SAN GORGONIO HYDROELECTRIC SYSTEM
San Bernardino National Forest
Banning vicinity
Riverside County
California

HAER CA-2278
HAER CA-2278

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

FIELD RECORDS

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
U.S. Department of the Interior
1849 C Street NW
Washington, DC 20240-0001

HISTORIC AMERICAN ENGINEERING RECORD

SAN GORGONIO HYDROELECTRIC SYSTEM

HAER No. CA-2278

Location:	The San Gorgonio Hydroelectric System is located in San Bernardino National Forest along the San Gorgonio River in Riverside and San Bernardino counties just north of California State Route 60. The hydroelectric system is located in Sections 1, 2, and 3; T.2S., R.1E. on the Forest Falls USGS topographic map and Sections 19, 29, 30, 31; T.1S., R.2E. on the San Gorgonio Mountains USGS topographic map. The southern boundary of the system is about seven miles north of the city of Banning. The northern most feature of the system is the East Fork Dam located at latitude: 34.03080, longitude: -116.857171. The coordinate represents the center of the East Fork Dam structure. The southern most feature of the system is Powerhouse No.2 located at latitude: 34.018537, longitude: -116.894919. The coordinate represents the center of the Powerhouse No.2. building. Both coordinates were obtained on June 30, 2010 using a GPS mapping grade unit accurate to +/-3 meters after differential correction. The San Gorgonio Hydroelectric System's location has no restriction on its release to the public.
Date of Construction:	San Gorgonio Powerhouse No.1: 1923; Powerhouse No.2: 1923
Builder:	San Gorgonio Power Company
Present Owner:	Southern California Edison Company (fee ownership and easements) 2244 Walnut Grove Avenue Rosemead, CA 91770
Present Use:	Vacant
Significance:	The San Gorgonio Hydroelectric System was found to be eligible for listing in the National Register of Historic Places under Criteria A and C in 1993. The system was found eligible under Criterion A, for its representation of 1920s hydroelectric development in southern California and the system was found eligible under Criterion C for engineering and architecture. In terms of engineering, it was found eligible for its early utilization of automatic controls which were a new innovation in the 1920s and for its use of tanks rather than forebays, which represented a departure from typical western hydroelectric systems, tanks were more commonly used on the eastern United States. In terms of architecture, the system's two powerhouses were found to be good examples of utilitarian structures influenced by Classical Revival style architecture.
Report Prepared by:	Ben Taniguchi, Historian II and Nicole Collum Architectural Historian II Galvin Preservation Associates 1611 S. Pacific Coast Highway, #104 Redondo Beach, CA 90277
Date:	September 2010
Project Information	SCE is planning to decommission the project's two power plants and part of their appurtenant water conveyance system. Some of the project components are scheduled to be decommissioned and removed, decommissioned and abandoned in place, or transferred to new ownership. The hydroelectric generators and other pieces of hardware and equipment

will be removed from the powerhouse buildings, but the buildings will remain. Components slated for removal will be demolished using bulldozers and other components will be removed using hand crews where there is no present vehicle access. The San Gorgonio Pass Water Agency plans to acquire those project facilities that are not decommissioned. The transferred facilities would no longer be used for the generation of power. As a result of this project the San Gorgonio Hydroelectric System was documented with Historic American Engineering Records. The entire system was documented in an overview report, San Gorgonio Hydroelectric System HAER No. CA-2278 and each contributing element of the system was documented with separate supporting reports as follows: San Gorgonio Hydroelectric System, East Fork Dam and Intake, HAER No. CA-2278-A; San Gorgonio Hydroelectric System, South Fork Dam and Intake, HAER No. CA-2278-B; San Gorgonio Hydroelectric System, Powerhouse No. 1, HAER No. CA-2278-C; San Gorgonio Hydroelectric System, Tank No. 1 and Penstock No. 1, HAER No. CA-2278-D; San Gorgonio Hydroelectric System, Operator's Bungalow, HAER No. CA-2278-E; San Gorgonio Hydroelectric System, Operator's Garage, HAER No. CA-2278-F; San Gorgonio Hydroelectric System, Powerhouse No. 2, HAER No. CA-2278-G; San Gorgonio Hydroelectric System, Flowline No. 2, Tank No. 2, & Penstock No. 2, HAER No. CA-2278-H. In addition as built and historic drawings of the system have been scanned onto vellum and are available in the Field Records Section of this report.

Location and Overview of San Gorgonio Hydroelectric System

San Gorgonio is a static-head hydroelectric system located in a mountainous area north of the city of Banning in both Riverside and San Bernardino counties, California, just north of California State Route 60 (SR 60). The system is owned by Southern California Edison (SCE), and located in the San Bernardino National Forest. The system begins at the Whitewater River with intakes at the south and east forks of the river and extends southwesterly for 10 miles terminating at the San Gorgonio River; the system runs parallel with the San Gorgonio River. Construction of the hydroelectric system was started in 1922 and completed the following year. A pre-existing irrigation system constructed in 1913 was used to power the turbines housed in San Gorgonio Powerhouses No. 1 and 2. Powerhouse No. 1 is located at Big Oak Canyon at an altitude of 5,300 feet, while Powerhouse No. 2 is located at Banning Canyon at an altitude of 4,200 feet.

The source of water for both powerhouses, Whitewater River, originates at San Gorgonio Mountain.

Part I: Historical Information

Physical History

The San Gorgonio Hydroelectric System was constructed from 1911 to 1923. The canals (flowlines) were completed by 1913 and the hydroelectric generating system including both powerhouses, was completed by 1923. There appears to have been an irrigation (flowlines) system that was constructed in the late 1880s and it is possible that the system followed the same route as the current system, however this has not been confirmed. The architect for the system, if any, is not known; however, Charles O Poole was the Chief Engineer and oversaw the construction of the project. The contractor for the system was C.D. Sotiras and original plans for both Powerhouse No. 1 and No. 2 remain and are described in detail in the Historic American Engineering Record for each powerhouse. Please see HAER Nos. 2278-C and 2278-G for more information. The flowlines installed in the early 1910s remain relatively intact. However some sections have been washed out due to a flood in 1938 and replaced with steel pipes. Other sections of the flowlines have also been reinforced with concrete. In 1998, Tank No. 1 collapsed and was not replaced or rebuilt.

General History of Hydroelectric Systems

Hydroelectricity is the production of electrical energy through the use of the gravitational force of falling or flowing water, a technology that has existed since the nineteenth century. The knowledge of applying water power for industrial uses, however, has existed for thousands of years. The Chinese and Egyptians, for example, were using water wheels in rivers in order to raise the water levels to irrigate land and to provide the energy to perform simple tasks such as grinding corn.[1]

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[1] Rushmore, David B. and Eric A. Lof. *Hydro-Electric Power Stations*. New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Limited, 1923, p. 1.

The Industrial Revolution began the process that led to the development of the hydroelectric system. Originating in Great Britain during the late eighteenth century, the Industrial Revolution had a tremendous impact on people's lives as industrialized nations moved away from a manual labor based economy to one that was machine and manufacturing based. The movement then spread throughout Europe and the United States. One of the results was the invention of steam and internal combustion engines and the creation of electrical energy. The first dynamo or electrical generator was perfected in 1867. The first water wheel used to generate electricity was built in 1882 in the eastern part of the United States. In the 1880s, experiments were being conducted in the United States and Europe to transmit electricity over long distances. It was also by this time that the technology was being used in the west coast, although it did not catch on as it did in the east coast.

One of the first hydroelectric systems in southern California was established near the town of Etiwanda in 1882; this and other similar systems that were built in southern California during the 1880s were small and generated only enough energy to light downtown districts. These early systems also generated direct current (DC) rather than alternating current (AC), which is now the most commonly used form. The first large scale effort to build a hydroelectric system came in the early 1890s, when Dr. Cyrus G. Baldwin decided to create a power plant to provide electricity to the cities of Pomona and Claremont; the system built by Baldwin was the first AC power plant in California.[2] Many of the DC systems that were built prior to the 1890s were being converted to AC by the turn of the century. AC as opposed to DC had a longer range in terms of transmitting its power and DC only had about a five mile range. By the late nineteenth and early twentieth centuries, generation and transmission technologies became advanced enough so that electricity became the established choice for energy.

There are basically two types of hydroelectric systems. Low-head uses a large amount of water collected using dams and falls and requires a relatively short distance to operate the system. This is more common in the eastern part of the United States where water is abundant and the topography is generally low. High-head uses a lower volume of water and travels through channels. It relies on greater topographic relief for the water to fall, sometimes as much as several thousand feet. The water travels through pipes to create the pressure necessary to turn the turbines.[3] San Gorgonio Powerhouses No. 1 and 2 are high-head systems. The maximum flow of water that went through both powerhouses was 16 feet per second.

