BIG CREEK HYDROELECTRIC SYSTEM, EAST & WEST TRANSMISSION LINE
11 Mile Section between Visalia and Farmersville
Visalia Vicinity
Tulare County
California

HAER No. CA-167-N

PHOTOGRAPHS

WRITTEN HISTORICAL & DESCRIPTIVE DATA

FIELD RECORDS

HISTORIC AMERICAN ENGINEERING RECORD
PACIFIC WEST REGIONAL OFFICE
National Park Service
U.S. Department of the Interior
909 First Avenue, Fifth Floor
Seattle, Washington 98104-1060

HISTORIC AMERICAN ENGINEERING RECORD

BIG CREEK HYDROELECTRIC SYSTEM, EAST & WEST TRANSMISSION LINE

HAER No. CA-167-N

Location: The transmission lines referenced in this HAER report are conventionally identified as Big Creek #1-Rector (East Line), Big Creek #3-Rector (West Line), Rector – Vestal #1 (East Line), and Rector – Vestal #2 (West Line) 220kV Transmission Lines. The transmission line segments were simultaneously constructed as a portion of a 241-mile corridor historically referred to as the Big Creek East & West Transmission Line installed between the Big Creek Hydroelectric System in the Sierra National Forest, and the Eagle Rock Substation in Los Angeles, California. The section of transmission lines documented in this HAER report starts at Mile 72 Tower 6 (M72-T6) of the existing Rector – Vestal #1 and Rector – Vestal #2 220kV Transmission Lines immediately south of the SCE Rector Substation located at 28361 Road 148 in Visalia, Tulare County, California, and spans approximately 11-miles north to Mile 61 Tower 4 (M61-T4) on the existing Big Creek #1 – Rector and Big Creek #3 – Rector 220kV Transmission Lines, where a proposed new Transmission Line will span east into the valley.

UTM Location/References:
Zone 11S 299202mE / 4037676mN**;** **Zone** 11S 299176mE / 4037677mN; **Zone** 11S 298562mE / 4019730mN; **Zone** 11S 298587mE / 4019729mN

Owner: Southern California Edison Company
2244 Walnut Grove Avenue, P.O. Box 800, Rosemead, CA.

Present Use: Transmission of electric power.

Significance: The Big Creek Hydroelectric System East & West Transmission Line was constructed in 1912-1913 from the Big Creek Hydroelectric System in the Sierra National Forest northeast of Fresno, California to the Eagle Rock Substation in Los Angeles, California. The purpose of the 241-mile transmission line was to convey electricity from the powerhouses at Big Creek to Los Angeles for distribution to SCE service territories. Put in service in 1912-1913 at 150kV and upgraded in 1922-1923 to carry 220kV, the East & West Transmission Line was the primary line installed to carry electricity to the Los Angeles region and its individual modern-day segments are contributing elements to Big Creek Hydroelectric System Historic District (BCHSHD). On December 24, 1993 the California State Office of Historic Preservation determined the generation and transmission facilities of the Big Creek Hydroelectric System Historic District to be eligible for listing on the National Register under Criterion A, B, and C within the 1911-1929 period of significance. The historic East & West Transmission Line is substantially intact along the entire 241-mile length, and although modifications have occurred in the past century, these changes have not diminished the historical integrity of the system.

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Project Information: Report prepared by Wendy L. Tinsley Becker, AICP, RPH, Principal and Heather Crane, Assoc. AIA, of Urbana Preservation & Planning, LLC. Existing conditions photographs by David G. DeVries and Marissa Rocke of Mesa Technical, 2630 Hilgard Avenue, Berkeley, CA 94709-1002. Project sponsored by Southern California Edison Company, Biological & Archaeological Resources Group (Antonina Delu and Koral Ahmet, Project Leads), Corporate Environment, Health & Safety Division, 1218 South Fifth Avenue, 2nd Floor, Monrovia, CA 91016.

INTRODUCTION

Southern California Edison (SCE) is planning to remove and consolidate an existing 11.1-mile section of the Big Creek Hydroelectric System Historic East & West Transmission Line in Visalia, California. The 11-mile section contains towers from four modern-day segments of the transmission line identified as Big Creek #1 – Rector (East Line), Big Creek #3 – Rector (West Line), Rector – Vestal #1 (East Line), and Rector – Vestal #2 (West Line) 220kV Transmission Lines into an 11-mile single span of Tubular Steel Poles to be installed at the west side of the subject Right-of-Way. An additional 11-mile span of new double-circuit transmission line will be installed at the East side of the subject Right-of-Way. The 11-mile project area is located in unincorporated Visalia in Tulare County, California between Mile 72 Tower 6 within the SCE Rector Substation property and Mile 61 Tower 4 to the north. New double circuit transmission lines would be installed easterly over 12.2-miles from Mile 61 Tower 4 and will terminate at the existing SCE Big Creek #3 – Springville 220kV Transmission Line.

The transmission line segments that comprise the 241-mile Big Creek Hydroelectric System Historic East & West Transmission Line Corridor were determined to be eligible for inclusion on the National Register of Historic Places as contributing elements to the officially determined National Register eligible Big Creek Hydroelectric System Historic District (BCHSHD). Contributing elements to the BCHSHD have been incrementally documented and submitted to HAER under HAER No. CA-167. The section of lines documented in this HAER, identified as the Big Creek #1 – Rector (East Line), Big Creek #3 – Rector (West Line), Rector – Vestal #1 (East Line), and Rector – Vestal #2 (West Line) 220kV Transmission Lines, are contributing elements to the National Register eligible Big Creek Hydroelectric System Historic District.

