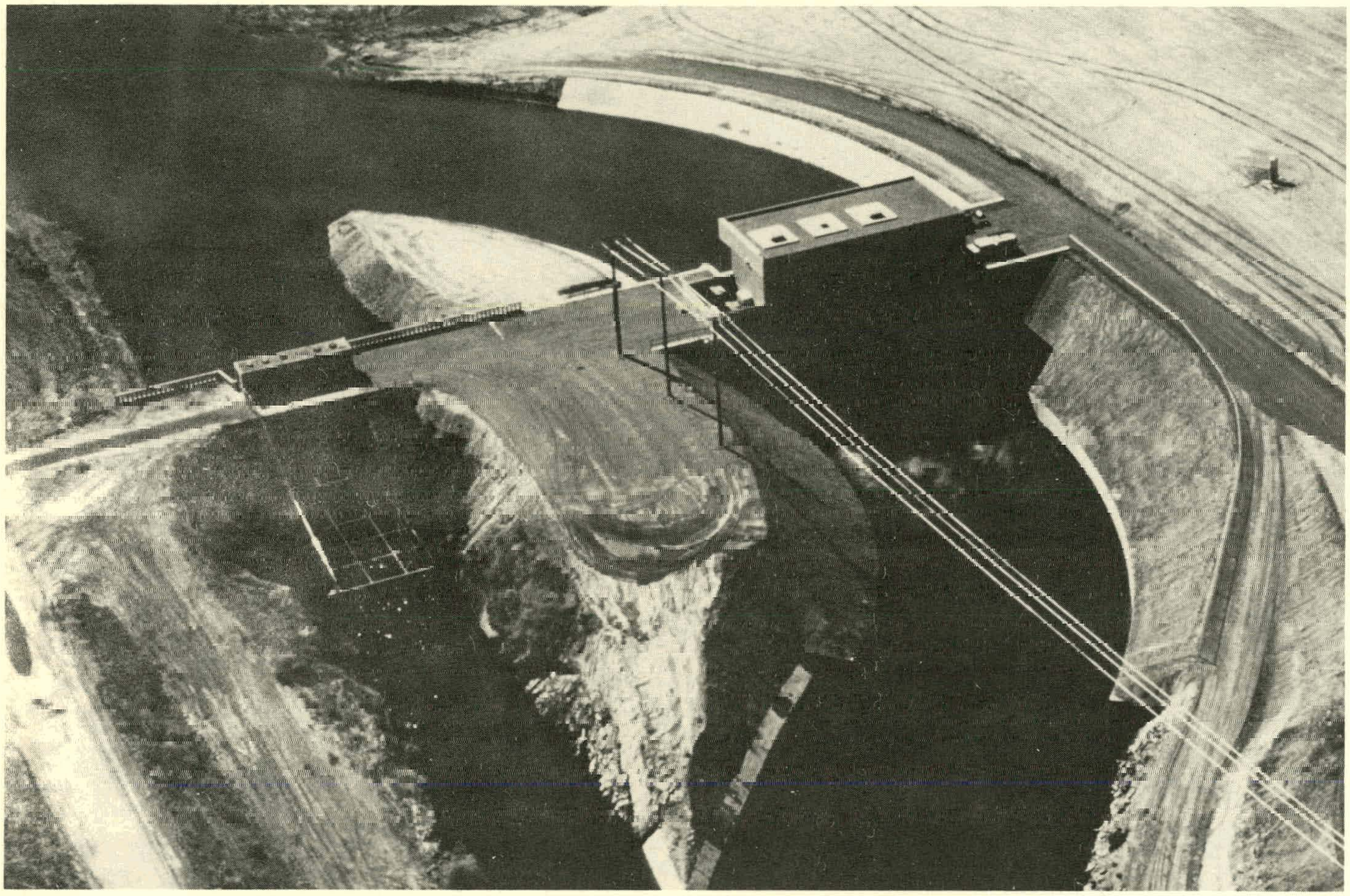
DOE-RA-23215-2

Small-Scale Hydroelectric Power Demonstration Project

Turlock Irrigation District
Drop No. 1 Power Plant



Design Report and Operations Manual

Department of Energy, Idaho Operations Office

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TURLOCK LAKE POWERHOUSE

TURLOCK IRRIGATION DISTRICT

DESIGN REPORT AND OPERATIONS MANUAL

BY

TURLOCK IRRIGATION DISTRICT

TURLOCK, CALIFORNIA

JANUARY 1981

PREPARED FOR THE

U.S. DEPARTMENT OF ENERGY

UNDER CONTRACT DE-FC07-79RA23215

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Section 1 - GENERAL

The purpose of this report is to outline the development of equipment selection and design and to establish operational criteria for the hydroelectric power drop at the Turlock Lake Powerhouse.

The outlet works and dam was constructed in 1913 as a reregulation and release facility for the Turlock Main Canal. There are six (6) slide gates for the release of a maximum flow of about 2,200 c.f.s. at an invert elevation of 202.84 U.S.G.S. Flows are generally limited to the irrigation season which runs generally between March 15 and October 15. However, some flows during the winter occur when the lake is full and when peaking operation is taking place at the Don Pedro powerhouse especially in years of above normal runoff and/or flood control operation. Maximum tailwater elevation is 214 feet.

In 1914 the dam embankment on the left bank of the outlet structure failed and a washout took place around the outlet structure. As a result of this failure, cutoff walls were constructed on each side of the outlet structure with an adobe puddle fill extending beyond the cutoff wall. No failures or problems occurred since that time.

Lake capacity is 45,599 a.f. between April 1st and November 1st (summer operation) at elevation 240.6 U.S.G.S. and 35,000 a.f. between November 1st and April 1st (winter operation) at elevation 237 U.S.G.S. At round 7,000 to 8,000 a.f. which corresponds to around elevation 223 U.S.G.S., the lake level begins to become too low for the boat launching facilities and recreation facilities on the lake becomes curtailed.

During the irrigation season, lake draw down is dictated by irrigation demands at the outlet works. Don Pedro is operated as a peaking plant but due to heavy irrigation demands at times during the mid summer months, the Don Pedro hydro units must be operated at constant output in order to deliver irrigation waters to Turlock Lake.

As control of lake elevation has not been critical in the past, coordination of Don Pedro power generation inflows and irrigation demand outflows from Turlock Lake was fairly loose, such as on a week to week basis and lake elevation has fluctuated widely.

With the addition of a power generation facility at the Turlock Lake outlet, the generation schedule at Don Pedro will have to be coordinated with the irrigation schedules on a daily basis or possibly even closer in order to maintain a constant elevation of around 239 in Turlock Lake. At elevation 239 (40,400 a.f.) there is 1.6 feet of regulation space above this level or 5,199 a.f. As this is not a great deal of space, close watch has to be maintained with rapid adjustments made at Don Pedro upon any sudden changes in irrigation demand (i.e. rain will drop off irrigation demand sharply and will cause a sharp rise in lake level if no adjustments are made at Don Pedro). There may be certain situations where adjustments at Don Pedro will not be sufficient to keep lake level from exceeding elevation 239.9. On this hopefully rare occasions, it will be necessary to infringe on the maximum elevation for a short time or spill the mismatch water into the river. If this condition occurs too frequently, then perhaps a lower operating elevation should be selected such as elevation 237. We will know this by experience. The available flow adjustment at Don Pedro is strictly peaking, mixed peaking and base load and strictly base load.

At elevation 239 there is a head of 30 feet available for the production of power. The tailrace or main canal downstream of the outlet structure was relatively narrow with a fairly steep hydraulic grade line.

This channel was widened and excavated in order to reduce tailwater elevation by around 7 feet. A resultant head of 31 feet increased power production by about 40%.

The construction of the Turlock Lake Powerhouse took place between March, 1979 and July, 1980.

Because of the relatively low output rating of the units and in the interest of economy, it was decided that governors will not be utilized. Instead, an electrically operated wicket gate operator is used to position the wicket gates to a desired flow and power level. (gate limit operation)

Also in the interest of economy, synchronizers are not utilized. The units have been designed to start similar to a synchronous motor where field is applied only after the rotor is brought to near synchronous speed and the unit breaker closed.

Again in the interest of economy, motor starters are utilized as the generator unit breaker in lieu of metal clad switchgear, which is more conventional in generating stations. Motor starters can be utilized because of the low output rating of the units and the resultant low interrupting duty required.

The power output from the three generators is transformed from 4.16 KV to 12.47 KV thru outdoor pad mounted transformers. Generated power then flows from the transformers thru an underground circuit to an overhead pole on the north side of the plant. An overhead line extension was constructed for a distance of about 2½ miles west along Lake Road to Hawkins Road where the extension is connected to the existing Feeder #1 from Hawkins Substation. 636 AA conductor is utilized from the power plant to Hawkins Substation. If generation is in excess of loads, then excess power will flow approximately 5 miles to Hawkins Substation for redistribution on other substation feeders.

Section 2 - TURBINE AND GENERATOR SELECTION

After taking competitive bids from General Electric, I.E.E., Allis-Chalmers and Stapenhorst and evaluating bids with respect to cost and efficiencies of turbines and generators and also with respect to cost of related civil and electrical facilities, General Electric was selected as the supplier of turbines and generators (3 units). The turbine manufacturer is Leffel Company and fixed blade vertical propeller turbines were supplied. The generator is manufactured by General Electric Company.

Bids were requested for turbines that would operate with a net head of 26 feet, assuming a four foot improvement due to downstream excavation. The four foot improvement figure was selected as a minimum from water level profile drawings which showed a potential improvement of 7 feet. Subsequently, a civil engineering consultant was selected and was directed to perform back water studies to determine more precisely what the economic improvement could be from downstream channel improvements. Studies showed that it would be economical to excavate for the full seven (7) foot improvement. Generators were therefore sized for a net head of 29 feet and turbine extension shafts were lengthened. Additional charges for the generator enlargement were determined by using the $/KW for generators ($207/KW) computed from the original bid prices. Additional charges made by Leffel for longer extension shafts amounted to $7,533 per machine.

If load rejection were to occur at maximum elevation, then overspeed and thrust bearing loads will exceed design limits. In order to allow for this contingency and to preserve a more conservative design, General Electric was directed to size the generator thrust bearing and overspeed rating for a lake elevation of 240.6 feet which corresponds to a net head of 33.6 feet. No additional charges were made for the overspeed rating, however additional charges were made for larger thrust bearings. Increasing the thrust bearing from 23" to 25" resulted in a net increase of $2,260 for each machine.

The original bids were based on generators with a Class B rise and Class B insulation. In order to provide for an overload margin in the event the turbines are more efficient than quoted or heads are greater than the design head, General Electric was directed to provide a full Class F insulation system with Class B temperature rise with cost adders of $3,000 per machine.

It was assumed at bid time that wicket gate control, speed detection switches, electrical switchgear, mechanical equipment and other miscellaneous equipment would be purchased separately. Subsequently, it was determined that it would be more efficient and expeditious to add some of the above equipment to the generator/turbine contract.

The following items were added:

1. Speed detectors mounted on the generator shaft for starting and shutdown sequences. The advantage would be factory installation of the detectors.
2. Current transformers in the generator phase winding on the neutral connection side. Current transformers are ordinarily purchased with the switchgear, however, in this application, better and more economical protection could be afforded by installing the current transformers as part of the generator.

Cost adders for items 1 and 2 above amounted to $6,125 per machine.

In order that generator power factors could be controlled from the Broadway Control center, it is necessary that the exciter be equipped with a motor operated rheostat. Also, in order to protect against over-excitation upon loss of control, a maximum excitation limit feature is desired.

Cost adders for the motor operated rheostat and maximum excitation feature amounted to $1,200 per machine.

