Prado Dam
Santa Ana River near Junction of State Highways 71 and 91
Corona Vicinity
Riverside County
California

HAER No. CA-178

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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
Western Region
Department of the Interior
San Francisco, California 94107

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HISTORIC AMERICAN ENGINEERING RECORD

PRADO DAM

HAER No. CA-178

Location:	North of Santa Ana River, northeast of the Junction of State Highways 71 and 91 Corona Vicinity Riverside County, California U.S.G.S. 7.5. minute Prado Dam, California, quadrangle Universal Transverse Mercator coordinates: 3749880 441760
Date of Construction:	1938-1941
Engineer:	Major Theodore Wyman, Jr., U. S. District Engineer U. S. Army Corps of Engineers
Builder:	W. E. Callahan Construction Company, Los Angeles, California
Present Owner:	U. S. Army Corps of Engineers, Los Angeles District
Present Use:	Flood control, water conservation, recreation
Significance:	The construction of Prado Dam was a significant event in the history of flood control in southern California and specifically Orange County. The Dam has played a vital role in the economies and development of Orange, Riverside, and San Bernardino counties. Prado Dam is a distinctive and recognizable representative of its type, period, and method of construction, of worthy design and retaining unusual integrity. At the time of its construction it was the largest earthen dam in the United States. The attention to architectural detail, particularly the control house and control tower, demonstrates that government structures can be aesthetically pleasing and simple at the same time.
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Date:	June 1996

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1. INTRODUCTION

Prado Dam is an integral part of one of the largest flood-control projects in southern California. Begun under the auspices of the Orange County Flood Control District in the late 1930s, the dam was finished hy the U.S. Army Corps of Engineers, Los Angeles District, which has maintained and operated the structure since its construction. Prado Dam is located on the Santa Ana River in the southwest corner of Riverside County, about three miles north of the Orange County line.

Behind the dam the flood basin, which includes all lands below the present 556-foot above sea level taking line, covers 9741 acres of prime agricultural land in Riverside and San Bernardino counties. Sixty-eight percent of this land is now owned directly by the Federal government; most of the remainder is currently owned by the Orange County Water District, which manages the land solely for water conservation in Orange County (U. S. Army Corps of Engineers [CoE] 1988a).

Following decades of discussion, controversies about its location and primary purpose, and spurred finally by the flood of 1938, Prado Dam was completed in 1941, on schedule and without untoward incident. Since its dedication, it has served its objective of flood control, thereby contributing to the rapid development and urbanization of Orange County. The dam was the largest single component in the flood control system for Orange County, and remains the second largest earthen dam in southern California. It has served its purpose well, even though modifications will be needed. The statement that the design and engineering were essentially simple should not be taken as a critical assessment. It is, perhaps, the major reason why the existing facility has performed so well over the years and remains in good to excellent operating condition, as well as demonstrating architectural integrity.

The facilities maintain their architectural integrity and are well maintained, without modification or intrusion. Even the operating mechanisms are original; the generator has been replaced, but all of the other equipment is otherwise original, even down to the hand-lettered signs on the control panel inside the control tower. Even though the design is relatively simple, there were explicit efforts made to achieve a pleasing architectural result. The most unique element is the concrete tower and control house. The tower was designed in an unusual open-frame style, with a self-contained control house above. The band of recessed dentation below the roof subtly repeats the arches between the concrete pillars, and is interrupted only by the simple, embossed letters which identify the facility. The pillars taper toward the top, embellished with corner recesses which contribute to the shadow pattern. What might otherwise present a rather stark elevation is relieved by these design details created with incised and cast concrete, and the recessed entrance and windows.

There is little visible change other than the removal of the caretaker's house and addition of maintenance roads, both away from the dam or its immediate setting. The closing of the conduits in 1971 marked only a change in function and operations, in that the flow of water is now regulated at gate level, reflecting a secondary role in water conservation.

The construction of Prado Dam was a landmark event in the history of flood control in Orange County and southern California. The original design was well planned and executed, even if not particularly innovative. Construction was completed in a timely and orderly manner, and all difficulties or contingencies were addressed by Change Orders managed by the CoE and implemented hy the contractors. What was prophetic for the future was the realization of the need for broad, regional planning (i.e., that problems like flood control or water conservation could no longer be addressed only within - or by - a politically or geographically defined unit such as a single county). As exemplified by Prado Dam, the major benefits were to Orange County, although the natural resource originated outside its borders. As a result, the solution was constructed in Riverside County, Orange County became an important landowner and holder of water rights in San Bernardino, and the functioning of the dam became of increasing concern throughout the region. It has played a pivotal role not only in downstream development but in the economy of all three counties. The construction displaced a whole town (Rincon/Prado) and many other rural residents in the basin; affected the dairy industry, ranching, and agriculture; caused the relocation of highways and a railroad; and contributed to biotic changes as a result of the higher water table behind the dam. Losses to the local tax base have been partially offset by leasing and recreational opportunities for the public.

Prado Dam is a significant cultural resource eligible to the National Register of Historic Places. There is no question that it possesses integrity of location, design, setting, materials, workmanship, feeling, and association. It meets Criterion A, association with events which have contributed to broad patterns of history, in its direct effects on the lives and economies of three counties and as an early example of regional planning for flood control and water conservation which has influenced subsequent projects. No claim is made that the engineers, politicians, landowners, or others directly associated with the dam are individually significant (Criterion B), although each played an important role in facilitating the construction. Under Criterion C, the structure is a distinctive and recognizable representative of its type, period, and method of construction, of worthy design and retaining unusual integrity. The attention to architectural detail demonstrates that government structures can be aesthetically pleasing and simple at the same time. The research conducted has already yielded a wealth of historical information (Criterion D); it is possible that additional data may exist below the surface in the areas occupied by construction yards, shops, or workers' housing.

The only "flaw" in the design of Prado Dam was probably unavoidable: the planners did not foresee the incredihle rate of growth and development that was to take place in southern California from the end of World War II to the present. And, largely as a result of this, the dam has been put to a use (water conservation) for which it was not originally designed. The managers of Prado Dam are not alone in having to cope with unanticipated development pressures, but are joined with countless planners, engineers, public agencies, developers, and scientists in adapting or modifying older technologies to newer needs. With the improvements being contemplated, Prado Dam can again fulfill its authorized function of flood control, protecting life and property in Orange County, and add the more contemporary objective of water conservation, to the benefits of all southern California.

This document summarizes the beginnings of flood control along the Santa Ana River, and outlines the various plans and proposals for dam construction along the Santa Ana - plans that eventually led to the construction of the present Prado Dam and the reservoir area behind it. With its promise of comprehensive flood control, Prado Dam has in effect permitted the phenomenal growth of Orange County, first as a center of the citrus industry and finally as an urban conglomerate spread across the Santa Ana River floodplain.

Flood control, however, is only part of the story. Even in the planning stage, Prado Dam was the focus of an on-going controversy between the often conflicting interests of flood control and water conservation, a controversy that has become more, not less, acute since the dam was constructed. Officially built solely for flood control, the dam was quickly embroiled in long-standing controversies over water rights and water use along the Santa Ana. Prado Dam, situated between Orange County downstream and Riverside and San Bernardino counties upstream, has been the fulcrum in a see-saw war between two areas increasingly desperate for water.

Sources of Information

Research was conducted by Swanson and Hatheway (1989) and Dana N. Slawson at the following major repositories of information:

Federal Records Center, Laguna Niguel
University of California at Los Angeles, University Research Library
University of Southern California, Watt Library
Santa Ana Public Library
U. S. Army Corps of Engineers, Real Property Records and Map Room
Sleeper Collection (private papers and newspaper files).

Of these, the Federal Records Center provided the most critical information about the design and construction of the dam. The archives included a copy of the original Invitation to Bid, the various Change Orders issued by the District Engineer during construction, miscellaneous correspondence, and a series of photographs in the quarterly reports documenting the progress.

The next most important technical resource was the *Southwest Builder and Contractor*, a trade journal which carried all construction and building news in southern California from the late nineteenth century to the mid 1960s. This series is available in hard copy at the Watt Architectural Library and on microfilm at UCLA.

The Santa Ana Public Library contains a large collection of general information regarding flood control in Orange County. The CoE's Real Property Records, plans, and other files were consulted to check for any details not available at Laguna Nigel. Finally, Jim Sleeper, Orange County historian, provided access to his extensive clippings and files as a consultant.

The information gathered at these repositories, added to more general sources, provided sufficient data to compile a chronological and history of the planning of the Prado Dam, a detailed account of the bidding and construction process, and a description of the operations and architecture of the structures.

Project Setting

The Prado Dam was built to contain major floods along the Santa Ana River and its tributaries, which drain a watershed of almost 2500 square miles in San Bernardino, Riverside, and Orange counties (Prado Dam 1971:1; Scott 1982:15). The Santa Ana is the longest and largest river in southern California, and has its origin in the San Bernardino Mountains in the run-off from slopes which rise more than 11,000 feet (Figure 1.1). From this point, the river courses 100 miles in a southwesterly direction on its way to the Pacific Ocean (Post 1928:31).

En route to the sea, the river passes through two constrictions, both named Santa Ana Canyon. The Upper Santa Ana Canyon is located between the high mountain valleys where the river begins, and the plain far below formed by the San Bernardino Valley. The Lower Santa Ana Canyon is located about 30 miles from the sea and is formed by the Puente Hills to the northwest and the Santa Ana Mountains to the southeast (Figure 1.1). Unless otherwise identified, the Santa Ana Canyon in this report will refer to the lower of the two constrictions.

FIGURE NOT AVAILABLE

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Figure 1.1. Santa Ana River Watershed. After Post 1928: Plate 1.

The Lower Santa Ana Canyon is a gorge approximately 12 miles long, divided between Riverside County to the northeast and Orange County to the southwest (Bailey 1940:3). Just before reaching this constriction, the river is joined by all of its major tributaries -- Temescal Wash, Cucamonga Creek, San Antonio Creek, Mill Creek, and Chino Creek. It is this confluence that forms the Prado Basin.

After the river leaves the basin and the canyon, it enters the coastal plain for its final 21-mile run to the river's mouth, now permanently channeled between Huntington Beach and Newport Beach. Before being stabilized, the river channel on the coastal plain was often poorly defined and the potential for flooding was high.

The Santa Ana River floodplain in Orange County covers at least 170 square miles, and encompasses the communities of Anaheim, Orange, Fullerton, Buena Park, La Palma, Cypress, Stanton, Garden Grove, Westminster, Santa Ana, Fountain Valley, Los Alamitos, Costa Mesa, Huntington Beach, and Seal Beach (Prado Dam 1971:1). These communities constitute the very heart of Orange County, and as they have grown, county authorities have left no stone unturned in securing adequate flood protection. Orange County has always been in the forefront of the struggle to control and harness the Santa Ana. It is thus ironic that the most feasible place to control the river flood is in the Prado Basin, at the upstream end of the Lower Santa Ana Canyon, located in Riverside County.

Prado Basin owes its existence to an active fault line. The Lower Santa Ana Canyon is formed by the Puente Hills and the Santa Ana Mountains. Both ridges are part of a single uplift along the Chino-Elsinore Fault that occurred at the close of the Tertiary and beginning of the Quaternary periods (Figure 1.2). The Santa Ana River, an "antecedent stream," was not displaced as the land rose because it was able to cut through the uplift (Post 1928:242-47). Both the Puente Hills and the Santa Ana Mountains consist of generally water-tight sandstones and shales of Tertiary age. From a base of around 500 feet above sea level, the Puente Hills rise to a height to 1800 feet; the Santa Ana Mountains are much higher, rising to over 5000 feet. The Chino-Elsinore fault line runs along the northeast edge of these mountains, almost directly under the Temescal Wash and Chino Creek. Upthrust and fault lines have helped define the Prado Basin, an extensive low-lying area drained by the Santa Ana and its tributaries before the river passes through the Lower Santa Ana Canyon (CoE 1938c:13-15; Means 1942:10-12).

Prado Basin consists of gently sloping river bottom land, approximately two miles square, bordered by the Puente Hills to the west and the Santa Ana Mountains to the south. To the north and east, the boundaries of the basin are less well-defined, but are generally formed by an irregular rim rising between 30 and 60 feet above the basin, often broken by spring-fed recessions along the edge of the rim. The basin itself is lined with sandy deposits that range in depth between 50 and 100 feet below surface, resting on a water-impervious base of sandstone or shale (Means 1942:10-12).

Local Hydrology

The Santa Ana is a river of extremes, flowing full after winter rains and running almost dry in summer. The seasonal flow is directly related to the semi-arid climate of southern California, with its winter rainy season and virtual drought at other times of the year (Scott 1982:16). The winter rains, which fall anytime between November and March, account for at least 75 percent of the total rainfall in the Santa Ana drainage (U. S. Department of Agriculture 1938). Precipitation is particularly heavy in the San Bernardino Mountains, where the Santa Ana originates in the pine forests of the intermontaine valleys. There, rainfall can average as much as 40 inches per year. In the San Bernardino Valley below, rainfall is much less, averaging about 12 inches per year.

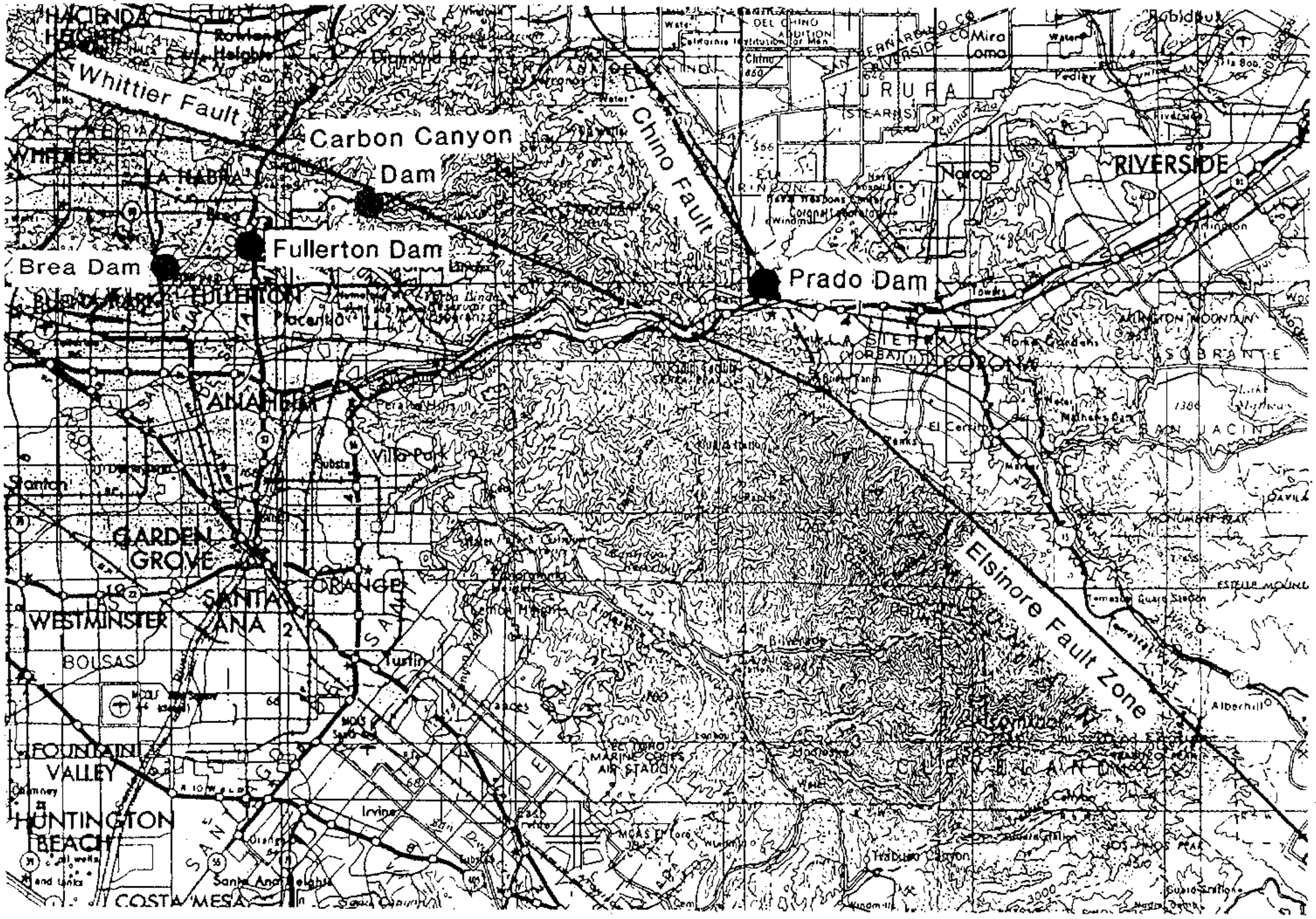

Figure 1.2. Active Fault Lines in Prado Basin (After Analysis of Design 1938: Plate 5)

The low level of precipitation and lack of summer rain limits the vegetation that can grow in much of the project area. The chaparral found below the mountain valleys is not capable of soaking up much water. Even this cover is often reduced by summer fires that leave the ground denuded. Historically, the Santa Ana did not even flow to the sea in summer, losing all of its water to evaporation, plant transpiration along the river banks, and percolation through the soil (Blaney et al. 1930:19). As a result, the river channel on the coastal plain has always been vague and subject to braided flow. Particularly heavy rainfall under these conditions often resulted in a flood, characterized by a wall of water in the mountain canyons, and widespread inundation in the low areas. At such times, the coastal plain, from Newport Beach to the mouth of the San Gabriel River, was subject to flooding (U. S. Department of Agriculture 1938).

The watershed of the Prado Basin, located above the Lower Santa Ana Canyon, contains the upper two-thirds of the Santa Ana watershed, an area of about 1460 square miles. About half of this area is located in the mountains, where water percolation tends to be limited. The other half is on the main valley floor, which consists of vast deposits of sand and gravel. The percolation potential of the valley floor is great (Post 1928:31). This area stores most of the water that eventually forms the Santa Ana River in the Prado Basin.

All moisture that falls on the San Bernardino Mountains or in the upper Santa Ana River valley has to escape to the sea through the Prado Basin and the Lower Santa Ana Canyon, either in the Santa Ana River itself or as part of the underground flow that percolates through the pervious sand and gravel deposits above the shale and sandstone bedrock. Because of this constriction, underground water flow in the San Bernardino Valley, especially from the sandy Cucamonga basin (also known as the Chino Basin; Conkling 1930a:10), is forced close to the surface as it enters the Prado Basin. This augments the surface flow of the Santa Ana River as everything squeezes through the lower canyon (Elliott et al. 1931:34).

As a result of this accumulation, the Prado Basin is far wetter than most areas either upstream or below. The increased moisture can support a luxuriant plant community of willows, tules, brush, trees, and grasses. This underground flow is generally found between 3 and 8 feet below the surface of the basin, with depth depending on distance from the nearest stream and the time of year (Elliott et al. 1931:37). The underground flow from the Cucamonga basin is actually sufficient to create a stream, Mill Creek, which is constantly fed by springs just north of Prado Basin. In 1931, it was noted that Mill Creek was backed up by an earthen dam between 4 and 6 feet high at a point where the stream left the bluff line to enter the basin. The stream flow behind the dam was sufficient to flood a 40-acre area (Elliott et al. 1931:37).

All of this water, forced together at the canyon, is of vital importance to the groundwater supply of the coastal plain. Here, the local rainfall, averaging less than 12 inches a year, is not sufficient to percolate to the water table, or even create viable streams on the south slopes of the Puente Hills and the Santa Ana Mountains (Blaney et al. 1930:21). The Santa Ana River, with its wide sandy bed, is absolutely essential for recharging the groundwater aquifer of the coastal plain (Elliott et al. 1931:9). As agricultural interests began to pump this ground water in the late nineteenth century, and as urban development began to deplete it in the twentieth, the falling water table has been a paramount worry for coastal plain residents, who keep a jealous guard on the Santa Ana River. With the creation of Orange County on the coastal plain in 1889, this proprietary attitude toward the Santa Ana quickly became a driving concern of Orange County officials, who have attacked the twin problems of flood control and water conservation with a single-minded zeal not often found at the county level.

2. PHYSICAL DESCRIPTION - PRADO DAM, RIVERSIDE COUNTY, CALIFORNIA

Dam Embankment

Prado Dam is an earthen structure, the axis of which runs east-west across the Santa Ana River at the upstream end of Lower Santa Ana Canyon (Figure 2.1). The dam abuts the sandstone canyon walls at either end. It measures approximately 2280 ft from abutment to abutment at the crest, and extends approximately 830 ft at mid-dam from the toe of the upstream slope to the downstream toe. A band of spoil material deposited at the base of the downstream slope to prevent scouring adds an additional 250 ft to the lateral dimension of the structure. The dam rises to a height of 106 ft above the stream bed, with the crest at 566 ft above mean sea level (Figure 2.2).

In cross-section, the slope of the upper portion of the dam is symmetrical. The upstream slope maintains a consistent gradient to the toe, while the downstream slope becomes more gradual and is extended farther from the central axis. The crest of the dam is graded level and is crossed by a 20-ft wide asphalt paved roadway flanked by 5-ft wide shoulders on either side. The uppermost portion of the dam is sloped at a 1:2.5 gradient on both the upstream and downstream sides, with the slope lessening to 1:3 at a distance of 90 ft from the central axis. Horizontal berms 20 ft wide running the length of the embankment occur on both upstream and downstream slopes. Two berms exist in the downstream slope while the upstream incline is broken by only one berm. The upper berm in the downstream slope occurs roughly 125 ft south of the centerline, at an elevation of 525 feet. Below the berm the slope changes to a 1:5 ratio until it reaches the second berm, approximately 295 ft from the axis, below which the slope decreases to a 1:6 incline to the toe. The berm across the upstream slope is located approximately 170 ft north of the central axis at the 510 ft elevation level. The 1:3 slope gradient is continued below the berm to the toe.

The composition of the dam embankment is described in detail in Chapter 4. It was constructed with a central core of impervious material approximately 155 ft wide at the base, with random material of graded permeability (least permeable next to core, most permeable material farthest from core) used adjacent to the core on the upstream slope, overlain by a layer of pervious material. For the downstream slope, only pervious material was used. A concrete key wall was set into the underlying foundation material along longitudinal axis of the dam for its entire length, and continuing eastward to intersect the axis of the spillway ogee.

The upstream slope of the dam embankment is paved with a layer of "one man stone" roughly 12-in thick laid on a 6 in layer of spall material. Paving stones used are generally rectangular in section, rough dressed, and hand placed, forming a fairly even pavement over which additional spall material was spread, filling gaps between stones and creating a regular surface. The rock paving immediately adjacent to the control structure is grouted with concrete. The grouted paving is continued below the toe in the intake approach channel which extends to the northeast of the intake structure. The downstream slope of the dam embankment is covered by a 12 in blanket of coarse gravel and cobbles laid directly on the pervious fill material. At the base of the downstream slope a rock toe 30 ft wide and roughly 10 ft thick was constructed using "toe rock"- rocks weighing up to 1000 pounds. Toe rock was also used at the toe of the upstream slope and along the border of the upstream berm. The downstream toe and the lower portion of the slope are covered by a substantial layer of spoil material, roughly 250 ft in breadth and up to 25 ft thick, that is graded nearly level and acts as

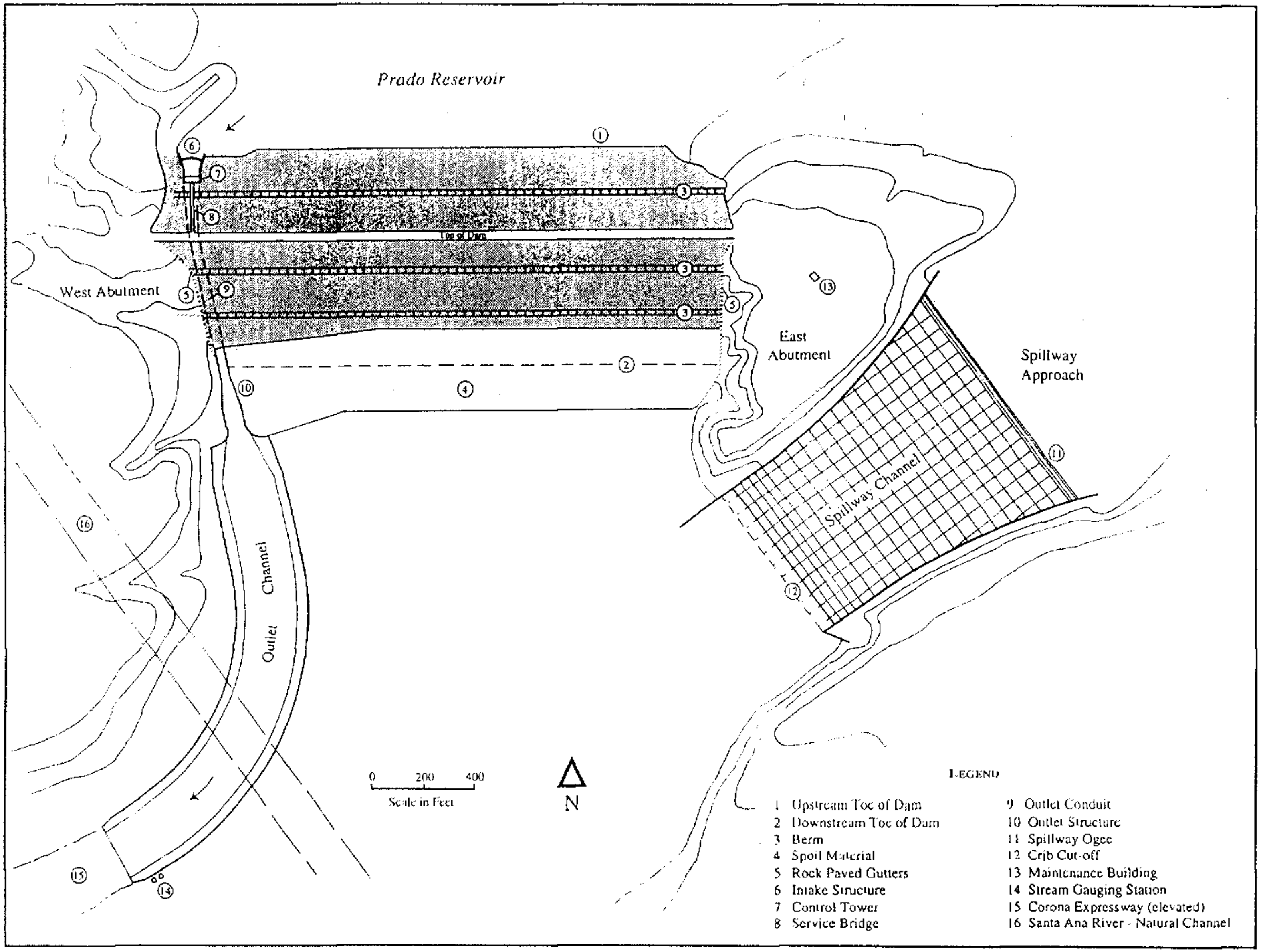

Figure 2.1. Schematic of General Plan of Prado Dam.

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Figure 2.2. Overall Upstream View of Dam. (Photograph by Wayne Rowe)

scour protection for the base of the slope at times when water is discharged from the spillway. The downstream terminus of the spoil layer is paved with 12 in rip-rap. The surface of the layer is regularly graded to keep it free of vegetation.

The downstream dam slope is crossed by a system of grouted rock paved gutters, placed to collect and drain away surface run-off. Constructed of rough-dressed stone, the gutters are approximately 4 ft across and 1.5 ft deep, with flat bottoms and sloped sides. Two gutters run the length of the embankment along the northern edge of each berm. These drain into four gutters that run downslope, perpendicular to the dam's axis, along either embankment/abutment interface, and at two locations in the central portion of the dam. The two outer gutters begin at the dam crest and angle inward toward the center of the dam initially, then run straight down slope. The west gutter drains into the outlet structure and the east empties below the rip-rap toe of the spoil berm. The outer gutters are open; the central gutters, and also along the berms, are covered by the 12 in blanket of gravel which protects the downstream slope and are not apparent on the surface. The inner gutters likewise drain into the depressed basin below the rip-rap toe.

At the base of the upstream embankment, beginning immediately west of the intake structure, a raised berm (or levee) with a level crest 20 ft wide and sloped, grouted rock sides extends to the northeast roughly 400 ft into the reservoir (CA-178-B-2). The berm forms the west bank of the intake approach channel and also serves to direct water emptying from a small drainage in the slope forming the dam's west abutment away from the intake and into the reservoir, thereby preventing the accumulation of silt in the approach area. The outermost portion of the berm is surfaced with ungrouted stone paving. A boom of linked planks extends across the intake approach channel from the end of the berm southeasterly to the dam embankment, preventing debris from reaching the intake trash racks.

From the paved access road which enters the Prado Dam site from Route 71 to the west and crosses the dam crest, an unpaved roadway branches at the west end of the upstream slope adjacent to the abutment, allowing maintenance vehicles to access the intake structure, base of the control tower, and berm during period of normal water level. Another unpaved access road also descends from the dam crest to the basin below the dam and spillway along the east abutment/embankment interface. The outlet structure, outlet channel, earthquake monitoring stations, and stream gauging station may be reached from this roadway.

Two small metal clad sheds on concrete slab foundations are located along the south edge of the dam crest at the center of the embankment and at the dam's east end. A similar 5 ft 4 in square structure exists to the south of the dam, below the rip-rap toe of the spoil area. These structures house celographs, strong motion indicators, which record seismic activity of a magnitude of 3.5 and above on the Richter scale.

