Roosevelt Power Canal
and Diversion Dam
Roosevelt vicinity
Gila County
Arizona

HAER No. AZ-4

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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
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HISTORIC AMERICAN ENGINEERING RECORD

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Location:	The Roosevelt Power Canal is located in Gila County, Arizona, and runs parallel to the Salt River for approximately 19 miles. From the Diversion Dam, its intake source, the canal travels westwardly on the south side of the river to Theodore Roosevelt Dam.
Date of Construction:	The Power Canal and Diversion Dam were constructed between 1904 and 1906. Both features were rehabilitated in 1936 and 1937.
Engineers:	Arthur Powell Davis, Louis C. Hill, Charles R. Olberg, Chester W. Smith, Fred Teichman, U. S. Reclamation Service
Present Owner:	U. S. Government and administratively controlled by the Salt River Project
Present Use:	No longer in service
Significance:	The Roosevelt Power Canal was built as an integral part of the Salt River Project and represents the U. S. Reclamation Service's first involvement in the construction of hydroelectric power facilities. The canal played a critical role in providing electric power used during the construction of Roosevelt Dam. Roosevelt Dam was the first major federally-sponsored reclamation project in the Southwest. Operated intermittently for more than 40 years, the power canal was permanently removed from service in 1952. With the completion of the new Roosevelt Dam, the canal will be inundated during periods of high water.
Historian:	David M. Introcaso, Salt River Project Archives
Transmitted by:	Jean P. Yearby, HAER, 1985

THE ROOSEVELT POWER CANAL AND DIVERSION DAM

Built as part of Salt River Project in Arizona, the Roosevelt Power Canal was among the first structures constructed under the authority of the National Reclamation Act. However, the Canal had nothing to do with reclaiming land nor did the Reclamation Act provide for any such construction. Regardless, the Power Canal was a vital component in the development of federally sponsored reclamation projects, as the power generated by the Canal was used to build the Reclamation Service's first large scale reclamation work, Theodore Roosevelt Dam. In addition, the Power Canal pioneered the beginning of the Reclamation Service's (later the Bureau of Reclamation) vast hydropower system by generating power which was sold commercially and used for groundwater pumping. Completed in 1906, the Power Canal was used intermittently for over 40 years. Although still relatively intact, it has been replaced by larger and more efficient power alternatives and consequently has not been operational since 1952.

The National Reclamation Act was signed into law by President Theodore Roosevelt in June 1902. The Act gave the Secretary of Interior discretionary power to locate, survey, examine and construct irrigation works in 16 western states and territories. 1/ Within one year after the passage of the Act, Secretary of Interior Ethan Allen Hitchcock had approved four projects: the Milk River Project in Montana; the North Platte Project in Nebraska and Wyoming; the Newlands Project in Nevada; and the Salt River Project in Arizona, authorized on 12 March 1903. 2/ Original plans for the Salt River Project called for the construction of a massive 245 foot high gravity arch masonry dam on the Salt River on the border of Maricopa and Gila Counties. 3/

Plans for a hydropower generating facility at the Salt River damsite were developed at an early date by the Reclamation Service. Although power production eventually would be realized by impounding a large reservoir of water, Arthur Powell Davis, Chief of the Division of Hydrography of the U.S. Geological Survey and later head of the Reclamation Service, foresaw the use of hydropower on the Salt River long before the dam's completion. 4/ Davis wrote that since power was an essential element in the construction of a dam, hydropower should be developed before the dam was built. 5/

In remote locations, power for construction during the nineteenth and early twentieth centuries was usually provided by steam engines fueled by wood, oil or coal. However, in the case of Roosevelt Dam, hydroelectric power production was seen as the only cost efficient means of producing power because utilization of other sources was too expensive due to excessive transportation costs. There was a limited amount of wood available at or near the damsite. The cost of oil was 19 cents in Bakersfield, California but by the time it reached the damsite the cost jumped to $3.48 a barrel. The cost of coal was ten dollars per ton in Globe but it doubled when freighting costs to the damsite were included. 6/ Power would be used, Davis reported, "for drilling purposes, for handling rock, for mixing and handling mortar, and for crushing the rock used in concrete." 7/ The amount of power needed for construction was 1200 horsepower: 300 horsepower to be used at the cement mill and 900 horsepower at the dam. 8/

The method of producing this power was fairly simple. Located slightly further upstream than the reservoir would extend, a concrete diversion dam would be built. The water diverted by this dam would be channeled into a canal which would travel with a grade of slightly more than 30 feet per mile to a point above the damsite. The water would then drop 220 feet in a 620 foot long Penstock Tunnel within the wall of the canyon. 9/ The water turbine and generator would be located temporarily south and below the damsite in a shallow cave in the vertical cliff. 10/ The turbine and the generator initially were placed in this cave in order to protect them from blasting. Utimately the Power Canal would supply water for three generating units housed within the power house located directly downstream from the dam. The Arizona Republican reported that this power system would reduce the cost of construction by an estimated $1.8 million. 11/

Although the Diversion Dam and Power Canal served the immediate purpose of providing electrical power for construction, it served other important functions. By diverting the water around the river, the Diversion Dam and Power Canal could keep low water flow out of the reservoir and by doing so reduce the accumulation of silt at the base of the dam. In time of drought, when there was not enough water in the reservoir to produce power, the Diversion Dam and Power Canal could carry the river's flow, however slight, and produce electrical power. For reasons not fully explained, the Power Canal also "kept the river cloudy" which "kept down the growth of moss in the Canals," because moss "will not grow in dirty water." 12/ Finally, after construction was completed, the power generated by these two features could be sold to mining interests for drilling and lighting or be transmitted 70 miles to Phoenix to pump groundwater for irrigation purposes. 13/

Preliminary plans for the construction of the Power Canal and Diversion Dam were undertaken in 1901, one year before the Reclamation Act became law. A. P. Davis, in cooperation with Maricopa County, conducted this work and the results were published in Water Storage on Salt River, Arizona, and in the First Annual Report of the Reclamation Service. 14/ In October of 1902, under the direction of Charles Real Olberg, the U.S.

Geological Survey drew "a detailed topographic map of the vicinity of the [Power Canal] line" because "the Canal was found to traverse a very broken country." 15/ In the following year, 1903, the location surveys for the Power Canal were finalized.

The survey work completed, proposals for the construction of the Power Canal were advertised on 31 October 1903 and the bids were opened on 7 January 1904. 16/ Because of the rough terrain, many different features would need to be constructed, for example, 20 tunnels varying from 70 feet to 1695 feet needed to be dug, two double pressure pipes or siphons had to be built and various flumes, bridges, culverts, silt settling basins, cut and covers and weirs needed to be erected to transport water the Canal's length of 19.33 miles. 17/

The construction work was therefore divided into three timetables. Schedule one consisted of excavation in open cuts and fills using "structures of concrete, timber and cast iron," and schedule two included tunnels and lining. The third schedule, never let because the Reclamation Service used steel-reinforced concrete, constituted "alternative bids for wood-stove pipe and concrete pressure pipe." 18/

The bids were awarded to two California contractors. Robert Sherer & Co., of Los Angeles was awarded the open excavation contract. This contract was entered into on 18 March 1904 and involved the excavation of approximately 600,000 cubic yards of material. 19/ John Tuttle of San Francisco was awarded schedule two, that of tunneling, on 23 March 1904. 20/ Nearly ten percent of the Canal's run, or 9000 feet, would consist of tunnels. 21/ Work began by both parties in the following month, April 1904.

The Power Canal's general course began at the three intake gates located at the south end of the yet-to-be built Diversion Dam. Upon passing these gates, water immediately entered the first of 20 tunnels, the 1695 foot Intake Tunnel. The Canal then traveled past Lee's Wash (mile 1), the Wehrli Farm (mile 2), and intersected the road to Globe (mile 4). The Canal was then pressure piped under Pinto Creek (miles 5 and 6), which is south of Livingstone, and traveled through three more tunnels before reaching the Grapevine Springs Tunnel (mile 9). Continuing southwest, the Canal, with a depressed grade line siphon, passed School House Wash (mile 11), traveled through six more tunnels past Porter Springs (mile 14), and headed toward Cottonwood Canyon. At Cottonwood Canyon the Canal entered the second pair of pressure pipes or siphons (mile 16). The Canal then passed a series of clay pits (mile 17), and continued below and past Government Hill, the site of the Reclamation Service's camp (mile 18). The Canal finally passed the cement mill (mile 19) before entering the Penstock Tunnel. For the last 1.25 miles, the Canal was lined with concrete to prevent excess seepage into rock which was "more or less porous." 22/ (See Appendix I.)

The standard Canal section was planned to have a base width of eight feet, with a total water depth of 4.5 feet. Slopes were one-to-one in excavation and 1.5-to-1 inch in embankment. The first 12,000 feet of the Canal would have an increased depth to "provide for seepage losses." 23/

Tunneling work on the Canal was supervised by Tuttle himself and by his engineers' Mill and Duncanson. 24/ General government supervision for the work was under the charge of Louis C. Hill, Supervising Engineer, Reclamation Service, and Chester W. Smith, resident engineer in charge, USRS, with George Y. Wisner and W. H. Sanders serving as consulting engineers for the USRS. 25/ Construction of the upper end of the Power Canal was supervised by Assistant Engineer O. T. Reedy, USRS, while the lower end of the Power Canal was built under the direction of Assistant Engineer Spriggs, USRS, and Jack Whitney, USRS, who would later supervise construction of the Diversion Dam. 26/

Progress on the Power Canal was made under very trying circumstances. The area was almost completely uninhabited, making it impossible at times to secure workers. The difficulty in supplying grain for stock and the extreme temperatures in the tunnels during the summer compounded problems. 27/ Some of the tunneling was made through sand so dry and fine that it would "run like water." Consequently the work required heavy timbering for support. 28/ Massive boulders were also encountered. "These had to be dealt with separately," the Reclamation Service reported, "and worked out an inch at a time, regardless of size or position, it being impossible to break them with powder...." 29/ With all these problems recognized, Chester W. Smith bet Superintendent Crowley of Sherer & Co. a suit of clothes that tunnel excavation would not be completed by August 1905, the contractual deadline. 30/ Smith, of course, won the wager.

In order to meet the terms of his contract, Tuttle subcontracted much of the work. Patterson subcontracted for the Robinson Tunnel (151.7 feet). Harris subcontracted the Moffat Tunnel (213.5 feet). Burnett constructed the Chilton Tunnel (1026.5 feet); Ramona & Co. and Gregorio both excavated Pinto (990 feet), and Baxter & Co. of St. Louis lined all 20 tunnels with concrete. 31/

Open excavation by Sherer was no less a problem. Flumes, weirs, sluice gates, culverts, bridges and other features needed to be constructed in order for the water to be transported down the Canal. All told there were 152 numbered structures on the Canal. 32/ Consequently, Scherer also subcontracted much of his work. Redmond Toohey of Phoenix employed 30 men and 20 teams of horses for excavation, and subcontractor Clark used ten men and 20 head of horses. 23/ By August of 1904, four months into the work, The Arizona Republican reported that approximately 800 men were working on the Power Canal line. These men were largely Mexican and Indian laborers. 34/

The numerous and various structures along the Power Canal were necessary because the right of way had to pass through many creeks and washes which became "veritable raging torrents" during the rainy season. 35/ A variety of engineering methods were used to carry the Canal either above or under these waterways. The most frequent features along the Canal were culverts or conduits which varied in size and shape from simple 24 inch pipe culverts, which enabled runoff to pass under the Canal, to longer 12 foot arch culverts. 36/ Wooden flumes of various lengths were constructed to carry runoff water above the Canal or to transport Canal water above a creek or wash, e.g., Whitney's Flume (mile 18). 37/ Cut and cover structures also transported runoff water over the Power Canal. Many of these "cuts" were extended concrete pipes constructed by J. F. Davey, USRS Superintendent. 38/

Protection against the rise of water in the Canal due to drainage was provided by seven overflow weirs, any two of which were no more than six miles apart. Sluice gates served a similar function by providing the ability to empty the Canal at any time from five separate points. A sandbox and two settling basins also were constructed. Their purpose was to filter out silt that had entered the Canal. A water gauge for determining water flow in the Canal was located just below the sandbox (mile 0). It was read by an electrical indicator at the gatekeeper's house at the Diversion Dam. 39/

In addition to a gatekeeper housed at the Diversion Dam to monitor the intake flow, the Canal maintenance was primarily under the care of two ditchriders. Both ditchriders lived along the Canal. One was housed near the terminus of the Pinto Pressure Pipes and the other near the entrance to the Cottonwood Pressure Pipes. Their duties were to perform general maintenance along the Canal, repair minor leaks, remove large debris, maintain the Canal embankments and service the Canal in any other necessary way. 40/

The most novel feature of the Power Canal was the design by Reclamation Service engineers of the pressure pipes which were used at Pinto Creek and Cottonwood Canyon. These structures, steel-reinforced concrete pipes without joints, were not only a new engineering design -- "hitherto such pipes were made of iron or steel, or of wood staves bound with iron or steel rods" -- but were also the "first extensive use of reinforced concrete pipe to carry a large head of water under great pressure." 41/ The Republican reported that these would be the largest pipes of their kind in the world. They were designed by Reclamation Service engineers Chester Smith, O. T. Reedy, Paul J. Pagh, A. P. Cox and O. T. Reedy, Sr. 42/

Pinto Creek is located six miles below the Canal intake and is nearly .5 miles wide and 25 feet below the Canal grade. It has a watershed of 190 square miles, and at the Canal crossing has a grade of one percent. The Cottonwood crossing is situated

2.5 miles above Roosevelt Dam, is 250 feet wide and 75 feet below the Canal grade. Its watershed is 45 square miles and has a grade of four percent. Both sets of double pressure pipes were buried underground approximately two to five feet below the surface. Simply explained, the pressure pipes were reinforced, both longitudinally and transversely with 5/8 inch steel rods. The pipes were five feet, three inches in diameter and 12 inches thick at the thinnest part and carried the water under a maximum head of 80 feet. Because of the unique design of the pressure pipes, the government undertook this work on its own. 43/

The first length of pipe, 200 or 300 feet, was completed at Pinto in June 1905. 44/ During the summer, the work was frequently interrupted due to several floods and the difficulty in obtaining cement. By November 1905 the first line at Pinto was completed. Because power was needed as soon as possible at the dam and because one line would carry "all the water needed to furnish power for building the dam," the forms for the pipe were moved to Cottonwood. 45/ The two Cottonwood lines were completed in December 1905 and January 1906. The second line of Pinto was begun in March and because of "various delays," was not completed until August 1906. 46/

Perhaps the most remarkable aspect in the construction of the pressure pipes was Fred Teichman's design of a movable form which would permit continuous construction of the piping. Since it was "desirable to work continuously on the pipe," to avoid "transverse joints," Teichman designed a "steel semi-cylinder, called 'the alligator.'" This device formed the inside of the lower half of the pipe and was described by Chester Smith as follows:

> . . . This piece is pulled along by a cable from a horse-power whim in the trench ahead. It is kept to line and grade by a steering apparatus, extending about 8 ft. in front of its nose, and either rolling or sliding on a light wooden track previously laid. The inner form for the upper half of the pipe consists of steel semi-cylinders in 2-ft. lengths, each in three pieces, that is, hinged at two points, to facilitate moving and erection.
>
> These upper stationary plates are bolted together, end to end, making a continuous form, from the front end, where concrete is going in, to the rear end, where the concrete has set sufficiently to permit their removal; they are supported by rollers on a track which is part of the alligator, the alligator thus rolling out from the upper stationary plates. Immediately behind the alligator are introduced lower stationary plates in 2-ft. lengths, one plate being inserted as often as a length of 2 ft. of invert is exposed. On the withdrawal of the alligator, an upper stationary plate is thus supported by the plate ahead on the alligator and a plate behind on a lower plate, until the insertion of its lower plate. Upper and lower plates are removed at the rear end and sent ahead on a small truck hauled back and forth with a rope, on a track in the bottom of the lower plates and alligator.
>
> The outside lagging was of 2-1/2 in. lumber in narrow pieces, about 5-1/2 ft. long, laid on the same slope as the nose of the alligator (1 in 4) between iron ribs hung from a wooden superstructure. This superstructure also carried the runways for wheeling out the concrete. 47/

Many difficulties were encountered in constructing the pressure pipes. The "alligator" tended to travel off the line or grade, even though the steering apparatus was designed to stop this, and concrete often peeled or fell off when the upper stationary plates were removed. 48/ But the most important and perplexing problem was that of leakage which persisted for some time. The problem was finally solved on the evening of 10 March 1906. Chester Smith recorded in his diary that evening:

> After supper [at] Roosevelt Hill, Harris, Teichman and myself discussed cracks and finally arrived at the conclusion that they were caused by concrete shrinking while settling and bringing tension in the concrete and compression in the steel - so that upon applying the water pressure the steel does not take any load till after the concrete cracks. Decided to repair by simply caulking up the cracks and not reinforcing the pipe any more on the outside. 49/

One other unique feature designed for the Power Canal deserves notice and explanation. Although a sandbox (mile 0) was constructed and settling basins were built to filter out silt, sediment and other debris in the Canal, an additional feature was designed to protect the guide buckets and the runner of the turbine from damage. This protection was developed in the form of a rotating screen located at the head of the Penstock Tunnel. Again, Fred Teichman engineered this device. 50/ He described the device this way:

> The screen has the form of a truncated cone, the water entering the cone at the base. The axis of the cone is at an inclination of 1:4. The cone is made to rotate slowly around its axis. To the entrance ring of the cone is fitted (with a small clearance of only 1/4 in.) the stationary entrance ring. The screen of the cone is made of No. 18 galvanized wire, 1/2-in. mesh, and is supported by circular rods (5/8 and 3/4 in. in diameter) which in their turn are supported by sixteen 3/4 by 4-in. bars, riveted to the steel head of the drum at one end, and to the entrance ring at the other. At a point about two-sevenths of their length from the entrance ring the sixteen bars are connected and supported by the trunnion ring. Between the trunnion ring and the steel head these bars are connected by 7/8-in. stay-bolts. To the steel head is riveted a center casting, bored for a stationary shaft, 3 in. in diameter, held in a cast-iron shaft support. The structure of the screen, therefore, is supported by this 3-in. shaft and by two trunnions in the plane of the trunnion ring. To the steel head are bolted the segments of a cast-

iron ratchet ring of 72 teeth; and two pawls, actuated by a hydraulic cylinder, propel the screen, which makes a complete turn in about 1 hour.

The extension of the 3-in. shaft in the interior of the drum, and a concrete arch over the Canal about 16 in. from the drum support, in the interior of the drum, two 8-in. channels, slightly inclined, on which rests a galvanized-iron trough, 3-1/2 ft. wide and 16-1/2 ft. long, that terminates in a side trough. The motor which turns the screen also pumps water into a horizontal trough above the screen and centrally above the interior 3-1/2-ft. trough. At intervals this upper trough (the tipping trough) discharges automatically, and the water it contained strikes the screen in a jet (3/8 in. by 15 ft. 6 in.), carrying with it into the interior trough any material which had lodged on the inner surface of the screen. Material which does not adhere to the screen is lifted by blades attached to the interior of the screen, and dropped into the interior trough. The wash-water carries the screenings through the side trough over the edge of the Canal.

The area of the submerged screen is 232 sq. ft. with the Canal discharging 250 cu. ft. per sec. The screen would safely stand a difference in level of the water, inside and outside, of 4 ft., which may possibly occur during the first heavy rains of the season. 51/

While the pressure pipes were being completed in the spring of 1906, flood waters of November 1905 and March 1906 came precariously close to the Canal near the Wehrli Farm (mile 2). As a result, three additional tunnels were constructed and 2500 feet of the Canal had to be relocated. This came to be known as the Wehrli Cutoff.