PHYSICAL HISTORY

Date of Construction: 1912-1913, Upgraded in 1922-1923.

Engineers: Stone & Webster Construction Co., Boston, Mass. and Pacific Light & Power Company.[1]

Builder: Stone & Webster Construction Co., (1912-1913), Pacific Light & Power Company (1912-1913), and Southern California Edison (1916 forward).

Three transmission lines were installed from the Big Creek Hydroelectric System within the 1911-1929 period-of-significance – the Big Creek East Transmission Line (1913), the Big Creek West Transmission Line (1913), and the Vincent Transmission Line (1925-1927).

Constructed simultaneously as two parallel transmission lines with each line having its own set of towers, but referred to historically as a single line, the Big Creek East & West Transmission Line was designed to carry 150kV of electricity from the Big Creek Hydroelectric System Powerhouse #1 and #2 in the Sierra National Forest northeast of Fresno, California, to the Eagle Rock Substation in Los Angeles, California. Completion of the transmission system was the final step in the first phase of development at Big Creek. Planning for the line, including dedication of the route and purchase of the steel and aluminum construction materials, was completed in 1912. The system, comprised of two parallel transmission lines – one identified as the West Line and one identified as the East Line – was completed in November 1913. Upon completion of construction the transmission system was placed in service at 150kV (150,000-volts) and was regarded as the longest spanning and highest voltage transmission line in the world.[2]

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[1] "Hydro-Electric Development on Big Creek, California," Western Engineering, Vol.1, 1912: 650-651.
[2] Theodoratus Cultural Research / Laurence Shoup and Clinton M. Blount, *The Hardest Working Water in the World: A History and Significance Evaluation of the Big Creek Hydroelectric System* (Southern California Edison Company: 1988) 74.

The SCE Magunden Switching Station, located approximately 175-miles south of Big Creek, was the only interruption originally installed along the 241-mile span. A total of 3,341 transmission towers were installed along the span including 2,565 Standard Suspension Towers, 772 Dead End / Anchor Towers, and four Special Towers.[3] The typical span between towers was 660-feet; towers installed at snow or sleet areas were spaced at 550-feet. Special towers were installed where longer spans were required at river crossings or canyons. Minimum conductor clearance was specified at 25-feet at the center of the span. The East and West Transmission Lines were erected within a 150-foot Right-of-Way located primarily in privately owned property, with the center line of the East and West towers spaced at 82-feet.[4]

According to Historian Laurence Shoup, et. al., in *The Hardest Working Water in the World: A History and Significance Evaluation of the Big Creek Hydroelectric System*

> The final step in completing initial construction of the Big Creek Hydroelectric System was building the longest transmission line in the world. As with many other features of the Big Creek System, work on the transmission line began early. The route for the line was laid out in 1912, and most of the massive amount of steel and aluminum needed for a 241-mile-long line was purchased during that same year. The work of erecting steel towers and stringing aluminum began late in 1912 and continued until completion in November 1913. Like much of the rest of Big Creek's initial development, the transmission line was a significant achievement for its era. Operating at the highest voltage (150,000) ever used up to that point in time, it incorporated huge amounts of materials.[5]

Construction of the East & West Transmission Line was widely publicized. The features of the project were detailed in the November 2, 1913 edition of the *Fresno Morning Republican*.

> **241 Mile Power Line**
>
> For miles stretching away on either side through the valley and over mountain peaks is the pathway of the transmission line, a line 241 miles long, such as in length has never been contemplated, carrying in its strands of steel and aluminum that constant current of 80,000 horsepower, alone sufficient to supply a region half the size of Southern California with all its lighting, all its transportation, all its manufacturing power.
>
> This transmission line will carry a pressure of 150,000 volts, the largest known to go over the longest known line.
>
> To do this it was necessary to use an aluminum cable of seven strands of steel core, around which are placed fifty-four strands of aluminum.
>
> The 241 miles of aluminum cable, weighing eight million pounds, is supported by eight-four million pounds of steel used in the towers.[6]

Period references to the East & West Transmission Line as a singular entity, rather than two separate transmission lines, minimized the significance of the engineering accomplishment achieved at the system.

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[3] Fowler, Fredrick Hall, US Geological Survey, Water Supply Paper 493: Hydroelectric Power Systems of California and Their Extensions into Oregon and Nevada (Washington D.C.: U.S. Government Printing Office, 1923) 694.
[4] Woodbury, Edward, "150,000-Volt Transmission System – Some Operating Conditions of the Big Creek Development of the Pacific Light & Power Corporation" *Transactions of the American Institute of Electrical Engineers*, Volume XXXIII, Issue No. 2, June 1914, 1291.
[5] Shoup, et. al., 74.
[6] "Subjugate Nature's Forces to Man's Uses in Southern California through $12,000,000 Big Creek Expenditure" *Fresno Morning Republican*, November 2, 1913: 15.

All accounts, including PLPC press releases, identified the East & West Transmission Line as a single line rather than the two separate but adjacent lines that were simultaneously planned and constructed. The dual lines were documented simultaneously on PLPC / SCE field data engineering sheets, simply referred to as 'East Line' and 'West Line'. In sum the line was constructed to include 3,401 steel lattice transmission towers; with 2,565 Standards Suspension Towers, 772 Dead End / Anchor Towers, and four Special Towers over the 241-mile span. Of the 2,565 standard suspension towers, four were designed to be 'special towers' that were designed to hold greater loads at longer spans over the Kings River and the Kern River. The entire dual 241-mile transmission line was completed in one year and was energized in November 1913.