Outlet Works

The flow of water from the Prado Reservoir is controlled by the outlet works. Located at the west end of the embankment, they comprise the intake structure situated at the base of the upstream (north) embankment slope, concrete outlet conduits which carry waters beneath the embankments, and the outlet structure itself, consisting of an open conduit and stilling basin, from which discharged waters continue their downstream course along the outlet channel. The intake structure functions as a base for the control tower which rises to the level of the top of the dam and is surmounted by the control house - architecturally the most intriguing elements of the Prado Dam complex. A service bridge which extends from the top of the dam embankment provides access to the control house.

Intake Structure

The intake portion of the outlet works channels in-flowing reservoir water into the outlet conduits. It contains the control gates which regulate the flow of water through outlet works and acts as a base for the control tower (CA-178-B-4). Constructed of cast-in-place concrete, the intake structure is essentially rectangular in plan, with gravity-type side walls flaring outward and extended into the intake approach channel at the north end (Figure 2.3). The intake portal bay, which comprises the upstream portion of the structure, has a semicircular north face defined by seven rounded piers. The piers carry horizontal members that radiate out spoke-like from the deck covering the outlet conduits. The intake structure serves to funnel waters into six concrete conduits which are rectangular in section and arranged in line; these, in turn, contain the control gates. The piers and roof beams of the intake entrance bay essentially act as framing for metal "trash racks" spanning the piers: These grills fit into vertical slots in the piers and prevent large pieces of debris from flowing into the conduits and control gates. A metal frame above the trash racks carries a track mounted mobile maintenance winch used in cleaning the rack. Steel trash racks cover the open top of the intake structure as well, allowing overflow to enter from top and front during periods of high water. The openness and perceived lightness of the intake enhances the overall sense of permeability and weightless quality of the outlet structure and tower when viewed from the north. The total height of the intake structure is 40 ft, measured from the invert (floor of channel), and it is approximately 94 ft across at the entrance.

The inlets to two 66-inch unrestricted bypass pipes, which allowed continuous drainage of water from the reservoir, exist in the side walls of the intake chamber. They were later sealed when water conservation became a function of the dam's operation, in addition to flood control, in the 1950s and 1960s. A concrete encased 60-inch steel infiltration pipe which extends upstream to collect water passes beneath the intake structure invert.

The control gates are seated at the very base of the outlet conduits. The 7 x 12 ft, 11 ton, riveted steel gates move within cast iron frames with steel roller races. Broome caterpillar-type gates manufactured by Philips and Davies, Inc. of Kenton, Ohio were selected for use as their roller hearing movement made them more durable and less likely to jam due to water pressure or silt than simple slide gates. Each gate is individually raised and lowered by means of a series of six 1-in diameter steel cables attached to a sheave at the top of the gate and a drum hoist in the control house above. The control cables descend through an aperture in the top of the control structure base (CA-178-B-9). Removable steel plates in the deck of the control structure allow access to the gate well for maintenance or removal of the gate assemblies.

Immediately south of the control gates, the six outlet conduits are merged in a 90-foot section referred to as the conduit transition into a double conduit.

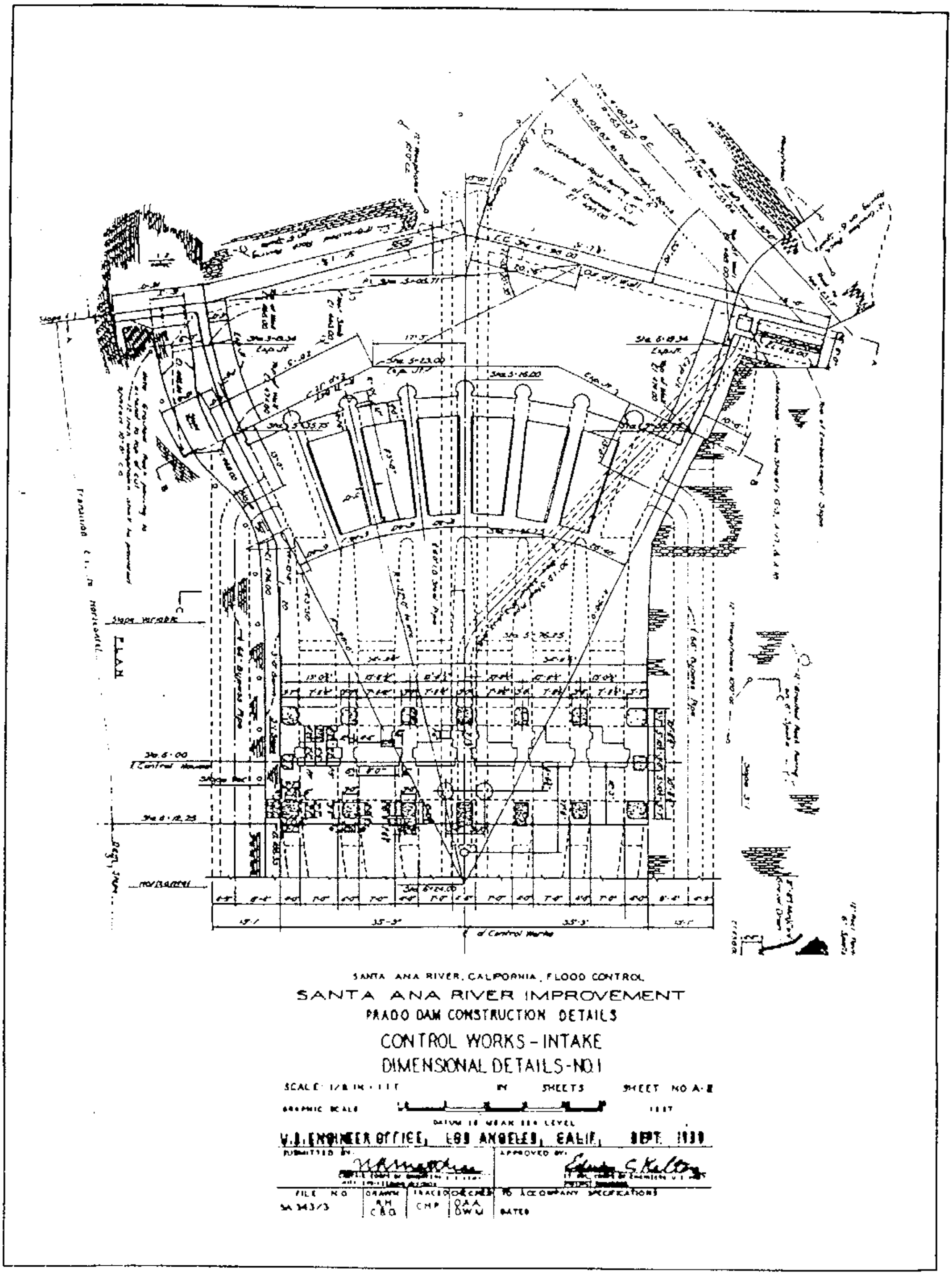

Figure 2.3. Control Works - Intake Plan View

Control Tower

The control tower is an open, rigid frame design incorporating concrete columns and horizontal struts formed of cast-in-place reinforced concrete (Figure 2.4). The three tier tower is surmounted by a monolithic single story control house. The open frame of the tower creates a lightness which is balanced by the solidity of the mass of the control house. The tower rises from the southern end of the intake structure and its upright members bear on the substantial walls of the outlet conduits below. Its total height to the top of the control room is approximately 84 feet. The tower is six structural bays wide by one deep, though the ends have an

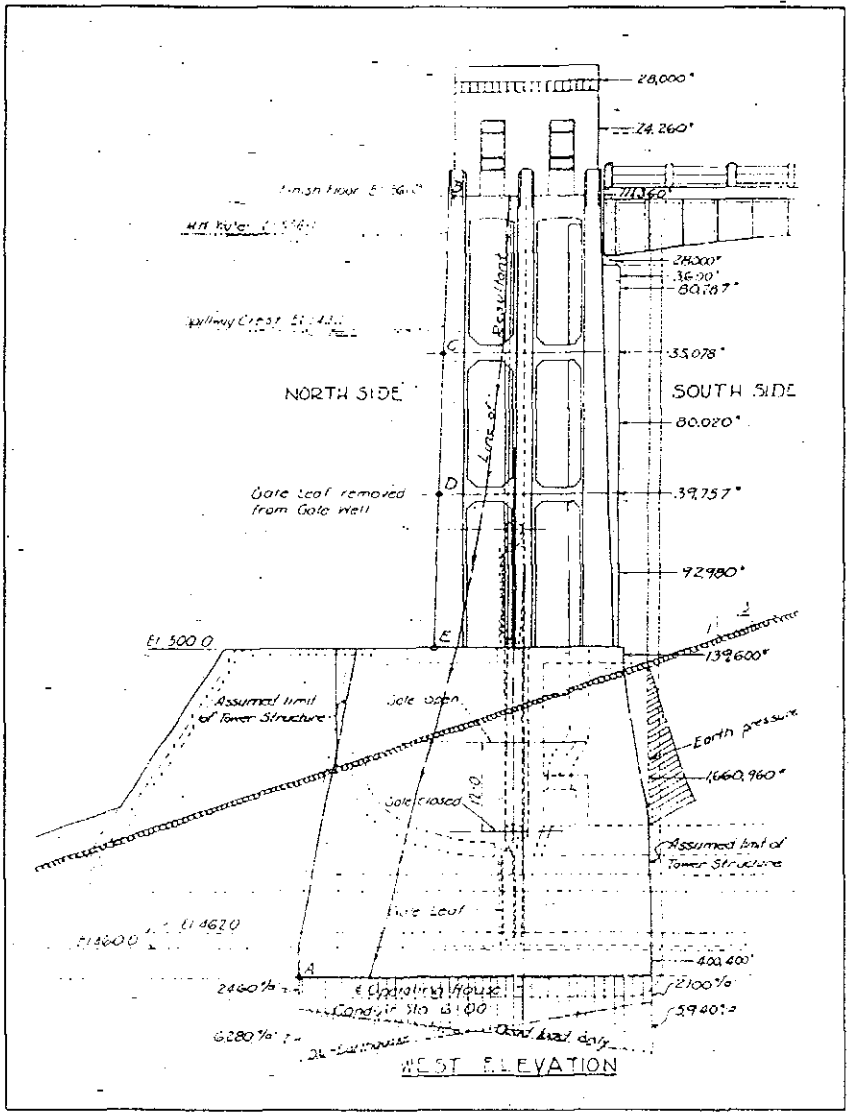

Figure 2.4. Control Tower and House

intermediate column. In a manner typical of the Art Deco style, the scale of the tower is exaggerated somewhat by the slight attenuation or "battering" of the outer surfaces of the columns. At 70.5 x 22 ft, the base is somewhat more than 2 ft wider than the top of the structure. The outer comers of the rectangular section columns display a chamfered reveal, which also serves to diminish the perceived mass of the members. The tapering of the vertical elements is continued as the columns are extended up the face of the control house in the form of reduced pilasters with stepped heads which terminate at the window sill level. The horizontal members spanning between columns are rectangular in section, with slightly beveled edges, and are flared at the ends, dumbbell-shaped. The three central columns on the south side are deeper, and carry an additional cross member on which the north end of the control tower service bridge is supported. The uppermost horizontal members are segmentally arched and form the base of the control house. Immediately north of the central vertical member on the south side, two large diameter steel air vent pipes rise from the intake structure, terminating immediately below the control house. The vent pipes are attached to a gallery with ducts into the conduits immediately behind the gates.

The Control House

The control house is a symmetrical rectangular structure, one story in height with a parapeted flat roof. The cast-in-place concrete walls are smooth finished, and the heavy horizontal impressions of the narrow board forms used on the tower structure and base are not apparent here. Its fenestration is regularly placed, with two windows in the east and west elevations, six windows in the north elevation, and two windows on either side of the central entrance in the south elevation. The single entrance is accessed by way of a service bridge which extends from the top of the dam embankment. Beyond the tapered pilasters which occur in the lower wall, an 18 inch reeded frieze band at ceiling height is the only decorative embellishment of the control house. The frieze band is interrupted at the center of the south elevation and "PRADO DAM" in simple block capital letters the height of the frieze is inset in the wall above the entrance (Figure 2.5). The streamlined typographic style is typical of the era. The entrance is without elaboration, consisting of double, vertical folding, hollow metal doors with a narrow molded metal frame. Each leaf is hinged in the center, with one elongated molded recessed panel in the upper portion of each section leaf. The panels were originally glazed, each containing three wire glass lights. The original wall mounted lamp which hung above the door has been replaced with a halogen flood light. A metal date plaque mounted on the exterior wall immediately east of the door bears the inscription: "Constructed by the U.S. Army Corps of Engineers 1941."

The three light steel casement windows also had wire glazing which has been replaced with metal panels. The lower and central sash are operable hopper and awning-type casements, the lower sash opening inward, and the upper sash, outward from the top. The windows have simple steel frames set in openings with beveled edges. Recessed panels below the windows extend from sill to base of the control house.

The interior of the control house is a single large room dominated by the six 60-ton drum hoists used to raise and lower the control gates (Figure 2.6). A small frame office enclosure has been added in the southwest corner. The hoists are arranged linearly and numbered 1-6 moving west to east. The walls and ceiling of the control house are of unfinished concrete. The floor has a grey painted finish, as do the infilled windows and door. Exposed concrete roof beams are trapezoidal in section and run north-south, spaced 2 ft 7 in apart. The north and south wall planes are interrupted by engaged columns corresponding in location with pilasters on the exterior of the building. The columns are rectangular in section. They protrude from the walls 1 foot, terminate approximately 1 foot above the level of the window heads, and carry steel I-beams on which the tracks for a traveling crane are mounted. Lighting in the control house consists of suspended industrial fixtures with metal shades.

FIGURE NOT AVAILABLE

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Figure 25. Detail of Control House. (Photograph by Wayne Rowe)

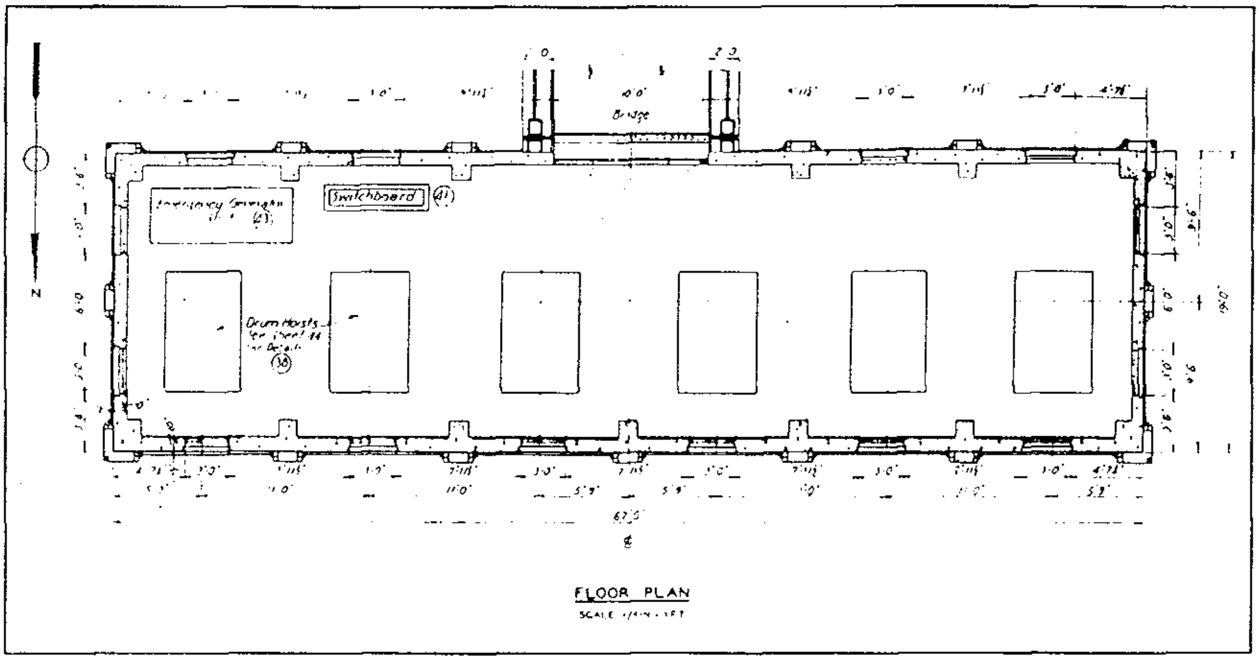

Figure 2.6. Control House Floor Plan

The frame enclosure in the southwest corner of the control house functions as the dam keeper's office. Added to the control house in the late 1950s, the enclosure measures 6 x 8 ft and is 8 ft 2 in in height with an open ceiling. The painted plywood enclosure has a wood hollow core door and currently houses computer equipment linked to the regional flood control telemetry system.

The drum hoists used to raise and lower the control gates were manufactured and installed by Philips and Davies, Inc., of Kenton, Ohio (CA-178-B-14). Each 60-ton capacity hoist is mounted on a 5 x 8 ft riveted steel I-beam base and is powered by a 6.25 horsepower, 13/26 amp, 440 volt, 50 cycle electric induction motor manufactured by General Electric. The motor turns a series of massive gears, and ultimately the cable hoist drum mounted at the north end of the unit. The hoist is controlled by a four position magnetic switch located at the southeast corner of the unit. A gate leaf position indicator with a large circular dial attached to the hoist drum indicates the height of the "gate opening in feet." These indicators provide readings based on the amount of cable fed out, but do not necessarily give a true reading of the position of the gate, e.g., in the instance of a jammed gate. For this reason, a second set of linear gate height recorders, which are connected directly to the gates via conduits on the south wall/columns, was later installed along the north wall of the structure. An electric gate height recorder box mounted below each gauge keeps a permanent record of gate heights. Six, 1 in diameter steel cables which descend through 4 ft rectangular openings in the floor of the control house connect the drum hoists to pulleys or "sheaves" at the top of the control gates. The hoists are capable of raising or lowering the gates at a rate of one foot per minute. They may be turned by hand in an emergency, at 600 rotations per foot of height.

Immediately northeast of the control house entrance is a free-standing electrical switchboard from which power to the drum hoists, traveling crane, and lights is controlled. Electrical service is supplied to the switchboard via a conduit run from the top of the dam and across the service bridge. From the switchboard, the power supply to the gates may be transferred from the utility grid to the backup generator within the control house, or to an alternate backup generator which would be brought to the site in an emergency situation. The switchboard has a steel case mounted on a concrete base and is 6 ft 4 in high by 5 ft 4 in wide. In addition to fused switches for each piece of machinery, the switchboard also includes ammeters and voltmeters to monitor performance and test blocks and plugs for equipment testing. A circuit panel for lights on the interior and exterior of the control house is mounted on the east wall.

The original gasoline powered backup electrical generator located in the southeast corner of the control house was replaced with the present diesel powered generator in the mid-1960s (Riggle, personal communication 1996). The present CAT Electric Set D320 Series A generator is capable of producing 75 kilowatts and utilizes the original mounting platform. An exhaust stack exits through the roof of the building.

The control room is equipped with a three-ton, electrically powered traveling crane capable of moving the drum hoists or other equipment for maintenance or replacement. The crane moves the length of the building on I-beam mounted tracks atop the pilasters along the north and south walls. A single steel I-beam cross-rail allows the hoist mechanism to traverse the building. The crane was manufactured by Wright and is original to the building.

Telemetry equipment use to monitor water depths in the outlet channel is also housed in the control room. A water surface recorder (float gage recorder) manufactured by Leapold & Stevens Instruments, Inc. is mounted on the south wall, immediately east of the entrance. The mechanism uses clock and counterweight operation rather than electricity. The float mechanism descends from the recorder to the outlet works through a "well" - a 20-in diameter steel pipe - located at the north end of the service bridge and tied to the central control tower support.

Service Bridge

The service bridge provides access to the control house from the roadway at the top of the dam embankment. The bridge is riveted steel plate girder below-deck structure consisting of two spans with a total length of 190 ft 2 in (CA-178-B-43). The south end of the structure is supported on a gravity-type concrete abutment with reinforced concrete wing walls which give the bridge an overall length of 218 feet. The north end of the bridge bears on built-out sections of the three central columns on the south side of the control tower. The spans are also supported by a monolithic concrete central pier. The pier is rectangular in section and attenuated, being 12 ft wide at top and flaring to 39 ft below embankment slope. The pier extends through the dam embankment to bear on the outlet conduit. Connections at the abutments and at the central pier are pinned, with rocker supports at both the north and south ends. Riveted steel plate girders with arched lower chords which would compliment the arches of the control tower were originally planned for the service bridge. Plans were later revised to employ straight girders. The bridge girders are 6 ft ½ in deep, placed 8 ft apart, and braced internally with diagonal struts and regularly placed cross-members. An 8-in reinforced concrete slab forms the bridge deck, with a 10 ft wide vehicle lane and 2 ft wide concrete curbs on either side. Railings placed atop the curbs consist of square concrete posts 3.5 ft in height and 8 ft apart spanned by three pipe railings with flanged connections. Set in the center of the north end of the bridge deck is a hinged steel plate door providing access to the float gage recorder box and float gage recorder well - an 18-in pipe which descends to the outlet conduit from this point. The well is attached to the central column of the control tower with three steel brackets. A steel pipe rail gate placed at the joint of the south span and the bridge abutment prevents unauthorized access of the bridge and control house.

Outlet

Upon passing through the control gates, released waters immediately enter the conduit transition, a 90 ft section in which the six outlet conduits merge into two adjoining closed outlet conduits, each measuring 13.5 ft square, constructed of reinforced concrete 4 ft thick. At regular intervals along the exterior of the conduit structure are concrete "cut-off collars" - baffles which prevent the seepage of water along the outside of the conduit (CA-178-B-24). The alignment of the conduit bends gently to the southeast along its 684 ft length before released waters exit the outlet portal and are discharged into the outlet structure.

The outlet structure consists of an open conduit the same width as the closed conduit 126 ft long with vertical concrete walls, and the stilling basin (CA-178-B-17). Upon entering the basin, the floor (or invert) of the channel slopes 20 ft and the outlet widens from 31 to 70 feet. Over the 200 ft length of the stilling basin, discharged waters flow over a series of three rows of baffle piers - stepped piers 5 ft in height which act to slow the speed of the effluent and, finally, a full width stepped baffle curb located at the downstream end of the basin. Waters in the basin are contained by vertical concrete gravity-type walls and channel floor slabs 5 to 6 ft thick. Immediately downstream of the baffle curb the outlet walls curve sharply outward, becoming perpendicular to the channel and extending to a total width of 223 feet. At this point, waters enter the outlet channel.

The channel has side walls or banks sloped at a 1:2 gradient which extend outward to the ends of the flared concrete outlet walls. The banks and channel bed are paved with three feet of grouted rock derrick stone for the first 50 ft, then 12 in grouted rock paving. Beyond the outlet structure the outlet channel gradually widens to a maximum width of 272 ft and becomes shallower, 12 ft from the bed to top of bank. Upon attaining its ultimate depth and width, the grouted rock paving of the outlet channel bed is discontinued and uncompacted backfill is used for the remainder of the channel's length. The grouted rock banks extend to the end of the outlet channel, with 12 in of rock on 6 in of spalls, and a 7 ft thickness of "two man" stone deposited at the toe of the slope. The outlet channel continues southward and curves to the west, passing beneath the Corona Expressway and ultimately terminating 1850 linear feet southwest of the outlet structure. The improved outlet channel terminates with a sheet steel piling cut-off wall extending across the width of the channel, the top driven flush with the channel floor. Immediately downstream of the cut-off wall, the channel bed is again paved with three feet of grouted rock paving, which drops gradually over 50 ft to the level of the natural channel of the Santa Ana River. Large boulders and pieces of concrete have been placed in the river channel downstream of the improved channel to prevent scouring as the flow reenters the unmodified waterway.

Spillway

The spillway is a secondary control structure which functions during periods of high water levels in the Prado Reservoir. Trapezoidal in plan, the spillway is approximately 1147 ft in length, slightly over 1000 ft wide at the upstream end, and 660 ft at its outlet (Figure 2.7). Elements of the structure include the ogee, a broad barrier which allows water to spill from the reservoir evenly across its entire width, the spillway channel, a broad, tapering channel with a concrete floor and walls, the drop structure or "lip," and the cut-off crib or "bucket." The spillway is located east-southeast of the dam embankment. Its axis is rotated 37 degrees counter-clockwise from the east-west axis of the dam; the ogee runs northwest-southeast. The structures are separated by the elevated area which serves as the east dam abutment and the northwest boundary of the spillway, and are approximately 325 ft apart at their closest point. The spillway's southeast wall is also bounded by an elevated bluff.

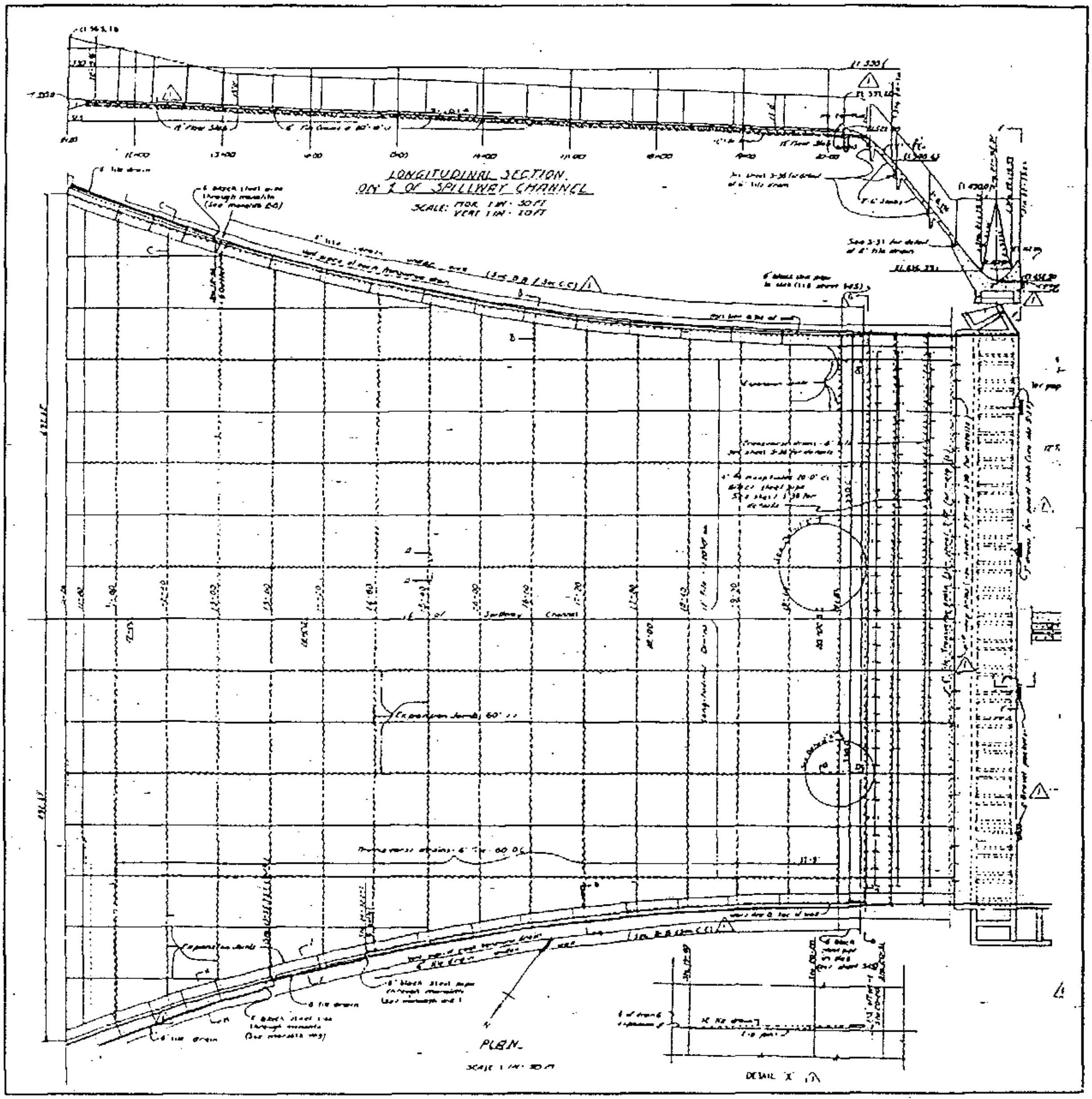

Figure 2.7. Plan View of Spillway Channel.

The spillway ogee is formed of reinforced concrete and is supported on gravity-type foundations (CA-178-C-2). The northeast face of the structure is a straight, vertical wall which rises to a height approximately 12 ft above the approach channel to the northeast. A 20-ft wide concrete slab apron runs the length of the base of the ogee. At the top of the vertical face, the ogee curves upward slightly before recurving and sloping gently downward over roughly 50 ft to meet the plane of the spillway channel. The superstructure resembles the top half of an airfoil with a blunt leading edge in cross-section. The elevation at the crest of the ogee is 543 ft above sea level, which is 13 ft below the maximum high water level of the dam, and 23 ft below the dam's crest.

The spillway channel is at an elevation of 535 ft above mean sea level where it meets the base of the ogee. Perfectly horizontal in transverse section, the floor of the channel drops 13 ft over its length before reaching the lip at its southwest end. The spillway channel is composed of reinforced concrete slabs measuring 60 x 60 ft and 12 in thick. Each expansion joint between slabs in the transverse direction is underlain by 6 in drain tile. Twelve-inch collecting tiles underlie every other joint (120 ft apart) running the length of the channel and draining through the face of the spillway lip. The outermost slabs, which support the gravity and cantilevered side walls, are heavier, measuring 2 ft 8 in to 3 ft thick, with keyed connections to the interior slabs. At its southwest end, in the section referred to as the spillway "lip," the spillway channel slopes steeply, dropping approximately 55 ft to the cut-off crib or "bucket." The cut-off crib is a long trough-like structure designed to break the fall of exiting waters and prevent erosion of the underlying strata. Leaving the cut-off crib, the discharged water reenters the natural flood plain of the Santa Ana River. The cut-off crib is a heavily reinforced structure formed of concrete up to 11 ft thick which is supported on coffer-type foundations 62 ft deep. The spillway lip is constructed of 2 ft 6 in thick slabs supported along the north and south edges by foundation walls 7.5 ft deep. Four rows of 4-in weep holes along the face of the spillway lip allow ground water to escape. The spillway bucket was back filled after construction to the 470 ft elevation level - completely concealing the structure.

