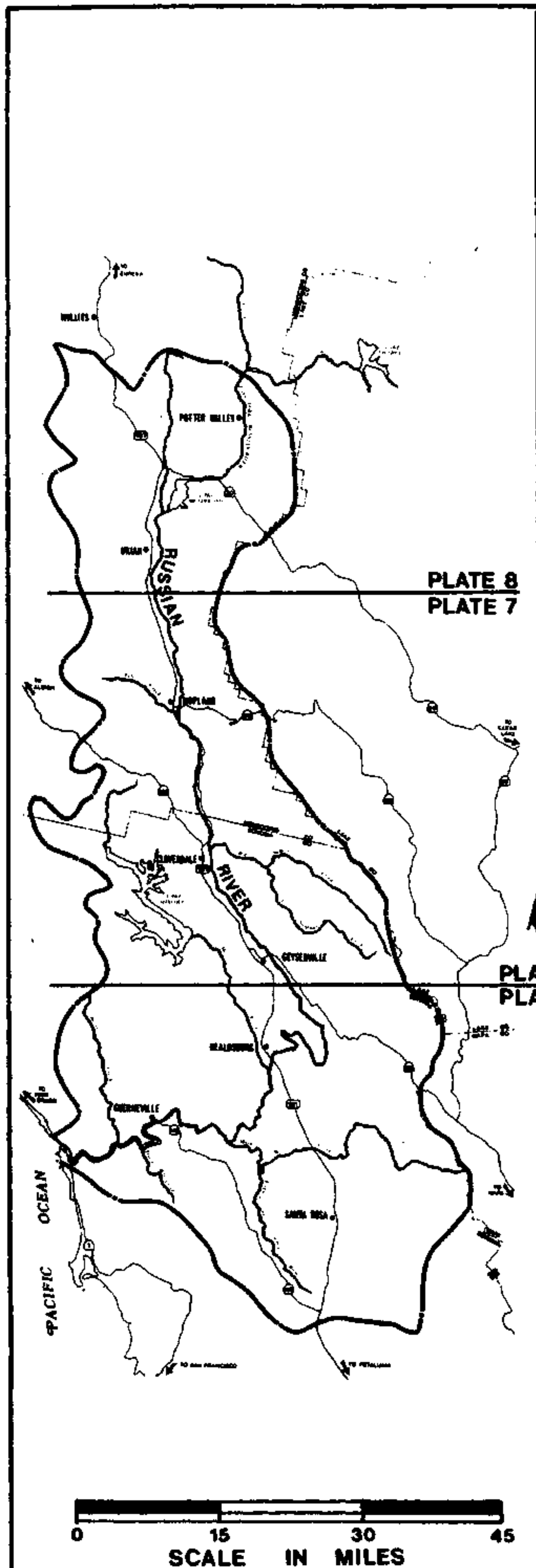
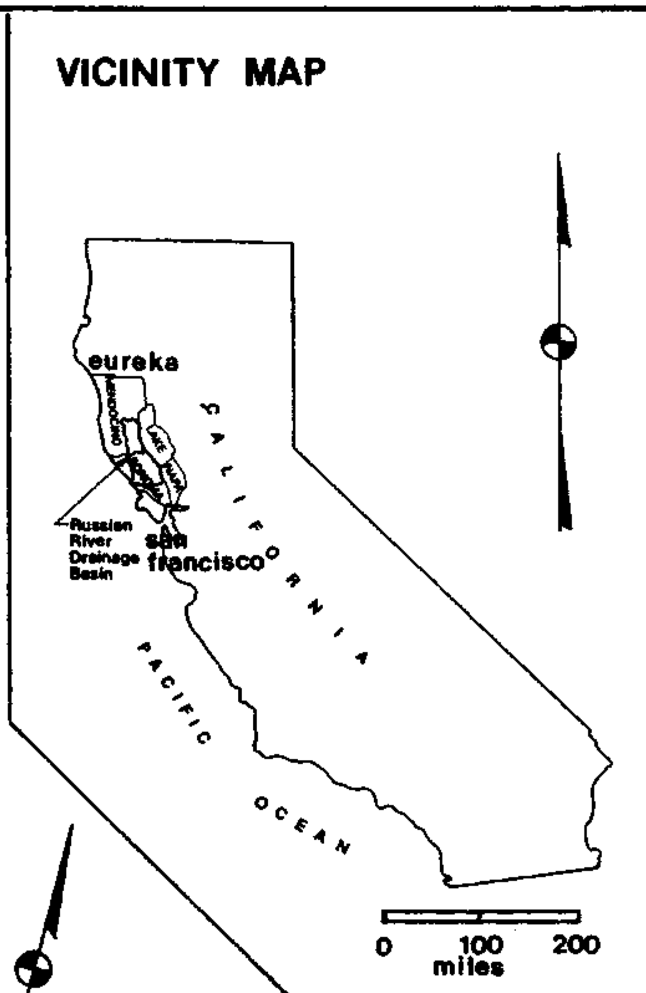
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA
PLATE 4





RUSSIAN RIVER
BASIN STUDY

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LOCATION OF SUMMER DAMS AND LOW FLOW CROSSINGS

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MAIN HIGHWAY

COUNTY LIMITS

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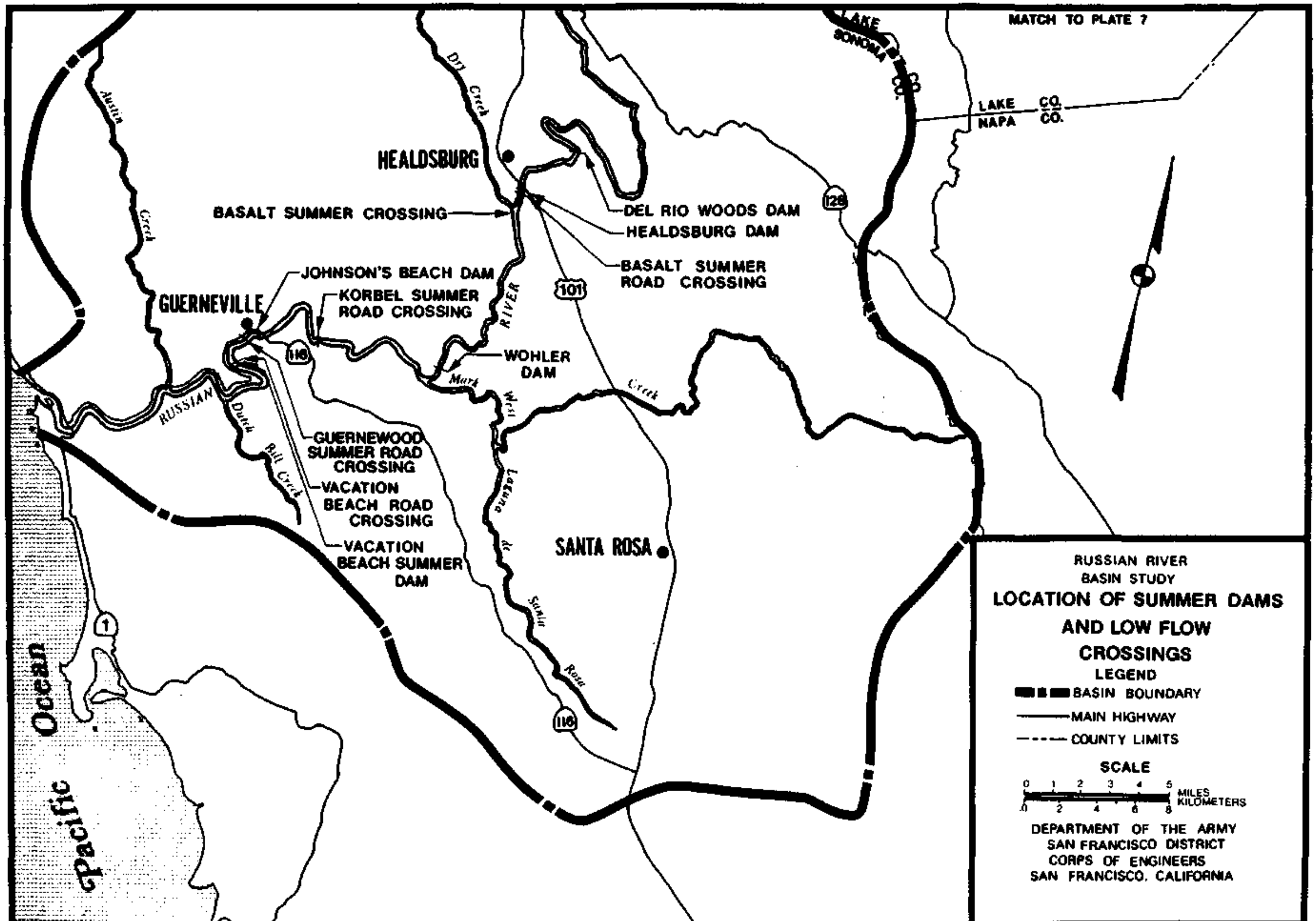
SAN FRANCISCO DISTRICT
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA


MATCH TO PLATE 7
LAKE CO.
SONOMA CO.
LAKE CO.
NAPA CO.
HEALDSBURG
Dry Creek
BASALT SUMMER CROSSING
DEL RIO WOODS DAM
HEALDSBURG DAM
BASALT SUMMER ROAD CROSSING
128
101
JOHNSON'S BEACH DAM
GUERNEVILLE
KORBEL SUMMER ROAD CROSSING
RIVER
WOHLER DAM
116
Austin Creek
RUSSIAN
Mark West Creek
Dutch Bill Creek
GUERNEWOOD SUMMER ROAD CROSSING
VACATION BEACH ROAD CROSSING
VACATION BEACH SUMMER DAM
Laguna de Santa Rosa
SANTA ROSA
1
Pacific Ocean
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0 1 2 3 4 5 MILES
0 2 4 6 8 KILOMETERS
DEPARTMENT OF THE ARMY
SAN FRANCISCO DISTRICT
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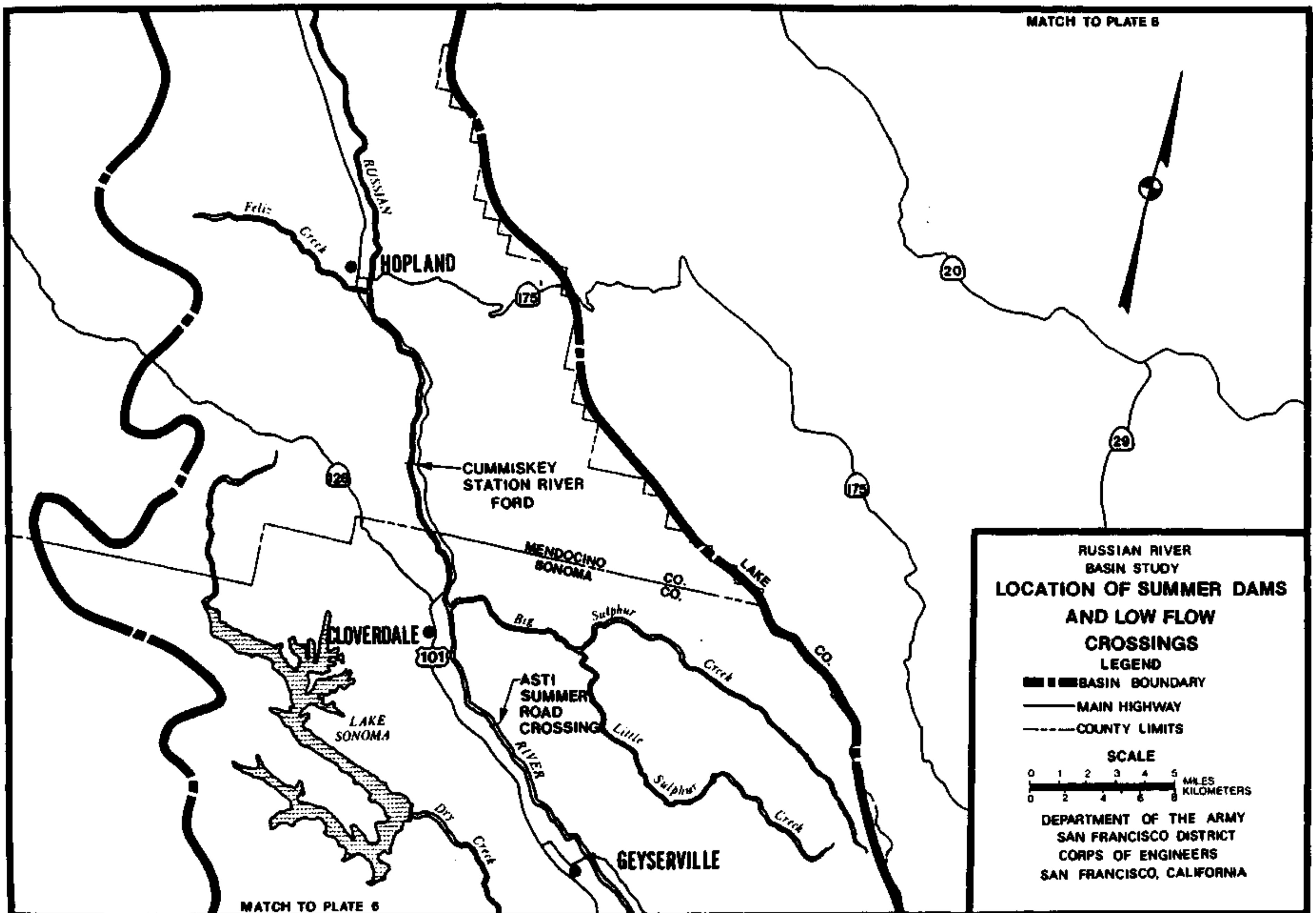
PLATE 6


MATCH TO PLATE 8
RUSSIAN
Feliz Creek
HOPLAND
175
20
CUMMISKEY STATION RIVER FORD
128
29
175
MENDOCINO CO.
SONOMA CO.
LAKE CO.
CLOVERDALE
101
Big Sulphur Creek
ASTI SUMMER ROAD CROSSING
Little Sulphur Creek
LAKE SONOMA
RIVER
Dry Creek
GEYSERVILLE
MATCH TO PLATE 6
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0 1 2 3 4 5 MILES
0 2 4 6 8 KILOMETERS
DEPARTMENT OF THE ARMY
SAN FRANCISCO DISTRICT
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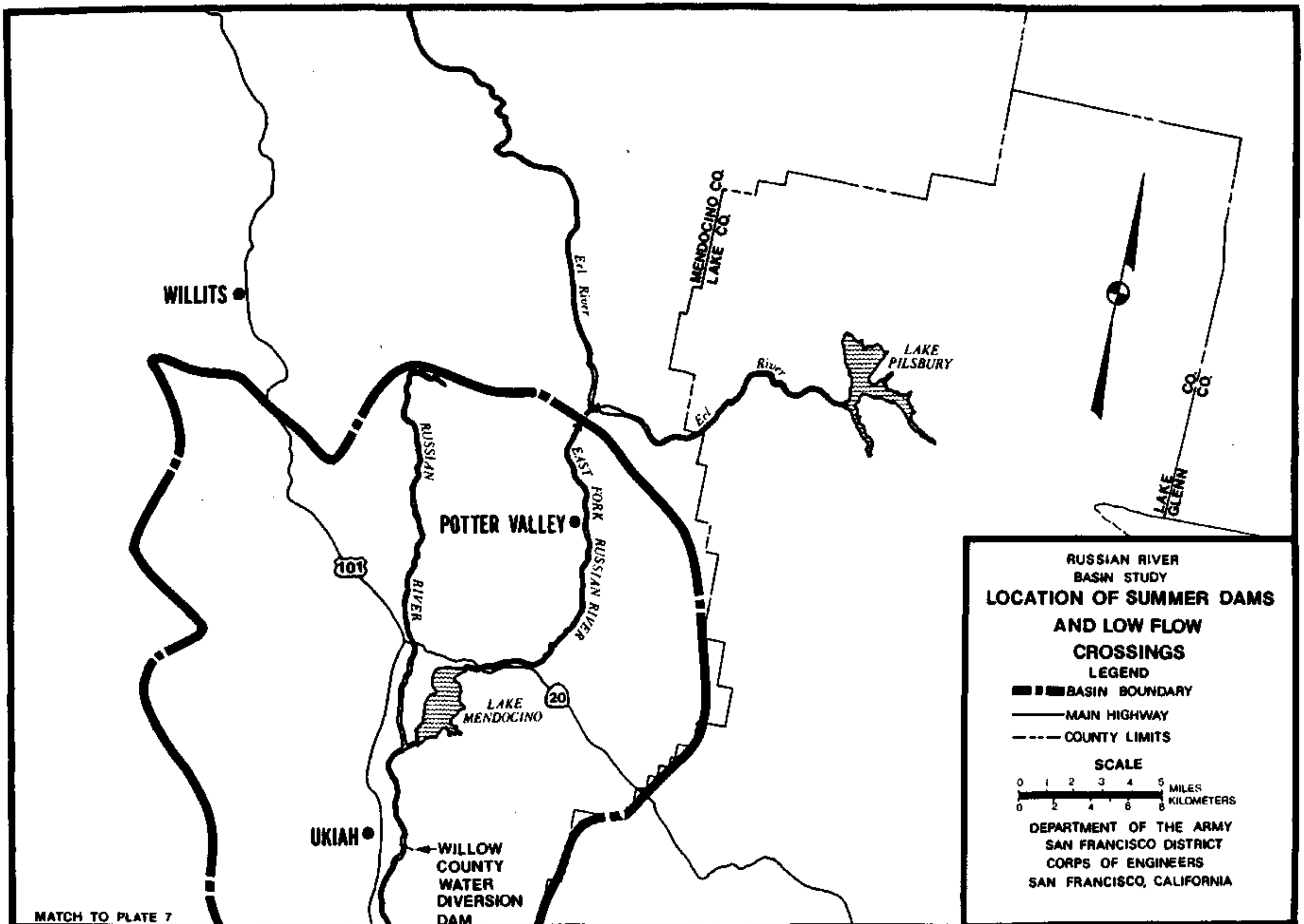
SAN FRANCISCO, CALIFORNIA

PLATE 7



RUSSIAN RIVER
BASIN STUDY

LOCATION OF SUMMER DAMS AND LOW FLOW CROSSINGS

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0 1 2 3 4 5 MILES
0 2 4 6 8 KILOMETERS

DEPARTMENT OF THE ARMY
SAN FRANCISCO DISTRICT
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

Appendix A

Gravel Mining and Sediment Influx

Appendix A

GRAVEL MINING AND SEDIMENT INFLUX

The following discussion is intended to summarize for the reader historical information and current issues related to gravel mining and sediment influx and movement in the Russian River basin. The discussion also includes a description of a computer program for modeling sediment deposition and scouring in a river system, and a description of gravel mining regulations applicable to the Russian River basin.

1. Existing Conditions

The Russian River, although perennial, is characterized by large variations in flow. In the summer, the low flows are clear of sediment; however, during winter floods, a sizable sediment load is carried downstream. Coarse sands and gravels of the riverbed support a sizable aggregate mining industry along the Russian River, particularly in Sonoma County.

Plates 1 through 4 in the report show the gravel mines which have recently operated or are currently operating along the Russian River. Several mining methods have been used to remove the gravel deposits:

a. the shallow excavation of exposed gravel bars in the river channel to remove gravel deposited by winter floods;
b. the excavation of deep in-channel ponds which then trap and collect gravel transported by floods;
c. the excavation of large pits separated from the river by dikes, often removing vegetation and topsoil to expose the gravel;
d. the excavation of gravel in quarries away from the river; and
e. the shallow excavation of the river channel to remove gravel deposited by winter floods.

Several large pits have been excavated alongside the river between Wohler Bridge and Healdsburg. According to a one-year industry survey conducted in 1978 and 1979, these mines account for approximately 502 of Sonoma County's total aggregate production. In-channel gravel bar mines and quarries each account for approximately 25% of the total production. California Division of Mines and Geology data indicate a total annual aggregate production of approximately 3,500,000 tons since 1967. Out-of-stream pits have accounted for 65%, instream mines 15%, and quarries 20% of the production according to their data.

Downstream of Healdsburg, the gravel companies mined principally inside the summer channel until the late 1960's, but this reach of the river is almost "mined out." The companies have therefore removed vegetation and top soil from nearby land and excavated large pits as deep as 60 feet, leaving dikes between the pits and the river. These pits are known as "terrace" mines because they are located in the river terraces. Drag lines are used to remove gravel, and sedimentation ponds are used to trap fine sediments from wet processing of the gravel. Figure 2 in the report shows the profile of a typical terrace mine.

In the Alexander Valley, miners scrape the exposed gravel bars down to the summer water surface elevation as allowed by their County gravel extraction use-permits. The sites are then smoothed to prevent fish entrapment and abandoned to the winter floods. The floods replenish some of the gravel so that mining can resume the next spring.

In gravel-bar mining, the gravel is excavated with front-end loaders, scrapers, or paddle skimmers and hauled to a processing site on the gravel bar, just above the winter-flow channel, or outside the immediate area. In the latter two cases, the gravel may be processed year-round. Processing includes screening and crushing and may be either "dry" or "wet," with "wet" processing requiring sediment holding ponds to trap fine sediments. At least one operator yearly removes the accumulated fine sediments from the ponds and adds them to farmland. In other cases, the ponds are abandoned to the winter floods. Gravels over 1-1/2 inches and cobbles are sometimes used to armor nearby river banks.

2. Planning Objectives

A major objective of the planning process with respect to gravel mining is to minimize the negative impacts of the mining. Possible negative impacts of instream mining include:

a. degradation of the stream bed;
b. bank erosion;
c. disruption of riparian growth;
d. effects on wildlife;
e. visual impacts;
f. the reduction of effective groundwater recharge area by fine sediments replacing removed sands and gravels.

Possible negative impacts of terrace mining include:

a. disruption of riparian growth;
b. loss of farmland;
c. visual impacts;
d. changes in groundwater movement;
e. evaporation of groundwater; and
f. the reduction of effective groundwater recharge area by the accumulation of fine sediments in the gravel pits and the covering of instream gravel percolation beds by fine sediments washed from streamside sedimentation ponds.

Some possible negative impacts common to both methods of mining include:

a. adverse effects of the transport of mined materials away from the site, such as the effects of heavy trucks on local traffic patterns, noise levels, air quality, and road and bridge stability, and on the safety of travelers and residents;
b. adverse effects of some gravel mining operations on the replenishment of nearby sites used in other operations; and
c. adverse water quality impacts, including the discharge of untreated wash water into the river, grease and oil spills, and excessive turbidity caused by the operation of heavy equipment in or near the streambed.

3. Planning Constraints

If planners considered only the objective of minimizing negative impacts of gravel mining, the obvious solution to the problem would be to halt mining along the river. However, certain planning constraints exist which would most likely lead to a different solution. These constraints include social, economic, and environmental considerations such as:

a. The demand for gravel. Gravel is needed for construction both in and out of Sonoma County. The effect of this constraint on the problem will depend on how much gravel is available from sources away from the river, such as quarries. The cost and quality of gravel from various sources should also be considered.
b. Possible effects of mining on floods. Degradation often increases the flow capacity of the channel. A marked reduction of mining activity could cause aggradation of the river bed and increases in overbank flooding.
c. The economic effects of mining in Sonoma County. A change in overall mining activity would affect both employment and taxes. Indirect effects on the local economy, such as changes in commercial activity, should also be considered.

4. Hydrologic Description

From its headwaters about 12 miles north of Ukiah, the Russian River flows in a southerly and southeasterly direction for about 90 miles toward Healdsburg, where it changes direction toward the southwest. The river then flows another 20 miles, passing Guerneville on its way toward Jenner near which it discharges into the Pacific Ocean about 60 miles north of San Francisco. The Russian River basin has an area of 1,485 square miles and spans about 80 miles in the north-south direction. The Santa Rosa-Rohnert Park-Sebastopol urban area is within the basin. In the east-west direction, the basin width varies from about 30 miles near its southern end to about 12 miles near Hopland.

Elevations range from 3,553 feet at Sanei Mountain on the western edge of the basin and 4,500 feet near Cobb Mountain in the eastern uplands, to sea level at the point of discharge. The slope of the mainstem of the Russian River varies from several hundred feet per mile in the upper reaches of the river, to about 2 feet per mile near the Pacific Ocean.