Although the Wehrli rerouting was not completed until August 1906, the Canal began operation in March 1906. Water was carried, it can be inferred, through the original Wehrli section from March until the 2500 foot section was completed. The temporary power plant was also completed in March. The beginning of hydropower generation by the U.S. Reclamation Service began that month, and the power plant was operating 24 hours a day by June of 1906. 52/

A good deal of excitement was generated by the completion of the Power Canal. The Arizona Republican wrote with acclaim:

> To have 'water in the Canal' has been the watchword of all for many months past. There is possibly no rougher country in all the west through which a Canal of any kind has been driven and this one throughout all the 19 miles of its length has presented seemingly almost insurmountable obstacles to those who have had its construction in charge. There were hills to be tunneled, long heavy fills to be made and great canyons to be crossed. . . . The completion of the Power Canal means cheap power and plenty of it. It means that the contractor [John O'Rourke] will have all he needs. . . . 53/

With the Power Canal completed the reclamation engineers turned next to the Canal's intake source. The Diversion Dam was constructed upon completion of the Power Canal for two simple reasons. Water could always be diverted by the construction of a temporary brush and earthen dam into the Power Canal. The Diversion Dam, however, was useless without the Canal. Second, since maintaining and acquiring a labor force was, at times, as arduous as the work itself, construction of both power features simultaneously was impractical if not impossible.

The Diversion Dam was constructed by the Reclamation Service with Jack Whitney supervising a crew of 50 men. 54/ It was a simple structure built of boulders and concrete; and was 400 feet long and seven feet high. The dam was not secured on bedrock but built on silt, sand and gravel. It was referred to as an overflow weir dam because water was expected to inundate the dam at times. The spillway of the dam, which comprised the downstream side of the dam, had an ogee shape. 55/

The three intake gates for the Power Canal were located at the south end of the Diversion Dam. The sluiceway was in front of these gates, on the upstream side, and was 7.5 feet below the crest, or top of the dam. Water was diverted by the dam into the sluiceway and then into the three intake gates that measured five feet high and seven feet wide. To prevent excessive silting in the Intake Tunnel, the bases, or sills of the intake gates were 3.5 feet higher than the level of the sluiceway. "Both sluicing and intake gates were of the sliding hand-operated type." 56/ These features were designed by Reclamation Service engineer A. L. Harris. 57/ At the north side of the dam, a concrete "U" abutment was constructed to unite the dam to the river bank and to prevent erosion at that point.

The dam itself was completed on 19 October 1906 but the dam apron was not finished until early November 1906. The apron, a cobblestone in concrete plane, extended from the base of the dam downstream a distance of approximately 15 feet. Such aprons were constructed to prevent scouring under the dam when water flowed over the crest. The cost of constructing the Diversion Dam was $127,353.22. 58/

Shortly after the dam was completed, its durability was tested. On 2 November 1906, a flood 8.5 feet in height passed over the crest of the dam. 59/ The dam remained intact; the flood caused no noticeable damage to the structure.

The Power Canal and Diversion Dam were completed after two and one half years of formidable work requiring hundreds of laborers and an expenditure of $1.2 million. Upon their completion, power generated from these features was in immediate demand. The cornerstone for Roosevelt Dam had already been set on 20 September 1906, and work was being pushed as rapidly as possible toward completion before the winter runoff. Prior to this, excavation for the dam and preliminary work had begun as early as the fall of 1905. All of this work, of course, required power.

The Power Canal and Diversion Dam generally operated successfully throughout the construction of Roosevelt Dam between 1906 and 1911. 60/ In fact, the only substantial problem to develop involving these two features was not an engineering difficulty but a legal one. The Power Canal, in the course of its route, needed to cross the property of John W. Lee. Although Lee apparently made an offer for sale of his property, the Salt River Valley Water Users' Association (Association) thought the offer was extortionate. As a result, the Association filed a condemnation suit in Globe against Lee's property in June 1904. 61/

Like many legal matters, this one was not readily solved. Both sides, under legal advice, carried on the affair for nearly four years, long after the Power Canal had been completed. During this time, the Association proposed a conditional right of way through Lee's property for the Power Canal. Lee rejected this idea. The Association then offered $6500 and later $8000 for Lee's property. Lee declined both times. Lee proposed to settle the matter for $11,000 in 1907, but this time the Association refused. Apparently frustrated, the Association then contemplated a motion to secure a change of venue in the case and also to have the federal government file a condemnation suit against Lee. 62/ Finally, in February 1908, the matter was settled. Though the settlement terms were somewhat complicated, the Association agreed to pay Lee $7725 plus the $1500 of Lee's mortgage, the $75 in unpaid interest and $700 Lee owed to the Old Dominion Company, for a total payment of $10,000. 63/

Little attention was given to the Power Canal and Diversion Dam after their completion. The engineers for the Reclamation Service were now concerned with a more monumental task, constructing Roosevelt Dam and all its associated features. Besides the work on the dam itself, there was the cement mill, the various stone and clay quarries, and the lumber mill in the Sierra Anchas to be operated. The permanent power house and transformer house needed to be built. Roads, telephone lines, a sluicing tunnel and tramways all needed the engineer's attention. The engineers also had to deal with tremendous flooding, freighting difficulties and the perennial problem of securing labor.

As a result of the Reclamation Service's change in focus, there is little documentary material regarding the Power Canal and Diversion Dam during the period from 1906 through the dam's completion in 1911. Most of what information exists can be found in the annual reports of the Reclamation Service. The Sixth Annual Report (1906-1907) stated that, "the Power Canal has been in constant use since its completion, with the exception of a few inconsequent delays, due to small breaks, none of these having occurred in the last several months." 64/ The Seventh Annual Report (1907-1908) stated that other than two minor breaks at the upper end of the Power Canal and one near the Cottonwood Creek pressure pipes, the Power Canal had been in constant use throughout the year. 65/ The Eighth Annual Report (1908-1909) recorded that the Power Canal, for three weeks in January 1909, was drained, cleaned and generally repaired while extensions to the penstock were made in the power house. 66/ The Ninth Annual Report (1909-1910) simply gives an overview of the Power Canal and Diversion Dam features, while the Tenth Annual Report (1910-1911) never specifically mentions either of these structures. 67/

Newspaper articles reporting the state of the Power Canal and Diversion Dam during this period were rarely written and were often inaccurate. The Republican reported on 30 May 1909 that the Power Canal would have to be cemented for its entire length, approximately 16 or 17 miles. One week later on 6 June 1909, the Republican made the correction that the Power Canal was "already cemented 16 or 17 miles," and that the "government doesn't intend to cement the rest." 68/ The government neither intended to cement the Canal nor had ever done so.

We know that the Power Canal and Diversion Dam were operating dependably and successfully during this five year period because the Reclamation Service quickly took advantage of selling the power they generated. As soon as the permanent power plant was completed in August 1909, 69/ one and one half years before completion of Roosevelt Dam, power generated at the damsite was sold to the Pacific Gas & Electric Company by a contract dated September 1909. 70/ Power was also transported to the Gila River Indian Reservation to pump underground water. The Indians began to receive this power in May or June of 1910. 71/

The commercial sale of power was a profitable business for the government. In a lengthy memorandum to A. P. Davis, by this time Director of the Reclamation Service, Louis C. Hill outlined the financial benefits of the Power Canal and Diversion Dam. If these features had not been built, the cost of building and operating an oil-fired steam plant at the damsite would have amounted to $530,000, Hill estimated. Although this cost was less than that of the Power Canal and Diversion Dam, an oil-fired system could not give a return on investment. The Power Canal and Diversion Dam, however, returned a significant dividend after

Roosevelt Dam was completed and the power sold commercially. In fact, if the Power Canal and Diversion Dam had been kept operational beyond 1916, Hill estimated that the sale of power generated by these features would have amounted to $500 per day or $180,000 per year. 72/

The Reclamation Service in its Annual Reports gave the impression that from 1911 to 1916, the Power Canal and Diversion Dam provided a steady head of water to the power house at Roosevelt Dam. 73/ The Power Canal was not operational from January through August of 1913. During this time, the penstock was coated with bitumastic enamel "to prevent corrosion due to the excessive sweating." 74/ In 1914, 40 feet of Canal bank washed out during a summer cloudburst. The repair work took 20 days and required the work of 24 men and ten teams of horses. 75/ On 20 February and 27 July 1915, cloudbursts again caused washouts at the upper end of the Canal where it was in a sandy formation. The repair work consisted of "replacing old wooden culverts with concrete pipes and riprapping the bank" of the Canal. In the same year, the Canal was not in operation from 10 April to 22 June. Because of the high elevation of water in the reservoir, the water in the Canal was released to prevent a washout from excessive wave action. Wave wash would become an intractable problem in maintaining the Canal. Since the height of Roosevelt Dam was increased 35 feet over the original plan the

Canal came close to being inundated when the reservoir filled. 76/

By 1916, the Power Canal and Diversion Dam were ten years old and had proven to be, as Davis claimed in 1901, "a valuable asset." 77/ But these structures were soon to be changed for three reasons. Plans were underway to connect the sluicing tunnel with the Power Canal Penstock Tunnel, thereby making it possible to operate the Power Canal generators with reservoir water. In the process of determining the final repayment sum of the Project, the Association was disputing the construction cost of the Power Canal which they thought was exorbitant. A. P. Davis had estimated the Canal would cost $91,100 but the final cost climbed to $1.2 Million. 78/ Finally, the Diversion Dam failed when a tremendous flood washed away 230 feet of the dam in January 1916.

The construction of a gate-controlled bypass connecting the sluicing tunnel with the Canal penstock began sometime in 1915. Since it was expected that the reservoir level would remain high enough (above 130 feet) for the dam's power facilities to operate effectively for many years, and since the Power Canal suffered from wave wash during times when the reservoir impounded a large amount of water, it was deemed desirable to operate the Power Canal turbines with reservoir water. In times when the reservoir capacity was sufficiently decreased, it was thought the Power Canal could always be reactivated. 79/

The second matter, that of fixing the total cost of the Project, was a rather complicated affair. In accordance with section four of the Reclamation Act, those landowners using water impounded by a reclamation project were legally required to repay the entire cost for that project to the government in ten years or less. 80/ Naturally this meant that the Association had to repay the construction costs of the Salt River Project. Although well aware of this provision, the Association membership was unaware that the cost at completion would be four times the original estimate. 81/ Because of the great financial cost of the Project, Interior Secretary Franklin L. Lane appointed a three member local cost review board in 1915 to determine an appropriate and just amount for repayment. 82/

The cost review board, after examination of the building charges, did not reach a consensus opinion. Fred A. Jones and Thomas U. Taylor, in the majority opinion argued that the Reclamation Service and the Association had essentially entered a commercial contract. They thought, "the relation is that of an owner of land to a contractor undertaking a work for the owner adapted to the accomplishment of a particular purpose. In such case, the work should be limited in extent and scope to that purpose; should not exceed in cost, the cost for which proper and adequate works can be installed." 83/ In respect to the Power

Canal, therefore, some "imaginary substitute system" or alternative, having the same utility, could have been constructed at a much more reasonable cost. 84/ As a result of this logic and other reasons, Jones and Taylor recommended that the cost of the Project be reduced approximately $3.5 million from the $13 million sum.

Frank Hanna filed the minority opinion stating that the cost for construction should be reduced by only $640,000 from the $13 million total figure. Hanna agreed with fellow committee member Jones that the Power Canal may have been constructed differently and at less expense. But Hanna argued that in determining the cost of the Project one should weigh the costs against the benefits. Construction costs were worth "the expense if the Water Users [the Association] derived substantial benefit from it." Therefore, in determining whether the cost of the Power Canal was a legitimate expenditure, Hanna argued the Power Canal should be measured against alternative power sources, i.e., highly priced coal and oil fired systems. Since the benefits of the Power Canal "outweighed" all other power alternatives, it was thus a legitimate expenditure. 85/

Hanna's minority opinion was forwarded to A. P. Davis as it was the recommendation of Elwood Mead, Chairman of the Central Cost Review Board. 86/ Davis objected to reducing the cost of the Project by a single dollar because such a reduction would imply the Reclamation Service erred in building the Power Canal.

The matter was finally settled by Secretary Lane. He accepted the Central Cost Review Board report. The final price tag for the Salt River Project was only slightly reduced and set at $10,279,191 or $60 per acre irrigated with no money deducted for the Power Canal. 87/

The repayment cost set by Secretary Lane must have been particularly frustrating to the Association; it was still three times the original estimate. In addition to paying for the Power Canal, the Association must have been irritated when the Power Canal was rendered useless by the destruction of the Diversion Dam. On 19 and 28 January 1916, floods completely washed away 230 feet of the Diversion Dam's length and moved 45 feet of the Dam 4.5 feet downstream, tipping it backward. The flooding also caused and crack down the north abutment wall. 88/ As a result of this, although undamaged, the Power Canal was no longer functional. 89/

The Reclamation Service almost immediately recommended that the Diversion Dam be rebuilt. 90/ After the damaging flood of 1916, however, the Association gained operation and maintenance of the Project's works in September 1917, and the Diversion Dam was not repaired nor was the integrity of the Power Canal maintained by the Association. 91/ This decision may seem questionable in light of the significant profit the Reclamation Service made on the sale of power generated by the Diversion Dam and Power Canal from 1909 to 1917. Under the 1917 contract between the U.S. and the Association, power receipts went to the Association.

The Association's decision to forego repairs of the Diversion Dam is understandable for many reasons. The penstock-sluicing tunnel bypass left the Power Canal with little purpose provided there was sufficient water in the reservoir. The Association was now faced with a bill of approximately $10 million for the Project's construction, and any additional charge to this amount probably was not welcomed. It was not dissatisfied with the Project's construction, but the cost of $60 per acre irrigated was more than it had imagined.

Repair of the Diversion Dam in 1916-1917 was unnecessary since there was an oversupply of water for the year. As a result, the power house at Roosevelt Dam operated at maximum capacity, producing enough electricity for a total gross income of $491,812.51. 92/ Although the excessive water maximized power production, flooding cost the Project $250,000 in repairs in 1916. 93/

America's entry into World War I also affected the Association's decision. Richard Sloan, attorney for the Association, stated that, "In 1917 and 1918, all effort was, as a matter of course, automatically diverted from project development by the World War." Despite the inflated wartime agricultural prices which made the cotton produced in the Valley very profitable, the Association again paid $250,000 for flood damage in 1920. The Association also expended a significant sum to keep farmlands from becoming worthless due to waterlogging during these years. 94/

After the war, plans to redevelop the Diversion Dam could not be undertaken because flooding once again caused severe financial strain. The protective work below the south spillway of Roosevelt Dam was damaged to the extent of $84,000. Flooding in Cave Creek also caused extensive damage, and waterlogging was still a problem. 95/ The post war farming depression, the expensive repair costs due to flooding, and the waterlogging problem all contributed to the failure by the Association to meet its repayment installments to the government in 1920-1921. 96/ In all events, rehabilitating the Diversion Dam after 1916 was either unnecessary or impossible. Financial constraints, the war and the weather all dictated the fate of this structure. A reconstructed Diversion Dam would have to wait until favorable circumstances accorded its use.

Although the Diversion Dam and Power Canal were rendered unusable in January 1916, the generators at the Roosevelt power plant which handled the Power Canal head were working until June 15 of that year. 97/ For this five month period they handled water from the forebay gates. After completion of the sluicing tunnel bypass in October 1917, the generators were supplied with water from the reservoir.

It is fair to assume that the Power Canal was not operating from 1917 to 1925. No mention is made of this structure in the Eighteenth, Nineteenth and Twentieth Annual Reports of the Reclamation Service. 98/ Nor was it mentioned in the Annual Histories of the Salt River Project for the years 1918-1919 through 1923-1924. Nothing can be found in the Minutes of the Association's Board of Governors regarding the structure during this period.

Until 1925 the power requirements for the Association were met with the water in the Roosevelt reservoir and other Association power sources. 99/ But because rainfall and snowmelt significantly decreased during the mid 1920s, in the spring of 1925 the Power Canal was put back into operation. The low head available to the Roosevelt powerhouse from the reservoir was not sufficient to provide an adequate head for the powerhouse generators. 100/ Apparently the expectation that the level of the reservoir would remain sufficient over time to provide a high head was not met.

In order to make the Power Canal once again operational, the river water needed to be diverted. The Diversion Dam was not reconstructed, but a temporary dam of sand, gravel and brush was built at the Diversion Dam site to divert water into the Canal. A temporary dam would not last through the winter runoff, however slight, so it was reconstructed after the winter months had passed. In fact, the Association rebuilt the temporary dam several times between the years 1925 and 1934 in order to keep diverting water into the Power Canal. 101/

The Power Canal generated power at the powerhouse from 1925 until 1932. 102/ In the Salt River Project Annual History for 1932-1933, it was reported that, because the water level in the reservoir was sufficiently high, the Power Canal was not operated during that year. 103/ But this situation did not last long. In September 1934, another brush dam was built and the Power Canal was once again in operation. The level of the reservoir for that month was a meager 65 feet. 104/ The Canal operated until 26 March of the following year when the dam again washed out. It was not rebuilt this time, however, because the level of water in the reservoir was sufficient to operate the power house 95 percent of the time for the year. 105/ In 1936 the level of the reservoir remained high enough so the Power Canal was not used for the year. 106/

As is evident, the Association was using the Power Canal only as a backup measure when the reservoir level was not sufficient to power the dam's generators or the sluicing tunnel bypass. Repair work on the Canal during this time consequently was kept to a minimum. The only way the Power Canal would ever again become a permanent asset instead of a standby facility would be to reconstruct the Diversion Dam and thoroughly rehabilitate the Power Canal which had deteriorated significantly, despite intermittent use, over the past twenty years.

Rehabilitation of the Diversion Dam and Power Canal became a possibility with the contract of 26 November 1935 between the Association and the Reclamation Service. 107/ This contract provided for the construction of Bartlett Dam on the Verde River and also the improvement of the spillway gates at Roosevelt, Horse Mesa, Mormon Flat and Stewart Mountain Dams on the Salt River. The contract also made provision for the rehabilitation and reconstruction of the Power Canal and Diversion Dam if funds were available after monies for Bartlett and the spillways were allocated. 108/ Money was made available for the work a year later and, under the contract of 14 October 1936 between the Reclamation Service and the Association, the work was authorized. 109/

The Association desired to rebuild the Diversion Dam and rehabilitate the Power Canal for two principal reasons. In repairing the spillways of the four Salt River dams, power production would have to be curtailed. 110/ This was because water levels and water releases in all four reservoirs had to be sufficiently lowered and then restricted while spillway construction was underway. In addition, there would be no power production whatsoever at Mormon Flat Dam since the power plant there was being relocated. 111/ Curtailment of power would naturally affect the Association's power sales. The value of copper had risen "suddenly" during this period, and "nearly all the mines in the state" were operating and requiring power. 112/ For these reasons the Diversion Dam and Power Canal once again became very attractive features.

Unlike the original construction which was done by the Reclamation Service, the reconstructed Diversion Dam was built by a commercial contractor. Invitations for reconstruction were let on 12 August 1936. Of the eight bids submitted, the low bid of $82,935 was presented by Daley Corporation of San Diego, California. The contractual period for construction ran for 90 days from 21 October 1936 to 21 January 1937. 113/

The Diversion Dam reconstruction was essentially a duplication of the original Dam. "The cross section of the new ogee spillway was identical with that of the original Dam except that the apron on the downstream side was lengthened 12 feet and terminated at the downstream edge in dentated sills" to dissapate the force of the spilling water. The two remaining original spillway walls which were still in place were incorporated into the new structure. The Dam's length was increased by removing the old "U" abutment at the north end and extending the spillway 85 feet. Another sloping abutment was constructed at the end of the extension with reinforced concrete. Rock riprap was placed on both upstream and downstream sides of the Dam. The new Diversion Dam was capable of safely discharging a maximum of 150,000 cfs. 114/ (See Appendix II.)