A combination of gravity and cantilevered reinforced concrete walls, poured in 60 ft long monolithic segments, was used to construct the side walls of the spillway channel. Cantilevered wall segments - inclined walls which rest on the outer edge of the channel floor slabs and bear in part on the sandstone walls of the abutments - were used in the central portions of the channel walls where structural forces exerted by discharged water would be the least (Figure 2.8). In areas at the north and south sections of the channel, gravity walls were employed. The self-supporting gravity walls bear completely on the outer edge of the channel slabs. The outer face of the gravity walls is vertical, while the inside wall plane is sloped at a ratio of 4:1. This degree of slope holds true for all channel wall sections, including the cantilevered sections. Also, both cantilevered and gravity wall sections have keyed joints with the channel slabs, which prevent horizontal movement. Cantilevered wall sections are uniformly 1.5 ft thick and 15 ft high. Gravity-type wall sections are also uniformly 1.5 ft thick at the top, but their thickness at the base varies relative to the wall height (Figure 2.9). Fifteen feet is the minimum wall height for the spillway, and at this height, the basal dimension of the gravity wall is 5 ft 3 in, while at a point adjacent to the ogee crest where the wall rises to a height of approximately 29 ft, the base of the wall is 10 ft 3/4 inches. In the area adjacent to the ogee, the spillway side walls are higher. Their height begins to increase in a regular slope 180 ft south of the ogee, reaching a maximum height of 30 ft at the ogee axis (17 feet higher than the top of the ogee). In this area the length of the monolithic segments is reduced to approximately 42 ft, and an additional 3-ft deep footing is added to the base of the supporting slab. The side walls are extended beyond northeast face of the ogee for a distance of approximately 85 ft, decreasing abruptly with distance to near grade level. In the spillway approach area, the side slopes behind these wall extensions are covered with rock paving.

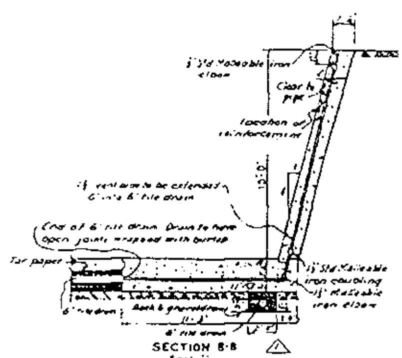

Figure 2.8. Cantilevered Reinforced Concrete Wall.

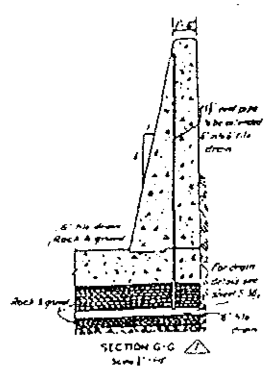

Figure 2.9. Gravity Reinforced Concrete Wall

The side walls are also elevated in the area at the ends of the spillway hucket, where they rise to a height of 37.5 ft above the base of the bucket. On the west, the cut-off wall is extended 206 ft beyond the end of the bucket, in line with the side wall. The wall extension directs the flow of discharged water to the southwest, away from the dam embankment and east abutment, and toward the natural Santa Ana River channel. At the east end of the spillway bucket, the side wall turns sharply to the east at the end of the bucket, extending an additional 115 ft to embed itself in the rock sideslope. The cut-off wall extensions on both the east and west sides are partially freestanding and are supported by deep coffer-type foundations 50 ft wide. Soil was backfilled along the outer face of the east and west sidewalls to the top of the walls, with a horizontal berm 20 ft wide left between the wall and the side slope on either side. The sidewalls are surmounted by chain link security fences. Run-off from the side slopes is collected in a single rock-paved gutter on either side, which empties into the spillway near its north end. Ground water is drained through weep holes in the side walls. The broad approach to the spillway, and the spillway outlet have been graded level and planted with grass which is maintained and kept free of trees and brush.

Maintenance Building

A small structure used for storage of equipment used in dam maintenance is located on the elevated piece of land between the east dam abutment and the spillway (CA-178-D-1). Built in 1941, the building was originally associated with the dam caretaker's residence, now demolished, which stood immediately west of the structure. The maintenance building is a one story, wood frame, stucco clad structure with a low-pitched hipped roof. It is rectangular in plan with a low, shed roof addition on the northeast side. The addition is also of wood frame construction, with asbestos shingle cladding applied over the original clapboards.

The maintenance building rests on a concrete slab. The north elevation is dominated by a full-width vertical metal panel, tilt-up garage door - an alteration of the original design. Personnel doors are located in the southwest and southeast sides. The southwest door is a single panel wood door centered in the elevation, with a two-over-two double-hung sash window with horizontal lights placed southeast of the door. A one-over-one sash window occurs in the southeast wall, and the second personnel entrance is located in the southeast side of the shed-addition. It is a wood hollow core door with a small two light casement window placed immediately to the northeast. An identical window exists around the corner on the northeast wall and both windows relate to a bathroom in the east corner of the shed. A large window on the northeast elevation has been infilled. All of the windows and doors of the garage have been covered with metal security bars. The maintenance structure is unfinished on the interior, with exposed frame and wall cladding, except for the rear third of the building which was used as an office area at one time and is finished with painted plywood. The bathroom is in the east corner of the shed addition, with the remainder of the wing providing additional equipment storage space. The structure's roof is covered with composition shingles. Concrete slabs exist on the northwest and southwest sides, with concrete walks along the other two sides as well. A small metal clad portable shed stands off the west corner of the structure, and the entire maintenance building and surrounding concrete apron are enclosed by a chain link fence.

Approximately 100 ft southwest of the maintenance building, a second fenced enclosure contains three cylindrical metal storage tanks and a small wood framed shed. The tanks and the shed rest on concrete slabs. The largest tank is an upright galvanized corrugated steel tank with a conical roof used for water storage. The two other tanks are used for chlorine mixing and pressurization. The shed is clad with horizontal drop siding with a roof composed of corrugated sheet metal (no roof framing). A one panel wood door is present in the south wall of the structure and a fixed, multi-light window in the north wall has heen covered. The shed houses a pump and water controls.

Stream Gauging Station

Approximately 2100 ft downstream from the dam outlet, near the southern terminus of the modified portion of the outlet channel, immediately adjacent to the east bank of the channel, are two small utilitarian structures which house stream gauging equipment. Both buildings were built and maintained by the United States Geological Survey (USGS); they are a single story in height and square in plan. The eastern structure is of relatively recent construction, built of concrete block with a flat roof. It has no openings beyond a steel slab-type door in the south elevation and it is supported on a concrete slab foundation. An antenna is attached to the building's west side and a steel pipe extends from the base of the north wall into the river channel.

The western building is constructed of cast-in-place concrete and is contemporaneous with the dam. Although a modest utilitarian structure, the stream gauging shed displays several Art Deco stylistic elements, design flourishes which are noteworthy in a building of its scale and function (Figure 2.10). Constructed of cast-in-place concrete and set on a concrete slab, the structure is covered by a low-pitched pyramidal hipped roof which is also of cast concrete. Corners of the building are expressed with chamfered squared corner pilasters that terminate in stepped back heads. Narrow vertical windows are centered in both the east and west wall. The openings have beveled edges and are infilled with metal panels through which electrical conduits now protrude. Small rectangular screened vents also occur at the lower right corner of the west wall and the upper left corner of the north wall. Entrance to the building is by way of a steel industrial type slab door in the south elevation. A galvanized steel cabinet is attached to the north wall of the structure, and a grated opening and plate steel access door exist in the grouted stone bank of the outlet channel immediately below the structure to the north. A large diameter steel pipe supporting an antenna stands immediately west of the building.

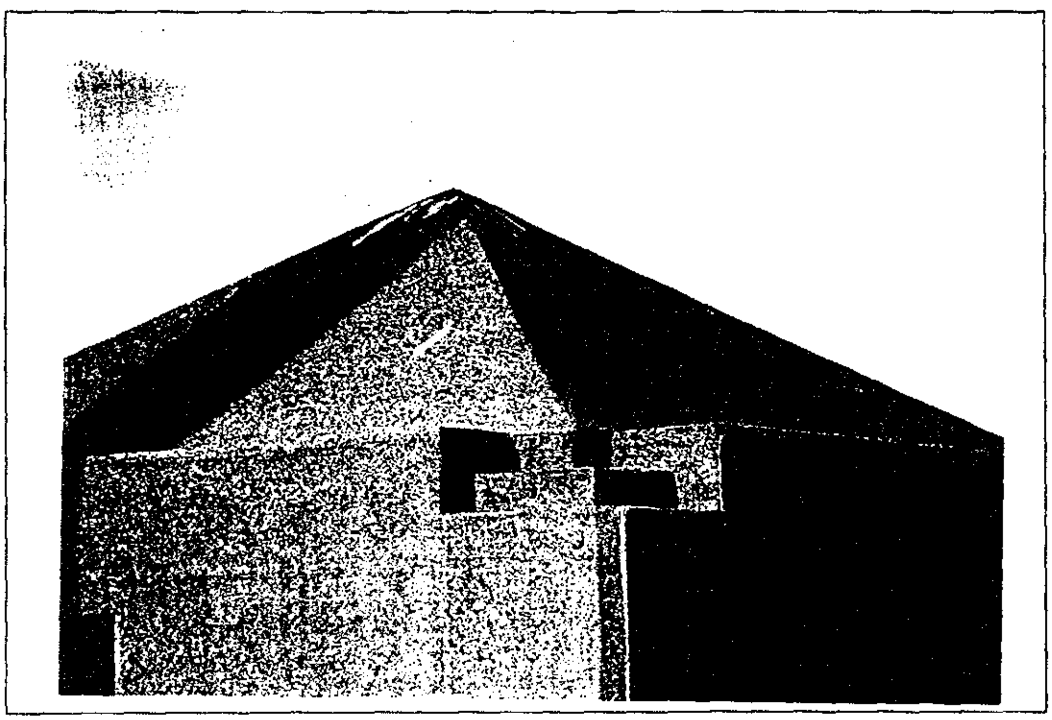

Figure 2.10. Detail of Stream Gauging Station (Photograph by Dana N. Slawson)

3. EARLY PLANNING CONCEPTS

Floods and Water Rights

Vernon C. Heil, former president of the Orange County Farm Bureau and chairman of the Orange County Water District, once said that, "there are only two times when people are vitally interested in the supply of water; when there is too much of it,... or when there is too little" (*Farm Bureau News* 1944). One or the other problem has always confronted Orange County, and the solutions to both have proven increasingly difficult with the subsequent development of the coastal plain. Unlike San Bernardino and Riverside counties, Orange County does not have direct access to the mountain run-off that naturally recharges the underground water table and supplies the Santa Ana River with its water. Orange County, limited to the coast, is dependent on the Santa Ana itself for both surface water and the water needed to recharge the water table. For this reason, the Santa Ana has always been of vital interest to Orange County residents and their elected officials.

At the time Orange County was separated from Los Angeles County in 1889, water conservation was not yet a major concern because the demand on the water table was still low. When this problem finally came to the attention of Orange County water interests around the turn of the century, they were quick to buy land and water rights in the Prado Basin to secure a reliable flow of water in the river downstream. The major water interests involved in this operation were the Anaheim Union Water Company, the Santa Ana Valley Irrigation Company, and the Santa Ana River Development Company (Orange County Water District 1948). The latter bought the huge Durkee Ranch in the center of the Prado Basin around 1900 for the sole purpose of acquiring water rights to the Durkee Ditch, so that its water could be returned to the Santa Ana. This action also stopped most ditch use for crop cultivation (Scott 1977:92). By the terms of an agreement dated to 1907, the Santa Ana River Development Company allowed the waters from the Durkee Ranch to flow down the Santa Ana, where the water rights were bought by Anaheim Union and Santa Ana Valley Irrigation (Conveyance 1907).

From this beginning, the Santa Ana River Development Company continued its expansion in the Prado Basin. By 1930, the company had bought up much of the land and water rights around the Santa Ana River, to ensure the supply of water into Orange County (Scott 1977:89).

The initial expansion of Orange County water interests into the Prado Basin helped lead to the creation of the Tri-County Water Conservation Association in 1909 (Hinckley 1944). The association, formed by representatives of San Bernardino, Riverside, and Orange counties, agreed to reduce river evaporation by allowing water to percolate into the gravel and debris cones in the river beds immediately below the mountains. For a while, this helped recharge the underground aquifers around San Bernardino with enough water left over to contribute to the flow of the Santa Ana at Prado Basin. As agricultural development in San Bernardino and Riverside counties increased rapidly in the early twentieth century, the upstream counties drew off more water, affecting water conservation in the Prado Basin. Orange County became dissatisfied and finally withdrew from the association altogether in 1932 (Bookman and Baker 1949:13-14).

In many ways, the 1916 flood was the turning point in the brief era of tri-county cooperation. Most of the Santa Ana River floodplain below the canyon was inundated as the river left its banks and washed over northwest Orange County (Figure 3.1; Orange County Flood Control District [OCFCD] 1931). Orange County, with the most to gain from both flood control and river water conservation, began to consider taming the Santa Ana and regulating its flow. After 1916, Orange County became more acutely aware of its own

FIGURE NOT AVAILABLE

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Figure 3.1 Extent of 1916 Flood in Orange County (After Elliott et al. 1931: frontispiece).

interests in this matter. As its need for flood control and water increased, the county's water interests began to diverge from those of Riverside and San Bernardino counties. Orange County began to act on its own.

The first action of Orange County was to begin monitoring the complex pattern of water flow in the Prado Basin, an operation that became comprehensive after about 1930. Soon it was noted that the artesian wells of Chino, covering a 23 square mile area in 1900, became progressively weaker until they finally ceased to flow unaided by around 1940 (Elliott et al. 1931:37; Means 1942:17). This development was attributed to the increase in groundwater pumping in the Pomona and Ontario areas (Means 1942:17). In the Prado Basin itself, the increase in irrigation water drawn from wells along Mill Creek and Chino Creek began to lower ground water levels and decrease the flow of water in the Durkee Ditch, which only averaged five second-feet (i.e., cubic feet per second) in 1931 (Elliott et al. 1931:37-39). By this time, about half of the land within the Prado Basin was irrigated, mostly from wells and springs adjoining Chino Creek. Although the use of irrigation water in the Prado Basin, computed to be 1.25 acre-feet per acre, was consistent with other areas of southern California (Elliott et al. 1931:45-46), the continued development of the area could only pose a threat to Orange County, which was solely interested in getting basin water downstream as quickly as possible.

To monitor the flow of the river as it entered the Santa Ana Canyon, Orange County officials took measurements of the river's mean monthly discharges, starting at least as early as 1919. January was found to be the month of the greatest mean flows, ranging from about 100 to 170 second-feet; August had the smallest, ranging from about 30 to 70. It was noted that the annual river discharge had a tendency to shrink from year to year, an omen viewed with the utmost concern (Means 1942:22). Orange County officials could read the handwriting on the wall: while everyone admitted that something had to be done about flood control, Orange County knew that something had to be done about water conservation as well.

The First Studies

Water conservation was a perennial issue, but it seemed that only floods got immediate results. The idea of a dam on the Santa Ana to control floods and effect water conservation was seriously entertained only after the 1916 flood. The first engineering investigation for a dam site within the Prado Basin was conducted in 1918 by a body of consulting engineers - John H. Quinton, F.H. Olmstead, A.L. Sonderegger, and W.K. Barnard - retained by the boards of supervisors of Orange, Riverside, and San Bernardino counties. Little is known about this study, except that later investigators found it general in nature. This report apparently identified the need for both flood control and water conservation (Bookman and Baker 1949:4), and recommended additional study and a continuation of water-spreading in the cone areas south of the mountains (Lippincott 1925:24,38).

The second dam study was sponsored by Orange County alone. It was conducted in 1925 by J.B. Lippincott, an hydraulic engineer from Los Angeles retained by the Orange County Board of Supervisors. Lippincott's report went into great detail about the phenomenal growth of Orange County, both urban and agricultural, and the increase in groundwater pumping associated with this growth. It was noted that Orange County's 1890 population of 13,589, had jumped to 61,375 by 1920. Almost half of that growth had occurred in a single decade (Lippincott 1925:1). With this phenomenal growth in mind, Lippincott took a hard look at the flood control and water conservation associations to which Orange County was then committed.

According to Lippincott's report, Orange County was then a member of a tri-county Flood Control Association, as well as the Tri-County Water Conservation Association that was mentioned earlier. The Flood Control

Association was financed by appropriations from the three counties within the watershed, each of which had contributed $3000 a year for the past three years into a common fund that contained $27,000 in 1925. This association apparently concentrated its water-spreading in the Barton Flat area in the high intermontaine valley near the source of the river (Lippincott 1925:43).

The Tri-County Water Conservation Association conducted most of its work in the debris cones at the base of the mountains. The association had been constructing contour ditches and rock dams in these areas since at least 1911. By agreement with Orange County, the association promised not to spread water in the cones until there was river flow at the Chapman Street bridge in Orange County (Lippincott 1925:45).

After reviewing the work of these associations, Lippincott concluded that Orange County did not really benefit from the water-spreading conducted by the tri-county Flood Control Association in the mountains. It seems likely that Orange County dropped out of this association shortly after this report was filed, since nothing more is ever heard about it in the Orange County records. Lippincott was more favorably inclined toward the Tri-County Water Conservation Association, which had been formed in 1909 and began water-spreading at the cone areas by 1911. He warned, however, that in the future this connection might not be beneficial to Orange County (Lippincott 1925:52).

After documenting current efforts in the upper watershed, Lippincott made his most pressing recommendation for a large dam in the Lower Santa Ana Canyon, a construction that would be closer to Orange County and more easily subject to its control. He suggested two locations for the dam: Sculley's Point, at elevation 410 feet ASL; and the location of the Santa Fe Railroad bridge over the Santa Ana at the head of the Canyon, elevation 460 feet. Sculley's Point, two miles downstream from the canyon's head, was considered the better location from a geological point of view, but the bridge site was considered more economical, since there would be less of the railroad to relocate if the dam were built at the canyon's head. Although the reservoir site, which included most of the Prado Basin, was surveyed by the Orange County Engineer Office from Sculley's Point (410 feet) to elevation 530 feet, Lippincott appears to have made calculations for the hypothetical "Rincon or Prado" reservoir based on a dam at the bridge location (Lippincott 1925:55-56).

Lippincott's "Rincon or Prado" reservoir would have been created by a dam about 70 feet high, behind which would have been a reservoir capable of containing 174,000 acre-feet of water. The lower 81,500 acre-feet would have been devoted to water storage for Orange County, with the upper 92,500 allotted for flood control (Lippincott 1925: General Summary, 56). Although the actual plans for Lippincott's dam do not appear to have survived, he briefly described its operation under flood conditions. The dam was to have three syphons, each capable of discharging 1000 second-feet of water. The first syphon would begin operating when flood waters reached the 510 foot elevation; the second, at 515; the third, at 520. At this point, the dam syphons could discharge a total of 3000 second-feet. At the 525 foot elevation, five feet from the crest of the dam, the overflow spillway would be activated (Lippincott 1925:62-68).

Due to the poor condition of the rock of the canyon walls, Lippincott recommended that the dam itself be constructed of hydraulic fill, the cost of which he estimated at $1,770,000. The "Prado Dam," however, was only a part of the entire flood control package Lippincott recommended to the Orange County Board of Supervisors. Additional dams on tributaries and main stem river channel enlargements were also suggested. The whole plan came to an estimated 5 million dollars (Lippincott 1925:62-68).

One of the greatest problems Lippincott foresaw in the operation of a dam at Prado was the inevitable siltation of the reservoir basin, a problem he discussed at some length in his report (Lippincott 1925:59-61). He calculated that siltation would be such a problem that the dam would have to be raised 10 feet every 78 years to accommodate 174,000 acre feet in the reservoir (Lippincott 1925:General Summary). For Lippincott, this problem was hypothetical, since he suggested that any dam in the Lower Canyon would be too costly to build with local funds (Lippincott 1925:55). Lippincott's report, although not implemented, paved the way for state involvement in both flood control and water conservation in the Santa Ana watershed.

In conjunction with the Lippincott report, Orange County made a study of property in the Prado Basin to identify the owners who would have to be compensated in case of actual dam and reservoir construction. This resulted in the first known map of property tracts and owners in the Prado Basin, and the first assignment of tract numbers for each parcel (OCFCD 1926: Tract Map). There is no record that any property appraisals were made at this time.

The objectives of this survey work were never realized, since the voters of Orange County turned down the Lippincott plan after it was presented to them in 1925 (*Orange County Register* 1938a). County officials, however, continued to agitate in the state legislature for flood control money. The first state-funded study of flood control on the Santa Ana was finally authorized by the California legislature in 1925. Chapter 476 of that year's budget provided $50,000 for a survey of flood control possibilities throughout the entire watershed, with the proviso that an equal amount of money would have to be raised by local agencies (Post 1928:6).

Chapter 476 inaugurated the Santa Ana River Cooperative Investigations. Each of the three counties involved- Orange, Riverside, and San Bernardino- appointed an engineer to consult with the State Engineer, who was then Edward Hyatt. Appointed for San Bernardino County was George S. Hinckley; for Riverside County, A.L. Sonderegger; and for Orange County, J.B. Lippincott (Post 1928:9). This cooperative investigation must not have proved very productive, for little more is heard about it. Edward Hyatt was soon replaced as State Engineer by Paul Bailey, who apparently maintained close ties with Orange County.

The flood of 1927, though not nearly as extensive as the 1916 flood (Post 1928:Map 3), again spurred Orange County residents to seek some additional means of regulating the Santa Ana. In 1927, Orange County officials were instrumental in passing an act through the California legislature that created the Orange County Flood Control District (OCFCD). The importance Orange County attached to this district cannot be overestimated. The district borders were the same as those of Orange County, and the county board of supervisors doubled as the district board of supervisors. As established by the state legislature, the purpose of the district was to control all flood waters that might affect Orange County, including sources both inside and outside the county itself. The OCFCD was empowered:

> to provide for the control of the flood and storm waters of aid district and flood and storm waters of streams that have their sources outside of said district, but which flow into said district, and to conserve such waters for beneficial and useful purposes by spreading, storing, retaining, and causing to percolate into the soil of said district (Beard 1941).

This language made it possible for Orange County to effect flood control measures and water conservation on the Santa Ana River, even in areas outside the county (Elliott et al. 1931:5). It also granted Orange County a vested interest in any measures that might be enacted.

In August of 1927, shortly after the OCFCD was established, Paul Bailey resigned as State Engineer of California and was immediately appointed chief engineer of the Orange County Flood Control District by the OCFCD board (Bailey 1928:8; Bookman and Baker 1949:5). Bailey's interest in reservoirs as a means of flood control along the Santa Ana had already attracted the interest of Orange County officials; his last state publication on the subject had to be completed by his associate (Bailey 1928). Under the auspices of the OCFCD, Bailey was commissioned to prepare a comprehensive plan for both flood control and water conservation. The investigations he supervised took two years to complete, and when he finally filed his report in April of 1929, he had selected an altogether different location for the proposed dam site than the one chosen earlier by Lippincott (Elliott et al. 1931:5).

The 1927-1929 Plan

After his appointment as chief engineer of the Orange County Flood Control District in 1927, Paul Bailey investigated possible dam sites in and worked closely with state officials commissioned to study the possibility of creating a large reservoir on the Santa Ana itself. By far the most comprehensive of these studies was the 1928 work conducted by William S. Post-- work that was later amplified by Orange County's own consulting geologist, E.K. Soper.

Drawing on monies allocated by the California legislature in 1927 and apparently matched by local agencies, Post gathered a tremendous amount of geological data on the watershed, all of which was published for public perusal. He also developed a complete plan for flood control on the Santa Ana River. The construction of 50 possible structures was considered in a lengthy report he prepared with the assistance of Paul Bailey in Orange County, A.L. Sonderegger in Riverside County, and George Hinckley in San Bernardino County (Post 1928:Acknowledgements). Post adopted the premise that any flood control system erected within the watershed would also address the need for water conservation. In fact, he wanted to capture flood waters for later water conservation use, and never assumed that one task precluded the other. The report stated that only dams in the mountainous portion of the watershed should be true flood control dams, equipped with permanently opened gates (Post 1928:29).

The central feature of Post's watershed study was the examination of 12 possible dam sites within the Lower Santa Ana Canyon, one of which would have to be the basic flood control structure along the main stem of the Santa Ana River. These 12 sites, located where the local topography was conducive to dam construction, were judged on their geological merits. As Post was careful to point out, all of the possible sites had serious drawbacks, such as proximity to fault lines and the poor quality of the rock, which was generally soft and folded. The middle sites in the canyon, Nos. 1 through 4, were summarily dismissed because they either crossed or were too close to the Whittier fault. With Sites 1 through 4 eliminated, the remaining options were dam sites at either the upper or lower ends of the canyon. Both of these areas, separated by four miles, had significant deposits of blue shale, which was considered the best locally-available bedrock support for a large dam.

The locations at the upper end of the canyon, Nos. 5 through 7, were considered less desirable than those at the lower end (Nos. 8 through 12) because the upper end sites were dangerously close to the Chino fault. The Prado site (No. 7) in particular was ruled out for this reason. Even though the Chester site (Nos. 5 and 6), located about 2000 feet below it, had the best dark blue-gray shale deposits in the area, Post also considered it too close to the Chino fault. By Post's first reckoning, the best dam sites within the canyon were the lower three, Nos. 10 through 12 (Post 1928:252-61).

In a supplemental report dated to December 1928, Post altered his opinion somewhat by providing a series of options for dam sites. He rechecked three of the 12 dam sites, Nos. 6 (Chester), 7 (Prado), and 12. Out of these, Post identified the two best options as Nos. 6 and 12, located at opposite ends of the canyon. Finally, he made his choice for the best, which was No. 12, located at the lower end of the canyon (Post 1928:265).

The alternative locations discussed by Post soon came to be known by a confusing array of terms. Post himself identified many of them by names that he borrowed from the closest rail siding along the Atchison, Topeka & Santa Fe line that hugged the course of the river through the canyon. Site No. 7, at the upper extreme of the canyon, thus became known as the Prado site, since it was close to the small community of that name; Site Nos. 5/6 were identified as the Chester site (Figure 3.2). At the lower extreme of the canyon, Site No. 12 was referred to by Post as the "Oil Well Site" (Post 1928:60-61), but this name did not stick. It soon became known as the Esperanza site, after the closest rail siding of the same name (Figure 3.3).

To confuse matters more, the dam and reservoir proposed for any of the locations within the canyon were often referred to as "Prado" in Post's geological report and the reports that followed. With the popularization of the Chester and Esperanza sites, these two locations became known as the Upper and Lower Prado sites, respectively (Post 1928:20). To complicate matters further, the "Upper Prado Reservoir" could refer to either the Prado site itself (No. 7) or the Chester site (Nos. 5/6) immediately below it (Post 1928:74).

The costs of building a dam at either the Chester or Esperanza site were explored by Post, who favored these two sites because they had blue shale across the canyon floor. It was estimated that a Chester site dam would have to be 93 feet high to hold back a flood capacity of 180,000 acre feet. The cost of this dam, including land purchases and transportation artery relocation, was computed to be $7,600,000. A dam at the Esperanza or "Oil Well" site would have to be both longer and higher (155 feet high) to contain the same quantity of water. The cost was comparably greater: $11,800,000 (Post 1928:60-61). With the danger of earthquakes so prominent, it was assumed that a dam at either location would have to be earthen.

After exploring the different dam site options of the canyon, Post made his final selection for Site No. 12, which soon became known as the Esperanza or Lower Santa Ana Canyon site. In addition to this large structure on the main stem of the river, he also recommended a series of reservoirs along the upper Santa Ana and on Mill Creek in San Bernardino County, channel improvements around the city of San Bernardino, and channel improvements from Prado Dam to the sea (Post 1928:18).

Post included within the report all the information he could gather on the hydrology of the Santa Ana River system. His calculation of the canyon water underflow beneath the river and above the bedrock, as registered at the Prado USGS gauging station, was 1.4 second-feet (Post 1928:181). Little was made of this fact in the Post report, but it would later play a crucial role in the controversy between flood control and water conservation.

As a result of Post's study, only the Chester and the Esperanza dam sites were seriously considered by Bailey and his staff in their 1929 report. The OCFCD consulting engineer, E.K. Soper, obviously had access to Post's report, since he used Post's nomenclature in identifying possible dam sites. Sites 6 and 7 in the upper canyon were considered good, as were Sites 10 through 12 in the lower canyon. Finally, in a supplemental report, Soper re-examined the rock beds of what he considered the three best sites: No. 6 (Chester), No. 7 (Prado), and No. 12 (Esperanza). Of these three, Soper determined that the best two were 12 and 6; and the best single location was No. 12 (Soper 1928).

