KERN RIVER 3 HYDROELECTRIC SYSTEM HAER No. CA-2309
Along the North Fork of the Kern River
Kernville Vicinity
Tulare County
California

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

National Park Service
Pacific West Region
909 First Avenue, Fifth Floor
Seattle, Washington 98104-1060

HISTORIC AMERICAN ENGINEERING RECORD

KERN RIVER 3 HYDROELECTRIC SYSTEM
HAER No. CA-2309

Location: The Kern River 3 (KR3) Hydroelectric System is located in Kern County and Tulare County, California. The KR3 powerhouse is located approximately 2.0 miles north of the town of Kernville in Kern County. From the powerhouse, the KR3 system facilities extend to the north for approximately 13 miles, on a nonlinear route that runs approximately parallel to the Kern River and Mountain Highway 99 (the Kern River Highway). From the highway, KR3 facilities are reached via access roads under the private control of the Southern California Edison Company (SCE).

The northern or "upper" end of the KR3 system, at approximately the center of the crest of the KR3 dam, is located at UTM Zone 11S, easting 311332.00m, northing 4180387.00m. The southern or "lower" end of the KR3 system, at approximately the point where the tailrace exits the powerhouse, is located at UTM Zone 11S, easting 311332.00m, northing 4180387.00m. Distances and coordinates were obtained on February 6, 2013 by plotting location using Google Earth. The coordinate datum is World Geodetic System 1984.

Present Owner: Southern California Edison Company
P.O. Box 800
Rosemead, California 91770

Present Use: The KR3 system uses the force of moving water to generate electricity for commercial use. The major system components include a dam and intake; a settling basin; a conduit comprised of interconnected tunnels, flumes, and a siphon; a forebay; two penstocks; and a powerhouse. The powerhouse operates with two reaction turbines direct connected to the generators.

Significance: The KR3 system, constructed primarily between 1919 and 1921, is significant in the areas of commerce (National Register of Historic Places Criterion A), engineering and architecture (Criterion C), and potential for associated archaeological sites (Criterion D). Under commerce, the system made an important contribution to the development of private electric power utilities in Southern California and nationwide. Under engineering, it was the highest-head reaction turbine in the world at the time it was constructed; it used the longest hydroelectric system tunnel in California at the time it was constructed; and it included a unique and innovative settling basin. Under architecture, the powerhouse is a fine example of Mediterranean Revival style, and a rare example of a powerhouse designed with architectural beauty and sophistication. Under historic archaeology, the system contains sites associated with construction/worker camps and a trail and road system that have the potential to provide information. The Period of Significance begins in 1910, when the earliest construction activities were initiated, and ends in 1930, which is an approximate date that the three areas of significance no longer apply.

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Project Information: The Historic American Engineering Record (HAER) is a long-range program that documents and interprets historically significant engineering sites and structures throughout the United States. HAER is part of Heritage Documentation Programs (Richard O'Connor, Manager), a division of the National Park Service (NPS), United States Department of the Interior. The KR3 Hydroelectric System recording project was undertaken by GPA Consulting, Inc. (GPA) for SCE in cooperation with Christy Avery, HAER Historian (NPS). SCE initiated the project with the intention of making a donation to NPS. Archaeologist Crystal West, SCE, oversaw the project and provided access to the site. Architectural Historian Andrea Galvin, GPA, served as project leader. Preservation Planner Matthew Weintraub, GPA, served as the project historian. James Sanderson, GPA, produced the large format photographs. The field team consisted of Matthew Weintraub, GPA; James Sanderson, GPA; Michael Crippen, SCE; and Crystal West, SCE.

Part I. Historical Information

A. Physical History:

1. Date of Construction:
Construction related activities occurred as early as 1910 with road construction and establishment of a company work camp. Construction of the intake began in 1914 and tunneling occurred by 1915. However, work proceeded slowly through 1918, due in large part to the United States involvement in World War I. The system's operating facilities were constructed primarily between 1919 and 1921. Work at the powerhouse site commenced in March 1919. The entire system was completed in March 1921.[1] The generators began operation on April 1 and May 13, 1921.[2]

2. Engineer:
F. C. Finckle, Chief Engineer of the California Power Company (SCE) from 1901 to 1909, originally surveyed the KR3 plant site between July and October 1900. William A. Brackenridge, Vice-President and General Manager of SCE from 1909 to 1918 (later President and Senior Vice-President), was responsible for the detailed design of the KR3 system. Brackenridge provided overall supervision of the construction project; Russell A. Ballard was Vice-President in charge of construction; and Harry W. Dennis was resident engineer.[3]

3. Builder/Contractor/Supplier:
The origins of construction materials for the KR3 facilities, such as cement, sand, gravel, and steel are not known. Materials were shipped to the site from Los Angeles.[4] The Pelton Water Wheel Company of San Francisco supplied the reaction turbines used in the KR3 powerhouse, and the General Electric Company supplied the generators.[5] Shaw manufactured the overhead traveling crane.[6]

4. Original Plans:
Several construction and after-construction drawings of the KR3 hydroelectric system and facilities were found in SCE electronic records. In addition, a paper written by Ely C. Hutchinson, Vice-President and General Manager of the Pelton Water Wheel Company, and published in 1922 described the original design and construction of the KR3 system. The paper, "Kern River Number Three Plant of the Southern California Edison Company: With Special Reference to the Hydro-

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[1] Bob Powers, North Fork Country (Exeter, California: Bear State Books, 2003), 93-94, 100.
[2] Stephen D. Mikesell, "National Register of Historic Places Nomination, Kern River No. 3 Relicensing Project" (Walnut Creek, California: Entrix, Inc., 1989), 8-8, 8-10.
[3] Mikesell, "National Register," 8-5, 8-6, 8-10.
[4] "Freighting with Motor Trucks on Kern River Project No. 3," Engineering News-Record 18 (1920): 868-869.
[5] Ely C. Hutchinson, "Kern River Number Three Plant of the Southern California Edison Company: With Special Reference to the Hydro-Electric Installation" (San Francisco: The Pelton Water Wheel Company, 1922), 7-8.
[6] Powers, "North Fork Country," 94.

Electric Installation," was published the year after the KR3 system started operation by the Pelton Water Wheel Company, which supplied the turbines to the KR3 powerhouse. The paper included narrative descriptions, photographs, and drawings of the system and its facilities.

According to KR3 system plans from 1911, 1916, and 1922, which span its period of development, the general system design did not change dramatically during its construction. All of the drawings showed the dam, intake and sandbox (settling basin) in the same location at the upper end of the system, and the forebay, penstocks, and powerhouse in the same location at the lower end of the system. Between the upper and lower ends of the system, the drawings showed the conduit on a meandering route, generally north-to-south, and approximately parallel to and east of the Kern River and the Southern California Edison Company Road.[7]

An early construction drawing from 1915 showed detailed plans of the diversion dam, intake, and the sandbox. The dam was designed as a straight-axis structure with a crest approximately 240 feet long. The elevation of the crest was designated as 3632'. The southeast end of the dam contained sluice gates and a gated intake flume that was partially carved out of the rock surface. The flume was contained behind the dam within a wall that topped at 3642'; the bottom of the flume was at 3623'. The dam and flume appear to have been constructed according to this plan.[8]

However, the dynamic aspect of the KR3 construction project was evident by substantial changes that occurred in the design of the sandbox (settling basin) during its development. The 1915 and 1925 drawings both showed the sandbox as an open structure approximately 400' long, tapered at the ends, deeper in the middle than at the ends, and with sluice gates in the northwest wall. However, the earlier design and the later design differed distinctly, with the as-built sandbox being more regular in shape, more sophisticated in design, and located further away from the dam than the sandbox proposed by the earlier plan.[9]