Work on the reconstructed Diversion Dam was supervised by F. E. Stearman who represented the Daley Corporation in its Arizona work, and O. Greer. Laborers were retained from the Works Progress Administration (WPA) relief rolls and from union lists in both Globe and Phoenix. 115/

The Dam was completed on 6 February 1937. On the very next day the river began to rise and a flood discharging between 65,000 cfs to 75,000 cfs was recorded that evening. When the flood had abated it was revealed that "a large hole had been scoured out immediately downstream from the Dam near the left end of the ogee spillway section." A large amount of the downstream riprap had also been either washed away completely or lowered significantly.

Due to the threat of another winter flood, immediate but temporary repair of the Dam's apron was made. Repair was in the form of rock and cobble-filled wire mesh baskets. The baskets were placed in the scoured hole and along the downstream edge of the Dam from the sluiceway structure at the south end to the center of the Dam. This work was completed by 12 March. Permanent repair work on the apron began in September. 116/

Gates & Huntley of Los Angeles, California, received the contract to repair the Diversion Dam apron. Under the supervision of Charles T. Gates, partner in the firm, and Philip Hutzell, general foreman, the work began on 9 September 1937.

Laborers were again obtained from union lists in Globe and Phoenix. 117/

After diverting the flow of the river, the work consisted of excavating the apron's length and removing several portions of the original Diversion Dam which now obstructed progress. The new apron which extended an additional 25 feet was constructed in 12 panels of 18 inch reinforced concrete. This apron, like the existing one, terminated in dentated sills. Work was completed on 1 December 1937. 118/

Gates & Huntley also performed a variety of other repairs to both the Diversion Dam and Power Canal. In addition to the apron extension, they constructed "a removable structural steel trash rack in twelve sections . . . in front of the gates of the intake structure." 119/ Gates & Huntley were also responsible for repairing the badly cracked Intake Tunnel, the nearly collapsed Gray Tunnel, replacing a cut and cover south of Porter Springs with a siphon, replacement of a redwood flume with a siphon 1.25 miles upsteam from Roosevelt Dam, and the restoration of several Power Canal sections with gunite lining. 120/ Gates & Huntley fulfilled their contractual agreement on 17 March 1938.

The Power Canal rehabilitation was also performed by government and Association work forces. The government, with a work force of approximately 18 men, constructed 22 redwood flumes, 20 as replacements and two as new structures. They built three wasteways to regulate accumulated storm water in the Canal, repaired the sand trap located .75 miles below the Diversion Dam, repaired various culverts, constructed 31 inspill chutes, and lined various sections with plaster and concrete. The government completed its work on 18 February 1938. 121/

The Association's work consisted primarily of excavation and road building. Under the direction of Calvin Kirk, a work force varying from 15 to 30 men removed fallen rocks from the 1.25 mile lined Canal section near Roosevelt Dam and removed 200,000 cubic yards of accumulated silt from the Canal. The Association also constructed six timber road bridges and four adobe houses for maintenance men. A new gate hoist was placed at the sandbox and a gasoline powered direct current motor generator set, and electric hoisting motors for the intake gates and sluiceway at the Diversion Dam were installed. The Association completed the rehabilitation work, and on 18 May 1938, the Power Canal and Diversion Dam were once again in operation supplying 200 cfs to the power house at Roosevelt Dam. The cost of the rehabilitation work was put at $368,000. 122/ (See Appendix III.)

The renovation of the Diversion Dam and Power Canal occurred at a very propitious time for the Association. The last years of the 1930s yielded very little rainfall. By December of 1938 the level of the reservoir at Roosevelt was 50 feet. Power output at Roosevelt Dam for 1938 was considerably less than 1937, despite the use of the Power Canal. 123/ In 1939 rainfall again was slight and power production for the year dropped below the

1938 level. 124/ By June of 1940 the reservoir at Roosevelt was nearly empty, and for the year the reservoir only used 12,000 acre feet more than that carried by the Power Canal to generate power. 125/

Fortunately for the Association the drought did not persist beyond 1940. In 1941 the average precipitation for the state of Arizona was a record 21.23 inches. By 13 April 1941, the reservoir at Roosevelt was filled and the spillway gates opened. 126/ With the reservoir full the Power Canal was shut down on 20 March 1941. 127/ Though no reason is given for this action in the Annual History of 1941, it would appear obvious that the supply of power generated with reservoir water at Roosevelt Dam and the other Project dams sufficiently met the demand. 128/ The Power Canal remained unused for the remaining nine months of 1941.

In 1942 the year's weather once again developed "a droughty condition," but the Power Canal was not put back into operation. This decision can be attributed to the great amount of water stored in 1941 and the production of power at the Crosscut steam plant and the purchase of power from Boulder Dam. 129/ Although unused, the Power Canal was serviced in 1942. A battery charging generator was added to the gas engine for the intake gates at the Diversion Dam, and the sluice valves at the Pinto Creek pressure pipes were inspected and repaired. 130/

Despite the tremendous demand for power from 1942 through 1945, primarily a result of the war effort, records show that the Power Canal remained unused. 131/ It did not carry any water for these three years. As a consequence of remaining idle, the Canal began to fall into a state of disrepair.

By 1946, however, run off into the reservoir dropped again and therefore the Power Canal was brought back into service. On 2 August of that year, with the reservoir impounding less than a third of its capacity, the Power Canal became operational. 132/ Because the Canal had not been used in over five years, $100,000 was expended in 1946 on repair work along the Canal line. The work consisted primarily of rehabilitation work to the Canal tunnels. 133/

For the next six years the Canal provided power to the Association. Water stored at Roosevelt for this period was so low that little power could be generated from reservoir water. In 1947 the reservoir was dry for 33 days in July, August and September of that year. In 1948 the peak storage amount was only 10 percent of the reservoir's capacity. In 1949 storage nearly reached 500,000 acre feet but by the end of 1950 the reservoir stored only 2,400 acre feet of water. In 1951 maximum capacity of 131,000 acre feet was held for only two days in September. 134/

The drought condition in central Arizona abated quickly in 1952. From 31 December 1951 to 6 January 1952 the Roosevelt reservoir jumped 92,000 acre feet in water stored. By May the reservoir impounded over a million acre feet of water. With the reservoir rapidly filling the Power Canal was put out of service on 28 March 1952. 135/

Only a year later the Power Canal began again to deteriorate. The Intake Tunnel had settled considerably and cracked. The Canal gates and sluice gates needed lubrication; the Pinto Creek area needed repair along with Teichman's revolving screen at the forebay of the Penstock Tunnel. At the Diversion Dam the dentated sill blocks at the end of the apron were either damaged or broken. 136/

The disrepair of the Power Canal was reported again three years later in 1956 in a U.S. Bureau of Reclamation report. This report stated that, "much of the Canal had been lost due to lack of maintenance." However, by 1956, the fate of the Canal had been determined. In the same report it was observed, "the water users [Association] estimated that it would cost some $500,000 to rehabilitate the canal for serviceable use for power development at the Roosevelt power plant and stated that the benefits to power would not justify the cost." 137/

In the 1950s the Association was generating power at four Salt River dams and was purchasing power from dams on the Colorado River. The Association also generated power at their Crosscut facility and at their new steam generating plants at Kyrene and Agua Fria. The power generated by the Power Canal was therefore minimal by comparison. To expend half a million dollars to repair the Diversion Dam and Power Canal would be useless since they were now only a minor accompaniment to the entire power system. By the 1950s, the Association simply outgrew the usefulness of the Power Canal and Diversion Dam.

From the 1950s to the present, the Power Canal and Diversion Dam have remained unused and unserviced. Consequently, these structures are continually deteriorating. While the Diversion Dam remains basically intact, the Power Canal is greatly damaged in places. Some tunnels are either completely silted in or have collapsed. Flash flooding has broken or eroded the line in many places, and silting, vegetation and pooling water have obscured certain parts of the system. Many of the flumes and bridges are broken or gone, and in two locations reinforced steel bars extend openly and outwardly from broken concrete structures. The Penstock Tunnel was also altered, not by weather conditions, but by the Association. In 1972 the upstream entrance to the Penstock Tunnel just downstream from Teichman's trash rack screen was backfilled with concrete. 138/

By concreting the Penstock Tunnel entrance the Association terminated any hope of revitalizing the Power Canal and Diversion Dam. 139/ Instead, the Association is presently considering destroying the Diversion Dam and various parts of the Power Canal. Due to the increase of recreational activities in this still remote area, the Association desires to limit the potential risk of injury along the Canal line by removing or modifying a number of features. It has been estimated by Association officials that the removal or demolition cost of the Diversion Dam would amount to $100,000.

The Roosevelt Power Canal has become long overshadowed by the tremendous growth of both the Bureau of Reclamation and the Salt River Project. It has therefore become an outdated and inessential component to both these agencies. Today the Bureau of Reclamation operates over 300 reservoirs and 50 power plants, while the Project operates seven dams, several steam power plants and a share in a developing nuclear powered generating station. Nevertheless, historically the Power Canal was a significant engineering accomplishment primarily due to innovative design and engineering skill. The Reclamation Service planned the Canal not as a secondary or ancillary feature of Roosevelt Dam but as an integral part of the Salt River Project system. Its purpose was to provide electrical power in the construction of Roosevelt Dam, to initiate the commercial sale of power by Reclamation, and to pump groundwater. With the addition of other power facilities to the Project, the role of the Power Canal has diminished to its present state of disrepair. Despite its lack of utility to the Project today, the Power Canal was vital to the beginning of federally sponsored reclamation in the West.

APPENDIX I

Map in 13 sheets drawn by the Reclamation Service in 1907 showing the original Power Canal line from the Diversion Dam to Roosevelt Dam.

LIST OF STRUCTURES

No	STRUCTURE
	Intake.
0A	48" Drainage Flume
0B	Road Bridge
0C	Sand Box with One Sluice Gate
0D	Overflow Wier
1A	120" Drainage flume.
1B	Road Bridge
1C	90" Drainage Flume
1D	60" " "
1E	108' Cut & Cover
1F	122' Tunnel (Lee)
2A	24" Pipe Culvert
2B	24" " "
2C	5 Ft. Arch Culvert.
2D	428' Tunnel.
2E	Concrete Drainage Flume
2F	129' Tunnel.
2G	271' "
2H	9' Square Culvert
2I	Road Bridge
3A	151.4' Tunnel near Wehnli Place
3B	30" Drainage Flume
3C	11'-6" Double Culverts
3D	Road Bridge
3E	Two Sluice Gates
3F	Overflow Wier
3G	30" Drainage Flume
4A	Road Bridge
4B	Double Culvert, 16" Pipe
4C	30" Pipe Culvert
4D	48" Dranage Flume.
4E	30" Pipe Culvert
4F	5 Ft Arch Culvert
5A	30" Pipe Culvert
5B	5 Ft Arch Culvert
5C	Double Culvert 30" Pipe
5D	Overflow Weir
5E	Sluice Gates at Pinto Set. Basin
5F	Ent. Gates, Pinto Press. Pipe

No	STRUCTURE
	Pinto Pressure Pipe
6A	Exit Gates, Pinto Press. Pipe
6B	999' Tunnel near Pinto Cr.
6C	60" Drainage Flume
6D	11'-6" Arch Culvert
7A	Road Bridge
7B	16" Pipe Culvert
7C	24" " "
7D	30" " "
7E	30" Pipe Double Culvert
7F	16" Pipe Culvert
	Sluice to Government Farm.
7G	16" Pipe Culvert
7H	3' Arch Culvert
7I	1026.5' Tunnel (Chilton)
8A	16" Pipe Culvert
8B	30" " "
8C	30" " "
8D	72" Drainage Flume
8E	151.7' Tunnel (Robinson)
8F	84" Drainage Flume
8G	90" " "
8H	24" Pipe Culvert
8I	48" Drain
8J	761 Ft Tunnel (Grey)
9A	5 Ft. Arch Culvert
9B	5 Ft. " "
9C	48" Drainage Flume
9D	213.5 Ft. Tunnel (Moffat)
9E	4 Ft Arch Culvert
9F	5 Ft " "
9G	30" Drainage Flume
9H	872.2 Ft Tunnel (Grapevine)
10A	11'-6" Double Culvert
10B	30" Drainage Flume
10C	Overflow Wier
10D	Two Sluice Gates
10E	30" Dramage Flume.

No.	STRUCTURE.
10F	30" Drainage Flume
10G	8 Ft Arch Culvert
10H	4 Ft " "
11A	30" Drainage Flume
11B	30" " "
11C	8 Ft Arch Culvert.
11D	93 Ft. Cut & Cover (Sch. Hz. Wash)
11E	30" Drainage Flume
11F	206' Tunnel (Old No. 6.)
11G	4 Ft Arch Culvert.
11H	4 Ft " "
11I	341.6 Ft Tunnel (Old No. 7)
12A	48" Drainage Flume.
12B	9 Ft Arch Culvert.
12C	553.2 Ft. Tunnel (Old No 8)
12D	16" Pipe Culvert
12E	94 Ft Cut & Cover
12F	30" Dranage Flume
12G	48" Drainage Flume
12H	4 Ft Arch Culvert
13A	30" Pipe Culvert
13B	6 Ft Arch Culvert.
13C	16" Arch Culvert
13D	320.1 Ft Tunnel (Old No 9)
13E	489.4 Ft " (Old No 10)
13F	50' Cut & Cover
13G	48" Drainage Flume
13H	30" " "
13I	624.6 Ft Tunnel (Old No 11)
13J	100 Ft. Cut & Cover
14A	4 Ft Arch Culvert
14B	30" Pipe Culvert
14C	6 Ft Arch Culvert
14D	30" Pipe Culvert
14E	12 Ft Arch Culvert
14F	6 Ft " "
14G	4 Ft " "
15A	8 Ft " "

No	STRUCTURE.
15B	4 Ft. Arch Culvert
15C	11'6" " "
15D	4 Ft " "
15E	12 Ft " "
15F	6 Ft " "
15G	6 Ft " "
15H	30' Cut & Cover
15I	6 Ft Arch Culvert
15J	12 Ft " "
16A	6 Ft " "
16B	Road Bridge
16C	8 Ft Arch Culvert
16D	Overflow Wier
16E	Two Sluice Gates
16F	Ent. Gates Cottonwood Press. Pipe
	Cottonwood Press. Pipe.
16G	Exit Gates Cottonwood Press. Pipe
17A	48" Drainage Flume
17B	10 Ft Arch Culvert
17C	24" Pipe Culvert
17D	Road Bridge
17E	8 Ft Arch Culvert
17F	24" Pipe Culvert
17G	20" " "
17H	24" " "
17I	12 Ft Arch Culvert
18A	Overflow Wier
18B	Aqueduct (Kelners Wash)
18C	36 Pipe Culvert
18D	6 Ft Arch Culvert
18E	Aqueduct (Whitney Wash)
18F	Road Bridge
19A	70 Ft. Tunnel (Old No. 12)
19B	Overflow Wier
19C	110 Tunnel (Old No 13)
19D	Overflow Wier
19E	Two Sluice Gates
19F	Penstock Gates

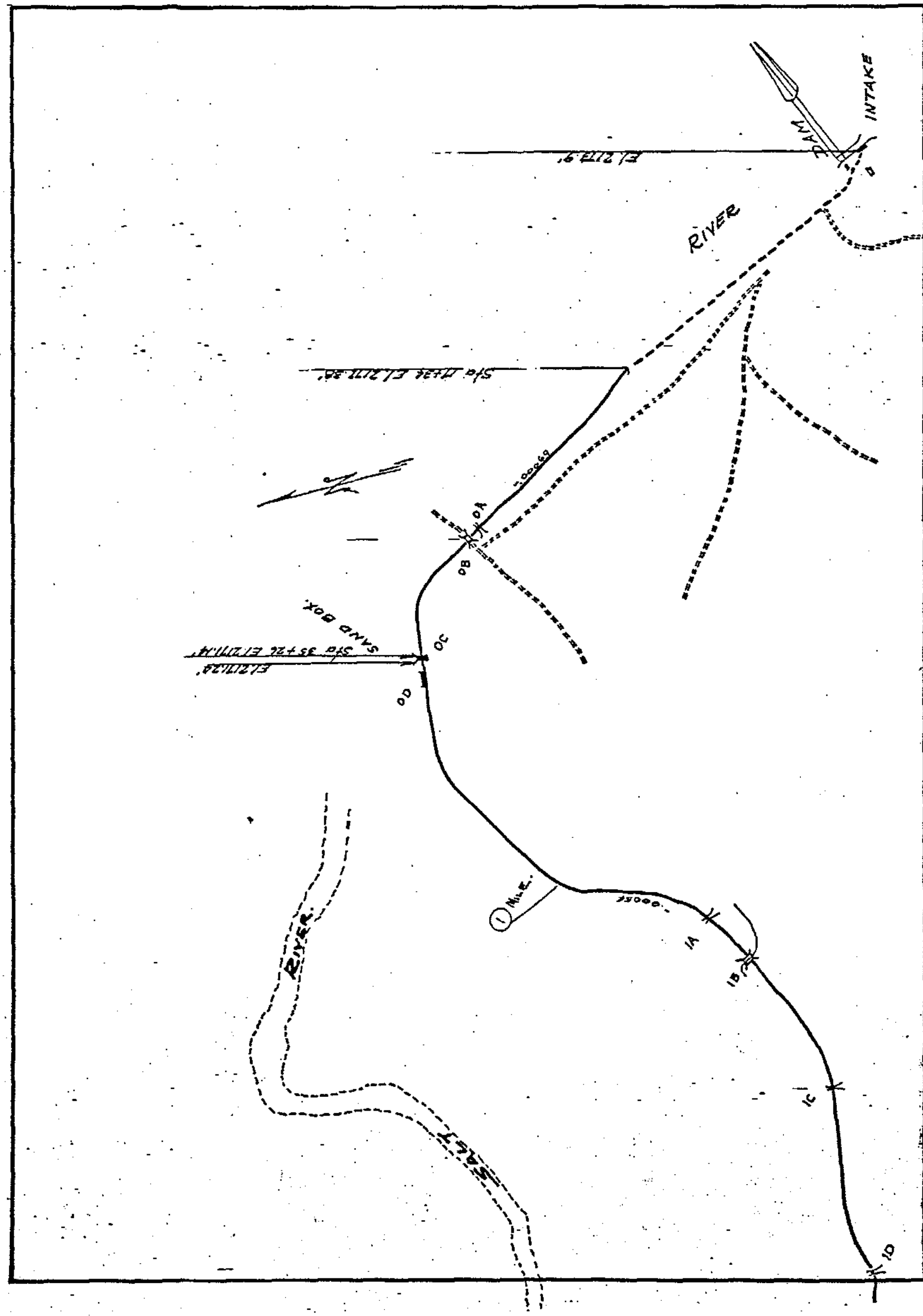
(10) — MILES ARE INDICATED FROM INTAKE TOWARD ROOSEVELT DAM

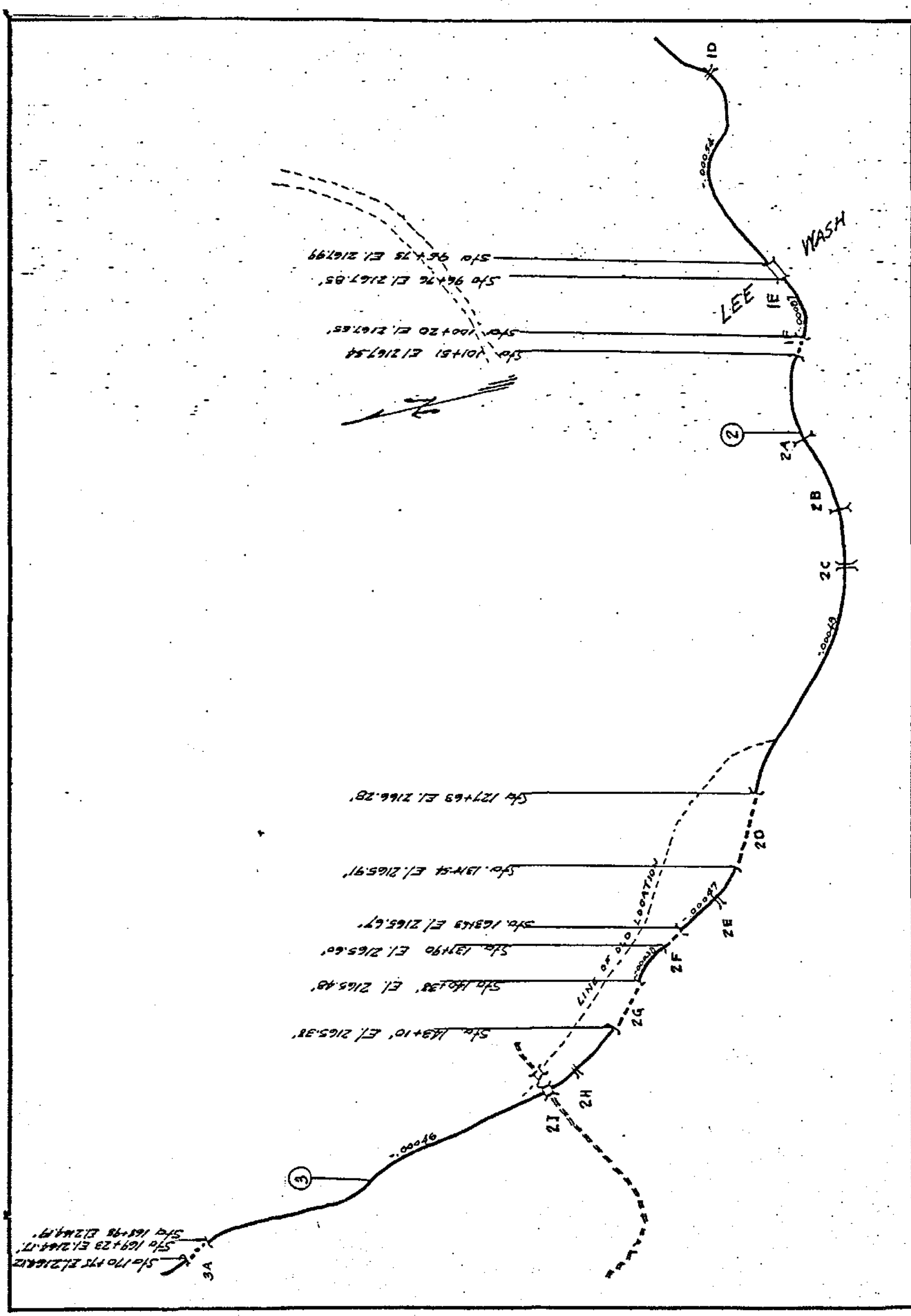
THIS LIST OF STRUCTURES WAS TAKEN FROM A REDUCTION OF THIS TRACING. REDUCTION #740 (OUR FILES)(USRS) DATED FEB., 1907, Copied, June 1935.
(Signed) J.R. Hook.