Over most of the southward course of the river, from Ukiah to Healdsburg, it travels through alluvial valleys separated by mountain gorges. Over its south-westward course from Healdsburg to the Pacific Ocean, it passes through a canyon in the Coast Range. The principal tributaries of the Russian River are the East Fork, Big Sulphur Creek, Maacama Creek, Dry Creek and Big Austin Creek. There are substantial gravel deposits along the Russian River and its tributaries. During the Ice Age, sea level dropped to about 250 feet below where it is today, causing coastal streams to deepen their valleys. As the ice melted, sea level gradually rose and sediment was deposited in the bed of the river. Today the gravel and sand deposits are at least 50 feet deep at Healdsburg and nearly 200 feet deep at the mouth of the river. Geologic materials alongside the river channel consist of deposits of gravel, sand and silt overlying the older material of the former channel. As the river meanders, these processes continue with the deposition of new alluvium over the existing channel bed.

The Russian River basin has a mild climate with warm, dry summers and cool, wet winters. Snow sometimes falls at high elevations in the basin, but the quantity is so small that snowmelt is an insignificant contributor to runoff. About 80 percent of the precipitation occurs during the five months from November through March. The mean annual precipitation varies from 80 inches per year at Cobb Mountain, about 16 miles east of Cloverdale, to slightly less than 30 inches per year in the area south of Santa Rosa. The mean annual runoff in the Russian River basin upstream of Guerneville (1,338 square miles or 90 percent of the basin) is about 20 inches.

In 1964, the California Department of Water Resources (DWR) estimated that 86 percent of the basin had a cover of native vegetation. The native vegetation includes widespread manzanita and chaparral, particularly in the foothill areas. The highest parts of the basin are moderately to heavily timbered, the principal trees being redwood, Douglas fir, and live oak. Parts of this land are used for quarrying, commercial timber production, and for livestock range land. The DWR also estimated that 4 percent of the basin was used for irrigated farms, 7 percent for dry-land farms and 3 percent for urban areas.

Erosion, transportation and deposition of sediment are natural processes that continually change the shape of the land surface. The Russian River basin is a geologically youthful region where these processes are especially noticeable. Rates of erosion (and consequent rates of transportation and deposition) in the Russian River basin are high in comparison to other regions of the United States. For example, according to Brown and Jackson, the 162-square mile Dry Creek drainage basin was stripped of at least 3,900,000 tons of soil and rock by erosion during a seven-year period beginning in October 1964. This amounts to an average erosion rate of about 3,400 tons per square mile per year, much greater than for basins of comparable size elsewhere in the United States. Studies conducted by the U.S. Geological Survey indicate that much of the erosion in the Dry Creek basin is due to the activities of man which accelerate the natural erosive process. Over the last 90 years, many acres of forest in the Dry Creek basin have been converted to grassland by timbering. This, when combined with grazing, has exposed the land surface to the ravages of rainfall and runoff, resulting in accelerated rates of sheet erosion and gulleying.

5. Hydrologic History

a. Stream Gradient

Before the late 1960's most of Sonoma County's aggregate production was centered at instream mines in the Russian River reach from Wohler Bridge to Healdsburg. Hans Einstein, in a study of Russian River gravel resources conducted for the Sonoma County Water Agency in the early 1970's, estimated an average gravel flow of only 14,000 tons per year into the river reach below Healdsburg. Gravel mining has been accompanied by a noticeable drop in bed elevation over the past thirty years along the Russian River mainstem from Wohler Bridge to Healdsburg and on lower Dry Creek. Between 1940 and 1977, degradation of 18 feet has been observed four miles upstream of Wohler Bridge. However, only a one-foot drop in bed elevation has occurred at Healdsburg Bridge. Apparently the Healdsburg Dam has helped stabilize the bed of the river in that region.

Along Dry Creek, degradation of over 12 feet has been observed at the Westside Bridge between 1964 and 1978. Degradation decreases upstream until it is approximately only one foot three miles upstream of the bridge. Changes in bed elevation have been mixed in the Alexander Valley. The thalweg elevation had increased five feet at the Jimtown Bridge and decreased four feet at the Cloverdale Bridge by 1971. Local landowners have also reported an increase in elevation at the Geyserville Bridge. The locations of gravel bar mines probably greatly affect bed elevation changes in this reach.

Regions of bed degradation are approximately coincident with those reaches of the river in which gravel removal operations have taken place. Mining in the river bed lowers the channel bottom, which in turn increases the stream gradient upstream of the point of extraction. An increased gradient causes higher flow velocities which result in downcutting. The notch-point of the downcutting migrates slowly upstream. Velocities are decreased over pits excavated in the channel because of greater depths of flow. Lower flow velocities cause the stream to deposit sediment in the pits. Downstream of the extraction point, the bed slope is reduced and the resultant lower flow velocities may cause deposition. However, this is not always the case since large pits reduce the downstream sediment load. The resultant "hungrier" water (relatively sediment-free flows with a higher erosion potential) may actually offset the effect of the lower velocities and cause degradation.

The terrace mine pits are separated from the river by dikes. Dikes which are high enough will prevent river sediments from filling the pits if they are properly maintained. Such pits will not contribute to degradation by increasing stream gradients or increasing erosion potential.

b. Channel Alignment

The Russian River meandered across large areas of the valley floor before its conversion to farmland. This is evidenced by old meander patterns still visible in the agricultural land. Between Wohler Bridge and Healdsburg, these patterns form a band as wide as 4,000 feet. Meandering accounts for the gravel deposits underlying topsoil in the areas of the present-day terrace mines.

Aerial photographs indicate that river meanders have shifted location considerably even since 1940, particularly in the Alexander Valley. Part of the changes may be attributable to gravel bar mining in the channel. Following the completion of Coyote Dam in 1958, channel modifications were undertaken by the Corps of Engineers in the Alexander Valley. The Corps did not attempt modifications along the entire river at once, but rather would dredge, clear vegetation, and install jacklines and flexible fencing as the need arose.

Much of the alignment change must be attributed to natural meandering, which, if left unhindered, would eventually cover the entire valley bottom. Even under completely natural conditions, meandering would cause bank erosion where the meanders impinge on the bank.

Aerial photographs indicate that considerable land covered with riparian vegetation has been converted to farmland since 1940. Streambed degradation may have facilitated the conversion by causing riparian areas, along with old distributaries (a branch of a river flowing away from the main stream and not rejoining it; contrasted with tributaries) and meanders, to become perched above the new channel. These areas thus become less susceptible to flooding. The conversion of land adjacent to the river from riparian to agricultural uses increases bank erosion damages because lands already subject to erosion become more valuable. Fill placed adjacent to the river may increase flow velocities and accelerate bank erosion.

c. Erosion

At a number of places, particularly on Dry Creek, landowners have complained that they have been losing land through bank erosion. The cause of the erosion is difficult to pinpoint. Under natural conditions erosion can be expected along the outsides of meanders. This condition is aggravated by abuse of the upstream watershed from timbering or overgrazing. Such activity results in increased erosion which brings heavy sediment loads to the stream. At the recession of floods, gravel bars are sometimes deposited near the middle of the channel. Later when flows once again increase, the flow path may be confined between one of these mid-channel gravel bars and the bank of the stream. So, once again, erosion of the bank occurs and land is lost. As already mentioned, the removal of gravel from the bed of the stream results in downcutting. The flow channel tends to become deeper and narrower. If the flow channel stays in the middle of the existing channel, there will be no deleterious effects; however, if the flow channel happens to become located alongside the bank, erosion of the bank and loss of land will occur. The loss of riparian vegetation along banks by erosion or degradation makes the banks more susceptible to erosion.

Besides along Dry Creek, serious bank erosion has taken place recently just upstream of the Geyserville Bridge. Several other isolated reaches within the Alexander Valley, such as at the Jimtown Bridge, have also been subject to erosion.

d. Bedload and Replenishment

Based on a 1971 study of gravel bar movement, Hans Einstein estimated that in an average year, 57,000 tons of gravel flows through the Alexander Valley reach of the river. Flood flows greatly influence the gravel resources of the Russian River because during periods of high flows gravel is moved as bedload and redeposited as gravel bars. Bedload is that part of the sediment which moves along the bed and is not suspended in the river. Very little gravel is conveyed at low flows, even as bedload. Einstein estimated that only 14,000 tons of gravel is conveyed into the Wohler Bridge-Healdsburg reach yearly, due to the reduction of significant amounts of gravel to finer sediments through fragmentation and abrasion. Any supplemental gravel flows from Dry Creek will be diminished when the Warm Springs Dam is completed.

According to California Division of Mines and Geology data, the average annual aggregate production for the 1970's from Russian River instream mines (not including terrace mines) was just under 200,000 tons. Most of this was mined in the Alexander Valley. Very recently the instream production climbed to 800,000 tons according to the 1978-79 industry survey. Even though some of the aggregate production is of sands rather than gravels, it appears that gravel extraction in the Alexander Valley exceeds replenishment. One should remember, however, that extraction and replenishment vary from reach to reach. Some short reaches may experience degradation while gravel bars are growing nearby. Both the gravel extraction and replenishment figures are rough estimates and also can be expected to vary from year to year.

Over 2,000,000 tons of aggregate are extracted yearly from the terrace mines below Healdsburg (assuming that 65 percent of Sonoma County's aggregate production comes from the mines). The gravel extracted greatly exceeds the estimated gravel flow of 14,000 tons per year. However, the terrace mines are separated from the river by dikes. Even when high winter flows inundate the mines, they are effectively removed from the gravel flow in the river.

e. Suspended Sediment

The bed of the river is made up mostly of coarse sands and gravels which move as bedload. Although there is considerable suspended sediment in floodflows, it has little effect on bed movement.

6. HEC-6 Program

a. Description of Program

1) General. HEC-6 is a simulation program designed to analyze scour and deposition in a stream by modeling the interaction between the water-sediment mixture, the sediment of the streambed, and the flow hydraulics. For a given flow hydrograph and initial boundary conditions, changes in the following are found with respect to time and position along the stream:

(a) total sediment load;
(b) volume and gradation of deposited or scoured sediment;
(c) armoring of the bed surface; and
(d) the bed elevation.

The sediment outflow from the study reach is also found.

2) Boundary and Initial Conditions. Sediment inflow into the upper end of the study reach is specified by a flow-sediment discharge rating table. A stage-discharge rating table is used to establish the water surface elevation at the lower end of the study reach. The initial bed elevations are given by stream cross-sections. Initial bed material gradations along the study reach are also specified.

3) Geometry. The geometry of the study reach is specified by cross-sections similar to those used in the HEC-2 backwater model. A cross-section is divided into a movable part subject to scour and deposition, the bed, and an immovable part, the banks and overbanks.

4) Hydraulics. The flow hydrograph is approximated by a series of steady discharges, each having a specific duration. The standard step procedure is used to solve the one-dimensional energy equation and the flow velocity, depth, width, and slope are calculated at each cross-section for each flow. In order to account for the lateral distribution of flow, each cross-section is divided into subsections.

5) Sedimentation. A finite difference form of the sediment continuity equation is used to adjust the bed elevations for scour or deposition. One of three methods may be used to

calculate the potential transport capacity for each of several classes of grain sizes: (1) Laursen's method; (2) Toffaleti's modification of Einstein's method; and (3) a general relationship fitted with user-given parameters.

The actual transport capacity equals the potential capacity multiplied by the fraction of the size class in the bed material. If the transport capacity exceeds the sediment discharge, available sediment is removed from the bed until continuity is satisfied. The fractions of grain sizes in the bed are recalculated as material is exchanged with the stream.

The transport capacity is corrected for armoring of the streambed. Manning's and Strickler's equations along with Einstein's bed-load function are used to calculate an equilibrium depth, or depth of no transport, for each grain-size class. An equilibrium depth for the mixture of grain sizes and accompanying maximum transported grain size is calculated such that there are enough larger grains above the depth to completely armor the surface. This equilibrium depth specifies the lower limit of scouring.

A new equilibrium depth for the mixture is calculated for each discharge. The armor layer formed by previous discharges is tested and disturbed if unstable. All or part of the old armor layer may be destroyed.

b. Description of Data Used

The following are data needs for various input cards in the model, as well as possible sources of this data.

1) Bed Material Gradation. The average gradation of the bed material is needed to a depth equal to the expected depth of scour. Bed samples are needed for conditions approximating those at the beginning of the simulation. For example, if one is to simulate the first large winter flood, he could sample the bed during the previous dry period.
Gradations are needed for each cross-section of the geometric model. Therefore, the bed should be sampled at various places along the river representing different sediment conditions.

2) Inflowing Sediment Load. For the lower Russian River and Dry Creek, the suspended sediment load and particle size distribution for various discharges can be estimated from USGS records of sediment samples at both Dry Creek and Russian River near Guerneville. A suspended sediment sampling program is needed to estimate the load elsewhere in the basin.

Bed load sampling, however, is probably not practical. It is therefore suggested that the model be applied to a short reach above the study reach which is fairly straight, uniform in flow and sediment characteristics, and not expected to aggrade or degrade. The model would be run for various amounts and gradations of inflowing sediment until the bed is stabilized. The out-flowing sediment could then be used as the inflowing sediment load for the study reach.

3) Water Discharge Hydrograph. The inflow hydrograph can be approximated by choosing a peak flow from an appropriate gage record in USGS "Water Resources Data." The sides of the hydrograph can be filled in by plotting mean daily flows.

4) Cross-Sectional Data. Cross-sections can be obtained from an Army Corps of Engineers' HEC-2 deck for the Russian River in Sonoma County. Cross-sections from Wohler Bridge to Healdsburg were surveyed in 1976; the rest were surveyed in 1940. The cross-sections should be resurveyed prior to running the model in order to reflect bed changes.

5) N-Values and Expansion Coefficients. N-Values and expansion coefficients can be obtained from the HEC-2 deck or from personal observations.

6) Limits of the Movable Bed. The horizontal limits of the movable bed can be estimated by studying aerial photographs of the river for the bank locations and extent of gravel bars. Personal observation should be made to determine if, for a cross-section, the scourable sediment is shallow enough to limit the depth of scouring. An estimate of the maximum scouring depth would then be needed.

7) Stage-Discharge Curve for Downstream Limit of Study. One should choose as the downstream limit of study a reach in which there is no expected aggradation or degradation. This will ensure a stage-discharge curve for the starting water surface elevation which is constant with respect to time. Points in the curve for very large flows can be obtained from water surface profiles provided by the Corps of Engineers.

8) Water Temperature. The average temperature of the water under the study conditions can be estimated from the USGS "Water Resources Data."

9) There are many parameters which have default values supplied by the program. These default values are usually adequate, but the accuracy of the model may be enhanced by supplying values specific to the problem. Some of these parameters are:

(a) deposition and scour threshold shear stresses for clay and silt;

(b) unit weights of consolidated clay and silt deposits;

(c) compaction coefficients for clay and silt deposits;

(d) unit weights of newly deposited silt and clay deposits;

(e) specific gravity of sand particles;

(f) unit weights of deposited sand;

(g) coefficients for the various available transport equations; and

(h) grain shape factor and specific weight.

c. Constraints and Assumptions of Model

HEC-6 is a one-dimensional model. It cannot simulate the development of meanders, nor can it specify a lateral or vertical distribution of sediment in a river. Density and secondary currents are not accounted for by the model.

The formation of bed forms cannot be directly accounted for by the model. The Manning's n-values can be made a function of discharge, however, which also affects bed forms.

The model requires a great deal of data which is both difficult and expensive to gather, and the evaluation of many parameters. Since the accuracy of model output can be no better than its input, and the model cannot be made more accurate than the sediment transport equations it uses, care must be taken to assure that the transport equation used is appropriate for the river reach to be modeled.

HEC-6 is a steady-flow model. A discharge hydrograph must be discretized into a series of constant flows. Since the flows have durations measured in days, rapid scour or deposition cannot be simulated.

The entire movable bed is assumed to aggrade or degrade the same vertical distance. The boundary between the movable and non-movable portions of the bed is assumed to be fixed. It is therefore impossible to directly simulate bank erosion and channel widening with the model. It cannot predict the exact locations bank erosion will occur; however, the extent of degradation, along with the meander of the stream are indicators of where bank erosion is likely to occur.

7. Review of Gravel Mining Regulations

a. Purpose

Gravel mining along the Russian River is regulated primarily by the counties through their permit systems. These systems assume gravel mining is necessary but also attempt to minimize negative impacts of the mining. This is accomplished by:

1) Granting permits for mining only in locations where negative impacts are relatively minor; and

2) Specifying conditions under which the permits are granted.

b. Permit Conditions

The counties' permit systems are structured to interface with the California State Department of Fish and Game's 1601-1603 permit system. The State program is intended to eliminate or reduce any adverse impacts of construction or other similar activities conducted in any water body in the state. The Department reviews plans, construction methods and the like, and specifies any changes needed to reduce adverse impacts. The counties are similarly able to control certain operating procedures and thereby insure minimum negative impacts by specifying conditions such as:

1) The operator will not mine below the summer low-flow water elevation on gravel bars. This condition prevents the creation of sharp breaks in continuity in the stream bed and minimizes excessive turbidity.

2) Process water will not be allowed to enter the stream directly, but will be gathered in holding ponds.

3) Stockpiling sites and sedimentation ponds will be reseeded upon completion of the mining.

4) The surfaces of mined gravel bars will be smoothed and sloped toward the river to avoid fish entrapment during the recession of winter high flows.

5) The operator will provide cross-sections of mined areas to the Planning Department before and after excavation.

6) Riparian vegetation will not be removed without prior approval.

7) Operations will be limited to specific hours.

8) The operator will comply with applicable regulations from other state and local agencies. This condition is to assure that the interests of other agencies are not neglected.

9) The operator must pay a bond to ensure that reclamation is completed upon cessation of mining.

b. History and Description of Present Regulations

Sonoma County has operated a "use" permit system for gravel mining since 1946. Mendocino County has operated a similar program since 1956. Initially, permits were granted with few conditions. As local governments became more aware of the environmental effects of gravel mining, more conditions were attached to the permits. The permit procedure became much more extensive in the early 1970's as the preparation of environmental impact reports became required to satisfy the requirements of the California Environmental Quality Act (CEQA). It also was becoming apparent that each mining operation would need to be studied in the context of the entire river system in order for its true impact to be determined. Sonoma County's approach to this problem was to initiate a comprehensive gravel study which resulted in 1980 in an Aggregate Resources Management Plan. Certain provisions of this plan have been incorporated into the County General Plan.

The California State "Surface Mining and Reclamation Act" was passed in 1975. To satisfy requirements of this act, Sonoma County passed its "Surface Mining Ordinance" in 1978. Mendocino County passed its "Surface Mining and Reclamation Ordinance" in 1979. These ordinances set up "mining" permit procedures to be used when gravel miners wish to open new mines or expand into new land parcels. They do not apply to legal nonconforming uses operating under the old use permits. The new procedures have much the same objectives and results as the "use" permit system. For example, Sonoma County's permit program includes the following steps:

1) The miner submits a permit application and reclamation plan to the County Planning Department which conducts investigations and makes recommendations.

2) The County Project Review and Advisory Committee conducts an environmental assessment to determine if an impact report is needed or if a negative environmental declaration is sufficient for the permit to be granted. In cases requiring no EIR, the committee recommends conditions for the granting of the permit. The committee is made up of representatives of the following County agencies:

   a) Road Department

   b) Environmental Health Departmen

   c) Water Agency

   d) Agricultural Commission

   e) County Surveyor

   f) Sanitation Department

   g) Planning Department

3) A public hearing is held before the Board of Zoning Adjustments regarding the environmental determination. If a negative declaration is approved, the permit will then either be denied, approved, or approved with conditions. If an environmental impact report is required, then action on the permit is postponed by the board until it accepts the EIR.

4) Any member of the public may appeal a decision by the Board of Zoning Adjustments to the County Board of Supervisors within specified time limits. The courts may also uphold or overturn a decision upon appeal.

c. Permit Review Agencies

There are several state and local agencies which are referred *to* by the counties' planning departments prior to conducting the environmental assessment for a gravel mining permit application. They therefore have input regarding the permit conditions. Some of these agencies are the:

1) State Department of Fish and Game

2) North Coast Regional Water Quality Control Board

3) Bay Area and Northern Sonoma County Air Pollution Control Districts

4) State Department of Water Resources

5) State Water Resources Control Board

Although several mining companies have filed applications for vested rights, no system for handling the applications has yet been finalized. A mining operation determined to have vested rights will be required to file a reclamation plan, but will not need a permit.

d. Other Permitting Agencies

Several agencies other than the counties also issue permits to control gravel mining:

1) Army Corps of Engineers. This agency requires issuance of its "404 permits" for any excavation or disposal of dredge or fill material below the normal high water mark. Therefore, any terrace mine located above the normal high water mark does not require a permit. The Corps may issue three types of permits: a. nationwide permits requiring no individual reporting for small operations; b. general permits for districts with planned, on-going projects; and c. individual permits. When a permit application is received, the Corps requests comments from interested agencies, such as the State Fish and Game Department, then either issues or denies the permit. The Corps may require changes in the proposed mining operations as conditions of the permit.

2) The State Department of Fish and Game. Sections 1601 to 1603 of the Fish and Game Code require that anyone wishing to divert, obstruct, or change the natural flow or bed of a river must submit plans to the Department. The Department reviews the plans and makes recommendations

of operation or construction changes to protect fish and wildlife. If the recommendations are unacceptable to the operator, a panel of arbitrators is established to make binding decisions concerning the recommendations.

3) The North Coast Regional Water Quality Control Board. This board administers the National Pollution Discharge Elimination System (NPDES) permit system for the Russian River basin. A permit is needed if gravel is processed with water that is discharged into a holding pond next to the river or if a dike is constructed. An NPDES permit contains a list of conditions under which the miner must operate and requires on-going monitoring of the river during operation of a holding pond and short-term monitoring during construction of a dike. Direct discharge from a sedimentation pond is not permitted. Terrace mines which process gravel and drain washwater to ponds away from the river do not require NPDES permits; however, they must operate according *to* the waste-discharge requirements set up by the board for the Russian River.

4) The State Division of Water Rights. A permit is required from this agency if the miner wishes to appropriate water for gravel washing.

Appendix B

Anadromous Fish Life History Data

APPENDIX B

ANADROMOUS FISH LIFE HISTORY DATA

The following life history descriptions of steelhead, silver salmon, king salmon and American shad were developed by the California Department of Fish and Game. They are presented to give the reader an understanding of the life stages of these fish which form the basis for the evaluations presented in the Russian River Basin Study main report.

1) Steelhead

The steelhead trout is the most widespread fish within the Russian River drainage. It occupies all of the major tributaries and most of the smaller ones up to natural or artificial barriers, such as falls, steep gradients or dams. Steelhead are anadromous, spending a portion of their life cycle in freshwater and the remainder in the ocean. Adult steelhead migrate into the Russian River on high streamflows during the winter and early spring. They dig a depression in the streambed and deposit their eggs in redds (nests) in areas that have suitable sized gravel and sufficient water velocity to oxygenate the incubating eggs, then return to the ocean(l). Most spawning occurs in the upper Russian River and tributary streams. The eggs hatch in 30 to 60 days, depending on water temperatures and other environmental factors, and the young fish wiggle up through the gravel. They then live and grow in the stream near where they were hatched for a period ranging from a few months to several years, but most spend either one or two years in freshwater before migrating to the ocean. The majority of the young fish go to sea in the spring as flows decrease and temperatures start to increase, usually during March, April and May; however, some migration occurs virtually all year. Juvenile fish grow and mature in the ocean, returning to spawn after one to three years at sea, thus completing the cycle.

In early 1980 the California Department of Fish and Game introduced a strain of summer steelhead to the Russian River. Native strains of summer steelhead exist in the Eel and Mad River basins north of the Russian River. The first plants in the Russian River were approximately 150,000 yearling smolts expected to migrate to the ocean soon after planting. The adult fish are expected to return to the river in one to three years between the months of April and July. They are expected to spend the summer in cool, deep pools in the upper river and spawn late in the following winter and early spring. Plants were made in March 1981 and will be made again in March of 1982. The first mature fish are expected to return to the basin in mid-1982.