In addition to sandbox design, differences in conduit details were evident between early and later system plans. The 1911 company drawing showed that four tunnels, numbered 9 to 12, were planned between Salmon Creek and Bryn Canyon; later drawings from 1916 and 1922 showed that five tunnels, 9 to 13, were constructed in that location along a slightly different alignment. The 1911 drawing also showed two tunnels, 17 and 18, immediately south of Corral Creek, with a sharp angle at their juncture; the later drawings show them as combined

[7] "K. R. 3 System as Resurveyed in 1911" (1915), Drawing #51011; "K. R. 3 System as Resurveyed in 1916" (1916, revised 1919), Drawing #51056; Hutchinson, "Kern River Number Three," 7 (Figure 1).
[8] "Diversion Dam, Intake, Sand-box" (1915), Drawing #8139.
[9] "Exhibit L, Plan of Sandbox & Adjacent Flumes, Kern River Powerhouse #3 Project" (1925), Drawing #56475.

into a single straight tunnel numbered 18. The later drawings also identified subparts to tunnels 8a, 8b, 9a and 9b.[10]

The estimated and constructed tunnel lengths differed as well, as did specifications for flumes.[11] For instance, the length of tunnel 20, the longest tunnel in the system, was variously estimated at 6512' in 1911, and 7126' in 1916; and it was listed at 7132' after construction in 1922. Likewise, the length of the siphon between tunnels 22 and 23, in Little Brush (Cannell) Creek Valley, was estimated at 910' in 1911, and 968' in 1916; and it was recorded as 925' in 1922.[12] Meanwhile, the 1911 plan showed flumes in only two locations, at the sandbox and at Corral Creek, while the 1916 plan also showed flumes at the forebay, and between tunnels 8a and 8b. The plan published in 1922 provided much greater flume detail. It indicated a total of 22 flumes, including at most tunnel junctures, except between tunnels 5 and 6 and between tunnels 20 through 23. The lengths of the longest flumes were listed, including one over 1700' and two more over 1000'. The 1922 plan calculated the total length of the built system between the intake and the end of the penstocks as 13.39 miles.[13]

The six types of conduits that were used in construction of the KR3 system were illustrated in cross section drawings published in 1922. The sections included: an arched tunnel section, 8½' wide and 8' high at its sides, used in the upper two-thirds of the system; an arched tunnel section, 9½' wide and 8' high at its sides, used in the lower third of the system; covered flume, surface (uncovered) flume, and trestle flume sections, all square, 8½' wide and 8¼' tall; and a circular pressure flume section 9½' in diameter. Section drawings were also published for the siphon spillway, which consisted of an inverted V-shaped pipe that led from the siphon chamber to a valve-controlled overflow chamber. The spillway was designed to operate if the water level in the siphon chamber exceeded a certain elevation. In addition, section drawings of the forebay showed the interior of the surge-chamber, where the conduit split into two flows that connected to the two penstocks, and a large relief valve located before the split. The bottom of the concrete flume entered the forebay at 3485.15' in elevation, while the top of the forebay structure was at 3509.15' in elevation.[14]

The KR3 powerhouse was designed with the generator room and two levels of transformers located above the foundation, according to a 1920 company cross-section drawing. The generator room was outfitted with a 65-ton overhead

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[10] "K. R. 3 System as Resurveyed in 1911," Drawing #51011; "K. R. 3 System as Resurveyed in 1916," Drawing #51056; Hutchinson, "Kern River Number Three," 7 (Figure 1).
[11] The tunnels were numbered sequentially from higher to lower elevations, except that 2 and 3 were not used in the numbering system, and 8a, 8b, 9a and 9b were added.
[12] Powers, North Fork Country, 96, refers to "the inverted siphon that connected tunnels 23 and 24," which is an erroneous reference to the location of the siphon.
[13] "K. R. 3 System as Resurveyed in 1911,", Drawing #51011; "K. R. 3 System as Resurveyed in 1916," Drawing #51056; Hutchinson, "Kern River Number Three," 7 (Figure 1).
[14] Hutchinson, "Kern River Number Three," 7 (Figure 2).

traveling crane on rails that ran along the walls. The floor of the generator room, and the top of the foundation, was located at 2706.5' in elevation. Two generator units were mounted vertically at the center of the generator room, with associated machines such as governors, governor oil pressure tanks, and governor oil pumps installed nearby. Directly below the generator installations and the generator room floor, the turbines and casings were mounted vertically between the two basement levels that were constructed within the foundation. The first floor below the generator room, at 2694' in elevation, accessed the shaft-mounted connections between the turbines and the generators, the turbines (mounted in the floor), the relief valves, and the penstock valves. The second floor below the generator room, at 2684' in elevation, accessed the turbines (mounted in the ceiling), and the connections between the turbines and the draft tubes (or release tubes), which passed down into the foundation and out at the tailrace.[15]

The as-built company drawings of the powerhouse elevations from 1925 show a rectangular building five bays wide and seven bays long. At each elevation, the corner bays contained narrow, rectangular windows with divided panes and round-headed arched transoms, variously glass or vented. The middle bays at each elevation contained very large multiple-part, round-headed arched windows that occupied the entire bays. At the downstream elevation, the glazed bays extended all the way down to grade and contained pedestrian and service doors. At the upstream elevation, the central glazed bay similarly extended to grade and contained a pedestrian door. Architectural details included Classical pilasters between window bays, spandrels at the arcade windows, decorative keystones, headers, and bracketed sills at the smaller windows, a Classical entablature of architrave, frieze, and cornice, and a flat parapet that terminated at 2764' in elevation. The friezes in the entablatures at the landside and downstream elevations were engraved for the Southern California Edison Company.[16]

The Pelton Water Wheel Company provided this description of the KR3 system a year after it was completed:

> The water is taken from the river by means of a concrete diversion dam of ogee form. After passing through an inclined grizzly, and through two motor-operated headgates, each 8 feet square, it is carried by concrete flume for about one-half mile to a double compartment, reinforced concrete, sand-settling basin, 400 feet long by 60 feet wide by 20 feet deep. . . .
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> From the sand-box to the surge-chamber, a distance of about 11½ miles, the conduit is mainly in tunnel, alternating with short

[15] "Section F-F, Showing Equipment through Unit No. 2" (1920), Drawing #20553-11.
[16] "Exhibit L, Elevations of Power House, Kern River Powerhouse #3 Project" (1925), Drawing #56477.

stretches of concrete flume. A section of this flume, not far back of the surge-chamber, is provided with a siphon spillway.

The surge-chamber is of reinforced concrete and is designed to equalize the flow between the tunnel system and the supply to the turbines. A separate steel pipe, 84 inches in diameter at the surge-chamber, and tapering to 60 inches at the power house, leads to each of the two turbines. Each penstock is 2520 feet long, the upper 795 feet being $^{3}/_{8}$ inch riveted construction, and the remainder forge-lap welded, the thickness increasing with the head to a maximum of 1-$^{1}/_{16}$ inches. A recording Venturi meter is permanently installed in each pipe for measuring the water.

Main water control at the power house is by means of Johnson needle-type valves, with outlets connecting directly to the inlet flanges of the turbines. Each penstock is equipped with a bursting plate to prevent damage from excessive pressure. Control gates are provided for each pipe at the surge-chamber. These gates are electrically operated from the power house.

The power house is a reinforced concrete building 88 feet wide and 130 feet long, situated on the bank of Kern River, tail water from the turbines being returned directly to the stream. The structure houses all the electrical equipment required, in addition to the hydro-electric units.

The generator equipment consists of two 17,500 K.V.A. General Electric Company vertical units, operating 3-phase at 11,000 volts for 60-cycle and 10,000 volts for 50-cycle current. They are provided with Reist spring type, water-cooled, thrust-bearings for supporting the entire rotating element, inclusive of the hydraulic turbine runner and shaft. . . .