FIGURE NOT AVAILABLE

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Figure 3.2. Location of the Prado Dam and Chester Dam Sites (After Post 1928: Map 1)

FIGURE NOT AVAILABLE

This item has been removed from the formal documentation for this structure because:

- the item is registered or otherwise protected under the 1976 Copyright Act as amended and thereby ineligible to enter the public domain as formal HABS/HAER documentation

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Items protected by current copyright law may include--but are not limited to--photographs, prints, drawings, letters, maps, unpublished manuscripts, photo albums, theses, dissertations, books, and periodicals.

Figure 3.3 The Esperanza Dam Site or Dam Site No. 12 (After Post 1928: Map 1)

In addition to the Post and Soper reports, Bailey helped coordinate other pertinent studies at both the county and state level. Ground water studies in the canyon, conducted in 1928 by the State Department of Public Works, Division of Engineering and Irrigation, reported that no outlet could be found for groundwater in the Prado Basin other than the channel of the Santa Ana through the canyon. These studies concluded that dam sites at either the upper or lower canyon locations were adequately impervious to water and were capable of holding back a flood of approximately 180,000 acre-feet, as specified in the OCFCD flood control plan. These studies, however, did not specify which of the sites might be the best (Bookman and Baker 1949:6; Elliott et al. 1931:37).

All of this discussion led to some controversy over which of the two preferred sites should be chosen. The advantages and disadvantages to both were aired in the months before the Bailey report was published. Following the lead of the two previous geological studies, Bailey chose the Esperanza site in his final report. Nonetheless, he was concerned enough about the controversy to defend his selection with another paper submitted to the OCFCD on the same day he filed his official report, April 30, 1929 (Bailey 1929c).

The final criterion of site selection was the issue of costs. The Chester dam site would require a structure just 93 feet high to contain a reservoir of 180,000 acre feet, whereas the Esperanza site would require a more expensive dam 155 feet high (Elliott et al. 1931:35). Alternatively, the Esperanza dam site was located in Orange County, which would significantly reduce the tax complications expected from a dam site in the Prado Basin, located in Riverside and San Bernardino Counties (Bailey 1929b).

The Bailey report, which has been preserved in its draft and final versions (Bailey 1929a; 1929b), was an exhaustive treatment of flood control and water conservation problems in the watershed. Bailey proposed the construction of eight small dams along the river's tributaries, as well as the purchase of land along the river channel from Esperanza to the sea so that the reservoir outlet channel could be widened (Bailey 1929b). He noted that the existing channel could only hold a maximum flow of 6000 second-feet without some form of enlargement (Bookman and Baker 1949:5).

The major feature of the report were the plans for a dam in the Lower Santa Ana Canyon. Bailey apparently omitted the totally undesirable sites and renumbered the rest; the Prado site was now called No. 1, the Chester site, No. 2, and what would later be known as the Esperanza site, was simply referred to as the "Lower" site (OCFCD 1928, 1929a). In order to store a capacity of 180,000 acre feet, the Esperanza dam would have to be 155 feet high and 950 feet thick at the base. The stability section of the dam could be formed with the sand and gravel from the local stream bed. The upstream side of the stability was then to be reinforced with a concrete core wall, which would in turn be covered by another layer of sand and gravel. The upstream face of the dam would then be paved with hard rock to resist any wave action in the reservoir. To allow for flood outlets during construction, 25-foot diameter tunnels lined with concrete would be excavated through the north abutment (Bailey 1929b:61).

The reservoir created by a dam at the Esperanza site would effectively fill the Santa Ana Canyon, with the headwaters of the reservoir located just above the head of the canyon (OCFCD 1929b). Even though no water was to be permanently stored behind the dam, it was proposed that the OCFCD would purchase all the land within the canyon. The Santa Ana River channel downstream from the dam was also slated for acquisition, so that it could be diked and baffled for groundwater recharge and flood control. Bailey estimated that a dam at the "Lower" site would cost $11,802,300, with the total watershed project estimated at $16,500,000 (Bailey 1929a).

The selection of the Esperanza dam site was controversial, and certainly had its detractors, who noted that a dam at the Chester site would cost less money to build (Elliott et al. 1931:35). Bailey justified his selection of the Esperanza site by arguing that a dam at Chester would periodically flood the Prado Basin itself and thus lead to basin siltation. This, it was feared, might clog the Cucamonga basin springs that fed the Santa Ana in the summertime, adversely affecting the total volume of water that would reach Orange County. The Bailey report also noted that if Prado Basin flood waters were backed up at the Chester dam site, reservoir water might percolate through some yet undiscovered outlet through the Puente Hills or the Santa Ana Mountains. There was also the vague fear that the Chester dam, located in Riverside County, would somehow fall under Riverside County control through taxation (Elliott et al. 1931:11, 35-36).

The Bailey Plan, consisting of a river dam at Esperanza and eight smaller constructions on adjacent tributaries, was put before the voters of Orange County in June of 1929. The total cost of the package was $16,500,000, which was to be raised by authorizing a bonded debt. The controversy over the dam site and the proposed cost of the project had its effect upon the voters. The proposal was rejected by a narrow margin in the election of June 25 (Bookman and Baker 1949:6; Elliott et al. 1931:5; *Orange County Register* 1938a). With the defeat of his plan, Paul Bailey was ousted from his post of OCFCD chief engineer (Bookman and Baker 1949:8), and county officials began working almost immediately on another proposal.

The 1931-1935 Plan

Orange County officials realized that every year they postponed a decision on the dam, their options would become both fewer and more expensive. Since the last major flood, in 1916, the population of the county had more than doubled. Most of the new inhabitants had no personal knowledge of the areas susceptible to flooding, and citrus groves continued to expand into low-lying areas adjacent to the river banks. The river was even being encroached by urban development, its channel narrowed by levees and bridges. The lower channel was reduced to a width of 300 feet, with a carrying capacity of only 6000 second-feet. Since the 1916 flood carried an estimated load of 44,000 to 45,000 second-feet, this discrepancy was the spur for a new plan (Elliott et al. 1931:8; Post 1928:18).

Paradoxically, as development began to encroach on the river, hemming the channel, there was an increased need for a wider channel to aid the spread and percolation of water entering the county from Prado Basin. Far more water was being pumped out of the ground than was being put back in; the water table, about 23 feet below surface in 1898, had dropped to about 116 feet in 1930 (Elliott et al. 1931:9). There was an urgent need for both flood control and water conservation, and the first step had to be the construction of a dam.

After the rebuff of the Bailey Plan, OCFCD laid the groundwork for a new proposal carefully, beginning with a new geological study of the Santa Ana Canyon dam sites. George D. Louderback, professor of geology at the University of California at Berkeley, was commissioned to re-investigate these sites and make recommendations for another dam. By this time, the dam sites had been re-numbered so that the Prado site was now Site No. 1, and the Chester site, No. 2.

Louderback determined that any proposed dam, especially if it was to be a rigid dam, would have to rest on a foundation of Tertiary sediments, especially shales; the lower Santa Ana Canyon, while suitable for an earthen dam, was not bordered by rocks that would be suitable for a rigid dam. The rocks of the Esperanza site were too folded and potentially too porous. Louderback determined that the best dam sites were located in the upper portion of the canyon, and he designated the Chester site, with its bed of shale, as the best of all

(OCFCD 1929a; Louderback 1930). He also examined the Prado site (Site No. 1), just 2000 feet north of the Chester site and now the location of the present Prado Dam. He did not consider this location as suitable as the Chester site, primarily because of the variability of the rock layers in the canyon walls and the possibility of abutment slump and seepage around and under the dam.

Armed with a geological report that clearly recommended the Chester site, the OCFCD appointed a board of engineers in 1930 to work up a new plan. This engineering board was comprised of G.A. Elliott, B.A. Etcheverry, and Thomas H. Means, all from San Francisco (Bookman and Baker 1949:7). Their first task was to gather new information on the flow of the Santa Ana and the flood of 1916 so as to design a dam that would contain a similarly destructive force (Elliott et al. 1931:5-6). After compiling pertinent information on the river flow, Elliott, Etcheverry, and Thomas declared their preference for the Chester site, as recommended by Louderback. The engineers felt that underground flow into the Prado Basin would not be affected by flood siltation. They also suggested a close cooperative arrangement between the OCFCD and the local Orange County irrigation companies that already had a vested interest in the basin (Elliott et al. 1931:47; OCFCD 1931a).

Etcheverry finished the preliminary plans for the Chester site dam by 1931 (Etcheverry 1931). The dam was to be an embankment construction, anchored to a solid foundation of shale along the abutments and 60 feet below the river bed. The plans called for an underground water cut-off wall consisting of concrete sheet piling extending 60 feet through a matrix of sand and gravel to a solid base of shale below. This concrete sheet piling would be pressure-grouted to ensure water-proofing (OCFCD 1931d). It was not considered essential that the pilings be water-proof all the way to the rock foundation below the dam, although plans were made to ensure that the dam was impervious at the abutments (Elliott et al. 1931:18).

The dam itself was to attain a height of 92 feet above the stream bed (Elliott et al. 1931:18), or 547 feet above sea level. It would have a sand and gravel base, reinforced by a concrete core wall, with impervious material adjacent to the core wall. This would be followed by another layer of sand and gravel, followed by a cement-grouted rock rip-rap facing the reservoir (OCFCD 1931d). To replace the natural flow of the Santa Ana River, a permanently opened outlet was proposed at river grade level. Identified as the "conservation outlet," this outlet was designed with maximum discharge of about 2000 second-feet when the water reached a level of 503.5 feet (Elliott et al. 1931:14).

The highwater mark of this projected reservoir was to be 532 feet above sea level (OCFCD 1931d). At 503.5 feet, a siphon flood control outlet north of the dam on the west side would begin to flush water through a series of conduits under the dam to the Santa Ana channel downstream. This siphon had a projected maximum capacity of 3350 second-feet when the reservoir height reached 532 feet. Combined with the water released from the open outlet at the base of the dam, a total of 4400 second-feet could be discharged if the water level was at 503.5 feet. A total of 5790 second-feet would be discharged at level 532 feet (Elliott et al. 1931:14,18-19). It was felt that this series of releases could handle almost any flood, and still not overtax the estimated 6000 second-feet carrying capacities of the channel downstream from the dam.

In the case of an extraordinarily large flood, the 1931 plan called for an emergency spillway that would be opened when the level of the flood waters reached a point about five feet below the crest of the dam. At that time, the emergency spillway was to carry a maximum capacity of 100,000 second-feet. This emergency feature was to be combined with an emergency bottom gate with a maximum capacity of 10,000 second-feet (Elliott et al. 1931:14).

The dam proposed by the 1931 plan would have a holding capacity of 180,000 acre-feet, with allowances for siltation up to 12,000 acre-feet. It was believed at the time that this reservoir would contain the greatest flood that could realistically be expected, a flood that would be two and one-half times greater than the 1916 disaster. It was designed so that, failing a flood of extraordinary proportions, the release rate of flood water would not exceed the rate of absorption in the channel below. Elliott, Etcheverry, and Means estimated that the dam itself, the purchase of reservoir lands, and the relocation of transportation arteries, would cost an estimated $7,215,397 (Elliott et al. 1931:14-19), a significant savings over the proposed cost of the 1929 dam and reservoir.

The engineers made a number of other recommendations in their 1931 report. They suggested acquisition of a channel 500 feet wide, from the proposed dam to the Yorba bridge. The following segment of the channel, between the Yorba bridge and the north line of the Newbert District, would also be bought and the surface prepared for maximum water spreading and percolation. The remainder of the channel to the sea, unessential to percolation, was to be bought to ensure the unimpeded flow of excess flood waters. The document also made provisions for other, much smaller reservoirs to complement flood control on the Santa Ana. Dams were planned for a number of small tributaries within Orange County itself: the Santiago, San Juan, Carbon, and Brea Creeks, and the Fullerton Drainage (Elliott et al. 1931:20-33).

The 1931 plan was comprehensive. In addition to plans for the dam, there were provisions for the acquisition of the reservoir basin itself. Plans were drawn for the relocation of various transportation arteries within the basin, such as the Atchison, Topeka & Santa Fe Railroad, the Santa Ana Canyon Road, the Aubumdale Bridge, and the Chino Creek Bridge (OCFCD 1931c). The whole basin was mapped, highlighting the Durkee Ditch and local land use (OCFCD 1931c).

Plans were also drawn up for the acquisition of the land tracts within the proposed Prado reservoir basin. A master map was compiled of the 203 affected land tracts, each of which was numbered from "1" in the northwest comer of the proposed reservoir basin, to "203" in the vicinity of the proposed dam at the Chester site (OCFCD 1931b). This numbering system was almost identical to that used by Orange County officials in their first study of land tracts in the Prado Basin in 1925.

On the basis of information compiled for the Prado Basin, the OCFCD apparently dispatched appraisers to assess the property value, both land and buildings, of each tract. Unfortunately, no record of these appraisals has survived, but they are alluded to in some of the later correspondence between property owners and the U.S. Army Corps of Engineers (CoE). As one property owner later complained, the first OCFCD assessments, conducted by local land appraisers, were much higher than the later 1936 appraisals (Lillibridge 1938). Although an exact year for the first series of appraisals has not been discovered, it probably dates to this time.

Even at the 1931 planning stage, OCFCD was anticipating the changes they would make to the Prado Basin in order to maximize the recovery of ground water. Long-range objectives of the OCFCD were to eliminate unnecessary brush from the basin to reduce water loss to plant transpiration, and discourage agricultural activities in the basin to reduce water loss from evaporation. Maps were drawn up identifying the brushy areas of the basin and irrigation lands (OCFCD 1931c). At that time, the major brush areas within the basin were located at the headwaters of Mill Creek, some of the smaller tributaries of Chino Creek, and a large area along the Santa Ana River itself; irrigated lands clustered adjacent to Mill Creek, between the Pomona-Rincon Road and Chino Creek, in the vicinity of the old Durkee Ranch, and in a large area south of the Santa Ana.

The OCFCD plans for the reservoir led to some tension between Prado Basin residents and Orange County water interests. The tension remained muted, since very little work was actually undertaken; the new plans had not yet been approved by the voters of Orange County, who would have to pay for the project. It appears that the only work actually conducted at the Chester dam site was a series of test holes dug along the axis of the proposed dam (OCFCD 1931d).

In the meantime, friction from other sources increased between Orange County and upstream water interests, and it was probably these tensions that postponed resolution of the 1931 plan for four years. In 1932, Orange County finally pulled out of the Tri-County Water Conservation Association, which was a prelude to the "Irvine Case," a suit filed by the Irvine Company of Orange County against the old Tri-County Water Conservation Association at the end of 1932. This suit, which dragged out for 10 years, was later enjoined by the OCFCD. The case eventually led to the creation of all of the present water associations within the three-county area: the Orange County Water District, the Riverside County Flood Control and Water Conservation District, and the San Bernardino Valley Water Conservation District. The story of how this case developed is recounted briefly below.

One of the largest landowners in Orange County, the Irvine Company, headed by James Irvine, had long been concerned about the loss of water to spreading and percolation at the stream cones at the base of the San Bernardino Mountains. This concern was brought to a head in 1931, when the California legislature apportioned money to increase the extent of the spreading. Irvine commissioned his own engineer, C. Roy Browning, to conduct a study of the practice and its impact on Orange County water interests. About the same time, the OCFCD also became concerned. In 1931, the district commissioned their consulting engineer, G.A. Elliott, to recommend what Orange County should do about the matter (Hinckley 1944). Elliott's report in June of 1932 recommended that Orange County should:

> not only not participate in the proposed spreading plan in the Upper Basin, but should prevent, if possible, any further conservation above the lower [Santa Ana] canyon until equitable agreement has been agreed to by all parties in interest (Hinckley 1944).

Based on these recommendations, Orange County withdrew from the Tri-County Water Conservation Association in the summer of 1932. This was followed, in November 1932, with a suit filed by the Irvine Company against the Association in the federal court in Los Angeles, both on its own behalf and in the interest of groundwater recharge in Orange County (Hinckley 1944; Scott 1977:222). On this basis, the suit was later assumed by the OCFCD.

In response to all this, the Orange County Water District was created in June of 1933 by act of the California legislature to manage groundwater conservation in the county and protect Orange County's water rights (Hinckley 1944). Paul Bailey was appointed the first chief engineer. Orange County Water District coordinated the work of recharging the county's groundwater, which has since been its primary function (Banks and Halatyn 1971:7,11; Bookman and Baker 1949:8). The District has gradually assumed greater control over this task from the various Orange County-based water companies that preceded it (Nick Richardson, personal communication 1989). Historically, the Orange County Water District has only been interested in water conservation or recharge. It has not participated in flood control (Richard Runge, personal communication 1989).

Probably because of the complications created by the Irvine Case, the 1931 Plan, based on the recommendations made by Elliott, Etcheverry, and Means, was not put before the voters of Orange County until 1935. In its final form, the plan called for 11 different projects-- nine dams and two conduits-- for a total estimated cost of $11,600,000. The Santa Ana dam at the Chester site comprised most of this amount-- just over 7 million dollars (OCFCD 1935). On October 21, an election was held on a bond issue to raise this sum of money. The plan was defeated. On December 19, another bond issue for 6 million dollars was voted on to finance various flood control projects in connection with the Federal Work Relief Program, and this measure failed as well (Bookman and Baker 1949:8).

The 1931 Plan failed because Orange County's water interests still feared that a dam at the Chester site and a reservoir in the Prado Basin would adversely affect their surface water rights below the dam. In 1935, they were less concerned about siltation in the basin itself, than about groundwater flow below the dam. The 1931 Plan did not address underground water flow at the dam site, or what would be done about it if the dam were built with concrete sheet pilings that would make the ground beneath the dam largely impervious. This was something of a problem, since it had previously been estimated that the groundwater flow passing the dam site was an estimated 1.4 second feet (Bookman and Baker 1949:8; Post 1928:181). In 1935, it would appear that water conservation had successfully blocked flood control.

The 1936 Flood Control Act and a New Plan

Just one month after the Elliott, Etcheverry, and Means Plan was voted down in Orange County, the Orange County Board of Supervisors, in their capacity as directors of the OCFCD, made a formal and unprecedented visit to a meeting of the Riverside County Board of Supervisors in November 1935. There they filed application for the construction of a flood retarding basin in the Prado Basin. The visit, they said, was not considered a legal necessity, but was rather a courtesy call to state their intentions. The Riverside County Board approved the application, which was based on the "Elliott Plan" of 1931 for flood control. Years later, officials in Riverside County would insist that the project's more controversial water conservation measures were not discussed at this meeting, which concentrated mostly on the problems of relocating roads and highways (Bookman and Baker 1949:11). Whatever was discussed, it was clear that Orange County had every intention of pushing through yet another flood control and water conservation plan for dealing with the Santa Ana River. This time, they would go to the federal level for assistance.

Orange County officials, through their Congressmen in Washington, were instrumental in including the proposed Santa Ana dam and reservoir in the 1936 Flood Control Act, which allotted over $300 million to 270 flood control projects in 31 states (U.S. Army Corps of Engineers [CoE]1939:9). This Act of June 22, 1936 (Public No. 738, 74th Congress, Title 33, USCA, Section 701 et seq.) declared that flood control was, "the proper activity of the Federal government, in cooperation with the states, their political subdivisions, and localities thereof." As pertained to the Prado Basin, the act specified that local work was to be for, "Santa Ana River, California, construction of reservoirs and related flood control works for the protection of metropolitan areas in Orange County" (USA 1946:4). The act specified money for flood control work along the Santa Ana, but no direct provision was made for water conservation (Bookman and Baker 1949:9).

The 1936 Flood Control Act, while declaring the Federal government's intention to involve itself in local flood control, fell far short of assuming the full responsibility for the project. According to the terms of the act, no federal money was to be spent on construction until either state or local agencies fulfilled three prerequisites. The first was to provide, without cost to the federal government, all lands, easements, and rights-of-way needed for both the dam site and the reservoir. The second was to hold the United States exempt from all damages that might result from any construction work. The third was a commitment by state or local agencies to maintain and operate all flood control works after their construction (Beard 1941).

After reviewing the implications, the Orange County Board of Supervisors resolved on October 6, 1936, to fulfill its responsibilities as outlined in the act (Beard 1941). A month before, the first $50,000 had been allocated to the U.S. Army Corps of Engineers, Los Angeles District, for the preparation of plans for what would later be Prado Dam (Bookman and Baker 1949:9). With the passage of the 1936 Flood Control Act and the Orange County response, there commenced a period of close cooperation between the OCFCD and the CoE, whose task it was to construct the dam. A December 22, 1936 resolution of the OCFCD empowered M.N. Thompson, OCFCD flood control engineer, to begin work on a report detailing the project costs to be borne by Federal government and the OCFCD.

Before the conclusion of 1936, this new effort resulted in a series of maps detailing land tracts within the Prado Basin. The numbering system used in 1925 and again in 1931 was completely revised. From a comparison of the two systems, it would appear that the OCFCD planned to acquire the lower basin before even identifying and numbering the tracts that might be impacted in the upper portion of the reservoir. Preliminary plans were also made for the relocation of Prado basin highways and railroads (OCFCD 1936).

The CoE published the first preliminary plans of the Santa Ana River dam on April 15, 1937. The report stated that the, "Prado Retarding Basin is primarily for flood control, with water conservation secondary" (Bookman and Baker 1949:9). The reservoir proposed for the dam would contain a total of 180,000 acre-feet: 54,000 for conservation and 126,000 for flood control, which included 12,000 for siltation. The initial plans called for one 4-by-8 foot ungated opening at river level, which would be used to release reservoir water for Orange County water conservation (Bookman and Baker 1949:9). In spite of these initial plans, two ungated openings, each 66 inches in diameter, were actually constructed.

Shortly after the CoE issued its preliminary report, M.N. Thompson filed his report with the OCFCD, on June 7, 1937. The Thompson report was a scaled-down version of the "Elliott Plan" and covered the land acquisition and highway and railway relocation costs of eight different projects that were to be coordinated with the CoE. The cost to be borne by the federal government was calculated at $12,748,000, while the costs to Orange County were put at $2,500,000 (Thompson 1937). Orange County money allocated for the Prado Reservoir was an estimated $961,300. The bond issue to raise the full $2.5 million was quickly brought before the voters of Orange County and passed on July 27, 1937 (Beard 1941; Thompson 1937), the first time a massive flood control measure had been approved by a county-wide vote.

By the terms of this 1937 bond issue, the site of the dam on the Santa Ana River was left to the discretion of the CoE (*Orange County Register* 1938). Even before this, however, available records indicate that the CoE (and possibly the OCFCD before them) had lost interest in the Chester site. It would appear from the re-drafted OCFCD maps of the Prado Basin dated 1936, that the Chester site had already been abandoned in favor of "Damsite No. 1," also known as the Prado site, located 2000 feet north of Chester. It is important to note that the OCFCD did not relinquish all interest in the details of dam construction. The OCFCD continued to work up plans for particular parts of the dam until the final plans were approved in 1938. The County was often able to get the CoE to modify small details of the dam in favor of some increase in water conservation (OCFCD 1938).

The 1938 Flood and Flood Control Act

By far the greatest spur to flood control along the Santa Ana, one that temporarily ended all debate between flood control and water conservation, was the massive flood of 1938. In a series of storms that buffeted southern California between February 26 and March 3, unusually high precipitation fell during a period of unusually warm weather in the mountains. A tremendous amount of debris washed down by the rain clogged up the mountain reservoirs, forcing a great volume of water over dams like that at Big Bear Lake (Scott 1982:3). A wall of water washed down the Santa Ana River Canyon in the San Bernardino Mountains, flooding over the river banks in San Bernardino and Riverside counties. The Prado Basin was extensively inundated as water backed up before surging through the Santa Ana Canyon. Orange County was widely flooded as the Santa Ana flood waters quickly overflowed the river levees and found their own way to the sea.

By the end of March, at least 74 people were known to have died in the flood, 20 were missing, and at least 116 were injured. There was major damage to the local highways, roads, powerhouses in the upper Santa Ana Canyon, and railroads. The losses to the local citrus groves was massive, with residual damage caused by the scouring of the top soil and deposition of poorer eroded materials (U.S. Department of Agriculture 1938; Rogers 1941). The 1938 flood was thoroughly documented by the CoE, which compiled several notebooks of photographs showing flood damage throughout southern California. The destruction left by the Santa Ana River, from San Bernardino to Orange County, was also recorded. Aerial views of the Prado Basin taken shortly after the flood graphically illustrated the level of destruction (CoE Miscellaneous 1938a, 1938b).

In the aftermath of the flood, Orange County was galvanized into pressing Congress for greater speed in addressing the urgency of flood control. So was Riverside County. On May 3, the Riverside City Council petitioned the CoE for flood control measures along the Santa Ana River. Flood control was also strongly supported by local Congressman Harry R. Sheppard (Scott 1982:12).

All of this clamor contributed to the 1938 Flood Control Act, which was an umbrella for another series of flood control projects in 19 states, and preliminary studies for work in another 345 localities. The Act passed on June 28, 1938 (Public No. 761, 75th Congress, Third Session, Ch. 795, Title 33, USCA, Sections 701 a-l et seq.), and was budgeted to cost $375 million. The Act authorized the federal government to acquire any lands needed for the completion of construction projects authorized by the 1936 Act. The United States was to assume this responsibility from the local agencies previously entrusted with this task. For any costs already outlaid, the local agencies were to be reimbursed only for direct costs, not indirect or speculative damages. The United States was also authorized to pay for any highway relocation (CoE 1939:9; USA 1946). The reimbursement provision of the 1938 Flood Control Act caught the OCFCD by surprise, for the district had already begun to purchase the Prado Basin tracts needed for the dam reservoir.

OCFCD Land Appraisal and Acquisition, 1936-1939

Within a month of the passage of the 1936 Flood Control Act, the OCFCD had appointed a board of appraisers to determine the value of every tract of land in the Prado Basin so that the OCFCD could forecast with some accuracy the amount of the bond issue needed in 1937. Comprising the board were three Federal Land Bank appraisers from Berkeley: W.P. Stanton, G.F. Meredith, and J.N. Tate. They began work in the Prado Basin on July 16, 1936, and filed their report with the OCFCD on December 8, 1936 (Beard 1941).

All of 1937 was taken up with preliminary studies, bond issue votes, the arrangements that detailed how the CoE would construct the dam, and the final approval of the appraisal reports (Beard 1941). By February 1, 1938, the OCFCD was ready to begin land acquisition on the basis of the 1936 appraisals. In February, Charles H. Chapman, a respected businessman from Santa Ana, was appointed the right-of-way agent charged with buying land and obtaining easements for the Prado Basin. His salary was $300 a month (*Orange County Register* 1939e). Chapman was not authorized to offer landowners more money than the appraisal figure without the prior consent of the OCFCD board of supervisors (Beard 1941). Thus commenced a roughly two-year period in which the OCFCD acted as land agent for the CoE, purchasing the dam site and the reservoir lands.

Land acquisition had hardly begun when the 1938 flood devastated the basin at the end of February and beginning of March. Much of the physical plant in the basin was damaged and a great deal of property was ruined. Despite the damage, the OCFCD promised to pay landowners on the basis of the 1936 assessments (Beard 1941). The flood made some of the landowners more willing to sell.

The general procedure practiced by the OCFCD in the acquisition of lands was to purchase an option to buy within a certain period of time, and then exercise that option before it expired. This was a more gradual method of acquiring the land, one that raised fewer objections among the residents of the Prado Basin and spread the expenditures over a longer period. Some property owners, of course, were not satisfied with the 1936 appraisal figures. When purchase negotiations broke down, condemnation was the next step. The OCFCD avoided this process as much as possible because it was soon discovered that Riverside County juries generally awarded landowners more money than allowed by the 1936 appraisals (*Orange County Register* 1940).

Among the first lands to be obtained, by both purchase and condemnation, were those that covered the dam site itself. Part of this 500-acre area was purchased by the OCFCD on July 19, 1938. The grantor in this case was the Santa Ana River Development Company, which had a history of cooperation with the OCFCD (Grant Deed 1938). The balance of the land, Tract 335, was 82 acres that belonged to E. Penprase and Isabella Chavez. Tract 335 had to be condemned in September of 1938 (OCFCD 1938). This action made it possible to begin preliminary work on the dam as early as the fall of 1938, when much of the basin had still not been purchased or otherwise obtained.

This haste caused some problems with landowners in the Prado Basin. The OCFCD had made it clear that it would purchase land piecemeal, as the opportunity arose and prices fell within their range. In the meantime, the district would continue to conduct tests and preliminary work at the dam site. The district did not feel committed to buy all the basin lands before starting work on the dam (Johnson 1938). This procedure caused many basin landowners to complain to the CoE, and it led directly to the formation of the Rincon Basin Protection Association in 1938, established solely for protection against the OCFCD (Johnson 1938; Lillibridge 1938).

The progress of the OCFCD in acquiring the basin land can be inferred from a series of colored maps adapted from the official 1936 base map (OCFCD 1936). These maps, unaccompanied by any text, were found in the Third Floor Blueprint Room and Flood Design of the Orange County Environmental Agency, Santa Ana. They provided some insight into the status of land acquisition in the basin in late 1938 and early 1939. From these maps, it would appear that by the end of 1938, most of the basin was already optioned, obtained, or under contest. Properties falling under these three categories will be discussed briefly below.

A large block of land, comprised of the old Durkee Ranch and adjoining properties, was covered by an option agreement made on July 5, 1938. The owner of the Durkee Ranch, the Santa Ana River Development Company, entered into a complex settlement with the OCFCD, whereby the district had a nine-month option on the property, with the right to an extension (Kelton 1940e). It was understood at the time that the Santa Ana River Development Company, a major Orange County water interest, was working in some sort of collusion with the OCFCD (*Orange County Register* 1939e). Option agreements appeared to have been entered into only in instances where it was generally understood that both parties had similar interests: flood control and perhaps even water conservation.