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[2] Robinson, John W. "Cyrus Baldwin Southern California Hydroelectric Pioneer," *The Westerners Los Angeles Corral*, Spring 1996, p. 3 and 4.

[3] Taylor, Thomas T., "Bishop Creek Hydroelectric System," HAER No. CA-145, Historic American Engineering Record (HAER), National Park Service, U.S. Department of the Interior, February 1994, page 2.

Historical Context

The San Gorgonio Hydroelectric System received its water source from the south and east forks of the Whitewater River; the forks are located at the 7,000 feet elevation (above sea) level of the river.[4] When the town of Palm Springs, located approximately 20 miles southeast of San Gorgonio Mountain, was first developed in the late 1880s, it appears that an irrigation system was installed to bring water to the new town. According to a *Los Angeles Times* newspaper advertisement for the new town dated October 8, 1887 the source of the water came from the Whitewater River and a system of stone lined canals were built.[5] By the 1890s, with the creation of a hydroelectric power plant for the cities of Pomona and Claremont, efforts were being made to provide electrical power to cities and towns in both Riverside and San Bernardino counties. In 1899, a hydroelectric plant (Mill Creek 1) was constructed in the San Bernardino National Forest and it provided power for the city of Redlands. The power plant received its water from Mill Creek, which was linked to the south fork of the Whitewater River.

An attempt at harnessing the Whitewater River for power was made by John G. North in June of 1897 when he filed water claims to 3,000 inches of water from one fork of the Whitewater River.[6] For the next few years other investors also filed water claims to the Whitewater River; however there appears to have been no attempts at establishing a power generating system. In 1906, the Consolidated Reservoir and Power Company (CRPC), which was based in Los Angeles, was formed in order to provide water to the town of Banning; the town was located approximately 25 miles south of the headwaters of the Whitewater River, in the county of Riverside. The company had also planned to create a power plant that would provide electricity not only for Banning but to the city of Los Angeles.[7] By 1910, the CRPC was granted water rights to the east and south forks of the Whitewater River specifically for the creation of an irrigation and electric power generating system.[8] The water used to generate power was to provide water for a newly formed 2,400 acre farming tract known as "Banning Heights." Located on the southern slope of San Gorgonio Mountain, Banning Heights was created by the CRPC and they sold tracts ranging from five to forty acres, which were specifically marketed for agricultural use.[9] W.E. Pedley was hired as contractor for the project.[10] Construction of the irrigation system began in 1911 and was completed in 1913, a year after the incorporation of the town of Banning. The newly created irrigation system became known as the Whitewater River Diversion Conduit. It is unclear if the CRPC incorporated either a portion of or the entire pre-existing late 1880s irrigation flowlines into their system.

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[4] "Giant Engineering Feat is Accomplished," *Los Angeles Times*, August 31, 1913, p. I11.
[5] "Palm Springs (advertisement)," *Los Angeles Times*, October 8, 1887, p. 7.
[6] "Important Water Claims Filed," *Los Angeles Times*, June 8, 1897, p. 7.
[7] "New Power Project," *Los Angeles Times*, July 1, 1908, p. II9.
[8] "Deal in Water Rights," *Los Angeles Times*, April 10, 1910, p. I 11.
[9] "Great Whitewater Irrigation Works," *The Banning Record*, June 5, 1913, p. 1.
[10] "Whitewater River Makes Greater Banning." *The Banning Record*, September 4, 1913, p. 1.

The irrigation system established by the CRPC consisted of a six mile long concrete lined ditch that carried the water to Banning Heights. By September of 1913, the CRPC had sold 200 acres.[11] A 144,000 cubic foot water tank (now owned by the Banning Heights Municipal Water Company) was also built by the CRPC near what is now Powerhouse No. 2. Once the water reached Banning, distribution was controlled by the Banning Heights Water Company and the irrigation system was managed by the CRPC. At the time of completion, it appears that the plan to construct a power generating plant was shelved. By 1917, the system was providing enough water to irrigate the entire farming tract at Banning Heights, which by this time were planted with apple and cherry orchards.[12]

Likely due to financial difficulties, the CRPC reorganized as the San Gorgonio Power Company (SGPC) in 1921 and the newly organized company made immediate plans to construct hydroelectric power generating plants along the existing irrigation system. One of the objectives of constructing the power plants was to sell power to the Southern Sierras Power Company (SSPC), who at the time was providing power to the city of Banning; it is also during this time that the city was seeking to make improvements to their infrastructure, which included its electrical distribution system. The chief engineer for the hydroelectric project was Charles O. Poole of the SSPC and the contractor was C.D. Sotiras.[13] By September of 1922, construction began on two powerhouses and there were plans to construct a third powerhouse.[14] The first powerhouse (Powerhouse No.1), also known as "Big Oaks", was built at Big Oaks Canyon, which is situated at approximately 5,300 feet above sea level. The second powerhouse (Powerhouse No.2), "Pine", was built 1,100 foot downstream from the Big Oaks Powerhouse and located at Banning Canyon. Construction of both powerhouses was completed by 1923; the third powerhouse was never built. Also during this time, three residences were also constructed near the powerhouses to house the generator operators. On December 5, 1923, Powerhouse No. 1 was placed into service and 12 days later on December 17, 1923 Powerhouse No. 2 placed into service. [15] By August of 1923, the entire system had a generating capacity of 3,300 volts and fed into the Southern Sierras trunk line at Banning.[16] The power produced by this system was transmitted as far south as the Coachella and Imperial Valleys.

However, the output of the powerhouses was not sufficient enough to meet the power demands of the residents of Banning, especially during peak usage. Thus they were later downgraded to back-up status. Due to their back-up status, Banning continued to receive its primary power from the SSPC.[17] With the onset of the Great Depression in the 1930s,

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[11] "Company is Formed to Harness Whitewater," *Los Angeles Times*, September 21, 1913, p. I11.
[12] Robinson, John W. *The San Bernardinos*. Arcadia, CA: Big Santa Anita Historical Society, 1986, p. 222.
[13] Weber, Carmen A. and Richard Starzak. *A Historical Assessment of the San Gorgonio Hyrdroelectric System*. Irvine, CA: Chambers Group, Inc., 1993, p. 3.
[14] "Power Plants Going In," *The Banning Record*, September 28, 1922, p. 1.
[15]B.J. Mount and H. L. Fryer. "Southern/Hoover Hydro Generation Division History," Southern California Edison Manuscript, May 21, 1980.
[16] *Southern Sierras Service Bulletin*, Vol. 2, Number 11 August 1923.
[17] Weber, p. 222.

a number of small power companies in the state experienced financial difficulties and either dissolved or reorganized. Thus the SGPC fell under the ownership of San Gorgonio Electric Company (SGEC) in 1932. In 1938, massive flooding affected areas of both Riverside and San Bernardino counties (in addition to Los Angeles and Orange counties) when the Santa Ana River, which is linked with the Whitewater River, jumped its banks.[18] The flooding washed out sections of the flowlines near both the east and south fork intakes. The damaged sections were immediately repaired with spiral weld steel pipes that were reinforced to withstand any future flooding or landslides. On January 9, 1950 the San Gorgonio Electric Company sold the plant to the California Electric Power Company and on December 31, 1963 the San Gorgonio Hydroelectric system became part of the Southern California Edison Company by license transfer (this occurred when California Electric Power merged with the Southern California Edison Company).[19] SCE continued to use both the former SGPC power generating facilities until they were finally shutdown in 1998; the property remains under ownership of SCE.[20] The irrigation system remains in operation (as of 2009) and the water rights are still owned by the Banning Heights Water Company; the system is owned and maintained by SCE.

Part II: Description: Structural/Design Information

General Description

The San Gorgonio Hydroelectric System operates under the Federal Energy Regulatory Commission license number 344-41. Contributing elements to this system are described in general below and individual contributing elements of the system are described in the subsequent reports: East Fork Dam, Intake & Flowline No. 1(HAER No. CA-2278-A), South Fork Dam & Intake (HAER No. CA-2278-B), Powerhouse No. 1 (HAER No. CA-2278-C), Tank No. 1 & Penstock (HAER No. CA-2278-D), Operator's Bungalow (HAER No. CA-2278-E), Operator's Garage (HAER No. CA-2278-F), Powerhouse No. 2 (HAER No. CA-2278-G), Flowline No.2, Tank No. 2& Penstock No.2 (HAER No. CA-2278-H).