Modifications
The East & West Transmission Line continued to convey electricity from the Big Creek Hydroelectric System at a level of 150,000 volts (150kV) until May 6, 1923 when the entire Big Creek Hydroelectric System, including the line, was upgraded to 220,000 volts (220kV).[7] With the 220kV upgrade the East & West Transmission Line was again regarded as the highest voltage transmission line in the world, and SCE's Big Creek transmission system continued to receive acclaim for its engineering feats with the 1925-1927 construction of the third line from Big Creek – the Vincent 220kV Transmission Line. The Vincent Line was built in a separate Right-of-Way approximately 50-miles east of the original Big Creek East & West Transmission Line, and terminated at the SCE Gould Substation.[8]

The 1923 system upgrade required modifications to the original Big Creek East & West Transmission Line Towers including installation of new longer insulators (three) at each tower top, onsite use of four lift elevators (one per tower footing) to raise the tower, and installation of a new steel tower base built in place at the ground level. According to SCE Historian William Myers

> …when the Initial Development at Big Creek was finished in 1913, the 150,000-volt power line to Eagle Rock Substation was the longest-distance, highest-voltage line in the world. By 1922, with substantial new generation coming on line and more planned, the capacity of these original transmission lines was adequate. The change-over to "220KV" began in the spring of 1922. New "switch gardens" containing new transformers, bigger switches and circuit breakers had to be installed at all the Big Creek plants and at Eagle Rock. The most difficult single aspect of the job was converting the transmission towers themselves. New, longer insulators had to be installed, and most of the towers physically raised from 10 to 30 feet so the power lines would adequately clear the ground, all while the lines remained "hot" – energized at 150,000 volts – for the vital flow of energy to Los Angeles could not be interrupted. On Sunday morning May 6, 1923, the line was cut over to 220,000-volt operations, establishing another technological first for Edison. For this achievement, the Southern California Edison Company in 1923 became the first winner of the Charles A. Coffin Medal, today known as the Thomas A. Edison Award."[9*]

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[7] Redinger, David H., Edith I. Redinger and William A. Myers, <u>The Story of Big Creek</u> (Tucson, AZ: Ironwood Press, 1998) 265.
[8] Urbana Preservation & Planning, LLC / Wendy L. Tinsley Becker, *NRHP Eligibility Review of SCE Vincent 220kV Transmission Line* (Southern California Edison Company: 2011) 1.
[9] Myers, William A, <u>Iron Men and Copper Wires: A Centennial History of the Southern California Edison Company</u> (Glendale, CA: Trans-Anglo Books, 1986) 118-119.
[*]Note: The Charles A. Coffin Medal was established in 1922 to commemorate and celebrate the May 16, 1922 retirement of Charles Coffin, the founder and creator of the General Electric Company, which established the Charles A. Coffin Foundation. The Charles A. Coffin Medal was established as an annual award for an electric railway company in the United States that made the greatest contributions toward increasing the advantages of electric transportation for the convenience and well-being of the public and the benefit of the industry. "Charles A. Coffin Foundation Is Set Up" *Electrical World* McGraw-Hill Company, Inc.: New York, December 9, 1922, Volume LXXX, 1293.

Today, the East & West Transmission Line still operates at the 220kV capacity, and aside from the 1922-1923 tower raising and insulator replacements to accommodate the voltage increase, the transmission towers remain intact and consistent with the original design and appearance. Additional base extensions were completed at some towers in the 1980s to comply height requirements of energized conductors pursuant to Government Order 95. Through the decades, as SCE service territory expanded and other system changes occurred, additional substations were installed along the 241-mile Big Creek East & West Transmission Line span. As these substations were installed and energized, the portion of transmission line conveying electricity to and from the station were renamed. Today the entire 241-mile span has been segmented into the following identifiers.

East Transmission Line

- Big Creek #1 – Rector,
- Rector – Vestal #1,
- Magunden – Vestal #1,
- Magunden – Pastoria #1,
- Pardee – Pastoria (East),
- Pardee – Sylmar #1, and
- Eagle Rock – Sylmar (East).

West Transmission Line

- Big Creek #1 – Big Creek #2,
- Big Creek #2 – Big Creek #3,
- Big Creek #3 – Rector,
- Rector – Vestal #2,
- Magunden – Vestal #2,
- Magunden – Pastoria #2,
- Pardee – Pastoria (West),
- Pardee – Sylmar #2, and
- Eagle Rock – Sylmar (West).

The 11-mile section of the Big Creek #1 – Rector, Big Creek #3 – Rector, Rector – Vestal #1, and Rector – Vestal #2 220kV Transmission Lines documented in the HAER report reflect the engineering design and general modification history of the total 241-mile span. Within the subject span the modifications identified that have occurred after 1929 include additional raising of some towers through a base extension as part of a circa 1988 upgrade campaign, installation of reinforced concrete footings that are above-grade, and reinforcement of tower cross-arms (tower tops) in some locations.