The transformers are water-cooled, and a spare is provided, so arranged that it may be connected at any required point. The transformers step up to 75,000 volts and are arranged to connect to either a 50-cycle or a 60-cycle bus through suitable oil-switches. Each bus is further provided with a disconnecting switch so that either generator unit may be operated at 50 cycles while the other is being operated at 60 cycles.

> Each main generator has a direct-connected exciter, and an auxiliary motor-driven exciter of sufficient capacity to excite the fields of both main generators is also provided.[17]

5. **Alterations and Additions:**

Company drawings produced in 1960, showing cross sections of the powerhouse and the forebay, indicated that minimal changes had occurred to these facilities by that time. The powerhouse structure and machinery appeared intact to their original conditions. At the forebay, a spillway and housing appear to have been constructed at the relief valve, and a small control house/equipment room was added by 1960.[18]

Field inspection in 2013 documented other minor changes to system facilities that occurred over time. At the diversion dam, a calibrated flume for water release into the Kern River was under construction in 2013, adjacent to the existing gates. The new flume was expected to improve system wide response to changes in water levels at the dam, while the older gates were to be retained as a back-up measure. At the sandbox, the mechanisms for operating the gates and the gates themselves have been replaced in the past, as indicated by the existing empty post holes in concrete mountings and the current hydraulic motive equipment. In 2013, replacement of the existing hydraulic-operated sandbox gates with electrical motor-operated valves was under consideration. Along the conduit, inspection of two adits indicated that they were sealed and no longer provided access to conduit segments; it is likely that most or all adits were similarly sealed. At the syphon, a remotely controlled mobile debris rake was installed with the capability of clearing the entrance chamber. At the powerhouse, changes were generally limited to upgrades of control boards, and installation of electronic sensors, meters, and automating equipment.

According to the National Register of Historic Places nomination for the KR3 system, the control building at the dam was demolished and replaced in 1968. Other alterations to the intake structure included the installation of automatic water control valves in 1931, raising the flume wall in 1933, installation of automatic fish screen control in 1946, and major concrete repair in 1954. In 1984, a small meter house was constructed at the downstream end of the sandbox. At the conduit, some flume walls were raised in 1928 and tie beams were repaired in 1933. At Salmon Creek, a small diversion dam and metal pipeline were constructed during the 1920s and 1930s as an addition to the KR3 water diversion and conveyance system. Similarly, a small diversion dam and pipeline were constructed at Corral Creek after 1945. Within the powerhouse, the turbines and generators were subject to frequent and annual maintenance that involved

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[17] Hutchinson, "Kern River Number Three," 6-8.

[18] "Exhibit L, General Design Drawings, Kern River No. 3 Project, Forebay Plan, Elevations & Section" (1960), Drawing #544454; "Exhibit L, General Design Drawings, Kern River No. 3 Project, Powerhouse – Sectional Elevation – Longitudinal" (1960), Drawing #544458.

replacement in kind, and the transformer equipment and control gallery equipment has been upgraded over the years. In addition, the workers village that originally consisted of 36 structures in the vicinity of the powerhouse was almost completely dismantled after plant automation made it superfluous.[19]

B. Historical Context:

The earliest progress toward hydroelectric development of the Kern River occurred in 1895 with the formation of the Kern River and Los Angeles Electric Power Company. William G. Kerckhoff and a partner, Charles Foreman, founded the company.[20] A civil engineer from Los Angeles by the name of Hawgood was also associated with it.[21] Reorganized as the Kern River Company in 1897, it was one of many companies competing to supply the expanding electricity markets of Southern California at the close of the nineteenth century.[22] It obtained franchises to construct transmission lines to Kern and Los Angeles counties.[23] However, the Kern River Company lacked of investors, likely due to the proposed plant's distance to a sizeable market,[24] and the engineering difficulties with constructing the proposed transmission line.[25] Very little development on the Kern River occurred until the Pacific Light and Power Company (PL&P) purchased the Kern River Company in 1902.

> To meet the growing demand for power, PL&P began to acquire existing power companies that controlled resources from which large amounts of electricity might be developed. Aside from the Sierra Power Company, purchased outright in 1902, the first major acquisition was the Kern River Company, which since 1897, had been constructing in rather desultory fashion a hydroelectric plant on the Kern River 11 miles below old Kernville. . . .
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> . . . Immediately work was begun to rush the plant to completion, spurred by the need to develop energy for the many new Pacific Electric trolley lines that [Henry] Huntington [a founder of PL&P] was building at that time.[26]

The PL&P plant on the Kern River, with 10,000 kilowatts generating capacity, became known as the Borel plant. Serviced by a 55,000-volt transmission line 127 miles long, it was "the most remote power plant serving Southern California" when it began operation in 1904.[27]

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[19] Mikesell, "National Register," 7-1, 7-2, 7-6, 7-7, 7-12, 7-13.
[20] Powers, North Fork Country, 89.
[21] William A. Myers, Iron Men and Copper Wires: A Centennial History of the Southern California Edison Company (Glendale, California: Trans-Anglo Books, 1986), 55.
[22] Mikesell, "National Register," 8-1.
[23] Powers, North Fork Country, 89.
[24] Myers, Iron Men, 55.
[25] Powers, North Fork Country, 89.
[26] Myers, Iron Men, 55-56.
[27] Myers, Iron Men, 57-58.

Concurrent with the completion of PL&P's Borel plant, the Edison Electric Company (Edison), a competitor of PL&P, undertook to develop hydro plants on the Kern River. Like PL&P, Edison successfully consolidated the holdings of other power companies in order to better meet the growing energy needs of Southern California. Edison's consolidations were often accompanied by investments in modernization to existing plants.[28]

> By far the most ambitious power development yet undertaken by Edison Electric, however, was the building of the first of series of three projected hydro plants on the Kern River. Begun in 1902, it took five years to build "K. R. 1," as the plant was nicknamed, but when completed, its four 5,000 kilowatt generators more than doubled Edison's generating capacity, Kern River No. 1 was squeezed into the precipitous, rocky Kern Canyon miles form any settlement on a site surveyed by F. C. Finkle, Edison Electric's Chief Hydraulic Engineer.[29]

The five years it took to complete the KR1 plant were considered a long time. In addition, the development of KR1 was troubled by a cave-in at a penstock tunnel that killed five men and trapped one.[30] The tunnel failure was attributed to engineer Finkle, who committed "a major miscalculation" by designing an inadequate concrete lining through bedrock.[31]

Previously, Finkle identified five potential plant sites on the Kern River, including the KR1 site. Finkle apparently favored the KR3 site, even though he chose KR1 as the first plant to construct under the erroneous belief that the rail costs would be substantially reduced. William A. Brackenridge, who assisted Edison in the repair of the failed penstock and became a Vice-President after Finkle's resignation in 1909, assumed the duties of developing further hydroelectric facilities on the Kern River.[32] However, in 1909 Edison Electric reincorporated as the Southern California Electric Company (SCE), and proceeded to embark on other projects.

> Despite the completion of Kern River No. 1 only two years earlier, the demand for electricity ha grown so quickly that Edison had leased the Los Angeles Pacific Railway's Vineyard Steam Plant to provide extra capacity. Thus, in 1909 it was decided to build a great new steam station to provide reserve capacity and emergency power for the entire Edison system, and to also enable the abandonment of the few small, obsolete steam plants remaining on the system.[33]

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[28] Myers, Iron Men, 40-41,
[29] Myers, Iron Men, 44.
[30] Myers, Iron Men, 44.
[31] Mikesell, "National Register," 8-6.
[32] Mikesell, "National Register," 8-5, 8-6, 8-7.
[33] Myers, Iron Men, 49.

Despite SCE's other programs, plans to develop the KR3 site were not forgotten, and the company made preparatory plans for construction.