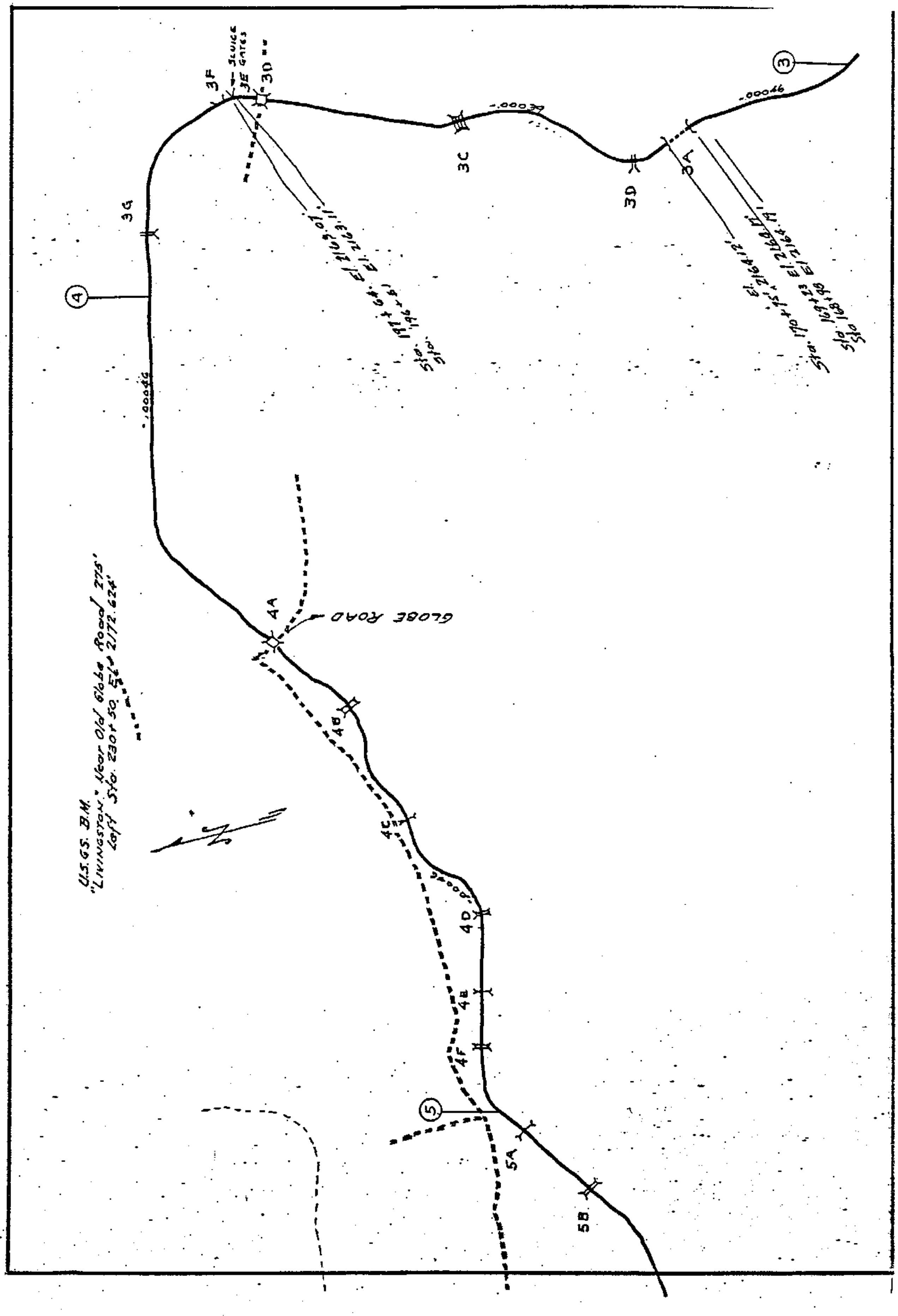
PLAN TRACED FROM U.S.R.S MAP #9261
STATION & ELEVATION DATA COPIED
FROM BR PROFILE # SR1.-6-75 ~ 4/14/41