HISTORICAL CONTEXT

Southern California Edison

In 1896, in Los Angeles, California a syndicate of businessmen formed the West Side Lighting Company in response to the city's increased need for electricity. The West Side Company sought to utilize the 'Edison three-wire' conduit technology invented years earlier by Thomas Edison, but soon discovered use of the Edison technology was prohibited due to a special contract negotiated between a speculative and inactive company established in 1884 under the name Los Angeles Edison Electric Company and Thomas Edison's own General Electric Company, which had provided the LA Edison Electric Company with exclusive Southern California rights to the three-wire technology. In 1897 West Side Company President George H. Barker met with General Electric officials in San Francisco to negotiate use of the Edison technology in the Los Angeles area and to discuss a potential merger between the West Side Company and General Electric. The new Edison Electric Company of Los Angeles (EEC) was incorporated on December 1, 1897, and with George Baker as the company head, the new company took over all the properties and franchises of the West Side Lighting Company and secured the valuable equipment licenses of the inactive Los Angeles Edison Electric Company. In the following years EEC merged with and acquired additional electric lighting and power companies including the Southern California Power Company, and soon expanded into communities outside of Los Angeles as far north as Santa Barbara and as far east as Redlands near Riverside, California.

At the turn-of-the-century, the EEC, alongside its primary competitors, the San Joaquin Power & Light Company and Pacific Gas & Electric, served as the pioneering commercial entities for electrical distribution in California. In California, at the inception of electrical transmission technology, power was distributed via wood poles and later iron poles, but was limited to short spans carrying a low voltage. The development of hydroelectric power at the end of the 19^{th} century set precedent for the demands of commercial electrical needs of the 20^{th} century, and led to the installation of electrical transmission lines spanning great distances from generating facilities at California's river banks, through mountain ranges and deserts, before terminating into the urbanizing communities of Southern California.

In 1907 EEC began operations at the Kern River #1 Powerhouse, a 75,000-volt facility located on the banks of the Kern River north of Bakersfield, California. In 1902, EEC Chief Hydraulic Engineer, F. C. Finkle surveyed the remote area of Kern Canyon with a vision of a great hydroelectric power plant supplying electrical needs to the rapidly growing region of Los Angeles. Two years after the initial survey, EEC Vice President, H.H. Sinclair, chose a suitable location along the Kern River – what was reckoned to become the location of Kern River Powerhouse No. 1. Located approximately 14-miles upstream from the mouth of Kern River, the EEC Kern River Powerhouse No.1 was set for service in early 1907.[10] The Powerhouse served as the generating facility for the EEC's Kern River to Los Angeles Transmission Line, a 117-mile span supported by 1,140 galvanized lattice steel transmission towers that were modeled after windmill frames, and supplied by the Wind Engine and Pump Company of Batavia, Illinois. The Kern River to Los Angeles Transmission Line conveyed 60,000-volts over its 117-mile span, and terminated at EEC's pre-existing Steam & Transformer Plant No. 3 in Los Angeles, where the electricity was then distributed out into Los Angeles via EEC's wood pole distribution system.[11]

The transmission line was cited in an August 10, 1907 *Electrical World* article as one of the longest transmission lines operating on the North American continent, and with its steel towers and specially designed insulators intended for a voltage capacity of 75kV, the Kern #1 Transmission Line with its associated Powerhouse "typified the latest modern practice in hydroelectric power plant design."[12] At the start of

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[10] Fowler, Fredrick Hall, US Geological Survey, Water Supply Paper 493: Hydroelectric Power Systems of California and Their Extensions into Oregon and Nevada (Washington D.C.: U.S. Government Printing Office, 1923) 632-638.
[11] "Kern River No. 1 Power Plant of Edison Electric Co., Los Angeles." Electrical World, vol. 50, August 10, 1907, pg. 277-281.
[12] Ibid.

operation, the Kern River Hydroelectric Project was identified as the "most permanent and costly hydraulic waterway in the country.[13]

By 1909 the company provided electricity to over 600,000 people throughout five counties. To reflect this expanded presence, the EEC was reincorporated as the Southern California Edison Company (SCE). Into the 1910s, SCE continued to expand throughout the growing Southern California region.

Simultaneous to the 1910s SCE expansion campaign, the Pacific Light & Power Corporation (PLPC), led by land baron Henry Huntington, initiated work at what would become the Big Creek Hydroelectric System, and soon thereafter, Huntington approached SCE with interest in selling his PLPC to SCE. A longstanding proposition that had been previously rejected by Edison's President John B. Miller, in 1916 Huntington's offer to merge was accepted by SCE. The merger was viewed as beneficial to both parties, for Huntington about $12 million in Edison stock and for SCE, absolute control over all former PLPC holdings and future expansion efforts, including at the Big Creek Hydroelectric System.

Within SCE's newly acquired holdings were the PLPC Borel Powerhouse and associated Borel to Los Angeles Transmission Line. PLPC first conceived the Kern River as a source of hydroelectric power when their initial plants located along the San Bernardino and San Gabriel Mountains could no longer generate enough electricity to meet power demands. Larger generating stations along Kern River proved to be an adequate source of power. The first facility to be installed was the Borel Powerhouse. Built by the Kern River Company along the North Fork of the Kern River on the outskirts of the town of Kernville, the Borel Powerhouse was put into operation on December 31, 1904 with its twin pole transmission lines spanning over 127-miles south into Los Angeles at 55,000-volts.[14] More important than the Borel complex, with respect to industrializing the Los Angeles Region, was the PLPC's Big Creek Hydroelectric System.