> Henry Sinclair's water rights for 25,000 miner's inches at Fairview had remained unused for years, although in 1906 Edison obtained a permit from the U. S. Department of Agriculture, signed by Thomas B. Sherwood, Acting Forester, to build a wagon road from the proposed Kern River No. 3 intake to the forks of the Kern. . . .
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> Although the work had been in progress on the upper Kern ever since the first survey was made in 1901, not much progress had been made until after 1909, except for the token right of way to retain their rights. By the last part of 1910, the Edison Company had a rough wagon road upriver as far as what is now known as road's End. They had a camp set up at this spot that later became Camp 8, as it was the uppermost in a series of camps to be used in construction o f the Kern River No. 3 Hydroelectric Plant.[34]

It was not until 1914 that Brackenridge submitted a report recommending that SCE proceed with construction of the KR3 plant. Even so, the project for which he recommended approval was not fully designed. Brackenridge did not specify whether impulse wheels or reaction turbines were to be used as prime movers. He did not specify whether a trestle or a siphon would be used at the Little Brush Creek valley. He described a design for the settling basin that was a concrete dam across a canyon, rather than the box-like sandbox that was constructed. He anticipated 12,500-kilowatt generators, while units rate at 17,500 kilowatts were used. He argued for rail shipments to Inyokern; the Caliente route was used during actual construction.[35] These discrepancies between Brackenridge's report and the as-built system highlighted the dynamic nature of the KR3 construction project, which was subject to adjustment.

Early construction activities at the KR3 site began in 1914 with work at the intake, setting up camps, and tunneling. Work continued into 1915.[36] However, during most of the period that the United States was involved in World War I, virtually no work occurred. During the hiatus, in 1917 SCE acquired and merged with PL&P,[37] thus also acquiring the Borel plant on the Kern River. When work resumed in earnest at KR3 in 1918, the intake was completed first. Between 1919 and 1921, the tunnels and flumes, the powerhouse, the forebay and the penstocks were constructed, approximately in that order. Following completion of the power plant in 1921, SCE constructed a workers village near the KR3 powerhouse for its employees to live on site.[38]

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[34] Powers, North Fork Country, 90, 93.
[35] Mikesell, "National Register," 8-8.
[36] Powers, North Fork Country, 98-99.
[37] Myers, Iron Men, 111.
[38] Powers, North Fork Country, 93-94, 96, 98-99

Brackenridge and SCE ultimately chose to install reaction turbines as the prime movers in the KR3 plant. This was a bold decision, though not an entirely unexpected development, given the state of advancement in prime mover technology at the time. Although the reaction, or “Francis,” turbine was invented first in 1849, the impulse, or “Pelton,” wheel became the standard in American use for the remainder of the nineteenth century after its invention in about 1870. The impulse wheel had the advantage of adaptability to a variety of situations, from low head to high head conditions. However, whereas impulse wheels operated at about 83-86% efficiency, reaction turbines operated at about 93% efficiency due to a higher possible rotation speed.[39] Therefore, the need to generate more power at each plant to meet the market demands ultimately led to the development of reaction turbines in a greater variety of circumstances, including at KR3.

> The demand for units of greater power has, naturally, had the effect, where heads have been moderately high, of changing the type of design form the impulse to the reaction turbine. For example: a maximum output of 5,000 hp. under the head of 700 ft. would fall naturally within the field of the impulse turbine; a development requiring units three to four times this capacity under the same head, however, would probably be made with reaction turbines. This condition must inevitably lead to the building of reaction turbines for increasingly higher heads.
>
> The highest known head under which reaction turbines have been built at present is at the Kern River No. 3 development of the Southern California Edison Company, where there are being installed two 22,500-hp., 600-r.p.m. Pelton reaction turbines, under an effective head of 800 ft.[40]

At the time that KR3 was completed, it was referred to as “the most important forward step in hydroelectric practice in recent years.”

> The hydraulic turbines and their auxiliaries are of particular interest, as they are operating under the highest head ever attempted with reaction turbine construction, and their design includes many novel features developed to meet special operating requirements.[41]

The KR3 plant was tasked with supplying electricity to the original markets of the various power companies that were consolidated by SCE.

> The present Southern California Edison Company is a consolidation, including the Pacific Light and Power Company, and the original Southern California Edison Company, both operating 50-cycle systems in Southern

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[39] S. L. Shuffleton, “Tendencies in Development of Hydraulic Prime Movers,” Stone & Webster Journal 5 (1921): 421-422, 426.
[40] Shuffleton, “Tendencies,” 424-425.
[41] Hutchinson, “Kern River Number Three,” 6, 8.

> California, and the Mt. Whitney Power and Electric Company, operating a 60-cycle system supplied from power plants on the Kaweah and Tule Rivers and serving a considerable area in the San Joaquin Valley.
>
> The New Kern River No. 3 Plant is required to supply 60-cycle current for pumping plants to irrigate the growing crops in the San Joaquin Valley during the summer season, when the demand in Southern California is comparatively low. With the approach of winter, the pumping load, and with it the demand on the 60-cycle system, decreases, while at the same time the demand on the 50-cycle system in Southern California is increasing. To meet this condition the plant must then be connected into the general transmission system supplying the Southern California territory.[42]

Of the SCE hydro plants on the Kern River, the cost of constructing the KR3 plant was the highest by far. KR3's cost per kilowatts of installed capacity was $333, well above the Borel plant cost of $206 and the KR1 plant cost of $160. In costs per million kilowatt-hours of mean annual output, KR3 was also the most expensive plant at $55,000. Borel was the next most expensive plant at $37,000, and KR1 trailed at $22,000. In 1920, the cost of SCE's planned construction program on the Kern River after KR3 was completed was estimated at only $152 per kilowatts of installed capacity.[43] However, none of SCE's other proposed hydro plants on the Kern River were ever constructed.

Part II: Structural/Design Information

A. General Description:

KR3 is a hydroelectric facility consisting of an intake structure, a conduit, and a power plant. Each of these components is comprised of several individual structures. The KR3 facilities are constructed largely of reinforced concrete. There are also sections of metal pipeline, metal equipment, and wood-framed support structures.

The intake consists of a dam, an intake structure, and flumes. The dam is a reinforced concrete ogee diversion dam. Its crest is 240' long and it is 60' high at its highest point. The west end contains a stepped fish ladder and the east end contains the intake structure. The intake structure is a wedge-shaped concrete box, 8' wide at the upstream end and 18½' wide at the downstream end. The wall of the intake that is perpendicular to the dam contains eight openings, each of which is 6½' wide and 3½' tall, which allow the entry of water. The wall of the intake even with the dam contains a pair of gates that allow water to flow from the intake into an open flume, which is approximately 9½' wide and 420' long. Adjacent to the intake structure, the dam also features gates that allow for release back into the natural river.[44]

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[42] Hutchinson, "Kern River Number Three," 6.
[43] State of California Department of Engineering, Water Resources of Kern River and Adjacent Streams and their Utilization (Sacramento, California: California State Printing Office, 1920), 177.
[44] Mikesell, "National Register," 7-1.