Environmental conditions conducive to steelhead trout production in the Russian River drainage include minimum depths of at least 0.5 feet, water velocities of 1-3 fps, and temperatures from 43 to 55 degrees F. Minimum dissolved oxygen levels of 7 ppm are necessary for normal growth, and channel gravels with less than 20 percent fine sediment content are required for spawning, egg incubation, fry emergence, and rearing of the young (Table B-l). Although steelhead are known for their jumping abilities and can clear individual 2-3 foot barriers, multiple barriers in a close series should be no greater than 1 foot to permit fish passage(2). Water depths of at least 0.6 foot and velocities of less than 8 fps are also necessary for fish passage.

2) Silver Salmon

The life history of silver salmon is similar to that of steelhead, with a few notable exceptions (Table B-2). Silver salmon spawn earlier in the winter than do steelhead, usually in November, December and January. They spawn in the tributaries of the lower Russian River, up to and including the Dry Creek drainage. In low water years some spawning may occur in the mainstem of the river. All adult salmon die after spawning, instead of returning to the ocean as do steelhead. The juvenile life history also varies from that of steelhead, in that nearly all young silver salmon migrate to the ocean as yearling fish the spring following the one in which they were hatched. Typically, they spend one to three years in the ocean before returning to spawn.

Environmental conditions conducive to silver salmon production in the Russian River drainage are similar to those described for steelhead trout.

3) King Salmon

King salmon are not currently established in the Russian River drainage. Several attempts to establish a self-sustaining population have failed, mainly because adults entered the lower river too early in the fall, encountering water temperatures that were too high for successful spawning (Table 8-3). Another attempt will be made to establish king salmon after completion of Warm Springs Dam on Dry Creek. Current plans call for rearing one million juvenile salmon per year at the Warm Springs Hatchery. A strain of late running king salmon (i.e., December-January) will be chosen so that adults will return to the river after temperatures drop in the fall, and juvenile fish will be released for their migration to the sea in the spring.

Occasional king salmon are observed in the Russian River, possibly a vestige of prior attempts at establishing a viable population. The environmental needs of king salmon in the Russian River are generally similar to those described for steelhead trout, although the larger body size of king salmon requires a minimum depth of 0.8 feet for adult passage and spawning.

4) American Shad

American shad, like salmon and steelhead, are anadromous. Shad are not native to California, having been brought from the Atlantic Coast in the 1870's and planted in the Sacramento River(3). From those plants, shad spread north into the most major river systems along the coast and have produced very popular fisheries in several areas. Much life history information is available for east coast stocks; however, many questions remain unanswered concerning the spawning, feeding, juvenile life history and migration of west coast populations. This is particularly true of the Russian River shad runs.

Upstream migration and spawning occurs in the spring and early summer as water temperatures increase to near 18.5 degrees C (65 degrees F) (Table B-4)(4). The exact timing of migration varies from year to year. In high water years migration is generally later, due to lower water temperatures, and in low water years the converse is true(5). Shad were found migrating through the Sacramento-San Joaquin Delta at temperatures between 11.1 and 21.1 degrees C (52 and 70 degrees F)(6). In the Eel River in 1968 adult shad migrated during the period April 21 to July 19(7). The peak of migration in 1968 occurred in late May and early June, but substantial numbers of fish were still migrating into the first part of July. Males usually dominate in the early part of the run; later the sexes are about equal or females are more numerous(8).

Spawning occurs over gravel or sand bottoms in areas with good current. Although some shad spawn in freshwater areas near the mouths of rivers, many migrate far upstream(9). Spawning takes place over a wide range of temperatures, from 8 to 26 degrees C (46 to 79 degrees F)(8), but 16 to 18.5 degrees C (61 to 66 degrees F) are preferred (4, 9).

Eggs are released into the water, at which time they are fertilized. The eggs are only slightly heavier than water and drift with the current or rest on the bottom until they hatch. Depending on water temperature, hatching usually occurs in 4 to 6 days, but can vary from as few as 2 at higher water temperatures to as many as 17 at lower temperatures(3). Shad eggs have been collected when water temperature was as low as 7.8 degrees C (45 degrees F)(10) to as high as 24 degrees C (75 degrees F)(5).

Juvenile shad remain in freshwater for several months after hatching. Stevens(6) found young shad migrating downstream out of the Sacramento-San Joaquin Delta in September, October and November.

Juvenile shad in Atlantic Coast streams behave similarly, migrating to the ocean in the fall when water temperatures decrease(4, 11).

California Department of Fish and Game observations of American shad in the Russian River have been collected sporadically in past years. Observations of Department personnel in the early 1950's indicated that the majority by shad migrated into the river between March 1 and July 1, peaking in May(12). The report goes on to say that young shad are found in the lower reaches of Austin Creek, the Monte Rio riffles, and on nearly all riffles in the lower reaches of the Russian River. In some years prior to the construction of Healdsburg Dam, shad were found to migrate as far up the river as Ukiah.

Environmental conditions necessary for shad production in the Russian River are generally similar to those described for salmonids. Minimum depths of about 0.5 feet are necessary for adult upstream migration and juvenile outmigration, with spawning, egg incubation and rearing of the young occurring in waters at least 3 feet deep with velocities of about 1-3 fps. Acceptable temperatures for shad are about 10 degrees higher than those for salmonids, ranging generally from 55 to 70 degrees F. Shad are poor at crossing over barriers and require a water slope of 1:6 or less; barriers of only 9 inches in height may not permit upstream passage.

Fishways on the Lower Russian River

The hydraulic characteristics of both fishways on the lower Russian River were evaluated by the California Department of Fish and Game in June 1973. The Vacation Beach (Hatcher's) and Johnson's Beach (Guerneville) fishways were found to have water slopes of 1:4.26 and 1:4.62, respectively; both exceeding the 1:6 slope recommended for shad by Bell (13). Flow velocity measurements within the Vacation Beach fishway ranged from 3.03 to 7.31 fps midway through the ladder section (47). Most of these values are above, and in some cases double, the recommended maximum flow velocity of 3 fps for adult shad passage(14). Flow velocity measurements for the Johnson's Beach fishway range from 2.3 fps to 6.15 fps. A number of flashboards were installed at each dam, with the result that flow velocity conditions were generally above the maximum recommended value of 3 fps for shad passage(14). The number of flashboards installed at each dam and the resultant water level within the impoundments also affects the hydraulics of the fishways, which are designed for a capacity of 40 cfs(15).

In 1975, the fishways at Vacation Beach and Johnson's Beach were modified to improve shad passage conditions, and their hydraulic characteristics were again evaluated (16). A 10-foot section was added to the original two 10-foot sections, increasing the length of the ladders to 30 feet. This was done to decrease the slope and water velocities through the baffle section(16). After this modification, the water slopes at the Vacation Beach and Johnson's Beach fishways were found to be 1:7 and 1:9.8 respectively; both are below the maximum 1:6 slope recommended for shad by Bell(13).

Average flow velocities measured within the Vacation Beach fishway were 4.94 fps halfway down the ladder section, and 2.15 fps at the lowermost baffle in the ladder section. These measurements indicate that water velocities in the fishway were decreased by approximately 26 to 57 percent.

The average flow velocity measured within the Johnson's Beach fishway halfway down the baffle section was 2.12 fps. Water velocity at the lowermost baffle was only 1.87 fps, as compared to a low value of 3.45 fps in 1973.

The decreased slopes and the lower water velocities through the fishways are both in general agreement with the shad passage requirements described in the "Environmental Criteria Guidelines" (Table B-4).

Although both fishways are designed to carry up to 40 cfs, they usually operate below capacity because the upper end of each structure is set too high to receive the full flow. This situation may be improved by lowering the fishways at their upper ends. If operated with flows closer to capacity, the fishways may have lower velocities than those recorded, and may further improve fish passage conditions without affecting pool elevations (16).

Table B-1

ENVIRONMENTAL CRITERIA GUIDELINES:
FRESHWATER ACTIVITIES/LIFE STAGES

<u>Russian River: Steelhead</u>

Activity/Life Stage

Factors	Adult Passage	Spawning Eggs-Adults	Incubation Eggs-Sacfry	Emergence Fry	Dispersal Fry-Finger	Rearing Fingers-Juv	Smolting Juveniles	Smolt Passage	Adult Out-Migration
Dates	Nov-Mar*	Jan-Mar	Jan-Apr	Feb-Apr	Apr-Jun	All Year	Mar-May	Mar-May	Nov-Mar
Minimum Depth (ft.)	0.6 (25% of Wetted Surface)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6
Velocity (fps)	<8	1-3	>1.5	1-3	1-3	1-3	1-3	1-3	1-3
Temperature (F)	45-60	43-55	43-55	43-55	43-55	43-65	45-55	45-60	45-60
DO (ppm)	>7	>7	>7	>7	>7	>7	>7	>7	>7
Substrate		Gravel (.5-4 in) <20% Fines	Gravel (.5-4 in.) <20% Fines	Gravel (.5-4 in.) <20%	Gravel <20% Fines	Gravel <20% Fines			
Barriers									
(Multiple)	≤1 ft.								
(Single)	2-3 ft.								

*For summer steelhead first planted in the Russian River in 1980 migration would take place from April through early July.

Table B-2

ENVIRONMENTAL CRITERIA GUIDELINES:
FRESHWATER ACTIVITIES/LIFE STAGES

Russian River: Silver Salmon

Activity/Life Stage

Factors Dates	Adult Passage	Spawning Eggs-Adults	Incubation Eggs-Sacfry	Emergence Fry	Dispersal Fry-Finger	Rearing Fingers-Juv	Smolting Juveniles	Smolt Passage
	Nov-Jan	Nov-Jan	Nov-Feb	Dec-Feb	Jan-Mar	All Year	Mar-May	Mar-May
Minimum Depth (ft.)	0.6 (25% of Wetted Area)	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Velocity (fps)	<8	1-3	>1.5	1-3	1-3	1-3	1-3	1-3
Temperature (F)	45-60	43-55	43-55	43-55	43-55	43-55	45-55	45-60
DO (ppm)	>7	>7	>7	>7	>7	>7	>7	>7
Substrate		Gravel (.5-4 in) <20% Fines	Gravel (.5-4 in.) <20% Fines	Gravel (.5-4 in.) <20% Fines	Gravel <20% Fines	Gravel <20% Fines		
Barriers								
(Multiple)	≤1 ft.							
(Single)	2-3 ft.							

Table B-3

ENVIRONMENTAL CRITERIA GUIDELINES:
FRESHWATER ACTIVITIES/LIFE STAGES

Russian River: King Salmon (Fall Run)

Activity/Life Stage

Factors	Adult Passage	Spawning Eggs-Adults	Incubation Eggs-Sacfry	Emergence Fry	Dispersal Fry-Finger	Rearing Fingers-Juv	Smolting Juveniles	Smolt Passage
Dates	Sep-Nov	Nov-Dec	Nov-Feb	Jan-Feb	Feb-Apr	All Year	Mar-May	Mar-May
Minimum Depth (ft.)	0.8 (25% of Wetted Surface)	0.8	0.5	0.5	0.5	0.5	0.5	0.5
Velocity (fps)	<8	1-3	>1.5	1-3	1-3	1-3	1-3	1-3
Temperature (F)	51-67	43-58	43-58	43-58	43-58	43-65	45-58	45-60
DO (ppm)	>7	>7	>7	>7	>7	>7	>7	>7
Substrate		Gravel (1-6	Gravel (1-6 in.)	Gravel (1-6	Gravel <20% Fines	Gravel <20%		
Barriers								
(Multiple)	≤1 ft.							
(Single)	2-3 ft.							

Table B-4

ENVIRONMENTAL CRITERIA GUIDELINES:
FRESHWATER ACTIVITIES/LIFE STAGES

<u>Russian River: American Shad</u>

Activity/Life Stage

Factors	Adult Passage	Spawning Eggs-Adults	Incubation Eggs-Sacfry	Dispersal of Fry	Rearing of Young	Juvenile Passage
Dates	Mar-Jun	Apr-Jul	Apr-Jul	May-Aug	May-Nov	Sept-Nov
Minimum Depth (ft.)	0.5*	>3	>3*	>3*	>3*	0.5*
Velocity (fps)	1-3*	1-3	1-3	1-3*	1-3*	1-3*
Temperature (F)	41-62	55-68	58-66	68-72	43-75	38-43
DO (ppm)	>7	>7	>7	>7	>7	>7
Substrate		Sand and Gravel	Sand and Gravel			
Barriers	<9 inches (≤1/6 slope)					

*Estimates based on general shad life history characteristics described in the literature.

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Appendix C

Recreational Analysis Method of Estimating Recreational Use/Benefits at Small Dam Site Recreation Areas

APPENDIX C

RECREATIONAL ANALYSIS

METHOD OF ESTIMATING RECREATION USE/BENEFITS

AT THE SMALL DAM SITE RECREATIONAL AREAS

A. PURPOSE OF THE STUDY

The primary objectives of the recreational analysis are threefold:

1. Estimate the recreation use at the small dam recreational sites on the Russian River.

2. Estimate the recreational value (benefits) of the small dams.

3. Evaluate the recreational impacts (benefits) of alternative management and operational plans for the small dams.

B. STUDY METHOD

The objectives of the study required that a series of tasks be undertaken. These tasks will be described below as they are important in understanding the scope and limitations of the recreational analysis.

The first task was to locate and inventory the dam sites to be evaluated. Five dams were identified by the U.S. Army Corps of Engineers and previous Russian River basin studies as being of primary interest. These dams are described in the survey forms appearing in Tables C-1 to C-5. The area encompassing these dams extends from the vicinity of Fitch Mountain, east of Healdsburg (river mile 36) to just south of Vacation Beach (river mile 12). This portion of the basin defines the study area for purposes of the recreational analysis.

At the outset of the study, it was determined that recreation use and benefits attributable to the small dam sites would only be estimated for those areas and activities directly affected by the dams' water impoundments. The recreational areas and activities directly impacted by the dams were determined through field surveys and interviews with local recreation authorities and operators.

C. ESTIMATES OF RECREATION USE

Current recreation use data at the fourteen impacted recreation areas/facilities were generally lacking. The recreation use data that were available were past monthly estimates made at one of the five dam sites and a few annual use statistics at a number of areas along the river and within the study area.

The fourteen areas/facilities for which estimates of recreation use were made were primarily beach and water-oriented areas where a concentration of recreational activity takes place. Primarily picnicking, sunbathing, swimming, and boating were engaged in at these areas.

A survey of the thirteen recreation areas was made to determine the relative recreational attractiveness of each area (Table C-6). A visitation index for each site was then derived from this survey.

Monthly recreation use of the Healdsburg Memorial Beach was determined from data supplied by the Sonoma County Parks Department and served as a basis for estimating recreation use at ten other impacted areas. Recreation use estimates for two motor boating areas were made on the basis of each site's carrying capacity. The estimated summer season recreation use at the small dam recreational sites is shown in Table C-7. These estimates were checked for reasonableness and accuracy using a second method of analysis shown in Table C-8.

D. ESTIMATES OF RECREATIONAL BENEFITS

The recreational value of the summer dam recreation sites is estimated using the Unit Day Value Method described in Part IX Water Resources Council Procedures for Evaluation of National Economic Development (NED) Benefits and Costs in Water Resources Planning (Level C); Final Rule (Federal Register, Vol. 44, No. 242, Friday, Dec. 14, 1979, Rules & Regs., App. 3 to Subpart K, pps. 72962-72964). A unit day value of $1.85 is multiplied by the estimated recreation use to derive the aggregate monthly and summer season recreational benefits of the small dams. While this value may not include all peripheral costs associated with use of these facilities, it provides a basis for comparison of alternative resource management plans in the Russian River basin. As such, this value should not be considered definitive or inclusive of all benefits associated with summer dam recreation sites in the basin.

Table C-1

SUMMER RECREATIONAL SMALL DAM SURVEY

Name of Summer Dam:	Vacation Beach Summer Dam
Location of Dam:	River Mile 12 near Vacation Beach
Owner/Operator of Dam:	Russian River Recreation and Park District
Date in Place:	Approximately Memorial Day
Date Removed:	Approximately one week after Labor Day
Height of Dam:	8.0 feet
Impacted River Area:	From dam site to 2.0 miles behind dam to just beyond Guernewood Park

Recreation Facilities Affected:

Name of Facility(ies)	Size of Beach Area	Facility Inventory
Upper Vacation Beach	1.0 acre	Gravel Beach
Lower Vacation Beach (Russian River Rec & Park	1.0 acre	Gravel Beach with Parking area
Ginger's Rancho (Private Operator)	1.0 acre	Gravel Beach; 54 cabins, 32 campsites; canoe
East Guernewood Park (Russian River Rec & Park Dist.)	0.5 acre	Gravel Beach
East Guernewood Beach	1.0 acre	Gravel Beach
Fife's (Private Operator)	1.0 acre	Gravel Beach

Recreation Activities Significantly Affected by Water Impoundment: Swimming; Sunbathing.

Estimated Summer Season Recreation Use (Visitor Days):

	Upper Vacation	Lower Vacation	Ginger's Rancho	East Guern.Pk.	East Guern. Bh.	Fife's	Total
May	600	600	600	300	600	600	3,300
June	4,000	4,000	4,400	2,900	4,000	1,800	21,100
July	6,100	6,100	6,600	4,400	6,100	2,800	32,100
Aug.	5,500	5,500	6,000	4,000	5,500	2,500	29,000
Sept.	800	800	800	400	800	800	4,400
Total	17,000	17,000	18,400	12,000	17,000	8,500	89,900

SUMMER RECREATIONAL SMALL DAM SURVEY

Name of Summer Dam:	Johnson's Beach Summer Dam
Location of Dam:	River Mile 14, at Guerneville
Owner/Operator of Dam:	Russian River Recreation and Park District
Date in Place:	Approximately Memorial Day
Date Removed:	Approximately one week after Labor Day
Height of Dam:	8.0 feet
Impacted River Area:	From dam site to 2.0 miles behind dam to just beyond Guerneville

Recreation Facilities Affected:

Name of Facility(ies)	Size of Beach Area	Facility Inventory
Johnson's Beach (private operator)	4.0 acres	Beach area; canoe rentals; cabins
Donovan's Resort (private operator)	0.25 acre	Small beach; cabins
Southside Resort (private operator)	0.25 acre	Small beach; ; cabins campsites
Motor Boating Area	N. A.	1.5 miles river

Recreation Activities Significantly Affected by Water Impoundment: Swimming; Sunbathing; Motorboating.

Estimated Summer Season Recreation Use (Visitor Days):

	Johnson's	Donovan's/ Southside	Motor Boating	Total
May	2,400	300	100	2,800
June	8,400	2,500	300	11,200
July	12,700	3,900	500	17,100
Aug.	11,600	3,500	400	15,500
Sept.	3,200	400	100	3,700
Total	38,300	10,600	1,400	50,300

Table C-3

SUMMER RECREATIONAL SMALL DAM SURVEY

Name of Summer Dam:	Del Rio Woods Dam
Location of Dam:	River Mile 34, just east of Fitch
Owner/Operator of Dam:	Del Rio Woods Recreation and Park
Date in Place:	Approximately Memorial Day
Date Removed:	Approximately one week after Labor Day
Height of Dam:	12.0 feet
Impacted River Area:	Approximately 1.5 miles behind dam site

Recreation Facilities Affected:

Name of Facility(ies)	Size of Beach Area	Facility Inventory
Del Rio Woods Beach (Del Rio Woods Recreation and Park District)	3.0 Acres	Gravel/sand Beach with small parking area (50 cars)

Recreation Activities Significantly Affected by Water Impoundment:
Swimming; Sunbathing

Estimated Summer Season Recreation Use (Visitor Days):

May June	1,200
July August	3,600
September	5,500
	5,000
	1,600
Total	16,900

Table C-4

SUMMER RECREATIONAL SMALL DAM SURVEY

Name of Summer Dam:	Healdsburg Memorial Dam
Location of Dam:	River Mile 31, near Healdsburg
Owner/Operator of Dam:	Sonoma County Regional Parks
Date in Place:	Approximately Memorial Day
Date Removed:	Approximately one week after Labor Day
Height of Dam:	5.0 feet (winter), 16.5 feet (summer)
Impacted River Area:	Approximately 1.5 miles behind dam

Recreation Facilities Affected:

Name of Facility(ies)	Size of Beach Area	Facility Inventory
Healdsburg Memorial Beach Park (Sonoma County Regional Parks Department)	5.0 Acres	Swimming beach with diving platforms; 170 parking spaces; 28 picnic tables
Healdsburg Boat Club Area	1.0 Acre	Ten ski ramps; asphalt boat ramp

Recreation Activities Significantly Affected by Water Impoundment:
Swimming; Sunbathing; Motor boating

Estimated Summer Season Recreation Use (Visitor Days):

	Memorial Beach	Boat Club Area	Total
May	3,000	100	3,100
June	9,100	300	9,400
July	13,800	500	14,300
August	12,600	400	13,000
Septemb	4,000	100	4,100
Total	42,500	1,400	43,900

Table C-5

SUMMER RECREATIONAL SMALL DAM SURVEY

Name of Summer Dam:	Wohler Dam
Location of Dam:	River Mile 22, near Wohler Bridge
Owner/Operator of Dam:	Sonoma County Water Agency
Date in Place:	Depends on flow of river and water demand. Usually in place by Memorial Day.
Date Removed:	Depends on flow of river and water demand. Usually in place through Labor Day.
Height of Dam:	15.0 feet
Impacted River Area:	Approximately one mile behind dam site.

Recreation Facilities Affected:

Name of Facility(ies)	Size of Beach Area	Facility Inventory
Wohler Bridge Area (undeveloped area)	3.0 Acres	Gravel/Sand beach areas

Recreation Activities Significantly Affected by Water Impoundment: Swimming; Sunbathing.

Estimated Summer Season Recreation Use (Visitor Days):

May	1,200
June	3,300
July	5,000
August	4,500
September	1,600
Total	15,600

Table C-6

INDEXING OF SMALL DAM RECREATION AREAS*

Recreation Area	General Site Characteristics	Site Size & Configuration	Location of Facility	Site Development	Quality of Environment	Total Score**	Visitation Index***
Del Rio Woods Dam							
Del Rio Woods Beach	2	2	1	1	4	10	0.40
Healdsburg Dam							
Memorial Beach	5	5	5	5	5	25	1.00
Wohler Dam							
Wohler Bridge Dam	2	1	1	1	4	9	0.36
Johnson's Summer Dam							
Johnson's Beach/Lodge	4	5	5	5	4	23	0.92
Southside Resort/ Donovan's	2	1	2	1	1	7	0.28
Vacation Beach Dam							
Upper Vacation Beach	2	2	2	1	4	11	0.44
Lower Vacation Beach	2	2	3	1	3	11	0.44
Ginger's Rancho	2	2	3	2	3	12	0.48
East Guernewood Park	2	1	2	1	2	8	0.32
East Guernewood Beach	2	2	2	1	4	11	0.44
Fife's	(ESTIMATE)					5	0.20

*Areas not rated above include two motor boating areas. Estimates of visitation at these areas made on the basis of carrying capacities.

**Overall user attractiveness of a particular site evaluated based on five factors. One to five points assigned to each criteria for which a site is evaluated

***Visitation Index = Individual Site Score Maximum Site Score (25 points)

Source: Williams-Kuebelbeck and Associates, Inc.

Table C-7

ESTIMATED SUMMER VISITATION AT SMALL DAM RECREATION SITES

Recreation Sites	Visitation Index	Summer Visitation (Visitor Days) May*	June	July	August	September**	Total
Del Rio Woods Beach	0.40	1,200	3,600	5,500	5,000	1,600	16,900
Memorial Beach	1.00	3,000	9,100	13,800	12,600	4,000	42,500
Wohler Bridge Area	0.36	1,200	3,300	5,000	4,500	1,600	15,600
Johnson's Beach/Lodge	0.92	2,400	8,400	12,700	11,600	3,200	38,300
Southside Resort/Donovan's	0.28	300	2,500	3,900	3,500	400	10,600
Upper Vacation Beach	0.44	600	4,000	6,100	5,500	800	17,000
Lower Vacation Beach	0.44	600	4,000	6,100	5,500	800	17,000
Ginger's Rancho	0.48	600	4,400	6,600	6,000	800	18,400
East Guernewood Park	0.32	300	2,900	4,400	4,000	400	12,000
East Guernewood Beach	0.44	600	4,000	6,100	5,500	800	17,000
Fife's	0.20	600	1,800	2,800	2,500	800	8,500
Motor Boating-Healdsburg	(Allowance)	100	300	500	400	100	1,400
Motor Boating-Johnson's	(Allowance)	100	300	500	400	100	1,400
		11,600	48,600	74,000	67,000	15,400	216,600

*Estimated for a 3-day Memorial Day weekend operating at maximum capacity.