The San Gorgonio Hydroelectric System begins at the East Fork Dam, its northeast most feature. It is located at the East Fork of the South Fork Whitewater River and is the systems first of three diversion dams. Diversion dams are used to divert water from a natural water channel into the hydroelectric system. Once the water is diverted from the East Fork of the South Fork Whitewater River, the flow of water enters the East Fork Intake which is made up of a series of headgates, screens and a spillway. The flow of water enters the East Fork Intake through a rectangular concrete box with a series of metal screens, this initial set of metal screens help to prevent large debris from entering the system. From here the water passes into a concrete conduit and through a sliding metal gate or headgate. The headgate regulates the speed, flow, and amount of water

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[18] "Plane Trip Shows Scene of Desolation," *Los Angeles Times*, March 4, 1938, p. 1.
[19] *Southern Sierras Service Bulletin*, Vol. 2, Number 11 August 1923.
[20] Timothy Smith, "Water Restoration Plan Passes 1st Vote," *Record Gazette* , November 29, 2007 website accessed November 2009 http://www.recordgazette.net/articles/2007/11/30/news/01news.prt.

which passes through the system. Once the flow of water travels through the headgate it continues through the concrete conduit and enters the sandbox.

The sandbox is made up of three separate concrete quadrilateral structures and its primary use is to separate sand and small aggregate particles from the water and prevent them from entering the system. The first quadrilateral structure is nearly trapezoidal in shape with a diagonal metal screen at the southeast end. This screen, similar to the initial screens, helps to prevent large debris from entering the system. The bottom of the sandbox structure is angled to allow sand and smaller aggregate debris to settle to the base of the structure, separating it from the water. The flow of water then travels through a 1'-11" wide opening into the second concrete structure within the sandbox. It is rectangular in shape and channels the water through another 1'-11" wide opening into the third quadrilateral structure of the sandbox. This structure has an angled bottom and a 2'-10" wide opening covered with a metal screen.

From the sandbox the water enters an angled concrete flume covered with wood planks and continues into a drop inlet box. Once the water enters the inlet box it is funneled into a 16" steel pipe, also known as a siphon. The flow of water continues through the siphon and back into a poured concrete conduit known as Flowline No. 1. Flowlines are covered channels or tunnels used to transport the water from one section of the system to another. Flowline No. 1 measures approximately 16" in depth and 12" in width; the conduit is covered with wood planks that are approximately 1' wide, 4' long and approximately 2"-3" thick. The water continues within Flowline No. 1 and travels to the South Fork Dam and Intake. Note: the water from the East Fork Dam and Intake does not enter the South Fork Intake system. It joins the water from the South Fork Dam and Intake through a flowline after the water from this second diversion dam has completed its path through the South Fork Dam and Intake system and is free of debris and sand.

The South Fork Dam is located west of the East Fork Dam and Intake along the South Fork Whitewater River. Water from the South Fork Whitewater River is diverted by the South Fork Dam, which consists of a poured concrete rectangular structure with a 24" wide sliding gate with two flashboards flanking either side. The 24" slide gate is used to control the flow of water and functions like a headgate, if the flow of the river is too high for the system the gate can be opened to allow less or no water to pass through the South Fork Dam Intake. If the gate is opened, water passes over a tapered concrete apron located directly south of the 24" gate.

Once the water has been diverted by the South Fork Dam, it passes through a metal trash rack. The trash rack is used to prevent large debris such as leaves and twigs from entering the system, this type of debris can seriously damage the mechanical components and can obstruct the flow of water within the flowlines. From the trash rack the water enters the concrete intake structure.

The intake structure is square in shape and made of poured concrete, at the southeast there is a 24" wide slide gate, or headgate. Once the water passes through the headgate it is funneled into a concrete flume covered with steel plates. As the water approaches the South Fork sandbox the flume covers change from steel plates to wooden planks. The sandbox is square in shape with an angled bottom and functions the same way as the East Fork sandbox. The water then passes over a rectangular weir located at the south end of the sandbox. The weir measures 3'-0" wide and 1'-8" deep and is used to regulate the flow of water before it enters the gauging station to the south. Once the water passes over the weir it enters a nearly triangular shaped gauging station with a porcelain water gauge affixed to the inner part of the gauging station. Within the gauging station water from the East Fork Dam and Intake merges with the water from the South Fork Dam and Intake through a covered concrete conduit, located at the east end of the gauging station. The water from both diversion dams and intakes is measured by the porcelain water gauge. The water is then funneled back into Flowline No. 1 though a 2'-0" wide opening.

The water continues through Flowline No. 1 and merges with water from the Black Wheel Creek Diversion Dam. Once the water passes through the diversion dam it re-enters Flowline No. 1 and heads towards Tank No.1. Although, Tank No. 1 has since been dismantled the water originally continued southwesterly within the flowline to Forebay Tank No. 1. Prior to entering Tank No. 1 the water would enter another rectangular shaped sandbox constructed of poured concrete. The sandbox measured approximately 12'-0" in length and 5'-5" in width. From here, the water was funneled from a 7' wide covered concrete opening into a 2'-7" wide poured concrete flume covered with wooden planks. The water then entered a screen box measuring 13'-0" in length equipped with various metal screens to ensure no debris entered the system. Once the water passed through the screen box it entered a 24" diameter steel pipe and entered into Tank No. 1. Tank No. 1 was constructed of ¼"-½ " riveted steel plates and had a height of 38'-3" and a diameter of 64'.[21]

Tank No. 1 functioned in the same way that a typical forebay functions within a hydroelectric system. Forebays, and in this case tanks, are reservoirs usually located at higher elevations than the powerhouse, where the water is gathered before it enters the penstock. While the water gathers within the reservoir, silt and other heavier aggregate particles fall to the base of the reservoir helping to regulate the water before entering the penstock. The higher altitude of the reservoir also helps to increase the pressure of the water as it exits the tank or forebay downhill through the penstock. Before the water entered the penstock from Tank No. 1 it passed through an additional screen box and through an 18" gate valve into the penstock.

Penstock No. 1 consisted of 1390' of riveted 18"diameter steel pipe joined with steel drive joints, connected to 1850' of riveted 18"diameter steel pipe with flange joints,

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[21] There were two drawings of Tank No. 1 and Tank No. 2 for the San Gorgonio System. Since Tank No. 1 collapsed in 1998 the measurements used in this report were taken from the 1964 drawings rather than the FERC Drawings created in 1999 a year after Tank No. 1 collapsed. Copies of both sets of drawings are located in the field notes section of the HAER report for the San Gorgonio Hydroelectric System HAER-CA-2278.

connected to 2975'-4-3/16" of welded 18" diameter steel pipe with flange joints, for a total of 6215'-4-3/16" of 18" steel pipe. Penstocks within hydroelectric systems are generally built as vertical as conditions will allow. In the case of Penstock No. 1, it begins at an elevation of approximately 6988.55' at the base of Tank No.1 and ends at an elevation of 5241.59' where the nozzle of Penstock No. 1 enters Powerhouse No.1. This drop in elevation provides the increased water pressure necessary to operate the Pelton impulse water wheel within Powerhouse No. 1.

The water travels towards the Powerhouse No. 1 site which in addition to Powerhouse No. 1 also contains ancillary buildings immediately adjacent to the powerhouse, that consist of the following: the Operator's Bungalow to the south, a concrete shed directly east of the Operator's Bungalow, a concrete root cellar to the west of the Operator's Bungalow, and the Operator's Garage located to the northwest of Powerhouse No. 1. These buildings were constructed to support the powerhouse operator when he lived on site.

Water from Penstock No. 1 enters Powerhouse No. 1 at northeast side of the building. The powerhouse within a hydroelectric system is the building that houses all of the electrical power generation and distribution equipment. The machinery used to generate the electricity is referred to as a "unit," and includes in the case of Powerhouse No. 1, a water wheel, a governor to control the water wheel's loading, an electrical generator and an "exciter." Once the water enters Powerhouse No. 1 from Penstock No. 1 the water passes through the penstock valve, enters the needle valve and passes through the Pelton impulse water wheel, the exciter provides the direct current to energize the electromagnets within the larger alternating current generator, which is a Westinghouse 3-phase, 60 cycle, 2.4kv generator. Once the electricity has been generated it is distributed using a series of switches, circuit breakers and related controls which are connected to a transformer. The transformer increases the voltage so that the power can be transmitted over long distances. The water once it has passed through the Pelton water wheel exits Powerhouse No. 1 through the tailrace and is funneled into Flowline No. 2 which consists of a poured concrete conduit covered with wood planks.