The flume leads to the sandbox (settling basin), which is technically part of the conduit. The sandbox is 448' long, 82' feet wide along most of its length, and 20' deep at its center. Its upstream end is flared and its downstream end constricts into a long neck. The sandbox is divided lengthwise into two compartments by a vertical wall. Each compartment can operate independently with its own intake gate, fish screen, and outflow gate. The lower neck of the sandbox curves southward into a flume.[45]

From the sandbox, water enters the remainder of the conduit, which consists of nearly 13 miles of concrete-lined arched tunnels, covered and open concrete box flumes, and a metal siphon. The total conduit length is 68357', and it descends between 1½" and 2" vertically for each horizontal 1000'. It contains 24 tunnel sections varying in length from a few hundred feet to $1^1/_3$ miles (7132'). There are also 3582' of covered flume and 1705' feet of open flume. Between tunnels 22 and 23, a V-shaped inverted siphon conveys water over the Cannell Creek chasm. The siphon pipeline is 925' long. At the upstream end of the siphon, it is outfitted with a spillway consisting of a 45'-long concrete reservoir that is used to regulate excess flows. In the event the water backs up and exceeds a certain elevation within the reservoir chamber, it is forced through three siphon-like openings at the downstream side, where it is spills onto the ground and eventually flows back into the Kern River.[46]

Functionally, the Salmon Creek and Corral Creek diversion dams and conduits are part of the KR3 system, although they were not part of its original design and were constructed afterward. These dams are of the concrete gravity type with battered sides. They each feed a metal pipeline that conveys water to flume sections of the KR3 conduit. The Salmon Creek and Corral Creek diversion dams augment the flow in the KR3 system.[47]

The conduit ends at the forebay, which is an open concrete box, approximately 60' long, 20' wide, and 30' high, located above the powerhouse site. It regulates the flow of water from the conduit, either by forwarding it through to the penstocks, which are controlled by 24" slide gates, or by releasing it through a spillway. The forebay is roughly wedge-shaped, with the narrower end joined to the pressure flume and the wider end at the split to the penstocks. The spillway compartment and its control gate are located at one side of the forebay structure. The forebay structure is 26' feet taller than bottom of the pressure flume that enters it at 3483' in elevation. The top of the forebay structure is at approximately 3509' in elevation, while the spillway crest is at approximately 3505½' in elevation.[48]

The penstocks are a pair of riveted and lap-welded metal pipelines that deliver water to the powerhouse via gravity-drive acceleration. The penstocks, which are each 2520' long, drop 821' feet in elevation between the forebay and the powerhouse. They gradually

[45] Mikesell, "National Register," 7-2.
[46] Mikesell, "National Register," 7-3, 7-4, 7-5.
[47] Mikesell, "National Register," 7-6, 7-7.
[48] Mikesell, "National Register," 7-7, 7-8.

decrease in diameter as they descend, which is accomplished with reducers. The penstocks are secured into the ground with large concrete anchors that encase the pipes at major grade changes, and by polygonal concrete piers that are spaced approximately every 20'. The last 160' feet of the penstocks travel under the earth fill.[49]

The powerhouse is a reinforced concrete building designed in the Mediterranean Revival style. It is rectangular in plan, approximately 130' long and 88½' wide. The building stands 57½' above grade on the uphill side, and extends 40' below grade. It has a slightly pitched reinforced concrete slab roof and a low parapet. It is five bays wide and seven bays long. The middle sections of each elevation are filled with large round-headed windows and square pilasters, while the corner bays feature smaller, recessed round-headed windows with decorative keystones, headers, and bracketed sills. Glazed entrances with metal grills are found at the narrow ends of the powerhouse. It terminates with a Classical entablature and a frieze engraved for the Southern California Edison Company. Nearby, a one-story flat-roof tool shed mimics the architectural treatment and complements the powerhouse.[50]

At the interior, the largest space is the generator room, which is 105' long, 47'wide and nearly 50' tall. It contains two generators centrally located. A line of transformers occupies an adjacent space. The upstream and hillside sections of the powerhouse are divided into four levels, with the control gallery located at the second level on the upstream side. The basement level, directly below the generator room, is a partial-width level and contains the turbines mounted in the floor between the basement and the smaller sub-basement. The penstocks connect to the turbines by passing underneath the unexcavated portion of the building. Water passes through the turbines and exits the powerhouse at the tailrace, which is a concrete wall, pointed downstream.[51]

1. **Character:**
   KR3 exhibits the historic character of an early twentieth century, "run-of-the-river" hydroelectric system. It displays the historic elements that comprised its original design and operation, including the diversion dam, intake structure, sandbox, flumes, tunnels, siphon, forebay, penstocks, and powerhouse. These elements are largely intact and operating according to original specifications. Changes to the original system that have occurred over time are largely limited to repair work, replacement in kind of hydroelectric machinery, upgrades to manually operated gates and valves, and installation of automating machinery. These changes have not altered the underlying components or operation of KR3, and they have generally resulted in improved functionality of the historic system as a whole.

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[49] Mikesell, "National Register," 7-8.
[50] Mikesell, "National Register," 7-9, 7-10, 7-11.
[51] Mikesell, "National Register," 7-10, 7-11.

2. **Condition of Fabric:**
   The KR3 facilities are in excellent operating condition. Under ownership by SCE for their entire existence, they have benefited from periodic repair and improvement programs. Concrete has been repaired when necessary and facilities do not show signs of major failures. Metal components are generally intact and painted to prevent rust. Architectural features of the powerhouse are generally in good condition.

B. Construction:

According to a company drawing of SCE's construction program at the KR3 site from 1915, a total of eight construction camps were planned to support the project, most of which were located along the SCE company road that followed the course of the Kern River on its east bank. The largest camp was Headquarters Camp, at five acres. Other camps, numbered 2 through 8 in the upriver direction, were planned as three acres in size, except for Camp 4, which was two acres. In addition, a total of eight half-acre sites were strung along the system route near to the construction camps, containing facilities such as cement warehouses, blacksmith shops, and compressor houses.[52] During system construction, the actual locations and numbering of camps differed somewhat from plans. For instance, SCE originally planned Camp 4 at Corral Creek, very close to Camp 5. However, Camp 4 was actually located near Adits 18-19 and 19-20 during construction. Also, Camp 6 was originally planned at Bryn Canyon, but instead was located at Salmon Creek during construction. In addition, Camp 7¼ appears to have replaced Camp 7 in a different location between Camps 6 and 8.[53] The actual locations of Camps 4 and 6 corresponded to sections of the conduit alignment that underwent substantial changes from design to construction, including tunnel relocation and re-segmenting (Tunnels 8a, 8b, 9a, 9b, 10, 11, 18, and 19).

In 1915, the Headquarter Camp, Camps 2 and 3, and Hospital Flats were established. Headquarters Camp was located along the company road north of Little Brush (Cannell) Creek, a half-mile above the town of Riverkern. It contained bunkhouses, an office, a commissary, and a cookhouse. Camp 2 was located just upstream from Headquarters Camp on Little Brush Creek. Workers based at Camp 2 completed Adit L21-W22, one of the first tunnels to be opened. From Camp 3, workers completed Adit 20 in 1919. Camp 4 opened in 1919 and commenced work on Tunnel 20, which was already hand excavated to a depth of 80' by Camp 3 when Camp 4 opened. From Camps 4 and 5, workers made open cuts, lined and roofed with concrete, and constructed a flume over Corral Creek. Camp 8, which had been set up since 1910, occupied the upper end of the system. It served workers at the intake, which was started in 1914, and at the upper tunnels. After intake work picked up in 1918, it was completed quickly, including the head gates and the settling basin.[54]

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[52] "K. R. 3 System as Resurveyed in 1911," Drawing #51011.
[53] Powers, North Fork Country, 91; Natalie Brodie and Roderick McLean, "Final Kern River 3 Hydroelectric Historic District Update" (Carlsbad, California: LSA Associates, Inc., 2012), 42.
[54] Powers, North Fork Country, 96, 98, 99, 100.

With the intake and conduit largely completed, work turned to the 18-acre powerhouse site itself and the nearby area, which contained a workers village.

> . . . Even though the project had been in progress for many years, it was not until March of 1919 that construction work commenced on the actual power plant site. After the foundation was in, the major construction of the plant – including installation of the generators – centered around a Shaw crane rated at 65 tons. The main arm for the crane weighed 20 tons, and it was quite a job to haul it over the rough dirt roads from Caliente and get it installed at the powerhouse.
>
> After completion of K. R. 3 in March of 1921, the Edison Company with teams and scrapers carved out a number of flat spots for dwellings on the small ridges just north and east of the power plant. On these niches above the river the Company built homes for its employees who were to operate and maintain the plant. . . .
>
> As soon as the major portion of the powerhouse was constructed, the forebay and penstocks were constructed. A hoist that pulled cars loaded with materials and supplies, located on-half mile above the plant, played a big part in this phase of construction. Another big job was the installation of the inverted syphon that connected tunnels 23 and 24 across Cannell Creek.[55]

Due to the remote location of KR3, the shipping of materials and equipment to the site during construction presented a challenge. While construction of hydro plants on the Kern River previously involved hauling by mule teams from the railhead, SCE sought a more modern solution to reach KR3, as reported in 1920.