**Estimated for a 4-day Labor Day weekend operating at maximum capacity.

Source: Sonoma County Regional Parks Department; Russian River Recreation and Park District; Del Rio Woods Recreation and Park District; Sonoma County Water Agency; Private Recreation Owners/Operators; Williams-Kuebelbeck and Associates, Inc., Field Survey, October 1978 - January 1979.

Table C-8

ESTIMATED RECREATION USE BASED ON CARRYING CAPACITY ANALYSIS

Recreation Site	Size	Estimated Instanteous Capacity(1)	Daily Turnover Factor(2)	Total Daily Capacity(3)
Del Rio Woods Beach	3.0 AC	200	2.0	400
Memorial Beach	5.0	500	2.0	1,000
Wohler Bridge Area	3.0	200	2.0	400
Johnson's Beach/Lodge	4.0	400	2.0	800
Southside	0.5	50	2.0	100
Upper Vacation Beach	1.0	100	2.0	200
Lower Vacation Beach	1.0	100	2.0	200
Ginger's Rancho	1.0	100	2.0	200
East Guernewood Park	0.5	50	2.0	100
East Guernewood Beach	1.0	100	2.0	200
Fife's	1.0	100	2.0	200
Motor Boating-	1.5	10	2.5	25
Motor Boating-	1.5	10	2.5	25
		1,920		3,850
Average Summer Use Factor(4)				0.40
Average Daily Summer Use				1,540
Total Estimated Summer Visitation(5)				235,620

(1) Instantaneous Capacity = Maximum practical number of persons to be accommodated at one particular time.

(2) Turnover Factor = Number of times a particular facility can be used by different individuals during one day.

(3) Daily Capacity = Instantaneous Capacity x Daily Turnover Factor.

(4) Average Summer Use Factor = 40% of Total Daily Capacity.

(5) Average Daily Summer Use x 153 day summer season.

Source: Bureau of Outdoor Recreation, Optimum Recreation Carrying Capacity, 1977; Sonoma County Regional Parks Department, Russian River Recreation Study, September 1976; Williams-Kuebelbeck and Associates, Inc., Field Survey, 1978 and 1979.

LIST OF CONTACTS

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APPENDIX D

DRAFT OF THE PROPOSED

OPERATIONAL AGREEMENT FOR FISHERY RELEASES

FROM

THE WARM SPRINGS DAM - LAKE SONOMA PROJECT,

SONOMA COUNTY, AND

THE COYOTE VALLEY DAM - LAKE MENDOCINO PROJECT,

MENDOCINO COUNTY, CALIFORNIA

BY AND BETWEEN

CALIFORNIA DEPARTMENT OF FISH AND GAME

AND

SONOMA COUNTY WATER AGENCY

APPENDIX D

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MENDOCINO COUNTY, CALIFORNIA

BY AND BETWEEN

CALIFORNIA DEPARTMENT OF FISH AND GAME

AND

SONOMA COUNTY WATER AGENCY

1. In order to operate the Warm Springs Dam - Lake Sonoma Project (hereinafter called the Warm Springs Project) and the Coyote Valley Dam - Lake Mendocino Project (herein-after called the Coyote Valley Project), in a manner that will preserve, protect and maintain the existing fisheries of the Russian River basin and enhance those fisheries wherever and whenever desirable and feasible within the context of Congressional authorities and the related requirements of the Corps of Engineers, the State of California, and the Sonoma County Water Agency, these operational criteria have been developed relative to scheduled releases of water to meet fishery needs in Dry Creek downsteam of Warm Springs Dam and in the Russian River.

2. The following principles, procedures and concepts are hereby adopted as the operational criteria for fishery releases from the Warm Springs and Coyote Valley Projects and it is requested that the U.S. Corps of Engineers embody such operational criteria in its reservoir regulation manual(s) and any related documents or agreements.

A. In order to mitigate for potential fishery losses occasioned by construction of the Warm Springs Project, a fish hatchery is included in the authorized project plan and the following minimum flows as provided in the joint agreement between the Agency and the California Department of Fish and Game (hereinafter called the Department) dated 24 February 1970, will be released and maintained from Warm Springs Dam downstream to the mouth of Dry Creek:

(1) From 1 April through 30 November of each year, 25 cubic feet per second (cfs).

(2) From 1 December through 31 March of the following year:

(a) 75 cfs when the maximum reservoir elevation (in feet above mean sea level datum) the previous spring was 441.0 or above; (b) 70 cfs when the maximum reservoir elevation the previous spring was from 431.0 to 440.9; (c) 60 cfs when the maximum reservoir elevation the previous spring was from 421.0 to 430.9; (d) 50 cfs when the maximum reservoir elevation the previous spring was below 421.0.

It should be noted that under the terms of the agreement of 24 February 1970, the Agency, at the request of the Department, may instruct the U. S. Corps of Engineers to decrease the flows described above and subsequently to increase flow by using saved water.

B. In the interest of providing flows in Dry Creek to enhance the fishery potential, particularly with respect to king salmon, the following flows will be released from the Warm Springs Project during those years when sufficient storage exists within the silt reservation space and permanent pool reservation of the project as defined in Section 2.E.:

(1) From 1 May through 31 October, a minimum continuous flow of 80 cfs in Dry Creek between the dam and the mouth;

(2) From 1 November through 31 December, a minimum continuous flow of 105 cfs in Dry Creek between the dam and the mouth; and

(3) From 1 January to 30 April, a minimum continuous flow of 75 cfs in Dry Creek between the dam and the mouth.

(4) In addition to the above scheduled releases, an amount of stored water equal to 5,000 acre-feet to be released annually between May 1 and April 30 of the succeeding year, at the request of the Department for beneficial fishery uses.

C. During the initial filling of the Warm Springs Project reservoir, in the absence of a declared drought emergency, releases will be made at the levels given under Section 2.B.

D. During the early years of Warm Springs Project operation, when it is determined by the Agency that excess water is available, the Agency will make additional water available to the Department to experiment with release schedules higher than those presented in Section 2.B. to obtain additional basic data about the downstream fishery. These experimental releases shall not be construed as constituting an obligation for additional water requirements above and beyond those presented in Sections 2.A. and 2.B. and will be coordinated so that other beneficial uses of the Russian River, such as prior water rights and lower river recreation, are not impaired.

E. Prior to May 1 of each year, the Agency and the Department shall confer with the U. S. Corps of Engineers to determine the total water available in storage in Lake Sonoma below the elevation of the bottom of the 130,000 acre-foot flood control pool, including permanent pool, water supply pool and total remaining silt reservation storage capacity, and the extent to which said total storage has been reduced by past releases of stored water for fishery enhancement. Water shall be considered to have been released from storage for fishery enhancement purposes when said releases are made in excess of the mitigation releases set forth in Section 2.A. or releases which the Agency has made for water supply purposes. Water released for fishery enhancement purposes shall not encroach on the storage designated for water supply purposes nor shall it reduce available permanent pool storage below 5,000 acre-feet. Initial water storage available for fishery enhancement purposes shall constitute the 26,000 acre-foot silt reservation storage plus 8,000 acre-feet of the 13,000 acre-foot permanent pool. It is understood that the 34,000 acre-foot storage total will be reduced by the amount of siltation in the reservoir. In the event it is determined that the water storage available for enhancement purposes plus water releases required for water supply purposes will accommodate the desired enhancement flows, the Agency will instruct the Corps of Engineers to provide minimum releases from Warm Springs as provided in Section 2.B. In the event there is insufficient water storage available for the fishery enhancement flows provided in Section 2.B when added to releases required for water supply purposes, the Department will inform the Agency in what manner it desires release of any water still available for fishery enhancement purposes, and the Agency shall notify the Corps of Engineers to release such water based upon the release schedule provided by the Department.

F. For the purposes of this agreement, the Department shall be considered the lead agency pursuant to the provisions of the California Environmental Quality Act.

G. The agreements signed by the Department and the Agency, dated 21 August 1959 and 24 February 1970, relative to operation of the Coyote Valley Project and the Warm Springs Project will remain in full force and effect. It is mutually agreed that the intent of the 21 August 1959 Coyote Valley Project agreement is to provide a minimum flow, from the confluence of the Russian River and the East Fork to the Agency's Wohler diversion facility, of not less than the flow required at the confluence of the Russian River and the East Fork.

APPENDIX E

LAND USE AMD FLOOD PLAIN MAPPING

I. INTRODUCTION

Data for land use and flood plain maps of the Russian River basin were developed from color infrared aerial photography of the entire basin, an area of 1,485 square miles. The actual photography was performed in August and September of 1974 by Geoscience (later to be known as Esca Tech) Corporation of Long Beach, California, who produced transparencies at 1:24,000 scale. This was done in order to match U.S. Geological Survey quadrangle maps, so as to provide a ready format for graphic presentation of the final data. Individual photographs are numbered and identifiable on flight line index maps.

In addition to the photography produced by Geoscience, a military unit from Ft. Huachuca, Arizona generated large-scale color photography of the Russian River corridor itself through use of low-level flights with a Mohawk surveillance aircraft in 1975 and 1976. This additional source of information eliminated much of the field work that otherwise would have been necessary to substantiate data developed from the color infrared photography, and also provided high resolution imagery of the specific river environment.

Originally land use data for the entire Russian River basin were to be generated. However, due to cost considerations, land uses were determined only for those quadrangles including and immediately adjacent to the Russian River itself. These land use data were generated by Geoscience through computer-assisted land use interpretation techniques.

The land use data were presented graphically in polygon form on overlays to the 1:24,000 Geological Survey quadrangles as well as on magnetic tape. The data were generated almost entirely from the aerial photography with supplemental field work performed only to confirm a few questionable locations.

Each type of land use is denominated using an alphanumeric code (see Land Use Key). This coding system was originally developed by the U.S. Geological Survey and was modified for the purposes of this study by both Geoscience and the Corps of Engineers. The physical placing of the codes within the individual land use polygons corresponds to the Lambert coordinate system. This provides a geographical address by which one can reference supplementary land use statistics presented in printout form. The resolution of the land use data (smallest area represented by a polygon) is one-fourth acre in urban areas and four acres in rural areas.

The land use statistics provided for the study based on USGS quadrangles are further divided into tributary sub-basins. Land use areas are presented by individual polygons grouped together according to code within each sub-basin. Each polygon with its geographical address using the Lambert coordinate system, and its area in acres, square miles, and square kilometers is presented. A summary is presented at the end of the data on each sub-basin, giving the total area in acres, square miles, and square kilometers for each particular type of land use within the sub-basin. A similar summary is provided for each quadrangle, again giving the total area in acres, square miles, and square kilometers devoted to various land uses within the quadrangle.

The land use data developed were used first in the study itself in an attempt to determine the gross impacts of various land use practices on the river system. In subsequent stages of the study the aerial photography and other data were used to identify impoundments for detailed evaluation of fish habitats and barriers to fish migration.

In addition to its basic use in the Russian River Basin Study, the data generated have been utilized by numerous public and private groups and have been distributed to the following government entities:

(1) U.S. Fish and Wildlife Service

(2) California State Regional Water Quality Control Board, North Coast Region

(3) California State Department of Water Resources

(4) California State Department of Fish and Game

(5) Mendocino County

(6) Sonoma County

(7) City of Santa Rosa

(8) City of Ukiah

(9) City of Healdsburg

The information provided consisted mainly of reproductions of the land use maps and copies of the land use statistics printouts for the study area. In addition, both Mendocino and Sonoma Counties, the State Regional Water Quality Control Board, and several other users have purchased copies of some of the original aerial infrared photography in order to develop land use statistics for portions of the basin outside of the Russian River corridor and for other uses.

Copies of the Plan of Study (April 1975) and the Phase I Study Report (December 1976) for the Russian River Basin Study, and a report titled Evaluation of Fish Habitat and Barriers to Fish Migration, Russian River Mainstem and Lower Dry Creek, which was conducted as part of the Basin Study and utilized data generated from the land use investigation, were provided to local libraries in Sonoma and Mendocino Counties. These reports provided preliminary data on the study area for public use.

The land use data accumulated for the Russian River Basin Study are on file in the San Francisco Office of the Corps of Engineers and are available for public use.

II. LAND USE KEY

Several sets of data related to land use along the Russian River are depicted on Plates 1 through 24 (Figure E-l shows the areas covered by the plates). These plates were first assembled in February 1980, but represent data collected from 1974 to 1976, as discussed in the introduction *to* this appendix. Aside from the topographic data presented on the U.S. Geological Survey base maps used, the following information is contained on the plates:

- Delineation of the Russian River streambed (dark shading).

- Delineation of the Russian River flood plain corresponding to a flood expected to occur once every hundred years (light shading).

- Land uses along the Russian River (heavily outlined polygons labeled with letters).

It should be noted that due to the scale and limits on the printing quality of the plates, the flood plain information depicted thereon should be considered general in nature. For more detailed information, the reader should consult flood insurance maps prepared for Sonoma and Mendocino counties by the Federal Emergency Management Agency.

The labels of the land use polygons are defined as follows:

URBAN AND BUILT-UP LAND	U
RESIDENTIAL	UR
Single Family (detached)	URS
Multi-family	URM
Group Quarters (retirement homes, workers quarters)	URG
Mobile homes	URH
Transient Lodgings	URT
Other	URO
COMMERCIAL, INSTITUTIONAL, & SERVICES	UC
Wholesale Trade Area	UCW
Retail Trade Area	UCR
Business, Professional, Institutional, & Services	UCB
Cultural, Entertainment, and Recreational	UCC
Military	UCM
Other	UCO
INDUSTRIAL	UI
Heat Processing	UIH
Industrial Park	UII
Food Processing (Wineries)	UIF (UIW)
Wholesale Warehousing and Storage where not in Industrial Park	UIS
Lumber Mills and Storage	UIL
Other	UIO

EXTRACTIVE	UE
Oil and Gas Fields	UEF
Shaft Mining	UET
Geothermal Field	UEG
Strip Mines	UEM
Quarries	UEQ
Sand and Gravel Pits	UES
Other	UEO
TRANSPORTATION, COMMUNICATION, & UTILITIES	UU
Transportation	UUT
Telecommunications, Radio, and TV Facilities	UUF
Electric Plants	UUE
Water Plants	UUW
Sewage Plants	UUS
Solid Waste Disposal	UUD
Other Utilities	UUU
Marinas and Port Facilities	UUM
Other	UUO
URBAN OPEN	UO
Golf Courses	UOG
Cemeteries	UOC
Parks	UOP
Vacant and/or Cleared	UOV
Campgrounds	UOR
Other	UOO
<u>AGRICULTURAL LAND</u>	A
CROPLAND AND PASTURE	AC
Cropland	ACC
Pasture	ACP
ORCHARDS, GROVES, VINEYARDS, AND HORTICULTURAL	AV
Fruit and Nut Trees	AVF
Vineyard	AW
Nurseries	AVN
Other	AVO
CONFINED FEEDING OPERATIONS	AF
Feed Lots	AFF
Poultry and Egg Houses	AFP
Other	AFO

RELATED FACILITIES	AR
Equipment, Fodder, Stock Storage Buildings	ARE
Other	ARO
OTHER	AO
FORESTLAND	F
HARVESTED	FH
RECENTLY REFORESTED	FR
OTHER	FO
WETLAND	L
VEGETATED	LV
BARE	LB
RIPARIAN	LR
RANGELAND	R
WATER	W
STREAMS AND WATERWAYS	WS
STILL WATER	WA
Natural Lakes and Ponds	WAL
Reservoirs	WAR
Summer Dam Impoundments (Summer Dams)	WAS (WAD)
BAYS AND ESTUARIES	WB
WATERWAY (man-made)	WW
Stock Ponds	WWP
Water Canals	WWC
OTHER	WO
BARREN LAND	B
SALT FLATS	BS
SAND BEACHES	BB
River	BBR
Coastal	BBC
Other	BBO
SAND AREAS OTHER THAN BEACHES	BA

BARE EXPOSED ROCK	BR
ABANDONED EXTRACTIVE	BE
Strip Mines	BEM
Quarries	BEQ
Sand and Gravel Pits	BES

The land use designations are further defined as follows:

Single Family Residential (URS) - Includes grouped single family dwellings; includes scattered dwellings that are located in a rural or suburban setting with out-buildings; excludes remote single family rural dwellings where they cannot be grouped into an area where "residential" is the primary land use.

Wholesale Trade Area (UCW) - Only where retailing is evident in association with wholesale warehousing.

Business, Professional, Institutional & Services (UCB) - Churches identified in this group only include the larger, more identifiable type (with steeples, etc.).

Military (UCM) - Additional sub-categories to avoid a totally blank polygon on military reservations:

Military Single Family	MRS
Military Multiple Family	MRM
Military Group Quarters	MRG
Military Recreation	MCC
Military Electric	MUE
Military Water Reservoir	MUW
Military Sewage	MUS
Military Solid Waste	MUD
Military Utility Other	MUO
Military Transitional	MBT
Military Golf Course	MOG
Military Schools	MCB

Sand and Gravel Pits (UES) - Also includes other diggings for borrow material where it is apparent that no stratified material exists.

Cropland (ACC) - Including haycrops and fallow cropland showing evidence of once producing crops even though in "resting" stage at present.

Pasture (ACP) - Fenced or partitioned grazing land, identified by pastured textural indices with or without the presence of cattle; potential pastures.

Fruit and Nut Trees (AVF) - Where dwellings are located within orchards, the residential classification predominates. Apparently abandoned or non-vigorous stands are included if no other change of usage is evident.

Nurseries (AVN) - Includes greenhouses.

Agriculturally Related Facilities (AR) - Category used for agricultural headquarters and associated buildings.

Forestland/Other (FO) - Category used for general unused brushland, grassland and forestland; mix displaying neither lumbering nor reforestation.

Rangeland (R) - or potential rangeland; some boundaries represent a transitional zone between adjoining polygons.

Reservoirs (WAR) - Identified according to utility for human consumption and/or irrigation regardless of size; dry reservoirs are identified as (WAR) assuming a temporary condition.

Summer Dam Impoundments (WAD) - Identified according to dam site, location, accessibility, and recreational facility; otherwise recorded as reservoirs.

Stock Ponds (WWP) - Identified according to their association with stock and/or surrounding grazing facilities and damming configuration; otherwise recorded as reservoirs.

Water/Other (WO) - Includes water-filled borrow pits.

Bare Exposed Rock (BR) - Includes cliffs of unconsolidated deposits.

INTERIM REPORT NORTHERN CALIFORNIA STREAMS INVESTIGATION RUSSIAN RIVER BASIN STUDY

APPENDIX E

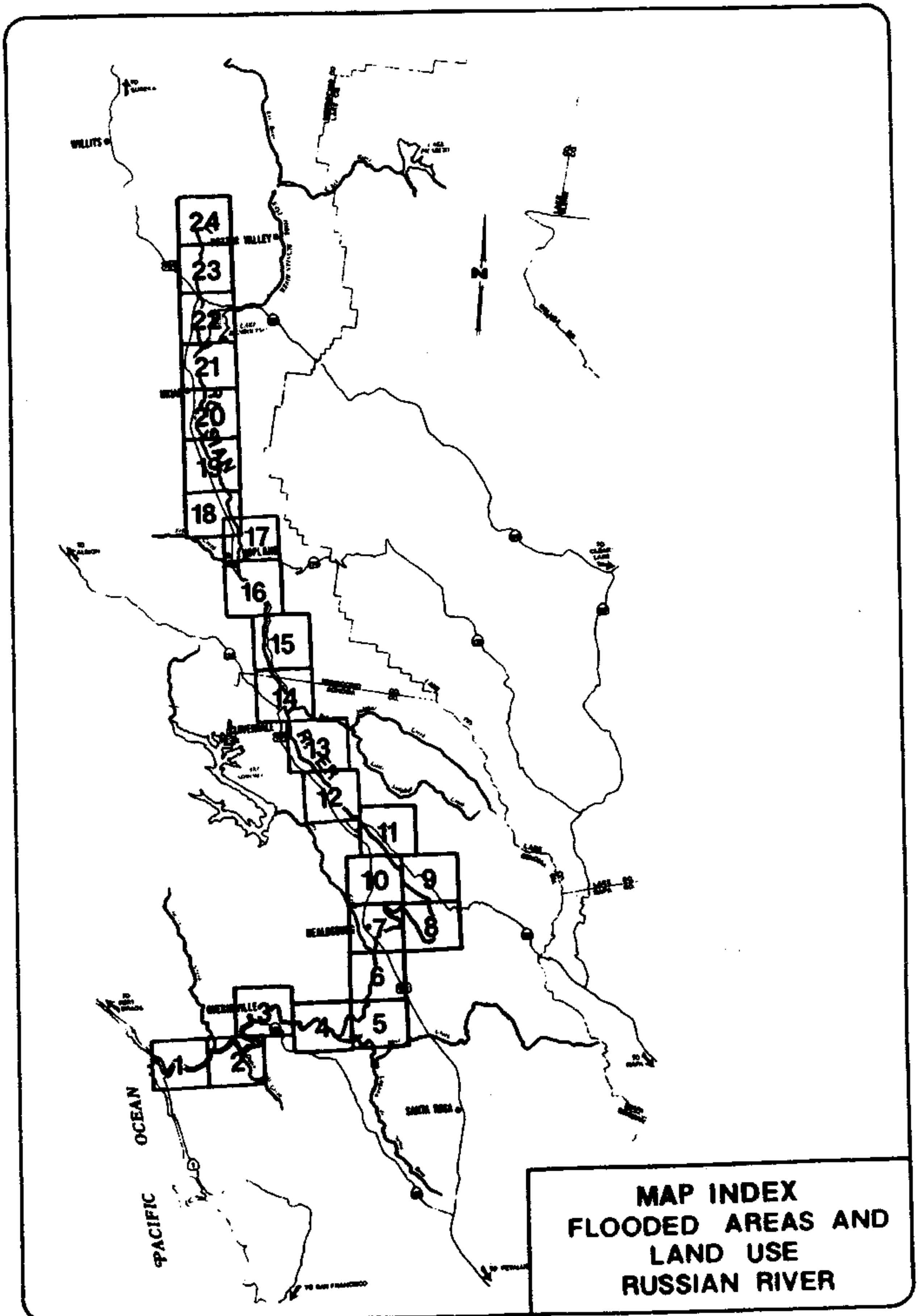
LAND USE AND FLOOD PLAIN MAPPING

March 1982

CONTENTS

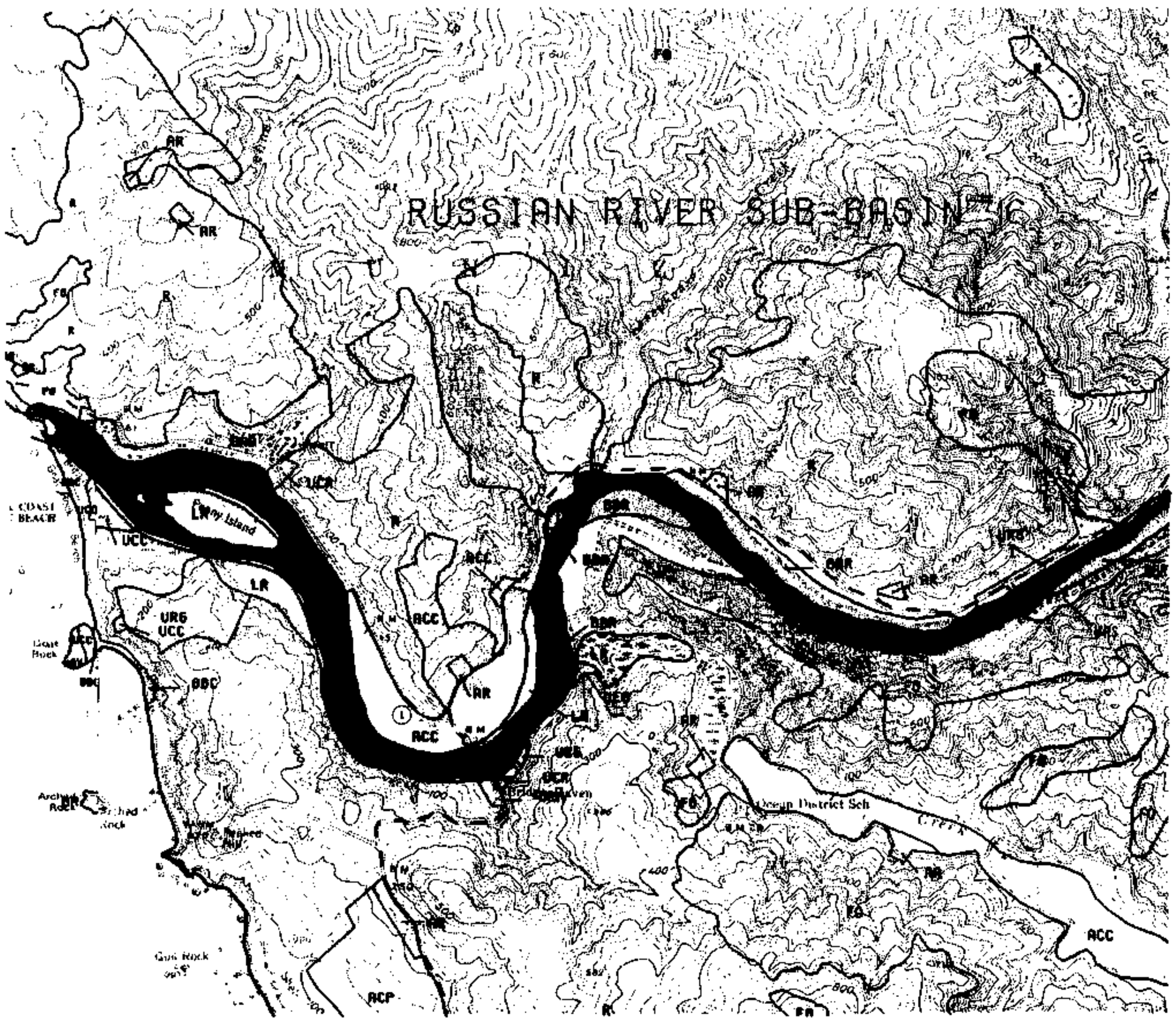
FIGURES

PLATES



MAP INDEX
FLOODED AREAS AND
LAND USE
RUSSIAN RIVER

FIGURE E-1



LEGEND

OVERFLOW LIMITS 100 YEAR FLOODING

RUSSIAN RIVER

~260~ GROUND ELEVATION IN FEET SEA LEVEL DATUM

LAND USE: SEE LAND USE KEY PRECEDING PLATES.

