HYDRAULIC LABORATORY
SUMMARY REPORT
FISCAL YEAR 1959

BUREAU OF RECLAMATION
ENGINEERING LABORATORIES
DENVER, COLORADO

FOREWORD

"* * * No civil engineer can now hope to possess all the knowledge and skill necessary for the design and construction of modern engineering projects; for success in his profession he will, however, have to be competent to collaborate fully and on equal terms with his specialist colleagues. What we need is a supply of engineers much more highly educated and trained than the average graduate from our universities and technical colleges. It would be well if we shed some of our prejudices against evening work in the universities and tried the experiment with certain of our post-graduate classes. Many more men would be able to benefit than can at present attend full-time courses.

"The most important function of any learned society is the promotion and dissemination of knowledge of the subjects within its purview. The importance of personal communication is sufficient reason why the meetings of the Institution are our most valuable form of activity. The contribution of ideas is just as much a duty of membership as the payment of subscriptions, and it is essential that anyone with something to contribute should feel it incumbent upon him to do so. Enhanced status for the civil engineering profession will come by the loyal co-operation of all the members of the Institution in its corporate work of increasing knowledge of both theory and practice."

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*Presidential Address to the Institution of Civil Engineers, by Professor A.J.S. Pippard, M.B.E., D.Sc., F.R.S., M.I.C.E., Institution of Civil Engineers, November 1958, Civil Engineering and Public Works Review, Volume 54, No. 632, February 1959.

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HYDRAULIC LABORATORY
Division of Engineering Laboratories
Commissioner's Office
Denver, Colorado
July 1, 1959

SECTION I--INTRODUCTION

General

This year witnessed an increase in the volume of direct project work over the previous year. This is attributed to the continuation of the Colorado River Storage Project design studies and to several new project starts. At the same time, there was a renewed interest of various design branches in laboratory and field testing which led to several interesting studies which have produced new information useful to present and future Bureau work.

An increase in the number of inquiries for technical information was apparent this year. Letters and technical memoranda on a wide variety of hydraulic engineering subjects were written in answer to these inquiries. Thirty-six laboratory reports, travel reports, papers, and publications were issued during the year.

Several complex problems dealing with transient hydraulic phenomena indicated that consultation with an expert in the hydraulic research field would be advisable. Accordingly, Dr. Arthur T. Ippen was employed to review the problems in question. As in his previous discussions with the staff in April 1957, assurance was gained that our methods and procedures of research do not differ appreciably from those of other prominent research laboratories. We are still hampered to a pronounced degree by a lack of precision equipment to measure and analyze hydrodynamic forces when our equipment is compared to that available from instrument companies. This gap has been partially closed since 1957, but much remains to be accomplished. Maximum benefit of our basic and applied studies can be obtained through analysis of reliable and accurate measurement of hydrodynamic forces. Quoting Dr. Ippen's report, "The importance of continuous study of modern instrumentation for the operation of the Hydraulic Laboratory cannot be over-emphasized. It is believed that many techniques which have become available through the rapid development in electronics in recent years are still unexploited or even unknown in hydraulic measurements. This pertains also to data analysis and processing. More time for independent search and analysis must therefore be made available to personnel interested in instrumentation in all our laboratories."

The laboratory is making gradual progress in bringing its instrumentation up to date. With the greatly increased demands for information on transient hydraulic phenomena instruments now on hand or on order will be put to good use in the immediate future.

The Hydraulic Laboratory cooperated with the Chemical Engineering Laboratory Branch in the study of hydraulic losses in the electrodialysis membrane stacks.

The expanded electronic digital computer facilities of the General Engineering Branch were utilized in analysis of tractive force research data.

Assistance was rendered by this branch in the college contact program. Two trips to engineering colleges were made by the chief of the branch. A member of the staff assisted the Board of Civil Service Examiners in examining applications for engineering and subprofessional positions.

A number of the Hydraulic Laboratory staff are reserve officers in the Armed Forces and have sought and obtained active duty training in special engineering and scientific centers. Several assignments have offered the opportunity to broaden the experience in fields directly related to their regular Bureau work.

The Hydraulic Laboratory had many distinguished visitors during the year. Dr. Pierre Danel, President and General Director of Laboratoire Dauphinois d' Hydraulique, Grenoble, France, an internationally known hydraulic engineer, favored the Bureau staff with a repeat of the James Clayton lecture which he gave at the fall meeting of the Institution of Mechanical Engineers of Great Britain in London, 1958. His lecture traced the course of developments of hydraulic turbines to the advanced state which the French have accomplished in recent years through research.

"Hydraulic Laboratory Practice" Engineering Monograph 18 was revised for reprinting. This publication has been very popular, several thousand copies having been issued.

Hydraulic Research Engineer William E. Wagner was honored with a Bureau of Reclamation Superior Performance Award given for outstanding work demonstrated by his paper entitled "Determination of Pressure Controlled Profiles" which received the J. James R. Croes Medal of the American Society of Civil Engineers.

The Hydraulic Laboratory staff receives a considerable number of long distance telephone calls from various parts of the country in which technical information and opinions are sought on a wide variety of technical problems. This seems to be a difficult problem to cope with. In many cases, the inquiring party can be declined by asking him to put his question in the form of a letter to the Chief Engineer.

In September 1958, remodeling of the northmost wing on the west side of Building 56 was started by General Services Administration. The Hydraulic Laboratory offices are in the rear ground floor portion of this wing. Major features of the remodeling consisted of (1) insulated panels in place of glass exterior walls, (2) new hung ceiling, (3) rewired and lowered and/or new light fixtures and controls, (4) completion of conversion to low pressure steam heat. This work was completed in April of 1959. Still pending is a request to paint interior ground floor wall surfaces.

This wing was the guinea pig, so to speak, to establish design and installation criteria for the remodeling contemplated for many of the Federal Center's buildings. As a result, it took 7 months to make the changes. The occupants lost much time through numerous shutdowns and frequent moving to and from the proximity of progressive stages of construction. In addition, they had to endure considerable noise and cold detrimental to the type of work required of them.

No compensation for these conditions was allowed the occupants during this period, and they are to be commended for their attitude and performance during the ordeal.

SECTION II--STUDIES FOR BUREAU PROJECTS

This year, the Hydraulic Laboratory staff and facilities were used to study a wide variety of hydraulic problems in the laboratory and on projects. The major studies are described in this section.

Prineville Dam Spillway and Outlet Works
Glen Canyon Dam Spillways
Flaming Gorge Dam Spillway
Palisades Dam Outlet Works Prototype Tests
Navajo Dam Spillway and Outlet Works
Sherman Dam Outlet Works
Merritt Dam Canal Outlet Works
San Acacia Diversion Dam
Shadehill Canal Outlet Works
Glendo Dam Outlet Works
Thomas Point Pumping Plant Tests

Jack and Jetty Studies, Missouri River Basin Project
Grand Valley Diversion Dam
Delta-Mendota Canal
Rainbow Bridge National Monument Model
Concrete Pipe Drain Tests, Coachella Valley
Clear Creek Tunnel Geophysical Measurements
Evaporation Studies, Lake Hefner, Oklahoma
Region 3, Discharge Tests on Irrigation Gates