General Electric has indicated that generator brakes will not be necessary for these 1 MW units. However, Leffel has indicated that it will take quite a long time before the generator-turbine unit will come to a stop after wicket gates are closed. This is especially true since the setting of the turbine is above tail water and the runner will be turning in air as soon as the water column in the draft tube falls to tail water level.

Other utilities operating similar Leffel units have incorporated generator brakes into their design and therefore cannot contribute to operating experience without brakes.

The generator-turbine unit will decelerate due to windage and friction. Possibly the final stopping friction will be the friction of the thrust bearing as lubricating oil is squeezed from the bearing face as rotational speed is decreased. Kingsbury Bearing Company has recommended that bearing not be operated at less than 5 rpm. It is of some concern that as the machine slows down there will be some period of time the rotational speed will be below 5 rpm as it coasts down to zero rpm. However, General Electric has checked this out with Kingsbury and they stated that the concern is unwarranted and stopping without brakes is satisfactory.

At the District's option, General Electric offered to install manual brakes on the flywheel for $5,000 per machine or make provisions only for brakes for $1,000 per machine.

Since it would be difficult to add brakes in the field if provisions were not made at the factory and since there was a certain element of unknown whether brakes would be needed or desired in the future, General Electric was directed to make factory provisions for brakes at $1,000 per machine. It was determined, after installation, that brakes are needed and will be used.

Synchronous generators were selected over induction machines on the basis that induction machines cost in the order of 30% more than synchronous machines at speeds near 200 rpm. Also synchronous machines are about 2% more efficient than induction machines when operated near unity power factor.

Section 3 - SITE SELECTION

Three alternatives were considered in locating the Drop No. 1 power plant as follows:

Site A - Locate power plant immediately downstream and in line with the existing outlet structure.

Site B - Locate power plant on the left bank of the canal downstream of the old structure and construct a bypass channel from the power plant to the dam embankment adjacent to the old structure.

Site C - Locate power plant on the dam embankment adjacent to the old structure and construct a tailrace channel around the old structure to the main canal.

The old structure is over 60 years old and there is some question as to the suitability of constructing a major structure immediately downstream of it. The concern is in respect to its structural integrity. (i.e. The structure may be put in jeopardy if the downstream retaining walls and spacer beams are removed.) Also there is insufficient space in the breach of the old structure to install three (3) one (1) megawatt units. In addition there is the problem of constructing the power plant during the off-irrigation season which would be over a period of 4 to 5 months. A major portion of the plant would have to be completed during this period in order that irrigation water could be passed for the next irrigation season.

Also the reliability of passing irrigation waters could be reduced by adding a power plant in series with the old structure. Problems associated with either the old structure or the new power plant could limit delivery of water.

For the above reasons Site A was not selected as the site for the power plant.

Site B was considered at one time as the site for the power plant but was eliminated in favor of Site C largely due to economics. If a forebay channel was constructed as in Site B, then the channel would have to be constructed to the same standards as the dam embankment for the forebay would be part of the lake. If the power plant was constructed on the dam embankment as described under Site C, then the tailrace channel, which would not be under the full head of the lake, could be constructed to the same standards as that for the main canal. The powerhouse structure at the dam embankment could also serve as a bridge for crossing the new channel with maintenance vehicles.

For the above reasons Site C was selected as the site for the Drop No. 1 powerhouse.

Section 4 - FLOW CHARACTERISTICS

The three (3) one (1) megawatt units are capable of passing 537 c.f.s. each at full load for a total of 1,611 c.f.s. Irrigation flow demands can be met by adjusting wicket gate openings on any or all of the turbine units. Electrical power production therefore, will follow irrigation patterns. Irrigation requirements in excess of 1,611 c.f.s. can be met by opening bypass gates which are a part of the power plant. Bypass gates consist of two 8 foot wide slide gates operated thru a common hydraulic system.

In the event of problems associated with the turbine units which prohibit the passing of water, the two slide gates will be able to pass irrigation water in accordance with the following table: (This table should be confirmed or corrected by experience.)

Lake Elev. (U.S.G.S.)	Lake Storage	One Gate	Two Gates
236	31,800 a.f.	2,000 c.f.s.	4,000 c.f.s.
230	18,900 a.f.	1,450 c.f.s.	2,900 c.f.s.
225	10,600 a.f.		2,000 c.f.s.

Section 5 - REGULATION OF LAKE LEVEL

In order to maximize the output of the power plant, it is necessary to keep the lake level nearly constant around a level of 239 U.S.G.S. This will provide a nominal head of 31 feet.

The main canal from La Grange is capable of conveying about 3,200 c.f.s., however, this flow may not be on a continuous basis since Don Pedro Powerhouse may be on a peaking schedule.

Historically, there were large swings in the water surface elevation at Turlock Lake because of mismatches in outflows and inflows. There were large dips in lake level when irrigation demands were heavy for a number of days. In order to bring the storage in Turlock Lake up, the Don Pedro generators were put on a base load schedule on a 24 hour basis and thru the weekend.

If irrigation demands are extra heavy, then Don Pedro will have to go on a base load operation on a 24 hour basis and barely be able to keep up with the demands. (Maximum flow out of Turlock Lake is around 2,200 c.f.s. La Grange diversion to Turlock Main Canal is 3,200 c.f.s.) If heavy irrigation demands continue for an extended period, then the lake elevation may fall off a bit.

It is expected with close supervision and control, we can maintain a fairly constant lake elevation for maximum power production.

The irrigation water master normally receives orders for water before 7 p.m. on the eve of the next days delivery. Historically, he would give the orders for flows from the outlet works to the reservoir attendant around 7 p.m. the night before and the reservoir attendant would make the ordered releases from the outlet works around 6 or 7 a.m. the following morning.

With the power plant, bypass gates and Drop No. 2 wier elevation remotely supervised and controlled from Broadway Control, the Broadway operator will be able to maintain close supervision on a continuous basis. There will be a need to set up some kind of liaison between the water master and the Broadway operator.

Hawkins Feeder #1 has a dead line relay installed at the substation end to prevent reclosure of the feeder breaker on live line conditions when it is possible that generation may be on and out of synchronism with the TID system.

Section 6 - GENERATOR

The generators are manufactured in Schenectady by the large motor and generator factory of General Electric Company and are rated at 1,144 KVA, .95 p.f. overexcited 4.16 KV, with Class F insulation and Class B temperature rises. Generators are designed to rotate in a clockwise direction looking from the top. The following General Electric drawings describe the specifications and characteristics of the generators:

Drawing		Description
136D5720	Rev 1	Outline
136D5720AB	Rev 1	Explanatory Notes
136D5746	Rev 1	Lifting and Handling Diagram
178C1229G1	Rev 0	Coupling Assembly
34C843583-001	Rev 0	Protective Component Assembly
136D5773	Rev 0	Assembly

The following letters further describe the generators:

1. August 30, 1978, Letter of Agreement between TID and GE setting forth the specifications and the conditions of purchase of the generators and turbines. Also included is a list of spare parts.

2. Instruction manual submitted by General Electric Company for Drop #1 Powerhouse and Hickman Powerhouse.

Each generator is equipped with the following auxiliary equipment:

1. Six (6) 10 ohm copper resistance temperature detectors (RTDs) embedded in the stator windings. All RTDs wired to a terminal box.

2. Upper and lower bearing temperature indicator and switch.

3. Upper and lower bearing oil level indicator and switch.

4. Cooling coils for the upper bearing oil housing. Eight (8) gallons per minute, .8 PSIG drop at 86°F, 50 PSIG maximum.

5. Generator brakes are not provided. Provisions only for adding brakes have been made in two places, 180° apart, at the flywheel level. A suggested manual handwheel brake design was submitted by GE.

6. Six (6) current transformers, two each at the neutral terminal of each phase winding (GE JCSO 200/5, relay accuracy Class C20).

7. High sensitivity type magnetic speed detection equipment is installed on the collector ring shaft at the top of the generator. The magnetic pickup drives a tachometer and the tachometer output drives a meter and remote signal device at 0-1 ma and also four SPDT relays. Each relay has individually settable set points, Airpax Cat. No. 085-202-0008 (120 tooth gear wheel), Cat. No. 11-0002 (magnetic pickup), Cat. No. 080-311-4110 (tachometer).

8. Space heaters, 1,600 watts, 240V, single phase.

The following additional equipment was installed on the generator in the field:

1. Terminal box for collecting all instrumentation and auxiliary wiring to a central location for remote wiring.

2. Float switch mounted in upper and lower bearing oil reservoir sight gage plumbing for detecting and alarming low oil level.

Synchronous generators were selected over induction generators on the basis that induction machines cost in the order of 30% more than synchronous generators at low speeds (200 rpm). Also synchronous generators are about 2% more efficient than induction machines when operated at near unity power factor.

Section 7 - EXCITER

The exciters are manufactured by the Basler Electric Company and are of the static type rated at 25 KW. Input voltage rating is 160 volts and dc output is 125V at 200 amps. Sensing voltage is 120V ac single phase. The regulators feature droop or cross currents compensation for paralleling.

The following describes the exciter/regulators:

<u>Basler Electric Company</u>

Drawing #9129100960	Rev E	Interconnection Diagram
Drawing #9107900910	Rev F	Schematic

<u>General Electric Company</u>

Instruction manual

The exciter is equipped with a manual (base) voltage adjust rheostat and an automatic voltage set rheostat. Auto-manual switch over is accomplished by an auto-manual switch located on the switchboard. Normal start up is with the switch in the auto position. Starting sequence circuitry will switch control automatically to manual and will switch a preset manual voltage adjust rheostat into the regulator. This will prevent large swings in exciter/regulator output during start up. After the unit has been successfully synchronized to the line, the starting circuitry will switch regulator control to automatic and automatic voltage control will be effected. The automatic voltage set rheostat will be automatically driven to the no load position during the starting sequence in order to prevent large swings in VAR flow and circulating currents when more then one unit is in operation.

At any time after successfully starting the units, the auto-manual switch can be switched to manual and the manual adjust rheostat can be used to set generator voltage. Manual control is only available at the switchboard. The auto-manual switch must always be in the auto position for remote operation of voltage adjust control. The voltage adjust control will be used to adjust voltage settings in order that VAR flow into the machine or out of the machine will be near zero.

Section 8 - TURBINES

The turbines are manufactured by The James Leffel & Company in Springfield, Ohio and are rated at a maximum of 1,534 HP at 29 feet of head and 200 rpm. The runner is a type A-20 fixed blade propeller type cast steel runner with a combined weight and thrust of 75,300 lbs. Runaway speed at 33.5 feet of head is 505 rpm. Maximum turbine flow is

537 CFS at rated output. Flows at maximum runaway speed can be expected to be 60% greater than full load flows.

Turbines are identical in design to the turbines for Hickman Powerhouse. However, there are differences in extension shaft, and gate shaft lengths and also gate shaft torque requirements.

The following Leffel drawings describe the characteristics of the turbine:

Drawing	Description
52502 Rev. #2	Assembly Section for Drops #1 & #9
52500 Rev. #6	General Arrangement
CS #2912	Expected Performance Curves
CS #2922	Expected Discharge vs. Gate Opening Curve

Section 9 - UNIT BREAKER

Power switchgear has normally been used for generation, transmission and distribution circuit protection in the industry and is considered standard. Power switchgear is available with high continuous ratings and interrupting capabilities but is not designed for frequent operations.

Industrial control (motor starters), however, are designed for frequent operations but are limited in maximum continuous ratings and interrupting capacities. Continuous ratings are limited to around 2,500 HP with interrupting ratings of around 50,000 KVA. Interrupting ratings can be extended to around 400,000 KVA with current limiting fuses.