BASE MAPS FURNISHED BY U.S.G.S.

- LIMITS OF OVERFLOW SHOWN MAY VARY FROM ACTUAL LOCATION ON GROUND AS EXPLAINED IN THE REPORT.
- AREAS OUTSIDE THE FLOODPLAIN MAY BE SUBJECT TO FLOODING FROM LOCAL RUNOFF.
- MINIMUM CONTOUR INTERVAL IS 20 FEET.

SCALE

0 1000 2000 3000 4000

SCALE IN FEET

N

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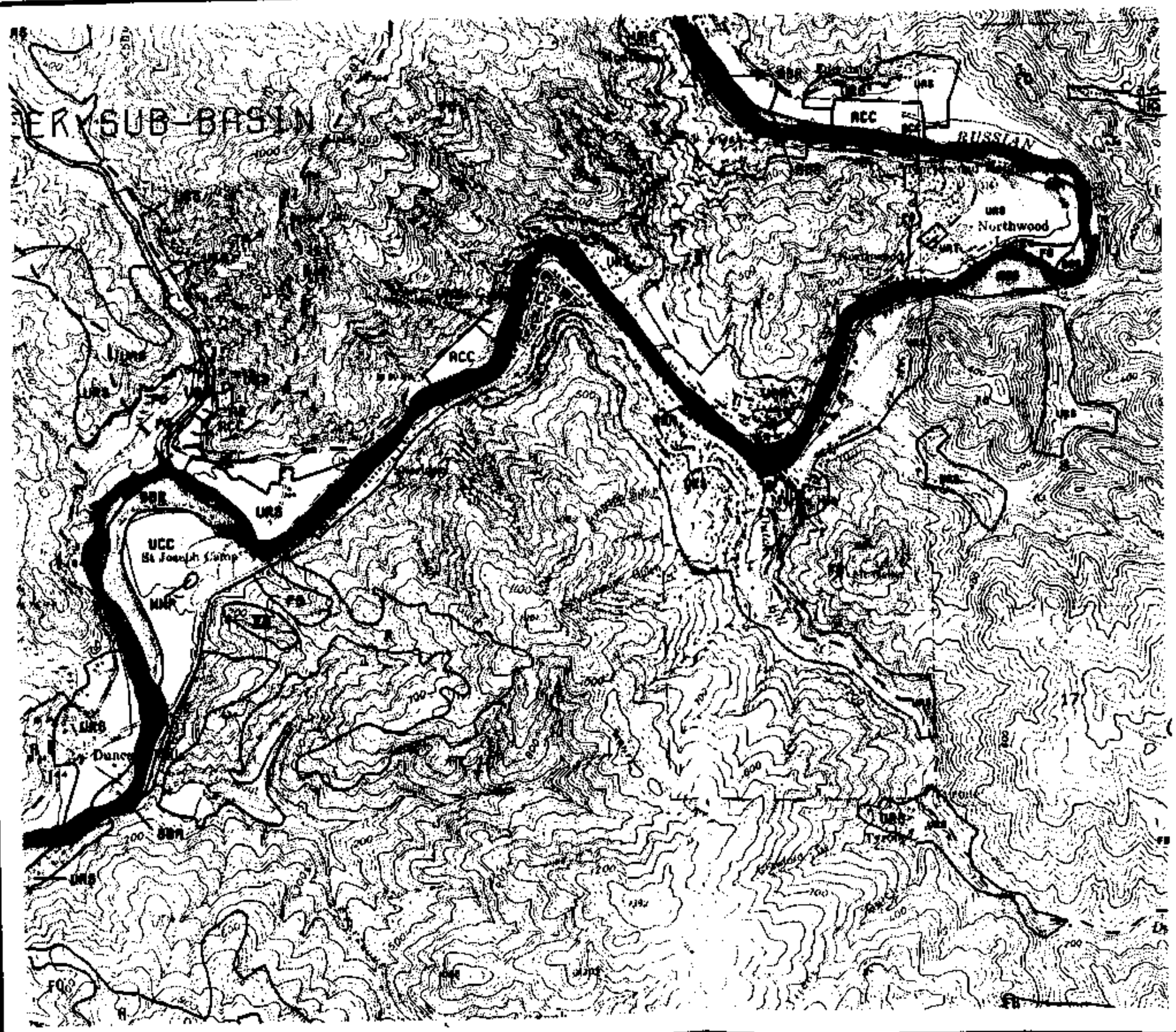
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

FLOODED AREAS AND LAND USE RUSSIAN RIVER

FEBRUARY 1980

PLATE 1



LEGEND

OVERFLOW LIMITS 100 YEAR FLOODING

RUSSIAN RIVER

~260~ GROUND ELEVATION IN FEET SEA LEVEL DATUM

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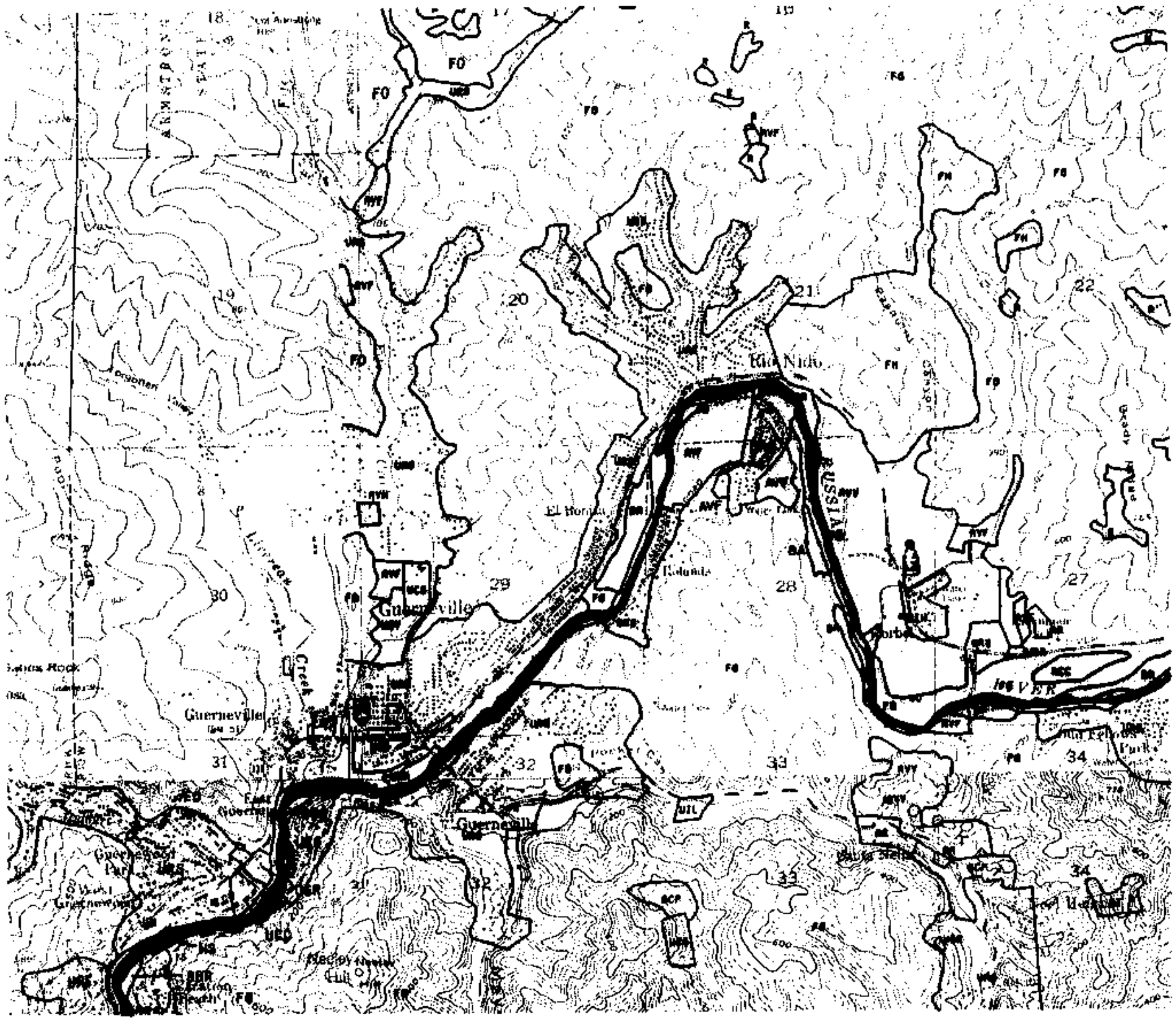
FEBRUARY 1980

PLATE 2



LEGEND

OVERFLOW LIMITS 100 YEAR FLOODING

RUSSIAN RIVER

~260~ GROUND ELEVATION IN FEET SEA LEVEL DATUM

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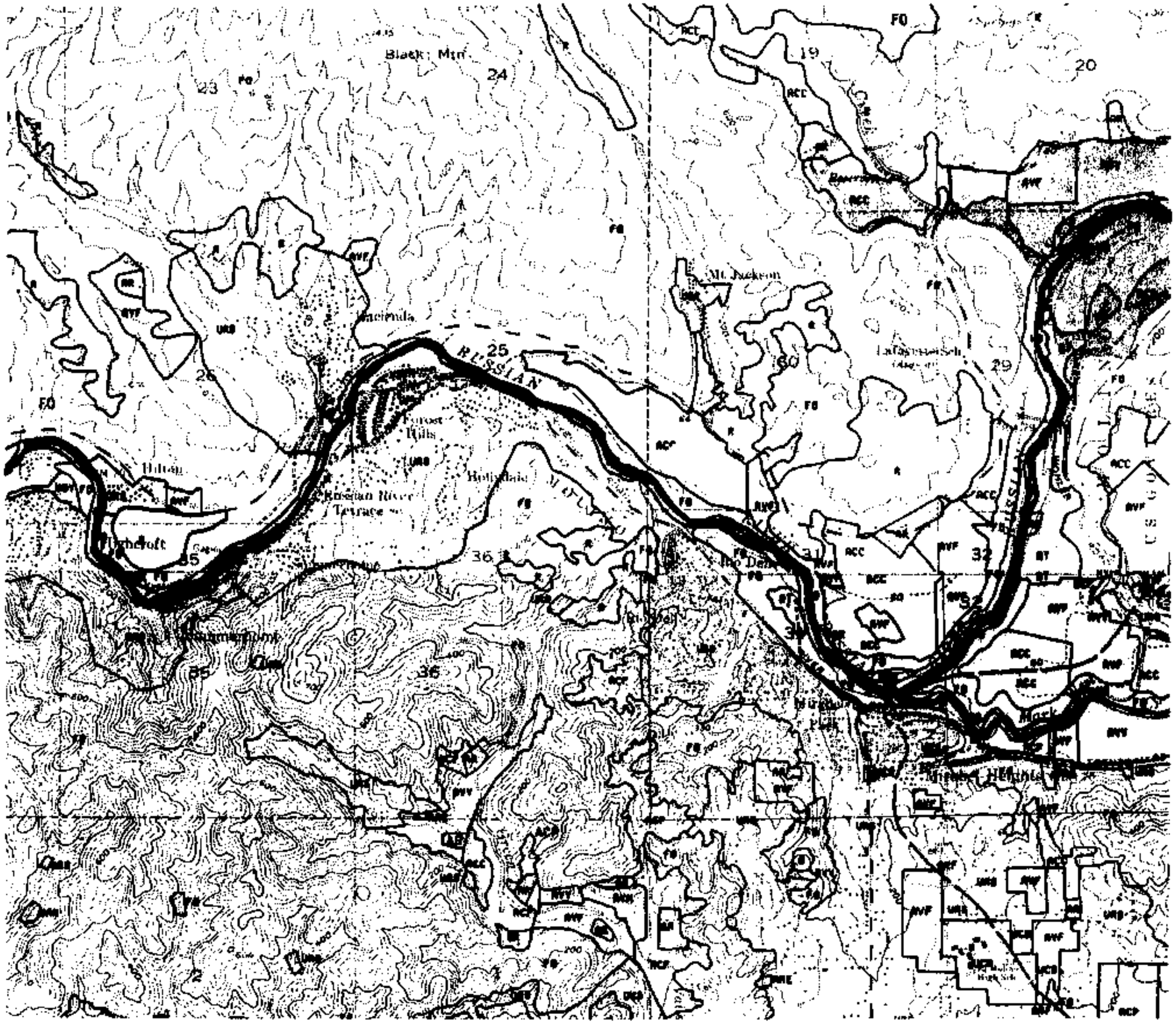
PLATE 3



LEGEND

OVERFLOW LIMITS 100 YEAR FLOODING

RUSSIAN RIVER

~260~ GROUND ELEVATION IN FEET SEA LEVEL DATUM

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0 1000 2000 3000 4000

SCALE IN FEET

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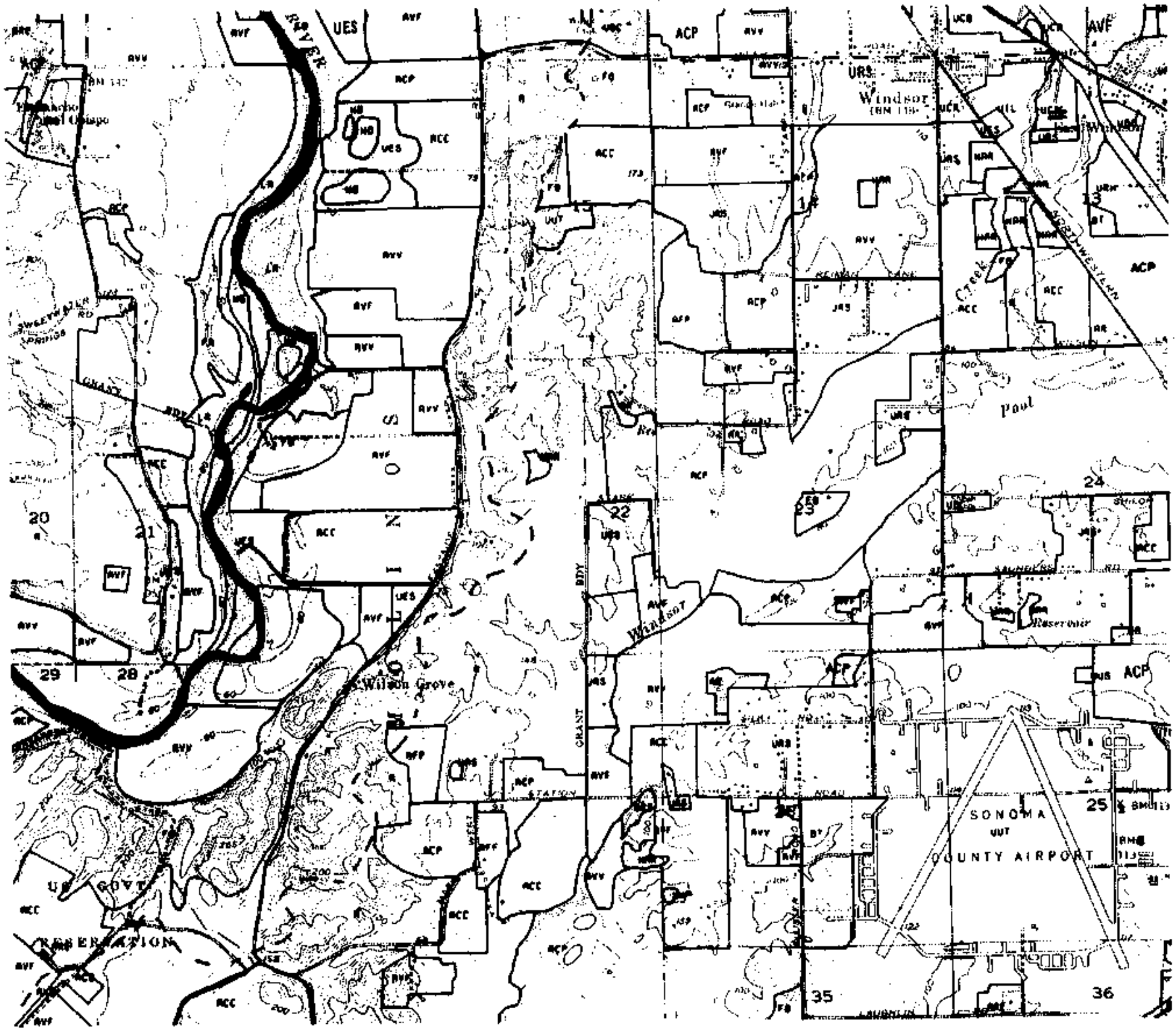
FLOODED AREAS AND LAND USE RUSSIAN RIVER

FEBRUARY 1980

PLATE 4



LEGEND

OVERFLOW LIMITS
100 YEAR FLOODING

RUSSIAN RIVER

~260~ GROUND ELEVATION IN FEET SEA LEVEL DATUM

LAND USE: SEE LAND USE KEY PRECEDING PLATES.

BASE MAPS FURNISHED BY U.S.G.S.

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SCALE IN FEET

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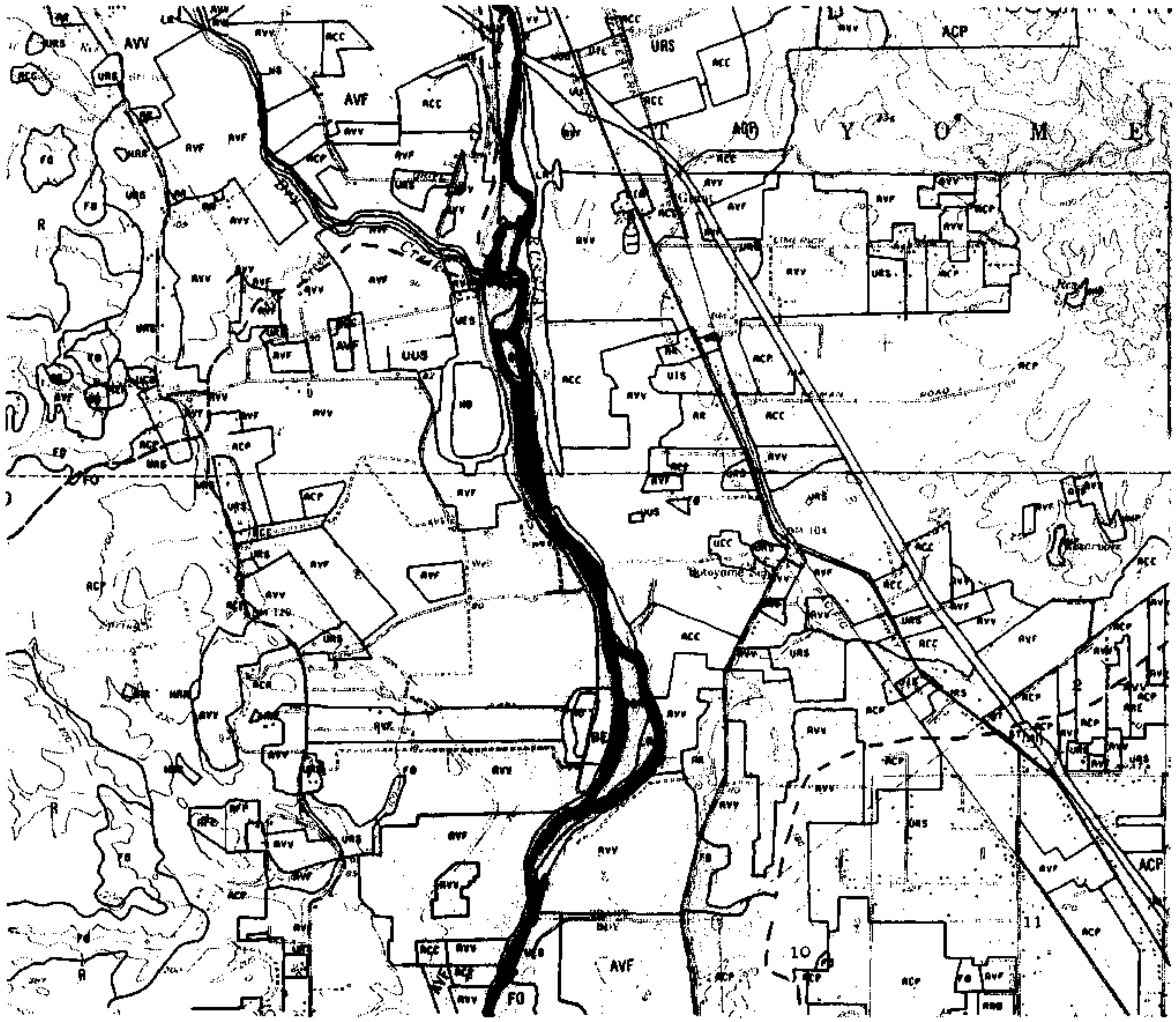
PLATE 5



LEGEND

OVERFLOW LIMITS 100 YEAR FLOODING

RUSSIAN RIVER

~260~ GROUND ELEVATION IN FEET SEA LEVEL DATUM

LAND USE: SEE LAND USE KEY PRECEDING PLATES.