The water travels through Flowline No. 2 southwesterly towards Forebay Tank No. 2. Prior to entering Tank No. 2 the water passes through a 12' long rectangular sandbox with an angled bottom, the design is almost identical to the sandbox that was present at Tank No. 1. The sandbox's angled base allows sand and larger aggregate particles to be separated from the water before entering the tank. Once the water passes through the sandbox it enters a concrete conduit approximately 25' in length before entering a screen box approximately 13' in length. The screen box filters the water once more before entering the 24" in diameter steel pipe that feeds into Tank No. 2. Tank No. 2 has a height of 33'-6" and a diameter of 40'-0".[22] It is constructed of riveted steel plates and

[22] There were two drawings of Tank No. 1 and Tank No. 2 for the San Gorgonio System. Since Tank No. 1 collapsed in 1998 the measurements used in this report were taken from the 1964 drawings rather than the FERC Drawings created in 1999 a year after Tank No. 1 collapsed. Copies of both sets of drawings are

similar to Tank No. 1, Tank No. 2 functions as a forebay within the system, providing the water a location to gather at a higher altitude prior to entering the penstock. Before the water enters the penstock from Tank No. 2 it passes through an additional screen box.

Once the water passes through the final screen box of Tank No. 2 it enters Penstock No. 2 which consists of an 18" in diameter steel pipe. Penstock No. 2 is made up of 2235' of 10 gage steel pipe with drive joints, and 4330' of steel pipe with flange joints. It begins at an elevation of approximately 5176.97' at the base of Tank No. 2 and ends at an elevation of approximately 4291.89 where the penstock nozzle enters Powerhouse No. 2. Penstock No. 2 enters Powerhouse No. 2 at the south end of the building's east elevation.

The design and layout of Powerhouse No. 2 is nearly identical to Powerhouse No. 1. Once the water enters Powerhouse No. 2 it goes past the penstock valve, through the needle valve and powers the Pelton Impulse water wheel, the exciter provides the direct current to energize the electromagnets within the larger alternating current generator, which is a Westinghouse 3-phase, 60 cycle, 2.4kv generator. Once the electricity has been generated it is distributed using a series of switches, circuit breakers and related controls which are connected to a transformer; the transformer increases the voltage so that the power can be transmitted over long distances. Once the water has passed through the Pelton water wheel it exits Powerhouse No. 2 through the tailrace and is funneled into conduit that feeds into the Banning Heights Municipal Water Tank (Tank 3). This tank is not part of the FERC project facility.

Character

The San Gorgonio Hydroelectric System is significant for the use of tanks rather than forebays, which at the time of its construction in the early 1920s, was a typical feature of eastern United States hydroelectric systems and rarely used on the west coast. The system is also significant for its use of automatic controls, which at the time was still in the experimental stage.

Condition

The overall condition of the system is good.

Mechanical Operation

The operating mode for Powerhouses No.1 and No. 2 of the San Gorgonio Hydroelectric System are unique in conception. Since the system gathers its water source from multiple streams, water could not be stored in a standard forebay, instead the system utilized tanks and relied on a special automatic system to maximize the flow of water.

The operator for Powerhouse No. 1 would regulate the operation of Powerhouse No. 2 by remote control. This remote control system included: a push-button control for starting and stopping Powerhouse No. 2; a push button control of the load carried at Powerhouse

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located in the field notes section of the HAER report for the San Gorgonio Hydroelectric System HAER-CA-2278.

No. 2, depending on the water level available in Tank No. 2 and an automatic control to shut down Powerhouse No. 2 when the available water level dropped below the minimum allowable. The system also used the following remote indicating devices with the electrical equipment: a water level indicator at both Powerhouse No. 1 and No. 2 for Tank No. 2, a load indicator at Powerhouse No. 1 for the load carried at Powerhouse No. 2 and audible indicator at Powerhouse No. 1 for when Powerhouse No. 2 goes off line automatically.[23]

They system was operated 16 hours a day, with powerhouse operators working in two 8-hour shifts. To begin the 16-hour cycle, the operator at Powerhouse No. 1 would manually start Powerhouse No. 1. Shortly after , the operator at Powerhouse No. 1 would start Powerhouse No. 2 from remote control. This system worked based on the assumption that Tank No. 2 would be full because at the end of the previous day the water from the Powerhouse No. 1 flowline would have been collected at Tank No. 2, filling the tank, when the system was shut down. Powerhouse No. 2 would carry a full load until Tank No. 2 reached the half empty mark. Once this mark was hit, the load would be automatically reduced to a compatible level of Powerhouse No. 1 since, by that time, water from Powerhouse No. 1 would have reached Tank No. 2. Just before the end of the 16-hour cycle, Powerhouse No. 2 was increased to a full load so that the water in Tank No. 2 would fall to the lowest operating level. Once this occurred, Powerhouse No. 2 would be automatically shut down. The operator at Powerhouse No. 1 would shut down Powerhouse No. 2 once he received notification that Powerhouse No. 2 had been shut down. The water would then flow from Powerhouse No. 1 to Tank No.2, to fill the tank for operating the 16-cycle for the following day.[24]

When the water levels were low, the system could only be operated when Tank No. 1 was sufficiently full. When this occurred the system could be operated at 50 percent or more capacity. One of the primary advantages to the design of the San Gorgonio Hydroelectric System was that it only required two operators to be on-site. A single operator at Powerhouse No. 1 to oversee the operation of Powerhouse No. 1 and Powerhouse No. 2 and a single operator at Powerhouse No. 2 which could leave the powerhouse to conduct routine maintenance throughout the system, including overseeing the flowlines and other mechanical equipment.[25]

The system became fully automated by 1980. Once the system became fully automated each powerhouse was connected by a cable to its respective tank. Once the tank was full, a control signal was initiated to start the plant. This signal initiated the opening of the turbine needles to provide adequate water to operate the turbines at high efficiency. When the water level in the tanks was at a predetermined low water level, the turbines were signaled to shut down and the cycle repeats. The units were synchronized to the

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[23] P.B. Garrett, Automatic Hydro-Electric Plant of the San Gorgonio Power Company. The Electric Journal, Vol. XXII, No. 6. p.286.
[24] Ibid. p.286-287.
[25]Ibid . p.286-287.

system as synchronous motors, aided by speed switches and the generators' amortizer windings.[26] The system was finally shutdown in 1998 following the collapse of Tank No. 1.

[26] Mount and Fryer p. 50.

Site Information

The San Gorgonio Hydroelectric System is located in a mountainous area north of the city of Banning in both Riverside and San Bernardino counties, California, just north of California State Route 60 (SR 60). The system is located in the San Bernardino National Forest. The system begins at the Whitewater River with intakes at the south and east forks of the river and extends southwesterly for 10 miles terminating at the San Gorgonio River, which it runs parallel to. Powerhouse No. 1 is located at Big Oak Canyon at an altitude of 5,300 feet, while Powerhouse No. 2 is located at Banning Canyon at an altitude of 4,200 feet.