By 1916 fifty-six Southern California communities were lit by SCE infrastructure. Of those 56 communities serviced, 22 were initially serviced by infrastructure installed in the EEC-period (1897-1909) and 34 were serviced by SCE-period (1910-1916) infrastructure. An additional 153 communities initially serviced by Huntington's PLPC, as well as the Mt. Whitney Power Company and the Southern Sierra Power Company, were added to SCE's service network in the post-expansion.[15] After the successful merger between SCE and PLPC, the company focused its labors at expanding the Big Creek Hydroelectric System, with it 241-mile transmission corridor initially in-service in 1913 at a level of 150,000-volts, and other similar efforts to harness the power of water to generate electricity, which brought increased power levels to the Los Angeles region and the surrounding areas that comprise present-day Orange, San Bernardino, and Riverside counties.

SCE continued to develop its hydroelectric system at Big Creek into the late 1920s through the creation of lakes, dams and reservoirs, building of powerhouses, rail lines, and tunnels, as well as support camps replete with food and housing for workers, recreation and entertainment offerings, medical facilities, and administrative offices. By 1929, when the Big Creek system was completed, its capacity consistently generated more electrical power than other systems in place at the time and the system was boasted as featuring many innovative engineering features, including the longest water tunnel in the world. The Vincent 220kV Transmission Line, a 224-mile span between the Big Creek Hydroelectric System and the Gould Substation in Los Angeles, was an important electric power conveyance system installed during the Big Creek development campaign of the 1920s.

Into the late 1940s, in the post-WWII period, additional SCE projects were undertaken at Big Creek to make improvements to existing powerhouses including the addition of new generators, and construction of new dams and powerhouses. This later phase of construction continued through the 1960s. The modern-period

[13] "Kern River No. 1 Power Plant of Edison Electric Co., Los Angeles," 277.
[14] Fowler, 628-632.
[15] Myers, 253-261.

upgrade campaign at Big Creek was instrumental in responding to the increased electricity needs of the Southern California Region resultant from post-war suburban expansion. Today SCE maintains an approximate 50,000 square-mile service territory comprised of individually constructed substations, transmission lines, and other electrical generation and distribution equipment developed to meet customer demands.

Big Creek Hydroelectric System

The Big Creek Hydroelectric System is considered a premier example of a single-integrated hydroelectric system, which required innovative engineering methods and advanced technological application to harness the power of water for the purpose of creating electricity. Between 1911 and 1929, the initial construction period of the project, the Big Creek Hydroelectric System was one of the highest generating systems in place and drew attention from engineers and laypersons globally. The concept behind the Big Creek system was developed by engineer John Eastwood, who formalized and executed his idea with the support and financial backing of capitalist Henry Huntington, railway, lumber and land entrepreneur William G. Kerckhoff, and electrical engineer and power and electric company founder Allan C. Balch.

Each of these three backers represented specific interests that aligned flawlessly to culminate in the creation of the Big Creek System as envisioned by Eastwood. Each was a capitalist, idealist, and visionary.

- Henry Huntington, nephew of Southern Pacific Railway owner Collis P. Huntington, developed an empire of Southern California land holdings, electric railroad transportation companies, and public utility companies, which by 1910 made him one of the most powerful men in the state.
- W.G. Kerckhoff, president of Kerckhoff-Cuzner Mill & Lumber, held interests in the San Gabriel Valley Rapid Transit Railway (SGV-RTR) which ran through Los Angeles County in the cities of Los Angeles, Pasadena and Monrovia. The SGV-RTR was acquired by the Southern Pacific Railway Company, of which Henry Huntington served on the Board of Directors. Kerckhoff's proceeds from the SGV-RTR sale provided him with substantial financial abilities to pursue his interests in developing electrical power systems to supply California, which in turn, would support his primary holdings in the lumber industry.
- Allan Balch received degrees in electrical and mechanical engineering from Cornell University in Ithaca, New York. He founded the Sierra Power Company, the Mentone Power Company, and the San Gabriel Electric Company. Through his academic background, entrepreneurial spirit and ownership of the San Gabriel Electric Company, Balch affiliated himself with Huntington and Kerckhoff.

In 1902 Huntington, Kerckhoff and Balch consolidated their holdings and formed the Pacific Light and Power Company, which included the holdings and territories of the San Gabriel and San Joaquin Valley Electric Companies. Prior to its acquisition by the Pacific Light and Power Company, the San Joaquin Valley Electric Company employed John Eastwood as vice-president and chief engineer. In this capacity Eastwood was able to propose his plan for designing and building one of the largest hydroelectric power systems in the world.

Eastwood spent much of 1902 and 1903 surveying the Big Creek area, designing the hydroelectric system, and filing patents, claims to water rights, and permit applications with the federal government. With the backing of Kerckhoff and Balch, Eastwood's proposal was submitted to Henry Huntington to decide whether the Huntington's Railways and the Pacific Light and Power Company's activities necessitated building of such an enormous undertaking. Huntington did not support the Big Creek proposal at that time, opting instead to develop a cheaper and more efficient steam power plant to service the Huntington, et al. companies. Although the proposal was not immediately approved, efforts to implement the project continued into the 1910s with Eastwood continuing his work on securing land use and road development permits and water rights claims, and designing powerhouses which ultimately would serve as primary components of the Big Creek System.