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SCALE IN FEET

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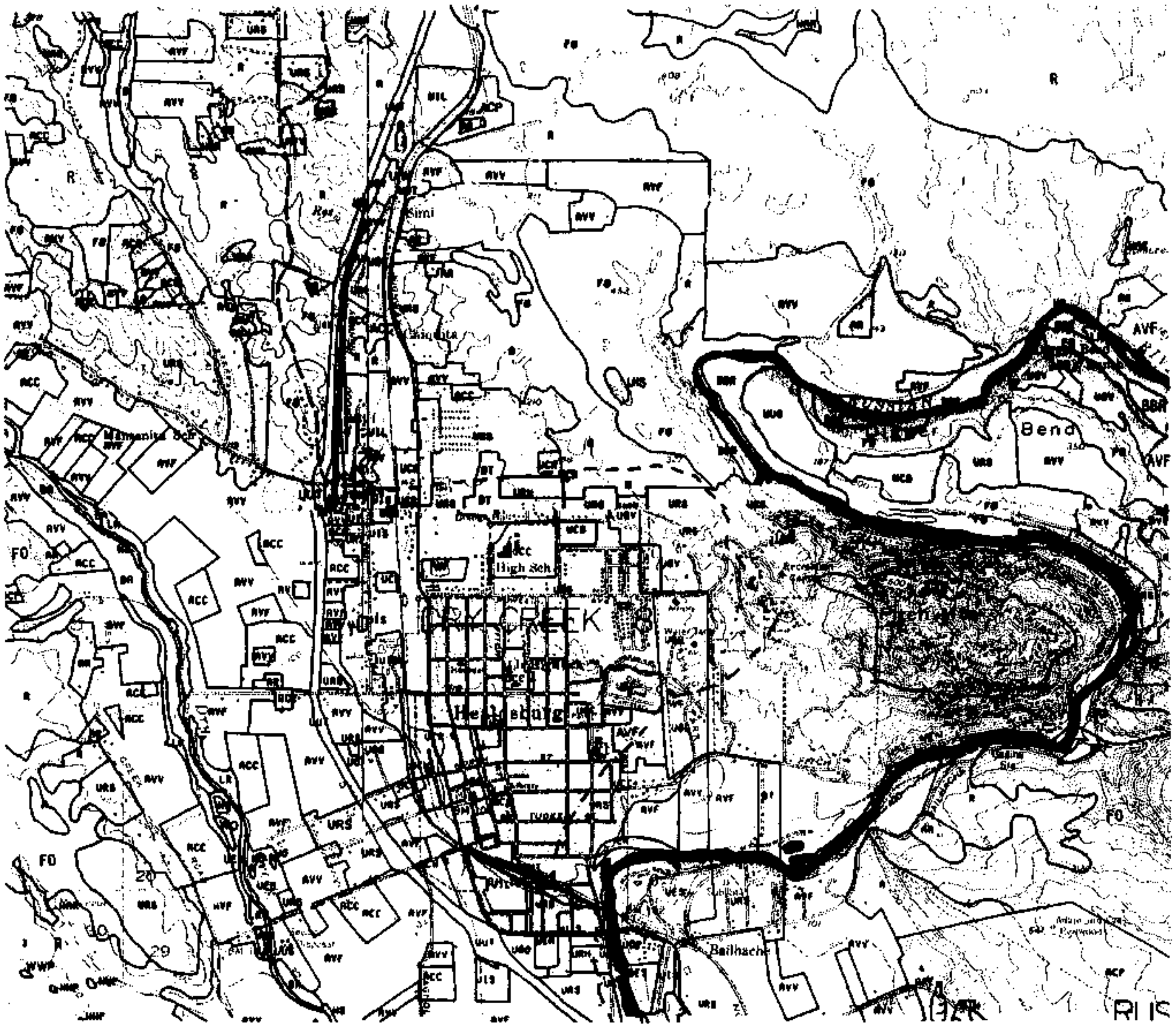

LEGEND

OVERFLOW LIMITS 100 YEAR FLOODING

RUSSIAN RIVER

~260~ GROUND ELEVATION IN FEET SEA LEVEL DATUM

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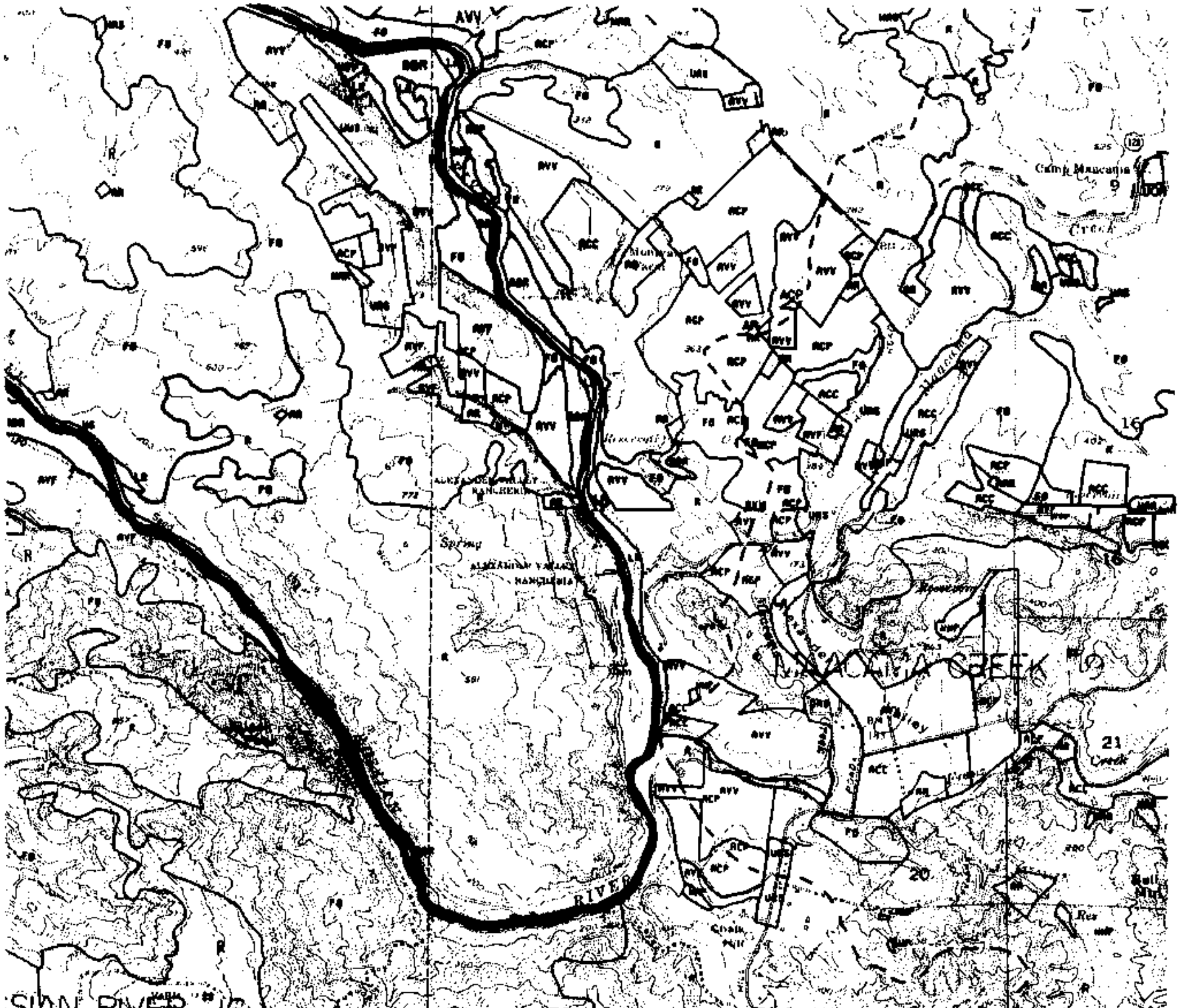
PLATE 7



LEGEND

OVERFLOW LIMITS 100 YEAR FLOODING

RUSSIAN RIVER

~260~ GROUND ELEVATION IN FEET SEA LEVEL DATUM

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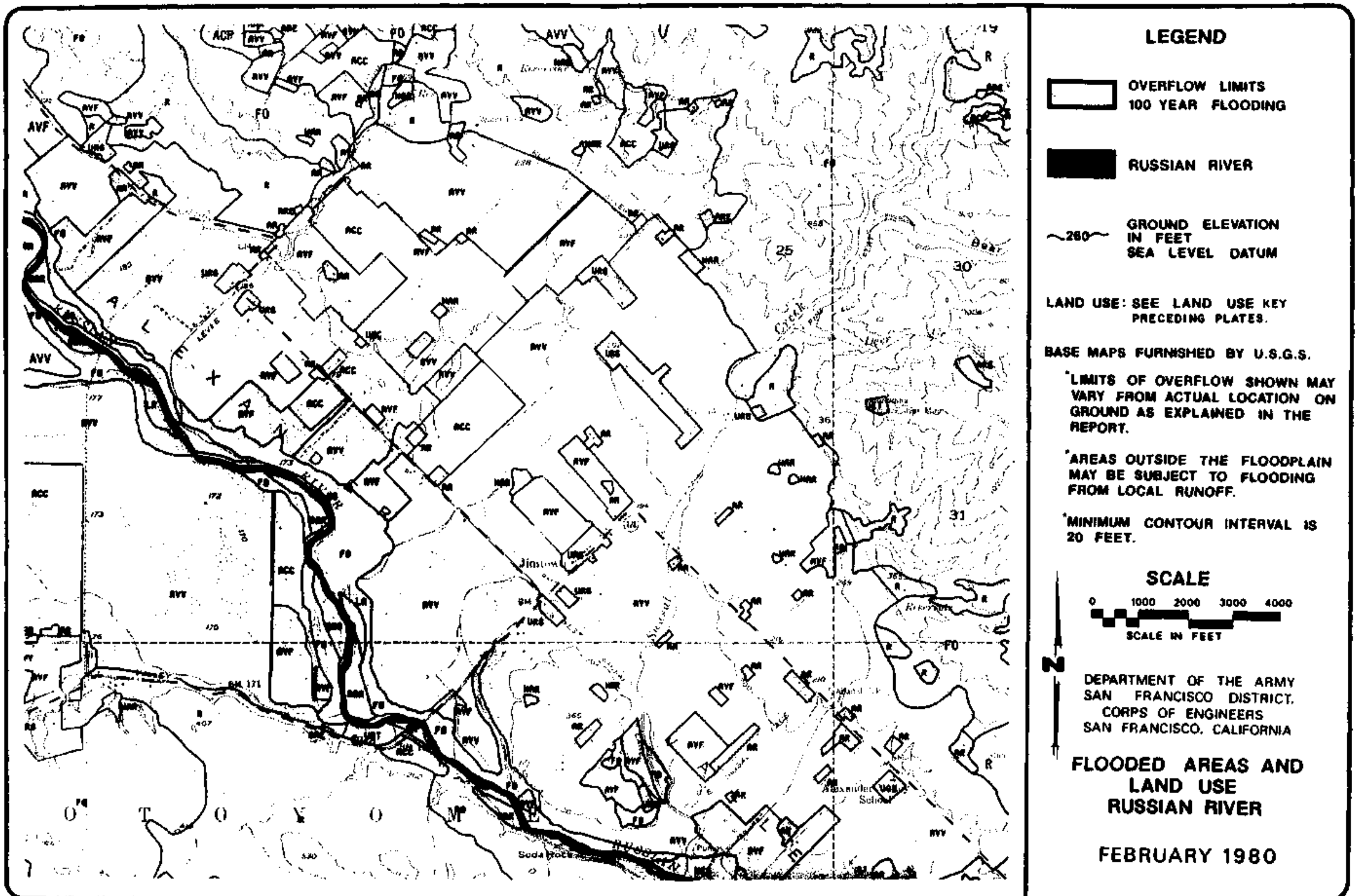
LEGEND
OVERFLOW LIMITS
100 YEAR FLOODING
RUSSIAN RIVER
~260~ GROUND ELEVATION
IN FEET
SEA LEVEL DATUM
LAND USE: SEE LAND USE KEY PRECEDING PLATES.
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SCALE
0 1000 2000 3000 4000
SCALE IN FEET
N
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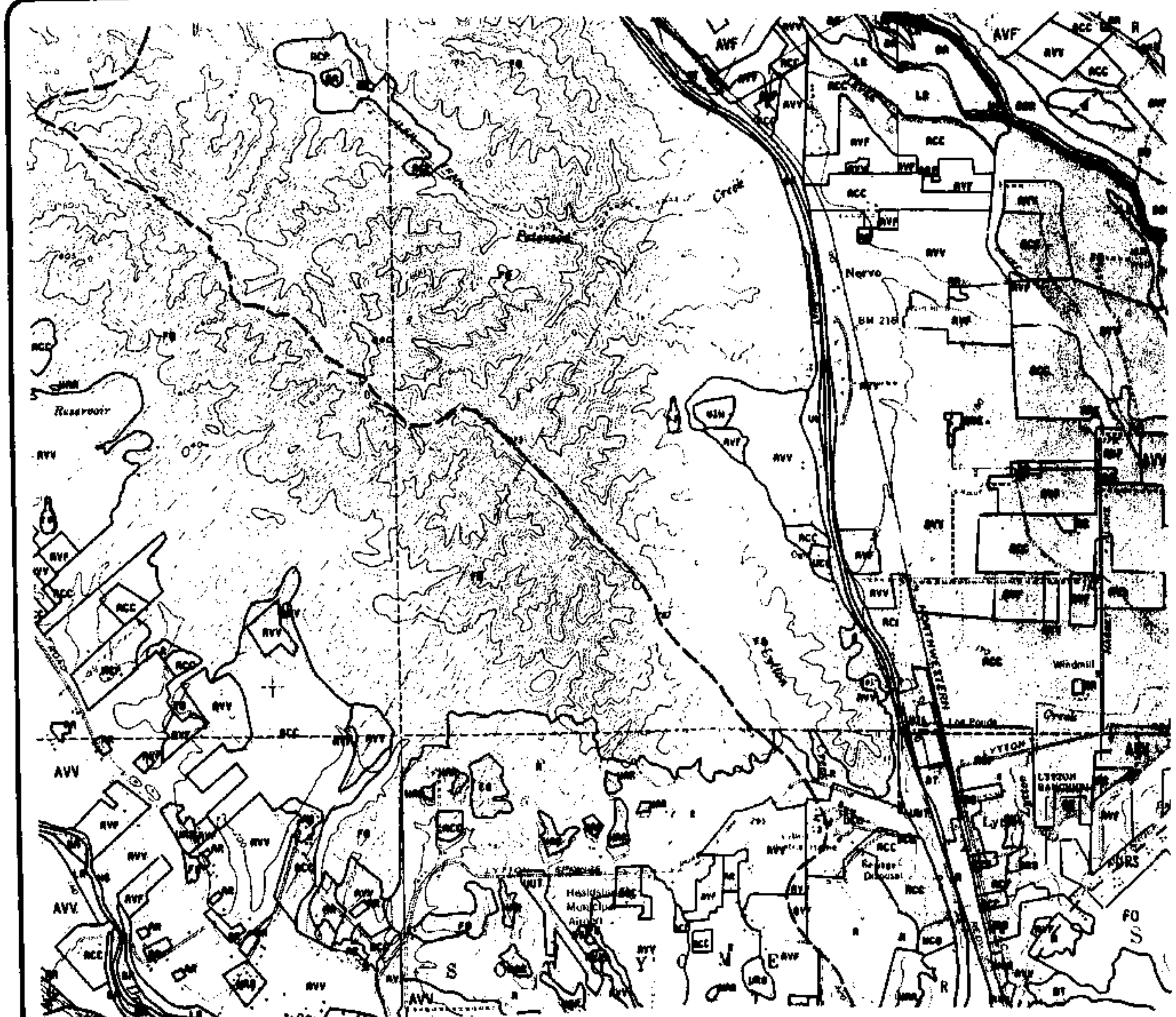
SAN FRANCISCO, CALIFORNIA
FLOODED AREAS AND
LAND USE
RUSSIAN RIVER
FEBRUARY 1980

PLATE 9



LEGEND

OVERFLOW LIMITS 100 YEAR FLOODING

RUSSIAN RIVER

~260~ GROUND ELEVATION IN FEET SEA LEVEL DATUM

LAND USE: SEE LAND USE KEY PRECEDING PLATES.

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SCALE IN FEET

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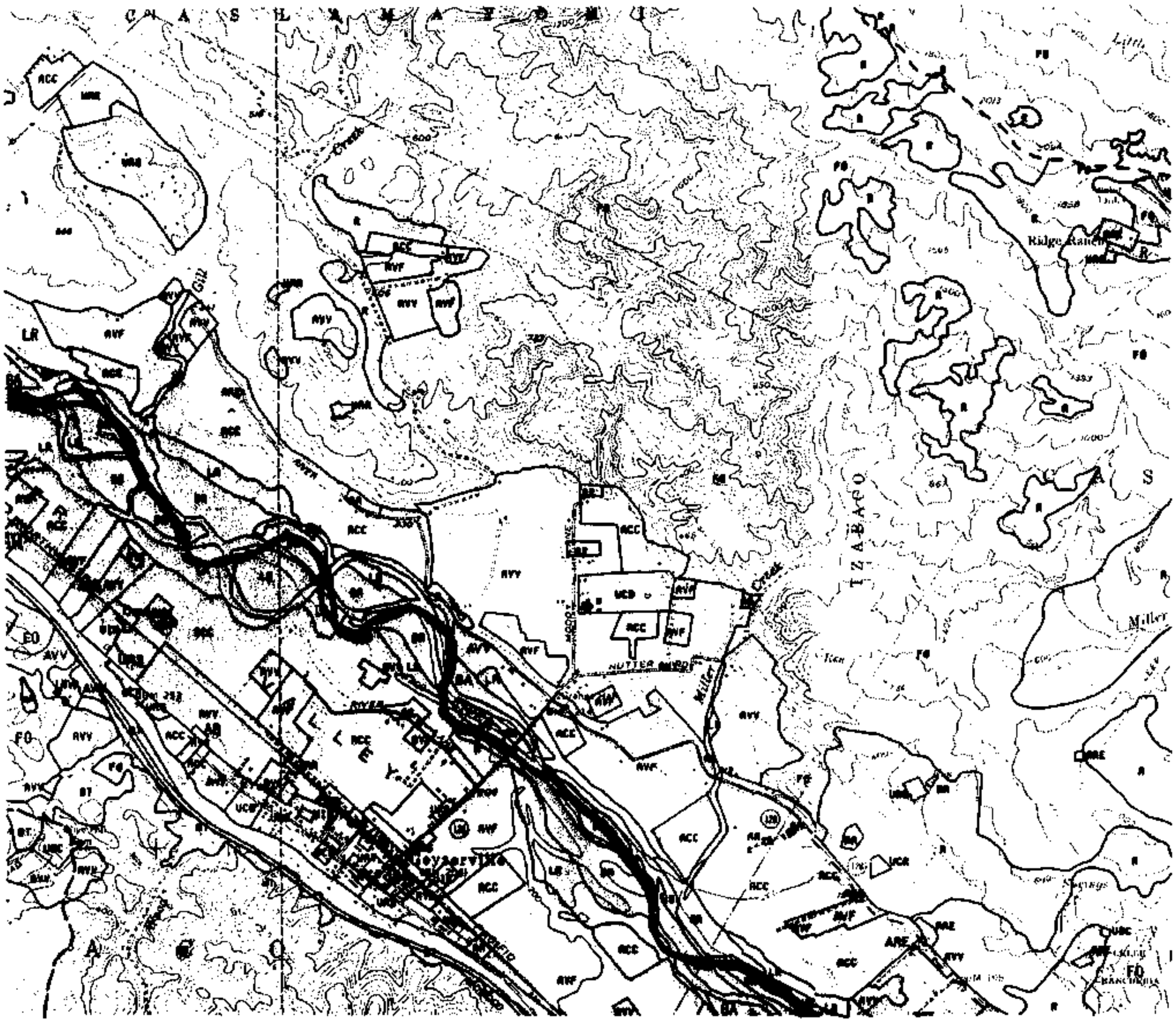
PLATE 10



LEGEND

OVERFLOW LIMITS 100 YEAR FLOODING

RUSSIAN RIVER

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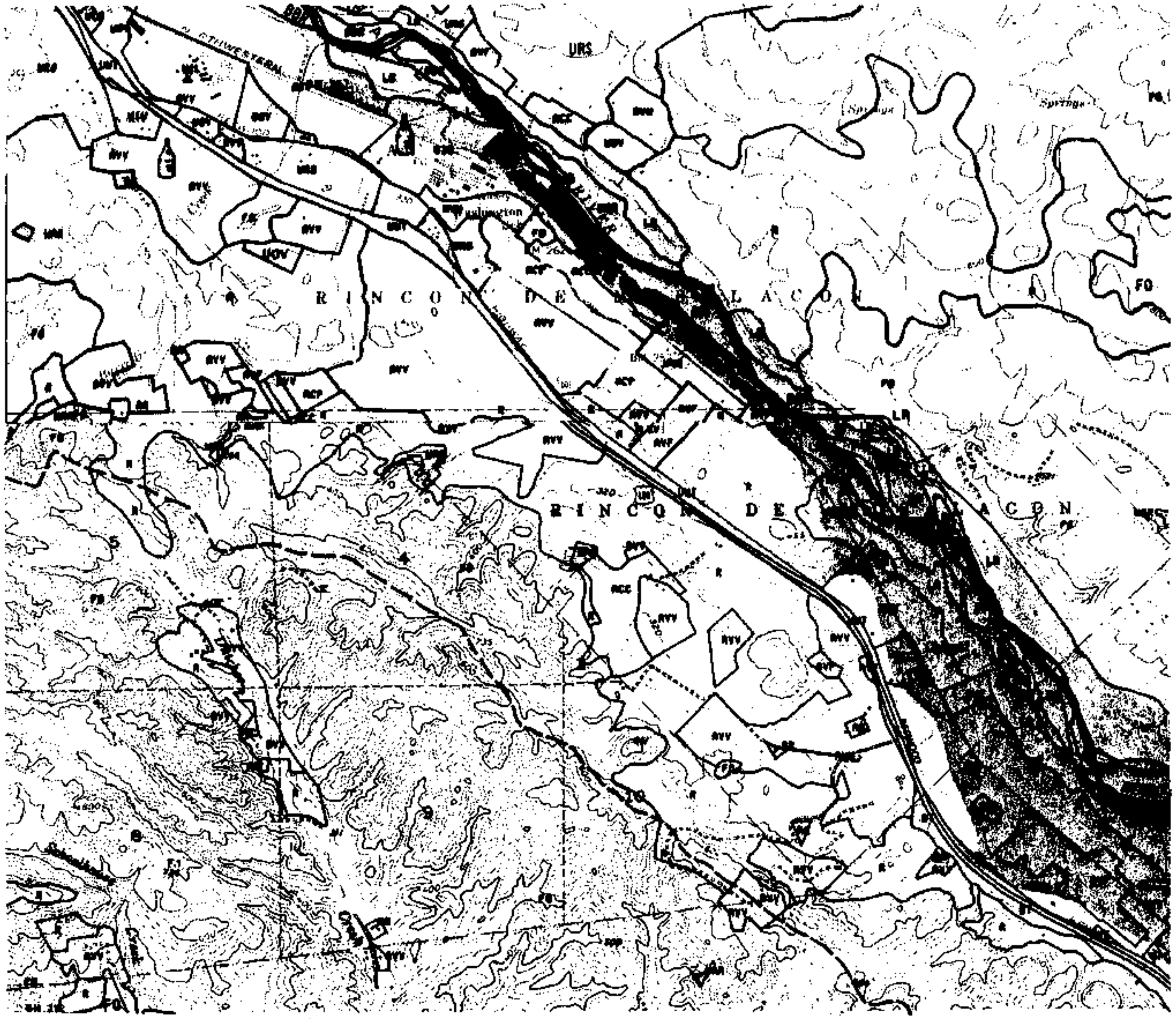
PLATE 11