Prineville Dam

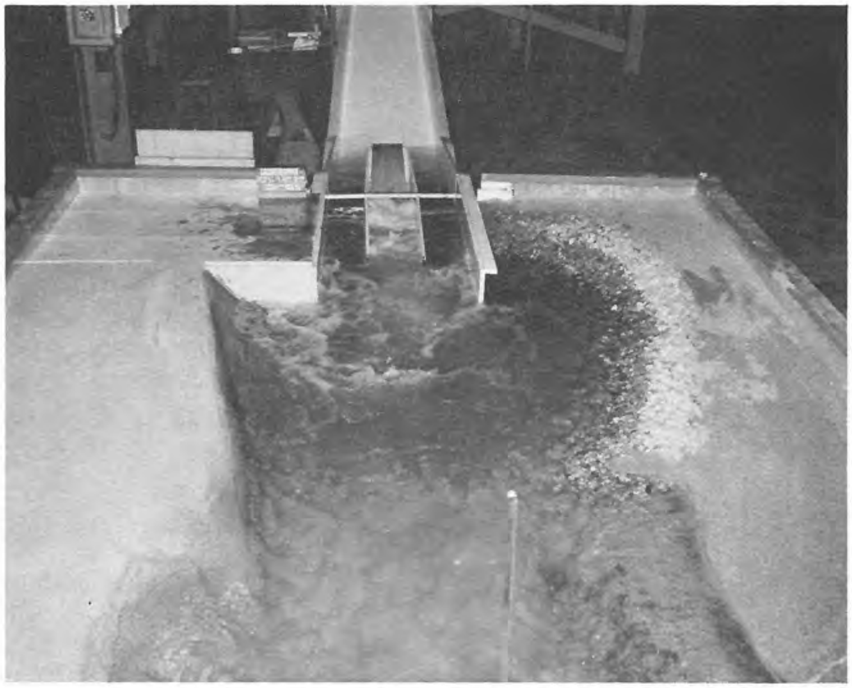
Tests made on the 1:24 scale model of Prineville Dam, using a loose sand bed downstream from the stilling basin, showed that material would be swirled around within the basin and deposited between the intermediate and outside training walls when the outlet works only operated. An extension of the intermediate training walls eliminated the movement of materials, but worsened the stilling action. A lowering of the extended walls improved the stilling action. However, with the rock cuts of the downstream channel represented on the model and the cuts in overburden protected with riprap, the movement and deposition of material were eliminated and wall extensions were not needed. Also, the erosion tests showed best protection of the riprapped left bank from wave action was obtained by warping the excavated surface from 2:1 at the end of the stilling basin to 3:1 at a point 100 feet downstream (Figure 1).

The pressures on the elliptical-shaped dividing pier in the bifurcation upstream from the 6-foot high outlet works slide gates were all positive for unbalanced gate operation when the gates were limited to a maximum opening of 5 feet 6 inches. The pier nose shape was made of circular curves to simplify construction when tests on this design showed lower but still positive pressures for the same operating conditions.

Interference with the outlet flow occurred at the spillway floor slab where the top of the outlet tunnel intersected the spillway chute floor. Tests indicated that a 3-foot cutback of the floor slab that increased the flow passage opening eliminated all but occasional impact by spray and intermittent slugs of water and the enlarged opening was considered adequate.

Glen Canyon Dam

Tests were made on the 1:63.5 scale model of the spillways to determine the difference in water surface elevation at the



A. Maximum outlet works flow of 3,529 cfs. Both gates full open.

B. River channel erosion after 3 hours model operation with maximum outlet works flow.

Figure 1. Prineville spillway and outlet works hydraulic model studies (1:24 scale).

powerhouse and a station 3,000 feet downstream for an open river channel and one blocked by rock slides. These tests showed that the ejector action, caused by either one or both of the spillway streams discharging into the downstream river channel, always produced a lower water surface at the powerhouse than at the downstream station. The difference was 1 foot at a flow of 50,000 cfs and 24 feet at a flow of 276,000 cfs. The representation of a rock slide that blocked 40 percent of the river channel did not cause a noticeable change in the water surface differences.

Tests were conducted to study the shape and orientation of the spillway flip buckets to best fit the field foundation conditions. As a result of these tests, the buckets were moved 20 feet upstream, and the wall height on the river side was reduced by about 20 feet to place its top 5 feet above the bucket lip.

Flaming Gorge Dam Spillway

The downstream end of the spillway tunnel, the outlet works, powerhouse, and a section of downstream river channel were added to the 1:36 scale spillway model.

The spillway inlet channel and tunnel entrance developed from previous model tests provided satisfactory flow conditions in the inclined tapered tunnel, the vertical bend, and the horizontal tunnel section. Numerous flip bucket shapes were placed at the downstream end of the tunnel to develop a design which would distribute and direct the flow to minimize erosion of the river banks. Buckets with lip angles up to 35 degrees with wall deflectors were studied (Figure 2). A flip bucket with a 15-degree lip and without a deflector was chosen from the designs tested.

Palisades Dam Outlet Works Prototype Tests

Test facilities installed during construction were used along with laboratory equipment to obtain head loss data through the numerous branches of the manifold during releases of approximately 8,000, 11,000, and 13,000 second feet evenly distributed through the six outlet gates and valves. Data necessary for computation of gate hoist loads and hydraulic downpull forces acting on the slide gate leaves were obtained by photographing the test instruments.

Computations show that the head losses in the manifold branches are very small for the relatively low discharge that could be released for the tests. Although downpull curves for the prototype slide gates are very similar to those for the model, the measured downpull is considerably less than that computed from model data.

A. 15° flip bucket
H-1321-78

B. 25° flip bucket
H-1321-95

C. 30° flip bucket
H-1321-84

D. 30° flip bucket, with deflector
H-1321-99

Figure 2. Flaming Gorge Dam flip bucket studies. Flow appearance with $Q = 28,800$ cfs.

Navajo Dam, Spillway, and Outlet Works

Tests were made on the 1:24 scale model to develop a stilling basin design which could be used for dissipating energy in the diversion flows during construction, and later used to dissipate the energy in the high velocity flow from two 72-inch hollow-jet valves. The tests showed that the basin designed primarily for the valves would need minor alteration to handle the diversion flows. The chute floor profile was reshaped to eliminate subatmospheric pressures which would induce cavitation. Modifications to the upstream end of the dividing wall were made to eliminate severe subatmospheric pressures and to prevent excessive splashing and overtopping of the basin training walls. The basin floor was lowered 2 feet and baffle piers and a downstream sill were added to improve energy dissipation and decrease erosion downstream. A satisfactory basin for both diversion and regular operation was developed from the tests (Figure 3).

Tests were made on the 1:48 scale model of the diverging open channel chute and spillway to study flow conditions in the approach channel, over the crest, in the chute, and in the stilling basin. Flow distribution in the chute leading to the stilling basin was improved by straightening the approach channel. However, further improvement was needed at high flows to obtain a uniform hydraulic jump throughout the width of the basin. Tests showed that good distribution of flow into the stilling basin was obtained by placing a hump 60 feet wide, 240 feet long, and 1-1/2 feet high at the chute center line, the floor of the sloping chute section a short distance downstream from the crest. (Figure 4). The thin sheet of water in the prototype spillway chute of maximum discharge made this an unusual model study. The relatively high friction on the model made it necessary to provide a greater fall to obtain the scale velocity at the stilling basin entrance. Also, it was essential that geometric proportions between the model and prototype be represented to study flow distribution. Extensive alterations to the model were needed to satisfy these two requirements.

Sherman Dam Outlet Works

Tests on a 1:20 scale model of the two slide gates and the stilling basin into which they discharge were made to evaluate the performance of the structure to assure smooth flow into an unlined canal.