Industrial control equipment was selected for the unit breaker application since the generator ratings are well within the industrial control ratings available. Since fault capacity at the power plant is within the 50,000 KVA rating of the contactor, current limiting fuses will not be required. Also industrial control is about one-fifth the cost of power switchgear.

Section 10 - TRANSFORMER

Because of the relatively small size of power plant (3.3 MW), it was felt that a fenced substation could be avoided by installing distribution type pad mount transformers. The pad mount transformers are completely enclosed and lockable with below ground incoming and outgoing cables.

A transformer capacity of 3,500 KVA is required. However, most standard distribution pad mount transformers are rated up to 2,500 KVA. In order to stay with standard ratings, two 2,000 KVA transformers are connected in parallel for a total transformer capacity of 4,000 KVA.

The transformer is manufactured by Westinghouse Electric Corporation and is further described by the following Westinghouse drawings:

Drawing 7224A35	Sub 1	Nameplate
Drawing 9592D35	Sub 1	Outline
Drawing 6763D59	Sub 7	Detail
Drawing 6763D60	Sub 4	Detail
Drawing 6331A67		Warning Plate

Section 11 - LINE BREAKER

Fuses were first contemplated for installation between the pad mount transformer and distribution line for isolation and protection.

However, fuses could result in single phasing and will not provide adequate ground fault protection for line faults (generator breakers will not see any ground faults on the line because of the transformer delta primary).

A breaker on the line side with phase overcurrent and residual ground relays will provide protection against ground faults on the distribution line as well as transformer ground faults. Also transformer phase faults and 4,160 bus faults could be afforded greater protection due to the steepness of phase fault relays as compared to fuses. Line phase faults will not be detected due to the low short circuit currents available from the generators.

Line breaker tripping could be supervised by other plant devices and tripping could be prevented in certain situations where tripping is not desired. Also, a line breaker could be reclosed from the control center under certain situations, such as temporary line faults and the system could be restored in a relatively short time (blown fuses will require a field trip to replace fuses). The most economical method of providing a line breaker is to install a pole mounted line recloser equipped with overcurrent protection. The recloser features are not desired and therefore will be blocked.

The line breaker is a McGraw-Edison type RXE recloser rated for 400 amps maximum continuous current and 6,000 amps short circuit capacity (symmetrical) at 14.4 KV. Vacuum interrupters are used for lower maintenance requirements. The line breaker consists of two parts. The actual power switching vacuum interrupters are mounted in a cast aluminum housing high on a pole just below line level. A second housing is mounted on the same pole, but at a lower level such that it can be serviced from the ground. This control cabinet contains the electronics, timing and control circuitry which operate the system. A cable connects the two devices. While multiple reclosing cycles are available within this unit, they will be blocked in this application because of the possibility of closing into an out-of-sync condition. Manual reclosing is possible only if all unit breakers are open and 4 KV bus is deenergized.

For Turlock Lake Powerhouse, the time-overcurrent curve is set to provide a phase trip at a 200 amp minimum setting. The phase trip curve is very inverse as compared to the ground trip curve.

Closing power is from the 12 KV source side of the recloser via a high voltage closing solenoid.

Several optional features are included. Auxiliary contacts are provided for use by external control equipment to determine the open/closed status of the breaker. A circuit is included which allows remote control of the recloser. Another option also prevents the unit from attempting to close if station service (120 VAC, 1Ø) is off. Since station service transformers are connected on the line side of the breaker, station service status is an indication of live line-dead line status. This option will prevent attempted energization of close control solenoid thereby avoiding unnecessary control power fuse blowing. A small thermostatically controlled heater is mounted in the control cabinet in order to keep out moisture. Forty-eight volts D.C. is supplied to the control cabinet from the station battery bank to provide trip/close voltage. In addition to these remote controlled options, all functions of operation can be monitored at the control cabinet.

Section 12 - STATION SERVICE

The station service is provided by pole mounted transformers connected delta-delta with secondary voltages of 120/240V, 3 phase, 4 wire service.

An underground voltage dip to the power plant is provided with metering provisions inside the plant.

Station service metering should be treated in much the same manner as station service metering at District substations from the standpoint of record keeping.

Generator auxiliaries such as heater strips dictated the 240V service instead of 208V. The 208V service was initially preferred from a balancing standpoint.

Section 13 - PRIMARY CABLE & TERMINATION

Cable termination method at the generator and switchgear is accomplished by stress cone and spade connectors. Cable connection at the pad mount transformer is accomplished by 200 amp load break connectors on the 12 KV and 600 amp elbows on the 4,160V side. The 200 amp load break elbows are District standard item used in underground subdivisions.

Cable connection on the pole riser is by means of "easy-on" Joslyn terminators, also a District standard.

Section 14 - CRANE & HOIST SYSTEM

The powerhouse is equipped with a 15 ton bridge crane. The crane is for use for installation and maintaining power plant auxiliary equipment and for maintenance and repair of generator and turbine parts.

The generator is factory assembled and weighs approximately 70,000 lbs each. Installation of the generators is accomplished by mobile crane thru roof hatches. However, the overhead bridge crane is capable of lifting generator parts during maintenance and repair cycles.

The traveling bridge portion of the crane is a permanent installation. The trolley is designed to be transportable between Turlock Lake Powerhouse and Hickman Powerhouse. Traction of the bridge and trolley is by means of manual pull chains. Vertical lift is motorized with controls at the floor level.

A 2 ton electric hoist is installed on the upstream side of the plant for the purpose of installing concrete stop logs to dewater turbine bays for maintenance or emergency situations.

In emergency situations, when generator load rejects and goes to overspeed and wicket gates fail to close by automatic or manual means, stop logs will have to be installed within one hour to prevent overheating of bearings.

Section 15 - WATER LEVEL MEASUREMENT

Forebay and tailwater water level measurements are accomplished by means of stilling wells and float systems. A potentiometer driven by the float system provides water level indication for monitoring by the control center.

High and low level limit switches on the forebay float system provides signals to the switchboard which utilize these signals for permissive start and shutdown control of each unit on the low level switch and annunciator of abnormal water levels, on both the low level and high level switches.

Low level switches on the tailwater float system provides signals to the switchboard which utilizes these signals for permissive start only of each unit. Annunciation of low level condition is accomplished by computer decisions at the control center.

No water level indications are provided at the switchboard. Water levels at the plant are determined by sighting staff gages in the canal.

Section 16 - GATE POSITION MEASUREMENT

The sluice gate is provided with a varec position transducer and a Sierra Control transmitter. The transducer is a spring charged cable which is attached to the gate. As the gate goes up and down the cable is played in and out of the transducer. The transducer determines gate position from the amount of cable played out. Indication of gate position is provided at the transducer and the indication is transmitted to the control center.

No indications are provided at the switchboard.

Section 17 - STATION BATTERY

The station battery system consists of 37 nickel cadmium cells and a battery charger built into an earthquake protected housing. It is a nominal 48 VDC system with an 8 hour capacity of 126 ampere-hours. The charger is rated 15 amperes output.

The 48 volt system was selected to minimize space requirements and cost, and yet maintain a reliable D.C. voltage system. The ampere-hour capacity chosen was based on the capacity required plus spare capacity for future additions in load. This system is the same size that is used for the typical 69/12 KV substation allowing standardization.

Nickel cadmium batteries were selected because of the short time higher D.C. power requirements of the plant. Gassing of Nicad batteries is minimal allowing their locations to be in the same area as other equipment. Space requirement is also minimized with Nicad batteries. The plant not being air conditioned, will experience high temperatures during the summer months. Nicad batteries perform very well in high temperature environments.

Section 18 - CABLE TRAY AND CONDUIT SYSTEM

Ladder type metal cable trays and PVC conduit are used for the routing of control and low voltage cable.

The cable tray was selected to afford ease and simplicity in installation and future modifications. PVC conduit meets all requirements and is more economical than metalic conduit.

Section 19 - CONTROL AND LOW VOLTAGE WIRING

Nine and four conductor, #12 AWG copper, cable is used for control wiring. Shielded twisted pair and shielded triad cables are used for low level signal and RTD wiring respectively.

Cabling makes wiring installation simpler and easier. Better reliability is realized using copper instead of aluminum conductor. Shielding of low level signals is necessary to maintain low noise levels.

Section 20 - INVERTER SYSTEM

A single phase inverter is provided to supply power to equipment requiring AC voltage and essential to plant operation during loss of station service power. The inverter is rated 1 KVA and 48 VDC to 120 VAC.

The equipment supplied by the inverter includes temperature recorder, revenue meters, panel meters and potentiometers for supervisory inputs.

Section 21 - LIGHTING

The AC lighting system is supplied by 120 volt circuits. The lighting was designed to provide a light intensity of 40 foot candles in the plant and approximately 1/2 foot candle outdoors.

High pressure sodium vapor lamps were selected on the basis of their high efficiency, long life and shorter restrike time.

The DC lighting system consists of 48 volt incandescent lamps. This system provides minimum indoor lighting during a prolonged outage of the AC system.

Plant indoor lighting is controlled by switches located by the entrance door. Outdoor lighting is controlled by one photo electric cell mounted on the roof.

Section 22 - VIBRATION DETECTORS

A vibration detector is mounted on the stator housing of each generator. This device protects the generating unit from extensive damage resulting from mechanical malfunction.

If excessive vibration is detected by this device, a normal shutdown and lockout is initiated. Local annunciation is activated and a signal is sent to the main control center via the SCADA.

Section 23 - SMOKE ALARM

Three ionization type smoke detectors connected to a control panel provide fire detection in the plant. The smoke detectors are equally spaced and mounted on the ceiling of the superstructure of the plant.

If combustion is detected by any one of the three detectors, the annunciator is activated locally and a signal is sent via the SCADA system to the main control center.

The equipment is of the industrial type with emergency battery carry over.

Section 24 - VENTILATION SYSTEM

Powerhouse ventilation is by means of two temperature controlled exhaust fans mounted in the roof. Intake air is thru filtered openings in walls of the powerhouse. A temperature switch will detect ambient temperatures above 110°F and will indicate an alarm condition at the control center. A lower set temperature switch will turn on the ventilating fans in the roof of the building. It was observed that keeping the large powerhouse door closed during extremely hot days provides better air circulation for all generators.

Section 25 - BEARING COOLING WATER SYSTEM

The generator bearing cooling water system consists of a heat exchanger fabricated with copper coils and installed in the turbine pit. The heat exchanger is connected to the generator thrust and upper guide bearing cooling coils with an AC motor operated pump for circulating cooling water in a closed cycle. The AC pump motors power service is from station service.

The cooling water system is designed with a maximum canal water temperature of 70°F.

As part of the cooling water system, a pressure switch is installed in the closed circulating system to provide a shutdown signal in the event pressure falls below 12 PSI.

Two temperature switches are installed to measure cooling water temperature, one will alarm on above normal temperature and the second will activate unit shutdown in the event of excessive temperatures.

Section 26 - WICKET GATE OPERATOR

Wicket gate operators are manufactured by Woodward Governor Company and consist of a pivoted ram operated by a DC motor. Each operator is equipped with its own battery pack and trickle charger.

The ram can generate a force of 10,000 lbs. In order to prevent overtorqueing on the wicket gate shaft, a circuit breaker is installed to be mechanically tripped to interrupt DC power to the drive motor whenever overtravel of the gate operator is experienced.

Manual hand operation of the operator is possible.

Section 27 - SLUICE GATES AND HYDRAULIC CONTROL

Sluice gates are designed and fabricated using steel beams and plate with J seals for water seals and teflon pad to reduce sliding friction. (One slide gate is fitted with ultra high molecular weight polyethylene pads instead of teflon.)