LEGEND

OVERFLOW LIMITS 100 YEAR FLOODING

RUSSIAN RIVER

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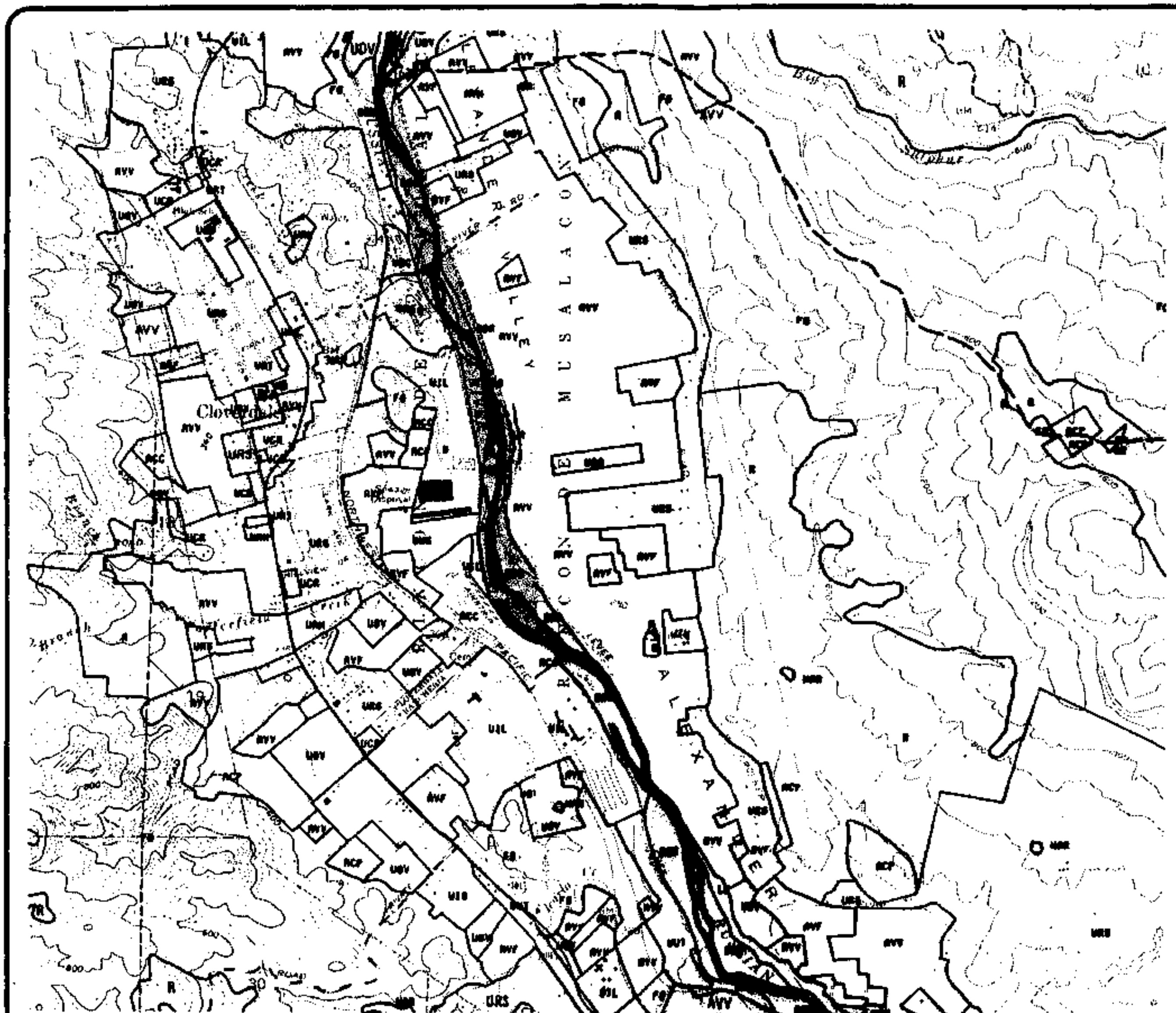
PLATE 12



LEGEND

OVERFLOW LIMITS
100 YEAR FLOODING

RUSSIAN RIVER

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FLOODED AREAS AND LAND USE RUSSIAN RIVER

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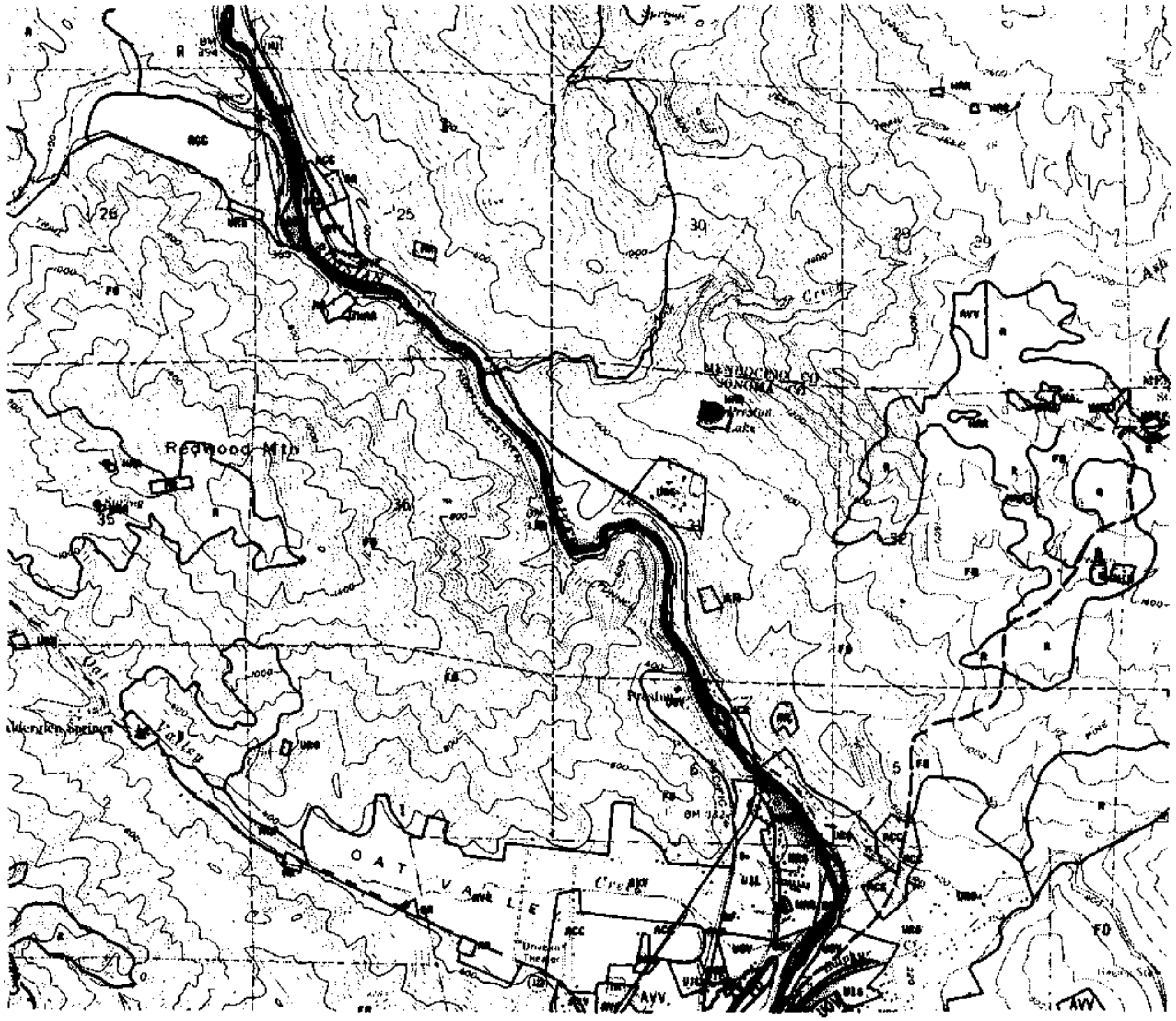
PLATE 13



LEGEND

OVERFLOW LIMITS
100 YEAR FLOODING

RUSSIAN RIVER

~260~ GROUND ELEVATION IN FEET SEA LEVEL DATUM

LAND USE: SEE LAND USE KEY PRECEDING PLATES.

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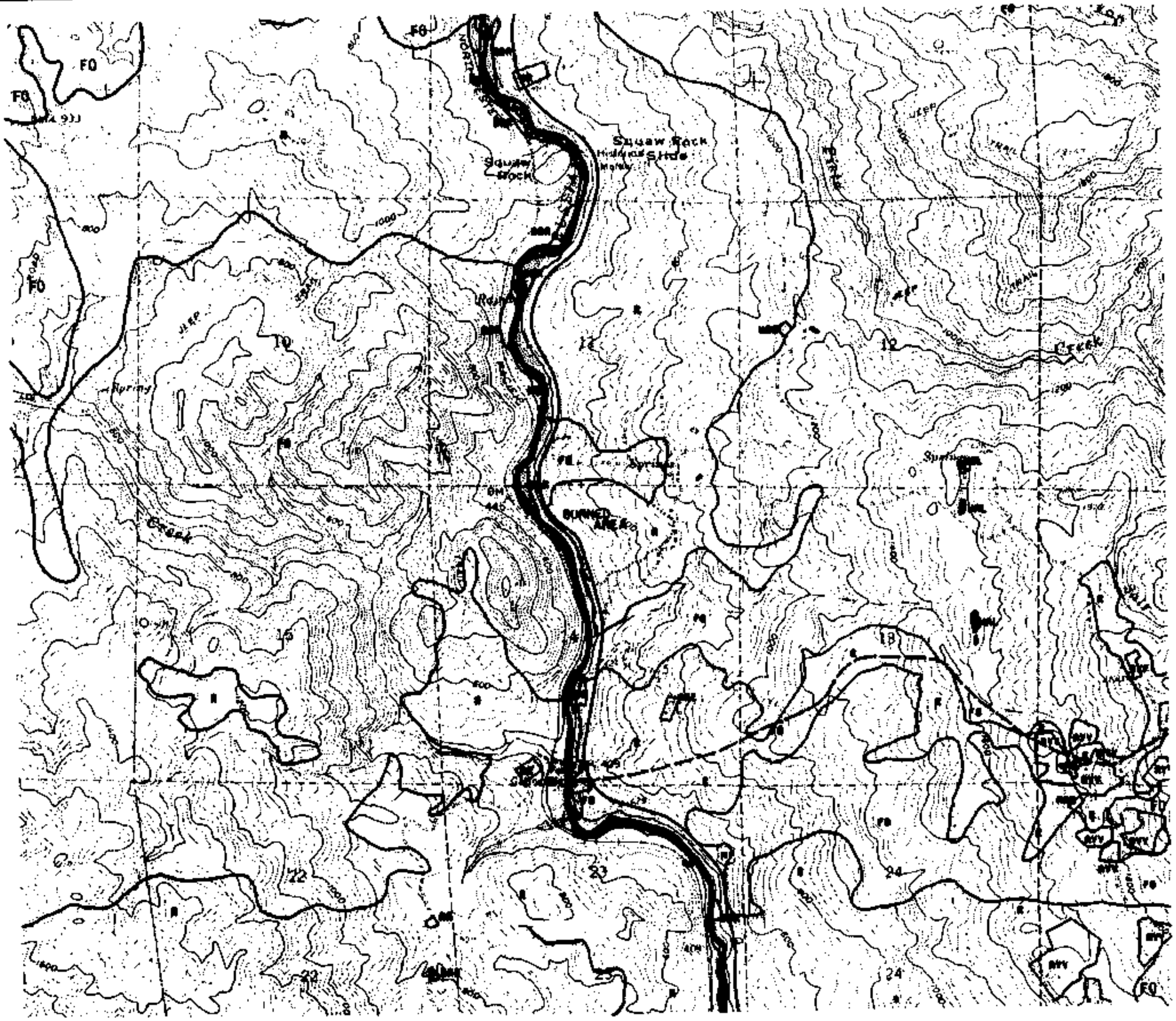
FLOODED AREAS AND LAND USE RUSSIAN RIVER

FEBRUARY 1980



LEGEND

OVERFLOW LIMITS
100 YEAR FLOODING

RUSSIAN RIVER

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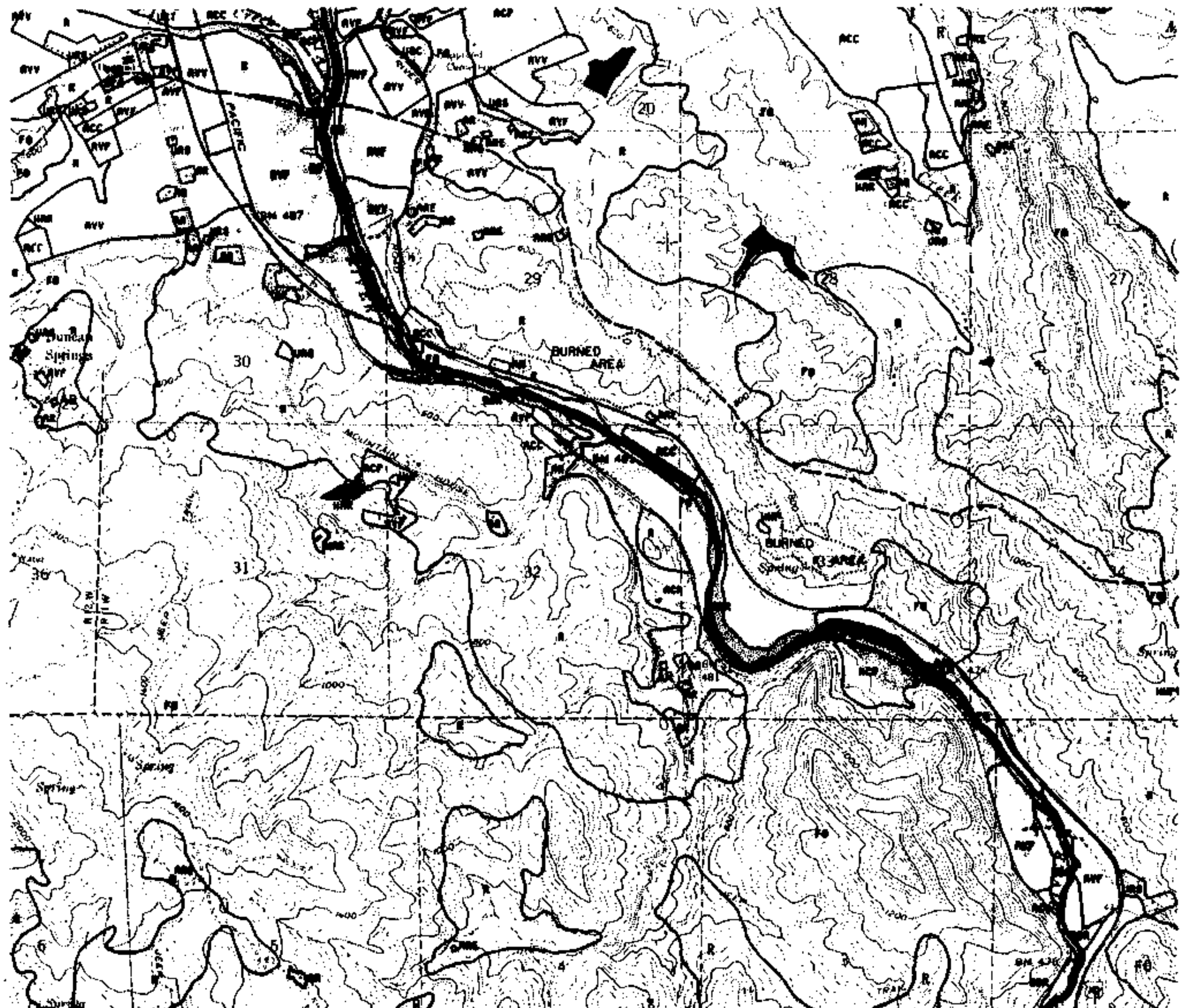
FLOODED AREAS AND LAND USE RUSSIAN RIVER

FEBRUARY 1980

PLATE 15



LEGEND

OVERFLOW LIMITS 100 YEAR FLOODING

RUSSIAN RIVER

~260~ GROUND ELEVATION IN FEET SEA LEVEL DATUM

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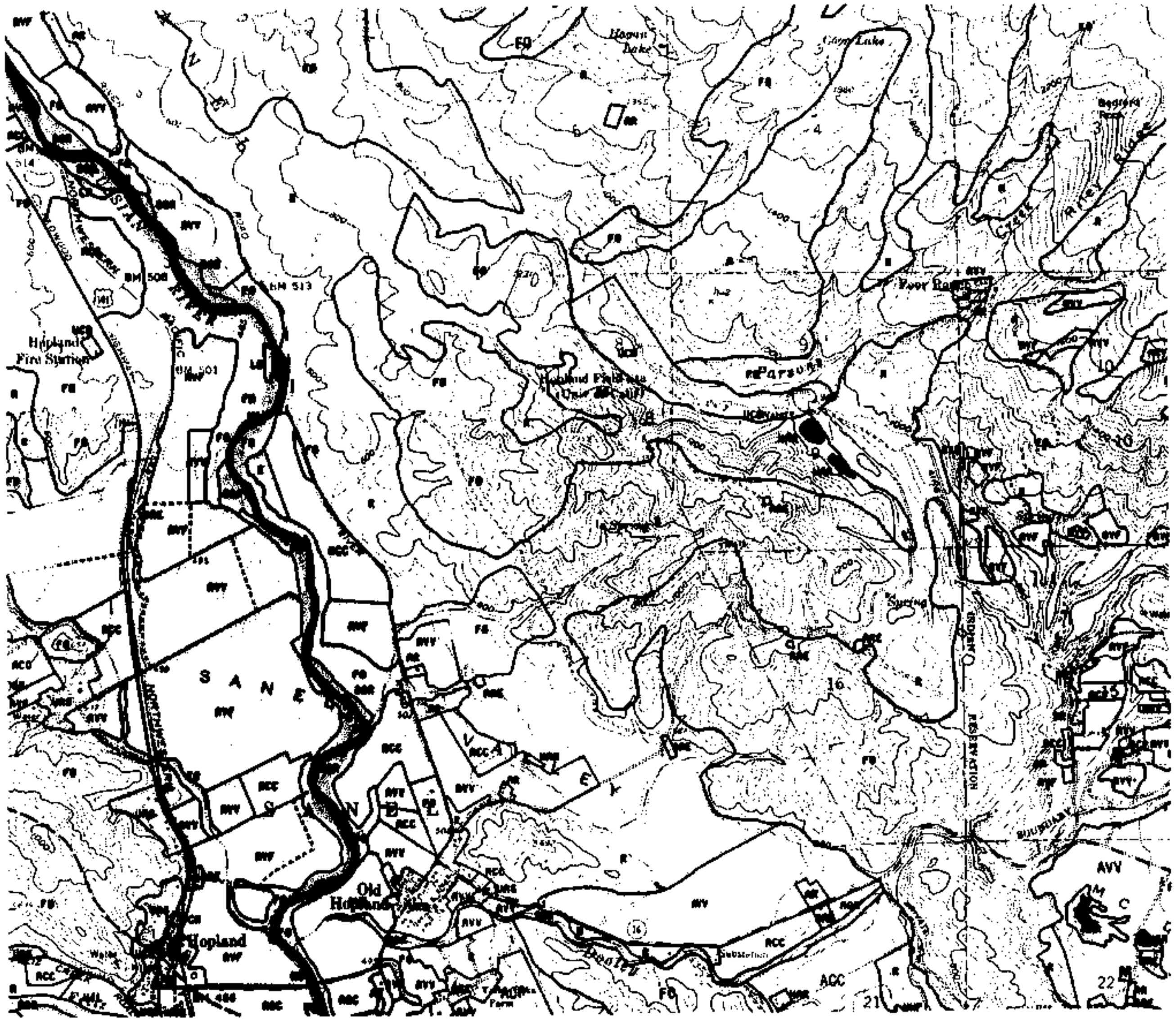
PLATE 16



LEGEND

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100 YEAR FLOODING

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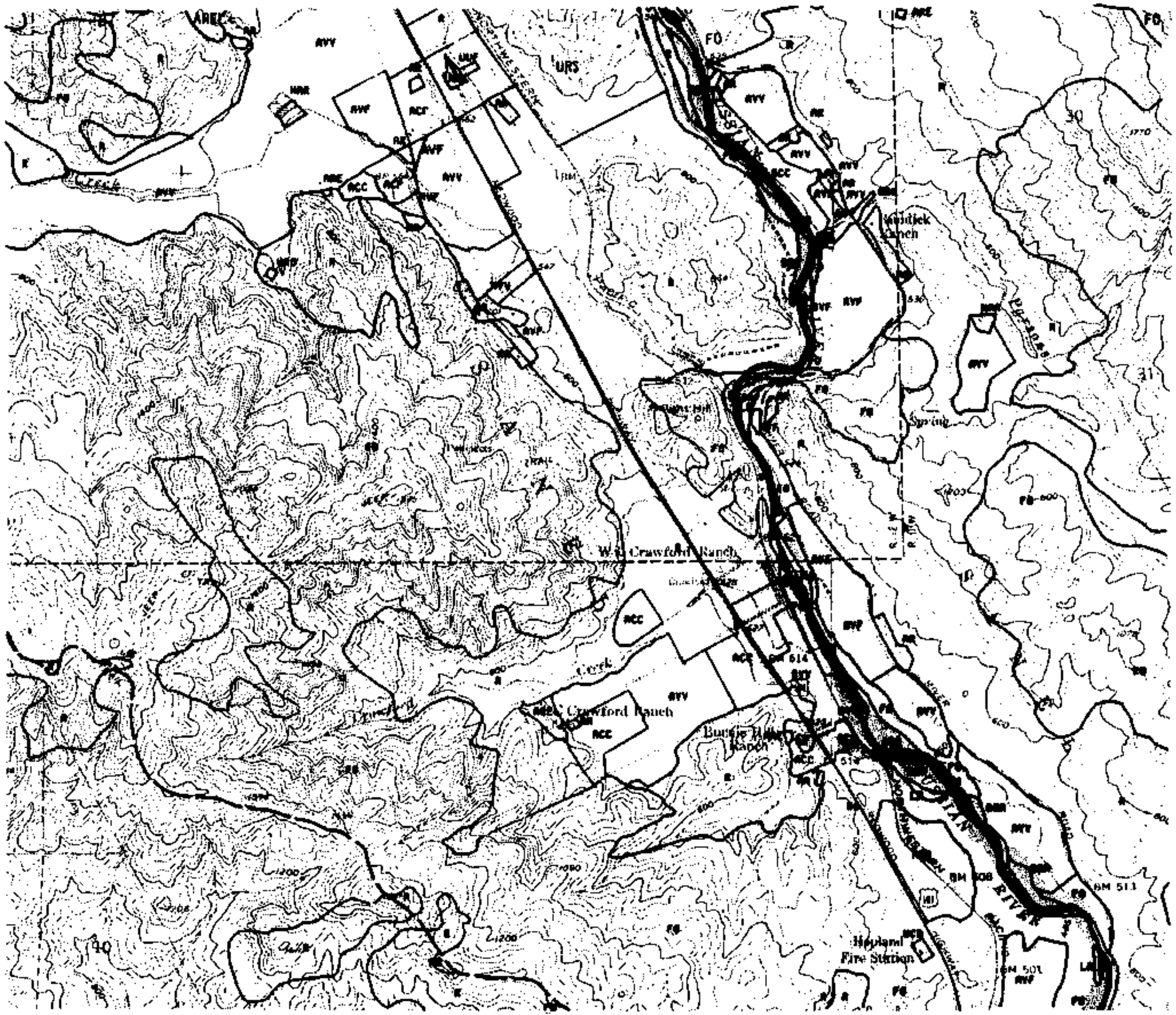
FEBRUARY 1980

PLATE 17



LEGEND

OVERFLOW LIMITS 100 YEAR FLOODING

RUSSIAN RIVER

~260~ GROUND ELEVATION IN FEET SEA LEVEL DATUM

LAND USE: SEE LAND USE KEY PRECEDING PLATES.

BASE MAPS FURNISHED BY U.S.G.S.

*LIMITS OF OVERFLOW SHOWN MAY VARY FROM ACTUAL LOCATION ON GROUND AS EXPLAINED IN THE REPORT.

*AREAS OUTSIDE THE FLOODPLAIN MAY BE SUBJECT TO FLOODING FROM LOCAL RUNOFF.

*MINIMUM CONTOUR INTERVAL IS 20 FEET.