The initial tests disclosed that the hydraulic jump was nearly swept from the basin when the canal design capacity was released through only one gate and that flow conditions were

Aug '58

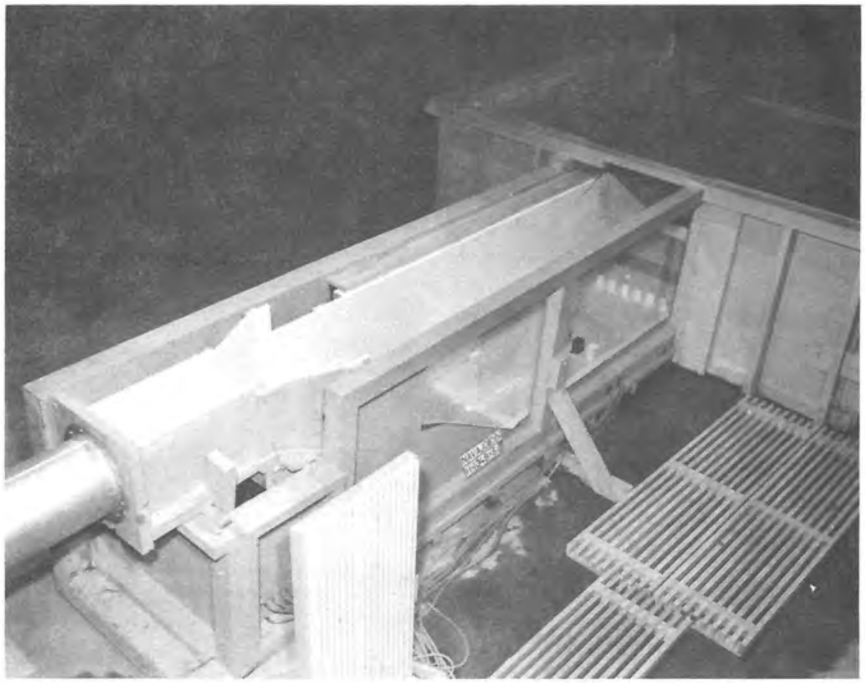
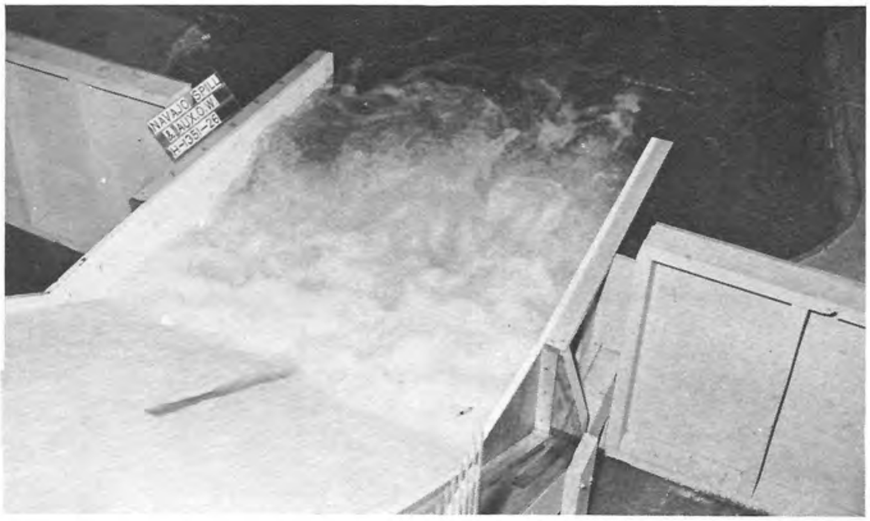
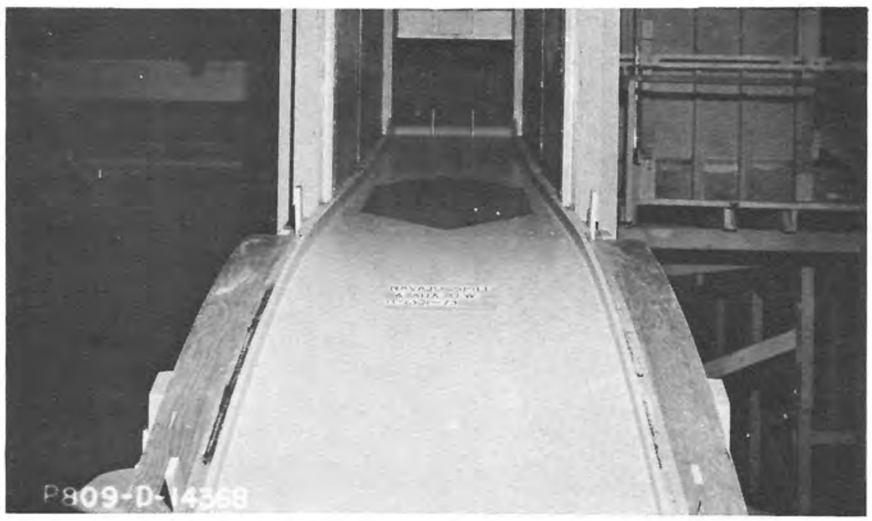


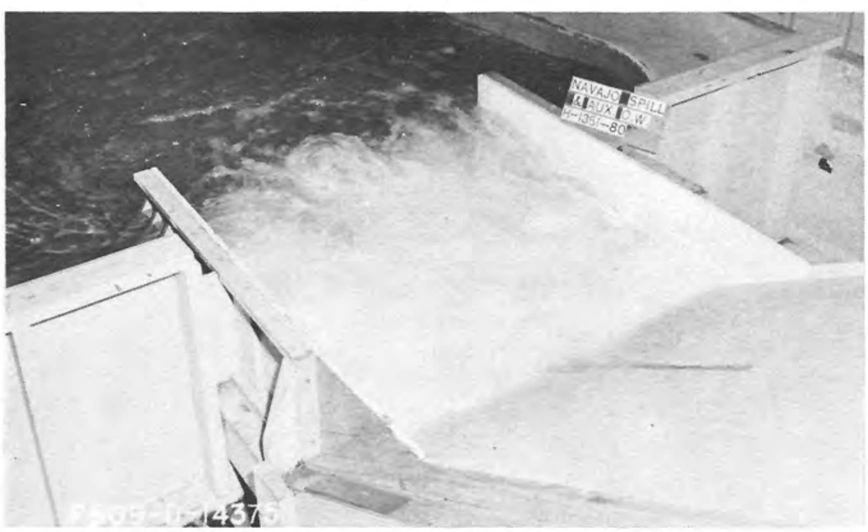
Figure 3. Navajo Dam stilling basin hydraulic model studies, 1:24 scale.



A. Operation without hump in chute floor



B. Chute floor hump 1-1/2 feet high by 60 feet wide by 240 feet long



C. Operation with hump in chute floor

Figure 4. Navajo Dam spillway hydraulic model studies.

extremely rough because of this fact. Further tests indicated that deepening the stilling basin 2 feet and shortening the center dividing wall improved the flow sufficiently to give good performance.

Merritt Dam Canal Outlet Works

Tests were made on a 1:20 scale hydraulic model of the twoslide gates, the stilling basin, and a short section of the downstream canal, to evaluate the performance of the structure, to assure smooth flow into the Parshall Flume, which measures the water released into the canal. The tests disclosed that excessive wave action would occur in the Parshall Flume, particularly for unsymmetrical gate operation. Also, that the wave action and rough flow conditions could be minimized by constructing a wave suppressor at the end of the basin, shortening the center dividing wall, and replacing the dentated end sill by a sloping sill.

San Acacia Diversion Dam

A 1:20 scale movable-bed hydraulic model was constructed to represent the Socorro Main Canal headworks, about 100 feet of the main canal, Socorro channelization headworks, about 100 feet of the channelization, eight bays of the diversion dam, and a portion of the Rio Grande River upstream from the diversion (Figure 5). Tests on this model were for the purpose of determining the best modification to the canal intake structure to alleviate the excessive deposition of sediment in the canal and to provide criteria for future operation. The model verified the excessive deposition of sediment that occurred in the canal during the summer of 1958. Tests on various types and arrangements of guide walls and weirs indicate that considerable reduction in the amount of sediment entering the canal may be realized from these additions.