Gates are operated by a hydraulic ram with associated hydraulic pump, reservoir and accumulators. A common hydraulic system is used for both gates.

If hydraulic pump fails, a 12 volt DC driven pump is provided to enable gate operation.

The two sluice gates are capable of bypassing the full irrigation flows around the 3 turbines if necessary.

Section 28 - PROTECTION

Protection features are incorporated in the switchboard manufactured by R T E Delta of Stockton, California. Refer to TID drawing # E1-509 to E1-557. Generally, features and settings are described in the following tables:

UNIT PROTECTION

Normal shutdown and lockout (86N) 100% wicket gate closure.

Device No.	Description	Source	Function
80WY	Thrust bearing cooling water flow.	Pressure switch in bearing cooling system via auxiliary relay.	Cooling water pressure should be at least 12 PSI to maintain effective cooling of thrust bearing oil and bearing. Pressures below 12 PSI will cause unit shutdown and lockout. Unit breaker opens after wicket gate is closed to SNL.
71B	Generator bearing low oil level.	Magnetrol level switch mounted on sight gage via auxiliary relay.	In the event of oil loss either in the upper or lower generator bearings, the low oil switch will cause unit shutdown and lockout. Unit breaker opens after wicket gate is closed to SNL.
38B	Generator bearing high temperature.	Temperature gage and switch via auxiliary relay.	High temperature in either the upper or lower generator bearing oil will cause unit shutdown and lockout. Unit breaker opens after wicket gate is closed to SNL.
39G	Generator vibration.	Vibration detector via auxiliary relay.	Abnormal vibration will cause unit shutdown and lockout. Unit breaker opens after wicket gate is closed to SNL.
49S	Generator stator temperature.	RTD sensors via L & N temperature recorder output contacts.	Abnormal stator temperature will cause unit shutdown and lockout. Unit breaker opens after wicket gate is closed to SNL.
26CW	Thrust bearing cooling water temperature.	Temperature switch.	Excessive cooling water temperature.

Normal shutdown non-lockout (5B) 100% wicket gate closure

Device No.	Description	Source	Function
71FBL	Forebay level low.	Upstream float switch via auxiliary relay.	Low forebay level will cause air bubble intake to turbine with resultant rough operation. Unit shutdown, non-lockout will take place when forebay level falls below a preset elevation. Unit breaker opens after wicket gate is closed to SNL.

Emergency shutdown and lockout (86E) wicket gate to SNL

Device No.	Description	Source	Function
87G	Generator differential phase O.C.	Westinghouse type CA25 percentage differential relay.	Unit shutdown and lockout on generator phase to phase faults. Will not operate on generator ground faults due to high resistance grounding. Unit breaker opens immediately.
87N	Generator differential ground O.C.	Westinghouse CWP-1 sensitive directional ground relay.	Unit shutdown and lockout on generator ground fault down to a point in generator winding approximately 10% from generator neutral. Ground faults closes to neutral will not be detected due to insufficient ground fault voltages. This relay is basically a voltage relay connected to the generator neutral transformer. Supervised by a differential current level which enables tripping only when the ground fault is within the generator winding. Unit breaker opens immediately.
48	Generator incomplete sequence.	Timing relay TDPU 0-50 sec.	Unit shutdown and lockout if field contactor is not closed after a time delay. Unit breaker opens immediately.
76	Generator field O.C.	Allen Bradley inverse relay in Basler cabinet via auxiliary relay.	Unit shutdown and lockout upon overcurrent in field. Unit breaker opens immediately.
40	Generator underexcitation.	Westinghouse KLF loss of field relay.	Activated after field contactor closed for a period of time. Unit shutdown and lockout upon loss of excitation or low excitation levels. Unit breaker opens after a short time delay.
64G	Generator ground fault.	G.E. IAV relay.	Unit shutdown and lockout upon ground faults from approximately 15% from generator neutral to 4.16 KV bus. Unit breaker opens immediately.

Emergency shutdown, non-lockout (94G) wicket gate to SNL

Device No.	Description	Source	Function
51V	Generator O.C.	Westinghouse COV-6	Unit shutdown, non-lockout due to phase faults from generator terminals to substation feeder breaker terminals. Also some backup capability for phase faults on other substation feeders. Because of the static exciter which is dependent on generator terminal voltage for its source of excitation power any phase faults will tend to decrement fairly rapidly to synchronous values (with .3-.4 seconds). The COV-6 relay was chosen to coordinate with the decrement curve. The COV-6 relay is torque controlled by bus voltage and will not be permitted to activate unless bus voltage is below 80% as would be the case with a fault condition. Current element is set to pick up at around 50% of generator rating. Unit breaker opens immediately.
12X	Generator overspeed.	Airpax speed relay.	12X closes beyond 120% speed and causes unit shutdown, non-lockout. Unit breaker opens immediately.
1E/CS	Emergency shutdown.	Control switch.	Operator decision to initiate emergency shutdown, non-lockout.

PLANT PROTECTION

Emergency shutdown, non-lockout (94P) wicket gate to SNL

152	Line breaker open.	McGraw-Edison line breaker auxiliary "b" contact.	All unit breakers open upon opening of line breakers. Line breaker cannot be reclosed if unit breakers are closed since units may not be in synchronism with distribution system. Unit breakers open immediately.
47B	Voltage unbalance or negative sequence.	G.E. NBV via auxiliary relay.	All unit breakers and line breakers open upon voltage unbalance or open line conditions. Amortisseur windings are capable of withstanding 20% negative sequence currents. Pick up at 5% unbalanced voltage will provide adequate protection. Unit breakers open immediately.

Device No.	Description	Source	Function
27B	Bus UV	G.E. NGV via auxiliary relay.	Bus UV relay is used to provide back up protection for the 51V unit O.C. relays in the event of failure of 51V relays on phase to phase line faults and for the unit 64G relays on line to ground faults on the 4.16 KV bus. The bus UV relay is also used to supervise the line breaker (152) and will prevent closure of the line breaker when bus is energized. Unit breakers and line breakers open immediately.
26T	Transformer high temperature.	Westinghouse transformer temperature switch.	All unit breakers and line breakers open immediately upon high transformer temperature.
81	Over/under frequency.	G.E. IJF frequency relay.	If feeder breaker opens at substation and line breaker or unit breaker at plant does not open, frequency will go higher if line loading is lower then plant output and will go lower if line loading is higher than plant output. Frequency relay will trip unit breakers and line breaker immediately under these conditions. If line load matches plant output, plant will continue to supply load until operator intervention.

TURLOCK LAKE DEVICE SETTINGS Unit 1

DEVICE NUMBER	MFG.	MODEL NUMBER	AVAILABLE RANGE	SETTINGS	LOCATION	FUNCTION	CHANGE
1CPX	Agastat	7024NI	6-60 Min.	60 Min.	P1 Rear	C. W. Pump Stop delay	
12	Air Pax	080-311-4110	0-500 RPM	240 RPM	P1 Front K1	120% Speed	
13	Air Pax	080-311-4110	0-500 RPM	190 RPM	P1 Front K2	95% Speed	
14	Air Pax	080-311-4110	0-500 RPM	40 RPM	P1 Front K4	20% Speed	
26CW1	Dayton	2E145	100°-240°F	105°F	Generator	Clg. water alarm	
26CW2	Dayton	2E145	100°-240°F	120°F	Generator	Clg. water SHDN	
27GX	Agastat	7022QD	5-50 Sec.	10 Sec.	P1 Rear	W.G. Batt. undervoltage	
33R3			Continuous	4.10 KV	Exciter Reg. Cubicle	N. L. Voltage Low limit	
33R4			Continuous	4.25 KV	Exciter Reg. Cubicle	N. L. Voltage Upper limit	
33W1			Continuous	Close > 0%	W. gate operator	Gate close limit switch	
33W2			Continuous	Close ≤ S. N. L.	W. gate operator	Gate S. N. L. limit switch	
33W3			Continuous	--	W. gate operator	Spare	
33W4			Continuous	Close < 100%	W. gate operator	Gate open limit switch	
38L	Trerice	L84000	30°-240°F	130°F	Generator	Lower brg. temp. SHDN	
38U	Trerice	L84000	30°-240°F	130°F	Generator	Upper brg. temp. SHDN	
39G	Robert-Shaw	366	0-4.5 g	Normal g level + 0.8 g	Generator	Vibration SHDN	
40	W	KLF 290B481A13		See separate relay form	P1 Rear	Under-excitation	
41X	Agastat	7014NC	1.5-15 Sec.	5 Sec.	P1 Rear	Exciter status time delay	
48	Agastat	7012ND	5-50 Sec.	50 Sec.	P1 Rear	Incomplete sequence	
49S1	L & N	250	0-150°C	135°C	P2 Front	Stator temp. alarm	

Initial Setting - Subject to Change - DO NOT USE - For Information Only

TURLOCK LAKE DEVICE SETTINGS — Unit 1

DEVICE NUMBER	MGF.	MODEL NUMBER	AVAILABLE RANGE	SETTINGS	LOCATION	FUNCTION	CHANGE
49S1X	Agastat	7022NE	20-200 Sec.	100 Sec.	P3 Front	Seal in for 49S1	
49S2	L & N	250	0-150°C	145°C	P2 Front	Stator Temp. SHDN	
49S2X	Agastat	7022NE	20-200 Sec.	100 Sec.	P3 Front	Seal in for 49S2	
51V	W	COV-6 1878495	2-2.5-3-3.5-4-5-6	Tap 2.0 T.D. 2 S.I. 0.2 90V D.O.	P1 Rear	Overcurrent-undervoltage	
52X	Agastat	7014NB	0.5-5 Sec.	3 Sec.	P1 Rear	Dly. to close field bkr.	
64G	G.E.	121AV-51K1A	5.4-7.5-12.5-20	Tap 5.4 T.D. 1.0 S.I. 2.0	P1 Rear	Ground fault back up	
71L	Magnetrol	249C-513	None	Activate ½" below normal	Generator	Lower brg. oil level	
71U	Magnetrol	249C-513	None	Activate ½" below normal	Generator	Upper brg. oil level	
76	A-B	810-A22BR	76-229	190A, TD = 1 min. at 150%	Exciter/Reg.	Field overcurrent	
80W	Barksdale	D1H-A80	0.5-80 PSI	12 PSI	Generator	Low clg. water flow (press SW)	
80WY	Agastat	7012NF	1-10 Min.	10 Min.	P1 Rear	Low C.W. flow SHDN	
87G	W	CA 290B892A10	None	Factory set	P1 Rear	Generator diff. current	
87N	W	CWP-1	0.5-0.7-1.0-1.4-2.0-2.8-4	Tap 0.7 T.D. 6 S.I. 2.0	P1 Rear	Ground fault SHDN	
288 WCX	Agastat	7022NB	0.5-5 Sec.	1.5 Sec.	Supv. P5	Timed output	
288 WOX	Agastat	7022NB	0.5-5 Sec.	1.5 Sec.	Supv. P5	Timed output	