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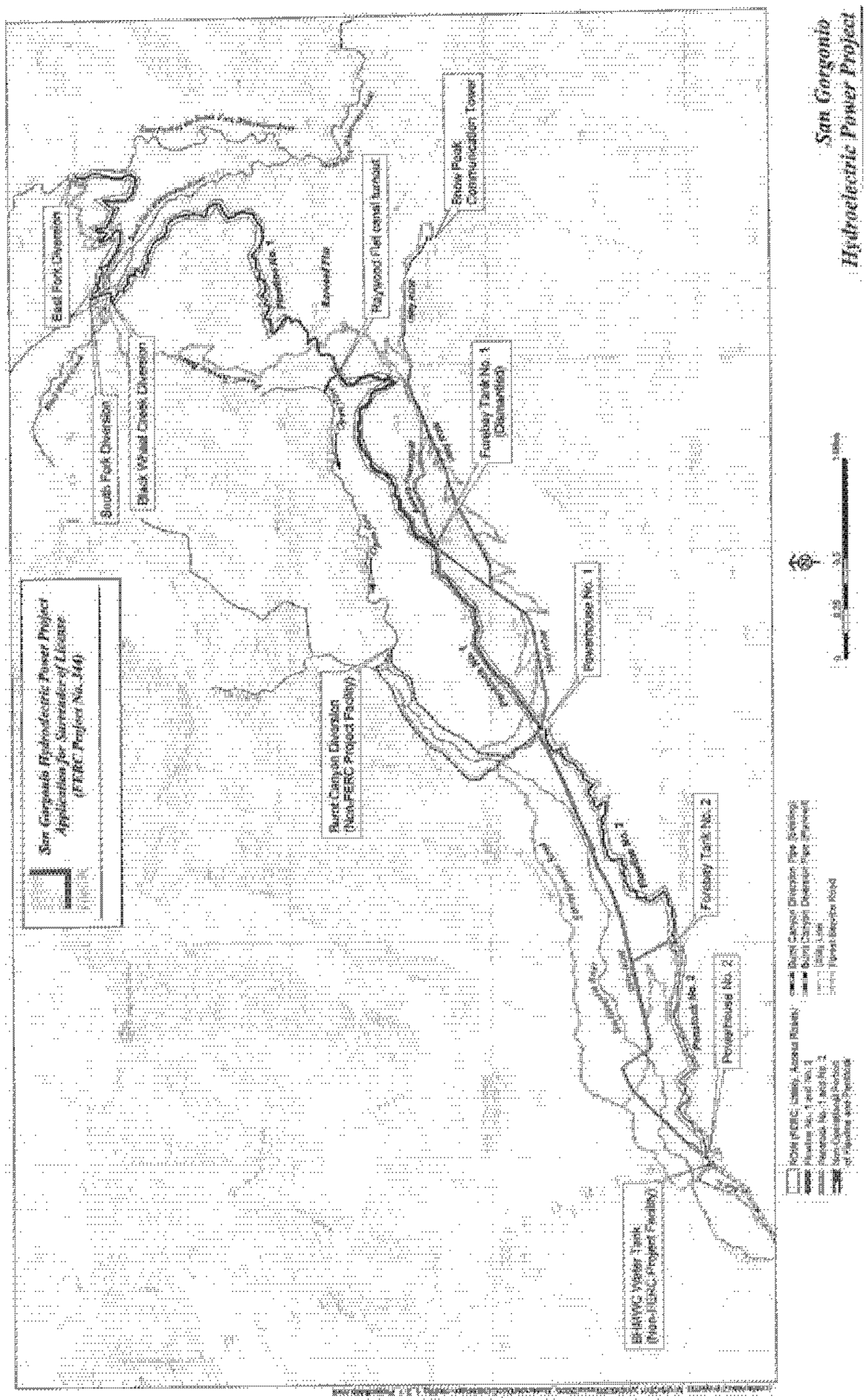
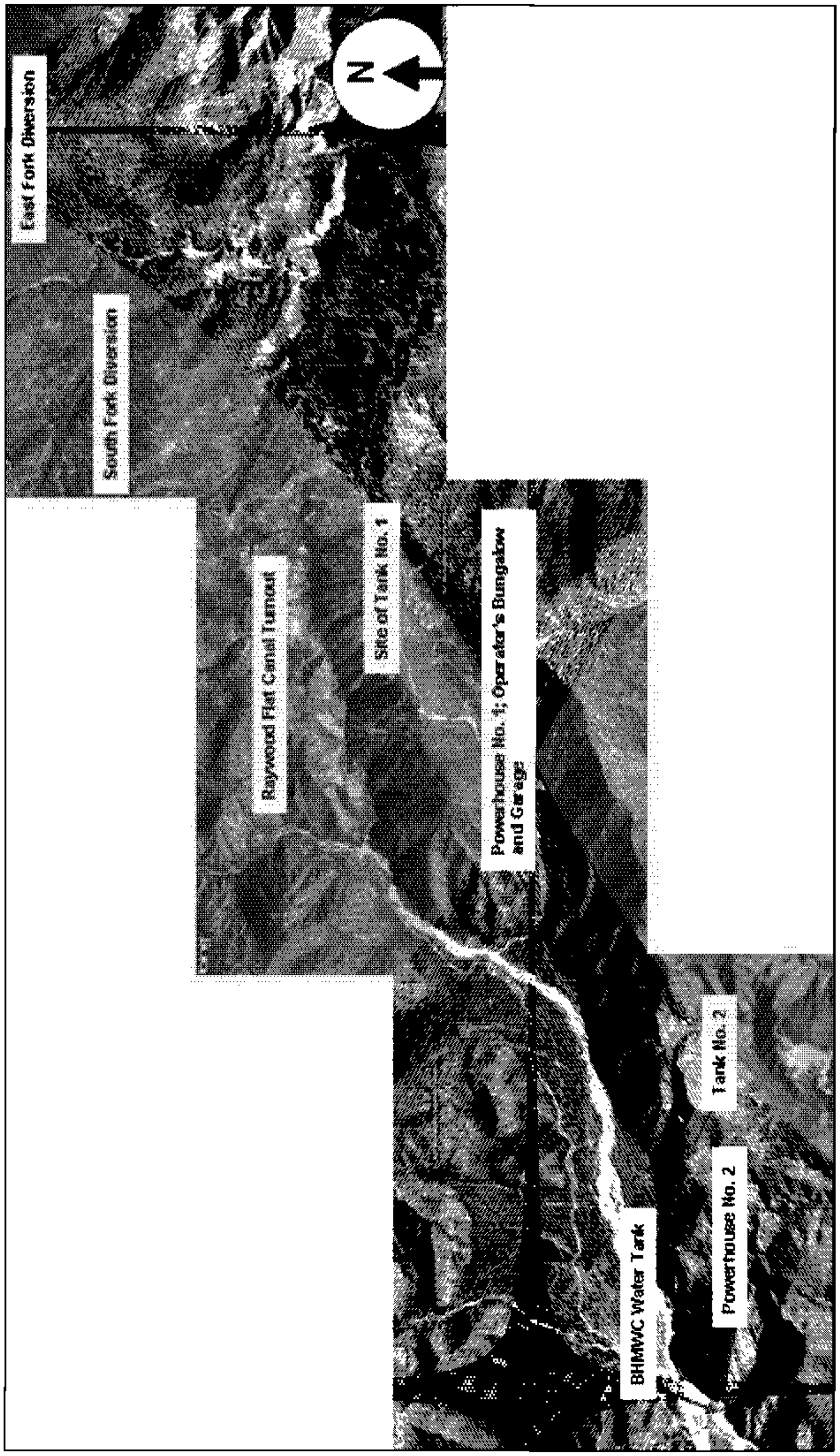
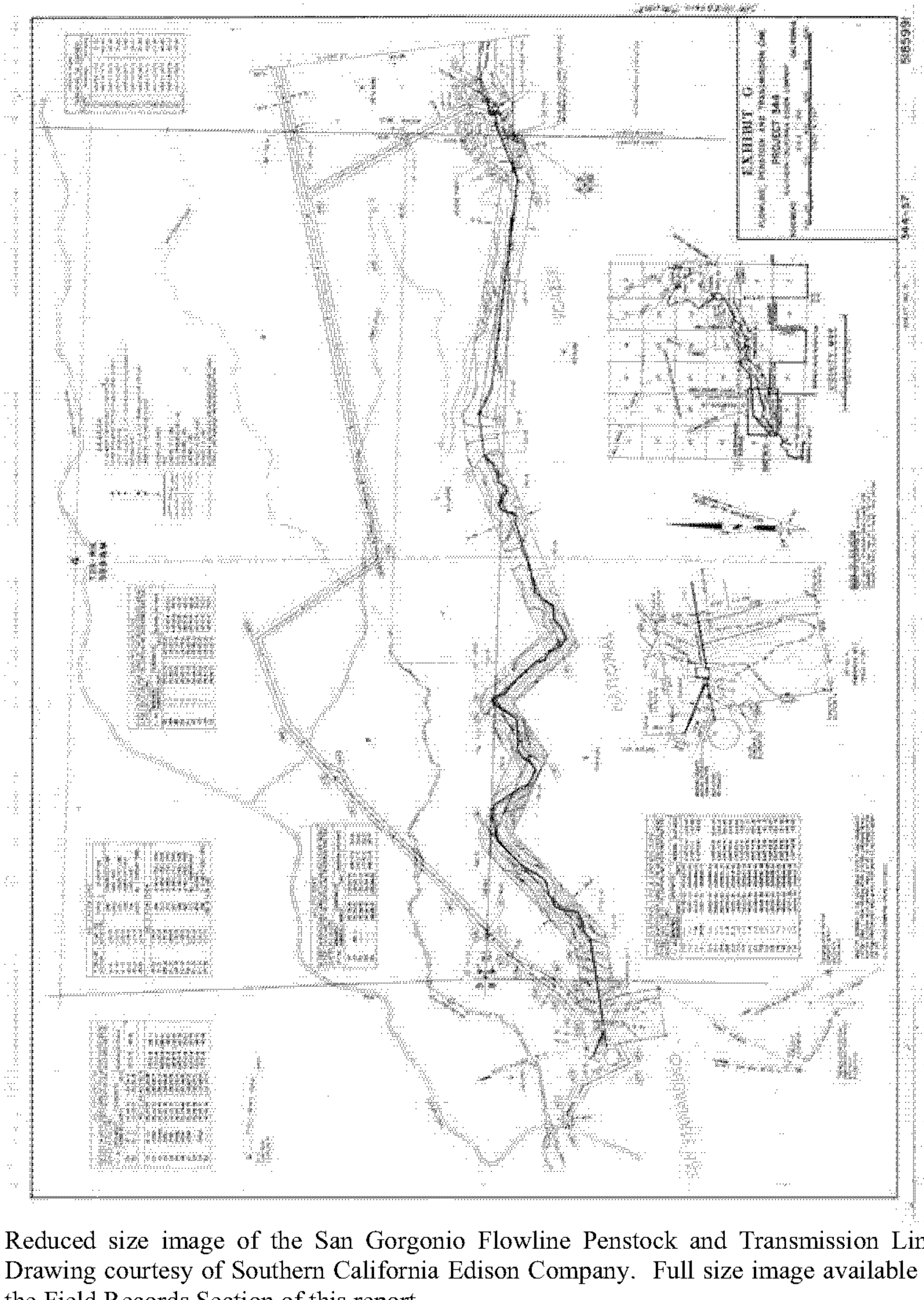