Shadehill Canal Outlet Works

When Shadehill Dam was constructed, the canal outlet works designed for 285 cfs was terminated at the end of its stilling basin and was not to be used until construction of the canal at future date. Tests were made the past year to determine the hydraulic characteristics of a proposed arrangement which would enlarge and extend the outlet works to handle 600 cfs and provide a means of spilling the flow from the canal headworks to the spillway stilling basin and to the river channel downstream, placing it in immediate use. The model represented the slide gates, original outlet works stilling basin, a length of expanded channel downstream of the basin, a wave suppressor in the channel, and a 6-foot-diameter tunnel sloping downward from the channel to the spillway stilling basin

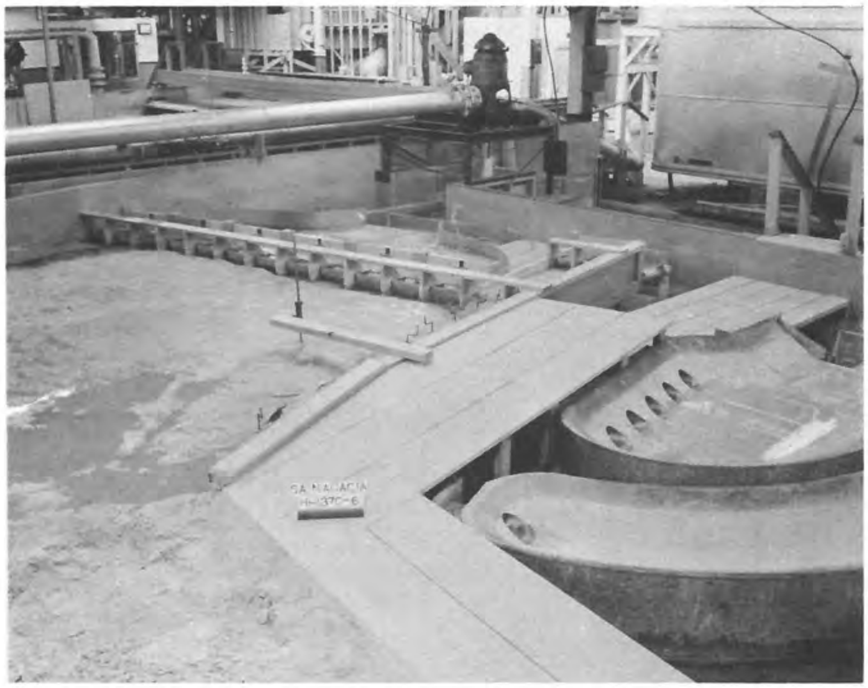


Figure 5. San Acacia Diversion Dam hydraulic model studies, 1:20 scale.

where it passed through the training wall at an oblique angle 19 feet above the basin floor. The model tests showed that satisfactory performance of the system would result when a large chute block was added to the original outlet works stilling basin, three baffle piers were installed at the end of this basin, the entrance of the 6-foot tunnel was shaped to contain an ogee crest, and a 27-degree vertical bend was rotated 45 degrees to direct the flow downstream and to the center of the spillway stilling basin. The tests showed that improvement in flow conditions at high discharges would result when the crown of the tunnel entrance was raised to increase the opening, and a deflector and air vent were added to the crown of the entrance.

Glendo Dam Outlet Works

Cavitation erosion occurred in the flared walls immediately downstream from the slide gate controls, at the stoplog slots near the end of the flaring walls, and along the sides of the chute block located in the stilling basin entrance, during operation of the outlet works in the summer of 1958.

Tests were made on a 1:18.4 scale model to study modifications which would eliminate the cavitation and accompanying vibration. Air vents in the form of hollow metal-plate wedges were tested on the model as a means of eliminating the erosion along the flared walls. The tests showed the vents to be effective and that cavitation tendencies at the stoplog slots could be removed by filling the slots to form continuous surfaces along the flared walls.

The cavitation erosion of the chute blocks resulted because of rather abrupt top corners, and model tests were made on blocks with greater degrees of streamlining to develop a cavitation-free design.

No cavitation erosion had occurred on the prototype baffle piers, located in the stilling basin floor a short distance downstream from the stilling basin entrance. However, the model pressures on these piers indicated that vapor pressure would form on the rounded upstream corners at high discharges and that further streamlining would be desirable.

The prototype structure was modified to include the changes developed from the model tests and the outlet works system was operated in June 1959. Controlled test releases up to 7,500 cfs were made. The wedge-shaped air vents were satisfactory and there was no cavitation noise evident along the wall, either at the vents or at the filled-in stoplog slots. Similar but less intense vibration than observed in the stilling basin in 1958, developed during the higher test releases. The source and cause of the vibration will not be known until the basin is unwatered. It is possible that some parts of the flow surfaces in the stilling basin were roughened sufficiently to cause cavitation during the test releases.

Pump-Turbine Performance Tests, Thomas Point Pumping Plant, Lower Yellowstone Project

Performance tests and an inspection of the two direct-connected pump-turbine units were made at the request of the Project Manager after a considerable decrease in the pumped water output had been noted. The pump capacities were found to be much lower than the rated capacity, and the water required by the turbines had increased in recent years.

Severe wear had occurred on the impeller inlet blades and moderate wear on the wicket gates, runner buckets, and stay vanes. Rough scale deposits had occurred in both the pump and turbine cases. Also, there was excessive wearing ring clearance.

As a result of the tests, recommendations were made to replace the pump impellers, repair or replace other worn parts, clean and paint the flow passages of the cases, and restore the design wearing ring clearances.

Jack and Jetty Studies, Middle Rio Grande Project, New Mexico

A model with a horizontal scale of 1:140, a vertical scale of 1:22, and nearly constant jetty field, river channel, and flood plain widths was constructed to determine the effectiveness of jetty fields using 500-foot spacing of tieback with those of lesser spacings. A hydrograph representing flows of 5,000, 10,000, 15,000, 10,000, and 5,000 cfs was used in the tests. Water surface elevations and flow velocities were measured at eight range lines across the entire width of the river, including the jetty field, channel, and flood plain for tieback spacings of 500 and 250 feet. Riverbed elevations were determined for each range line for the two tieback spacings.

The model indicated velocity reductions of from 13 to 19 percent for both spacings at 10,000 to 15,000 cfs.

An analysis of similar field data showed good agreement between model and prototype.

Tests with black granular plastic representing suspended sediment, with a tieback spacing of 250 feet, showed a general deposit of 1 foot of material to occur in the jetty field, and a scour of about 6 feet to occur in the channel.

Tests were in progress at the end of the fiscal year on the 500-foot spacing. Computations and comparison of the relative effectiveness of the two tieback spacings will be made in FY60.

Grand Valley Diversion Dam

A 1:30 scale sectional model of the existing dam and adjacent riverbed was constructed to determine the effectiveness of different methods in preventing undermining of the downstream end of the stilling basin apron. Tests were limited to sills placed at the end of the apron and to riprap protection of the riverbed downstream from the apron. Although a combination of a sill and riprap gave the best protection, construction of the sill was not considered justified when the model tests indicated that adequate protection could be obtained by covering the riverbed with a 4-foot layer of 24- to 36-inch stones for a distance of 30 feet downstream from the end of the stilling basin apron.

Delta-Mendota Canal--Central Valley Project

Assistance was provided to Region 2 for conducting studies pertaining to the carrying capacity of the canal. Techniques for measuring losses caused by bridge piers and other structures in the canal were developed, and a limited number of tests were made to ascertain the losses for the unobstructed canal, bridges having different orientation of piers, overchutes, check structures, and inverted siphons. Although the losses for some of the individual obstructions did not appear out of line with design criteria, the combination of losses results in a large deficiency in the carrying capacity of the canal. As a result of the study, plans have been developed to conduct a systematic study of losses for large canals and pertinent flow obstructions.

Rainbow Bridge National Monument Model

A 1:2,400 scale model of the Rainbow Bridge National Monument and surrounding area was constructed at the request of Region 4 to study plans for preventing the encroachment of Glen Canyon Dam reservoir waters upon the monument area. The model depicted an 18- by 23-mile area above the junction of Bridge and Aztec Creeks and the Monument proper. Inserts were made to represent conditions that would prevail under maximum reservoir storage with and without several proposals for protective facilities designed to prevent encroachment of the reservoir waters upon the monument area. Also requested was the proposed diversion for upstream runoff. Three copies of the model were made to satisfy study requirements of offices at different locations.