Initial Setting - Subject to Change - DO NOT USE - For Information Only

TURLOCK LAKE DEVICE SETTINGS — Unit 2

DEVICE NUMBER	MFG.	MODEL NUMBER	AVAILABLE RANGE	SETTINGS	LOCATION	FUNCTION	CHANGE
1CPX	Agastat	7024NI	6-60 Min.	60 Min.	P2 Rear	C. W. Pump Stop delay	
12	Air Pax	080-311-4110	0-500 RPM	240 RPM	P2 Front K1	120% Speed	
13	Air Pax	080-311-4110	0-500 RPM	190 RPM	P2 Front K2	95% Speed	
14	Air Pax	080-311-4110	0-500 RPM	40 RPM	P2 Front K4	20% Speed	
26CW1	Dayton	2E145	100°-240°F	105°F	Generator	Clg. water alarm	
26CW2	Dayton	2E145	100°-240°F	120°F	Generator	Clg. water SHDN	
27GX	Agastat	7022QD	5-50 Sec.	10 Sec.	P2 Rear	W.G. Batt. undervoltage	
33R3			Continuous	4.10 KV	Exciter Reg. Cubicle	N. L. Voltage Low limit	
33R4			Continuous	4.25 KV	Exciter Reg. Cubicle	N. L. Voltage Upper limit	
33W1			Continuous	Close > 0%	W. gate operator	Gate close limit switch	
33W2			Continuous	Close ≤ S. N. L.	W. gate operator	Gate S. N. L. limit switch	
33W3			Continuous	--	W. gate operator	Spare	
33W4			Continuous	Close < 100%	W. gate operator	Gate open limit switch	
38L	Trerice	L84000	30°-240°F	130°F	Generator	Lower brg. temp. SHDN	
38U	Trerice	L84000	30°-240°F	130°F	Generator	Upper brg. temp. SHDN	
39G	Robert-Shaw	366	0-4.5 g	Normal g level + 0.8 g	Generator	Vibration SHDN	
40	W	KLF 290B481A13		See separate relay form	P2 Rear	Under-excitation	
41X	Agastat	7014NC	1.5-15 Sec.	5 Sec.	P2 Rear	Exciter status time delay	
48	Agastat	7012ND	5-50 Sec.	50 Sec.	P2 Rear	Incomplete sequence	
49S1	L & N	250	0-150°C	135°C	P2 Front	Stator temp. alarm	

Initial Setting - Subject to Change - DO NOT USE - For Information Only

TURLOCK LAKE DEVICE SETTINGS Unit 2

DEVICE NUMBER	MFG.	MODEL NUMBER	AVAILABLE RANGE	SETTINGS	LOCATION	FUNCTION	CHANGE
49S1X	Agastat	7022NE	20-200 Sec.	100 Sec.	P3 Front	Seal in for 49S1	
49S2	L & N	250	0-150°C	145°C	P2 Front	Stator Temp. SHDN	
49S2X	Agastat	7022NE	20-200 Sec.	100 Sec.	P3 Front	Seal in for 49S2	
51V	W	COV-6 1878495	2-2.5-3-3.5-4-5-6	Tap 2.0 T.D. 2 S.I. 0.2 90V D.O.	P2 Rear	Overcurrent-undervoltage	
52X	Agastat	7014NB	0.5-5 Sec.	3 Sec.	P2 Rear	Dly. to close field bkr.	
64G	G.E.	121AV-51K1A	5.4-7.5-12.5-20	Tap 5.4 T.D. 1.0 S.I. 2.0	P2 Rear	Ground fault back up	
71L	Magnetrol	249C-513	None	Activate ½" below normal	Generator	Lower brg. oil level	
71U	Magnetrol	249C-513	None	Activate ½" below normal	Generator	Upper brg. oil level	
76	A-B	810-A22BR	76-229	190A, TD = 1 min. at 150%	Exciter/Reg.	Field overcurrent	
80W	Barksdale	D1H-A80	0.5-80 PSI	12 PSI	Generator	Low clg. water flow (press SW)	
80WY	Agastat	7012NF	1-10 Min.	10 Min.	P2 Rear	Low C.W. flow SHDN	
87G	W	CA 290B892A10	None	Factory set	P2 Rear	Generator diff. current	
87N	W	CWP-1	0.5-0.7-1.0-1.4-2.0-2.8-4	Tap 0.7 T.D. 6 S.I. 2.0	P2 Rear	Ground fault SHDN	
288 WCX	Agastat	7022NB	0.5-5 Sec.	1.5 Sec.	Supv. P5	Timed output	
288 WOX	Agastat	7022NB	0.5-5 Sec.	1.5 Sec.	Supv. P5	Timed output	

Initial Setting - Subject to Change - DO NOT USE - For Information Only

TURLOCK LAKE DEVICE SETTINGS Unit 3

NUMBER DEVICE	MFG.	MODEL NUMBER	AVAILABLE RANGE	SETTINGS	LOCATION	FUNCTION	CHANGE
1CPX	Agastat	7024NI	6-60 Min.	60 Min.	P3 Rear	C. W. Pump Stop delay	
12	Air Pax	080-311-4110	0-500 RPM	240 RPM	P3 Front K1	120% Speed	
13	Air Pax	080-311-4110	0-500 RPM	190 RPM	P3 Front K2	95% Speed	
14	Air Pax	080-311 4110	0-500 RPM	40 RPM	P3 Front K4	20% Speed	
26CW1	Dayton	2E145	100°-240°F	105°F	Generatcr	Clg. water alarm	
26CW2	Dayton	2E145	100°-240°F	120°F	Generatcr	Clg. water SHDN	
27GX	Agastat	7022QD	5-50 Sec.	10 Sec.	P3 Rear	W.G. Batt. undervoltage	
33R3			Continuous	4.10 KV	Exciter Reg. Cubicle	N. L. Voltage Low limit	
33R4			Continuous	4.25 KV	Exciter Reg. Cubicle	N. L. Voltage Upper limit	
33W1			Continuous	Close > 0%	W. gate operator	Gate close limit switch	
33W2			Continuous	Close $\leq$ S. N. L.	W. gate operator	Gate S. N. L. limit switch	
33W3			Continuous	--	W. gate operator	Spare	
33W4			Continuous	Close < 100%	W. gate operator	Gate open limit switch	
38L	Trerice	L84000	30°-240°F	130°F	Generator	Lower brg. temp. SHDN	
38U	Trerice	L84000	30°-240°F	130°F	Generator	Upper brg. temp. SHDN	
39G	Robert-Shaw	366	0-4.5 g	Normal g level + 0.8 g	Generator	Vibration SHDN	
40	W	KLF 290B481A13		See separate relay form	P3 Rear	Under excitation	
41X	Agastat	7014NC	1.5-15 Sec.	5 Sec.	P3 Rear	Exciter status time delay	
48	Agastat	7012ND	5-50 Sec.	50 Sec.	P3 Rear	Incomplete sequence	
49S1	L & N	250	0-150°C	135°C	P2 Front	Stator temp. alarm	

Initial Setting - Subject to Change - DO NOT USE - For Information Only

TURLOCK LAKE DEVICE SETTINGS   Unit 3

DEVICE NUMBER	MFG.	MODEL NUMBER	AVAILABLE RANGE	SETTINGS	LOCATION	FUNCTION	CHANGE
49S1X	Agastat	7022NE	2C-200 Sec.	100 Sec.	P3 Front	Seal in for 49S1	
49S2	L & N	250	0-150°C	145°C	P2 Front	Stator Temp. SHDN	
49S2X	Agastat	7022NE	2C-200 Sec.	100 Sec.	P3 Front	Seal in for 49S2	
51V	W	COV-6 1878495	2-2.5-3-3.5-4-5-6	Tap 2.0 T.D. 2 S.I. 0.2 90V D.O.	P3 Rear	Overcurrent-undervoltage	
52X	Agastat	7014NB	0.5-5 Sec.	3 Sec.	P3 Rear	Dly. to close field bkr.	
64G	G.E.	121AV-51K1A	5.4-7.5-12.5-20	Tap 5.4 T.D. 1.0 S.I. 2.0	P3 Rear	Ground fault back up	
71L	Magnetrol	249C-513	None	Activate ½" below normal	Generator	Lower brg. oil level	
71U	Magnetrol	249C-513	None	Activate ½" below normal	Generator	Upper brg. oil level	
76	A-B	810-A22BR	76-229	190A, TD = 1 min. at 150%	Exciter/Reg.	Field overcurrent	
80W	Barksdale	D1H-A80	0.5-80 PSI	12 PSI	Generator	Low clg. water flow (press SW)	
80WY	Agastat	7012NF	1-10 Min.	10 Min.	P3 Rear	Low C.W. flow SHDN	
87G	W	CA 290B892A10	None	Factory set	P3 Rear	Generator diff. current	
87N	W	CWP-1	0.5-0.7-1.0-1.4-2.0-2.8-4	Tap 0.7 T.D. 6 S.I. 2.0	P3 Rear	Ground fault SHDN	
288 WCX	Agastat	7022NB	0.5-5 Sec.	1.5 Sec.	Supv. P5	Timed output	
288 WOX	Agastat	7022NB	0.5-5 Sec.	1.5 Sec.	Supv. P5	Timed output	

Initial Setting - Subject to Change - DO NOT USE - For Information Only

TURLOCK LAKE DEVICE SETTINGS Plant

DEVICE NUMBER	MFG.	MODEL NUMBER	AVAILABLE RANGE	SETTINGS	LOCATION	FUNCTION	CHANGE
23P1	Dayton	2E206	30°-110°F	80°F	Plant East Wall	Plant air (2 ea) fan start	
23P2	Dayton	2E206	30°-110°F	110°F	Plant East Wall	Plant air temp. alarm	
26T1	W		38°-82°C	82°C	Main transformers	Trans. high (2 ea) temp. alarm	
26T2	W		62°-115°C	105°C	Main transformers	Transf. high (2 ea) temp SHDN	
27B/PH1	G.E.	12NGV-13A11A	70-100 volts	V 95	P4 Front	Bus undervoltage	
27B/PH2	G.E.	12NGV-13A11A	70-100 volts	V 95	P4 Front	Bus undervoltage	
27B/PH3	G.E.	12NGV-13A11A	70-100 volts	V 95	P4 Front	Bus undervoltage	
27BX1	Agastat	7024NB	0.5-5 Sec.	1.5 Sec.	P4 Rear	Bus undervoltage SHDN all units	
27BX2	Agastat	7022NB	0.5-5 Sec.	1.4 Sec.	P4 Rear	Bus undervoltage alarm	
27D	G.E.	12NGV 17A3F	32-48V	45 volts	P4 Rear	Battery undervoltage	
27DX	Agastat	7014NB	0.5-5 Sec.	5 Sec.	P4 Rear	Batt. undervoltage alarm	
27S	G.E.	12HFA-65D69F	40-90V	90 volts	P4 Rear	Station service undervoltage	
33S1	Sierra		0-100%	Gate fully closed	S. gate position trans.	S. gate close limit	
33S2	Sierra		0-100%	Gate fully open	S. gate position trans.	S. gate open limit	
33S3	Sierra		0-100%	Gate fully closed	S. gate position trans.	S. gate close limit	
33S4	Sierra		0-100%	Gate fully open	S. gate position trans.	S. gate open limit	
47B	G.E.	12NBV-11A1A	10-20 volts	V 10	P4 Front	Voltage unbalance	
47BX	Agastat	7012NB	0.5-5 Sec.	1.0 Sec.	P4 Rear	Voltage unbalance SHDN	
63SG1	CCS	604P21	200-3000 PSI	1600 PSI	S. gate operator	Alarm	
63SG2	CCS	604P21	200-3000 PSI	2100 PSI	S. gate operator	Press pump start	