In 1910 after reorganizing his business holdings - specifically dissolving his interests in the Southern Pacific Railroad Company - Huntington, with partners Kerckhoff and Balch, created a new company, the Pacific Light and Power Corporation, which replaced their previous Pacific Light and Power Company. Knowing the Southern Pacific Railroad Company would require major amounts of electricity as the company railroad lines were converted to electrical power and with a financing plan in place from a syndicate of New York bankers, the Pacific Light and Power Corporation commenced construction of the Big Creek Hydroelectric System in 1911. At the end of 1913 the first phase of the Big Creek System was completed. By that time, Huntington was the primary owner and stockholder of the Pacific Light and Power Corporation, having bought out Kerckhoff and Balch in the spring of 1913. In the 1910s Huntington was at the end of his enormously successful career, and was looking to merge his company with the Southern California Edison Company, a longstanding proposition that had been previously rejected by Edison's president John B. Miller. In 1916 Huntington's offer to merge was accepted by Southern California Edison. The merger was viewed as beneficial to both parties; for Huntington about $12 million in Edison stock and for Edison absolute control over company holdings, including future expansion efforts at the Big Creek Hydroelectric System.

The Southern California Edison Company continued to develop its hydroelectric system at Big Creek into the late 1920s through the creation of lakes, dams and reservoirs, building of powerhouses, rail lines, and tunnels, as well as support camps replete with food and housing for workers, recreation and entertainment offerings, medical facilities, and administrative offices. By 1929 when the system was completed its capacity consistently generated more electrical power than other systems in place at the time and was also boasted as featuring the longest tunnel and water tunnel in the world among other innovative engineering features. In the late 1940s additional projects were undertaken at Big Creek to make improvements to existing powerhouses including the addition of new generators, and construction of new dams and powerhouses. This later phase of construction continued through the 1960s.

The Big Creek Hydroelectric System was previously determined eligible for inclusion on the National Register of Historic Places as a Historic District under significance Criterion A (events/patterns of events), Criterion B (important persons) for an association with Henry Huntington and other founders, and Criterion C (Design/Construction) as one of the largest and highest generating hydroelectric systems in the world. Innovative engineering techniques and construction methods were undertaken to design and build the Big Creek project. The period of significance previously identified for the Big Creek Hydroelectric System is 1911, when construction commenced; through 1929 when the initial planned phases were completed. Although the Big Creek Hydroelectric System Historic District was identified to include only engineering features, further study could result in the determination that other features such as work camps, residential buildings and roadside features developed between 1911 and 1929, and which retain integrity to that period of significance, may also be considered potential contributors.[16]

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[16] Shoup, et. al., 212. Tinsley, Wendy L. / Urbana Preservation & Planning, *Historic Property Assessment Report – Southern California Edison Company's Kaiser Pass Cabin, Sierra National Forest* (Southern California Edison Company: 2007, August 2007.

ENGINEERING / DESIGN INFORMATION

Located within the SCE Right-of-Way on Federal and privately-owned lands, the 241-mile East & West Transmission Line features two tower types that traverse a range of settings and land uses from urbanized areas to rural valleys, to forested mountains. Within the documented 11-mile section, from Mile 72 Tower 6 within the SCE Rector Substation property north to Mile 61 Tower 4 immediately south of Cottonwood Creek, the transmission line spans through an agricultural landscape over citrus orchards, walnut orchards, rice fields, and corn and sorghum fields. A total of 3,341 transmission towers were originally installed along the Big Creek East & West Transmission Line including 2,565 Standard Towers, 4 Special Standard Towers, and 772 Anchor towers.[17] A total of 184 towers are present within the 11-mile section of the Big Creek #1 – Rector and Big Creek #3 – Rector Transmission Lines documented in this HAER report, including 158 Standard Towers and 26 Anchor / Dead End Towers. Two non-historic replacement towers are located within the documented span at M72-T5. All towers are placed parallel within the 150-foot width of the Right-of-Way and are spaced at 82-feet from the centerline of each tower.

Standard Tower (SCE Drawing No. E1398-4)
The Big Creek Standard Tower is the most common type found on the line. 79 Standard Towers are installed at the East Line and 79 Standard Towers are installed at the West Line within the 11-mile section of transmission line documented in this HAER report.

Standard Towers were originally designed to stand 43 feet in height, and feature an A-frame steel lattice configuration supporting one horizontal cross-arm with insulators mounted at a 45-degree position. The tower spread at the base measures 20-feet x 18-feet. Insulators on Standard towers are installed vertically with transmission cable connected to the insulators. The typical span between Standards Towers in valleys where sleet occurs is 550-feet, and 660-feet where no sleet occurs. The maximum span between Standard Towers is 1,822 ft.[18] Following are the original design assumptions cited for the Standard Tower type.

> *Standard Towers:*
> (1) Wind load, 22 ½ lb. per. Sq. ft. of exposed area, with or at right angles to the line; wind pressure simultaneously applied to both faces of tower, and
> (2) A pull in the direction of the line of 4250 lb. at the points of support of two adjacent conductors pulling on the same side of the tower, and
> (3) A vertical load of 1000 lb. at each conductor support where conductor is unbroken, and of 530 lb. at each ground wire support, and of 500 lb. if conductor is broken, and
> (4) A wind load of 600 lb. at right angles to the line at each conductor support where conductor is unbroken, and of 300 lb. at right angles to the line at each conductor support where conductor is broken, and of 500 lb. at each ground wire support.
> The above loads are simultaneously applied.
> Ground wire support designed to withstand an unbalanced pull of 5000 lb. in the direction of the line.[19]

Special Standard Tower
Big Creek Special Towers are similar in design to the Standard Towers with exception they were used to span long distances at the Kings River and at the Kern River where the spans is 2,776 ft. and 2,871 ft. respectively. No Special Standard Towers are located within the 11-mile section of the line documented in this HAER