> When the Southern California Edison Company early last year decided to rush construction on the hydro-electric development known as Kern River No. 3, the transportation problem presented itself first. The nearest railroad station was the little desert town of Caliente, 40 miles from construction headquarters, making the average haul to the several sites about 50 miles. The road was practically all up or down hill, the grades ranging up to 16 per cent. The construction contemplated called for supplies and materials amounting to 35,000 tons. The first question was whether it would be desirable to build a railroad. Surveys and estimates of cost were made but it was finally decided that it would be more economical to use motor trucks.[56]

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[55] Powers, North Fork Country, 93-94, 96. Note that the description of the location of the siphon is erroneous. The siphon is located between tunnels 22 and 23.
[56] "Freighting," 868.

SCE assembled a fleet of 95 trucks, including 43 company vehicles with capacity of 1 to 12 tons and 42 privately owned vehicles, to haul freight for KR3. Trucks in the fleet rated as high as 15 tons. Trucks used for heavier loads consisted of four-wheel motor sections and detachable two-wheel trailers. These were capable of handling 11-ton pipe sections. Teams of motor trucks attached to a single trailer were used to move heavier loads. Great attention was given to the organization of the workforce in order to minimize delays in loading and unloading. In Caliente, which served as the railhead where freight was unloaded, SCE set up a fully equipped truck maintenance garage. SCE also kept a warehouse in Caliente half full with cement in order to account for a fluctuating rail shipment schedule that could deliver either an abundance of cement or very little. A 50-mile long telephone line was installed along the road with stations approximately four miles apart to allow truck drivers to report.[57] SCE used Bulldog Mack trucks with hard rubber tires to haul materials, as well as Holt 75 Caterpillars to move very heavy pieces of equipment such as generator components.[58]

C. Mechanicals/Operation:

KR3 is a self-contained, run-of-the-river type of hydroelectric power plant. It operates without carryover capacity behind a reservoir. All water utilized by the system is transferred back into the natural Kern River. As a very late example of a run-of-the-river system, KR3 produced much more power than most other examples of its type, due to the sophistication of its facilities.[59] Over the years, various manual and/or mechanical operations were upgraded by installation of hydraulic, electrical, and automatic systems.

The KR3 power plant operates with reaction or "Francis" turbines. These consist of a pair of rings, inner and outer, with curved vanes arranged uniformly around their circumference. The turbines are mounted on shafts within casings. The water flow is guided into the casings, where the force of the flow against the curved vanes causes the turbines to spin.[60] Water passes through the turbines and out of the plant through draft tubes that release directly into the Kern River. In operation, the spinning turbines also spin up the direct-connected generators, which convert the kinetic energy into electricity that is stepped-up in voltage by transformers and transmitted over long distances to commercial markets.

The original two vertical reaction turbines at the KR3 powerhouse were rated at 25000 hp each and the generators were rated at a combined operating capacity of 32000 kw. Due to the original requirement that the KR3 plant operate as both a 50-cycle system and a 60-cycle system, depending on the transmission system being used, the turbines were tested to determine the most efficient configuration for both cycle rates.

At the time of the -re;ts one turbine was fitted with a 6o-cycle 6oo R.P.M. runner and the other with a so-cycle soo R.P.M. runner. Tests were run on each machine at both 600

[57] "Freighting," 868-869.
[58] Powers, North Fork Country, 90, 95.
[59] Mikesell, "National Register," 8-17, 8-18.
[60] Shuffleton, "Tendencies," 422.

R.P.M.and soo R.P.M. This gave an excellent opportunity to determine the effect upon the efficiency when operating the 6o-cycle runner at so-cycle speed and vice versa. It was also possible to make comparison between the efficiencies of the 6oo and 500 R.P.:'\1. runners when operating at the speeds for which they were designed. The results of the efficiency tests are platted in Fig. 9·

It will be noted from the middle pair of ntrves that while there is little difference in the efficiency of the so-cycle runner operating at 500 R.P.l\1. or 6oo R.J>.:-.t., there is a decided decrease of maximum output when the runner is not operating at its designed speed.

At the time of the tests one turbine was fitted with a 60-cycle 600 R. P. M. runner and the other with a 50-cycle 500 R. P. M. runner. Tests were run[61]

The KR3 system operates with a varying seasonal flow and without water storage.[62] To augment the flow to the KR3 plant, SCE constructed diversion dams and pipelines to the main conduit at Salmon Creek and Corral Creek between the 1920s and 1940s.[63]

Through extensive turbine upgrades, completed in 1984, the capacity has been increased to 28500 hp per turbine and a combined operating capacity of 36800 kw.

D. Site Information:
The KR3 system is located in and along the upper Kern River valley.

[61] Hutchinson, "Kern River Number Three," 8, 15.
[62] Hutchinson, "Kern River Number Three," 6.
[63] Mikesell, "National Register," 7-6, 7-7.

Part III: Sources of Information

A. Primary Sources:

"Freighting with Motor Trucks on Kern River Project No. 3." Engineering News-Record 18 (1920): 868-869.

Hutchinson, Ely C. "Kern River Number Three Plant of the Southern California Edison Company: With Special Reference to the Hydro-Electric Installation." San Francisco: The Pelton Water Wheel Company, 1922.

Shuffleton, S. L. "Tendencies in Development of Hydraulic Prime Movers." Stone & Webster Journal 5 (1921): 421-427.

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Drawings provided by SCE:

"Diversion Dam, Intake, Sand-box." 1915. Drawing #8139.

"Exhibit L, Elevations of Power House, Kern River Powerhouse #3 Project." 1925. Drawing #56477.

"Exhibit L, General Design Drawings, Kern River No. 3 Project, Forebay Plan, Elevations & Section." 1960. Drawing #544454.

"Exhibit L, General Design Drawings, Kern River No. 3 Project, Powerhouse – Sectional Elevation – Longitudinal." 1960. Drawing #544458.

"Exhibit L, Plan of Sandbox & Adjacent Flumes, Kern River Powerhouse #3 Project." 1925. Drawing #56475.

"K. R. 3 System as Resurveyed in 1911." 1915. Drawing #51011.

"K. R. 3 System as Resurveyed in 1916." 1916, revised 1919. Drawing #51056.

"Section F-F, Showing Equipment through Unit No. 2." 1920. Drawing #20553-11.

Secondary Sources:

Brodie, Natalie, and Roderick McLean. "Final Kern River 3 Hydroelectric Historic District Update." Carlsbad, California: LSA Associates, Inc., 2012.

Mikesell, Stephen D. "National Register of Historic Places Nomination, Kern River No. 3 Relicensing Project." Walnut Creek, California: Entrix, Inc., 1989. Prepared for SCE.

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Powers, Bob. North Fork Country. Exeter, California: Bear State Books, 2003.

Southern California Edison Company. Southern California Edison Hydro Generation Division (Draft). Rosemead, California: Southern California Edison Company, 1994.