Concrete Pipe Drain Lines, Coachella Valley Drainage System

Assistance was given the Coachella Valley County Water District in measuring losses in the Grant Street drain. The measurements were made to compare with similar data taken in 1954 to determine whether or not a high concentration of sulfate in the drainage water had affected the Type II cement concrete pipe to change the losses. The measurements made this year indicated the loss coefficients for the full pipe to be the same as previously and those for the partially full pipe to be increased slightly. A chemical analysis of a drainage water sample taken during the tests showed a decrease in sulfate concentration from 4,800 ppm in 1954 to 600 ppm in 1959. It was concluded that the high concentration observed in 1954 was of short duration and that there should be little change in losses in the future.

Clear Creek Tunnel Geophysical Investigations--Trinity River Division--Central Valley Project, California

Assistance was provided in making geophysical investigations in the tunnel. A total of 17 seismic lines were completed; 10 of which were in the tunnel, the balance on the surface. Seismic velocity measurements were made at two locations in the outlet leg of the tunnel where strain gages will later be placed in the lining and also in tunnel sections in areas of different rock types, such as soft, medium quality, and hard rock.

This is the first time the Bureau has made measurements of this type in a tunnel as related to both design and exploration problems. Other seismic measurements were made along lines on the surface to determine the depth of rock weathering and rock character.

Capacity Study and Calibration of Venturi Meter--Lake Hefner, Oklahoma

Assistance was given the Geological Survey and the Oklahoma City Water Department in an investigation as to the cause of changes in the discharge capacity of the raw water Venturi meter used at Lake Hefner to evaluate the effectiveness of a monomolecular layer on evaporation reduction. Tests were made at six discharges which covered the range of tests made shortly after the meter was installed. An inspection and recalibration of the meter disclosed that incrustations of about 1 inch had formed in the meter since the previous calibration in 1952, and that this incrustation had reduced the capacity an average of about 4.3 percent from the manufacturers curves. Correction factors obtained from these tests will be used in studies made to determine the effectiveness of the monomolecular layer in reducing evaporation from an open water surface.

Discharge Characteristics, Irrigation Delivery Gates--Region 3

A brief examination was made of a test installation for calibrating irrigation delivery gates and the calibration data for two sizes of gates to assist in determining the cause of a variation of 13 percent between the measured discharge per foot width for an 0.1-foot opening of a 36-inch gate and that obtained from generalized data obtained from a 24-inch gate. This examination was made at the request of the Salt River Valley Water Users' Association and Region 3. The cause of the difference was not readily apparent but physical differences in the two gates and inapplicability of procedures used to transfer the results of the calibration of one size gate to another were considered possibilities.

SECTION III--STUDIES FOR OUTSIDE AGENCIES

Assistance was rendered other Government agencies, as requested, for several special problems. The most important are described briefly in the following paragraphs:

Fish and Wildlife Service--Proposed Model Study of North Fork, South Platte River

During FY58, the Regional Office at Albuquerque, New Mexico, requested an investigation into the feasibility of performing an hydraulic model study of the river between Grant and South Platte, Colorado. During that year, preliminary studies were made and field data collected.

This year several conferences were held with the local office of the Fish and Wildlife Service in reviewing hydraulic data available from the cooperating agencies. Definite plans and requests for the laboratory study were not received this year. Funds were advanced by the Fish and Wildlife Service for the advanced planning performed to the present time.

Federal Civil Defense Administration--Air Flow Characteristics of Antiblast Valves

The valves tested were of the spring-loaded poppet type used on intakes and exhausts of ventilating systems to protect personnel and equipment from large pressure rises in case of blasts. The closing characteristics had been established as being satisfactory in atomic tests in Nevada, but the flow characteristics and capacity had not been evaluated.

Three sizes, 12-, 16, and 24-inch, were tested in the laboratory, both as intake and exhaust valves (Figure 6). Closure

Figure 6 missing,
(supply depleted)

forces, head losses, and capacities were of particular concern. The results of the tests were reported to the Federal Civil Defense Administration.

International Boundary and Water Commission--Diablo Dam

The Hydraulic Laboratory assisted the Design Division in reviewing a feasibility report for a proposed design of Diablo Dam. Specific assistance was given on the preliminary design of the outlet works.

Atomic Energy Commission, Richland, Washington

Advice was given on methods that could be used in testing high head pumps at the Hanford Works of the AEC. Unusual maintenance problems have developed in these pumps. A method of testing and development to eliminate serious cavitation erosion was being sought for the pumps which operate under unusually high heads (720 pounds per square inch shutoff). Each pump requires 5,500 horsepower.

SECTION IV--ASSISTANCE TO FOREIGN GOVERNMENTS

The Hydraulic Laboratory experienced a slight increase in work for foreign countries this year. Design studies continued for the Snowy Mountains Hydro-Electric Authority, Australia. Twenty-one engineering trainees were assigned to the laboratory for training periods ranging from 2 months to 1 year. In addition, 5 observers from foreign countries were assigned to the Hydraulic Laboratory. More than 40 foreign engineers visited the laboratory on an official basis during the year.

The principal foreign engineering activities of the Hydraulic Laboratory are described briefly in the following paragraphs.

Snowy Mountains Hydro-Electric Authority

James W. Ball spent the period September 7, 1958, through October 3, 1958, in Australia, at the disposition of the SMHEA. The activities of Mr. Ball, accompanied by H. K. Brickey, included inspection of completed projects, work under construction, and sites for proposed construction; review and appraisal of model studies on vortex chambers and entrained air by the Authority's Hydraulic Laboratory in Cooma; review and discussion of proposed designs and changes in current designs by the Authority.

Island Bend Control Gate

Tests were made on a scale model of the 9- by 16-foot coaster gate to be used in southeastern Australia by the Snowy Mountains Hydro-Electric Authority. It will regulate releases of Snowy River water from Island Bend Reservoir into Eucumbene Reservoir and the Murray series power system. The gate will be installed in a 16-foot-diameter tunnel and all operation will take place with the tunnel flowing full of water. The section of tunnel just downstream from the gate will be enlarged to a 28-foot-diameter to allow room for energy dissipation and to avoid damage to the lining. The heads acting across the gate will be high and can reach an extreme value of 410 feet.

Operating schedules may at times require very small releases, perhaps as low as 50 cfs. In a gate 9 feet wide, this necessitates openings of only a fraction of an inch. Such very small openings have been troublesome on other structures, with cavitation damage occurring on the gate leaf bottom and on the frame. It was therefore necessary to reduce the width of the passage at the bottom of the Island Bend gate so that reasonably large gate openings could be used for small discharges.

The width reduction was first obtained by inserting into the passage triangular filler blocks that extended from the gate slots to the end of the 13-foot-long passage. However, tests showed that severe negative pressures occurred on the surfaces of these blocks. Heavy flat plates, like weirs, placed in the bottom corners of the passage, were more satisfactory. With these weirs in place, the flow springs clear of the boundary surfaces as soon as it leaves the edges of the plates.

The shape of the gate leaf bottom greatly affected the pressures within the structure, and best results were obtained with an elliptical surface. The gate slot corners were found best in line and square for the submerged flow and the usually high back pressures at Island Bend. The floor was stepped vertically downward 1 foot at the weirs, and then sloped 45 degrees to a horizontal floor at a lower level. This provided more space for flow circulation around the jet. In a similar manner, the side walls were flared, starting about 7 feet from the slots, to provide additional space for recirculation.

Studies on a 1:24 scale hydraulic model of the above design were completed and detailed tests made to evaluate pressure and flow conditions in critical areas of the gate. In addition, calibration curves were prepared.