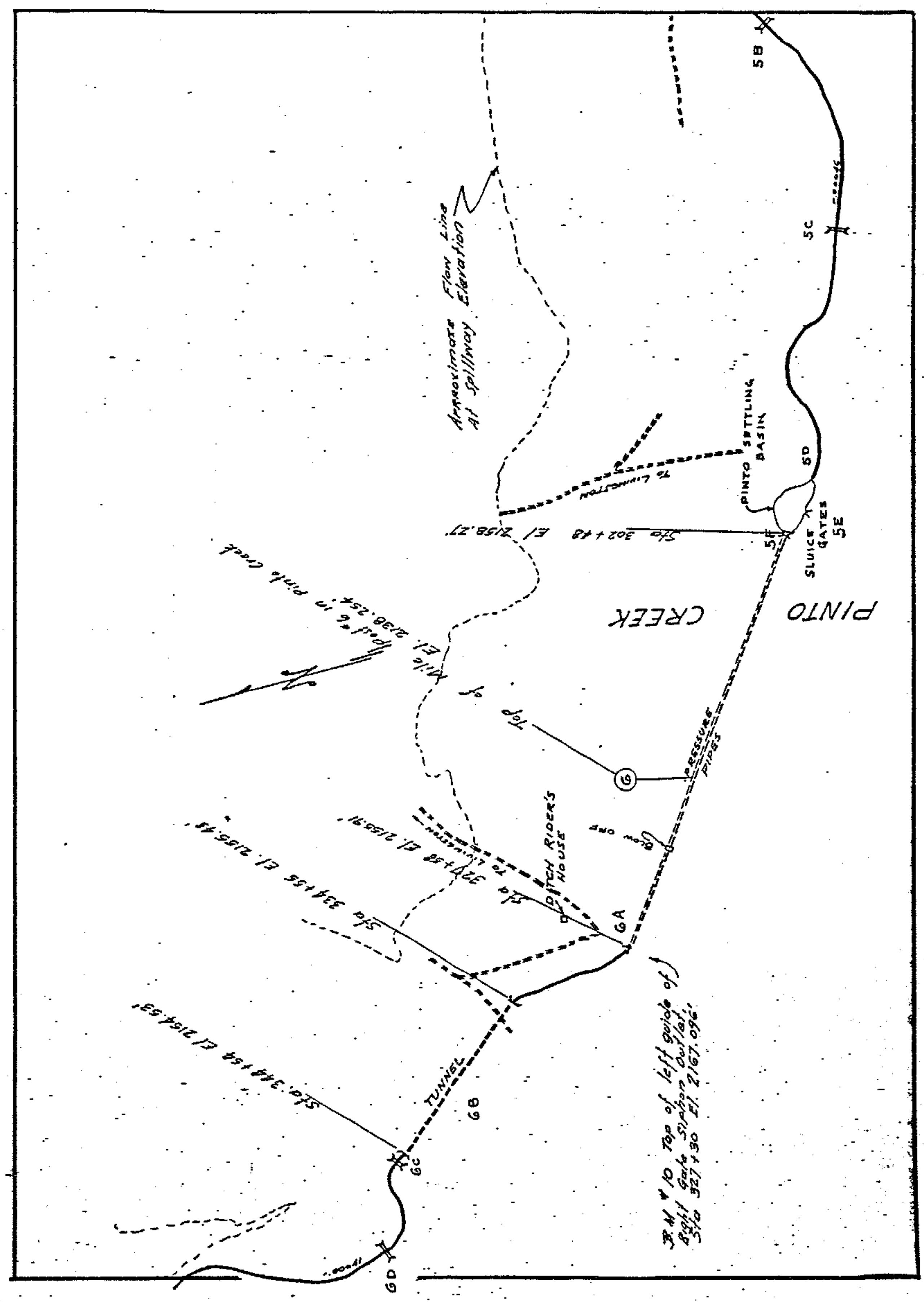
ROOSEVELT POWER CANAL

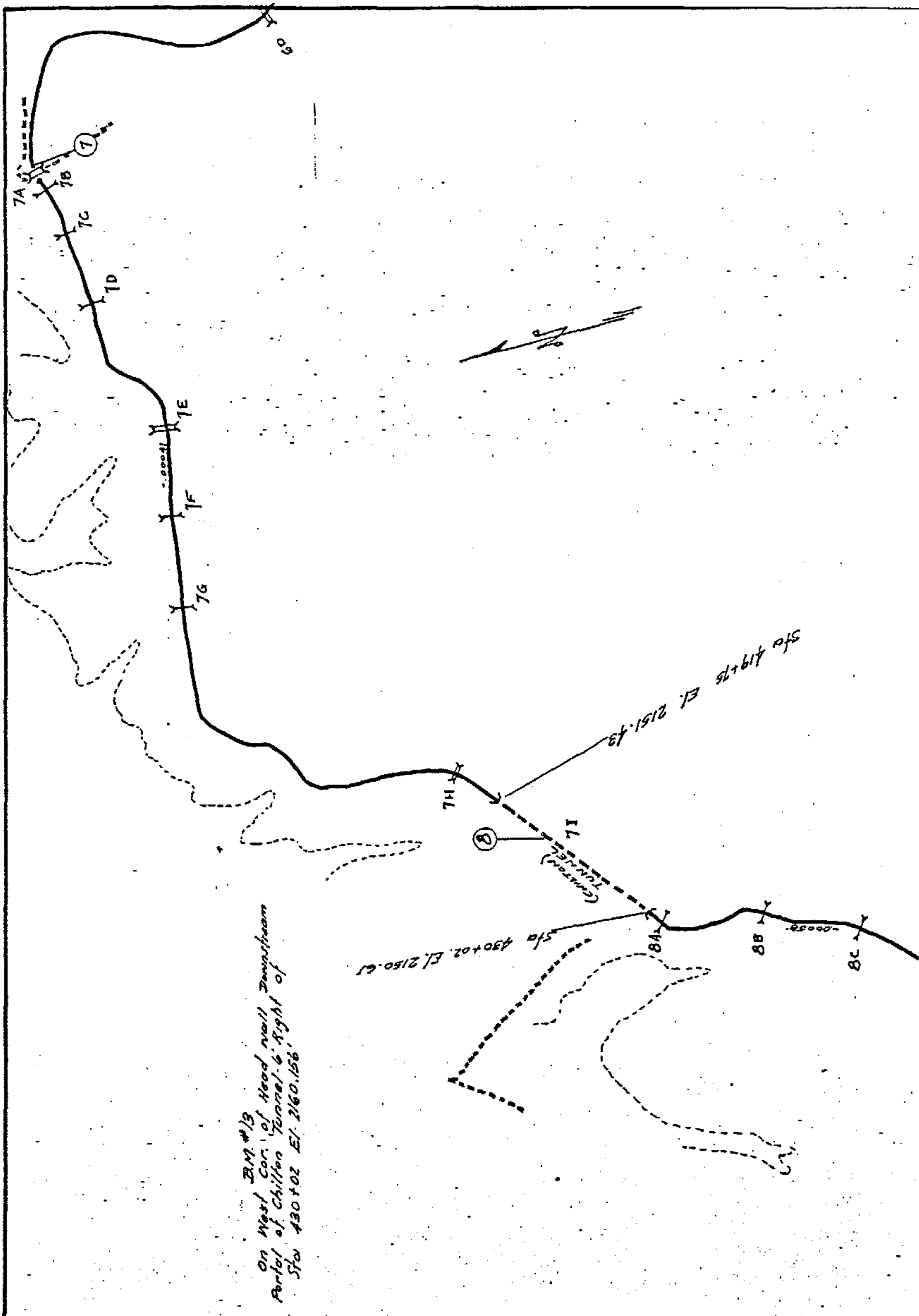
DWG. B-2-80

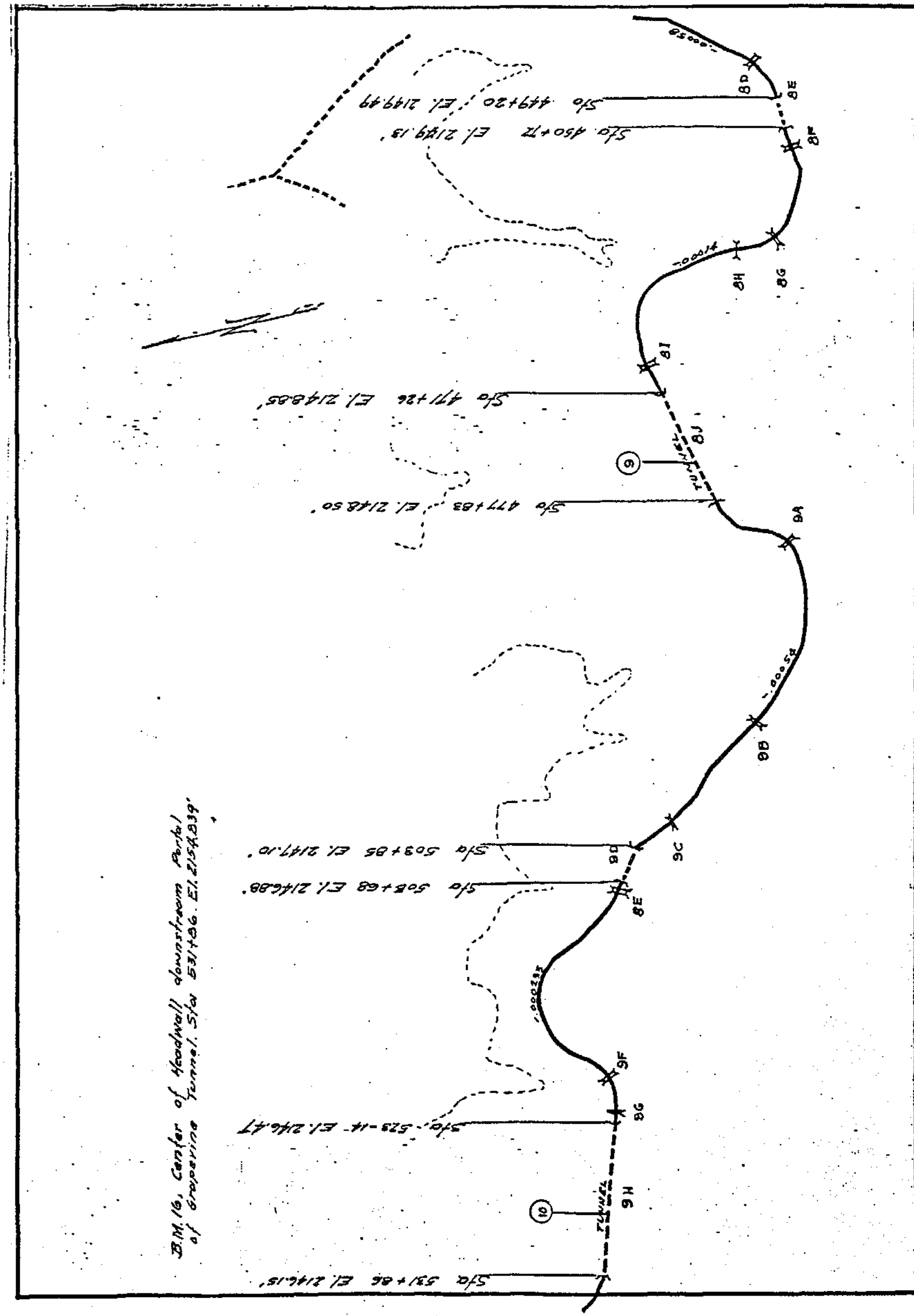

INTAKE
DAM
RIVER
SAND BOX
0A
0B
0C
0D
1 MILE
1A
1B
1C
1D
SALT
RIVER

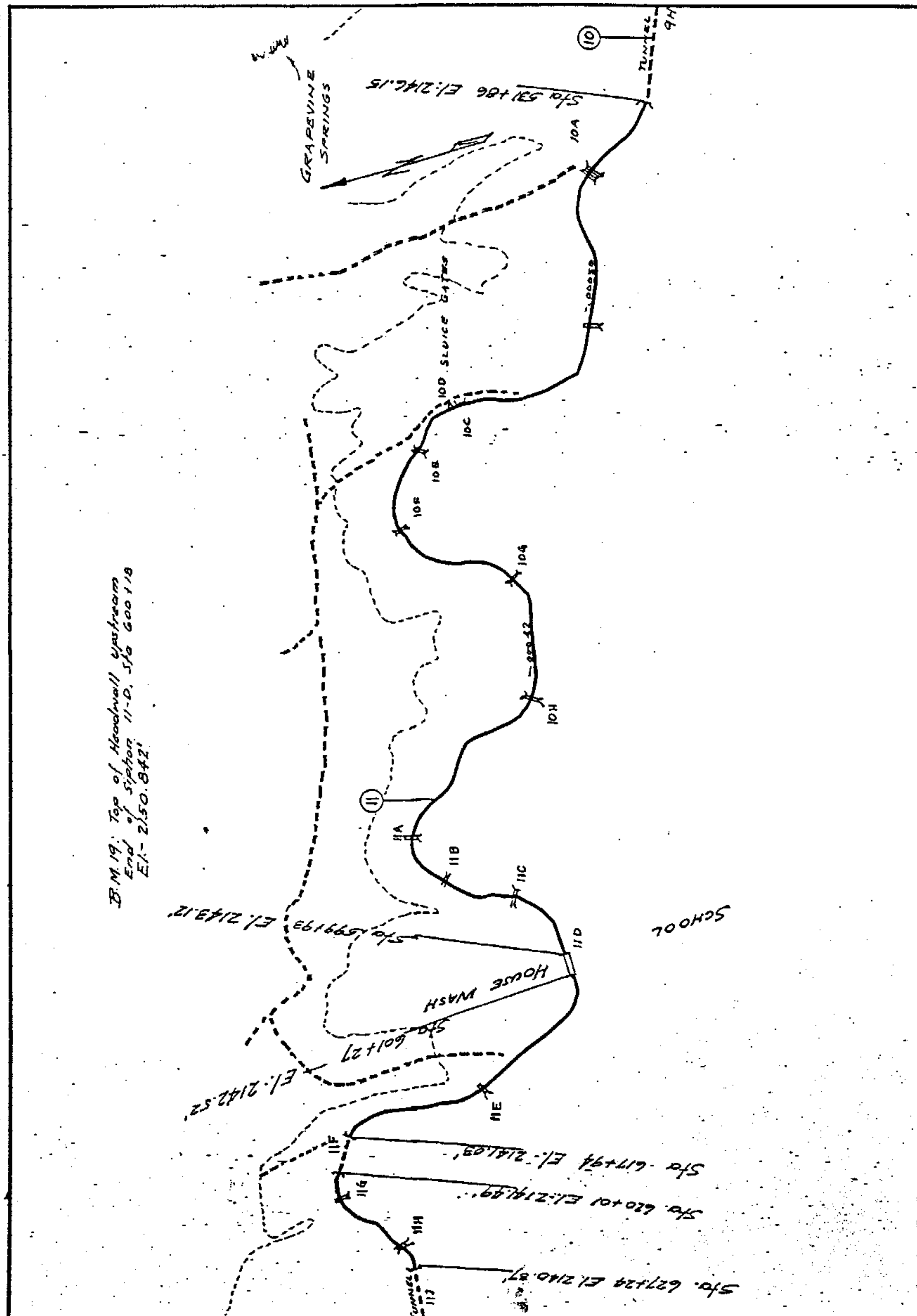

LEE
WASH
1D
1E
2A
2B
2C
2D
2E
2F
2G
2H
2I
3A
LINE OF OLD LOCATION

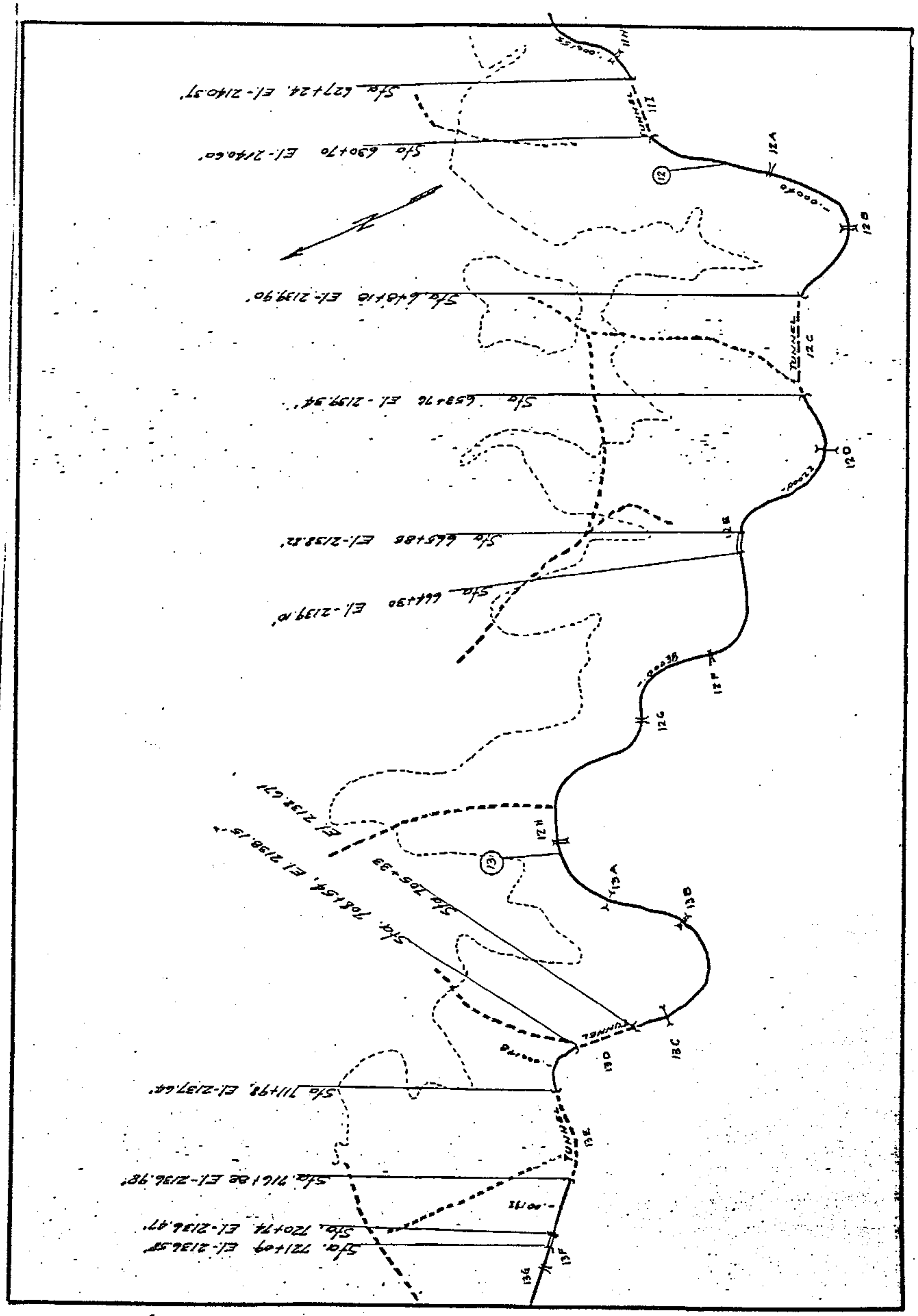

3
4
5
3A
3C
3D
3F
3G
4A
4B
4C
4D
4E
4F
5A
5B
SLUICE GATES
GLOBE ROAD
U.S.G.S. B.M.
"LIVINGSTON" Near Old Globe Road 275'
Left Sta. 230+50 El. 2172.624'

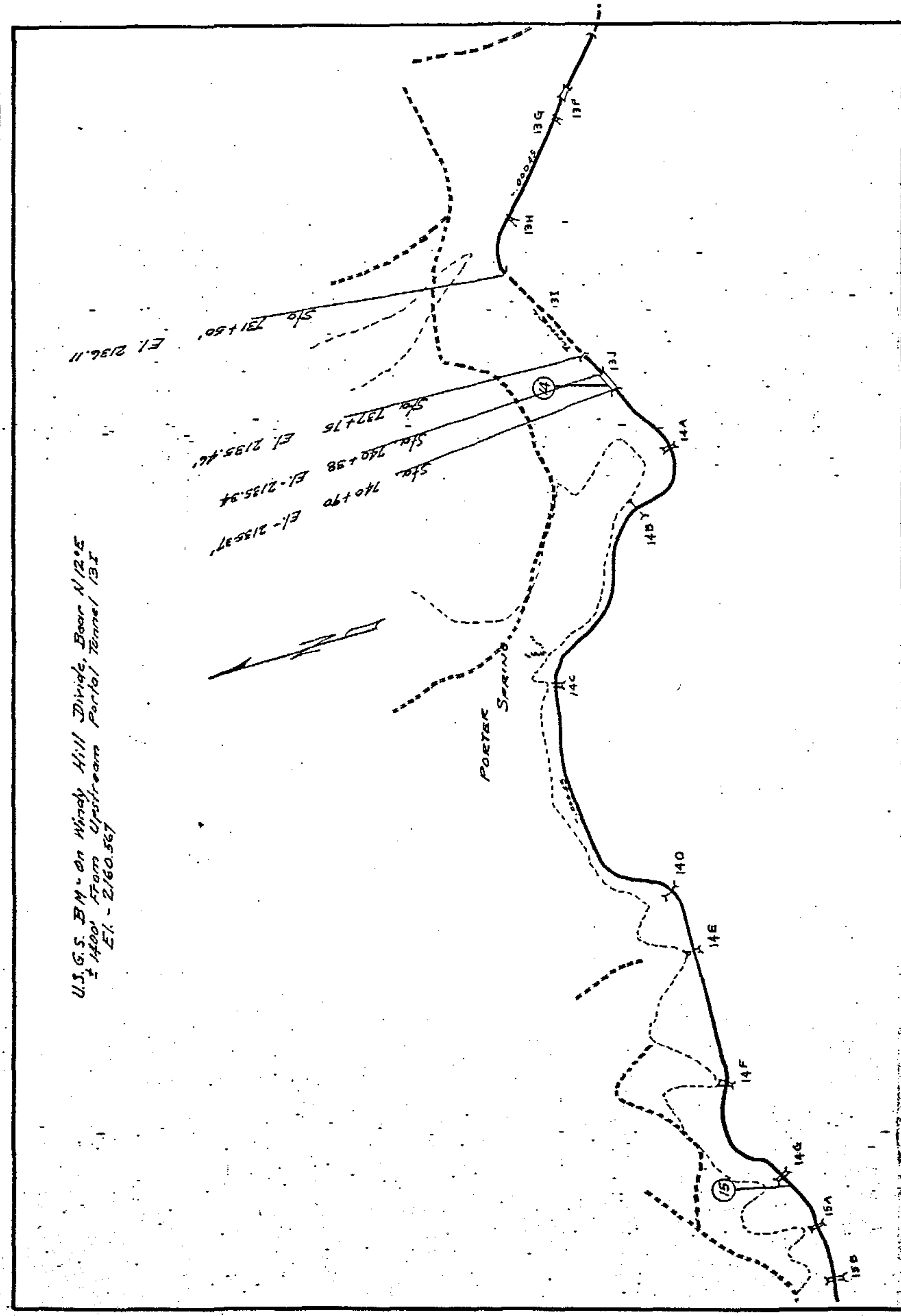

Approximate Flow Line
At Spillway Elevation
5B
5C
5D
5E
5F
PINTO SETTLING BASIN
SLUICE GATES
To Livingston
Sta 302+48 El 2158.27'
PINTO CREEK
PRESSURE PIPES
Top of
Blow off
DITCH RIDER'S HOUSE
Sta 334+55 El 2155.48'
GA
GB
GC
GD
TUNNEL
Sta. 344+54 El 2154.53'

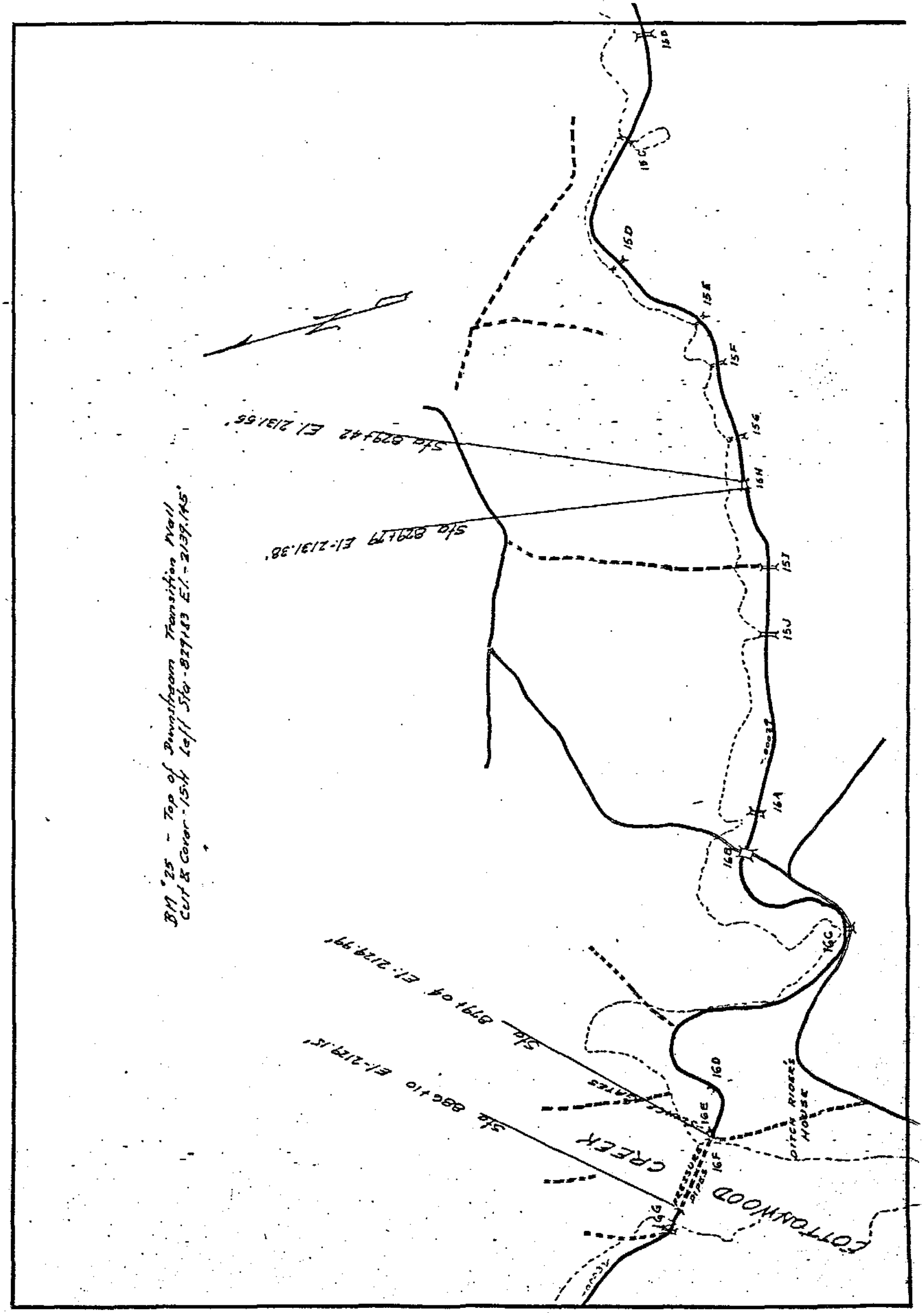

6D
7A
7B
7C
7D
7E
7F
7G
7H
7I
8A
8B
8C
Sta 419+15 El 2151.43
(Chilton) TUNNEL
Sta 430+02 El 2150.61
B.M. #13
On West Cor. of Head wall Downstream
Portal of Chilton Tunnel 6' Right of
Sta 430+02 El. 2160.156'

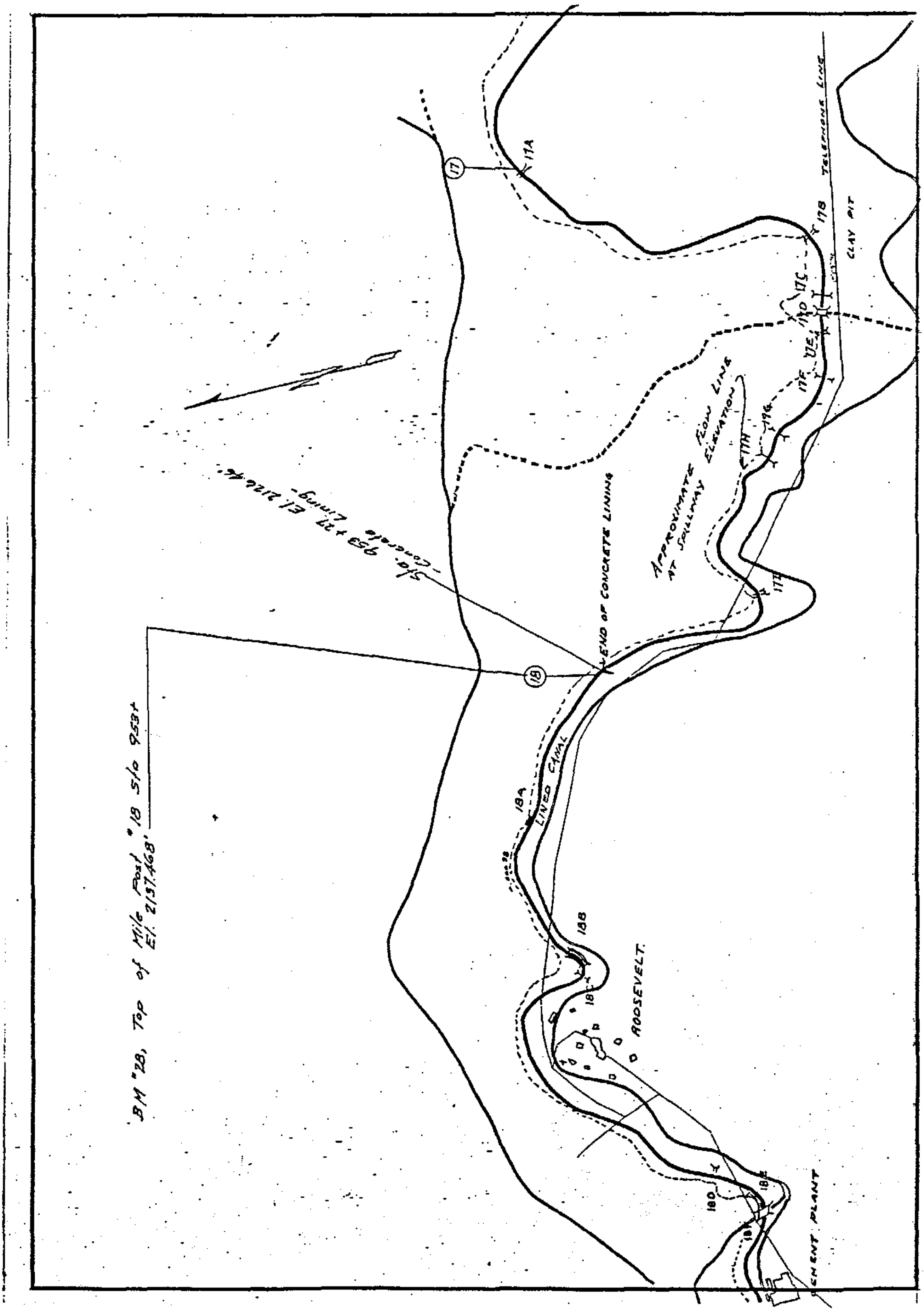

Sta 449+20 El. 2149.49
Sta 450+72 El. 2149.13'
Sta 471+26 El. 2148.85'
Sta 477+83 El. 2148.50'
Sta 503+85 El. 2147.10'
Sta 508+68 El. 2146.88'
Sta 523+14 El. 2146.47
Sta 531+86 El. 2146.15'
TUNNEL
TUNNEL
B.M. 16, Center of Headwall downstream Portal of Grapevine Tunnel. Sta 531+86. El. 2154.839'