Initial Setting - Subject to Change - DO NOT USE - For Information Only

TURLOCK LAKE DEVICE SETTINGS Plant

DEVICE NUMBER	MFG.	MODEL NUMBER	AVAILABLE RANGE	SETTINGS	LOCATION	FUNCTION	CHANGE
63T	W		None	Factory set at 10±1 PSI	Main transformers	Press relief alarm (2 ea)	
71FBH	Sierra		El 232-242 ft.	El ≥ 240.0 Closed	Water level transmitters	F. bay high level	
71FBL	Sierra		El 232-242 ft.	El ≤ 232.5 Closed	Water level transmitters	F. bay low level	
71TRL	Sierra		El 202-212 ft.	El ≤ 207.0 Closed	Water level transmitters	Tailrace low level	
71TRL	Sierra		El 202-212 ft.	El ≤ 207.0 Closed	Water level transmitters	Tailrace low level	
71T	W		None	Factory set	Transformers	Low oil level	
81	G.E.	121JF-52A4A	(L) 55-65 HZ (R) L+(.75 to 2) HZ	L 59 R 61 S.I. 0.2	P4 Front	Under/over frequency	
152X	Agastat	7014NB	0.5-5 Sec.	2.0 Sec.	P4 Rear	Line bkr. status time delay	
220SCX/C1	Agastat	7022NE	2C-200 Sec.	50 Sec.	Supv. P5	S. #1 gate control timed outputs	
220SCX/F1	Agastat	7022NC	1.5-15 Sec.	10 Sec.	Supv. P5	S. #1 gate control timed outputs	
220SOX/C1	Agastat	7022NE	2C-200 Sec.	50 Sec.	Supv. P5	S. #1 gate control timed outputs	
220SOX/F1	Agastat	7022NC	1.5-15 Sec.	10 Sec.	Supv. P5	S. #1 gate control timed outputs	
220SCX/C2	Agastat	7022NE	20-200 Sec.	50 Sec.	Supv. P5	S. #2 gate control timed outputs	
220SCX/F2	Agastat	7022NC	1.5-15 Sec.	10 Sec.	Supv. P5	S. #2 gate control timed outputs	
220SOX/C2	Agastat	7022NE	20-200 Sec.	50 Sec.	Supv. P5	S. #2 gate control timed outputs	
220SOX/F2	Agastat	7022NC	1 5-15 Sec.	10 Sec.	Supv. P5	S. #2 gate control timed outputs	

Initial Setting - Subject to Change - DO NOT USE - For Information Only

TURLOCK LAKE RECLOSER SETTINGS

Recloser Type - RXE

Control Type - ME Electronic Control

Accessories - Remote close, Remote lockout,

Auxiliary contacts, Dead-line block, 48 VDC power

Settings

Phase Trip: 200, Curve (1) None, Curve (2) W

Ground Trip: 25A, Curve (1) None, Curve (2) 3

Number of Operations:

Ground trip socket (0)-1-2-3-4

Lockout socket (1)-2-3-4

Phase trip socket (0)-1-2-3-4

Reclosing Interval Delays:

1st	1-2-5-7-10-15-30-45	Remove these plugs
2nd	1-2-5-7-10-15-30-45	Remove these plugs
3rd	1-2-5-7-10-15-30-45	Remove these plugs

Reset Delay:

10-15-30-45-60-90-120-180 Remove these plugs

Ground Block Switch Trip-(Normal)

Reclosing Switch (Non Reclosing)-Normal

INITIAL SETTINGS - SUBJECT TO CHANGE

FOR INFORMATION ONLY - DO NOT USE

Section 29 - CONTROLS

Plant controls are incorporated in the switchboard manufactured by R T E Delta of Stockton, California. Refer to T.I.D. drawing #E1-509 to E1-557.

General Method of Starting

Generators are designed with heavy amortisseur windings and are capable of being started as synchronous motors. (Synchronous motors are generally started by closing the main breaker and accelerating the rotor in the same fashion as an induction motor and then applying the field at an optimum phase angle near synchronous speeds.)

However, instead of accelerating the generator rotor from standstill, the wicket gate can be opened to a speed no load position. This will accelerate the rotor thru the 95% speed level. This will alleviate voltage dips of long durations during the acceleration period. At 95% speed, the unit breaker is closed and the rotor is accelerated to near synchronous speeds. After a short time delay, the field is applied and the rotor is pulled into synchronism with the distribution system.

Care should be taken to reduce flows thru the sluice gate in synchronism with the passing of water thru the turbine in order to minimize excessive surging of water downstream from the plant.

Unit Starting Procedure from Switchboard

Starting a unit from the switchboard may be accomplished as follows:

1. 43P plant "Local Remote" selector switch to "Local" position.
2. 43G generator "manual-local auto-remote" selector switch to "local auto" position.
3. 43R regulator "manual-auto" selector switch to "auto."
4. Check tailwater level by observing staff gage or marker on wall in tailwater bay. Tailwater elevation must be at least at elevation 207.0.

5. Check forebay level by observing staff gage. Forebay level should be at least at elevation 232.5.
6. Line breaker must be closed. If not closed, close line breaker.
7. To initiate starting sequence momentarily close 1/CS start switch. Sequencing relays will automatically bring generator on line if the following permissives are met:
   a. 43G in LA position.
   b. 43R in auto position.
   c. Exciter/regulator voltage set rheostat in no load position circuitry in exciter/regulator and switchboard is designed to force voltage set rheostat to the no load position.
   d. Generator speed less than 120% rated speed.
   e. 4.16 KV bus voltage energized.
   f. Wicket gate battery voltage normal.
   g. Forebay level normal.
   h. Lockout relays (86E and 86N) reset.
   i. Tailrace water level normal.
8. Observe cooling water pump indicator light.
9. Observe RPM meter. As soon as generator accelerates to 95% speed (95% of 200 rpm = 190 rpm), unit breaker should close. As soon as unit start switch is closed, red indicator light should go out. If red light does not go out, this indicates that cooling water pump has not been started.
10. The field breaker should close automatically, applying voltage to the generator field, approximately 5 seconds after closure of unit breaker. The field discharge resistor is automatically disconnected approximately 5 seconds after field application. The generator should now be in synchronism with the system.
11. If field breaker fails to close within 50 seconds of unit start, an incomplete sequence relay will shutdown and lockout in the emergency shutdown mode (86E).
12. Open wicket gate to desired flow and loading.
13. Adjust sluice gates.

Unit Shutdown Procedure from Switchboard

1. 43G selector switch in "local-auto" position.
2. Momentarily close 1/CS stop switch; relay 5B is energized and initiates shutdown sequence.
3. Start circuit is automatically deenergized.
4. Wicket gate closure is automatically initiated. Wicket gate will close to full closure in approximately 30 seconds.
5. Unit breaker trips at SNL (20% speed).
6. Field breaker trips as soon as unit breaker trips.
7. Field discharge resistor is reconnected.
8. If it is desired to bring rotor to a full stop, wait until generator speed slows to less than 25% (50 rpm) or normal. Gradually apply handbrake to bring rotor to a gradual and smooth stop.
9. Adjust flow through sluice gates.

Unit Starting Procedure from Broadway Control

1. 43G selector switch to "remote" position.

2. All other sequences same as unit start from switchboard except remote start 201/start switch replaces 1/CS/start switch.

Unit Shutdown Procedure from Broadway Control

1. Same as above procedure except remote stop 201/stop switch is closed instead of 201/start switch.

2. A man will go to the plant and apply manual brakes to stop the unit.

The following are manual start and stop procedures (non-automatic sequencing). However, this procedure is not recommended for normal starting and stopping of units.

MANUAL START

1. Set 43P on "Local," 43G on "Manual" and 43C on "Manual."

2. Check annunciator clear of alarms.

3. Close breaker 152. After short delay, check 4 KV bus voltage normal.

4. Start cooling water pump. After short delay check flow normal.

5. Activate start circuit through 1/CS start switch. Relays 4A, 4B and 4C will pick up.

6. Open wicket gate to approximately 200 RPM and close breaker 52.

7. After unit speed stabilizes, check voltage normal and close breaker 41 through 41 CS.

8. Use voltage adjust rheostat to set the power factor close to unity or slightly leading.

9. Open wicket gate to desired loading.

10. Sluice gates adjusted for flow requirements.

MANUAL STOP

1. Check 43P on "Local," 43G and 43R on "Manual."

2. Close wicket gate to speed no load adjusting voltage (vars) as load is reduced.

3. Trip breaker 41 through switch 41 CS.

4. Trip breaker 52 through switch 52 CS.

5. Close wicket gate fully.

6. Stop cooling water pump (pump will continue to run for 60 minutes).

7. Sluice gates adjusted for flow requirements.

Section 30 - REMOTE CONTROL

The remote control equipment is manufactured by System Northwest and is connected to the Honeywell SCADA system at the Broadway Control Center by leased telephone lines. Control and supervision of the power plant can be accomplished thru four CRT screens provided. Refer to T.I.D. drawing # E1-520 to E1-523.

The following remote functions are available at Broadway:

A. Control

a. For each of the three units:

1. Unit start.
2. Unit stop.
3. Unit wicket gate open - coarse.
4. Unit wicket gate open - fine.
5. Unit wicket gate close - coarse.
6. Unit wicket gate close - fine.
7. Unit voltage raise.
8. Unit voltage lower.

b. For plant functions:

1. Sluice gate #1 open - coarse.
2. Sluice gate #1 open - fine.
3. Sluice gate #1 close - coarse.
4. Sluice gate #1 close - fine.
5. Sluice gate #2 open - coarse.
6. Sluice gate #2 open - fine.
7. Sluice gate #2 close - coarse.
8. Sluice gate #2 close - fine.
9. Line breaker open.
10. Line breaker close.
11. Test relay close.
12. Test relay trip.

B. Data

a. For each of the three units:

1. Unit KW.
2. Unit KVAR.
3. Unit wicket gate position.
4. Unit RPM.
5. Unit output amps.

b. For plant equipment:

1. Forebay water level.
2. Tailwater level.
3. 4.116 KV bus voltage.
4. Sluice gate #1 position.
5. Sluice gate #2 position.
6. 5 volt power supply voltage.
7. Drop #2 flow.

C. <u>Alarm</u>

a. For each of the three units:

1. Unit overspeed. △
2. Unit emergency trip non-lockout (94G). △
3. Unit trouble. See paragraph E.
4. Unit generator bearing cooling water high temperature. △

b. For plant equipment:

1. Forebay water level low. ▲
2. Plant emergency trip. △
3. Plant trouble. See paragraph F. △
4. Forebay water level high. ⊘
5. Station service under voltage. ⊘
6. Plant ambient temperature high. ⊘
7. Plant fire alarm. ⊘
8. Sluice gate accumulator pressure low. ⊘
9. Annunciator horn "ON." ⊘

D. <u>Status</u>

a. For each of the three units:

1. Unit control mode "remote-local."
2. ON-OFF.
3. Unit breaker "OPEN-CLOSE."

b. For plant equipment:

1. Line breaker "OPEN-CLOSE."
2. Plant door alarm.
3. Unit breaker "OPEN-CLOSE."
4. Test relay ON-OFF.

Alarms are grouped as follows:

E. <u>Unit Trouble</u>

1. Cooling water low flow. ▲

△ Shutdown to speed-no-load.
▲ Complete shutdown to zero flows.
⊘ Non-shutdown points.

2. Incomplete sequence. △
3. Bearing oil temperature high. ▲
4. Bearing oil level low. ▲
5. Emergency shutdown and lockout (86E). △
6. Stator temperature high. ▲
7. Wicket gate battery under voltage. △
8. Field overcurrent. △
9. Normal emergency shutdown and lockout (86N). ▲
10. Generator vibration high. ▲
11. Cooling water high temperature.

F. Plant Trouble

1. Transformer alarm #1 (high temperature, low level or pressure relief device).
2. Transformer alarm #2 (high temperature, low level or pressure relief device).
3. 4 KV bus under voltage.
4. Plant over/under frequency.
5. Plant battery under voltage.
6. Bus phase sequence.

Section 31 - OPERATIONS

A. General

The Turlock Lake Powerhouse operates as a run of the canal plant and as such operates around irrigation schedules. Close coordination is required between the District's water master and the Broadway Control Center.