Yanhee Dam

Members of the staff of Engineering Consultants, Inc., made inquiries about certain technical problems concerning the design of spillways and other features of Yanhee Dam.

ICA Assistance

Over 2 days' assistance was given to ICA representative (Turkey) Emory Roberts on the newer concepts of hydraulic design.

The following foreign trainees, observers, and visitors were assigned to the Hydraulic Laboratory.

Foreign Trainees

Rodney J. Whitfield		Australia	5- 2-58 to 7-11-58
Talha M. Ermis		Turkey	5-27-58 to 7-10-58
Abdul H. Qureshi	Karachi,	Pakistan	6-10-58 to 8-29-58
also			11-21-58 to 1-21-59
Allen H. Peet		Australia	6-27-58 to 8-29-58
Michio Nakahara		Japan	7-28-58 to 9- 5-58
Colin J. Kilmartin		Australia	9- 2-58 to 11- 1-58
Yun-Hsu Lu	Taiwan,	China	9- 9-58 to 12- 1-58
Otto Pfafstetter		Brazil	9-11-58 (one day)
Ado Kadak		Australia	10-28-58 to 1- 1-59
Galip Aknil		Turkey	12- 1-58 to 2- 2-59
Han Young Lee		Korea	12- 1-58 to 2- 7-59
Tome Krstev		Yugoslavia	2- 2-59 to 2- 5-59
Lucio T. C. Washington		Brazil	1-12-59 (2 months)
Isao Yamaoka		Japan	1-23-59 (6 months)
Daniel Linsten		Australia	1-23-59 to 4-17-59
Un Choll Yoo		Korea	2- 9-59 to 7-10-59
Emile J. Haddad		Lebanon	2-16-59 to 5- 1-59 (about)
K. B. Murareppa		India	3- 2-59 to 5-12-59
Christopher C. Goodall		Australia	4-17-59 (9 months)
Mohammad B. Gholizadeh (Goalie)		Iran	4-20-59 to 6- 5-59
Muzaffer Balci		Turkey	6- 2-59 to 8- 9-59

Foreign Observers

Ahmed Ali El-Darwish United Nations Observer		Egypt	8-11-58 to 9-12-58
Arturo Suarez Arias		Chile	3- 9-59 (one day)
N. G. K. Murti	Konya Project	India	3-25-59 (one day)
V. R. Vaidya	Konya Project	India	3-25-59 (one day)
Neville Oliver Boughton		Australia	6-23-59 (5 weeks)

HYDRAULIC LABORATORY
Fiscal Year 1959

Foreign Visitors

Octavio A. Soda	Puerto Rico	7- 8-58	1 day
Pablo Kleiman	Chile	7-11-58	1 day
Emory Roberts (ICA Trainee)	Turkey	7-22-58 to	7-25-58
Sakik Toksoz	Turkey	8- 8-58	1 day
Kamal Davar (Colo State Univ)	Egypt	8-14-58	1 day
Another student with Davar	Israel	8-14-58	1 day
Mr. Nagata, Vice Pres of ICOLD			
Dr. T. Yoshida, Kiushu Univ		9- 3-58	1 day
Mr. J. Nishimura			
Edward Noyle	Tanganyika	9-22-58	3 days
Dr. Charles Yeager	Rugby, England	9-23-58	1 day
Mr. Serrafin	Portugal	9-25-58	1 day
Prof. Schnitter	Switzerland		
Mr. Marcel Mary	Paris	9-28-58	(Sunday)
Mr. George Beurle	Salzburg, Austria		
Adriano Borus	Eng Argentine Water &		
Antonio Prosseto	Power Federal Agency	9-30-58	
Khemmar Guriagli	Ministry of Public		
D. Cavassilas	Works Morocco	9-29-58	
Dr. Ing. Gustav Haux			
Dr. Ing. Otto Kirbschner			
Dr. Ing. Karl-Heinz Klenck	Germany	10-16-58	
Dipl. Ing. Kurt Liebschner			
Dr. Ing. Kurt Mueller			
Dr. Ing. Gerhard Wickert			
Mr. Balci, Trainee (Earth Lab)	Turkey	10-30-58	
A. W. Plummer	Ankara, Turkey	12- 3-58	
Dr. Kinji Shinohara	Fukuoka, Japan	12-17-58	
Sotsuith Kanchanagam (Form Trnee)	Thailand	1-26-59	
James B. Kirkwood	Sydney, Australia	2-17-59	
Abdel Dagi Omer Attich, Khartoum, Sudan		2-27-59	
Mar D. Ramos	Manila, Philippines	[illegible]-27-59	
Tao-Ken-Lee (Form Trnee)	Formosa	2-17-59	
Prof. Shragga Irmay	Israel	3-23-59	3 days
Dr. W. P. Jayasekara	Ceylon	4-13-59	1 day
Dr. K. Arumugam	Ceylon	4-13-59	1 day

Foreign Visitors
(Continued)

I. S. Foxall, Snowy-Mtns	Australia	4-20-59	1 day
Tor Muregard	Stockholm, Sweden	4-23-59	1 day
Pierre Danel	Grenoble, France	4-29-59	1 day
His Highness Paku Alan,	So. Java, Indonesia	6- 8-59	1 day
C. G. Hawes,	South Brent, Devon, England	5-14, 15-59	2 days
Philippe Alexandre	Grenoble, France	5-27-59	1 day
Fernando Juliet	Chile	6-11-59	1 day
V. Jevdjevich	Belgrade, Yugoslavia	6-29,30-59	

Sixth International Congress on Large Dams

Forty-three foreign engineers and 10 engineers from various United States organizations participating in the Midwestern Study Tour of the Sixth International Congress on Large Dams visited the Engineering Laboratories September 26, 1958. Thirteen foreign countries were represented including Austria, Algeria, France, Sweden, Switzerland, Canada, Italy, Great Britain, Germany, Japan, Portugal, Belgium, and Russia.

Special tours of the laboratories' testing facilities and of the major tests in progress were provided. Evidence of the interest in the work of the laboratories was displayed by the many requests for an opportunity to visit the laboratories a second time. In response, arrangements were made for opening and staffing the laboratories Sunday morning, the 28th. Also, a number of engineers from other ICOLD tours stopped over in Denver the following week.

Outstanding Trainee

Mr. Michio Nakahara of Japan, as a trainee, prepared the material in Engineering Monograph 25 in the Form 2 nomographs which are proving to be of considerable value in designing hydraulic jump or bucket-type stilling basins. In a matter of a few minutes, the overall dimensions of a bucket or a hydraulic jump basin may be determined from the nomographs. By their use, it is possible to see the effect on the structure dimensions caused by changing a variable. When the basic data used to design an energy dissipator are not firm, this manipulation can be of great value in reducing the amount of calculation necessary to provide limits for a proposed design.

SECTION V--HYDRAULIC LABORATORY INVESTIGATIONS

In view of the consolidation of the various special research programs with the general research program at the close of the fiscal year, it is convenient to report the activities on this new framework.

Here are four general categories of Hydraulic Laboratory investigations: Hydraulic, general; sedimentation; water measurement; lower cost canal lining. In addition to the programed projects for the fiscal year, important work contemplated in the future is described.

HYDRAULIC--GENERAL

1. Hydraulic Characteristics of Vertical Stilling Wells

A study of vertical stilling wells originated from the problem of converting waterflow of high energy content to one of low content, such as unwatering certain structures which contain water under high pressure, and supplying from high pressure conduits irrigation water to earth ditches. Investigations of particular structures and operation of a completed field structure have established the feasibility of the stilling well. Data are needed for general application to design. Area, depth, and shape of well for various discharges and entrance velocities are needed in generalized form to establish design criteria for a square well. Developments therefore permit limited use of the stilling well principle in design considerations.

Accomplishments FY59. This study was not pursued because of more urgent work.

Scheduled FY60. No work is contemplated during fiscal year 1960. Future tests should consist of obtaining data for both the square and the circular type.