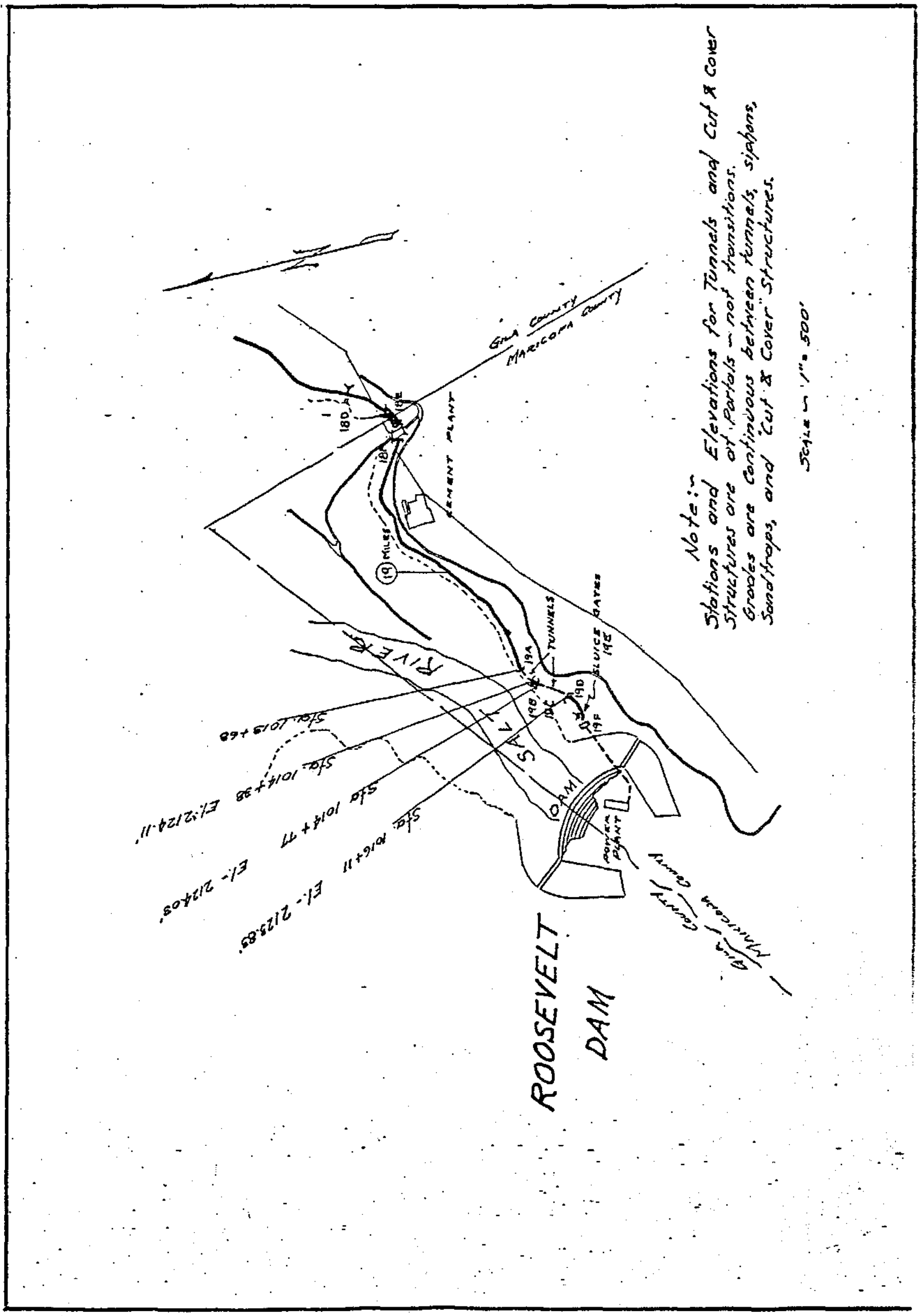

GRAPEVINE SPRINGS
TUNNEL
SLUICE GATES
SCHOOL
HOUSE WASH
TUNNEL


Sta 627+24, El-2140.37
Sta 630+70 El-2140.60
Sta 648+10 El-2139.90
Sta 653+76 El-2139.34
Sta 665+88 El-2138.82
Sta 664+30 El-2139.10
El 2138.67
Sta 708+54, El 2138.15
Sta 705+33
Sta 711+98, El-2137.64
Sta 716+88 El-2136.98
Sta 720+74 El-2136.47
Sta 721+09 El-2136.57
TUNNEL
N


U.S.G.S. BM - On Windy Hill Divide, Bear N12°E
± 1400' From Upstream Portal Tunnel 13I
El. - 2160.567
Sta. 731+50, El. 2136.11
Sta. 737+75 El. 2135.46
Sta. 740+38 El.-2135.34
Sta. 740+90 El.-2135.37
PORTER SPRING
13F
13G
13H
13I
13J
14
14A
14B
14C
14D
14E
14F
14G
15
15A
15B

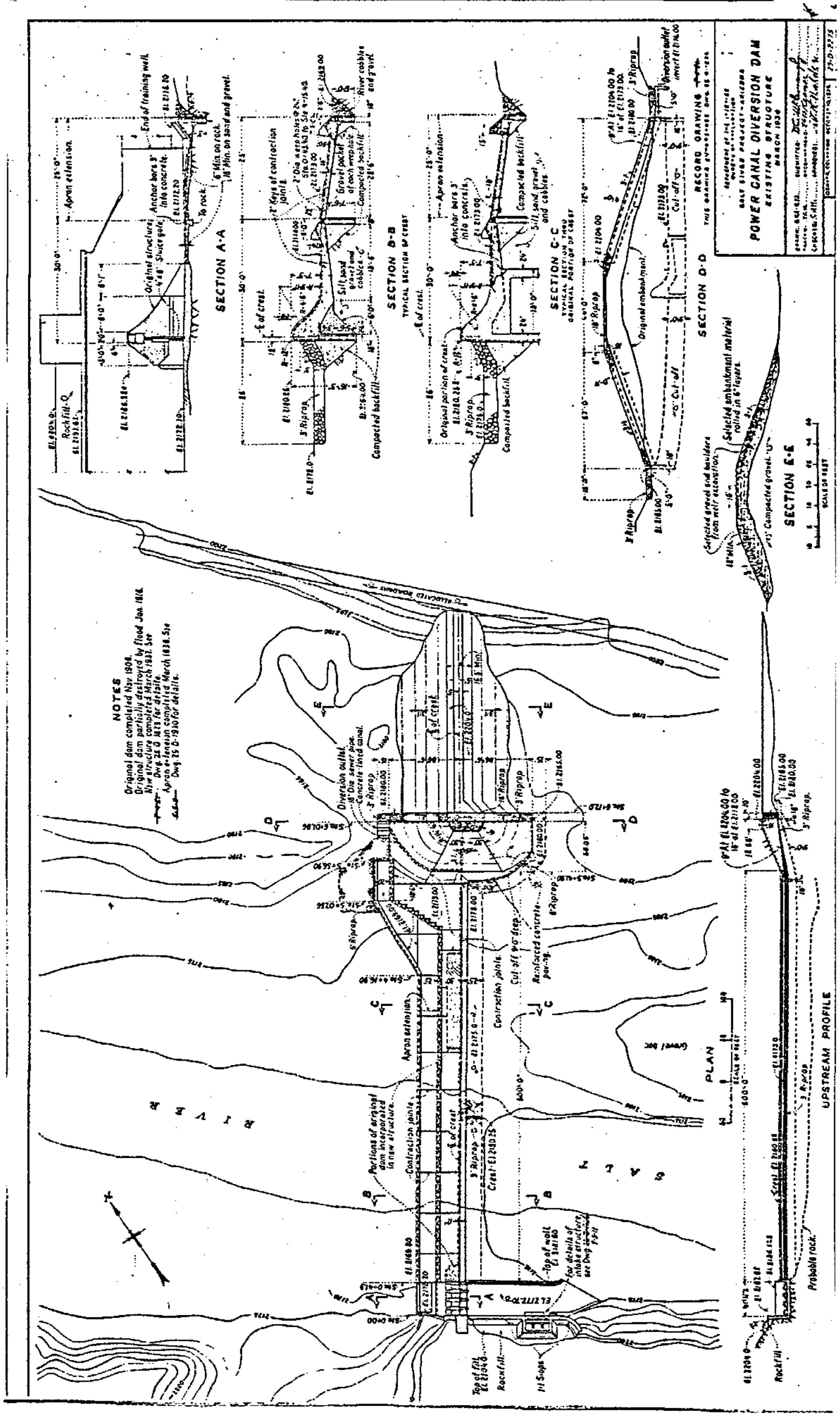

BM #25 - Top of Downstream Transition Wall
Cut & Cover 15.4 Left Sta. 829+83 El. 2137.145'
Sta 829+42 El. 2131.55'
Sta 829+79 El. 2131.38'
Sta 879+04 El. 2129.99'
Sta 880+10 El. 2129.15'
COTTONWOOD
CREEK
DITCH RIDERS HOUSE
PRESSURE PIPES
15D
15E
15F
15G
16H
16A
16B
16C
16D
16E
16F
16G


BM #28, Top of Mile Post #18 Sta 953+
El. 2137.468'
Sta. 953+27 El 2126.46
-Concrete Lining-
END OF CONCRETE LINING
APPROXIMATE FLOW LINE
AT SPILLWAY ELEVATION
LINED CANAL
ROOSEVELT
TELEPHONE LINE
CLAY PIT
17
17A
17B
18
18A
18B


Note:-
Stations and Elevations for Tunnels and Cut & Cover Structures are at Portals - not transitions.
Grades are continuous between tunnels, siphons, Sandtraps, and "Cut & Cover" Structures.
Scale - 1" = 500'
GILA COUNTY
MARICOPA COUNTY
CEMENT PLANT
19 MILES
TUNNELS
SLUICE GATES
SALT RIVER
DAM
POWER PLANT
Sta. 1013+68
Sta. 1014+38 El. 2124.11
Sta 1014+77 El.- 2124.05
Sta. 1016+11 El.- 2123.83
ROOSEVELT DAM
Gila County / Maricopa County

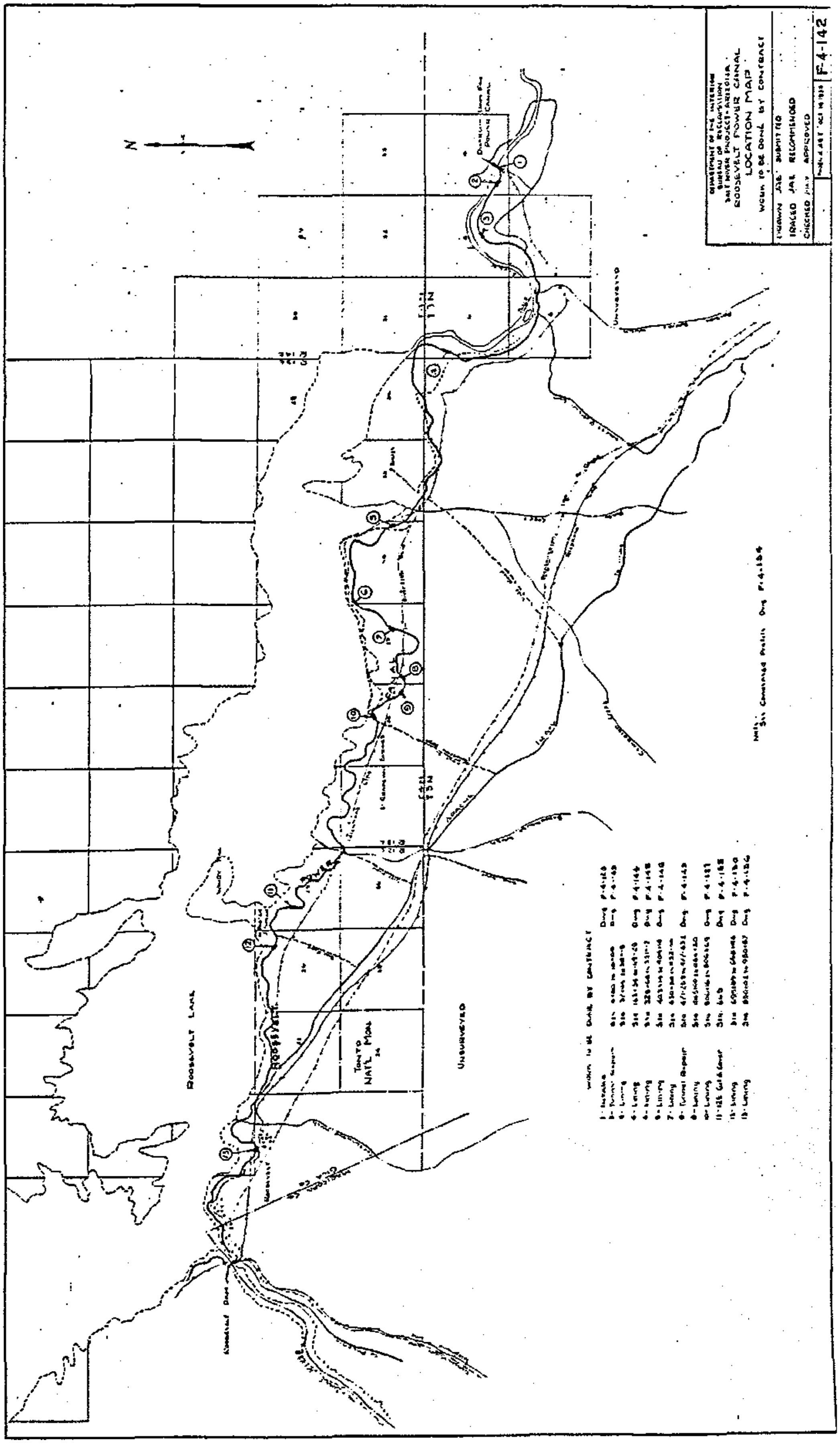
APPENDIX II

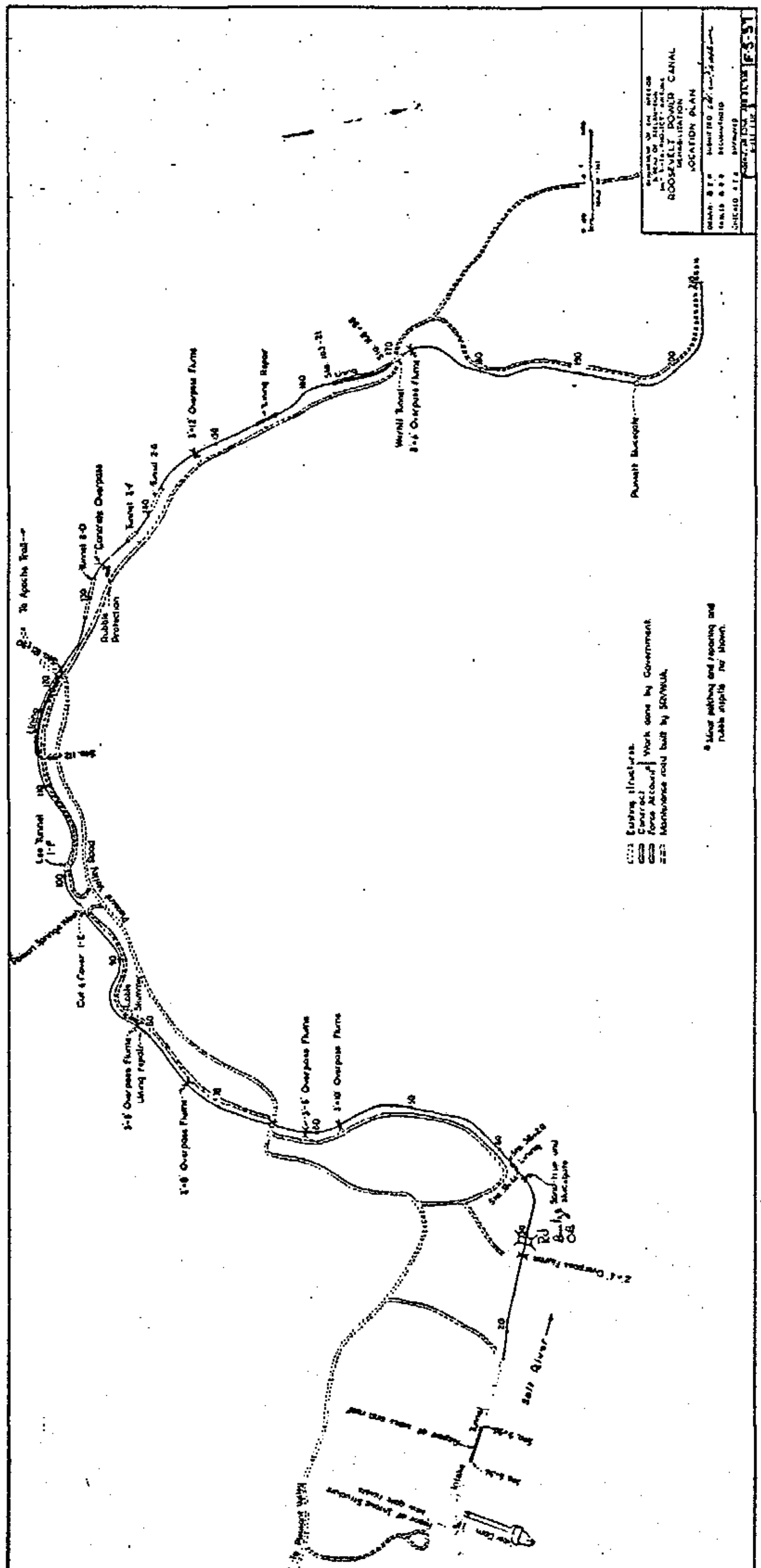
Drawing by the Reclamation Service showing the reconstructed Diversion Dam.

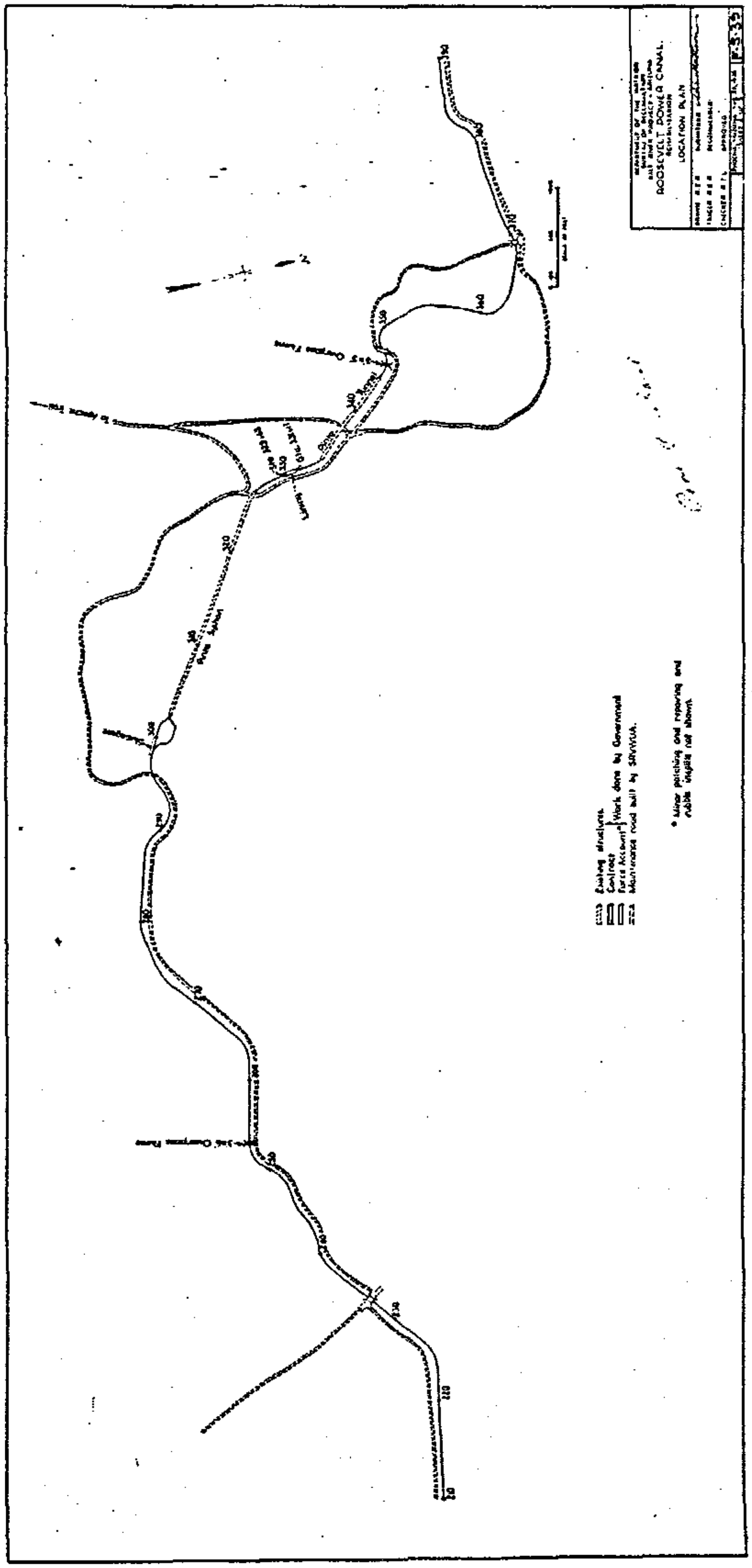

POWER CANAL DIVERSION DAM
RECORD DRAWING
SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D
SECTION E-E
NOTES
PLAN
UPSTREAM PROFILE