Outright purchases of land were most common along Chino Creek. Here, the standard procedure of purchasing an option to buy, and then buying, seemed to have worked without major hitches. Perhaps the particularly small size of many of the tracts in this area made it more difficult for individual landowners to fight what they saw as inevitable. The fact that many of the owners were absentee landlords was probably a factor in their willingness to sell. Condemnation proceedings seem to have been required for much of the property in Riverside County south of the Santa Ana River, including the townsite of Prado immediately east of the dam site. By April of 1939, condemnation suits were in place against most of the tracts in this area (CoE Miscellaneous n.d.).

Whether the reservoir lands were covered by option, direct purchase, or condemnation, the CoE made it clear to the OCFCD that all lands had to be cleared of human habitation below the taking line. This meant not only the relocation of the local residents, but the physical removal of most of the structures within the basin. In 1938 and 1939, the OCFCD began auctioning the houses and barns left by departing residents. Five-room houses sold for anywhere from $140 to $550; one seven-room house sold for $830 (*Orange County Register* 1939d). More important structures, or structures with a unique past, were identified by name in the local newspaper accounts that covered these events. Among these were the Pioneer School, established in the nineteenth century, the Ashcroft Ranch, the Serrano adobe, the Moreno Ranch, the Pine Ranch, and the Bandini-Cota adobe (Orange County Register 1939b).

The Pioneer School, and especially the fate of its bell, attracted considerable attention. This school, believed to have been built originally on the Mayhew property in the early 1880s, was moved to an acre of ground on the Pate Ranch in 1887. The school was sold at an OCFCD auction in 1940 (*Orange County Register* 1940a), and its subsequent fate attracted enough local attention that OCFCD engineer M.N. Thompson finally arranged for the structure to be sold to a Corona nursing home, where it could be reconstructed (*Orange County Register* 1941). The Prado School was purchased by the Callahan Construction Company of Los Angeles for $500 (*Santa Ana Register* 1938d). Orange County agents bought the abandoned Santa Fe bridge as part of the cost for relocation of the railroad right-of-way; the seven 90-foot spans weighing more than 561 tons were sold as scrap to the Pennsylvania Iron & Steel Company for $3925, on condition that the buyer dismantle and remove the structure by May 15, 1939 (*Santa Ana Register* 1939d). The 500 acres condemned for the dam, including 27 parcels and the entire townsite of Rincon/Prado, was appraised for $47,464, and distributed among 200 defendants (*Santa Ana Register* 1938h).

Mention was also made of even older cultural resources. It was noted that burials probably existed near or even under the Prado Dam, then in the beginning stages of construction. It was believed that a Civil War soldier and an undetermined number of "Indians and Mexicans" were buried in the vicinity of the dam, "at the edge of a mesa on a small knoll near the village of Prado." The Indians and Mexicans were said to have been laborers employed over the years by Raymundo Yorba. All of these graves were unmarked and had been farmed over for many years (*Orange County Register* 1939a).

The Taking-Line Controversy, 1937-1939

OCFCD Engineer M.N. Thompson's report on the Prado Reservoir costs, filed with the OCFCD on June 7, 1937, provided the first discussion of the land acquisition costs in the Prado Basin, based on the results of the 1936 appraisals. In this report, Thompson specified that, at least temporarily, the taking-line of the reservoir should not be higher than the 520-foot elevation line, as indicated on the official acquisition maps dated to December 1936 (OCFCD 1936). Thompson suggested that the OCFCD begin land acquisition below this taking-line (Beard 1941).

It is not clear now whether this 520-foot line was just a temporary measure, or whether the OCFCD really thought they could make some other sort of arrangement to clear the property above the 520-foot line. Since OCFCD land acquisition did not really start until after the 1938 flood, the whole issue lay dormant for about a year, until local landowners began to complain to the CoE about the land acquisition practices of the OCFCD. In a letter dated June 28, 1938, the commanding officer of the CoE Los Angeles District, Major Theodore Wyman, Jr., complained to the OCFCD that he and his superiors in Washington were receiving complaints from residents in the basin about land acquisition that stopped short of the 543-foot elevation of the dam's proposed spillway. Specifically, residents between 520 and 543 feet complained that the OCFCD appeared to be content to flowage rights only, leaving the land itself in private hands. To quell this unrest, Wyman informed the OCFCD that all areas below the 543-foot line had to be obtained in fee (Beard 1941).

Four months later, on October 25, 1938, Wyman advised the OCFCD through Thompson that Prado Basin lands now had to be purchased up to the 556-foot elevation of the dam itself. Apparently it was generally understood that there could be no human habitation below this line, although this policy does not appear to have been etched in stone until 1939 (Beard 1941; Johnson 1939). The CoE and the OCFCD both reaffirmed their commitment to the 556-foot taking-line in a letter to a U.S. Attorney in December 29, 1938 (Morgan 1939).

Then, on March 7, 1939, Major Wyman informed the OCFCD that, for the time being, the district was only to obtain in fee the lands below the elevation of the spillway (543 feet) until the actual taking-line had been determined by the CoE. On March 16th, however, Wyman explained to a confused Thompson and OCFCD that the 556-foot acquisition line was not superseded by the March 7 letter (Beard 1941). Five days later, on March 21, the OCFCD announced that it would take steps toward final land acquisition only for the lands below 520 feet, reserving the lands above 520 feet for another series of actions, to be held in abeyance until the Corps determined what the final taking-line would be. The U.S. Attorney, apparently contacted by the local residents on this matter, complained to the U.S. Attorney General that this confusing situation was unjust to the local landowners (Harrison 1939).

The March 21 decision by the OCFCD, to return the 520-foot taking-line, caused a storm of protest by local landowners in the Prado Basin in the late spring of 1939. Landowners claimed that if they did not bring suit against the government in this matter, the dam would be built above their heads to a height of 556 feet, after which the government would only have to pay damages in case of flood, and not buy the land, as they had promised to do (Morgan 1939). The controversy reached such a pitch that Major Wyman informed Thompson on May 26, 1939, that the OCFCD should now make it policy to buy lands up to the 556-foot line (Beard 1941).

Policy changed again in June. On the 14th, the CoE sent additional instructions to Flood Control Engineer Thompson that the OCFCD was now to purchase all lands below 520 feet in fee, whereas lands between 520 and 543 feet could be obtained in fee or secured through floodage easements. If properties were situated on both sides of the 543-foot line, fee or easement would have to be obtained for the entire property, up to a point not beyond the 556-foot line. It was made explicit policy that no human habitation would be allowed below 556 feet (Beard 1941; Wyman 1939).

By this time, both the CoE and the OCFCD probably felt as though they were working at cross-purposes. The CoE's Los Angeles District and the Chief of Engineers in Washington, D.C., were discussing the possibility of the CoE taking over land acquisition directly from the OCFCD as early as July 1939 (Johnson 1939). The OCFCD, in turn, felt like the middle man with all of the responsibilities and none of the power. To simplify relations with the CoE, on August 8 the OCFCD designated M.N. Thompson as the official negotiator for the OCFCD in all business with the CoE, even though it would appear that he had already filled this position for quite some time (OCFCD 1939).

The issue of the final taking-line was not resolved until September 21, 1939, when the OCFCD was informed that the Secretary of War himself had established the 556-foot elevation as the taking-line, and had outlined the following stipulations for land acquisition in the basin: all lands below 520 feet were to be obtained in fee simple, and all lands between 520 and 556 feet were to be secured through either title in fee or flowage easements (Beard 1941).

The issue may have been settled for the CoE and the OCFCD, but the matter had not been laid to rest for the basin landowners located between 520 and 556 feet, who still felt that the OCFCD had reneged on its promise to purchase all lands below 556 feet. The taking-line controversy did not abate in the months that followed, and the bad feeling that resulted only made it more difficult for Charles Chapman, the OCFCD right-of-way agent, to complete his assignment. Soon it looked more and more likely that the CoE would simply take over the responsibility of land acquisition in the Prado Basin.

Transition to the CoE

On December 15, 1939, Lt. Col. Edwin C. Kelton, who had replaced Wyman as District Engineer in September, informed the OCFCD that the U.S. Engineer Department was, "considering taking over direct acquisition of land, easements, and rights-of-way at Prado Dam and within the reservoir area created thereby under provisions of Flood Control Act, Public No. 761, 75th Congress, approved June 28, 1938" (Beard 1941). As Kelton told the OCFCD, the 1938 Flood Control Act, then over a year old, permitted the federal government to purchase lands needed for flood reservoirs. More pressing matters had kept the CoE from exercising this option before.

Four days later, the OCFCD ordered its employees to cease all land acquisition activities, with the exception of work already underway and three condemnation proceedings already scheduled to come to court in Riverside County (Beard 1941). Charles Chapman, the OCFCD right-of-way agent, had his employment terminated, as did many others -- appraisers, soil technologists, and engineers (Kelton 1940a; *Orange County Register* 1939e). On January 15, 1940, Kelton asked the OCFCD to remove its largest case, No. 754-M-Civil, from the court calendar so that all data for the trial could be turned over to the U.S. Attorney for adjudication in the federal courts (Kelton 1940a). The matter was a condemnation proceeding against most of the larger basin owners in Riverside County, who were named defendants in the case (Kelton 1940b).

This case, or some spin-off from it, apparently dragged out until 1941, and the OCFCD still had some involvement in the matter (Papers 1941). In all other respects, however, the OCFCD had long disassociated itself from the problems of land acquisition in the Prado Basin. After December of 1939, all remaining problems became the property of the CoE.

CoE Land Acquisitions, 1940-1942

The U. S. Army Corps of Engineers took over land acquisition from the OCFCD at the end of 1939. This simplified the process by eliminating the OCFCD as middleman. It was probably done, too, to placate irate Riverside County residents who frequently complained of irregularities in OCFCD land acquisition. Certainly one of the published reasons for the take-over was to protect the government against future financial problems with irregular OCFCD expenditures and requests for reimbursements. Some of the reimbursements had already been questioned by the government, which complained of the "overhead expenditures" reported by the OCFCD (*Orange County Register* 1939e).

By the time the OCFCD ceased land acquisition in December of 1939, the district had already purchased 80 parcels, or a total of 3205.59 acres, within the basin. Most of these properties had been purchased at 1936 prices, with the exception of 10 tracts that were bought at slightly greater prices in order to avoid litigation or condemnation proceedings (Beard 1941). Land acquisition was so far along that the OCFCD had already authorized, or was considering the authorization of, land leases on 2200 acres of purchased property, often to the original owners (*Orange County Register* 1939d).

Most of this activity was not seriously inconvenienced when the United States assumed land acquisition. In December of 1939 and January of 1940, the OCFCD flood control engineer M.N. Thompson was directed to turn over all pertinent land acquisition data to CoE engineers. At the insistence of Orange County authorities, the CoE agreed to preserve the existing water rights of the Santa Ana River Development Company, so long as these did not interfere with flood control needs. The CoE also agreed to authorize or guarantee the continuing lease of lands to those original owners who still wanted to use the land for agricultural purposes. The CoE, however, remained adamant that no human habitation could be allowed below the 556-foot line after the dam was completed. The first leases allowed by the CoE were for one year, to be paid in advance; if a leasee's crops were destroyed by flood, then the rent the following year would only be one dollar (*Orange County Register* 1939e). There would be no direct reimbursement for crop damage.

Federal lawyers quickly took over the OCFCD case that had been brought against most of the Riverside County landowners in the Prado Basin. Now identified as "U.S.A. vs the Anaheim Sugar Company, et al.," this case was filed on January 13, 1940 in the District Court of the United States, Southern District of California, Central Division. The defendants were required to file a response to the government's action within 20 days or obtain an extension. Negotiations on this issue were to be conducted through Mr. H.E. Spickard, Chief of the Right-of-Way Subdivision of the Los Angeles District (Kelton 1940b).

Apparently this case resulted in a condemnation, for soon the CoE was contemplating the blanket use of eminent domain to condemn the remaining properties in question and thus prod the other landowners into a negotiated sale. This action was contemplated as early as March of 1940 (Kelton 1940c). H.L. Thompson, special attorney for the OCFCD, urged the CoE to pursue this matter, not only because condemnation speeded up the process, but because it tended to prevent further prosecution by the local landowners against the OCFCD (Harrison 1940).

By May of 1940, 69 tracts had been singled out for condemnation. On the 25th of that month, Lt. Col. Kelton made a formal request to the Chief of Engineers in Washington, D.C., for permission to use condemnation by right of eminent domain to wrap up land acquisition in the Prado Basin. Kelton pointed out that the dam itself was already 60 percent complete, and that land acquisition had to be accelerated. Kelton proposed to sue for all the remaining lands in fee simple, hut if the landowners between 520 and 556 feet would agree to selling flowage easements, that the CoE would settle for that (Kelton 1940e).

It would appear that condemnation proceedings took up the remainder of 1940, and that the government obtained most of the lands that it wanted. Little documentation has been found pertinent to this period. By the time Prado Basin land status reported again, it would appear that the government was in control of the basin. According to a series of untitled articles that appeared in the *Orange County Register* in January 1941, the government was selling more houses and barns in the Prado Basin (Jim Sleeper Collection). By the following month, most of the land had been bought and most of the houses moved, for the CoE warned the few remaining residents of the basin that they had to leave the flood basin in February (*Orange County Register* 1941).

Eight months after the basin had been abandoned by permanent habitation, the OCFCD began to turn land titles over to the CoE. Apparently the first to be submitted were the properties along Chino Creek, which were handed over in October of 1941 (Status 1941). This transfer of title occurred throughout the fall of 1941 and winter and spring of 1942 (Tabulation 1942). Much like the OCFCD before it, the CoE did not bother to obtain title to the extensive lands of the Santa Ana River Development Company in the heart of the basin, since the aims of the company were not incompatible with the flood control measures proposed by the CoE. For this land, the CoE simply obtained a permanent easement and a guarantee that there would be no human habitation within the flood control basin (Kelton 1942).

The arrangement with the Santa Ana River Development Company highlighted the general feeling in Orange County that county interests should retain control over at least some of the lands within the Prado Basin, in order to influence how the area was managed. This was considered essential for the county's water conservation needs, since the CoE was mainly concerned about flood control. At least one engineer with the OCFCD even urged Orange County not to give the government any of the titles of its purchases, since it was believed that the CoE would allow unrestricted plant growth in the basin and so double the water loss to transpiration, estimated at 16,000 acre feet in 1939 (*Orange County Register* 1939c).

One provision of the 1938 Flood Control Act provided federal reimbursement to local agencies for direct expenses involved in land purchases for flood basins. For the Prado Basin work, the government began to reimburse the OCFCD for their expenses in relocating the Santa Fe Railroad, local highways, and public utility lines, at least as early as November of 1939 (*Orange County Register* 1939c). After the CoE informed the OCFCD that the government would take over land acquisition in December, the OCFCD began pressing for payment of all the reimbursements owed to the district. Apparently the OCFCD was told that the district would be paid for these expenses after July 1, 1940 (Kelton 1940e). This apparently was not done, since late 1940 still found U.S. government auditors working over each account the OCFCD had submitted for reimbursement (Beard 1941).

Apparently, so many irregularities were found that in the summer of 1941, the government re-appraised the properties bought by the OCFCD back in 1938 and 1939, to determine what in fact should be paid back to the OCFCD. These appraisals found that the extensive damage left by the 1938 flood had still not been repaired in most cases. Most of the lands examined were abandoned or occupied by tenants under lease to the OCFCD or the United States. The OCFCD complained that the re-appraisals were too low, lower in some cases than what the OCFCD paid to the original owners (Beard 1941). Details are not clear, but the matter was finally settled and the government apparently paid most of the reimbursements to the OCFCD by the end of 1941 (Status of Land 1941). While the reservoir lands were being bought, condemned, or otherwise acquired, the dam itself had been completed.

4. THE CONSTRUCTION OF PRADO DAM

Design Analysis

Hydraulic and Structural Criteria

The design of Prado Dam was regarded as a critical component in the protection of metropolitan areas in Orange County (CA-178-7). The site was ultimately chosen for two major reasons. First, the costs of relocation of highways and the railroad would have been prohibitive for any location at the lower end of Santa Ana Canyon in Orange County. Second, hydrological studies made by the United States Engineer Office determined that the siphon-type spillway required at the lower location would not provide adequate protection. As a result, the dam site was moved upstream to the present location, which allowed the use of an emergency spillway, and posed fewer problems with regard to relocating transportation facilities.

Prado Dam and the Prado Flood Control Basin were designed in accordance with a theoretical computed "design" flood, as outlined in a report titled "Hydrology of the Santa Ana River and Adjacent Coastal Basins." This hypothetical flood was based on a four-day storm in which the maximum rainfall occurred on the fourth day. The precipitation on the fourth day varied from a minimum of four inches to a maximum of 18 inches over a 2264 square mile area. The rainfall on the first three days was 15 percent, 32 percent, and 57 percent, respectively, of the fourth day. The design flood had a peak discharge of 193,000 cubic feet per second with a volume runoff of 275,000 acre feet.

It was determined that the gross flood control capacity at Prado Dam, to meet the stipulated design characteristics, was approximately 224,500 acre feet at the spillway crest. It was intended that the reservoir would be empty and that it would function as a flood control basin only during periods of heavy rain. Apart from the rainy season, the gates would remain open, and the level or pool of water would automatically regulate itself through open conduits during acceptable periods and levels of precipitation. Flood control during early flood stages would also be automatic, in that the size and shape of the basin itself, by allowing the waters to spread within basin perimeters, would provide ample time for the operators to determine the actual flood threat. If it was concluded that flooding posed a serious threat, they would then be able to operate the gates and control the outflow of water.

No special consideration was provided for earthquakes in the design of the hydrology of the dam. The possibility of an earthquake was not unknown, since the major faults in the vicinity were already identified, and the possibility of a seismic event was considered. However, in the opinion of the designers, the possibility of an earthquake occurring when the flood control basin was near its maximum capacity was considered so remote that no special provisions regarding earthquakes were made in the design of the dam.

Foundation Design

The overburden at the foundation site was thought to range from 20 to 40 feet deep (later found to be much deeper), and to consist of numerous layers of sandstone with some strata of shale. The overburden is inclined steeply to the upstream slope, and generally becomes more coarse with depth. The face of the left abutment along the dam axis is sandstone, and the abutment has an overlying layer of sand and gravel. The right abutment has a superficial layer of fine sand, formed by the decomposition of the underlying sandstone. An extensive series of tests was conducted prior to development and issuance of the contract. The evaluation included mechanical analysis of the foundation overburden, shear tests of foundation material, and permeability studies. The permeability tests concluded that as long as a cut-off wall extended through the foundation overburden to the foundation (see Change Orders), no problem would exist. No water solubility tests were conducted. In general, it was determined that no lateral flow or appreciable settlement of the foundation would occur.

Embankment Design

The embankment was to be composed of pervious and impervious areas or zones (Figure 4.1). Much of the latter material was to be obtained from borrow pits, although some was to be stored and reused from the excavation of the spillway. Most of the pervious material was to be obtained from the spillway excavations. Shear tests were run on the impervious borrow pit material, to assess the safety factor regarding the sliding of an upstream portion of the dam. The tests were conducted in accordance with guidelines developed in 1929 by Dr. Charles Terzagi for public roads construction. It was determined that most of the settlement of the embankment would take place during construction, and that little danger with regard to stability was likely. Compaction tests were made "in accordance with methods outlined by Proctor in the August and September, 1933 issue of *Engineering News-Record*" (U. S. Army Corps of Engineers [CoE] 1938c:210).

Some consideration for earthquakes was incorporated in the design of the embankment. In general, recommendations were made with reference to the slope of the embankment and the careful selection and placement of materials to be used in its impervious core.

Hydraulic Design of Spillway and Outlet Works

The spillway consists of an approach channel, an ogee control section, and a discharge channel (Figure 2.2). The discharge channel is sloped to the topography to reduce erosion below the concrete-lined section. The emergency spillway had a designed pond elevation of 556 feet, and a capacity of 180,000 cubic feet per second. The approach channel of the outlet works consisted of an intake with racks, six 7-foot by 12-foot gates, two bypasses, a 90-foot transition section connecting three gates to one conduit, two conduits approximately 590 feet long, a 126-foot long rectangular channel extending from the outlet portal to the stilling basin, a stilling basin, an outlet channel, and a control weir.

Structural Design of Spillway

The spillway is trapezoidal in shape (Figure 2.2). It is approximately 1135 feet long, and ranges from 1000 feet wide at the upper end to 660 feet wide at the lower end. It is detached from the embankment, and is located in a bluff which forms the east (left) abutment. The control section of the spillway is a gravity ogee. On either side of the ogee weir, the channel sides are cantilevered, built on rock, and drained by weep holes. The lower end of the spillway consists of a drop structure designed to direct the flow of water to the streambed below. At the lower end of the drop structure, a crib cut-off was designed to prevent erosion. In effect, the spillway is divided into the following components:

(1) Spillway Ogee
(2) Gravity Side Walls
(3) Cantilever Side Walls
(4) Slabs
(5) Concrete Cut-off Crib.

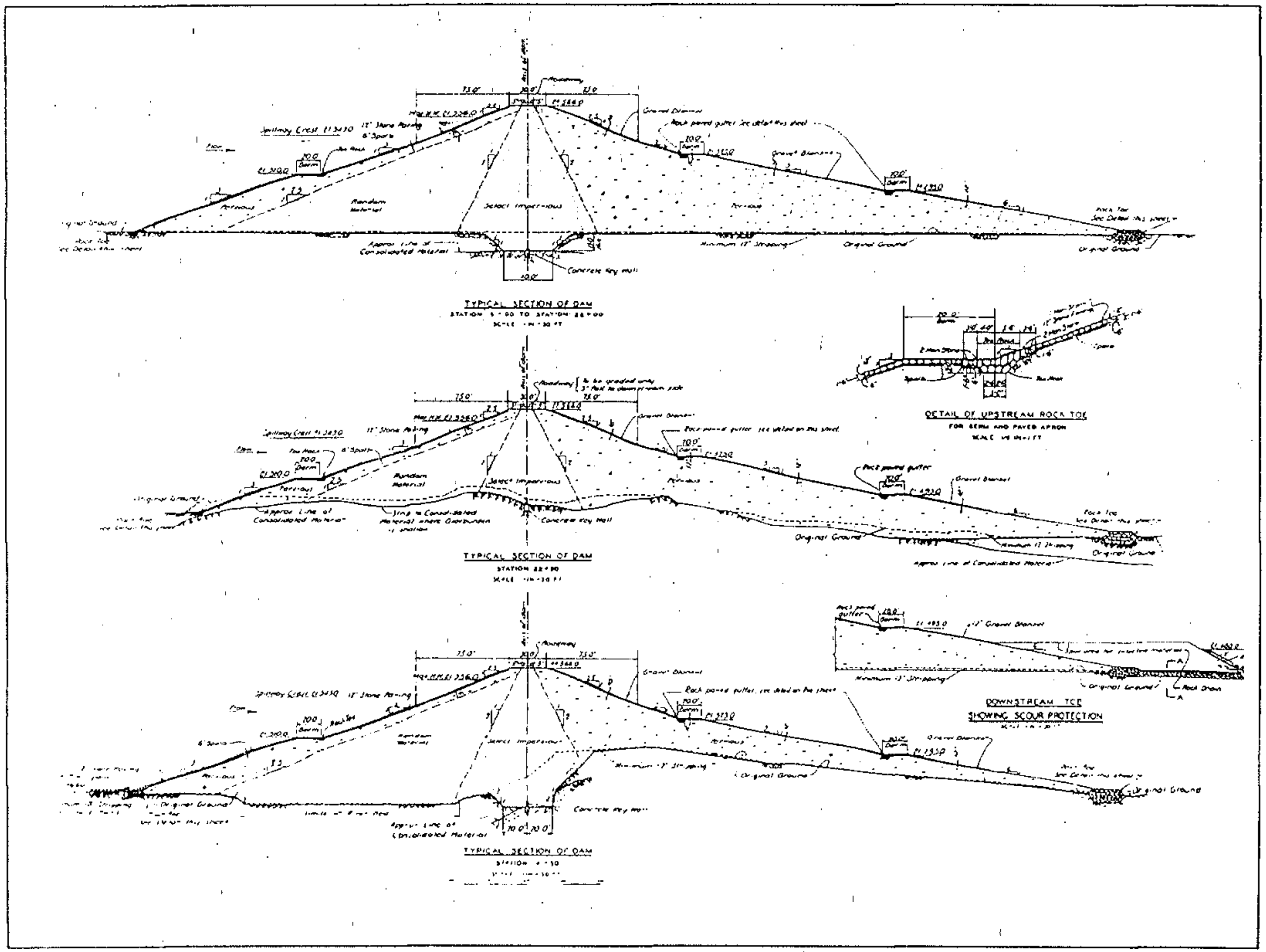

Figure 4.1. Typical Embankment Sections.

Structural Design of Outlet Works

The outlet works are located in the west (right) abutment. They consist of the following elements:

(1) Intake Structure
(2) Control House
(3) Control Tower
(4) Gates and Operating Equipment
(5) Conduit Transition
(6) Outlet Conduit
(7) Outlet Structure
(8) Outlet Channel
(9) Discharge Line for Gallery System
(10) Service Bridge.

The intake structure consists of two gravity-type entrance walls, with invert slab and piers. The sides of this structure contain the uncontrolled conduits and the supports for the trash racks.

The control house, as a part of the control tower, is built of concrete. The roof was designed for a "live" load of 20 pounds per square foot, whereas the floor was designed for a load of 200 pounds per square foot and the weight of the gates as operated under maximum load. Engineering provided for a wind load (vertical) of 20 pounds per square foot, and an earthquake (horizontal) or seismic coefficient of 0.2. The design of the control house was based on a bulletin published by the Portland Cement Association called *Analysis of Small Monolithic Concrete Buildings for Earthquake Forces.*

The control tower was designed of rigid frame construction with concrete columns and horizontal members (Figure 2.4). The tower was planned to carry all of the loads from operation of the control house, and to withstand a comparable earthquake. Included in these computations were the weight and horizontal force of the service bridge during an earthquake.

The gates and operating equipment, including six 7-by-12-foot caterpillar gates, were designed as manually operated with motor-driven drum hoists located in the control room (Figure 4.2). Much consideration was given to the type of gate utilized. Ultimately, it was determined that slide gates would not be readily operahle due to massive hydrostatic pressures, and caterpillar gates were selected as the preferred alternative. These gates had a relatively low friction coefficient, and had the added advantage of being closed by gravity. They also required no recess in the tunnel floor and therefore would not impede the flow of water. The hoists were rated at 55 tons, and were designed for a gate speed of one foot per minute. A manually-operated automatic electric brake was installed to hold the gate in any desired position, and gate indicator lights told the operator the position of each gate. The control station was designed with individual push buttons for each hoist. Electricity was to be provided by power company lines, with a standby gasoline engine generator in reserve.

The outlet channel was designed as an earth channel with a trapezoidal section. The purpose of this unit was to return the controlled or diverted water to the river channel. Included in the plans were a weir (a sill across the channel with retaining walls) and downstream sheet pile cut-offs to eliminate undermining of the weir.

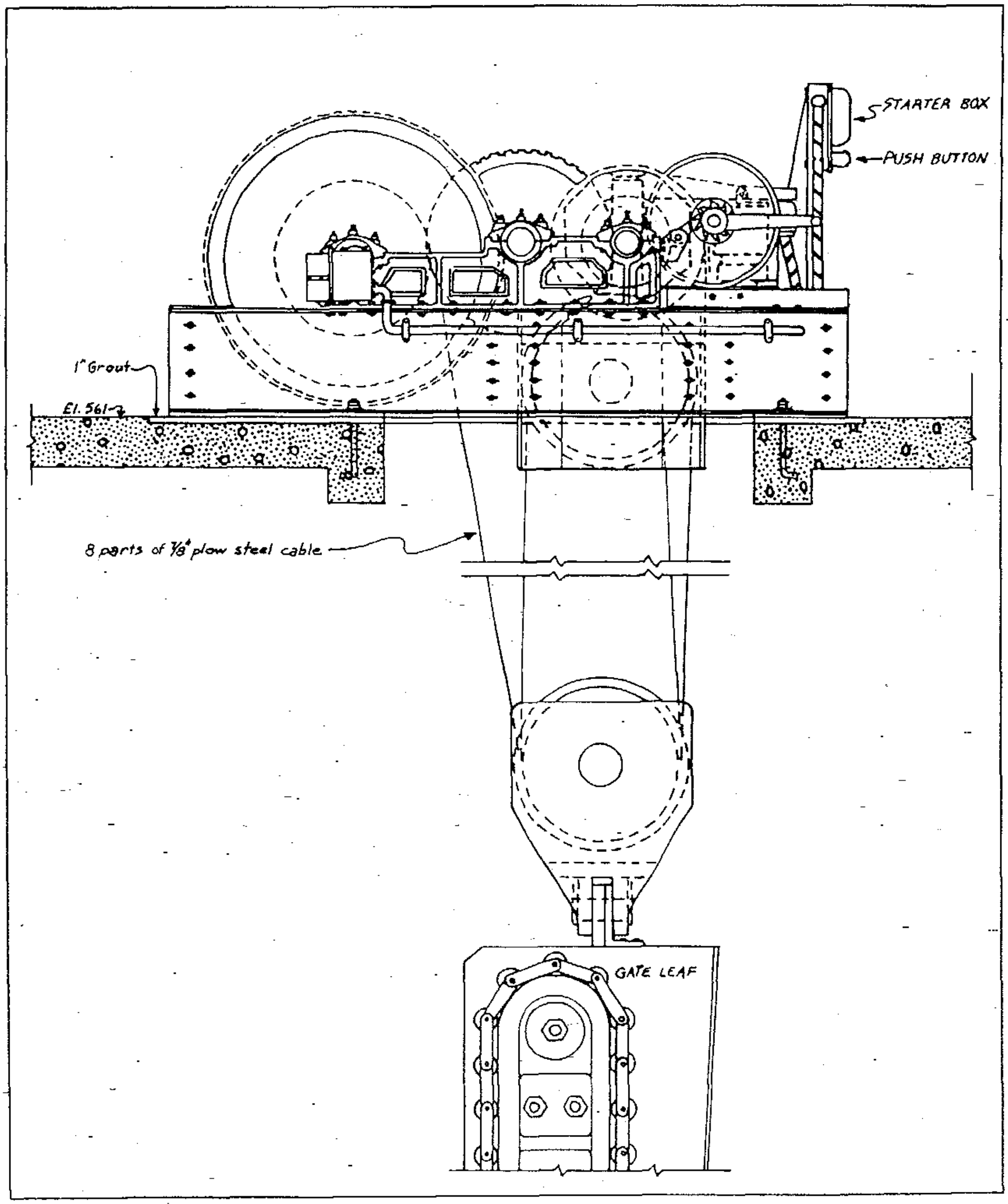

Figure 4.2. Drum Hoist Assembly.