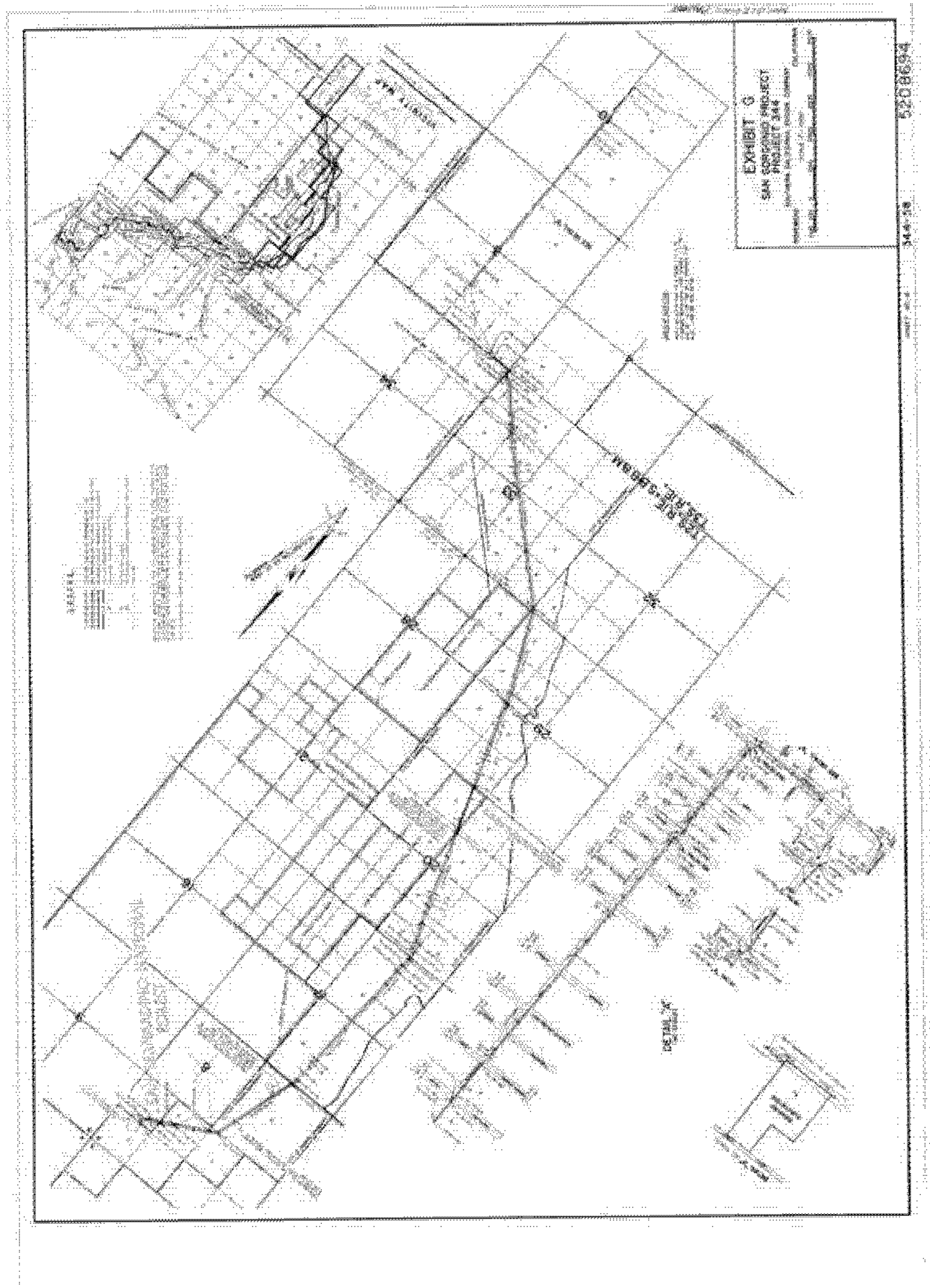
Reduced size overview map of the San Gorgonio Hydroelectric System. Map courtesy of Southern California Edison Company.



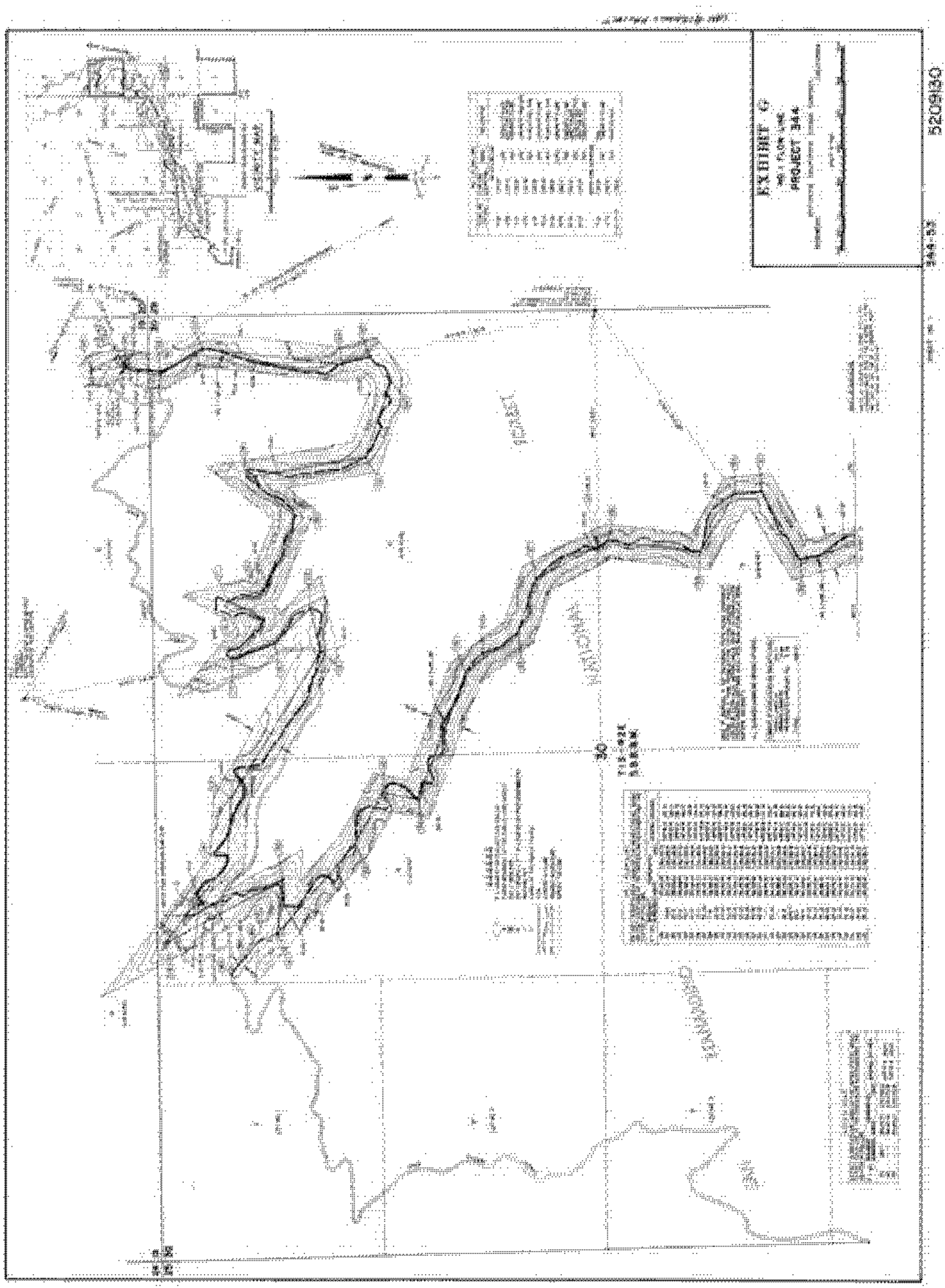
Aerial view of the San Gorgonio Hydroelectric System. Aerial images courtesy of Bing Maps.