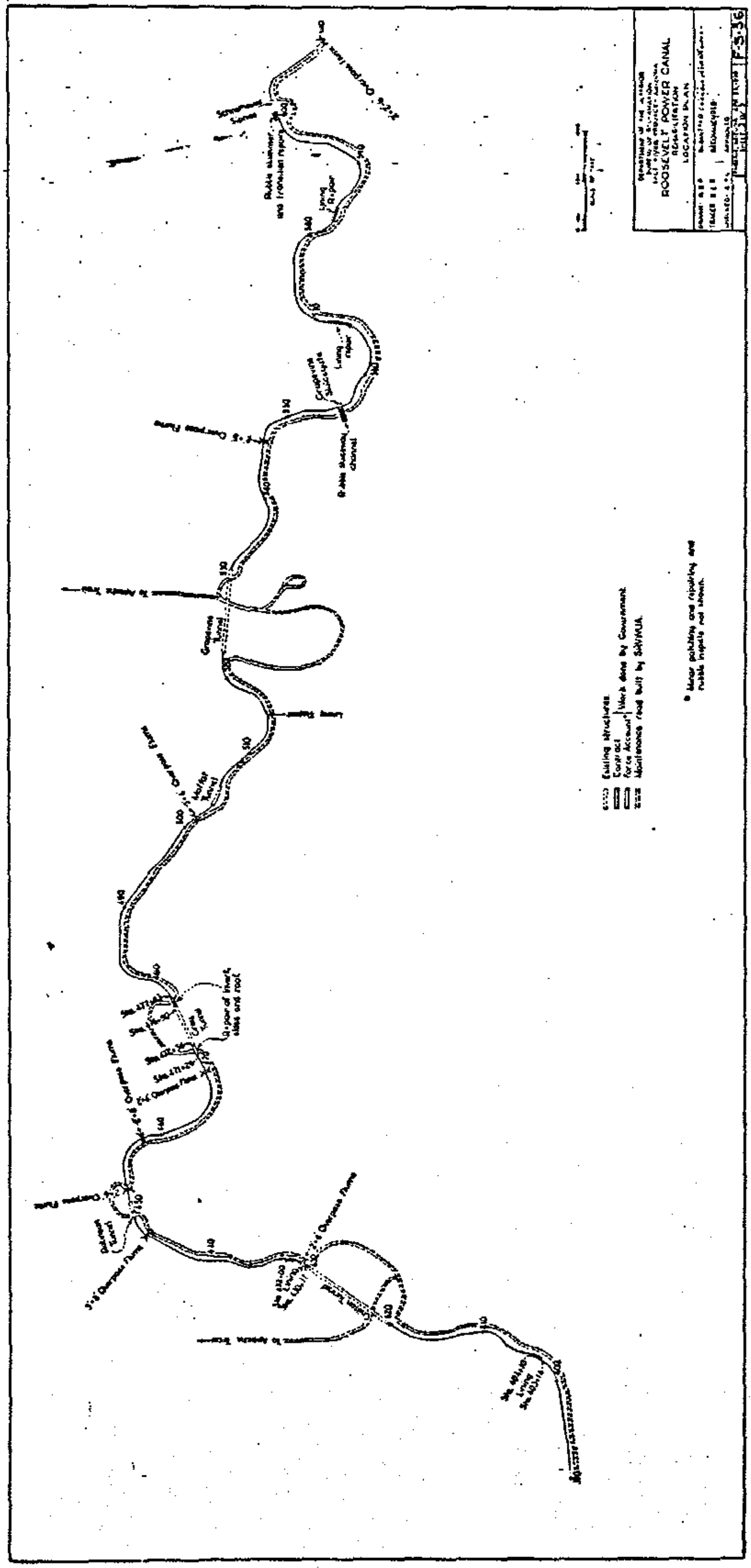
APPENDIX III

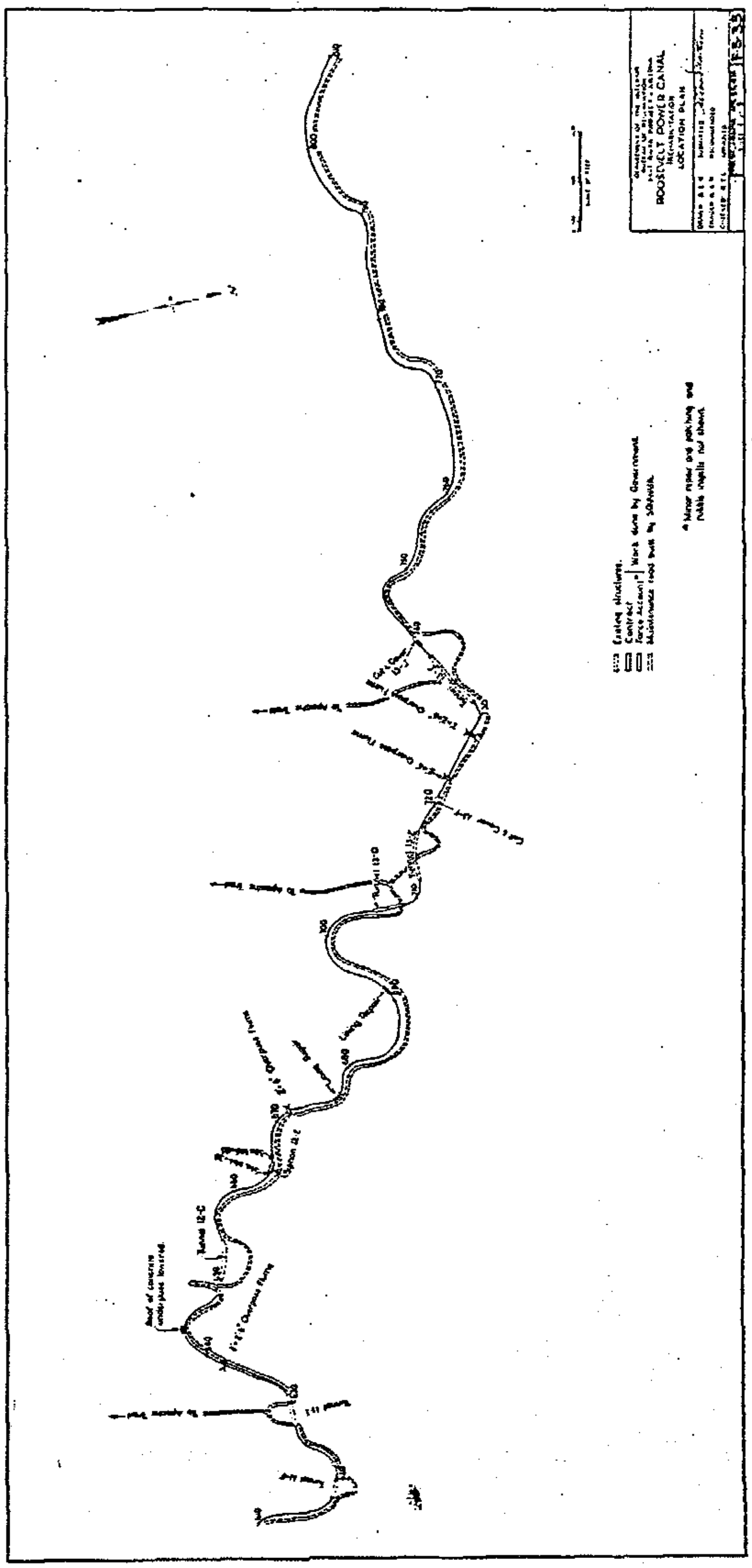
The first drawing shows rehabilitation work done under contract on the Power Canal. The remaining five drawings show all the rehabilitation work done on the Power Canal. All six sheets prepared by the Reclamation Service.

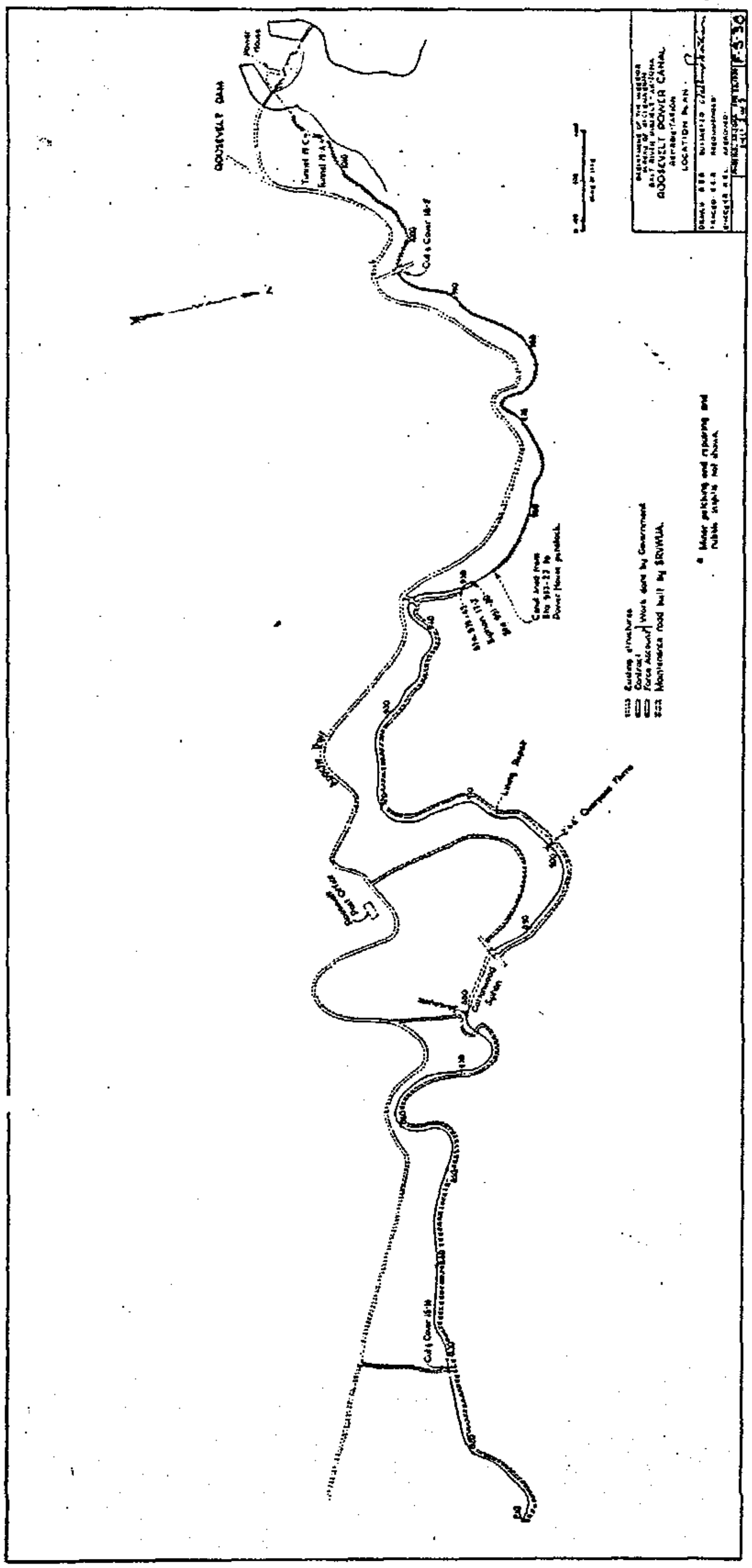

F-4-142
ROOSEVELT LAKE
UNSURVEYED
TONTO NAT'L MON.




ROOSEVELT POWER CANAL
LOCATION PLAN
Existing structures
Contract
Force Account*
Work done by Government
Maintenance road built by SRVWUA.
* Minor patching and repairing and rubble inverts not shown.




ROOSEVELT POWER CANAL
LOCATION PLAN


ROOSEVELT DAM
ROOSEVELT POWER CANAL

NOTES

1. 32 Stat. 388. In addition to the 16 original states and territories, the state of Texas was added in 1905 and 1906.

2. Leahmae Brown, "The Development of National Water Policy with Respect to Water Resources" (Ph.D. dissertation, University of Illinois, Urbana, 1937), pp. 92-94; U.S., Department of Interior, Reclamation Service, Third Annual Report of the United States Reclamation Service, 1903-1904 , (Washington: Government Printing Office, 1904), p. 130.

3. Arthur P. Davis, Water Storage on Salt River, Arizona, Water Supply and Irrigation Paper of the U.S. Geological Survey, No. 73, (Washington: Government Printing Office, 1903), p. 35; U.S., Department of Interior, Reclamation Service, First Annual Report of the United States Reclamation Service, (Washington: Government Printing Office, 1903), p. 91-102. The dam was eventually built to a height of 284 feet from lowest foundation to the top of the parapet. The increase in height enabled the reservoir to store substantially more water.

4. In the original construction plans for Roosevelt Dam there were no provisions for generating power from reservoir water. See Water Storage on Salt River, Arizona, drawing between pp. 27-28, pp. 45-48. On page 47 of this report Davis wrote, "there are other power possibilities in this reservoir site by arranging to draw all irrigation water from the reservoir under a considerable head through turbines which can be used to develop power for pumping purposes. Such development, however, will be of a very different character from the works already planned." It is interesting to note the nearly accidental way the Reclamation Service began to produce hydropower. In Reclamation in the United States, (Caldwell, Idaho: The Caxton Printers, 1961), Alfred Golzé wrote, "the entrance of the federal government into power production in the Western States was purely incidental." No provision for the generation or sale of hydropower was made for in the Reclamation Act. In fact, the General Land Office made such a recommendation in February 1902, four months before the signing of the bill, but the Secretary of Interior, E. A. Hitchcock, did nothing. See pages 69-70. See also William E. Warne, The Bureau of Reclamation, (New York: Praeger Publishers, 1973), pp. 86-89. Warne credits Louis C. Hill with realizing the potential benefits of developing a

hydropower plant at Roosevelt although he does not site any documentary evidence to support this claim. Nevertheless Warne's assertion seems to be true. In a letter to Frederick Haynes Newell, Commissioner of Reclamation, Arthur P. Davis wrote that "Mr. Hill . . . has gone a little mad on the power subject." See Arthur P. Davis to F. H. Newell, 21 February 1911, Record Group 115, Box 489, File 26, National Archives, Washington, D.C. Letter can also be found in Salt River Project Archives, Tempe, Arizona. By 1923 there were 18 power plants built by the Reclamation Service producing 33,000 kilowatts of power on 12 projects. See Michael C. Robinson, Water for the West, The Bureau of Reclamation 1902-1977, (Chicago: Public Works Historical Society, 1979), p. 29.

5. Water Storage on Salt River, Arizona, p. 45. The Reclamation Service also constructed a Power Canal on the Strawberry Valley Project in Utah although it was only approximately three miles long.

6. Harlan H. Barrows, "Roosevelt Dam and the Salt River Valley," The Journal of Geography XI, (May 1913), p. 280.

7. Water Storage on Salt River, Arizona, p. 45.

8. First Annual Report of the United States Reclamation Service, p. 97.

9. Water Storage on Salt River, Arizona, p. 45. James M. Gaylord, Power & Pumping System of the Salt River Project, Arizona to June 30, 1913, unpublished manuscript (1 January 1914), Salt River Project Archives, Tempe, Arizona, pp. 39-43. The penstock tunnel was lined halfway down with concrete, the rest of the way the concrete was lined with steel plating.

10. The Power Canal provided a water head of 220 feet and a flow rate of 225 cubic feet per second. The amount of power generated was 4400 gross horsepower. U.S. Department of Interior, Reclamation Service, Fourth Annual Report of the United States Reclamation Service, 1904-1905, (Washington: Government Printing Office, 1905), pp. 64-65; Chester Wason Smith, "The Construction of Roosevelt Dam: An Account of the Difficulties Encountered in Constructing a High Masonry Dam in Arizona," Engineering Record 62, (31 December 1910), p. 757.

11. The Power Canal and Diversion Dam generator was later moved to the permanent power house in 1907 and 1909. See Power and Pumping System of the Salt River Project, Arizona to June 30, 1913, p. 23; The Arizona Republican, 4 February 1902.

12. Louis C. Hill Memorandum to Arthur P. Davis, 23 February 1917, Central Classified Files, Record Group 48, National Archives, Washington, D.C. Memorandum can also be found in Salt River Project Archives, Tempe, Arizona, Box 1887, File No. 440.3, p. 4.

13. Salt River Valley Water Users Association, "Minutes of Board of Governors," meeting of 11 April 1904. "Mr. Davis further stated that after an extended and careful investigation, the government felt assured that there was available an underground supply for water for 35,000 to 40,000 acres of land and there would be power developed by the works at Tonto [Salt River damsite] sufficient to raise it to the surface for use. It is these facts that have rendered the power of the canal and the development of underground supply of so much greater importance than it was in the consideration of earlier plans for the work."

14. See endnote 3; First Annual Report of the United States Reclamation Service, pp. 91-106.

15. U.S., Department of Interior, Reclamation Service, Second Annual Report of the United States Reclamation Service, 1902-1903, (Washington: Government Printing Office, 1903), p. 71. C.R. Olberg would go on later to design Coolidge Dam on the Gila River.

16. Third Annual Report of the United States Reclamation Service, p.133.

17. "Final History to 1916, Salt River Project, Arizona," 3 vols., Record Group 115, p. 157, National Archives, Washington, D.C. Report can also be found in Salt River Project Archives, Tempe, Arizona; Power Pumping System of the Salt River Project, Arizona to June 30, 1913, p. 28.

18. Third Annual Report of the United States Reclamation Service, p. 58.

19. Ibid.; Robert Sherer and Company was located at 101 South Broadway in the 1906 Los Angeles City Directory. In 1924, the City Directory lists a Sherer & Crowley at 610 South Main, Room 607. In 1925 there is only a listing for Crowley at the same address. In 1927 the Los Angeles City Business Directory identifies the 610 South Main address as the Pacific Electric Building. It is still known today as the Pacific Electric Building. Information obtained from correspondence with William S. Byrne, Department Librarian, Business and Economics Department, Los Angeles Public Library, 630 West Fifth Street, Los Angeles, California.

20. John Tuttle of San Francisco may possibly have been copartner in the firm Bentley, Tuttle and Pelton Company of San Francisco.

21. Third Annual Report of the United States Reclamation Service, p. 137.

22. "Final History to 1916," p. 161.

23. Water Storage on Salt River, Arizona, p. 45.

24. The Arizona Republican, 4 April 1904; 8 June 1904.

25. Arthur P. Davis, Irrigation Works Constructed by the U.S. Government, (New York: John Wiley & Sons, Inc., 1917), p. 32.

26. The Arizona Gazette, 26 June 1905.

27. "Final History to 1916," p. 157.

28. Ibid., p. 165. This problem was primarily encountered in the Intake Tunnel. For a detailed account, see pp. 164-169.

29. Ibid., p. 166. The tunnels measured 8 feet wide and 7 feet 6 inches high at the center. See U.S., Department of Interior, Reclamation Service, Ninth Annual Report of the United States Reclamation Service, 1909-1910, (Washington: Government Printing Office, 1910), p. 61.

30. Chester Smith Diary No. 1, 7 June 1905. Work was completed in November 1905.

31. The Arizona Republican, 8 June 1904. The newspaper accounts do not give the contractors' first names nor their business addresses. The Arizona Republican, 16 May 1904; 15 June 1904.

32. "Final History to 1916," p. 158.

33. The Arizona Republican, 17 May 1904; 8 June 1904.

34. The Arizona Republican, 9 August 1904; "Final History to 1916," p. 167.

35. "Final History to 1916," p. 158.