Appendix A: Images

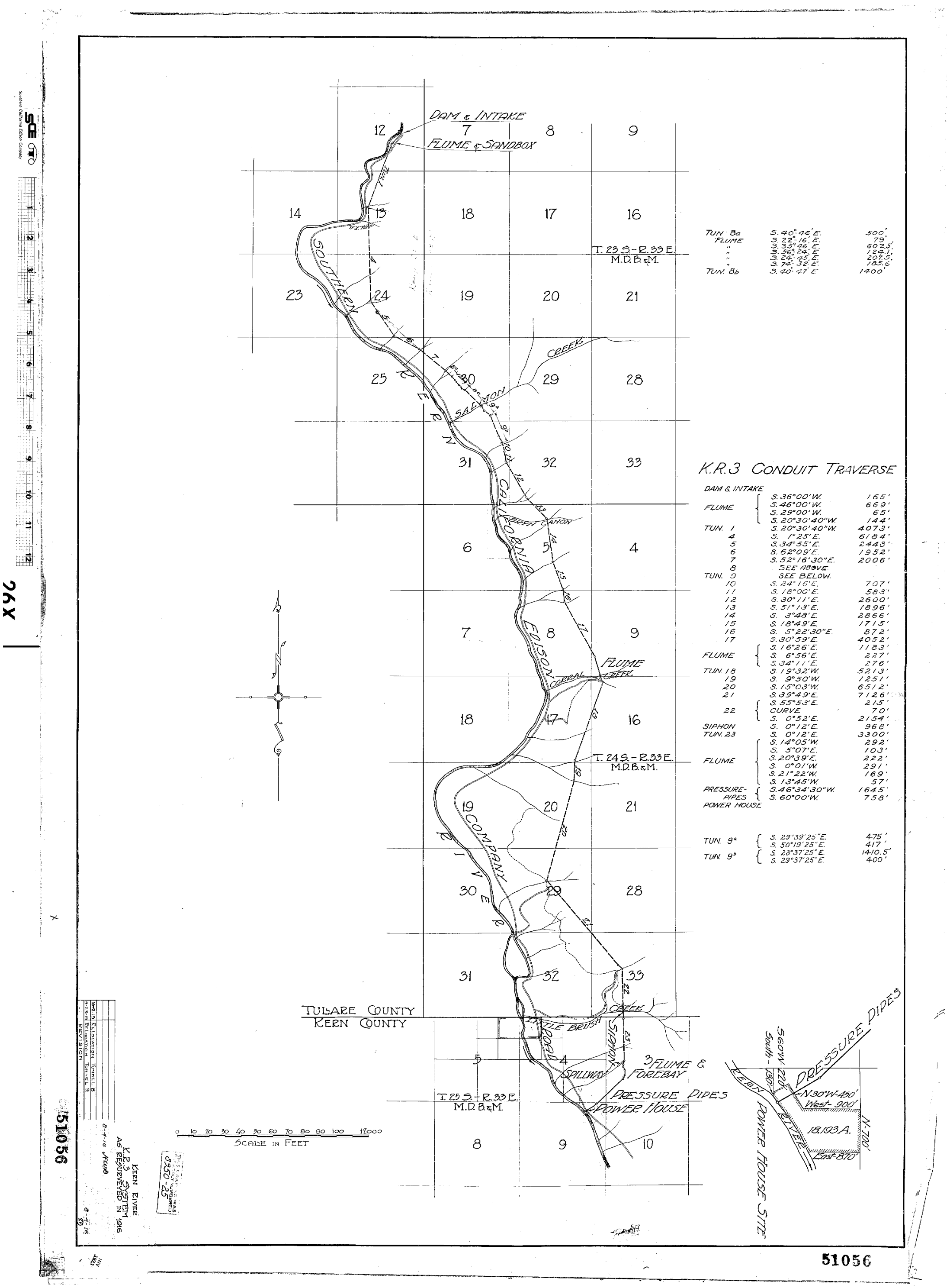

Figure 1: "K. R. 3 System as Resurveyed in 1916." 1916, revised 1919. Drawing #51056.

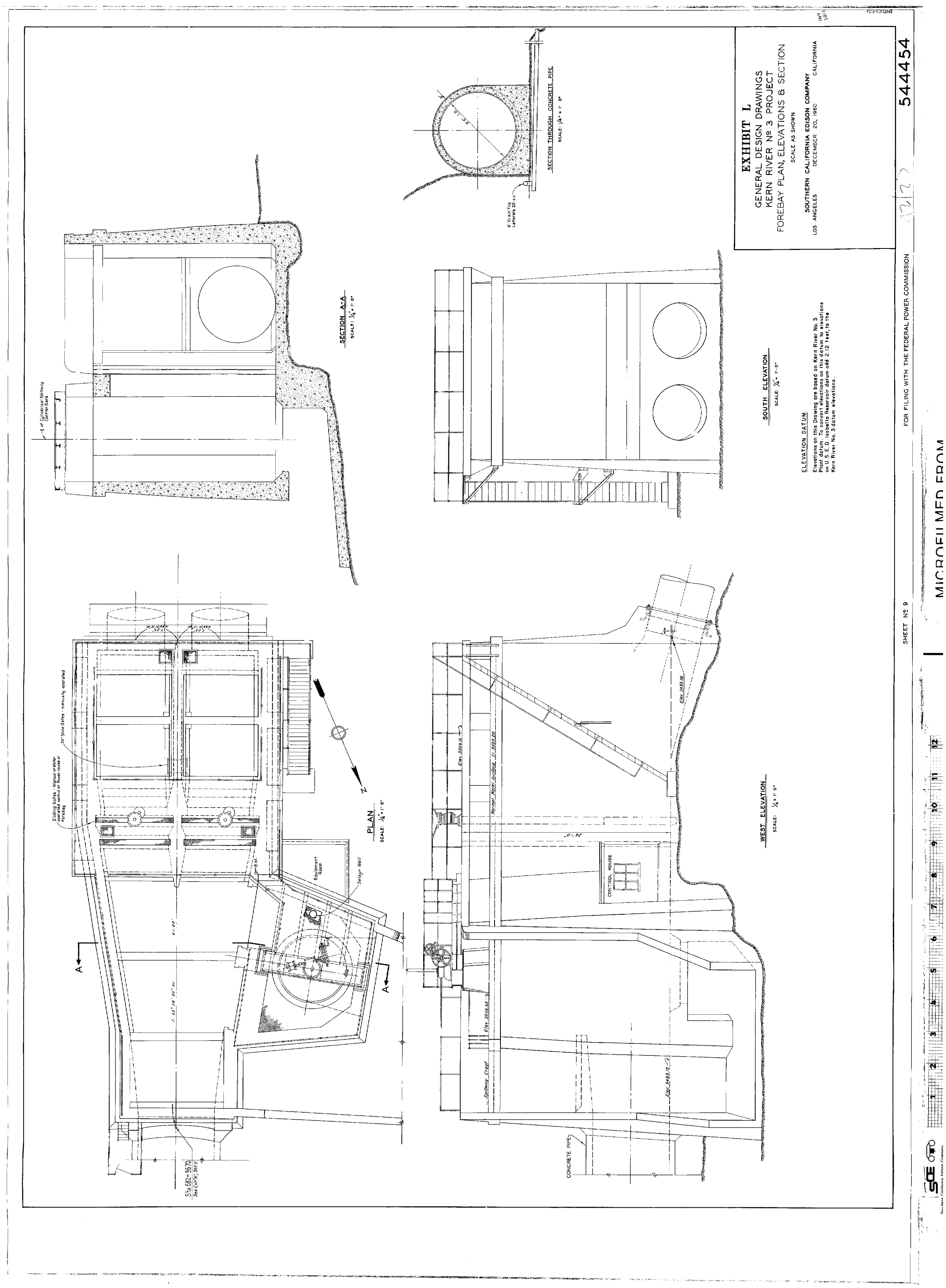

Figure 2: "Exhibit L, General Design Drawings, Kern River No. 3 Project, Forebay Plan, Elevations & Section." 1960. Drawing #544454.