At the request of the Orange County Flood Control District, the plans of a Discharge Line for Infiltration and Gallery System included a 60-inch steel pipe encased in concrete beneath the conduit. The pipe was to be enclosed at both ends until it was needed. It would later prove to be the subject of considerable controversy.

The purpose of the design of the service bridge was to "furnish a structure that would be architecturally pleasing," inexpensive, and earthquake resistant. To serve these objectives, structural steel was used in the construction because it weighed less than concrete. No provision was made for pedestrian walkways since it was anticipated that there would be only limited traffic on the bridge.

Discussion of the Design

The design of Prado Dam is of interest for several major reasons. These are:

Overall Simplicity of Design

This was possible largely as a result of the fact that the dam was to be used only to control the river during flooding episodes. The machinery and technology utilized were not complex, and the plan followed the general design criteria employed in other earth fill dams. The outlet works were, for example, designed to function like those of the Hansen Flood Control Dam on Tujunga Wash, and the spillway discharge channel was much like that of the Conewingo Dam.

The Concrete Outlet Tower and Control House

This is the outstanding and most architecturally and technologically unique feature of Prado Dam. The tower was designed in an unusual open-frame manner, with a self-contained control house above. It was also designed to resist relatively heavy horizontal earthquake effects, and special effort was made to achieve a "pleasing" architectural result.

Use of Design Guidelines

Despite the relatively simple design of the dam itself, considerable attention was given to a justification of the plan with regard to prevailing state-of-the-art technical literature. The War Department, United States Engineer Office, very carefully analyzed the design in a May, 1938 paper titled *Analysis of Design Prado Dam*. Numerous reference sources were cited in this document. The citations are incomplete as they appeared in the text and the sources are not available for reference, but the following were used in the analysis:

(a) *Hydrology of the Santa Ana River and Adjacent Coastal Basin*, dated April 22, 1938.

(b) Local interest group investigations, such as those prepared by the Orange County Flood Control District.

(c) Engineering Bulletin No. 7, 1937.

(d) Eckis, R., *South Coastal Basin Investigation*, California Division of Water Resources, Bulletin No. 45, 1934 et seq.

(e) Freeman, J. R., *Earthquake Damage and Earthquake Insurance.* McGraw Hill Co., 1932:615.

(f) *Bases for Design, Santa Ana River Improvement, Definite Project*, dated April 30, 1938.

(g) Charles Terzagi, *Public Roads*, issue of December 1929.

(h) Proctor article in *Engineering News-Record*, issue of August-September 1933.

(I) Conewingo Dam design in *Engineering News-Record*, January 1932:127.

(j) *Hydroelectric Handbook* by Creager and Justin.

(k) Mannings formula.

(l) Portland Cement Association, *Analysis of Small Monolithic Buildings for Earthquake Forces.*

These sources were consulted and cited in justifying and developing the contract to be issued. By today's standards, these references appear to be remarkably few and lack details. They are, however, reflections of both the overall simplicity of design, and of the relative level of design sophistication and analysis employed at the time of construction.

Model Testing

The comments presented above with regard to the evaluation and analysis of Prado Dam do not imply any contextual shortcomings in the design of the dam itself. Extensive model tests were completed prior to issuance of the contract and final preparation of the plans. For example, a model of the embankment was completed by February 1938. It was built in the U. S. Engineer District Office, Los Angeles, with all materials collected from the dam site. Additional and quite detailed tests, with models, were made for the spillway and to determine the proper rolled fill earth section required. These tests actually continued until well after the Invitation to Bid was issued, and they were subsequently responsible for several change orders in the procurement.

In summary, the design of Prado Dam is best viewed as a relatively straightforward process. Unlike the political arena with associated special interest group lobbying, the economic considerations which influenced the ultimate site selection, and the controversy over the social impacts of construction, the actual design of the dam is comparatively uncomplicated. And with relatively few exceptions, the bidding, award of contract, and actual construction of the dam were to be equally well thought out and brought to a cost-effective and timely conclusion.

The Bidding and Award of Contract

On August 26, 1938, *The Southwest Builder and Contractor* (SBC) announced that construction bids for the "Prado Flood Control Dam Notable for Unusual Design Features" would be received until noon on September 19, at the U. S. Engineer Office in Los Angeles. A notice of bids, along with a detailed list of quantities, had been published in this journal on August 19, and potential bidders were advised that a complete list of specifications was on file at the SBC offices at 168 South Hill Street. The bids were solicited under Invitation No. 509-39-90, dated August 20, 1938.

The SBC article further noted that the original Orange County flood control program was being executed under federal authorization. The original plan had been developed by M. N. Thompson, chief engineer of the flood control district. By 1938, however, jurisdiction had passed to the U. S. Army Corps of Engineers (COE), under the direction of Major Theodore Wyman, Jr., U. S. District Engineer. Captain N. A. Matthias was Military Assistant and Chief of the Engineering Division. G. B. Archibald was his assistant, and preparation of plans for Prado Dam and other flood control projects was under the direction of Deming W. Morrison, Senior Engineer. Captain G. W. Withers was Military Assistant and Chief of the Operations Division.

The SBC carried weekly listings of the contractors who had obtained plans for submittal of bids to Major Wyman. These notices were published on August 26, September 2, September 9, and September 16. By the 16th, nearly 70 firms had obtained the bid package, or reviewed plans at the SBC offices. Ultimately, 87 sets of specifications would be distributed. Although two-thirds of the prospective bidders were from Los Angeles or the immediate vicinity, widespread interest was generated by the opportunity. Two firms from San Diego requested bidding information, and nine firms from northern California, including six from San Francisco, two from Oakland, and one from Sacramento, expressed interest. Two East Coast companies, located in New York and Pennsylvania, obtained plans, and a number of Midwest firms, from Illinois, Nebraska, Colorado, Iowa, and Minnesota, also requested the bid package.

Two sealed bids were requested. The invitation also stipulated a guarantee bid bond, and a performance bond with surety or sureties sufficient to protect the government. Strict wage and labor conditions were made explicit, and each bidder had to document previous or current experience in work similar to that of the proposed project. Each bid was also to contain a statement of the proposed work plant with drawings, charts, and the location of all material yards and plant layout. A chart, in the form of plotted curves, was to detail time in days to complete work, and the percentage completion of each project task in time. Bidders were also to visit the site to acquaint themselves with conditions there, and were further invited to review samples taken from the borings and test pits.

Two modifications were made by the District Engineer to Invitation No. 509-39-90 prior to the final submittal of bids. Addendum No. 1, signed by L. Rosenberg, Executive Officer in the absence of the District Engineer, contained two alterations to the listed specifications, and four revisions to the drawings. Changes to the specifications were minor, but the drawings made several significant revisions including an extension of the limits of the contractor work area and a new, deeper thickness of the spillway tunnel (COE Miscellaneous Letters, Sept. 1, 1938). Addendum No. 2 was less complex, noting only that "all sand rock encountered in excavation of trenches will be classified as rock regardless of method of excavation" (COE Miscellaneous Letters, Sept. 14, 1938). It was requested that each prospective bidder acknowledge receipt of each addendum.

Several hundred people attended the opening of bids for the construction of Prado Dam, at the offices of the U. S. District Engineer, Los Angeles, at noon on September 19. The attendance at this meeting is understandable for two major reasons. For one, the Prado project was the largest undertaking in the Orange County flood control program, and was second only to the Hansen flood control dam in Los Angeles County. Second, it had been stated previously that the District Engineer would likely award the contract to the lowest qualified bidder. Clearly, the interest and attendance at the September 19 meeting was a product of these two variables.

Major Theodore Wyman, Jr., District Engineer, read the bids. Seven offers were submitted, ranging in cost up to $5,474,170. The lowest cost proposal was in the sum of $3,640,795, submitted by a group composed of the Guthrie-Marsch-Peterson Company, Chicago; George W. Condon Company, Omaha; and J. P. Shirley and W. E. Callahan Construction Company of Los Angeles. The second lowest bid was submitted by California Constructors, Inc., consisting of Jahn & Bressi and Elliot Stroud Seabrook of Los Angeles, and R. G. Clifford, San Francisco. The bid by this group was $3,837,600. The third lowest bid was $3,873,015, submitted by the Winston Bros. Co., Los Angeles. The four remaining bids were those of the Bates and Rogers Construction Company, Chicago, for $4,048,275; the Utah Construction Company and Griffith Company, Los Angeles, $4,368,500; the J. F. Shea Company, Inc., Los Angeles, $4,889,265; and the Atkinson-Kier-Dennis Co., San Francisco, at $5,474,170.

There was only a difference of approximately 5 percent between the lowest and second-lowest offers. In addition, each member of the consortium which submitted the low bid was associated with construction on the All-American Canal. It was duly noted that all were virtually finished with their All-American work at the time when the bids were opened (SBC 1938a). The District Engineer's estimate for completion of the Prado Dam flood control project was $4,570,074; all but the two highest bids, therefore, were less than the Engineer's estimate.

Events proceeded quickly. On September 30, 1938, the SBC reported that "Major Theodore Wyman...has forwarded to Washington his recommendation that the contract for Prado Dam be awarded to the low bidder at $3,640,975" (SBC 1938k:28). One week later, the "contract for Prado Dam...has been approved by Col. Warren T. Hannum, Div Eng, U S Army Engr., San Francisco, and has been mailed to the successful bidder" (SBC 1938l:36). The offices of the W. E. Callahan Construction Company were located at 206 South Spring Street. Throughout most of the contract period, this company would serve as the primary contact between the District Engineer and the other contractors, although the contractors subsequently incorporated as Prado Constructors, Inc., in order to execute the contract. The official contract reference was W-509-Eng.-749, dated September 23, 1938.

Plans and Specifications

The plans and specifications within Contract No. W-509-Eng.-749 filled 102 single-spaced pages of text. In addition, 49 prints and drawings had accompanied the invitation to bid, comprising virtually the entire set of working drawings for the project. Work was authorized by the Flood Control Act approved June 22, 1936, and amended May 15, 1937. Funding was provided under the War Department Civil Appropriations Act, as approved on June 11, 1938.

The contractor was to provide all labor and materials (with the exception of materials supplied by the government) for constructing Prado Dam and all appurtenances. The major structural items or operations required in the performance of the work were:

(1) Care of water, river, and drainage during construction.
(2) Clearing of existing structures, debris, grubbing, and stripping.
(3) Excavation in borrow pits and excavations for structures.
(4) Drilling and grouting anchors.
(5) Concrete work for structures.
(6) Installation of gates and accessories.

(7) Structure backfilling.
(8) Construction of earth dam and fills.
(9) Placement of fill, paving, filters, and drains.
(10) Construction of a steel service bridge.
(11) Installation of structural steel.
(12) Miscellaneous metal work.
(13) Installation of electrical and power systems.
(14) Construction of operating house and superstructure.
(15) Cleaning up of debris and needed incidental work.

Fifty-five separate categories were listed for various quantities of material and specific work items. The project was to be initiated within 10 calendar days of the notice to proceed. The outlet works and all dam embankments were to be completed prior to November 1, 1940, and all work was to be completed within 925 calendar days of the award. The contract contained numerous penalty clauses. The only major anticipated reasons for delay were related to the abandonment and relocation of Highway 18 and the Atchison Topeka & Santa Fe railroad tracks. Any delays related to natural events, such as flooding, were to be made up on an equal day-lost to day-added basis. Finally, no work was to be conducted on Sundays or the legal holidays designated by Congress.

Payments were made on monthly estimates of work conducted, with 10 percent retained from each payment until a total of 5 percent of the total contract had been withheld. The contractor was required to perform not less than 50 percent of the estimated work without delegating to subcontractors.

All work was subject to the detailed inspection of the contracting officer. In order to maintain compliance with the strict specifications and limitations of the contract, the contractor was required to maintain various lines, stakes, grades, and templates. Strict stipulations were placed on the use of domestic materials and supplies, with the exception of a specific list of materials which were not produced or manufactured within the United States.

The government agreed to provide the following:

(1) All cement. This was to be delivered to the contractor. Any cement not used within 120 days was to be condemned and charged to the contractor in full.

(2) Service Gates and Accessories. These would be furnished complete with all frames, guides, hoists, operating machinery, mechanisms, and motors. The contractor was to supply all electrical conduit and wiring.

(3) Traveling Crane for Operating House. This was to be delivered f.o.b. to the contractor at the Prado Dam siding.

Wage rates, compensation insurance, and the use of relief labor were also required and strictly regulated by the government. The wage rates were based on costs determined by the Department of Labor; minimum wage was established at $0.625 per hour, and the maximum was $1.375 per hour. The lowest rate applied to ax men, cleaners, flagmen, handymen, unskilled laborers, teamsters, and wagonwinders. The highest rate was paid to trench machine operators, power shovel operators, pile driver operators, and structural iron workers. Wages of $1.00 per hour were paid to blacksmiths, compressor operators, concrete mixers and operators, elevating grader operators, machine erectors, grouting machine operators, machinists, head powdermen, roofers' operators, roofers, tractor operators, and truck drivers. In all, 75 separate classes of laborers and mechanics were listed. The contract further specified that the contractor was to employ as many laborers as possible (both skilled and unskilled) from the Relief Rolls, and that such employees were subject to the same rates paid to other workers for comparable positions.

Final acceptance of all work was subject to a thorough examination of the site, and to the written approval of the Division Engineer, South Pacific Division, San Francisco. Final payment, including all funds retained, was to be made only upon signing of this approval.

Technical Provisions

The contract contained 12 major technical stipulations related to the structural items or activities previously noted. These provisions are important, in that they further detail the engineering and technological features of Prado Dam, and reflect the order of work scheduled by the CoE.

(1) Diversion and Care of the River During Construction

Permanent construction was carried out in areas free of water. In the event that work was required at elevations lower than that of stream or groundwater, cofferdams and levees were to be constructed to keep the water level below all activity. The contractor was allowed to use any type of engineering, as long as the upstream cofferdams provided protection to elevation 475 feet, and the downstream cofferdams provided protection to elevation 472 feet. In some instances, it was anticipated that sheet pile cut-offs might be necessary to safeguard the work.

The first task was therefore construction of the diversion channel, and construction of cofferdams, etc., to divert the stream flow through the new channel, thereby allowing all other work to go forward.

(2) Removal of Existing Structures, Clearing, Grubbing/Stripping

The contractor was required to remove all structures and any other obstructions at the site. This included pavement and other highway improvements in the dam and borrow pit areas, fences, guardrails, posts, test-pit lagging and sheeting, and any other miscellaneous debris. It was noted that many existing buildings would be removed by other agencies prior to construction, but that the contractor would be responsible for the disposal of any buildings or debris left at the site. All utilities were to be removed by other agencies, but the contractor was to dispose of all material in govemment-designated spoil areas, or bum all flammahle materials.

Clearing and grubbing required that the area to be occupied by the dam, including a 10-foot wide strip beyond the slope lines, be cleared of all trees, stumps, brush, and all vegetal matter including roots to a depth of 6 feet. The area to be covered by the dam was also to be stripped, or excavated, to a depth sufficient to ensure that no unsuitable foundation material remained below the new structure. The banks of the stream channel and the slopes of the abutments were also to be stripped. Unsuitable materials to be removed included topsoil, rubbish, material below ground surface not removed by grubbing, and the railroad and highway embankments. This stripped material was to be stockpiled for later use in the new embankments or, if totally unsuitable, placed in designated spoil areas.

(3) Excavation, Backfill, and Sheet Piling

Excavation was described as the removal, hauling, and/or disposal of any class of material encountered after clearing, grubbing, and stripping. Excavation work for rock foundations entailed the removal of all loose rock, and the cleaning of each bed or side wall. Excavated material not suitable for later use in the embankment was to be wasted in spoil areas. Suitable material was stockpiled for future use. Work on the excavation for the spillway was to proceed without stockpiling, with the material to be taken directly from the spillway cut to the embankment.

Borrow pit excavations first required clearing of the pit, and the subsequent removal of unsuitable material through stripping and disposal. It was required that slopes from the borrow pits be no steeper than 1 to 3, and that they blend into the surrounding topography as much as possible. The horrow pits were further graded following completion of the contract to ensure that all surface water would drain from the area. Rock excavation was authorized only when other means were determined to be unsuitable by the Contracting Officer. Heavy blasting was not permitted against rock which was to form the final foundation. Excavation was accomplished instead in such areas by the far more laborious means of barring, wedging, and close drilling. All excavated rock was stored for further use on the downstream slope of the dam.

Structure backfill included the filling of all excavated areas outside the limits of the rolled embankment. Backfill material was to be free of any roots, brush, or other flammable material. Compacted backfill was to be free of any stones larger than 2 inches in diameter.

Guidelines set forth for the actual backfilling operations were detailed. For example, backfill on either side of a concrete structure was to be kept to the same approximate level throughout the operation to equalize the load. Backfilling against concrete could not be completed until the concrete had been in place for at least 21 calendar days. Uncompacted backfill was completed with a raised or crown line, to allow for settlement, and the water content of compacted backfill was carefully regulated to provide for the maximum consolidation of material. Compacted backfill was placed in layers approximately 2 inches thick, and then compacted with power and/or hand tampers.

Steel sheet piling was to be used in place of concrete cut-offs when appropriate. The contractor was required to place a series of test piles to expose the locations of the underlying consolidated (foundation) material. Sheet piling was then driven with single or double-acting hammers (drop hammers not permitted), and driven so as to interlock with the adjoining pieces to form a water-tight diaphragm.

(4) Embankment

The term "embankment" was used to describe all of the earth fill portions of the dam, the outlet levees, and the filling of all trenches, test pits, etc., required to achieve the desired contour. The central core of the embankment was constructed of selected impervious material taken from the various excavations and supplemented with material taken from borrow pits.

The embankment section upstream from the central core was constructed of random unclassified material, although coarser material was dumped near the upstream pervious section, and the finer components dumped nearer the impervious section. In this manner a gradual transition was achieved from the pervious section of the embankment to the impervious section.

Prior to forming the embankment, the area of its foundation was plowed to a depth of 8 inches. All excavations for the keywalls, cut-off, test pits, exploration holes, and stumps were filled with the same materials as used in the embankment. After completion of such preparatory work, the embankment sections were constructed. Throughout the period of construction, the embankment was crowned with a grade not exceeding 2 percent, to allow for proper drainage.

The location of the borrow pits was determined by the government. The contractor was allowed to use Army type of equipment to excavate fill material. Again, all excavated material was to be kept free of roots and stones larger than 4 inches in dimension. Larger stones not acceptable as fill were used for rock paving, gutter paving, or rock fill, on the downstream slopes or else wasted in spoil areas.

Throughout construction of the embankment, the moisture content of the material was carefully regulated. It was anticipated that moisture content of approximately 15 percent was ideal for maintenance prior to compaction. The material was compacted by using a tamper-type roller, with a minimum of eight complete passes. The select impervious material was to be compacted by a roller weighing not less than 1100 pounds per linear foot; on the pervious sections, the weight of the equipment was to be not less than 2400 pounds per linear foot. Each trip of the roller was to overlap the previous path by no less than 2 feet. Additional roller passes were to be made if the Contractor Officer believed they were necessary to fulfill the requirements of the contract, prior to COE approval of the work.

(5) Rock Fills, Paving, and Drains

The materials used in all rock fills, paving, and drains were to be of a quality that would not disintegrate under the action of air, water, or during handling and placement. The paving stone was selected to be close to rectangular in section, with each piece having its greatest dimension no larger than three times its least dimension. "One-man" stone was graded in sizes of no less than 25 pounds and no larger than 150 pounds, with an average weight of 100 pounds. "Two-man" stone was to weigh between 150 and 250 pounds, averaging 225 pounds. Spalls or gravel consisted of broken stone from ledge or crushed rock. All stone or gravel used around drains, etc., was graded under Class "A" concrete specifications. Toe rock consisted of material weighing up to 1000 pounds, and derrick stone was quarry rock up to 2 tons. In general, the upstream slope of the dam embankment, and the approach and outlet channels, were protected by one or more grades of rock paving.

The paving was laid on a 6 inch layer of spalls or gravel. All stone was hand placed to form a flat, compact surface. On gutters and other sections where grouting was to occur, a layer of heavy burlap was laid over the spalls. The stone in these areas was laid with open joints to permit later grouting, with small stones placed in the joints to prevent movement prior to grouting. The connection between the slope paving and the toe rock was laid up with "two-man" stone, with the remainder of the slope covered by "one-man" stone. Weep holes were set in the grouted paving in the approach channel on approximately 10 foot centers. The grouting was composed of a mix of one part Portland cement to three parts sand, mixed in a power batch-type mixer in the same manner as concrete preparation. All grouted surfaces were carefully brushed and cured for a period not less than 14 days.

Toe rock was placed in the upstream and downstream toes of the dam, the toe of the rip-rap, the toe of the berm of the dam, and the rock fill at the edge of the approach apron. Rock fill below the outlet structure consisted of the large derrick stone. The downstream face of the downstream slope of the spoil area was to be laid in rip-rap 2 feet thick, conforming to the general guidelines describing toe rock.

(6) Concrete: Drilling, Grouting, Composition, Classification

The single largest component of the technical provisions section in the contract addressed the specifications for concrete in its various applications. Concrete was defined as a composition of cement, fine aggregate, coarse aggregate, and water. Most of the concrete used was Class "A," except under special applications where Class "B" was required. Fine aggregate was defined as consisting of strong, hard, and durable particles. Coarse aggregate was washed gravel or crushed stone.

The grading and mixing of concrete were carefully regulated with regard to water content, size of aggregate, cement content, mixing time, delivery, and placement. All concrete was to be cured for a period of not less than 14 days by a saturated water covering, water flow, or a system of mechanical sprinklers.

Forms were constructed primarily of wood or steel. Where walls were visible, such as on buildings or in the bridge superstructure, the forms were to be of pressed wood sheets. The objective was to provide a much more aesthetic appearance.

(7) Installation of Government Supplied Equipment

The following equipment items were supplied by the United States to the contractor: gate hoists, steel switchboard, standby unit, traveling crane and hoist, and the service gates. The gates, with all the associated hoists, guides, and frames, were installed under the supervision of the manufacturer. The contractor was to supply the necessary labor, and to ensure that the equipment operated well. The contractor was to install the switchboard and traveling crane in accordance with plans provided, and to test the equipment as installed in the control house. The generator was also to be installed by the contractor, with associated fire protection insulation consisting of magnesia, asbestos, white lead, and oil paint.

(8) Miscellaneous Structural Steel and Metal Work

Other structural steel installations included the trash racks and crane rail beams in the control house, and all associated priming and painting. Miscellaneous metal work included ladder rungs, guard chains, bolts, eyebolts, service bridge scuppers, standby generator exhaust, and a gasoline tank. The contractor was also to furnish all structural steel for the service bridge superstructure, with all bases, pins, and anchor bolts. Finally, all guard fences were to be constructed on top of the spillway channel, on top of the walls of the outlet channel, and along the flume wall.

(9) Conduits, Power and Light Systems, Underground Power

The electrical apparatus was installed in accordance with existing standard requirements of the National Electric Code of the National Board of Underwriters, except as modified by the Electrical Safety Orders of the Industrial Accident Commission of the State of California. All electrical work was subject to inspection and approval by the Electrical Division of the Department of Building and Safety of Riverside County, although the permit for the electrical work was granted by the Orange County Flood Control District.

All electrical conductors were run in rigid steel conduit. Most of the conduit was concealed within walls and floors, set in place during the course of the masonry work rather than by cutting into completed fabric at a later date. All conduit had a round cross section, and was made watertight with white lead. Underground electric power was supplied to the switchboard in the control room, and electric light was supplied from the transformer rack at the east end of the dam to a pull-box at the south end of the service building.

(10) Control House

The contractor was obliged to supply all labor and materials for the control house, with the exception of the cement and special equipment provided by the government. The contract specifications called for special care to be given to the ornamental portions of the walls and roofline. The form for the lettering on the wall consisted of a plaster cast mold, in accordance with details provided by the government. All exposed surfaces of concrete were rubbed, after removal of the forms, with a fine grained carborundum stone to polish the surfaces and achieve a uniform texture and color.

All window sash was of copper-bearing steel. The intermediate sash was to open down and outward, while the bottom sash was designed to open downward and in to the interior. The windows were arranged to be glazed from the inside. The doors and frames for the control house were made of hollow metal, designed to open inward. The active leaf was required to be on the west center side, and all plates and hardware were attached with machine screws.

All painting of metal work began with the application of a single coat of rust-resistant paint and two coats of mineral filler, baked on and rubbed, prior to assembly. Doors and trim then received three additional baked-on coats. A color coat was then added, and a final varnish coat was applied and rubbed to a gloss. Windows were then glazed with clear wire glass, one-quarter of an inch thick.

(11) Miscellaneous Specifications and Workmanship

The quality of workmanship required of the contractor was defined in detail in the contract. In general, the work was to conform to federal specifications, and/or those defined by the American Society for Testing Materials (ASTM). Requirements were set forth for each class of material to be utilized (Table 4.1).

The workmanship was to exemplify a consistently high level of quality. An unworkmanlike finish would constitute cause for immediate rejection. Welding, plugging, and shimming were allowed to correct defects in materials or workmanship, but only at a level which did not affect the strength or function of any object or part. Finally, any patterns, molds, templates, and jigs made as part of the project were to be supplied to the government at the dam site prior to final payment.

(12) Paints and Painting

The federal specifications applied as well to all paint and raw material. For example, all finish paint was to be composed of two pounds of pigment to one gallon of vehicle. The vehicle was to consist of not less than 50 percent non-volatile oil and resin, and the thinner for the vehicle was to be free of toxic hydrocarbons. The pigment was of aluminum powder. All paint was to be mixed on the job site, and only in quantities sufficient for one day's work.

Table 4.1. Quality of Workmanship Requirements

Material	Specification	Designation
Structural steel	Federal	QQ-S-711a
Steel castings	Federal	QQ-S-691a
Iron castings	Federal	QQ-I-651
Malleable castings	Federal	QQ-I-666
Bronze	Federal	QQ-B-746
Brass castings	Federal	QQ-B-601
Brass pipe	Federal	WW-P-351
Brass screws and bolts	Federal	QQ-B-611
Copper sheets	Federal	QQ-C-501
Zinc coatings	Federal	QQ-I-696
Iron, steel sheets	Federal	QQ-I-696
Bolts, screws, washers	Federal	FF-B-571a
Steel pipe	Federal	WW-P-403
Iron fittings	Federal	WW-P-521
Wrought iron fittings	Federal	WW-P-441
Corrugated metal pipe	Federal	QQ-C-806
Wire mesh	ASTM	A-82-34
Wire bars	Federal	QQ-B-71a
Chain	Federal	RR-C-271
Fencing	ASTM	A-171-33
Barbed wire	Federal	RR-F-221
Asphaltic paint	Federal	SS-A-701
Steel conduit	Federal	WW-C-581a

Change Orders

The Invitation to Bid and the resulting contract, as signed by the government and the contractor, were highly structured, setting forth lengthy sets of procedures, technical specifications, and guidelines to be followed during construction. However, it was anticipated by all parties that any project as large and complex as the construction of a dam required the issuance of numerous change orders (large and small) to accommodate unanticipated conditions encountered during construction. Thirteen change orders were added to Prado Dam Contract No. W-509-Eng.-749 between December 21, 1938 and January 23, 1941. These were revisions to the original plans and specifications as issued August 20, 1938, and amended on September 1 and September 14, 1938.

Change Order No. 1

Issued and approved on December 21, 1938, the first change order did not affect the time schedule or provide additional funds to the contractor. It did, however, reflect on the readiness and ability of the contractor to perform the required services. The contractor was directed to receive the government-supplied cement in bulk, rather than in paper sacks as originally stipulated. This is an indication of the equipment already in the possession of the contractor, most likely the same equipment previously used in the construction of the All-American Canal.

Change Order No. 2

The second change order was issued by T. Wyman on December 23, 1938, but not approved by M. C. Tyler, Acting Chief of Engineers, until January 20, 1939, because it involved more than $500. The change in scope was prompted by the need for additional tests to determine the nature of the overburden in relation to the assumed groundwater elevation. The contractor was to construct a test pit from the assumed groundwater level of 456 feet to the rock or foundation level at 406 feet. The amendment added three additional days for completion of the total contract.

Change Order No. 3

This revision was issued by T. Wyman, District Engineer, on January 9, 1939. It did not extend the time for completion, but the results of the recommended testing, at a cost of $484.37 would soon have a major impact. The depth to consolidated material (rock), along the axis of the dam, was much greater than projected on the original contract drawings. The constructor was therefore directed to drive sections of "H" piling to determine the depth of penetration into consolidated material. The change order illustrates that there were errors, however minor, in the scientific data gathered prior to the preparation of the invitation to bid.