[17] Fowler, 694.
[18] "150,000-Volt Transmission System – Some Operating Conditions of the Big Creek Development of the Pacific Light & Power Corporation," 1291-1292.
[19] Ibid., 1292.

report. Special Standard Towers are 43-feet in height with a base tower spread of 20-feet x 18-feet. The difference between the Standard and the Special Tower types is in the allocation of weight above the tower foundation (4,300 lbs. at the Standard type and 4,485 lbs. at the Special type) and the total steel utilized (5,605 at the Standard type and 5,790 at the Special type).[20]

Anchor Tower / Dead End (SCE Drawing No. E1338-4)
The Big Creek Anchor / Dead End Towers are shorter and heavier than Standard Towers, and were originally designed to stand 37-feet tall in the same A-frame steel lattice configuration employed for the Standard Tower type. 13 Anchor / Dead End Towers are installed at the West Line and 13 Anchor / Dead End Towers are installed at the East Line within the 11-mile section of transmission line documented in this HAER report.

Anchor / Dead End Towers are typically placed where the span changes direction and are designed to withstand increased tension in the line. The tower spread at the base measures 24-feet x 24-feet. Insulators at Anchor / Dead End Towers are positioned horizontally with a jumper wire connecting the transmission cables to insure continued flow of electricity. The typical span between Anchor / Dead End Towers in valleys where sleet occurs is 550-feet, and 660-feet where no sleet occurs. Following are the original design assumptions cited for the Anchor / Dead End Tower type.

> *Anchor and Angle Towers:*
> Anchor and angle towers are designed for each of the following groups of conditions, only one of which groups is to be taken at a time:
> *I.*
> (1) A Wind load, 22 ½ lb. per. Sq. ft. of exposed area, with or at right angles to the line; wind pressure applied simultaneously to both faces of tower, and
> (2) A pull in the direction of the line of 8000 lb. at each of the three conductor supports, on either side of tower, and of 8000 lb. at each ground cable support, and
> (3) A vertical load of 500 lb. at each of the three conductor supports and of 265 lb. at each ground cable support, and
> (4) A wind load of 300 lb. at each of the three conductor supports, and of 250 lb. at each ground cable support.
> *II.*
> (1) A wind load of 22 ½ lb. per. Sq. ft. of exposed area, with or at right angles to the line; wind pressure applied simultaneously to both faces of tower, and
> (2) A pull at right angles to the line of 8000 lb. at each of the three conductor supports, and of 8000 lb. at each ground cable support, and
> (3) A vertical load of 1000 lb. at each of the three conductor supports and of 530 lb. at each ground cable support, and
> (4) A wind load of 600 lb. at each of the three conductor supports and of 500 lb. at each ground cable support.
> Number of conductors supported by each tower, 3.
> Arrangement, in same horizontal plane.
> Number of lightning ground wires, one at first; space for two if needed.
> Smallest size angle iron used, 1 ¾ by 1 ¾ by 3/16 in.[21]

The additional integral components of the transmission line include the Conductor Cable, Ground Wires, and Insulators.

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[20] "150,000-Volt Transmission System – Some Operating Conditions of the Big Creek Development of the Pacific Light & Power Corporation," 1291-1292.
[21] Ibid.,1293.

Conductor Cable
Steel core aluminum cable conductors were originally installed at the line, with the cores comprised of seven strands of double-galvanized plow-steel wire. 54 strands of aluminum wire formed the outside of the cable. The steel and aluminum at each mile of cable weighed 1,119 and 2,999 pounds respectively, for a total of 4,118 pounds per mile. The line was engineered to sustain a tensile strength of 33,600 pounds per square inch for the entire cable, and the conductors were strung to avoid a maximum stress of 14,250 pounds per square inch. McIntyre Sleeve Joints were installed around the core wire at splice locations, and compressed aluminum sleeves wrapped the entire cable. The lines were strung for 3,130 pounds of tension per square inch at 83-degrees Fahrenheit under snow conditions and 4,740 pounds at ordinary conditions.[22]

Ground Wires
A single .5-inch seven-strand ground wire is installed at each tower. The ground wires were originally manufactured of Siemens-Martin steel and were designed to sustain a breaking tension (ultimate strength) of 13,000 to 15,000 pounds. The total ground wire weight at the combined East & West Transmission Line was initially cited as 1,306,000 pounds.[23]

Insulators
190,000 10-inch diameter P-Locke 2565 porcelain insulators were originally installed at the Big Creek Hydroelectric System East & West Transmission Line, with approximately 58% mounted to the Anchor / Dead End Tower type.[24] At Anchor / Dead End towers, the insulator configuration was two parallel sets each containing 11 disks; the Standard towers featured nine disk sets. The Locke Insulator Company, of Baltimore, Maryland – the first porcelain insulator company in North America, manufactured the insulators. Fred M. Locke founded the company in 1893, which by 1920, had been acquired by General Electric.[25] In 1916, three years after the East & West Transmission Line was completed, P-Locke 2565 porcelain insulators were installed at the existing SCE Kern River – Los Angeles (Kern #1) 60 / 66kV Transmission Line to replace the Victor M-4800 insulators original to the line.[26]

Following are the original design specifications cited for the Insulators.