2. Hydraulic Jump and Energy Dissipators

Considerable time is devoted to model studies of outlet works stilling basins for individual dams. Often there is insufficient background experience to approximate a first design of an outlet works stilling basin closely enough to make a good estimate of the ultimate cost of the structure. The objective of this research is to develop several or more types of stilling basins for general use so that laboratory development work for each individual case will be a minimum.

The complete program will require developing different types of basins including those for (a) discharges from hollow-jet valves, (b) discharges from pipes or conduits flowing partially full at low velocity and low discharge, (c) discharges from sluices or tunnels flowing partially full at high velocities and/or high discharges, (d) discharges where energy must be dissipated in a tunnel, (e) discharges into spillway stilling pools, (f) discharges into vertical stilling wells, and (g) discharges over baffled chutes.

The second Progress Report on this study, Hydraulic Laboratory Report No. Hyd-399, was modified and published as a group of six papers in a technical journal. A third Progress Report, "Slotted and Solid Buckets for High, Medium, and Low Dam Spillways," Hydraulic Laboratory Report No. Hyd-415, has also been published. The two Progress Reports have been combined into a single publication to be printed and issued as USBR Engineering Monograph No. 26.

Accomplishments FY59. Additional information was gathered on prototype performance of the hollow-jet valve stilling basin and the material included in Hydraulic Laboratory Report No. Hyd-446 which is in final form for publication. Further analysis was made of data for baffled chutes, information gathered on prototype performance, and material included in draft of Hydraulic Laboratory Report No. Hyd-445.

A limited number of tests on a model outlet works using the slide gate for control indicated the model to be too small for general studies on this type of basin.

Several tests were made using available equipment to study the pressure conditions and cavitation potential of baffle piers for stilling basins having various Froude numbers.

Tests were conducted to study and compare Type II and III stilling basins at high Froude numbers. These data showed good agreement with extrapolated data of previous tests.

Scheduled FY60. Hydraulic Reports No. Hyd-445 and -446 will be published and distributed. Investigations concerning pressure distribution on and the cavitation potential for baffle piers will be continued for various Froude numbers. Studies are to be carried on simultaneously with those on slide gate stilling basins.

An evaluation will be made of available data on stilling basins for submerged dams and a test program developed for the future.

3. Operation and Design Characteristics of Siphon Spillways

Studies of the operational characteristics of siphon spillways were begun several years ago when experience with this type of structure indicated certain deficiencies in design. Little consistency could be expected in the heads and times required for priming in identical designs, and discharges passed often differed from design values by as much as 30 percent.

Accomplishments FY59. Experimental work on an improved design continued. The bucket at the downstream end of the sloping barrel was redesigned to allow varying the size. The bucket was equipped with a movable sill to evaluate the effect of sill position with respect to the main barrel on the coefficient of discharge. The sloping leg of the barrel was provided with a flow deflector which may be rotated through a wide angle.

Two series of tests were completed. One series dealt with setting the length of the bucket for the best coefficient of discharge commensurate with other characteristics. The second series developed sufficient information to determine the proper position of flow deflector as an aid in improving the priming characteristic.

Scheduled FY60. Completion of tests in the fiscal year 1959 program will enable the design of a prototype installation which will be equipped with test facilities so that prototype data may be obtained.

Pending the acquisition of prototype information, efforts will be made to develop devices which will allow the proposed design to operate at partial prime. The devices will be patterned after French designs. Successful development of partialization devices would provide the Bureau with a siphon which can be used for the close control of reservoir water levels.

Designers have suggested that observations be made to confirm design criteria in regard to priming head, head loss, and capacity of siphon spillways with adjustable crests. Several siphon spillways of this type are under construction on the Culbertson Canal. These designs will be reviewed to develop an investigation program for the field and/or laboratory.

4. Standardization of Design of Small Canal Structures

Canal systems contain numerous small structures such as drops, turnouts, overchutes, wasteways, culverts, and bifurcation works. Many of these incorporate dissipating devices which are quite different from the conventional types. The velocity of flow is low compared to the larger structures, but efficient energy dissipation and transition design are essential in most cases to prevent undercutting of the structure and damage to the earth canal sections downstream. Because of the large number of structures involved, a poorly operating or uneconomical design will be repeated many times. Although a number of designs have been tested individually by models, standardization has not been established, as the structures operate under such a wide range of conditions. Research studies will be made to standardize designs and will include an orderly program to observe and check prototype installations designed in accordance with findings in the laboratory.

Accomplishments FY59. Five transitions for culvert and inverted siphon exits and entrances were tested, and the flow conditions, erosion, and losses analyzed for variations in flare angle, length, submergence, and conduit slope.

Scheduled FY60. The study will be continued for other types of transition designs including a closed expanding section in combination with open warped section and a progress report will be prepared.

5. Hydraulic Characteristics of Pipeline Distribution Systems and Related Structures

In localities where cost of right-of-way acquisition is high and where the usual losses by seepage and evaporation from open, lined, and unlined ditches make irrigation costly or infeasible, it is becoming common Bureau practice to use pipeline distribution systems operating under heads of more than 125 feet. The regulation of flow from such systems introduces many problems, including: (1) the dissipation of energy from high velocity jets before releasing the flow onto the land; (2) protecting parts of the system from damage by cavitation, vibration, and water hammer; (3) controlling surges induced by autooscillation or sudden changes in flow requirements; (4) regulating pressures to give constant turnout quantities; (5) developing simple automatic regulators; (6) determining hydraulic losses for various parts of the system; and (7) establishing entrance conditions for submerged pipe outlets. The information now available is widely scattered and not adequate for resolution of these problems.

Tests made on 6-, 8-, and 1-inch gate valves and a 6-inch globe valve in pipelines have established operation and cavitation characteristics of valves at moderate heads. Hydraulic Laboratory Report No. Hyd-337 presents limitations of head and back pressure to eliminate or minimize cavitation when valves are operated at partial openings and points out the effectiveness of placing sudden enlargements immediately downstream from valves to prevent cavitation damage. Some work has been accomplished in recent years on the use of the sudden enlargement to dissipate energy in flow from valves at heads up to 400 feet, but further investigation is necessary to establish limitations, operating characteristics, and design criteria.

Accomplishments FY59. Tests were made on three orifices and a flow nozzle placed in a 3-inch pipeline to determine flow characteristics, including cavitation potential and effect of cavitation on capacity. The data were reported in a technical discussion on orifices to be published in ASCE Transactions. Equipment for investigating flow characteristics, where high velocity jets from gate valves and orifices enter larger but still confined flow passages, has been revised and readied for continuing tests at heads up to 400 feet.

Scheduled FY60. Limited testing will continue on high velocity jets entering sudden enlargements in flow passages and on the use of baffles downstream from controls under high heads. A limited number of tests will be made to investigate frequency and magnitude of pressure fluctuations in sudden enlargements downstream of controls.

6. Cavitation and Head Loss in Conduit and Penstock Branches

Subatmospheric pressures of sufficient intensity to cause cavitation damage have been encountered in branches of large conduits which convey water at high velocity. Better shaping of these passages would alleviate this condition and reduce the head loss. However, little information is presently available for design.

This research will consider the relationships of (1) optimum angle of branch with main conduit for manifold branching, (2) angle of convergence of branch cone junction with main conduit, (3) arrangement of 2- and 3-way branches from and to a single conduit, (4) pressure distribution for various arrangements, (5) head loss caused by the branching pipes, and (6) the distribution of discharge through the branches.

Research on structural vibrations due to turbulence has not generally been included in previous programs. Work by von Karman shows that the vortex trail behind a stationary cylinder can cause forced vibrations of the cylinder and possibly its ultimate failure from fatigue. Various hydroelectric power companies report that they have severe vibrations in their penstocks which may be due to turbulence in manifolds and at junctions. Therefore, structural vibration due to turbulence should be included in the studies.