Change Order No. 4

Another change order was issued by Wyman on January 11, 1939, and approved by Major General J. L. Schley, Chief of Engineers, on February 15, 1939. Again, this work was required as a result of problems encountered with the nature of the soils along the axis of the dam. Here, the additional testing was to determine "the practicability of driving a deep cut-off of sheet piles along the axis of Prado Dam." One additional day and a sum of $3,000 were approved to conduct this effort.

Denial of Change Request

A request for a schedule change was denied by Wyman on January 13, 1939. It would appear that the contractors had earlier initiated discussions with him about the possibility of completing their work on an advanced schedule. Wyman wrote in response:

> With reference to our recent discussions concerning changing your construction schedule to permit completion of Prado Dam at the earliest possible date, you are advised that information has been received in this office from higher authority which is in part as follows: "The Department does not believe the payment of amount for earlier completion of Prado Dam justified...Authority for issuance of the change order is therefore not approved" [COE Miscellaneous Letters, Jan. 13. 1939].

Wyman's response implies several significant issues were related directly to the construction of the dam. First, the contractor must have believed that the work could have been finished earlier than the schedule set forth in the request for proposals. Second, Wyman must have had some misgivings about the denial as he states that a "higher authority" made the decision. Finally, the decision not to complete the dam "at the earliest possible date" may well have ben based on conditions unrelated to construction (political, social, legal, economic, etc.). It appears that the contractors had requested a bonus or accelerated payments to expedite the work.

Change Order No. 5

The results of testing conducted under Change Orders 2, 3, and 4 prompted this revision. The tests had demonstrated that the material beneath the axis of the dam was "so poorly constructed" that it would both permit and require the driving of a sheet pile cut-off wall to a much greater depth than first anticipated. The contractor was therefore requested to drive an additional wall of approximately 70,000 square feet between the originally engineered line of consolidated material and the actual line as determined by the tests. The additional amount authorized was $144,730. The order was issued by Wyman on February 24, 1939 and approved by J. L. Schley, Chief of Engineers, on March 24, 1939.

Change Order No. 6

The order issued by Wyman on April 12, 1939 was not approved until May 8, 1939 by John Kingman, Acting Chief of Engineers. It became necessary when excavation for the outlet structure uncovered rock which rapidly decomposed when exposed to the atmosphere. As a result, plans were made to cover this rock with a layer of "pneumatically placed concrete" to protect the surfaces. Additional time was not allowed for completion of the contract, but a budget increase of $10,000 was authorized.

Change Order No. 7

An order issued by Wyman on July 12, 1939 was not approved until October 17, 1939 by John Kingman, Acting Chief of Engineers. The schedule was not extended, but an additional amount of $132,615.15 was authorized. The stipulations outlined in this change order were many. They were almost all based on the fact that "unsatisfactory foundation conditions" had been encountered, this time during excavation for the spillway and outlet works. Provisions were made for additional common and rock excavation below the original grade plan, the removal of objectionable foundation material, additional sheet pile cut-off walls, dewatering and the driving of test pipes, the removal of concrete already in place, and the placement of additional backfill.

One reason for the delay in approval was that the Chief Officer of the COE Finance Division, E. E. Gessler, had noted a difference in unit price between Change Orders 7 and 8. He requested that approval be deferred until the question of price was resolved. This change order reflects the level to which each amendment was screened by different divisions within the CoE. Wyman also appears to have been put somewhat on the defense here, for he wrote on August 9, 1939, that "an error was made in laying out the work for the contractor...the error revealed that the work was done in conformity with the established lines and grades, and the contractor was not at fault in this matter."

Change Order No. 8

Issued on August 22, 1939, and approved hy John Kingman, Acting Chief of Engineers, on October 17, 1939, the change was prompted by the same problems which had led to Change Order No. 7. Specifically, unsatisfactory foundation conditions required that an additional 180,000 cubic yards of backfill be placed in the dam embankment upon removal of the same amount of unsuitable material. After much discussion and justification, the order was approved on the same day as Change Order No. 7. Theodore Wyman, Jr., was replaced as Division Engineer by Edwin Kelton after this date, and Kelton served in this capacity during the remainder of the construction of Prado Dam.

Change Order No. 9

Kelton's first change order as the new Corps District Engineer addressed the need for additional borrow pit excavations of approximately 700,000 cubic yards over the original 600,000 cubic yards specified in the contract. At $0.17 per cubic yard, the amendment amounted to an increase of about $119,000.

Change Order No. 10

A change order issued by Kelton on June 13, 1940 was approved by J. L. Schley, Chief of Engineers, on July 9, 1940. It was precipitated by yet another discovery of "unsatisfactory subsurface conditions," this time along the west wing of the spillway crib cut-off. Kelton carefully calculated the additional increase, while at the same time reducing the original contract commitment in light of the newly authorized work. The expenditure would be $215,000, minus the reduced work cost of $97,4842.30, for a net augmentation of $117,517.70. No extension of time for completion was approved.

Change Order No. 11

This change order called for the substitution of concrete pipe for the clay tile drains originally specified. The United States apparently had a surplus of 12-inch concrete pipe (probably from another flood control project), and it sought to use this material rather than have the constructor acquire clay pipe. The order was issued by Kelton on July 29, 1940, and approved by John Kingman on September 10, 1940. No additional time was involved, and the total cost was decreased by $1078.

Change Order No. 12

The last change order was dated January 23, 1941. It related primarily to cosmetic work including "filling gullies, smoothing the surface, and placing a gravel blanket on the downstream slopes of Prado Dam."

The entire sequence of change orders provides insight into both the difficulties encountered during the construction of Prado Dam, and the internal process of politics, finances, and review of construction-related activities. It is clear that the major problem arising during construction was the inaccuracy or inadequacy of scientific information regarding the nature of foundation soil and rock beneath the dam. Nine of the 13 change orders were issued as a direct result of this problem. Out of the total increase in contract commitment of approximately $550,000, at least 99 percent was necessitated by the discovery of unsuitable foundation conditions.

No change order greater than $500 could be approved by the District Engineer. Any greater commitment had to be approved by the Chief Engineer, and was subject to review by a variety of other divisions, most notably the Finance Division. This could result in lengthy delays in approval. Change Order No. 7, for example, took more than three months for approval. It would appear that the government took some steps both to limit costs, and to maintain the original schedule without any modification whatsoever. The Denial of Change Order dated January 13, 1939 is notable in that it set forth the government's policy not to consider an early completion of scheduled work. On the other hand, no additional extensions of time for completion were granted to the contractor under subsequent change orders, regardless of the size or complexity of the additional work involved.

In summary, the construction of Prado Dam was a tightly scheduled and well managed undertaking. The authorized increases in cost (approximately $500,000) were large, amounting to about 15 percent of the total original contract figure. However, this was still nearly $400,000 below the District Engineers' original cost estimate prior to the invitation to bid. Considering that severe problems were encountered and carefully corrected with regard to underlying soil conditions, the on-time completion of Prado Dam should be regarded as a tribute to the contractor and the CoE alike.

The Construction Schedule

Assigning a specific date to the first work associated with the construction of Prado Dam is problematic. Property and water rights acquisition had begun far in advance of turning the first shovel of earth by Prado Contractors. Water companies had acquired water rights in the early twentieth century, and the mechanism for purchasing property was established by the Orange County Flood Control District in February 1938. In addition, numerous celebrations, with appropriate speeches and ceremonies, were held throughout the late summer and fall of 1938 to commemorate the inauguration of various activities. On August 15, 1938, the *Santa Ana Register* reported, for example, that a gathering of about "200 leaders in water conservation from Orange, San Bernardino, and Riverside counties attended the celebration over plans for the culmination of more than 20 years of effort to harness the Santa Ana River in the name of flood control." Contractors Pederson and Hollingsworth hosted a barbecue, with Wilber C. Cole, the firm awarded the contract for the relocation (grading and building structures) of the railroad and Highway 18. The completion of the latter was essential to the scheduling of construction for the dam itself. The date for the beginning of construction, therefore, may be regarded as prior to the issuance of the request for bids by the U. S. Engineer Office in Los Angeles.

Actual construction work on the dam itself was begun by Prado Constructors, Inc., on November 1, 1938. The process of debris disposal, grubbing, and stripping was the first task item undertaken. By January 1, 1939, the *Santa Ana Register* reported that 10 tractors and auxiliary equipment were in use at the dam site, and by the end of March, nearly 150 men were at work on the dam including inspectors, surveyors, and engineers (*Santa Ana Register* 1939b). It was anticipated that this number would be greatly increased once the earth fill operations began.

By late spring 1939, work was in progress on the foundation excavation, drains, construction of the keywall, backfilling of the keywall trench, and excavations for the outlet structure. As of May 1, 1939, the following work had been completed in terms of the gross totals of materials used or moved:

(1) Stripping of 367,000 cubic yards out of a total estimated amount needed of 5,000,000 cubic yards.

(2) Common excavation of 520,000 cubic yards out of an estimated total of 1,375,000 cubic yards.

(3) A total of 3500 cubic yards out of an estimated total of 2,125,000 cubic yards of rock excavation.

(4) A total of 73,000 cubic yards out of a total of 2,125,000 cubic yards of rock fill in the dam toes.

(5) A total of 2000 cubic yards of concrete used in the outlet structure out of an estimated total of 168,000 cubic yards needed for all structures.

(6) A total of 31,000 pounds of reinforcing steel placed out of an estimated total requirement of 10,700,000 pounds.

(7) A total of 23,000 square feet of sheet steel pile driven, out of the original estimated amount of 67,000 square feet (later amended by Change Order No. 7).

Work progressed rapidly during the summer of 1939, and the labor force was increased as each new construction phase was initiated. The installation of the 60-inch drain, specifically requested and paid for by Orange County, had been completed by June 29, 1939, and construction of the outlet conduits was in progress. By the end of July, the initial sheet pile cut-off wall was completed, and the embankment material was being backfilled and compacted. Construction of the intake structure had begun, the uncontrolled bypass pipes were in place, the trash racks and frames were heing fabricated, and excavations near the ogee section of the spillway were under way. By the end of August, forms had been erected for the gravity wall sections of the outlet structure, and the baffle piers at the discharge end of the closed conduit near the stilling basin. The forms were also in place for the center pier of the service bridge.

By the end of December 1939, slightly more than a year after construction had begun, the gravity walls had been completed, the intake structure and the pier for the service bridge were finished, the embankment was well under way (including placement and compaction), the baffle piers had been completed, and grading had started on the stilling basin. The base of the control structure was nearly finished, and the slide gates for the control outlet were installed. The ogee section of the spillway was partially completed, and backfilling in progress along portions of it. Work had also begun on the crib cut-off walls.

The new year ushered in the only labor unrest recorded during construction of the dam. On January 24, 1940, the *Santa Ana Register* reported that union truck drivers had walked off the job, and that "a milling crew of pickets" had gathered at a nearby service station (probably at Prado). The strike was ended abruptly when the contractors replaced all the men who had walked off the job with non-union labor. Altogether, the trucks, then used primarily for transporting material to the embankment, were only idle for a period of several hours, and no measurable interruption to the schedule resulted. By the end of the month, the outlet control tower was completed. Construction of the embankment was also beginning to have a discernible impact, and all forms had been stripped from the service bridge pier.

On March 18, 1940, a landmark event in the construction of Prado Dam took place:

> ...the first water poured through the dam at 5:58 p.m., as Prado's rising stream was diverted from its old channel and harnessed to its new master. The diversion was completed at 7:50 p.m. The diversion was completed six weeks ahead of the originally scheduled May 1, 1940 date [*Santa Ana Register* 1940b].

The decision to advance the schedule was made largely as a consequence of the fact that construction was proceeding more rapidly than anticipated. The east abutment of the dam had already been completed to elevation 525 feet, with only 41 feet remaining before the maximum designed height was attained. The COE thus elected to divert the flow of water, in order to clear the way for construction across the old channel.

Work continued throughout the spring and summer of 1940 on the embankment and the embankment's rock paving. The outlet channel had been completed, and excavation continued on the spillway overflow section and apron. These tasks were massively labor intensive, involving both heavy equipment and hand labor to accomplish the tamping, placement of rock, and all associated grouting and finishing.

The fall of 1940 was devoted to finishing the embankment, left abutment, and on the excavation and completion of the spillway and crib cut-off wall. The steel reinforcing for the spillway bucket was in place by September 5, and by the end of September, the bucket was complete except for the wing wall. By mid-November the excavations for the spillway lip and trenches were complete, and pouring of concrete for the spillway slab was in progress. By the end of December, concrete was being poured on the spillway lip, and work was nearing completion on the spillway slab and the crib cut-off wall extension.

The first three months of 1941 were devoted to the various remaining "details," including completion of the service bridge (which could only be built after completion of the embankment), and completion of the spillway and spillway channel. Forms for the service bridge were in place by the beginning of February, and the unit was ready by the end of March. Excavation and grading for the spillway channel were finished, with the exception of the addition of the rock blanket on the downstream slope by March 5, 1941. Work was complete by the end of April, including the finishing, paving, and surfacing of all features.

One new contract was issued by the District Engineer, Los Angeles, early in April. Invitation for Bids No. 509-41-55 called for "Furnishing all labor and materials and performing all work for constructing Caretaker's House and Appurtenances--Prado Dam, located at Prado Dam near Corona, California" (COE Miscellaneous Letters January 3, 1941). The contract was awarded to Carl J. Flagstad and Edward Bock, located at 3517 Alsace Ave., Los Angeles. Contract No. W-509-Eng.-1292, dated January 22, 1941, stipulated that all work was to be conducted in accordance with the plans dated January 3.

Construction of the caretaker's house was delayed by a series of unusually heavy rainstorms during the period from February 23 to March 14, 1941. The site was actually flooded during much of this time, and heavy equipment could not be used to excavate the basement area. As a result, Edwin Kelton issued Change Order No. 1 for this procurement, providing an extension of 21 calendar days for completion of the caretaker's house.

On May 8, 1941, District Engineer Edwin Kelton issued the following brief and formal letter addressed to the W. E. Callahan Construction Company et al.:

> In accordance with paragraph 1-42 of the specifications forming a part of the above-numbered contract for furnishing all labor and materials and performing all work for the construction of Prado Dam and appurtenant work near the City of Corona, California, you are advised that all of the work under the contract was completed as of April 29, 1941; that it has been inspected and found to conform to the provisions of the contract plans and specifications, and that it is hereby finally accepted by the United States [COE Miscellaneous Letters, May 8, 1941].

A single sentence was all that Kelton wrote, bringing to a close several decades of effort and achievement. A similar letter was issued to Flagstad and Bock on June 13, 1941, accepting the work on the caretaker's house which was completed on June 2, 1941.

Prado Dam was complete. The work, begun by Prado Constructors on November 1, 1938, had been carried out in full by April 29, 1941. Despite the numerous change orders prompted by unanticipated subsoil conditions, delay in the approval of some change orders, an aborted strike, and inclement weather, Prado Dam was completed without penalty, and ahead of the May 1941 deadline.

5. THE OPERATION OF PRADO DAM

Operating Plan

Regulations entitled "Dam Caretakers: Rules and Regulations Governing Duties and Responsibilities" were issued by the War Department circa 1941 (U. S. Army Corps of Engineers [CoE] 1941). The directions for operating the dam and its systems were extremely brief, taking up less than two single-spaced pages of text.

In brief, the caretaker was instructed to patrol the grounds to prevent the admission of unauthorized persons, the removal of property without authority, and to maintain a check on the operation of all equipment. Trespass violations on the property were specifically and quite liberally construed, but only authorized persons were to be admitted to the works. The caretaker was responsible for the watering and maintenance of his own premises, and individual directions were issued for the maintenance and repair of equipment. A chart was placed in the control house, "in a prominent location for quick reference," regarding the operation of the gates during flood stages. The caretaker was to make sure that the trash racks were kept clear of debris, and was responsible for the burning and/or disposal of any debris removed. The caretaker was also to maintain all boats and motors supplied for the removal of debris. During emergencies, declared only by the District Engineer or a higher authority, guards were to be stationed 24 hours per day at the control structure and on the dam itself.

These directions are remarkably brief, given the critical role that Prado Dam played in the protection of metropolitan areas in Orange County. This was not an oversight, however, and should actually be regarded as testimony to the simplicity of design and maintenance required for the operation of Prado Dam. As noted earlier, the design was not complex. It used no new theoretical systems, and employed no new technological features.

Aside from the immediate environs and facilities of the dam, the caretaker had no jurisdiction within the flood control basin itself. Use and maintenance of these lands were the responsibility of CoE representatives in Los Angeles, who controlled the area through the regulation of leases. The low-lying areas of the basin, although frequently flooded, were normally reserved for pasturage; only the higher areas which were rarely inundated were allocated for farming (Means 1942:5). In 1940, prior to any agreements, the CoE was considering a series of five-year leases (Kelton 1940d), but it is not known whether this term was adopted. By the late 1940s, most of Prado Basin was under some sort of lease arrangement. In 1949, there were 48 separate agricultural and grazing leases, many negotiated with the previous landowners who now rented the same lands that they had once owned (Index to Leases 1949).

To review, the dam is approximately 106 feet high (above original streambed), with a base at elevation 460 feet. The spillway crest is at elevation 543, and the top of the embankment is at elevation 506. The top of the embankment is 30 feet wide and paved with asphaltic concrete. As originally designed, the reservoir had a capacity of approximately 223,000 acre feet, flooding some 6700 acres of the valley when water was at the spillway crest.

Four methods were originally provided for the outflow of water. Besides the spillway itself, there were two uncontrolled circular conduits which were to be kept open at all times, two tunnels controlled by six gates operated from the control structure, and the 60-inch pipe paid for by the Orange County Flood Control District to collect subsurface water drained from the wetlands to the reservoir bottom. One of the open conduits was closed by 1950, as it was discovered that the discharge was more than the river bed could safely absorb. This conduit was apparently reopened for a brief period of time, but plugged again in 1961. The second conduit was plugged in 1970. According to a 1978 inspection report, the second conduit was plugged at the request of the Orange County Flood Control District, which desired to obtain more complete control of the flow of water. This relatively simple act of closing the two conduits had far greater implications than were immediately apparent. In brief, it subverted the original design intent and purpose of Prado Dam.

Until 1971, however, the plan of operation was quite simple. As flooding entered the reservoir the open conduit would discharge water, automatically draining the reservoir, until the flooding stopped. At elevation 514, the inflow of water would exceed the capacity of the conduit(s). At this point approximately 3750 acres of the reservoir bottom would be flooded, and the discharge of water would be about 1240 second-feet of water. As the water rose above elevation 514, the gates would discharge water into the tunnels would gradually be opened to regulate the discharge to a maximum of 9350 second-feet at elevation 518.5. If flooding persisted, the waters would continue to rise to elevation 543, the spillway crest, and any additional downstream flow would be discharged directly into the river below.

After a flooding episode, the process was reversed. When the water fell below the spillway crest, the discharge was regulated by operation of the gates to 9350 second-feet, until elevation 518.5 was reached. At this level the gates would be closed to elevation 514, when the open conduit would again begin to drain the reservoir automatically.

The closing of the uncontrolled conduits (since 1971) has changed the original simple operating design. First, the waters behind the dam are no longer "automatically" drained. Second, all of the control of water has to be regulated at the gate level. This has posed some maintenance problems, since the gates were originally designed to be dry virtually year-round. Rust and sedimentation of the gates, never anticipated in the original engineering, are now major considerations. Finally, the purpose of the design has been altered; the dam now serves a partial water conservation function, whereas it was originally designed and operated only for flood control. This has served to complicate the sedimentation problems, currently under review, in relation to the overall adequacy of the protection which Prado Dam provides to downstream property.

Since completion of the dam in 1941, Prado Dam has performed its designed purpose (i.e., flood control) without incident. The structures and equipment are in good to excellent operating condition, and the dam has provided flood control which has allowed the increased development and urbanization of downstream areas in Orange County. Few alterations have been made in the operating facilities, apart from the closure of the uncontrolled conduits. The dam caretaker's house was removed in the early 1980s, and various unpaved access roads across the property have been added for the maintenance and inspection of the facility.

Operation in the 1940s

In its first year of operation, in the rainy season of 1940-1941, the dam gates were left open rather than risk the accumulation of flood waters that the dam could not yet contain (CoE 1940). In the CoE annual reports for every year after 1941, the dam was listed as 100 percent completed, with funds provided for operation and maintenance (CoE 1949). By 1949, annual upkeep of the dam ran around $16,000, with the budget allocated as follows: routine care, $4000; flood operations, $7000; stream gaging and sedimentation studies, $2000 each; and leases and permits, $1000. Some years required work crews to complete specific maintenance projects, and in those cases there might be $10,000-$14,000 added to the budget to cover the costs of hired labor (Walsh 1949b).

The increasing use of the basin under lease conditions in the 1940s led to some disputes over road and bridge maintenance and electric service. Both Riverside and San Bernardino counties effectively abandoned the area in 1944 and refused to maintain public facilities in the area since the basin was now in the possession of the federal government. Unfortunately, no federal funds were allotted for local roads and bridges, even though both were needed to allow tenants access to their leased lands (Walsh 1949). In a similar vein, Southern California Edison considered pulling down electric lines in the basin after local residents moved out. The CoE urged Edison to stay since tenants would still be using the land and would need electricity (Kelton 1940).

Flood Control vs. Water Conservation

The superimposition of the Prado flood control basin over what had been an established community led to residual service problems for the CoE and its tenants. The dam and its flood control basin also led to problems concerning existing water rights and water use. The dam overlaid a complex series of historical water arrangements extending up and down the river. Most of these rights were held by Orange County water companies, which had vested interests in the water of the Prado Basin. The Prado Dam temporarily upset many old arrangements, and Orange County interests were keen to restore their hegemony. Shortly after the 1938 Flood, the everyday needs of water conservation again rose to the top of the Orange County agenda. As water conservation began to vie with flood control, political decisions and considerations impacted the operation of the dam and reservoir.

Prado Dam and reservoir were originally established as a flood control measure, but this was quickly subverted by the intense pressure placed on the CoE by Orange County to make accommodation for water conservation as well. This was done almost clandestinely at first, until water conservation was finally recognized as a legitimate concern of the Prado Dam and reservoir by Act of Congress in 1968 (Bailey 1971:4).

When final construction plans were approved on August 20, 1938, it was believed at that time that the sand deposits below the dam and above the bedrock were at least 67 feet deep and could sustain appreciable underground water flow (Bailey 1940:10). It was also understood that the steel sheet-piling to be laid under the dam down to bedrock would effectively cut off this supply of water to Orange County, even though the sheeting would be laced by some gaps and bored holes. The sheeting would back up the underflow, raising the water table upstream from the dam, and result in greater water loss to plant transpiration and evaporation (Bailey 1940:20,31).

To forestall this problem, the dam plans were modified to include a 60-inch infiltration pipe 15 feet under the dam to permit the passage of this underground flow. This pipe was duly installed, even though it was capped, pending final approval for its use. This was the first of many water conservation measures pushed by Orange County and accepted by the CoE. The installation of this pipe was preceded by a number of test wells and gauges set up to measure the underground water flow, all of which were paid for and administered by the OCFCD (Bailey 1940; Means 1942:5,7).

The first evidence that the Corps formally recognized the importance of water conservation appeared in a July 1939 report prepared by Major Theodore Wyman, District Engineer in Los Angeles. In this report, Wyman promised to release flood flows out of the reservoir at rates within the absorption capacity of the channel downstream. He also promised to control the accumulation of debris within the basin itself, which might interfere with the smooth delivery of water to Orange County (Bookman and Baker 1949:10). In that same month, plans were drawn for an upstream extension to the 60-inch infiltration pipe to capture Prado Basin water above the area of greatest siltation (Plans on file, Los Angeles District, CoE, Drafting).

This activity did not go unnoticed in Riverside County, which took a dim view of Orange County's water conservation measures. The Riverside County Board of Supervisors was concerned that if the dam and reservoir were used for water conservation, it might lead to Orange County interests claiming an ever greater share of the Santa Ana River water, a development that would intrude on the water rights of Riverside County. By resolution adopted on August 7, 1939, the board addressed its complaint to Theodore Wyman, the District Engineer, requesting from him reassurance that Prado Dam would only be used for flood control and not become an instrument of Orange County water interests. Wyman's reply, dated August 10, 1939, reversed the position he had taken in July. Wyman told the Riverside Board that according to the 1936 Flood Control Act which authorized the dam, the Corps was without the authority to do anything other than flood control (Bookman and Baker 1949:11-12; Wyman 1939a).

This first controversy between flood control and water conservation, or more specifically between Riverside and Orange counties, was not without consequences for the Corps. Major Wyman was replaced as District Engineer at the end of August 1939 by Lt. Col. Kelton (Turhollow 1965:326-327), and there is some indication that Wyman left under a cloud. If so, he may have been a casualty of the water conservation issue, as well as the taking-line controversy discussed earlier. The water conservation controversy had repercussions at the dam itself. The 60-inch pipe placed under the dam remained capped, pending resolution of the dispute between Riverside and Orange counties. In fact, the pipe remained sealed throughout the 1940s, 1950s, and 1960s (Nick Richardson, personal communication 1989).

By March of 1940, after much controversy, the Orange County Cooperative Plan was hammered out between the OCFCD and the Army Corps. By the terms of this agreement, the Corps reaffirmed that water conservation must be subordinate to the needs of flood control, with the implication that there could be no surface reservoir water storage for the benefit of Orange County. The Corps did agree, in theory at least, that the OCFCD could operate the 60-inch pipe under the dam. The Corps also granted to the Santa Ana River Development Company the right to collect and send to Orange County any water on its lands, provided that this collection did not affect the water rights of others. The OCFCD was also allowed to cooperate openly with the Santa Ana River Development Company and other companies in the salvage of Prado Basin water (Shafer 1940).

This first cooperative venture does not seem to have operated effectively, and was at least partially undermined by the final court ruling in the Irvine Case, which was finally decided in 1942, 10 years after the case was first enjoined. By the terms of the ruling, a board of three "Special Masters," one from each of the three counties in the watershed, was appointed to settle on a system of water control based on information that predated construction of Prado Dam (Bookman and Baker 1949:14-15). This threw everything into confusion, and Orange County again began to agitate for more water.

Orange County's Renewed Push for Water Conservation

Floods occur rarely; alternatively, water conservation is an everyday need. This was especially true for Orange County, which was daily faced with the growing problem of groundwater overdraft-- pulling more water out of the ground than could be recharged. As memory of the 1938 Flood receded, Orange County became more concerned about water recharge. Since 80 percent of its recharge comes from the Santa Ana River, the outflow of water from the Prado Dam attracted a great deal of Orange County's attention (Shafter 1949:2).

What Orange County wanted from Prado Dam was a regular water flow, feeding as much water into the coastal plain aquifer as percolation would allow. This meant reducing the flow at Prado Dam when there was too much water in winter, and increasing the flow when water was more scarce in summer. For the Prado Basin, this meant the storage of water in the winter, and the drastic reduction of ponding in the summer. Obviously any winter storage of water would compete with space needed for flood control, and the decision of how to balance the priorities between flood control and water conservation was the very crux of the disagreement between Orange County and Riverside County. Caught squarely in the middle were Prado Dam and the U.S. Army Corps of Engineers.

By 1942, the effects of Prado Dam on river irrigation downstream were widely lamented. In that year, Owen Smith and his two brothers brought suit against the CoE for the disruption of their riparian rights. The Scully Ditch, from which they had irrigated their fields for 75 years, was now largely inactive due to fluctuations in the river level below the dam. The Smith brothers requested the construction of a pipe from the 60-inch sub-dam conduit to the Scully Ditch so their traditional water level could be restored (Schwartz 1942).

The irregularity of the river flow led the Orange County Water District to influence the CoE toward a more lenient water conservation policy. In March of 1943, the Orange County Water District board adopted a resolution denouncing the practice of releasing more water into the Santa Ana channel than could percolate into the ground. The board expressed a desire for more control over the use of reservoir for water conservation (Bailey 1944). Their justification for more water conservation was based on the actual wording of the 1936 and 1938 Flood Control Acts:

> Plans... may be modified to provide additional storage capacity for domestic water supply or other conservation storage, on condition that cost of such increased storage capacity is contributed by local agencies and that the local agencies agree to utilize such additional storage capacities in a manner consistent with Federal uses and purposes (Bailey 1944:2).

The board amplified this request for more control by making a specific recommendation: they wanted to close temporarily one of the two 66-inch diameter ungated openings built through the dam at stream level, and study the result of this closing on channel percolation. Orange County maintained that this action would not impair the dam's ability to contain floods (Bailey 1944:6), and would instead reduce the amount of water discharged through the dam to a level that would match the recharge capabilities of the channel downstream (Bailey 1971:2).

This request to regulate water flow downstream of the dam was developed in 1944 by Paul Bailey's "Report on Change in Ungated Bypasses at Prado to Increase Percolation from Downstream River Channel." According to this report, closure of one of the two ungated openings would save 5000 acre feet of water a year (Shafer 1949:9). The suggestion that one of the openings be closed was quickly adopted by the OCFCD, the Orange County Water District, and the Orange County Farm Bureau. In another document, it was noted that the permission to close one of these openings could be obtained from the Chief Engineer in Washington, D.C., and did not need Congressional approval (*Farm Bureau News* 1944).

The following year, the CoE tentatively acceded to the Orange County request to close one of the two openings, and brushed aside the objections posed by the City of Corona and the Riverside Water Company, neither of which had a vested interest in the Prado Basin water by the terms of the final 1942 ruling in the Irvine Case (Putnam 1945). The Orange County Water District won final permission to close one of the ungated openings in 1946, although it was later denied permission to have this same opening permanently sealed (Bailey 1971:2). By 1947, the ungated opening was finally closed (Nick Richardson, personal communication 1989).