> *Insulators*
> Number, 190,000; 58 per cent of which are on dead ends.
> Type, 2565-P Locke
> Diameter, 10 in.
>
> Dry flash-over voltage..........590,000 suspension
> 720,000 anchor
> Wet flash-over voltage.........420,000 suspension
> 420,000 plus anchor
> } 9 disks

By 1923, when the line was energized at the higher 220kV, the P-Locke 2565 insulators were replaced at approximately 154-miles of the East & West Line by Locke No. 6,000 (over 40-miles) and Locke No. 5996 (over 114-miles) types.[27]

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[22] "150,000-Volt Transmission System – Some Operating Conditions of the Big Creek Development of the Pacific Light & Power Corporation," 1293. Fowler, 693.
[23] Ibid., 1293. Fowler, 693.
[24] Ibid., 1294.
[25] NGK-Locke, Inc., *Porcelain Plant: Locke Insulators*, http://www.ngk-locke.com/locke-insulators.html.
[26] Mead, Carver, and Barbara Smith. *The Kern-1Line-1907: M-4800 'Largest Insulator Used for Long Distance Transmission, page 3.* http://www.r-infinity.com/Kern_M-4800/.
[27] Fowler, 694.

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ADDENDUM TO:
BIG CREEK HYDROELECTRIC SYSTEM, EAST & WEST TRANSMISSION LINE
241-mile transmission corridor extending between the Big Creek Hydroelectric System in the Sierra National Forest in Fresno County and the Eagle Rock Substation in Los Angeles, California
Visalia vicinity
Tulare County
California

HAER CA-167-N
HAER CA-167-N

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

FIELD RECORDS

HISTORIC AMERICAN ENGINEERING RECORD
PACIFIC WEST REGIONAL OFFICE
National Park Service
U.S. Department of the Interior
333 Bush Street
San Francisco, CA 94104

ADDENDUM TO:

HISTORIC AMERICAN ENGINEERING RECORD

BIG CREEK HYDROELECTRIC SYSTEM, EAST & WEST TRANSMISSION LINE

HAER No. CA-167-N

This report is an addendum to a 14-page report previously transmitted to the Library of Congress in 2013. The original documentation was of an 11-mile section between Visalia and Farmersville; this documentation encompasses the entire 241-mile transmission corridor.

Location: The Big Creek Hydroelectric System East & West Transmission Line is a 241-mile transmission corridor, with two parallel transmission lines historically identified as the East & West Transmission Line, installed between the Big Creek Hydroelectric System in the Sierra National Forest in Fresno County), and the Eagle Rock Substation in Los Angeles, California (Los Angeles County). The East & West Transmission Line is comprised of 16 modern-day transmission line segments. All modern-day segments are represented in this HAER report as installed between the Big Creek Hydroelectric System and the Eagle Rock Substation with imagery in the vicinity of: Big Creek Powerhouse 1; Big Creek Powerhouse 2; Big Creek Powerhouse 3; Highway 168 near Shaver Lake, California; Sanger, California near the Kings River; Richgrove, California; Bakersfield, California; the vicinity of the California Aqueduct in Kern County, California; Bear Trap Canyon in Tejon Ranch; Castaic, California; Santa Clarita, California; Sun Valley, California; and Altadena, California.

Latitude / Longitude References:
Map Datum: NAD 83;
Point 1: 73.203712 / -119.24307396526959;
Point 2: 36.304418 / -119.24324525871195;
Point 3: 3494955360999 / -118.9219468571321;
Point 4: 34.494955 / 118.61521944444443; and
Point 5: 34.15078 / -118.18434535118142.

Historian: Wendy L. Tinsley Becker, AICP, RPH, Principal, Urbana Preservation & Planning, LLC, October 2015.

Project Information: Addendum prepared by Wendy L. Tinsley Becker, AICP, RPH, Principal, Urbana Preservation & Planning, LLC. Additional existing conditions photographs by David G. DeVries of Mesa Technical. Project sponsored by Southern California Edison Company, 2244 Walnut Grove Avenue, Rosemead, CA 91770.

INTRODUCTION

The transmission line segments that comprise the 241-mile Big Creek Hydroelectric System Historic East & West Transmission Line Corridor were determined to be eligible for inclusion on the National Register of Historic Places as contributing elements to the officially determined National Register eligible Big Creek Hydroelectric System Historic District (BCHSHD). Contributing elements to the BCHSHD have been incrementally documented and submitted to HAER under HAER No. CA-167.

An 11.1-mile portion of the East & West Transmission Line, in the vicinity of the SCE Rector Substation in Visalia, California, was documented in 2011-2012 and was submitted as CA-HAER-167-N in advance of modifications to that section of the line. This CA-HAER-167-N amendment package has been prepared to provide complete photographic documentation on the entire 241-miles of the historic Big Creek Hydroelectric System East & West Transmission Line, including additional views of the line between the Big Creek Hydroelectric System and the vicinity of Visalia, California and then south of Visalia to the SCE Eagle Rock Substation, and remaining maps delineating the historic and current alignment of the East and West Line.

PHYSICAL HISTORY

Today the entire 241-mile span has been segmented into the following identifiers.

East Transmission Line

- Big Creek #1 – Rector,
- Rector – Vestal #1,
- Magunden – Vestal #1,
- Magunden – Pastoria #1,
- Bailey-Pardee
- Pardee – Sylmar #1, and
- Eagle Rock – Sylmar (East).

West Transmission Line

- Big Creek #1 – Big Creek #2,
- Big Creek #2 – Big Creek #3,
- Big Creek #3 – Rector,
- Rector – Vestal #2,
- Magunden – Vestal #2,
- Magunden – Pastoria #2,
- Pardee – Pastoria,
- Pardee – Sylmar #2, and
- Eagle Rock – Sylmar (West).