Irrigation orders are taken by a multitude of ditchtenders from various farmers within their respective beats. Orders are forwarded to the District's water master between 5 P.M. and 6 P.M. After the water master compiles the orders, he determines what the canal flows should be in the main canal for the following day and directs this information to the Broadway Control Center.

The Broadway Control Center will release the desired flows at the Turlock Lake Powerhouse starting at 6 A.M. Broadway will monitor

△ Shutdown to speed-no-load
▲ Complete shutdown to zero flows.

flow data telemetered from Drop #2 and make gate adjustments as necessary to maintain desired flows in the main canal.

Starting at Drop #4, two canal riders follow the change in canal flows down the canal and make adjustments to gates or boards at each drop structure to pass the new flows. However, at Turlock Lake Powerhouse, the Watermaster or outlet gate operator is required to communicate with Broadway Control in order to make the necessary flow changes thru the power plant. After the Watermaster or outlet gate operator is satisfied that the flows thru the power plant are proper, the Canal Riders will proceed to the division gates. At the division gates they will make the proper split between the Turlock and Ceres Main and each will follow their respective canals and flows to final destination.

The canal riders will make a daily check on the general conditions at the powerhouse and will make a report to Broadway Control on any abnormalities encountered, especially excessive trash buildup on the trash racks.

Broadway Control will dispatch the proper personnel to correct any problems that may exist.

Broadway Control will follow the directions of the Watermaster or outlet gate operator in making any initial daily wicket gate or sluice gate adjustments for proper flow passage thru the power plant structure.

At Turlock Lake Powerhouse, if the flows are below 1,611 CFS, the three turbine units should be utilized for passing flows and the sluice gates should be in the closed position. The turbines are capable of passing around 537 CFS each at full output at a head of 29 feet.

If the flows are above 1,611 CFS, the sluice gates could pass the additional flows. The sluice gate has a capacity of around 2,000 CFS at forebay elevation 236.00. If a load rejection occurs, flows will be sharply reduced thru the turbines within 30 seconds and the tailwater level will start to fall. The sluice gate should be immediately opened to compensate for the rejected flows in order to minimize the sudden change in flow downstream from the plant in order to provide continuity of irrigation deliveries and also to protect the canal system from possible damages caused by sudden drawdown.

Some types of load rejection will force wicket gates to full closure. Other types of load rejection will force wicket gates to a speed no load position. It is extremely important to distinguish between these two types of load rejections when compensating for flow with sluice gate operation, since a difference of up to 450 CFS can occur. Upon load rejection, the type of shutdown for each unit should be determined before sluice gate adjustment is initiated so that flow is correctly adjusted. An error in flow adjustment increasing the flow by a few hundred CFS could damage the canal system in a short time.

The following data shows characteristics of flow thru the turbines and sluice gate:

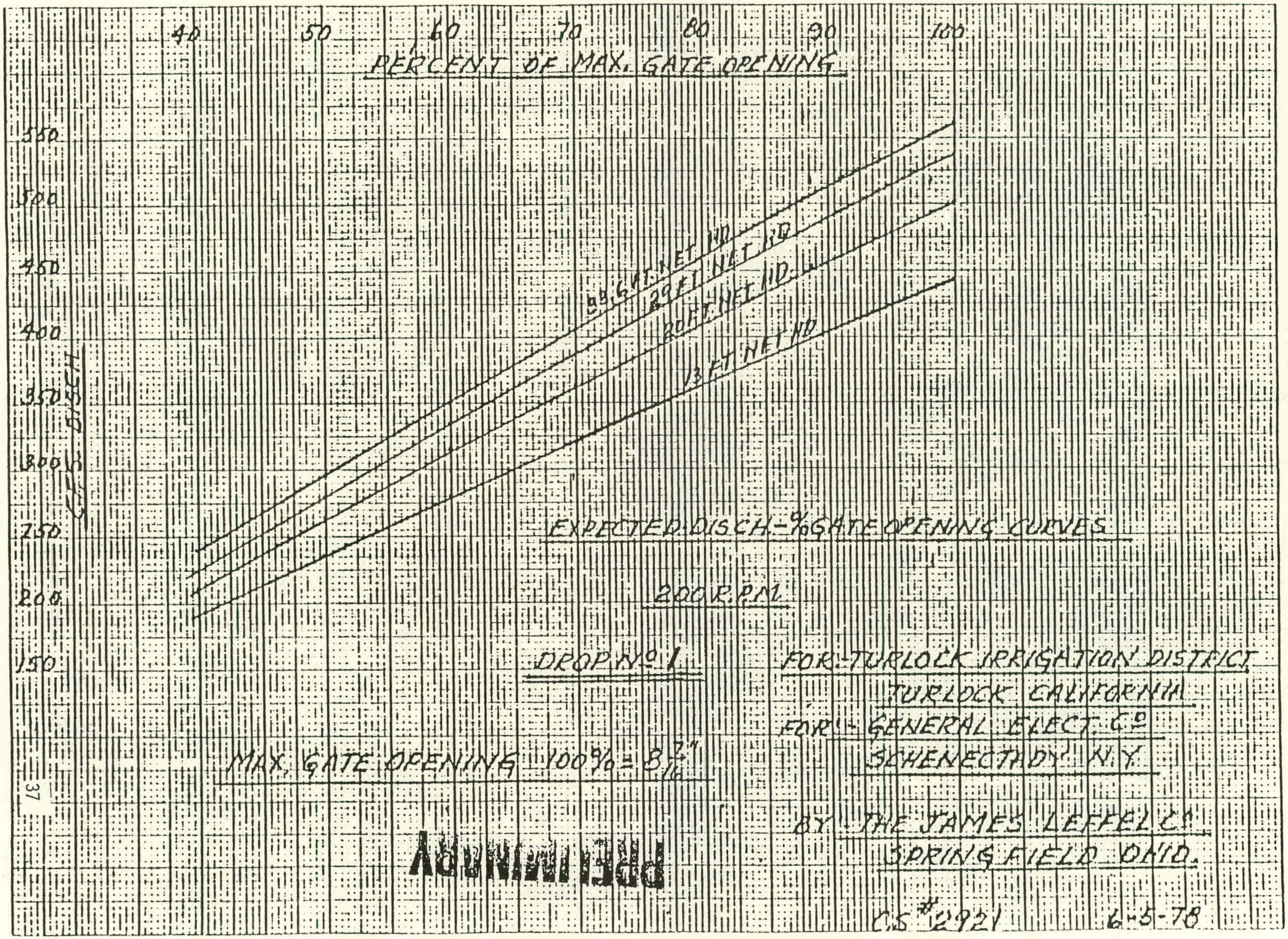
CS #2922 - Percent gate opening vs. discharge (CFS)

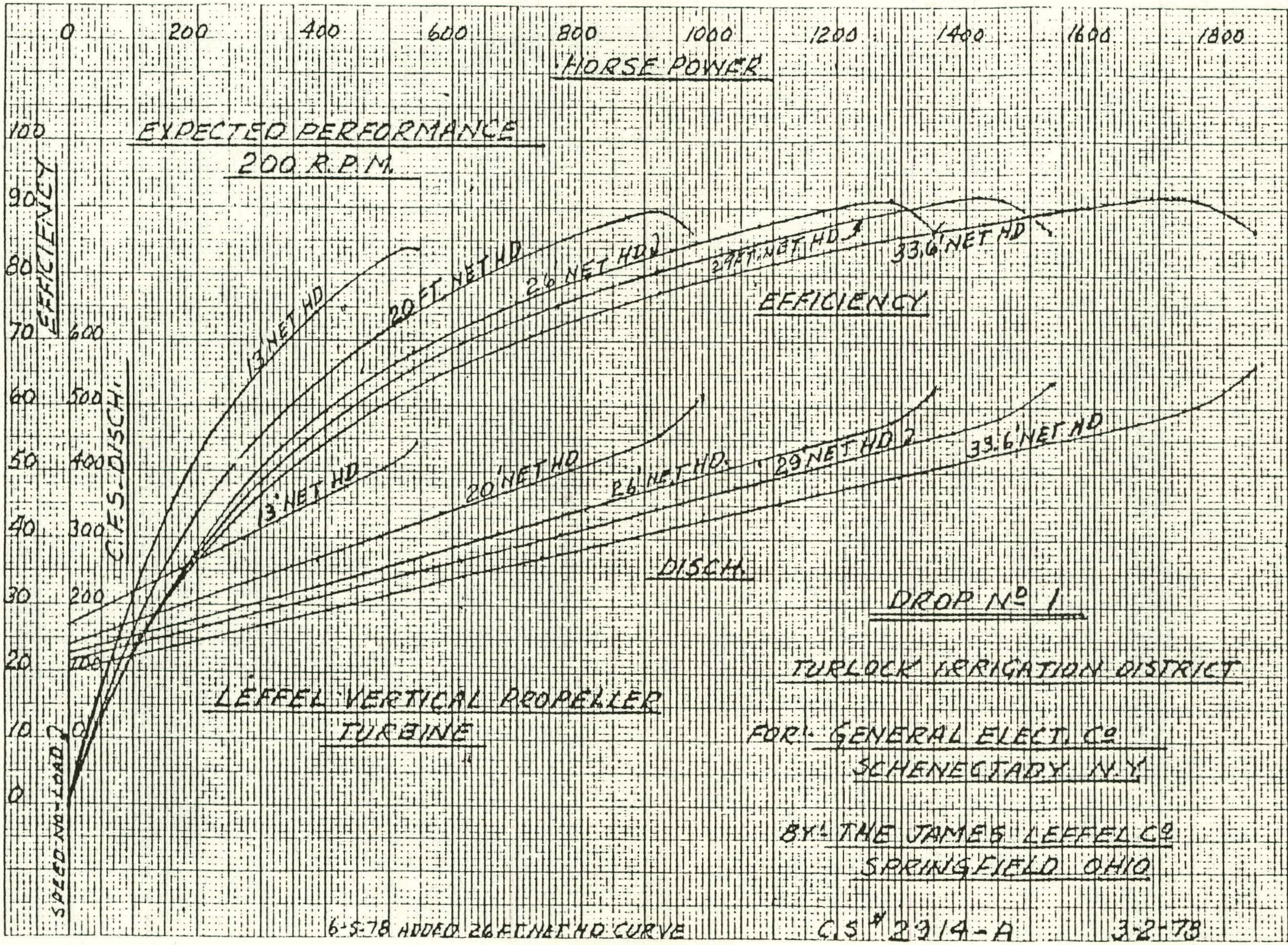
CS #2912 - Discharge vs. horsepower and horsepower vs. efficiency

Curve - Sluice gate flow CFS vs. stem opening ft.