In 1948, 19 separate Orange County water interests combined to form the "Orange County Committee on Additional Water Supply." This committee petitioned the CoE for additional water conservation measures. Under the influence of this kind of pressure, the California State Water Resources Board, headed by Edward Hyatt, the State Engineer, added its weight to the Orange County resolution for more water (CoE 1948). Finally, on October 22, 1948, the Orange County Water District formally petitioned the CoE to designate Prado Dam and Reservoir as a multi-purpose construction (flood control and water conservation) rather than its original single purpose designation (flood control). In other words, Orange County requested that the Corps reverse Major Wyman's promise to the Riverside County Board of Supervisors that Prado would only be used for flood control (Bookman and Baker 1949:21).

In conjunction with this formal petition, Orange County worked on a plan to reduce the amount of Prado Basin water lost to evaporation and plant transpiration, which had been estimated in 1931 as an annual loss of 17,000 acre feet (Shafer 1949:4-5). There were at least three elements to this plan: reduction of the plant life near the main water producing area; the construction of pipe extensions connecting these areas with the sub-dam conduit (which was still unopened), and the purchase of new lands in the basin for the extension of this water system. Orange County had always had an interest in reducing the plant growth near its main water sources. As early as 1944, the OCFCD prepared up maps targeting the timber and brush areas of the basin that needed to be cleared along the Santa Ana River and along Chino and Mill Creeks (OCFCD 1944). It is not known to what extent any clearing actually took place, if any, but the successful implementation of the second element of the plan would at least partly obviate the need for clearance, for it entailed a lowering of the water table below the root line.

The OCFCD and the Santa Ana River Development Company had long advocated lowering the basin's water table below the root zone as a means of saving water from plant transpiration. The Santa Ana River Development Company attempted this by using channels and ditches to drain water-logged areas and hurry water to the dam (CoE 1948). Orange County now proposed an upstream extension on the 60-inch conduit under the dam. In the late 1940s, the county requested a permit to extend the pipe to an underground water collecting system that would be relatively free of silt (Bradley 1947, 1948a, 1948b, 1949; CoE 1948). Such a system, equipped with well and pumps to speed the lowering of the water table in the basin and transport water to the sub-dam conduit, had been proposed since at least 1942 and was even mapped out in 1944 (Figure 5.1.; Means 1942:63; OCFCD 1944). By 1948, the OCFCD had the right-of-way for three pumping stations and water transmission lines in addition to its other drainage ditch arrangements with the Santa Ana River Development Company (Bookman and Baker 1949:18-19). Although the sub-dam conduit was not opened at this time, the upstream extensions were built and may have been used as a means of pumping water downstream (Nick Richardson, personal communication 1989).

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5.1. Proposed Upstream Extension, 1944.

Riverside County Reaction, late 1940s

The construction of the pipe extension and impending opening of sub-dam conduit elicited a strong reaction from Riverside County. Ever since the state legislature had created the Riverside County Flood Control and Water Conservation District in 1945-1946 (Scott 1982:23), the county had an agency capable of countering the demands of the OCFCD and the Orange County Water District. Max Bookman, Chief Engineer of the Riverside County Flood Control and Water Conservation District, was instrumental in fighting the flood of water conservation proposals that issued from the Orange County agencies. He even co-authored a manuscript detailing the whole controversy from a Riverside County perspective (Bookman and Baker 1949).

Riverside County's main complaint against Orange County, and indirectly against the CoE, was that the OCFCD and the Orange County Water District were getting piecemeal and almost clandestinely from the CoE all the water conservation measures they were not allowed to get openly. Going back to the beginning of the controversy, with the laying of the 60-inch conduit below the dam, Riverside County maintained that the five-foot diameter pipe was larger than was needed to accommodate the estimated underground flow beneath the river itself (Bookman and Baker 1949:17B). Further, Orange County had engaged in creeping water conservation, negotiating for new water rights directly with the CoE rather than applying for them with the California State Division of Water Resources, as they were required to do by the terms of the Water Commission Act of December 1914 (Bookman and Baker 1949:26). As for the Orange County request for formal recognition of a multi-purpose dam, the Riverside authorities were flatly opposed. They already resented the fact that up to one-third of the reservoir's capacity was devoted to water conservation (Bookman and Baker 1949:17B-18).

The Riverside County Board of Supervisors also took a dim view of the Orange County proposal for more land in the basin (CoE 1948), and their active opposition probably ensured that the CoE would not grant such a request. Riverside also rejected the further development of the upstream pipe extensions or "galleries" that were to connect with the sub-dam conduit. The enunciation of formal Riverside County opposition to Orange County's plans in the Prado Basin led to a war of words between the two counties. Orange County let it be known that it might consider litigation as a means of settling the matter of water rights in its favor once and for all. Hoping to avoid this step, the Orange County Board of Supervisors appointed a panel commissioned to educate Riverside County residents on the urgent needs of Orange County for more water (Shafer 1949:2).

Development of Recharge Basins in Orange County

Perhaps because the Orange County authorities perceived increasingly greater resistance to their proposals for water conservation in the Prado Basin, they began to entertain other schemes for water conservation within Orange County itself. Specifically, these strategies entailed recharging the Orange County groundwater aquifer in the area of maximum utility-- a six-mile wide band south of the mouth of the Lower Santa Ana Canyon. In 1949, the Orange County Water District began buying Colorado River water to help recharge the aquifer through spreading basins established in the river channel and nearby abandoned gravel pits (Banks and Halatyn 1971:7, 9). Eventually, these gravel pits, like the Crill Basin, were purchased and formally incorporated into the Orange County effort to recharge the water table.

Recreation Use in Prado Basin

To complicate the picture further, the Federal Flood Control Act of 1944 (Public Law 78-534) authorized the CoE to construct, maintain, and operate public parks and recreational facilities at water resource development projects such as Prado Dam and Reservoir. The CoE was also allowed to authorize local interests to establish and maintain such facilities (CoE 1976:1). By 1947, the Los Angeles District of the CoE was raising suggestions for recreational facilities in the Prado Basin (Suggested Recreation ca. 1948). Among the proposals considered by the CoE were a possible nine-acre lake on the Santa Ana River, devoted to boating, fishing, and other water activities, and an 80-acre lake created by a natural check dam on Chino Creek, surrounded by camping areas that would be accessible to the "Kota" adobe (Suggested Recreation ca. 1948). The CoE even went so far as to mark off lands for recreational purposes among the properties it held in fee simple (Orange County Water District 1948).

The CoE's suggestions for recreational facilities in the Prado Basin ran counter to the requirements of both flood control and water conservation, which have to allow for extreme fluctuations in reservoir water levels. For this reason, authorities in neither Orange nor Riverside counties looked with great favor on the early schemes to develop recreational facilities. The Orange County reaction was particularly strong, at least in the beginning. In May of 1948, the Orange County Board of Supervisors generated a series of resolutions protesting the use of Prado water for anything other than percolation into the groundwater aquifer of Orange County. The board, supported by most of the Orange County water interests, specifically opposed any proposed recreation use of the basin water (Memoranda on file, Box 3931, National Archives, Pacific Southwest Region, [NAPSWR]).

This opposition was soon modified, probably for political reasons. Since Orange County was embroiled in the struggle to declare the Prado Dam and reservoir a multi-purpose use area, it was probably perceived that a strong stand against recreation would be prejudicial to their own cause. Nonetheless, Orange County made it clear that recreational use in the basin should only be incidental (CoE 1948), and approved only if recreation did not interfere with other, more important uses (Orange County Water District 1948). By the following year, Orange County had adopted the attitude that recreation could be allowed on lands above the 514 foot elevation assuming the following conditions were met: the water used for recreational purposes could not exceed what had been used earlier for irrigation; and there could be no ponding of water or watering of lawns (Bookman and Baker 1949:2-3).

The reaction to the proposed recreational use of the Prado basin was more mixed in Riverside County. The local flood control district did not want to finance any recreational activities in the basin (CoE 1948), but the Riverside County Planning Commission actually encouraged the CoE to develop more recreation suggestions (Black 1948). Riverside County's more favorable reaction to recreation in the basin was perhaps a reflection of the local popularity of the CoE's suggestions. Similar ideas were even tendered by private citizens, like the suggestion that the basin be set aside as a waterfowl refuge. This suggestion had to be rejected because downstream water interests would object (Moore 1948). However, the demand for recreational use of the Prado Basin would continue to grow. The continued development of both Riverside and San Bernardino counties led to an increasing pressure for park and recreational facilities in the basin itself.

Resolution of the Conflict

The conflict between flood control and water conservation, with the added issue of recreational use, continued on a more subdued level throughout the 1940s, through the 1950s, and even until the end of the 1960s. Only with the passage of the Intergovernmental Cooperation Act of 1968 was the CoE explicitly directed to increase water conservation to the extent that such measures would not adversely affect flood control (CoE 1988a). It was about this time that the Orange County Water District bought the Prado Basin land held previously by the Santa Ana River Development Company (Nick Richardson, personal communication 1989).

The Intergovemmental Cooperation Act led to the Cooperative Agreement of 1969 between the CoE, Orange County Water District, and the California Department of Water Resources. An agreement was reached to determine and develop multiple uses of the Prado Dam and reservoir (Cooperative Agreement 1969). The facility had at last been declared a multi-purpose use area, and Orange County's pre-imminent need for more water was recognized.

Orange County's water needs in the Prado basin were further recognized with the conclusion of a water rights suit between Orange County Water District and the City of Chino, et al., finally decided in 1969. This case, settled in Superior Court, State of California, was essentially decided in favor of Orange County. By the terms of this settlement, the defendants upstream from the dam (City of Chino, Western Municipal Water District [Riverside County], Chino Basin Municipal Water District, and San Bernardino Valley Municipal Water District) agreed not to oppose water conservation of any storm flood in the basin below the 514 foot elevation (Cooperative Agreement 1969; Summaries 1971). Orange County was also awarded the right to an annual base flow of 42,000 acre feet (Bailey 1971:6), and the renewed right to close temporarily one of the two ungated openings, limiting the controlled release of water into Orange County to around 5000 cubic feet per second (Bailey 1971:2). This right was later buttressed by the closing of the second ungated opening around 1970. Henceforth, Orange County was to receive its allotted water through the dam gate, which could be closely regulated (Nick Richardson and Dave Riggle, personal communications 1989).

The controversial 60-inch pipe under the dam was not actually opened until 1972-1973, when it was finally hooked up to two massive sewage lines, one from Corona and the other from Chino. From under the dam, this sewage is now piped all the way to a treatment plant on the coast between the Santa Ana River and Huntington Beach. This operation is conducted under the auspices of the Santa Ana Watershed Project Authority (Nick Richardson, personal communication 1989).

6. THE FUTURE OF PRADO DAM

Plans to Raise Prado Dam

The possibility of modifying the flood control facilities at Prado Dam was first raised in 1964, as part of a review of the Santa Ana River watershed commissioned by resolution made on May 8 by the Public Works Committee of the U.S. House of Representatives. The CoE began this review that same year (Bailey 1971:3).

By November of 1969, the design review of the Prado Dam itself was completed. The dam and reservoir, which had a capacity of 198,220 acre-feet at the spillway discharge level in 1969, was found to be insufficient to contain a projected maximum flood. Such a flood could send 290,000 second-feet of water into the reservoir, with a total flood volume after one week of around 500,000 acre-feet. As a result of arrangements made with Orange County, the dam outflow would be no greater than 5000 second-feet, which would not begin to drain such a flood. When the waters reached the 543 foot elevation, they would begin to crest the spillway, and would continue to do so until there was a waterfall at least 12 feet over the spillway, sending 150,000 second-feet into the river channel below, which could not contain this volume. Flood waters would break free of the river banks, mostly on the north side, and flood about 100,000 acres to a depth of 2.5 to 4 feet. There would be damage to an estimated 200,000 homes and most of the transportation arteries across the river (CoE 1976; Prado Dam 1971:1-2; Prado Dam 1985).

The drastic increase in the potential damage caused by a maximum projected flood had two causes. One was the increase in the siltation of the reservoir as a result of seasonal rains and the minor floods that entered the basin every year since the dam had been completed (Hayward 1979). The other cause was the vast increase in the urbanization of the Santa Ana watershed since the dam had been built. With more housing, more asphalt and concrete, there was more water run-off and less percolation. With every new construction project, the flood potential increased (Hayward 1972; Prado Dam 1971:1-2). The cost of enlarging the dam and reservoir to the point where it would accommodate the run-off from a maximum projected flood was estimated at $400 million (Prado Dam 1971).

Local reaction to the proposed dam raising varied greatly. Orange County strongly supported the idea, but Riverside and San Bernardino counties were less than enthusiastic. Neither of the upstream counties wanted an enlargement of the basin and a reduction of the local settlement, since that meant revenue losses. They also resented having to absorb a tax loss for a project that would only benefit Orange County. There was the general feeling that Orange County should make some sacrifices, too, such as enlarging the Santa Ana River channel below the dam (Prado Dam 1971).

The communities directly threatened by basin enlargement were strongly opposed to the plan. The City of Corona disliked the idea because it would adversely affect the Butterfield Stage Park and the Corona Airport, both adjacent to the reservoir (Eldridge 1972). In both Corona and Chino, the local dairymen feared that an expansion of the reservoir would push them out of the area, forcing them to give up fertile lands for less productive plots (Ritter 1972a and 1972b).

Partly as a result of the local outcry in the upstream counties against raising the dam, the CoE began to float alternatives to test the local reaction. One potential solution was to build a series of smaller dams on the upstream tributaries of the Santa Ana, but this was acknowledged as a costly and not particularly effective alternative. The only upstream dam that was seriously considered was a flood control dam at Mentone, in the debris cone of the Santa Ana River immediately south of the San Bernardino Mountains. This dam remained an option for a number of years. Another alternative to raising the dam was to widen the river channel in Orange County so that it could handle a flood outflow. It was estimated that this action would require the relocation of at least 2500 homes and the rebuilding of 36 bridges (Hayward 1972). As might be expected, Orange County was not pleased with this alternative, and countered that any serious channel enlargement downstream from Prado would deprive the county of revenue from property taxes while costing more than any enlargement of the basin itself (Prado Dam 1971).

Soon it was acknowledged at the Corps that an enlargement of the Prado Dam and reservoir was the most cost-effective solution to the problem of flood control. By 1974, the CoE was back to its original scheme, known then as "Plan F," to raise the dam 34 feet and raise the spillway 23 feet. This conclusion, however, was still did not agreeable to Riverside and San Bernardino counties, and their attempts to modify this solution led to another war of words between Orange County and the upstream counties.

The 1974-1975 Controversy

In 1974, the CoE and Orange County supported the so-called "Plan F," which entailed raising Prado Dam by 34 feet and the spillway by 23 feet. Even though Orange County was committed to paying 98 percent of this projected work, local Riverside and San Bernardino County residents resented any loss of their property for the sake of flood control in Orange County (Hayward 1980b).

The San Bernardino County Board of Supervisors could be induced to support Plan F, but the Riverside County Board was strongly opposed, as was the City of Corona (Eldridge 1974b). Local dairymen were particularly opposed to the plan, since it was widely believed that any enlargement of the reservoir would cause additional land to be withdrawn from dairy production and eventually turned over to the public for recreation (Prado Dam 1971:15). Following their lead, Representative George Brown, Jr., the local Congressman from Colton, went on record as opposing the plan (Eldridge 1974a).

In December of 1974, when it became clear that there would be no Congressional action on raising the dam without an agreement from all three counties, Orange County threatened a law suit against the Riverside County Board of Supervisors for blocking the flood control measure (Eldridge 1974c). In December of 1974 and January 1975, there were numerous meetings, threats, and counter-threats between Orange and Riverside officials. In February of 1975, Orange County began a serious lobbying campaign in Congress through the "Santa Ana Flood Control Agency," designed to counter the effects of adverse publicity circulated by the Cities of Corona and Norco, the Corona and Norco Chambers of Commerce, and the Riverside County Board of Supervisors (Hayward 1975a).

The conflict between Riverside and Orange counties eventually settled into a stalemate, which was only broken by a proposed compromise worked out by the CoE in September of 1975. To placate the Corona residents, the CoE suggested raising the dam 30 feet rather then 34 feet, and the spillway 20 feet rather than 23. This more modest enlargement of the reservoir would affect 125 property owners, rather than 250, and the 125 owners would not necessarily have to vacate their land. Their property would either be bought out when the project began, or they could have the option of flood-proofing their property, or having flood easement bought from them by the Corps (Hayward 1975b).

This compromise was worked out with the assistance of Victor Veysey, Assistant Secretary of the Army in charge of the CoE, and former Congressman from the Corona area. It was through his good offices that Corona and the Riverside County Board were induced to accept the compromise, and a formal agreement between the CoE and the City of Corona was signed in December of 1975 (*Corona Daily Independent* 1975). All parties now agreed that the Prado Dam would he raised 30 feet above the present level and that the reservoir behind the dam would be increased accordingly. As though to symbolize the agreement and the end of the bitter controversy, a large red, white, and blue logo, "200 Years of Freedom, 1776-1976," was painted on the Prado Dam spillway in 1976 by students from the Corona High School (Hayward 1979). Easily visible from Highway 91 just south of the dam, the logo remains today one of the dam's most striking features.

New Proposals, 1975 to Present

Both recreational use and environmental studies came of age in the Prado Basin during the dam-raising controversy. Recreational development in the basin, though hinted at earlier, really began with the development of the Code 710 program, defined by regulation EC 11-2-119, dated May 30, 1975. According to a report developed for this document ("Recreational Development at Completed Projects"), federal funding was to be made available for recreational development at completed CoE projects if local agencies shared one-half of the development costs and assumed the operation and maintenance of the recreational facilities. By 1976, approximately 6500 acres of land within the basin had been leased for recreational use by San Bernardino and Riverside counties and the City of Corona (Recreation Master Plan 1976:1). There was also an increase in fishing within the basin, of both a legal and illegal nature (*Corona Daily Independent* 1983).

Almost in conjunction with the increased recreational use of the basin came the growth of local environmental and archaeological interest. The first Environmental Impact Statement for the Prado Dam and reservoir was compiled in 1975 and approved in 1977. It was followed by two others, one in 1980 and the other in 1988 (Steven Schwartz, personal communication 1989). The first comprehensive report to deal with the local cultural resources, both historical and prehistoric, was compiled by Paul E. Langenwalter II and James Brock in 1985. Since then, broad theoretical overviews of prehistory and history have been prepared, several representative archaeological sites have been tested and evaluated for their significance, and thematic studies have focused on water systems, the dairy industry, landholdings and settlement pattern, etc. Other environmental studies were conducted, such as that for Least Bell's vireo, a migratory bird living in the trees of the Prado Basin (Beeman 1985). The vireo has since been officially listed as endangered, and the Basin has been proposed (but not designated) as Critical Habitat.

Despite this research and planning, the fate of the dam itself was once again thrown into confusion. When it became apparent that the 1975 plans to raise the dam by 30 feet were not going to be acted on immediately, the consensus that had been reached by more than a year of wrangling was allowed to lapse, permitting the old feuds and resentments to resurface. This problem was only exacerbated by a new CoE study of the flood control issue that appeared at the end of the 1976. This study suggested abandoning the Mentone Dam idea and raising Prado Dam by 45 feet, thus negating the 1975 compromise of 30 feet (*Corona Daily Independent* 1977). To compound matters, President Carter's 1977 budget presented a series of funding problems for any proposed work on the dam, so that it became increasingly unclear just what would be done to improve flood control on the Santa Ana, and when any improvements would take place.

By 1980, with no resolution in view, Corona and Orange County were feuding about water impounded behind Prado Dam, which was good for water conservation measures downstream, but bad for Corona's airport runway

(Hayward 1980c). Chino dairy owners were again upset about any potential expansion of the flood control basin and were particularly incensed about the recreational uses proposed for the land. Many even suggested getting royalties for recreational use. Just as in 1975, dairy owners had to be reassured by the CoE that they would not necessarily have to move if the flood basin was enlarged: their property could be flood-proofed or the CoE could simply buy up flood easement rights (Kurtz 1980).

Behind much of this new uncertainty lay the realization that much more local monies would have to be spent on any flood control improvements than had been proposed in 1975. Riverside County was now expected to pay a portion of the costs for any improvements, when in 1975, it was not expected to pay anything at all. In addition to this problem, it was also recognized that any new solutions would be more difficult to implement now, since local authorities had permitted additional residential and commercial development along the peripheries of the basin since 1975 (Hayward 1980a).

The CoE's position on proposed flood control measures was ambivalent largely because of funding problems at the national level and renewed bickering among the local communities. To complicate matters, the CoE raised some resentment by letting it be known that local agencies would be required to pay at least 25 per cent of the cost of any flood-control measures. Even though the CoE still favored the so-called "all-river plan" essentially worked out in 1975, there was now the additional possibility that Prado Dam would be raised 45 feet, which would obviate the need for a Mentone Dam, which was hotly opposed by the local residents in that part of San Bernardino County (Hayward 1980b). One study of the Prado Dam modifications, finished in October of 1981, provided four alternatives for the solution to the flood control problems on the Santa Ana River (Prado Dam 1985).

By 1982, the Army Corps had pretty much settled on a modification of the 1975 compromise: raise Prado Dam by 30 feet; build a dam at Mentone; and conduct some river channeling work in Orange County. It was also proposed that the percentage of state and local money what would be required to complete the work be reduced to 11.5; Federal funds would account for the rest (Gottlieb 1982).

The most controversial portion of this plan was the proposed construction of the Mentone Dam, which was to be built within the extensive debris cone of the Santa Ana River immediately below the Upper Santa Ana Canyon in San Bernardino County. Building this dam would eliminate the need to raise Prado Dam by 45 feet and would save the government a great deal of money. It was estimated that raising Prado Dam by 30 feet would eliminate 158 houses, ranches, and businesses; raising the dam by 45 feet would eliminate 450. If the difference could be made up by a reservoir in the undeveloped debris cone of the river farther upstream, then the government would end up saving money (Gottlieb 1982).

As proposed by the CoE, the Mentone Dam would be 250 feet high, 3.5 miles long, and cost $477 million to construct. The dam, though not particularly controversial in concept, was strenuously opposed by the local residents, who feared that such a construction so close to the San Andreas fault might prove disastrous (Gottlieb 1982). Local opposition to the Mentone Dam was so fierce that Congress actually resolved in the early 1980s that the CoE abandon this portion of the plan (Steven Schwartz, personal communication 1989).

By the terms of the Water Resources Development Act of 1986, the CoE's "Santa Ana River Flood Control Project" had dropped any plans to construct the Mentone Dam and had gone back to the 1975 compromise of raising the dam by 30 feet (566 to 596 feet) and the spillway by 20 feet (543 to 563 feet). Also planned were levees to protect specific properties, like the California Institution for Women, from any flood damage that might result from an enlarged reservoir. New Prado Dam outlet works were also planned to increase controlled flood water release. Once again, it was assumed that local agencies would have to pay an estimated 25 percent of the flood control costs (Environment Scoping 1987).

No final decision or action was forthcoming, and by 1988 the Orange County Water District, sole owner of most of the water rights in the Prado Basin since 1968, was emphasizing its 1969 court-ordered right to store water in the reservoir up to elevation 514 feet. Up to that point, the CoE had allowed incidental storage up to 494 feet (Nick Richardson, personal communication 1989). The CoE, however, countered that such an increased level of storage would interfere with other land uses, such as recreation and the protection of environmental resources, specifically the habitat of Least Bell's vireo. The CoE instead, approved seasonal water conservation up to the level of 505 feet elevation (Steven Dibble, personal communication 1996).

Plans for raising the dam are still in flux. The present Santa Ana River Mainstem Project calls for a flood control dam at Seven Oaks, currently under construction, at the upper end of the Upper Santa Ana Canyon in the middle of the San Bernardino Mountains. This construction would mean that the Prado Dam would only have to be raised 28.4 feet (from 566 to 594.4 feet above sea level), with the spillway being raised 20 feet as before. Also involved in the project is the on-going modification of the Santa Ana River channel in Orange County (CoE 1988b:iii-iv).

From its inception, the plan to raise Prado Dam has been the subject of local controversies about objectives (flood control and water conservation), allocation of costs among the counties, and the respective benefits to Orange, San Bernardino, and Riverside counties. The project is clearly in need of some modification. It has been determined that the dam has insufficient capacity to control a volume larger than a 70-year flood. This is primarily due to the spillway design, greater than anticipated rainfall, sedimentation which further reduces capacity, and increases in upstream runoff as a result of the urbanization and development of the Chino and Pomona Valley area. In some ways, contemporary concern for water conservation is antithetical to the original design, since it contributes to sedimentation.

Peak-discharge rates have been substantially increased due to higher runoff resulting from urbanization. As the peak discharge rate increases, so does the volume and peaking time. This has raised the design volume of a Probable Maximum Flood from about 230,000 acre-feet to as much as 1,543,000 acre-feet. If all of the flood waters were directed through the existing Prado Flood Control reservoir, this would mean that the embankment could be topped by as much as 4.3 feet of water. This would pose a major threat to an earth filled structure such as Prado Dam, and a major, catastrophic release of water could occur.

Prado Dam has always been the subject of political controversy, particularly between the competing demands of flood control and water conservation needs in the Santa Ana watershed. With the greatly accelerated growth downstream from the dam in recent years, there has been an even greater demand for what is a limited water supply. Because of the tremendous residential and commercial development that has taken communities to the brink of almost all flood control basins and river channels, even the obvious solution of increased dam and reservoir size cannot be implemented without creating its own set of problems. The Prado Dam and reservoir are now much more than a simple flood control device envisioned by the CoE in the late 1930s. It has long been a political weathervane, attracting attention from all sides. In such a climate, its solutions can never be approached from a wholly dispassionate point of view; they too will have to be political.

Project Information Statement

This document has been prepared at the request of the United States Army Corps of Engineers, Los Angeles District, as one of several mitigation measures undertaken in anticipation of modifications which may affect Prado Dam. The facility has been determined to be a cultural resource eligible to the National Register of Historic Places for its historical, engineering, and architectural values. The governing authority is contained in the National Historic Preservation Act; the Archeological and Historic Preservation Act, amending the Reservoir Salvage Act on 1960; and Corps of Engineers regulations ER 1130-2-438 for Historic Preservation and 36 CFR 800, "Protection of Historic Properties."

This report supplements and illustrates the original historical report prepared in 1989 (Swanson and Hatheway). Under the supervision of Roberta S. Greenwood as Principal Investigator, the new photographs and reproductions of historical engineering drawings were prepared to archival standards and indexed by David De Vries. Descriptions of the functioning elements and overall architecture were prepared by Architectural Historian Dana N. Slawson, M. A., and Jeffrey Skiles, M. A., was in charge of production.

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No.	10	March 31, 1939:	Axis of Dam Showing Keywall

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No.	14	Sept. 29, 1939:	Intake/Service Bridge Pier Construction
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No.	16	Aug. 16, 1939:	Lower End of Outlet/Gravity Wall
No.	17	Sept. 29, 1939:	Gravity Walls and Stilling Basin
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No.	20	Sept. 29, 1939:	Concrete Foundation of Spillway

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No.	15	Nov. 13, 1939:	Intake Structure Slide Gates
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No.	17	Nov. 29, 1939:	Conduit Outlet/Baffles/Stilling Basin
No.	18	Dec. 18, 1939:	General View along East Abutment
No.	19	Dec. 18, 1939:	Upslope of Dam from East Abutment

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No.	12	Jan. 29, 1940:	Control Structure and Bridge Pier

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(before 1975, Orange County Flood Control District)
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Right-of-Way Engineering (old land files)
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APPENDIX

Pertinent Data, Prado Flood Control Basin

Drainage area	Square Miles	2,233*
Reservoir:		
Area at spillway crest	Acres	6,710
Capacity at spillway crest	Acre-feet	222,000
Area at maximum water surface	Acres	8,720
Capacity at maximum water surface	Acre-feet	322,000
Area at top of dam	Acres	11,250
Capacity at top of dam	Acre-feet	420,000
Allowance for silting	Acre-feet	12,000
Regulation:		
Inflow of storm (7 days)	Acre-feet	275,000
Inflow peak	c.f.s.	193,000
Outflow peak	c.f.s.	9,200
Reduction in peak	c.f.s.	183,000
Dam:		
Type		Earth
Top elevation	Feet, msl	566
Height above stream bed	Feet	106
Length at crest	Feet	2,280
Embankment	Cubic yards	3,090,000
Spillway:		
Type		Concrete ogee
Length	Feet	1,000
Crest elevation	Feet, msl	543
Maximum water surface elevation	Feet, msl	556
Surcharge on crest (max. w.s.)	Feet	13
Discharge (max. w.s.)	c.f.s.	179,000
Excavation	Cubic yards	3,100,000
Concrete in spillway	Cubic yards	130,000
Outlets:		
Gates - number		6
Gates - size	Feet	7 x 12
Openings - ungated (bypass) - number		2
Openings - ungated (bypass) - diameter	Feet	5.5
Conduits - type		Square
Conduits - number and size	Feet	2 - 13.5 x 13.5
Conduits - length	Feet	750
Regulated capacity at spillway crest	c.f.s.	9,200
Maximum capacity at spillway crest	c.f.s.	17,000
Gate sill elevation	Feet, msl	460
Gate sill to maximum flood control pool	Feet	73
Concrete in outlets	Cubic yards	35,000
Excavation	Cubic yards	360,000

* Includes San Jacinto River-Lake Elsinore drainage area of 798 square miles (Source: Hunter 1945)