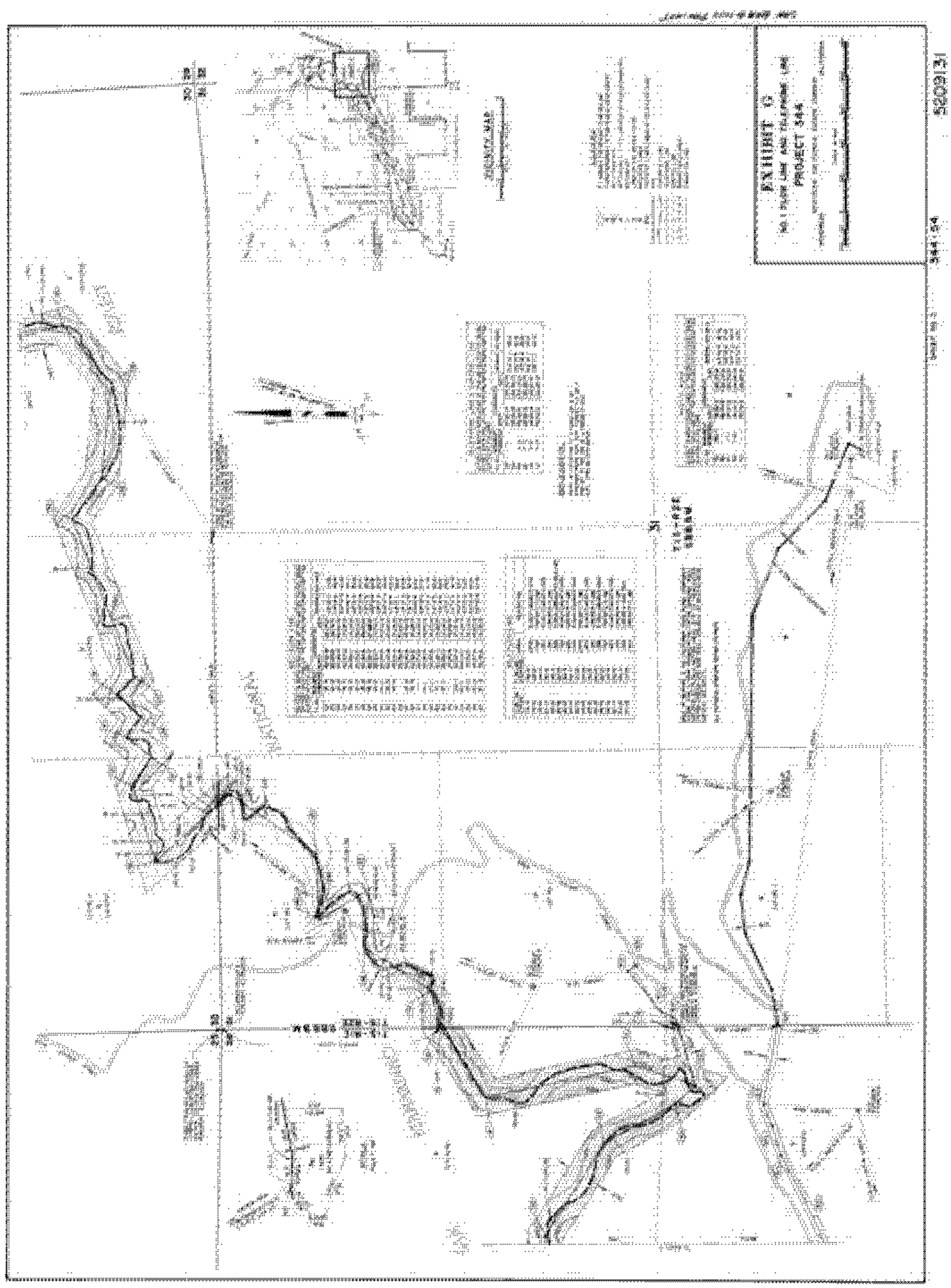
Reduced size image of the San Gorgonio Flowline Penstock and Transmission Line. Drawing courtesy of Southern California Edison Company. Full size image available in the Field Records Section of this report.



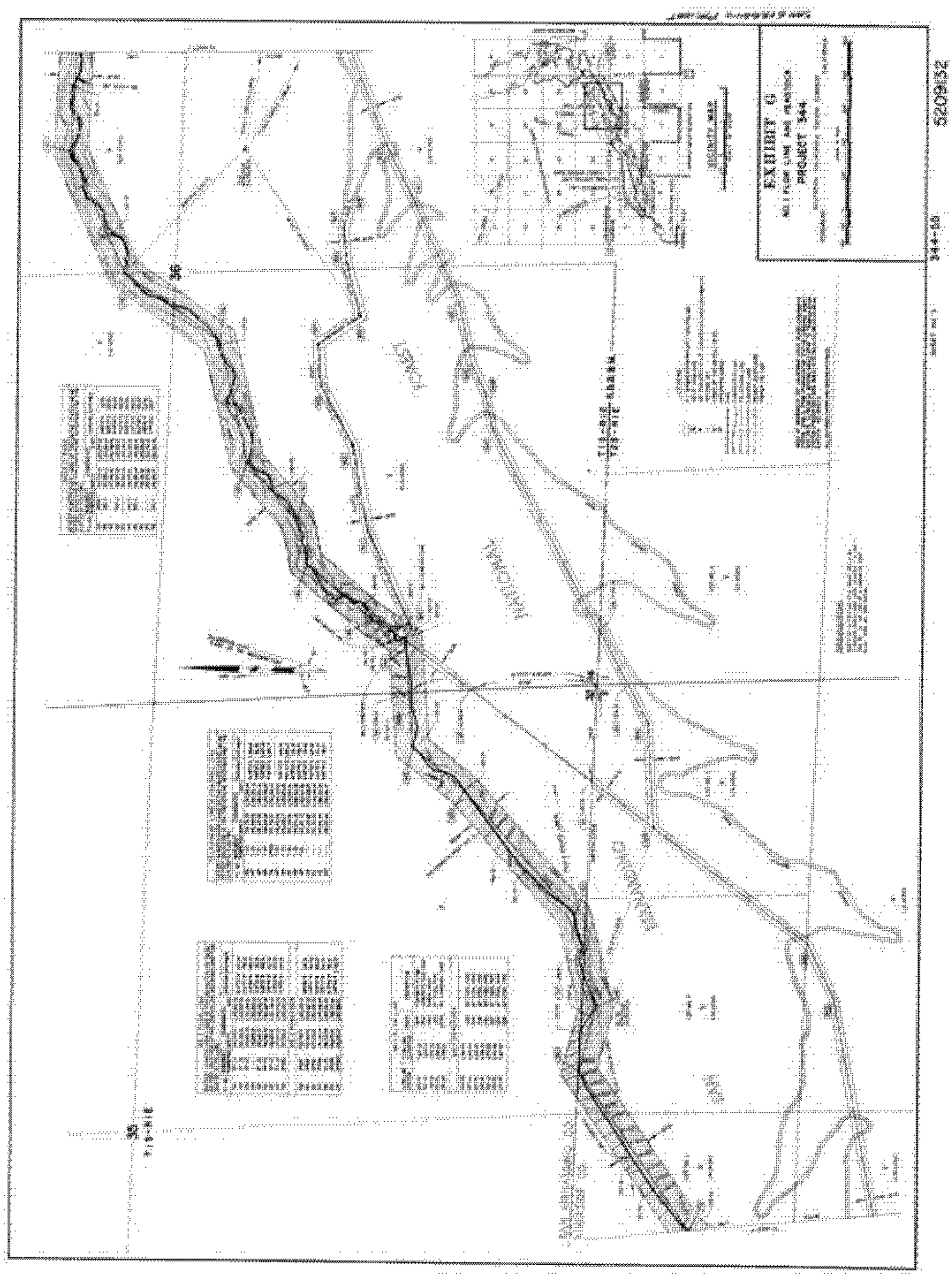
Reduced size image of the San Gorgonio System. Drawing courtesy of Southern California Edison Company. Full size image available in the Field Records Section of this report.