36. Over 65 culverts were employed along the Canal line. For a good discussion on canals and their features, see Frederick H. Newell and D. W. Murphy, Principles of Irrigation Engineering, (New York: McGraw Hill, 1913), pp. 35-101.

37. Whitney's flume is called an aqueduct on the List of Structures, feature 18E in Appendix I.

38. The Arizona Republican, 6 June 1904.

39. "Final History to 1916," pp. 161-162. An additional settling basin was added in April 1909 just above the Penstock Tunnel entrance. See "Final History to 1916," pp. 161, 182-183.

40. The only records remaining of the ditchriders are photographs and drawings indicating the location of their houses along the Canal line. There is still one house remaining at the Cottonwood Canyon intake. By the 1940s there were as many as eight men assigned to maintain the Power Canal. Interview with Walter Robbins, Mesa, Arizona, 12 April 1984.

41. John H. Quinton, Experiments on Steel-Reinforced Concrete Pipes on a Working Scale, Water Supply and Irrigation Paper of the U.S. Geological Survey, No. 143, (Washington: Government Printing Office, 1905), p. 9; Sharlot M. Hall, "The Great Tonto Storage Reservoir," Out West 25 (November 1906) p. 398.

42. The Arizona Republican, 27 April 1905; The Arizona Gazette, 30 June 1905.

43. Chester W. Smith, "Reinforced Concrete Pipe for Carrying Water Under Pressure," Transactions of the American Society of Civil Engineers, LX (1908), pp. 124-141; "Final History to 1916," pp. 173-174.

44. "Reinforced Concrete Pipe for Carrying Water Under Pressure," p. 127.

45. Electric power at the damsite, before the completion of the Power Canal, was supplied by a wood generated steam plant which was very costly. The Arizona Republican reported on 8 April 1906 that prior to the completion of the Power Canal and Diversion Dam the cement mill was running at half its capacity and at a fuel expense of $150 per day. With the sale of power to the contractor (John O'Rourke) through the use of the Canal, the daily savings was estimated at $350 per day. "Reinforced Concrete Pipe for Carrying Water Under Pressure," p. 127.

46. "Reinforced Concrete Pipe for Carrying Water Under Pressure," p. 128.

47. Ibid., pp. 128-130.

48. Ibid., p. 131.

49. Chester Smith Diary No. 2, 10 March 1906. The Arizona Republican reported on 30 March 1906 that water leakage at the Cottonwood pipes was less than .25 of one percent and at the Pinto pipes .07 of one percent.

50. F. Teichman, "Rotating Screen of Power Canal, Salt River Project," Transactions of American Society of Civil Engineers, LX (1908), pp. 337-341.

51. Ibid., pp. 337-338.

52. "Final History to 1916," p. 167; U.S., Department of Interior, Reclamation Service, Fifth Annual Report of the United States Reclamation Service, 1905-1906, (Washington: Government Printing Office, 1906), p. 87. The Republican reported that the Canal began operation on 22 March 1906. See The Arizona Republican, 24 March 1906. The temporary plant installation consisted of a 1300 horse power turbine, and a 900 Kw, 3 phase, 2200 volt, 25 cycle generator with necessary exciter and switchboard. See Power and Pumping System of Salt River Project, Arizona to June 30, 1913, p. 26.

53. The Arizona Republican, 30 March 1906. The power generated by the Power Canal was sold to the contractor of Roosevelt Dam, John O'Rourke, for .5 cents per kilowatt hour. See Chester W. Smith, "Progress on Roosevelt Dam, Salt River Project, U.S. Reclamation Service," Engineering News 60 (10 September 1908), p. 267.

54. The Arizona Republican, 22 July 1906.

55. "Final History to 1916," pp. 151-152. See glossary for definition of ogee.

56. Power and Pumping System for the Salt River Project, Arizona to June 30, 1913, p. 27.

57. Fourth Annual Report of the United States Reclamation Service, p. 65.

58. "Final History to 1916," p. 152.

59. U.S., Department of Interior, Reclamation Service, Sixth Annual Report of the United States Reclamation Service, 1906-1907, (Washington: Government Printing Office, 1907), p. 65.

60. The dam was dedicated on 18 March 1911 by Theodore Roosevelt. Breaks in the embankment along the Canal did occur on occasion due primarily to heavy rains. The Cottonwood and Pinto Pressure Pipes did "blow out" in 1906. See photo No. 27.

61. The Arizona Republican, 7 June 1904; 14 June 1904.

62. A motion to change the venue of a case simply means to change the jurisdiction in which the case is being adjudicated.

63. "Minutes of Board of Governors," Book 2, pp. 18, 22, 163, 233-234, 243, 280, 284, 286, 288.

64. Sixth Annual Report of the United States Reclamation Service, p. 65.

65. U.S., Department of Interior, Reclamation Service, Seventh Annual Report of the United States Reclamation Service, 1907-1908, (Washington: Government Printing Office, 1908), p. 52.

66. The extension work referred to, lengthening the Penstock, meant extending the Penstock Tunnel from the wall inside the cave where the temporary power plant was built to the permanent powerhouse located outside this cave. See U.S., Department of Interior, Reclamation Service, Eighth Annual Report of the United States Reclamation Service, 1908-1909, (Washington: Government Printing Office, 1909), p. 45.

67. U.S., Department of Interior, Reclamation Service, Ninth Annual Report of the United States Reclamation Service, 1909-1910, (Washington: Government Printing Office, 1910), pp. 61-62; U.S., Department of Interior, Reclamation Service, Tenth Annual Report of the United States Reclamation Service, 1910-1911, (Washington: Government Printing Office, 1911), pp. 64-71.

68. The Arizona Republican, 30 May 1909; 6 June 1909.

69. Ninth Annual Report of the United States Reclamation Service, p. 44.

70. 34 Stat. 117; Louis C. Hill to A. P. Davis, 23 February 1917, p. 2; Power and Pumping System of the Salt River Project, Arizona to June 30, 1913, pp. 63, 169-175. The Salt River Valley Water Users' Association Board of Governors approved the sale of power to Pacific Gas and Electric as early as 1 June 1908. See "Minutes of Board of Governors," Book 2, p. 307. Although Hill mentions selling power to the Inspiration Copper Company in the same sentence with Pacific Gas and Electric, records show that the Inspiration contract was not signed until July 1912. See Glenn W. Brandow, Historical Documents Pertaining to Power Contracts and Agreements of the Salt River Project, Salt River Project Archives, Tempe, Arizona, Inventory Box 101, No. 1887. See also "Minutes of Board of Governors," Book 3, p. 99. The Board approved the sale of power to Inspiration and Miami Copper companies at the rate of .75 cents per kilowatt hour for a ten

year term on 6 May 1912. The Reclamation Service had developed additional hydropower generating facilities in the Phoenix Valley. By 1913 the South Consolidated Power Plant was generating 2000 Kv and the Arizona Falls Power Plant was generating 1,050 Kv. Power from these facilities was sold to South Western Sugar and Land Company, Agua Fria Water Company, Consolidated Canal Company, S. D. Lount and Son, Arizona Alfalfa Milling Company, the town of Glendale, Arizona Portland Cement Company, and the Bartlett-Heard Land Company.

71. Ninth Annual Report of the United States Reclamation Service, pp. 65 and 67; Power Pumping System of the Salt River Project, Arizona to June 30, 1913, pp. 186-200.

72. L. C. Hill to A. P. Davis, 23 February 1907, pp. 1-2.

73. U.S., Department of Interior, Reclamation Service, Eleventh Annual Report of the United States Reclamation Service, 1911-1912, (Washington: Government Printing Office, 1912), p. 47; U.S., Department of Interior, Reclamation Service, Twelfth Annual Report of the United States Reclamation Service, 1912-1913, (Washington: Government Printing Office, 1913), p. 51; U.S., Department of Interior, Reclamation Service, Thirteenth Annual Report of the United States Reclamation Service, 1913-1914, (Washington: Government Printing Office, 1914), p. 64; U.S., Department of Interior, Reclamation Service, Fourteenth Annual Report of the United States Reclamation Service, 1914-1915, (Washington: Government Printing Office, 1915), p. 49.

74. U.S., Department of Interior, Reclamation Service, Salt River Project, Arizona, "History of the Project for the Calendar Year 1913," Salt River Project Archives, Tempe, Arizona, p. 82.

75. U.S., Department of Interior, Reclamation Service, Salt River Project, Arizona, "History of the Project for the Calendar Year 1914," Salt River Project, Tempe, Arizona, p. 58.

76. U.S., Department of Interior, Reclamation Service, "Annual Report on the Operation and Maintenance for the Agricultural Year 1914-1915, Ending September 30, 1915 with Supplements for the Months of October and November 1915, Salt River Project," Salt River Project, Tempe, Arizona, p. 27; Power and Pumping System of the Salt River Project, Arizona to June 30, 1913, pp. 32-33.

77. Water Storage on Salt River, Arizona, p. 45.

78. "Final History to 1916," p. 163; Water Storage on Salt River, Arizona, p. 46.

79. U.S., Department of Interior, Reclamation Service, Sixteenth Annual Report of the United States Reclamation Service, 1916-1917, (Washington: Government Printing Office, 1917), p. 49; U.S., Department of Interior, Reclamation Service, Seventeenth Annual Report of the United States Reclamation Service, 1917-1918, (Washington: Government Printing Office, 1919), p. 66. The bypass work was completed in October 1917. Although the sluice tunnel intake is at the base of the reservoir, the second intake is at the 80 foot level on the upstream face of the dam. Water elevation in the reservoir must remain over the 130 foot level for this intake to supply water for power otherwise a whirlpool will be created.

80. First Annual Report of the United States Reclamation Service, p. 69.

81. The Third Annual Report of the United States Reclamation Service estimated the cost of the Project to be $3.2 million. The Board of Cost Review estimated the cost at approximately $13 million. See Karen L. Smith, "The Magnificent Experiment: Building the Salt River Reclamation Project, 1890-1917" (Ph.D. dissertation, University of California, Santa Barbara, 1982), pp. 262-263.

82. "The Magnificent Experiment: Building the Salt River Reclamation Project, 1890-1917," p. 260. Franklin L. Lane became Secretary of Interior in March 1913.

83. Elwood Mead, Central Board of Review Report, 19 November 1915, Record Group 115, National Archives, Washington, D.C., p. 5. Document can also be found in Salt River Project Archives, Tempe, Arizona, Box 5011, File No. 150.22.

84. "The Magnificent Experiment: Building the Salt River Reclamation Project, 1890-1917," p. 262.

85. Ibid., pp. 263-264.

86. See endnote 82.

87. "The Magnificent Experiment: Building the Salt River Reclamation Project, 1890-1917," p. 268.

88. U.S., Department of Interior, Reclamation Service, Fifteenth Annual Report of the United States Reclamation Service, 1915-1916, (Washington: Government Printing Office, 1916), p. 61; U.S., Department of Interior, Reclamation Service, Salt River Project, Arizona, "History of the Project for the Calendar Year 1916," p. 112; U.S., Department of Interior, Reclamation Service, "Damage from January 1916 Flood to Roosevelt Power Diversion Dam

- Salt River Project," Salt River Project Archives, Tempe, Arizona, pp. 1-5. The 19 January flood peaked at 1 pm. The river's flow was measured at 108,000 cfs. This flood damaged the north abutment wall. The 28 January flood peaked at 6 pm on that date with approximately the same flow. This flood damaged the main structure.

89. "History of the Project for the Calendar Year 1916," p. 113.

90."Damage from January 1916 Flood to Roosevelt Power Diversion Dam - Salt River Project."

91. See contract between United States of America and Salt River Valley Water Users' Association dated 6 September 1917, Salt River Project Archives, Tempe, Arizona.

92. Sixteenth Annual Report of the United States Reclamation Service, p. 50.

93. Richard E. Sloan, "Land and Water Rights, Salt River Project," 10 May 1922, Salt River Project Archives, Tempe, Arizona, p. 22.

94. Ibid.

95. Salt River Valley Water Users' Association, "History of the Salt River Project for the Period October 1, 1920 to September 30, 1921," Salt River Project Archives, Tempe, Arizona, p. 13.

96."History of the Project for the Period October 1, 1920 to September 30, 1921," p. 10. The federal government extended the repayment policies through the years 1922 and 1923. See 42 Stat. 489 and 42 Stat. 1324.

97. Fifteenth Annual Report of the United States Reclamation Service, p. 61.

98. These reports cover the years 1918-1919, 1919-1920 and 1920-1921 respectively.

99. Richard T. Larsen, "Reconstruction and Rehabilitation of Diversion Dam and Roosevelt Power Canal," Salt River Project Archives, Tempe, Arizona, p. 3.

100. Salt River Valley Water Users' Association, "History of the Salt River Project for the Period October 1, 1924 to September 30, 1925," Salt River Project Archives, Tempe, Arizona, Chapter VI, p. 2.

101. In the "Reconstruction and Rehabilitation of Diversion Dam and Roosevelt Power Canal," it is reported that the temporary Diversion Dam was reconstructed seven times during these years. See p. 3.

102. There is no mention of the Power Canal or Diversion Dam in the Salt River Project Annual Histories under Chapter VI, Power and Pumping for the years 1925-1926, 1926-1927 and 1927-1928, but it can be assumed that because of the lack of rainfall during these years the Power Canal did operate at various times.

103. Salt River Valley Water Users' Association, "History of the Salt River Project for the Period October 1, 1932 to September 30, 1933," Salt River Project Archives, Tempe, Arizona, Chapter VI, p. 1.

104. Salt River Valley Water Users' Association, "History of the Salt River Project for the Period October 1, 1933 to September 30, 1934," Salt River Project Archives, Tempe, Arizona, Chapter VI, p. 1.

105. Salt River Valley Water Users' Association, "History of the Salt River Project for the Period October 1, 1934 to December 31, 1935," Salt River Project Archives, Tempe, Arizona, Chapter VI, p. 1.

106. Salt River Valley Water Users' Association, "History of the Salt River Project for the Period January 1, 1936 to December 31, 1936, Inclusive," Salt River Project Archives, Tempe, Arizona, Chapter VI, p. 3.

107. Contract between the United States of America and the Salt River Valley Water Users' Association Providing For The Construction of Bartlett Dam and Repairs To and Completion of Other Dams and Project Canals, 26 November 1935. Salt River Project Archives, Tempe, Arizona, File Nos. 410.1 and 480.4.

108. Ibid., see sections 7b, 7c, 7d, 7e and 7f of contract.

109. Supplemental contract between the United States of America and Salt River Valley Water Users' Association Providing For The Construction of Bartlett Dam and Repairs and Completion of Other Dams and Project Canals. Salt River Project Archives, Tempe, Arizona, File No. 480.4.

110. Acting Chief Engineer to Acting Engineer, U.S. Reclamation Service, 28 August 1935, Project Correspondence Files, Record Group 115, National Archives, Washington, D.C. Memo can also be found in Salt River Project Archives, Tempe, Arizona, Box No. 5025, File No. 410.1.

111. Chief Engineer to Acting Commissioner, U.S. Reclamation Service, 14 March 1936, Project Correspondence Files, Record Group 115, National Archives, Washington, D.C. Memo can also be found in Salt River Project Archives, Tempe, Arizona, Box No. 5025, File No. 410.1.

112. "Reconstruction and Rehabilitation of Diversion Dam and Roosevelt Power Canal," p. 7.

113. Ibid. The Daley Corporation of San Diego, California is still in operation. Mr. Daley, the founder, remains as head. Correspondence with Daley Corporation revealed that the company does not have any surviving records regarding this contract.

114. "Reconstruction and Rehabilitation of Diversion Dam and Roosevelt Power Canal," p. 10.

115. Ibid., pp. 8-9.

116. Ibid., p. 4.

117. Ibid., pp. 21-22.

118. Ibid., pp. 20-28.

119. Ibid., p. 29.

120. Ibid., pp. 30-43.

121. Ibid., pp. 44-47.

122. Ibid., pp. 48-50, 58-62; Annual Hydro Tabulation Stream Flow, Book 3, Code 41, Hydrology Department, Salt River Project, Tempe, Arizona.

123. Salt River Valley Water Users' Association, "History of the Salt River Project for the Period January 1, 1938 to December 31, 1938, Inclusive," Salt River Project Archives, Tempe, Arizona, Chapter VI, p. 1.

124. Salt River Valley Water Users' Association, "History of the Salt River Project for the Period January 1, 1939 to December 31, 1939, Inclusive," Salt River Project Archives, Tempe, Arizona, Chapter VI, p. 1.

125. Salt River Valley Water Users' Association, "History of the Salt River Project for the Period January 1, 1940 to December 31, 1940, Inclusive," See photos in Chapter II and Balance Sheet of Salt River Reservoirs in Chapter III.

126. Salt River Valley Water Users' Association, "History of the Salt River Project for the Period January 1, 1941 to December 31, 1941, Inclusive," Chapter III, p. 1. The year 1941 was the wettest year in recorded history for the state with the exception of 1905. Roosevelt Reservoir is capable of impounding approximately 1.3 million acre feet of water.

127. Ibid. See Balance Sheet of Salt River Reservoirs contained in Chapter III; Annual Hydro Tabulation Stream Flow, Book 3, Code 41.

128. Ibid. No mention is made of this decision in the "Minutes of Board of Governors" of the Association.

129. Salt River Valley Water Users' Association, "History of the Salt River Project for the Period January 1, 1942 to December 31, 1942, Inclusive," Salt River Project Archives, Tempe, Arizona, Chapter III, p. 1; Chapter VI, p. 1.

130. Ibid., Chapter VI, p. 7.

131. See Balance Sheet of Salt River Reservoirs in Chapter III of the Annual Histories of the Salt River Project for the years 1943, 1944, 1945.

132. Low storage capacity occurred on 17 September. The reservoir impounded 19,427 acre feet on that date. See "Storage Extremes For Reservoir System on Salt River at and Below Roosevelt Dam 1910 to 1946 Inclusive," Box 74, Power System Information File, Salt River Project Archives, Tempe, Arizona; Reservoir Data Book No. 2, Code R-7, Hydrology Department, Salt River Project, Tempe, Arizona.

133. U.S., Department of Interior, Bureau of Reclamation, "Condition of Major Irrigation Structures and Facilities, Salt River Project Region 3, 1956." Travel Report by W. L. Harrison and O. L. Rice, 31 December 1956, Appendix 5, p. 2, Salt River Project Archives, Tempe, Arizona.

134. Reservoir Data Book No. 2, Codes R-5 and R-7.

135. Annual Hydro Tabulation Stream Flow, Book 3, Code 34.

136. A. W. Tesmer et al., "Annual Inspection of River Projects 1953," Salt River Project Archives, Tempe, Arizona, pp. 9-10.

137. See endnote 133. U.S., Department of Interior, Bureau of Reclamation, "Condition of Major Water System Structures and Facilities, Region 3, 1972," April 1972, Salt River Project Archives, Tempe, Arizona, p. 5.

138. James E. Ayres, "Archaeological Survey and Evaluation of Structural Components of the Roosevelt Power Canal," June 1983. Prepared for the Salt River Project by Archaeological Research Services, Inc., Tempe, Arizona, pp. 19-59.

139. "Condition of Major Water System Structures and Facilities, Region 3, 1972," p. 5.

GLOSSARY

Culvert - A tranverse drain.

Cut and Cover - A structure variously designed used to convey two intersecting waterways.

Flume - A channel with sidewalls used for conveying water, usually constructed of wood or concrete.

Head - The mass of water in motion; the pressure of a fluid.

Ogee - A pointed arch having on each side a reversed curve near the apex.

Penstock - A pipe or conduit for carrying water.

Pressure Pipe - An inverted siphon.

Sandbox - A receptacle containing sand used to filter water.

Sluice Gate (or) Sluiceway - A flood gate.

Weir - A dam in a stream to raise the water level or divert its flow.

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ADDENDUM TO:
ROOSEVELT POWER CANAL & DIVERSION DAM
Parallels Salt River
Roosevelt vicinity
Gila County
Arizona

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FIELD RECORDS

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