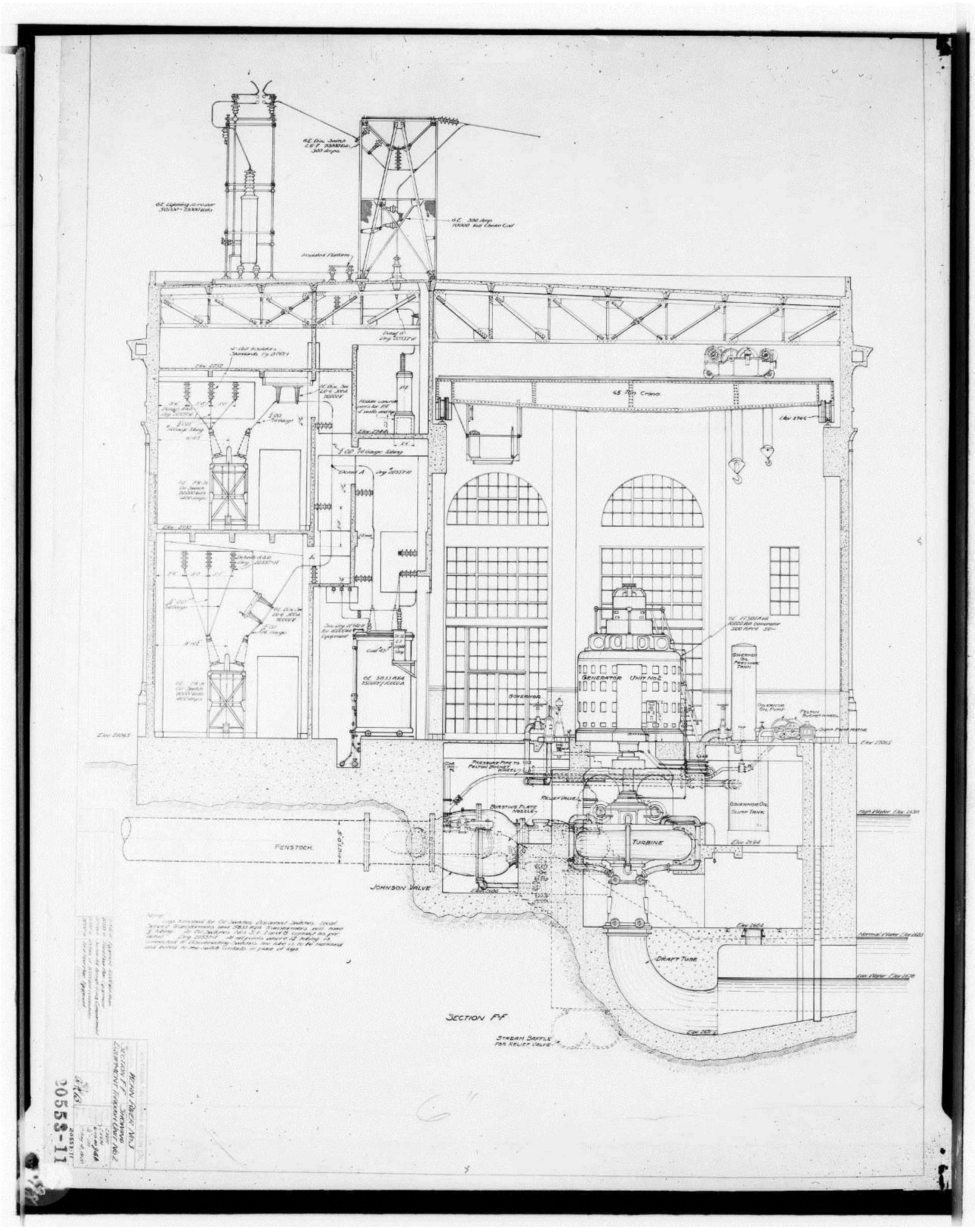

Figure 3: "Section F-F, Showing Equipment through Unit No. 2." 1920. Drawing #20553-11.

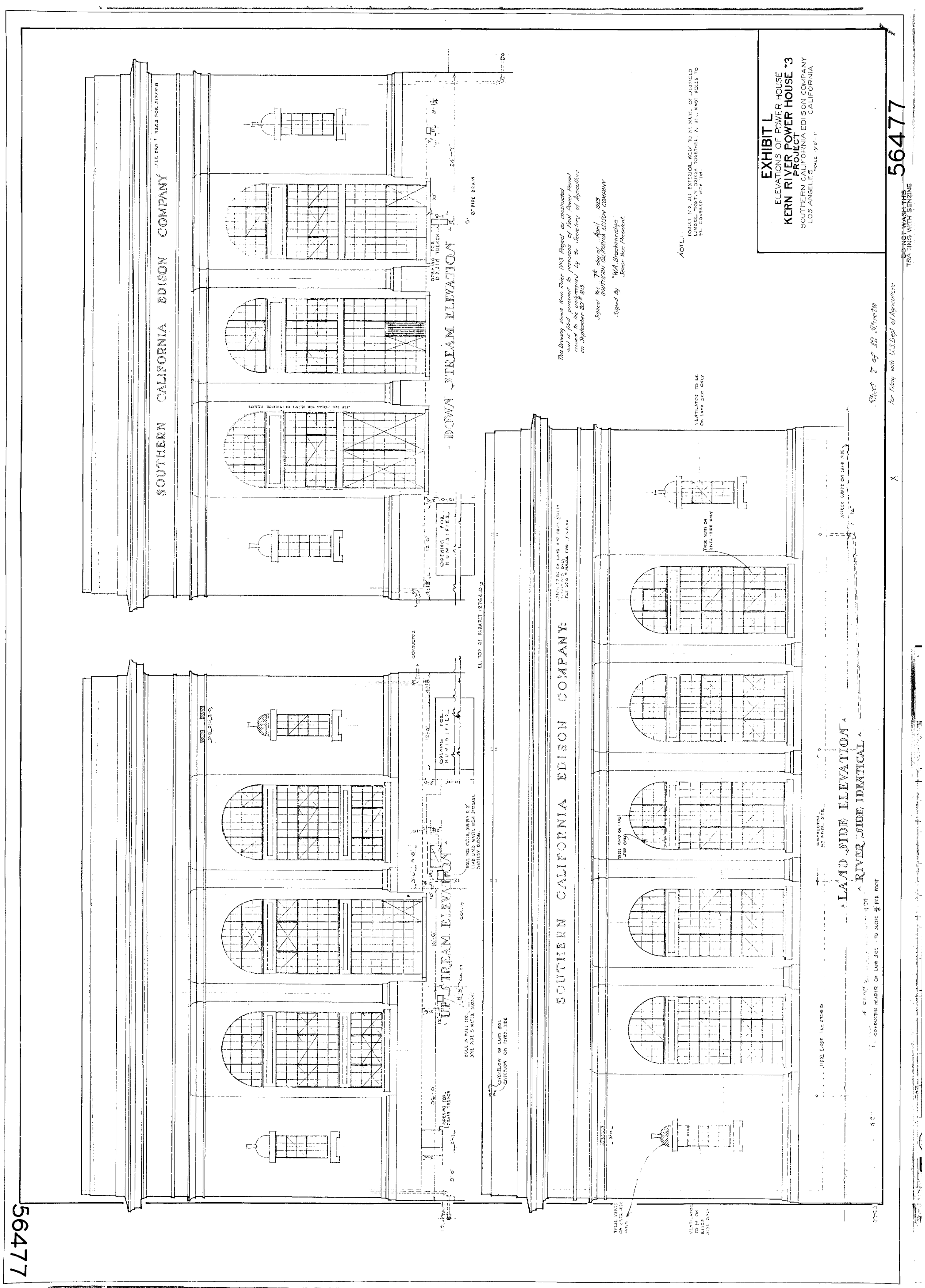

Figure 4: “Exhibit L, Elevations of Power House, Kern River Powerhouse #3 Project.” 1925. Drawing #56477.