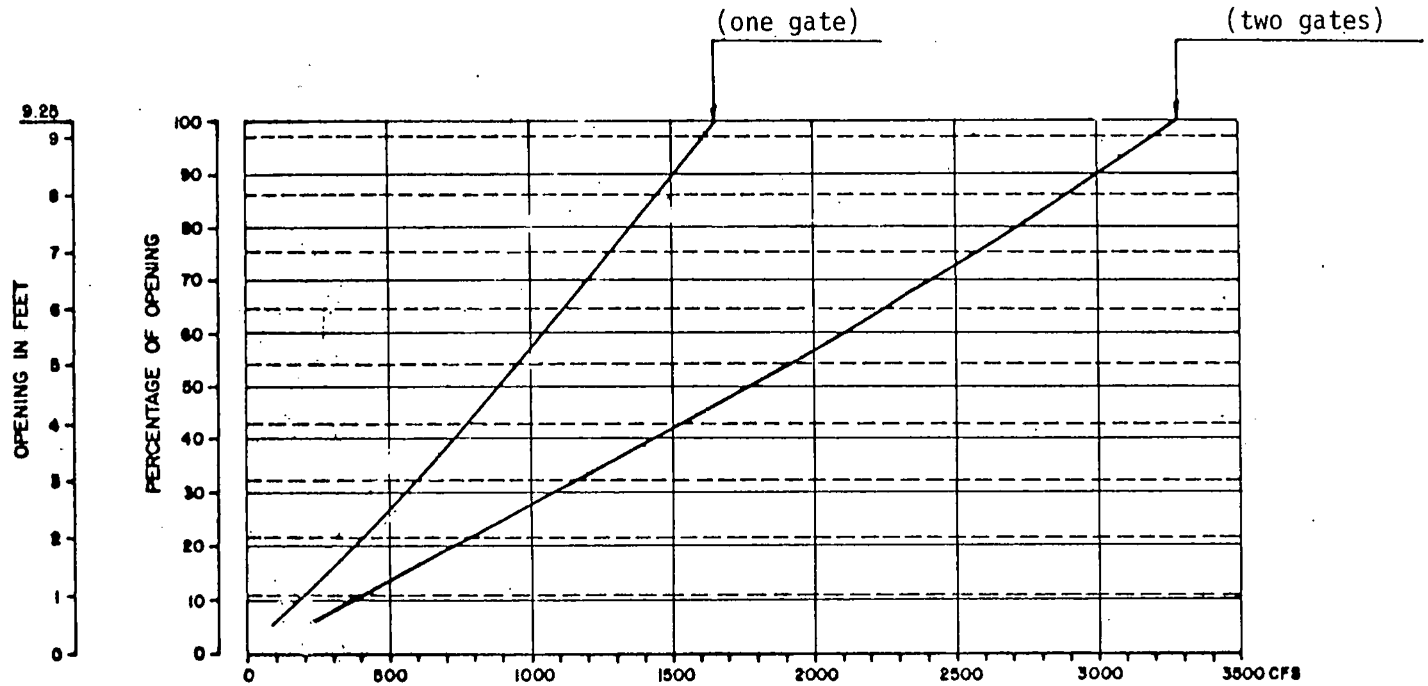
Table 40 - Turlock Powerhouse Flow Table

Table 44 & 45 - Main Canal Flow vs. Elevation


40 50 60 70 80 90 100
PERCENT OF MAX. GATE OPENING
550
500
450
400
350
300
250
200
150
29 FT NET HD
20 FT NET HD
13 FT NET HD
EXPECTED DISCH - % GATE OPENING CURVES
200 R.P.M.
DROP Nº 1
FOR - TURLOCK IRRIGATION DISTRICT
TURLOCK CALIFORNIA
FOR - GENERAL ELECT. Cº
SCHENECTADY N.Y.
MAX. GATE OPENING 100% = 8 7/16"
BY THE JAMES LEFFEL Cº
SPRINGFIELD OHIO.
C.S #2921
6-5-78



0
200
400
600
800
1000
1200
1400
1600
1800
HORSE POWER
EXPECTED PERFORMANCE
200 R.P.M.
EFFICIENCY
100
90
80
70
60
50
40
30
20
10
0
600
500
400
300
200
100
0
C.F.S. DISCH.
SPEED-NO-LOAD
13' NET HD
20 FT. NET HD
26' NET HD
29 FT. NET HD
33.6' NET HD
EFFICIENCY
13' NET HD
20' NET HD
26' NET HD
29' NET HD
33.6' NET HD
DISCH.
DROP Nº 1
TURLOCK IRRIGATION DISTRICT
LEFFEL VERTICAL PROPELLER
TURBINE
FOR: GENERAL ELECT. Cº
SCHENECTADY N.Y.
BY: THE JAMES LEFFEL Cº
SPRINGFIELD OHIO
6-5-78 ADDED 26 FT. NET HD CURVE
C.S. # 2314-A
3-2-78



SLUICEGATE DISCHARGE CURVE, TURLOCK LAKE

U/S WS = 239.9

TUDOR ENGINEERING COMPANY
149 NEW MONTGOMERY STREET
SAN FRANCISCO, CALIFORNIA

TURLOCK LAKE POWERHOUSE
FLOW TABLES

CFS Flow	Unit 1, 2 or 3 KW @ 30 Head	Sluice Gate @ 30 ft. Head % Opening	Ft.-In.
0	0		
50	0	3%	
100	0	6%	0 - 6
150	S.N.L.	9%	
200	280	11%	1 - 0
250	360	14%	
300	450	16%	1 - 6
350	575	18%	
400	700	21%	1 - 9
450	875	23%	
500	1060	26%	2 - 5
550		29%	
600		32%	3 - 0
650		35%	
700		38%	3 - 6
750		41%	
800		45%	4 - 1
850		47%	
900		50%	4 - 7
950		54%	
1000		58%	5 - 4
1050		61%	
1100		64%	5 -10
1150		67%	
1200		70%	6 - 6
1250		73%	
1300		76%	6 -10
1350		80%	
1400		84%	7 - 9
1450		87%	
1500		90%	8 - 4
1550		92%	
1600		95%	8 -10
1650		100%	9 - 3
1700			
1750			

Table 40

B. Canal Water Flow

A level transmitter is installed at Drop #2. This transmitter sends a 4-20 ma signal to the Turlock Lake Powerhouse where the level is displayed on a meter and transmitted through the SCADA to Broadway Control room. A level to flow conversion chart is placed by the level meter at the powerhouse for flow determination.

The operators at Broadway Control Center will use the Drop #~~1~~ 2 flow data point to determine canal flow.

C. Trash Racks

It is expected that trash racks in front of the turbine units and the sluice gate will become plugged from time to time and will need to be cleared. The Substation Division is responsible for maintenance of the powerhouse including clean out of trash tracks, if necessary, in order to maintain free flow and maximum output of the plant. An indication of plugged trash rack is an excessive power swing which should result in alarm condition.

D. Machine Speeds

Normal speed of the turbine-generators is 200 rpm. In the event of load rejection at full gate, runaway speeds as much as 505 rpm is possible. The automatic features of the plant are designed to close the wicket gates to near normal speeds. Each wicket gate operator is equipped with a self contained battery with trickle charge and a manual operating handle. In the event wicket gate fails to close automatically, manual operation of the operator handle is necessary in order to close the gate and reduce speeds to safe levels. If the manual operation is not successful, concrete stop logs will have to be inserted. This can be accomplished either with the electric hoist installed over the stop log slots or a portable manual hoist provided and stored in the building.

At runaway speeds, rotor coils and mechanical parts are stressed to design limits so operating for extended periods of time at these speeds is not recommended.

At runaway speeds, the first component of the generator that will be stressed beyond design limits will be the generator lower guide bearing. The temperature of this bearing is expected to exceed design limits after operating at runaway speeds for one hour and bearing damage is probable. For this reason, a spare lower guide bearing is part of the spare parts complement.

E. Voltage Control

Each generator is equipped with a voltage regulator with motor operated voltage adjust control. As distribution line voltage fluctuates up and down, VAR flow in and out of the machines will vary.

The voltage adjust control on the machines can be used to change the set-point of voltage regulation to match line voltage. If this is done, VAR flow will be kept to a minimum, preferably at zero and power factor of that plant at near unity.

Care must be exercised in ensuring that VAR flow is not going out of one machine and into the other. This is a circulating current condition and the voltage adjust control of one or all machines must be adjusted to correct the problem.

F. Start Up

Before units can be started, forebay level must be at least at elevation 232.5 and tailwater elevation at 207.0. Permissive circuits in the starting equipment will prevent start up unless these and other conditions are met.

Prior to starting the units up at the beginning of the season, the sluice gate must be used to fill the tailwater section of canal down to the division gates to at least elevation 207.0.

TURLOCK IRRIGATION DISTRICT

Rating 1978

ELEVATION TO FLOW CONVERSION TABLE
TURLOCK MAIN CANAL BELOW TURLOCK LAKE POWERHOUSE

DISCHARGE IN CUBIC FEET PER SECOND

TABLE 44

GAGE HEIGHT IN FEET	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
202.50							75	76	80	82
202.60	84	86	88	90	92	94	96	98	101	103
202.70	105	107	110	112	114	117	119	121	124	126
202.80	128	130	133	136	139	142	145	148	151	154
202.90	157	160	163	165	167	169	171	174	177	180
203.00	182	185	188	191	194	197	200	203	206	209
203.10	213	217	221	225	228	231	235	240	243	246
203.20	250	253	257	261	264	267	271	275	279	282
203.30	285	288	292	296	300	305	312	315	319	322
203.40	326	329	333	336	340	343	346	350	353	357
203.50	360	364	367	371	375	378	382	385	388	392
203.60	396	400	404	408	412	416	420	424	428	432
203.70	436	440	444	448	452	456	460	464	468	473
203.80	477	481	485	490	494	499	504	508	513	517
203.90	521	526	530	535	539	543	548	552	557	561
204.00	566	571	576	581	586	591	596	601	606	611
204.10	616	621	626	631	636	641	646	651	656	661
204.20	666	671	676	681	686	691	696	700	705	710
204.30	715	720	725	730	735	740	746	752	757	762
204.40	767	771	776	780	784	788	793	798	802	808
204.50	813	818	823	828	834	839	845	849	854	859
204.60	864	869	875	881	887	892	898	903	908	913
204.70	918	923	928	933	939	945	951	957	963	969
204.80	976	983	989	995	1,001	1,007	1,012	1,017	1,023	1,028
204.90	1,034	1,039	1,046	1,052	1,057	1,064	1,070	1,076	1,081	1,086

TABLE 45

TURLOCK IRRIGATION DISTRICT

Rating 1978

ELEVATION TO FLOW CONVERSION TABLE
TURLOCK MAIN CANAL BELOW TURLOCK LAKE POWERHOUSE

DISCHARGE IN CUBIC FEET PER SECOND

GAGE HEIGHT IN FEET	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
205.00	1,092	1,097	1,103	1,109	1,115	1,122	1,128	1,134	1,139	1,145
205.10	1,151	1,156	1,162	1,168	1,174	1,180	1,186	1,192	1,197	1,203
205.20	1,209	1,214	1,220	1,226	1,233	1,239	1,245	1,251	1,256	1,262
205.30	1,268	1,273	1,279	1,285	1,291	1,297	1,303	1,309	1,314	1,320
205.40	1,326	1,332	1,338	1,344	1,350	1,356	1,362	1,368	1,374	1,380
205.50	1,387	1,392	1,398	1,404	1,410	1,417	1,423	1,429	1,435	1,440
205.60	1,446	1,452	1,458	1,464	1,470	1,477	1,483	1,490	1,497	1,503
205.70	1,509	1,515	1,522	1,528	1,535	1,542	1,548	1,555	1,562	1,569
205.80	1,575	1,581	1,588	1,595	1,602	1,609	1,616	1,623	1,630	1,637
205.90	1,644	1,651	1,658	1,665	1,672	1,679	1,687	1,694	1,701	1,708
206.00	1,715	1,722	1,729	1,737	1,744	1,751	1,758	1,765	1,772	1,779
206.10	1,787	1,795	1,802	1,809	1,817	1,824	1,831	1,839	1,847	1,854
206.20	1,862	1,870	1,877	1,885	1,892	1,900	1,908	1,916	1,923	1,931
206.30	1,939	1,947	1,954	1,962	1,969	1,977	1,984	1,992	2,000	2,007
206.40	2,015	2,023	2,030	2,038	2,045	2,053	2,060	2,068	2,076	2,084
206.50	2,091	2,099	2,107	2,115	2,122	2,130	2,137	2,145	2,153	2,160
206.60	2,168	2,176	2,184	2,192	2,200	2,208	2,216			