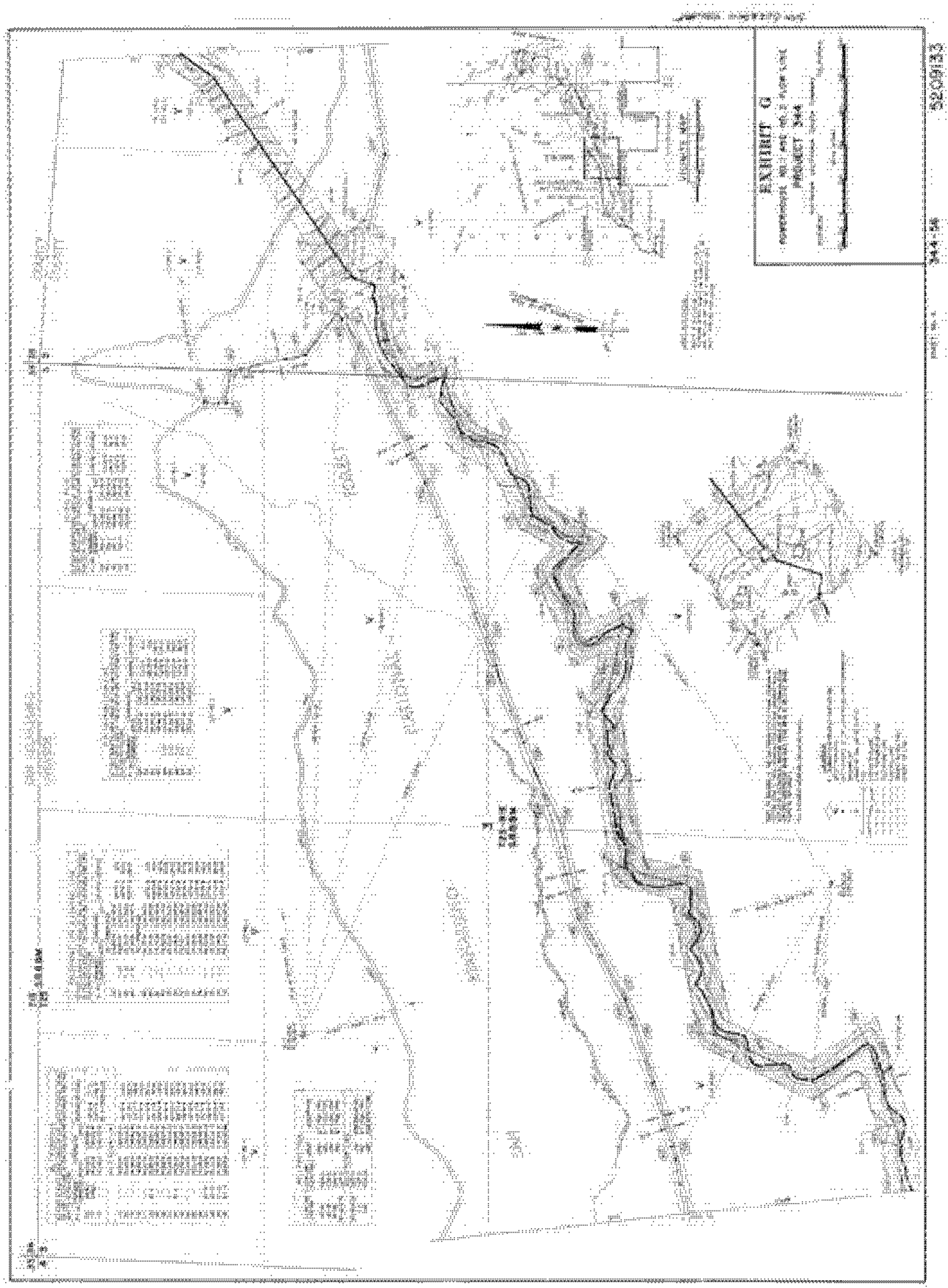
Reduced size image of San Gorgonio Hydroelectric System project No. 1 flowline. Drawing courtesy of Southern California Edison Company. Full size image available in the Field Records Section of this report.



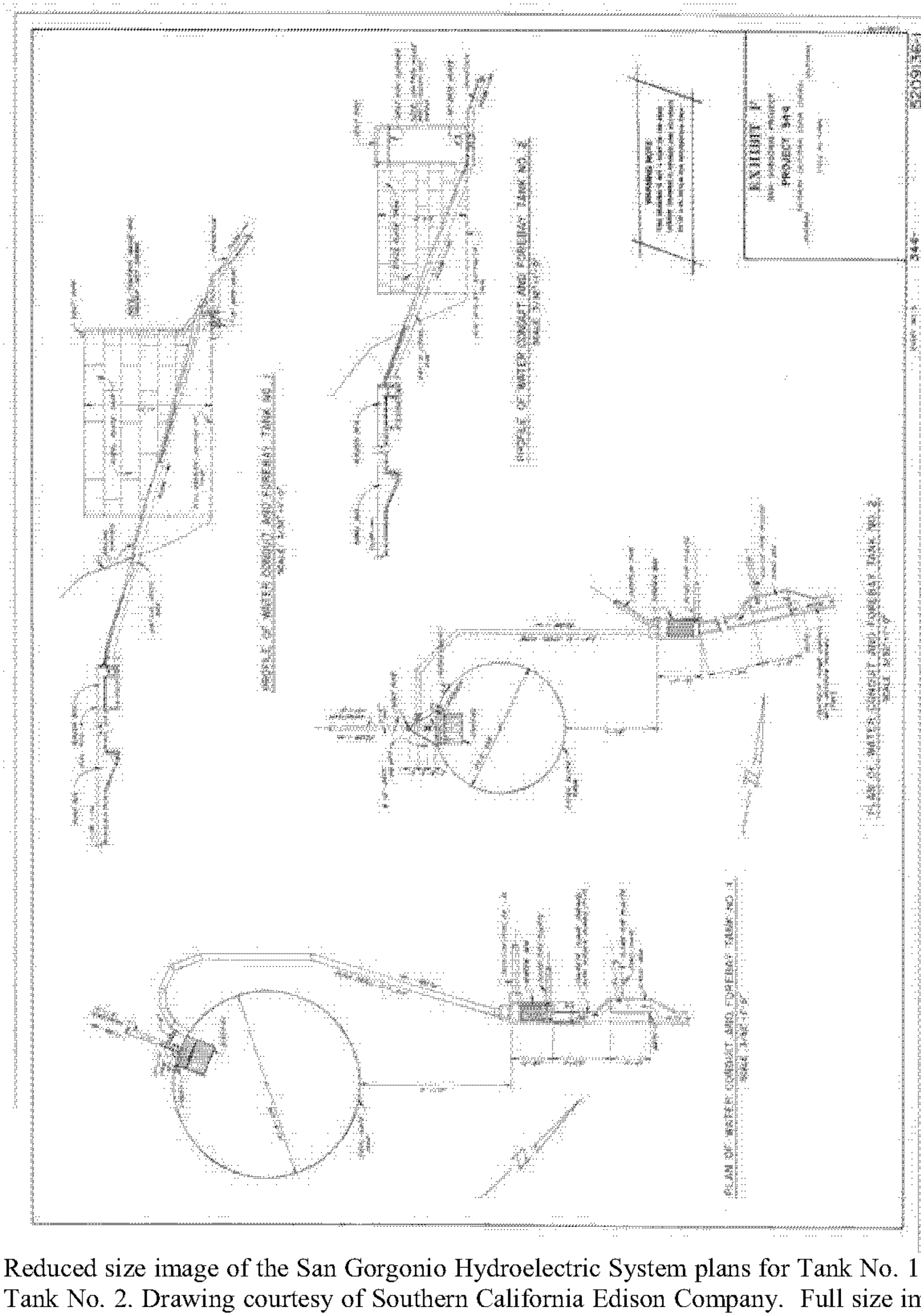
Reduced size image of the San Gorgonio Hydroelectric System No.1 flowline and telephone line. Drawing courtesy of Southern California Edison Company. Full size image available in the Field Records Section of this report.



Reduced size image of the San Gorgonio Hydroelectric System, flowline and penstock. Drawing courtesy of Southern California Edison. Full size image available in the Field Records Section of this report.



Reduced size image of San Gorgonio Hydroelectric System Powerhouse No. 1 and No. 2 Flowline. Drawing courtesy of Southern California Edison Company. Full size image available in the Field Records Section of this report.



Reduced size image of the San Gorgonio Hydroelectric System plans for Tank No. 1 and Tank No. 2. Drawing courtesy of Southern California Edison Company. Full size image available in the Field Records Section of this report.