SCALE

0 1000 2000 3000 4000

SCALE IN FEET

N

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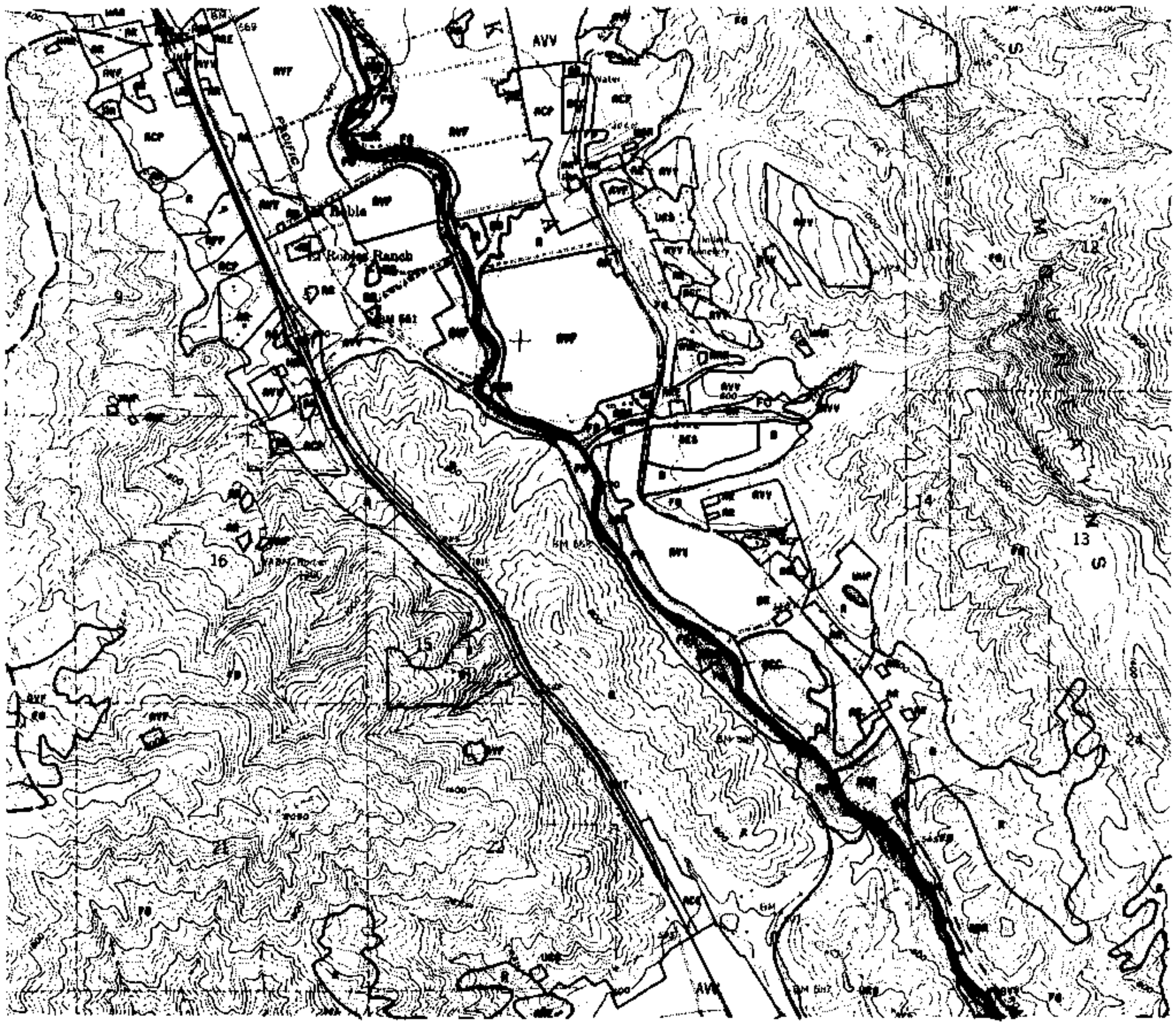
SAN FRANCISCO DISTRICT,
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

FLOODED AREAS AND LAND USE RUSSIAN RIVER

FEBRUARY 1980

PLATE 16



LEGEND

OVERFLOW LIMITS 100 YEAR FLOODING

RUSSIAN RIVER

~260~ GROUND ELEVATION IN FEET SEA LEVEL DATUM

LAND USE: SEE LAND USE KEY PRECEDING PLATES.

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0 1000 2000 3000 4000

SCALE IN FEET

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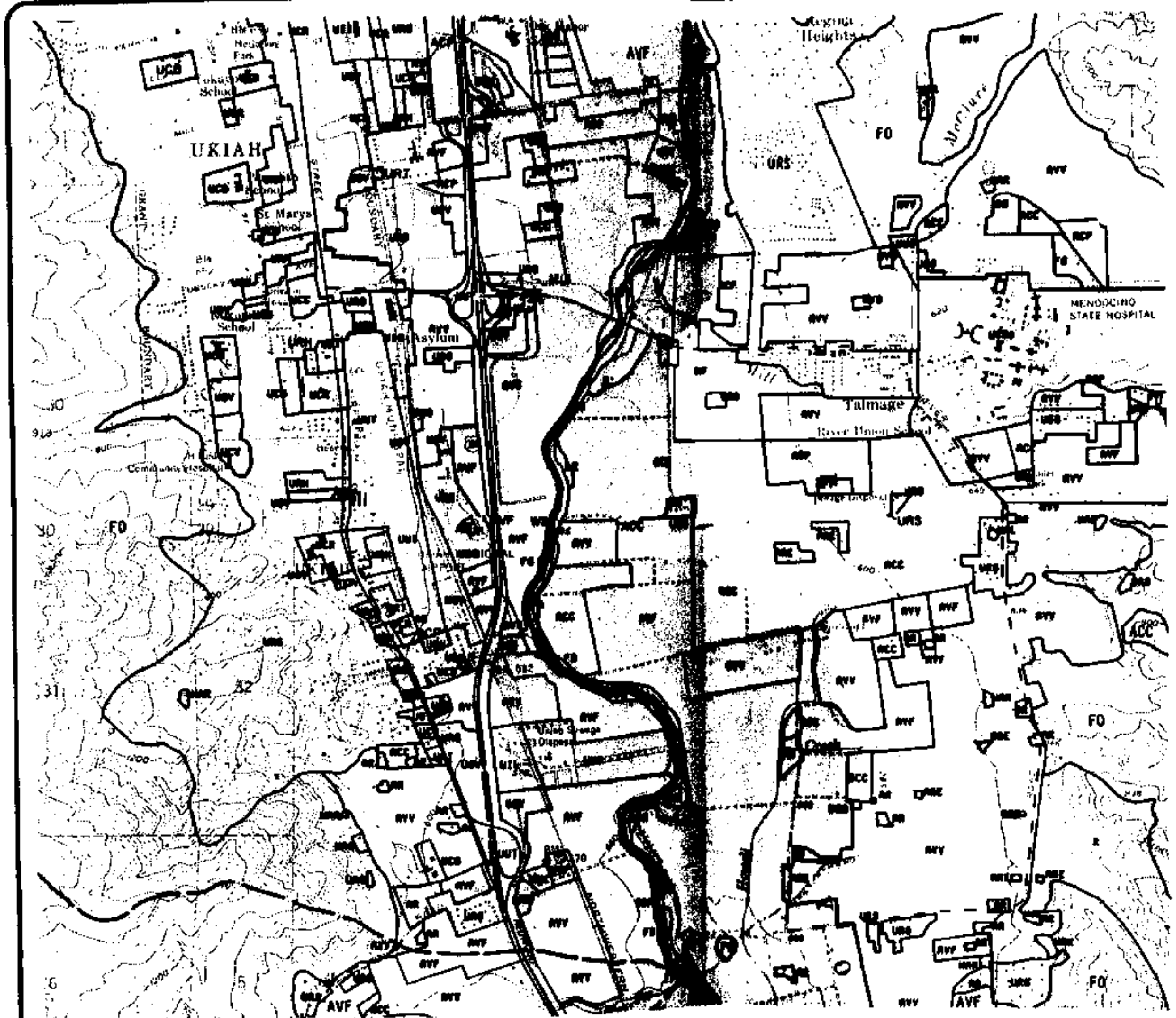
FEBRUARY 1980



LEGEND

OVERFLOW LIMITS 100 YEAR FLOODING

RUSSIAN RIVER

~260~ GROUND ELEVATION IN FEET SEA LEVEL DATUM

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0 1000 2000 3000 4000

SCALE IN FEET

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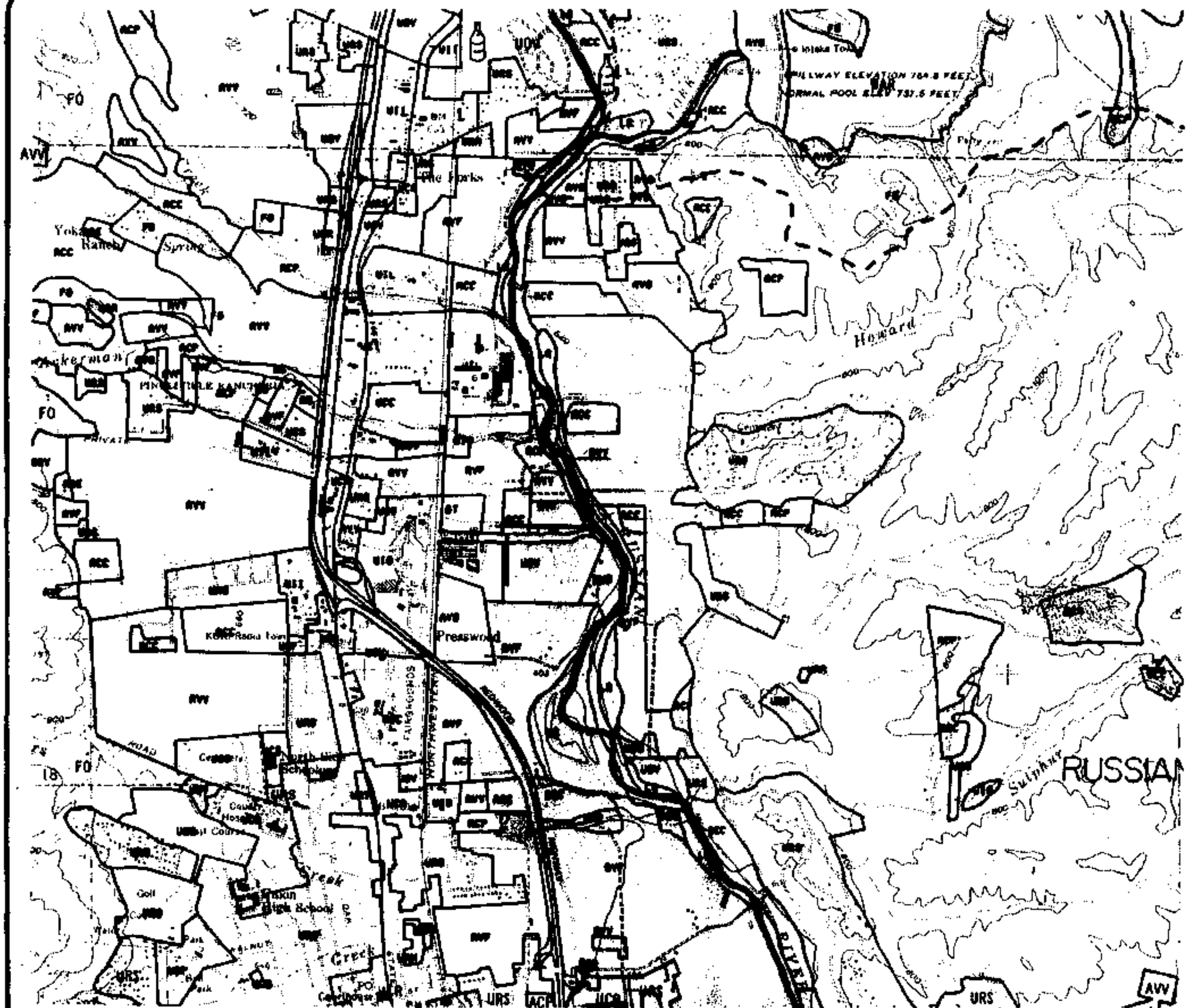
PLATE 20



LEGEND

OVERFLOW LIMITS 100 YEAR FLOODING

RUSSIAN RIVER

~280~ GROUND ELEVATION IN FEET SEA LEVEL DATUM

LAND USE: SEE LAND USE KEY PRECEDING PLATES.

BASE MAPS FURNISHED BY U.S.G.S.

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SCALE

0 1000 2000 3000 4000

SCALE IN FEET

N

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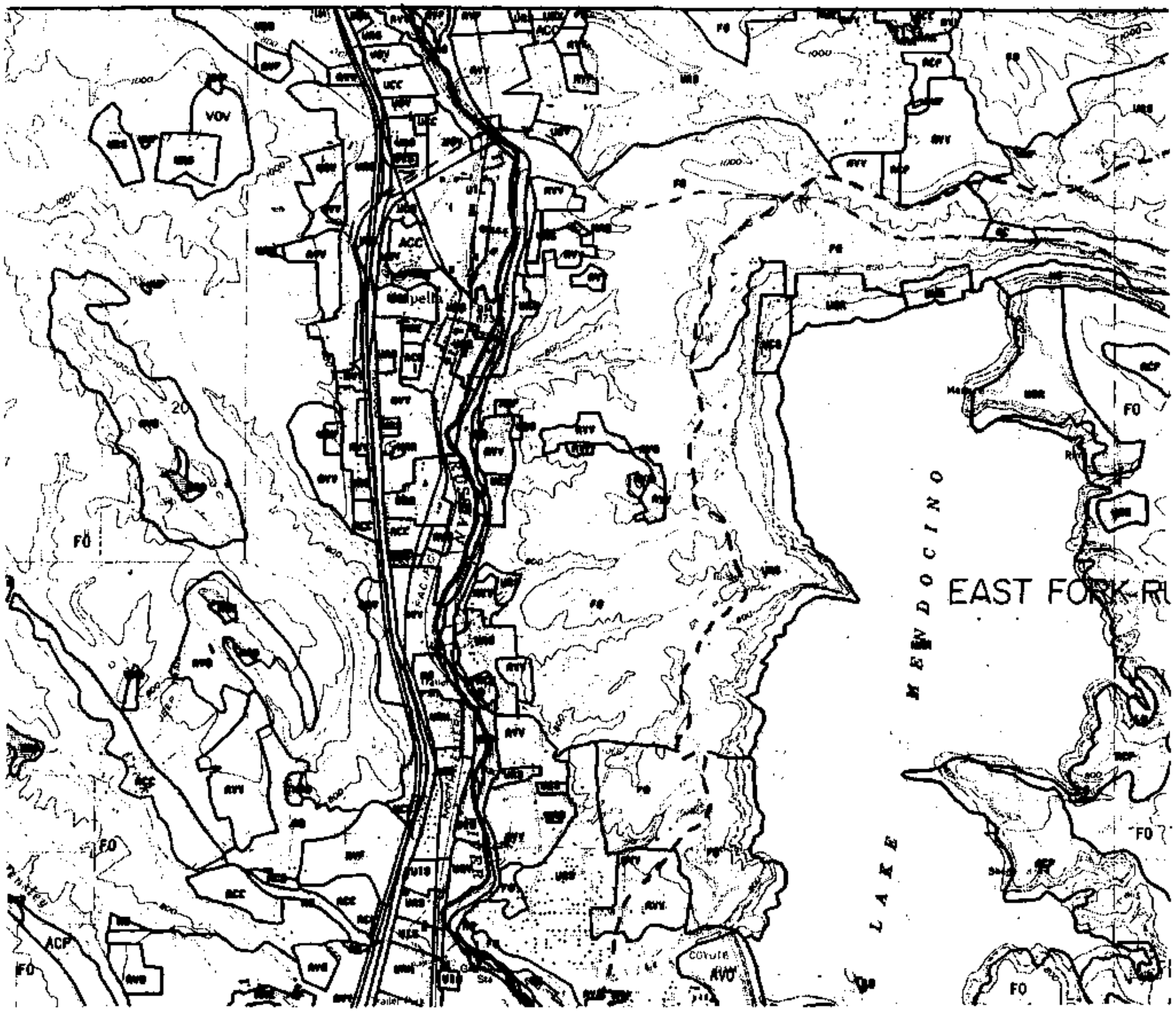
PLATE 21



LEGEND

OVERFLOW LIMITS 100 YEAR FLOODING

RUSSIAN RIVER

~260~ GROUND ELEVATION IN FEET SEA LEVEL DATUM

LAND USE: SEE LAND USE KEY PRECEDING PLATES.

BASE MAPS FURNISHED BY U.S.G.S.

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0 1000 2000 3000 4000

SCALE IN FEET

N

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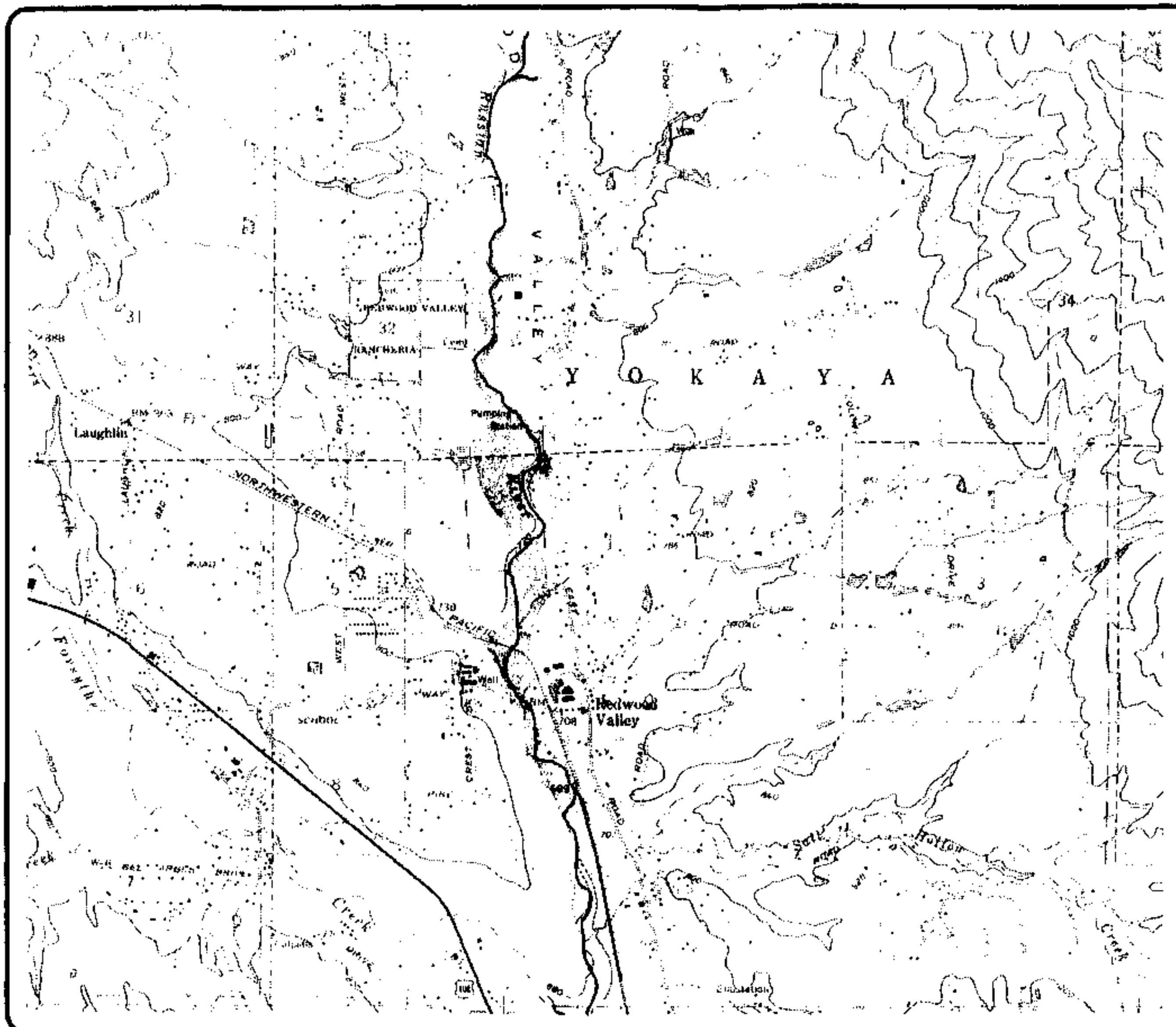
FEBRUARY 1980



LEGEND

OVERFLOW LIMITS 100 YEAR FLOODING

RUSSIAN RIVER

~260~ GROUND ELEVATION IN FEET SEA LEVEL DATUM

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SCALE IN FEET

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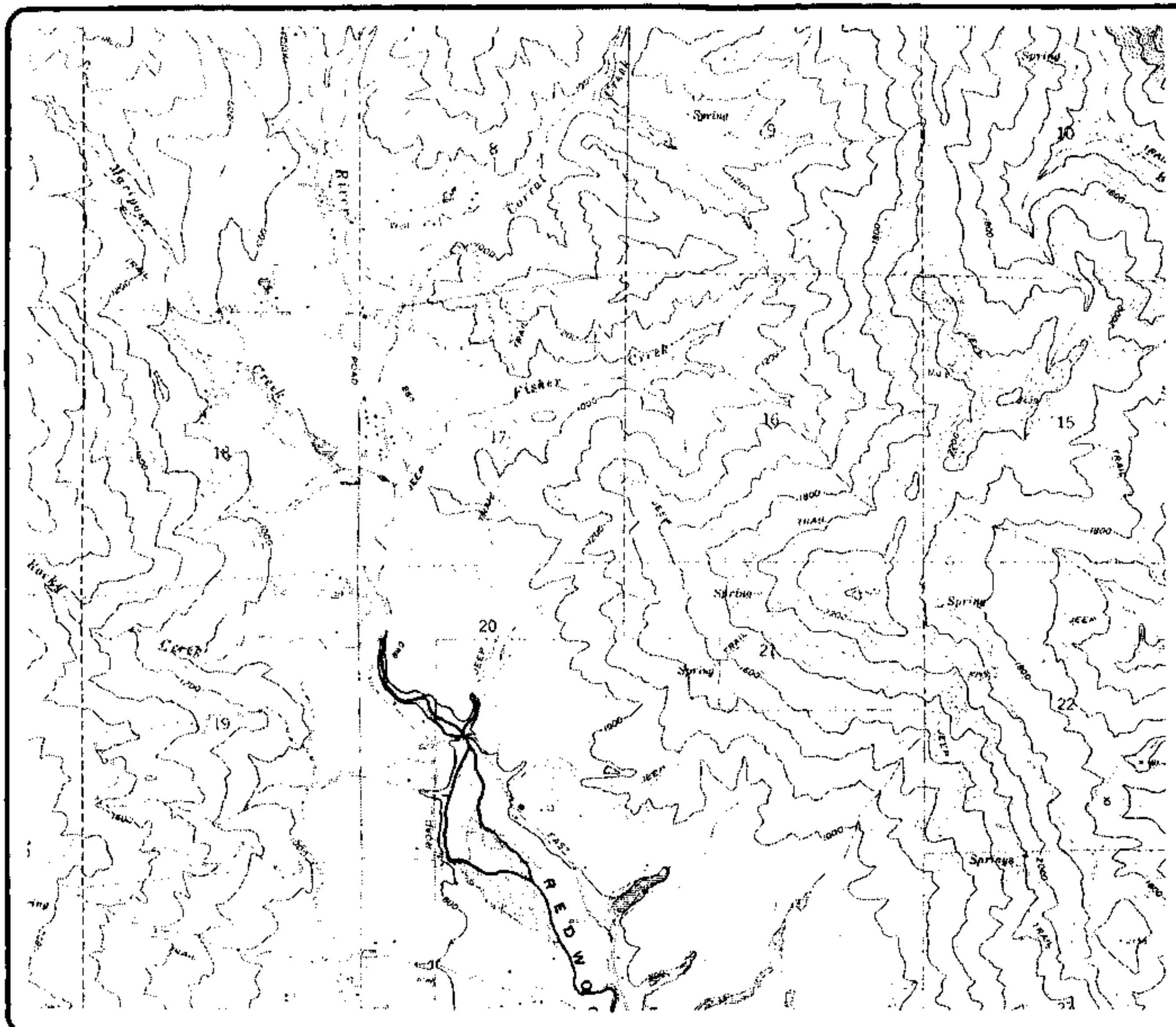
PLATE 23



LEGEND

OVERFLOW LIMITS 100 YEAR FLOODING

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SCALE IN FEET

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FLOODED AREAS AND LAND USE RUSSIAN RIVER

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PLATE 24