Because of the lack of information on hydraulic losses in branched pipes and on the correlation of losses between relatively small models and their prototypes, piezometer installations have been made in the prototype structures. Some of the penstocks and pipes have already been constructed and are in use. Programs for the measurement of losses are contemplated and the measurements made while the outlets are in use. Information for design and correlations with future model studies will thus be acquired.

Accomplished FY59. Information from literature reviews was offered to design engineers in answer to questions on junction losses in Trinity penstock and Molina power intakes. References were often cited for use by the designers. Careful search of available published literature indicated that there is yet a lack of information on losses in large pipe junctions and branches.

Details of the head loss tests in the outlet pipe branches of Palisades Dam were completed. With the cooperation of Region 1 and Palisades Project, head loss measurements were made during May 1959. The results will be reported in fiscal year 1960.

A report was reviewed on the vibration in the modified wye branch in the penstock at Falcon Dam. Additional information on existing conditions was requested to permit further study.

Scheduled FY60. A test program for head loss measurements in the pipe branches in Glendo Dam outlet works is proposed. Necessary piezometers and leads were placed in the structure during fabrication and construction. Test programs for other prototype installations will be prepared or kept current as necessary and as suggested by the Design Division.

A correlation of all available data will be started with a view of determining whether deficiencies exist and to establish the need for model studies to produce data to fill any gaps in our present knowledge. If model data are needed, suitable test facilities will be designed.

7. Cavitation-erosion of Roughened Surfaces

Because concrete has low resistance to cavitation-erosion, the Bureau specifies very smooth surfaces wherever high velocity flow is encountered. However, experience such as that at Grand Coulee Dam, where periodic inspection of a roughened surface revealed that damage was not continuing, indicates that tolerances may be too stringent.

Limited project funds have been available for exploratory investigations into a method of determining the cavitation potential of various types and degrees of roughened surfaces. A test apparatus has been designed and built and an interpretation method evolved from which any specific surface can be evaluated. The susceptibility of roughened concrete surfaces to cavitation has been evaluated and pressure-velocity relationships for eliminating cavitation on two surfaces of different texture determined. The information is contained in a technical paper entitled "Cavitation Damage of Roughened Concrete Surfaces."

Accomplished FY59. No work done.

Scheduled FY60. No work contemplated. At some time in the future, studies will be made on roughened surfaces other than concrete, e.g., in gates and valves.

8. Downpull Forces on Coaster, Cylinder, and Fixed-wheel Gates

When gates are used for control or emergency closure of penstocks and outlets, large downpull forces (forces tending to pull the gate closed) are often encountered. To design the hoist and gate support properly, knowledge of the forces resulting from an emergency closure of the gate is necessary. Similar information is required for cylinder gates. Needed information includes (1) pressure distribution on the gate bottom for different ratios of gate thickness to lip extension, (2) effect of recess above the gate in the face of the dam, (3) effect of gate slots, (4) effect of aeration on pressure distribution, (5) gate seal shape and location on gate, and (6) more field confirmation of laboratory data.

Generally applicable data and criteria have been compiled from laboratory tests and are presented in Hydraulic Laboratory Report No. Hyd-130. Additional information, including the use of air models to determine downpull forces, is contained in two technical papers. Further laboratory and field investigations are necessary to establish the effect of the physical characteristics of the gate setting on the downpull force.

Accomplished FY59. Suitable equipment, a test technique, and a program were developed for field tests on two of the service gates in the Palisades Dam outlet works conducted in May 1959. The data have been partially analyzed.

A limited number of tests were performed on one model gate to correlate downpull data obtained when using air and water as test fluids.

During the year, discussions with designers were kept current, especially in regard to prototype tests on the fixed-wheel gate at Glendo Dam. Because suitable equipment was not included in this gate during fabrication, the desirability of conducting field tests is presently in question.

Scheduled FY60. A report will be prepared covering the results of prototype tests at Palisades Dam. It is proposed that this report will include a summary of tests made to date and an initial outline for future tests.

Data obtained from water and air tests will be analyzed and the results presented in a written discussion of an ASCE paper "Air Model Studies of Hydraulic Downpull on Large Gates" published in fiscal year 1959.

If the opportunity occurs, tests of the fixed-wheel gate at Glendo Dam may be made. Other test sites will also be considered.

9. Air Demand of Gates and Valves in Conduits

The use of "in-line" gates and valves for regulation of flow in closed conduits requires well-established criteria for determining the size of air vents to prevent adverse effects of vibration and cavitation-erosion. The empirical relation now in use gives little assurance of adequacy. Resolution of the problem by model studies alone is not possible because similitude relationships in the area of air-water flow are too imperfectly known. A coordinated program of laboratory and field testing is required to develop the needed information.

Data are available from laboratory and field studies of Bureau projects, as well as from Corps of Engineers' tests, but additional testing is required to generalize the information.

Accomplished FY59. No work was performed on this project because of more urgent assignments.

Scheduled FY60. No work is planned this year.

10. Development of Cavitation-free Gate Slots

Experience has proved that expensive and troublesome maintenance is required on the surface downstream from conventional, high head gate slots due to damage incurred by cavitation-erosion. Because slide gates of various designs are used extensively by the Bureau, this problem is of considerable importance.

Studies so far have indicated that practical slot shapes can be provided for gates discharging at partial opening under high heads. Continued research is needed to better establish the effect of various design elements on cavitation formation, and ultimately to yield a practical cavitation-free slot. The study should be extended in a general way to permit the use of slide gates in high head installations where cavitation would otherwise make them prohibitive.

Tests to develop a cavitation-free gate slot have been made and the results presented in a paper which is to be published in a technical journal. Although a cavitation-free gate slot shape has been developed, additional investigation will be necessary to develop design criteria for various sizes and gate settings.

Accomplished FY59. The laboratory worked with the designers in planning the installation of pressure taps in pertinent parts of outlet works slide gates at Navajo and Glen Canyon Dams. Plans were completed and the installations approved. Studies were made of the laboratory's present water tunnel in an attempt to overcome some of the air accumulation difficulties encountered in previous tests.

It was learned that the French will present a paper on this subject at the IAHR Meeting in Montreal, August 1959.

Scheduled FY60. Further studies are to be made on the laboratory's water tunnel to ascertain its possible use in determining the cavitation potential of various gate slot designs. If the facilities prove suitable, a limited number of tests will be made to correlate the air and water tests and to determine the critical cavitation index for the various designs.

11. Instrumentation for Acquiring and Recording Hydraulic Data

Continuous study of modern instrumentation for use in hydraulic measurements cannot be overemphasized. Instruments and use techniques change rapidly and unless continually noted by literature review and discussion, will remain unexploited and possibly unknown in fluid dynamic measurements. This pertains also to data analysis and processing.

Accomplished FY59. Additional dynamic pressure cells were acquired during the year to facilitate measuring and correlating transient pressures in various parts of systems under study. These cells were used to especially good advantage in Glendo Dam and Prineville Dam stilling basin studies.

A resistance-type wave recorder for measurement of surface water waves generated by winds was constructed for field installation.

This instrument will be used to correlate model and prototype studies of canal bank erosion caused by wind-generated waves. Data obtained from the studies and their correlation will help make information usable for Bureau canal design.

An SR-4 strain gage velocity meter was constructed and initial study shows promise for this instrument in measurement of low velocities in water.

Scheduled FY60. A limited number of tests will be made to extend design criteria for riprap protection of channels downstream from typical culvert exit transitions.

13. Friction Loss Tests in Large Conduits

The resistance coefficient for a particular type pressure conduit is the controlling factor for determination of conduit size necessary to convey a required rate of flow for a given set of hydraulic conditions. When long reaches of pressure conduit are involved, such as for the proposed Gulf Basins Project, size of the conduit may control the economic feasibility of an entire project. Therefore, it is desirable to know the true resistance coefficient of a pipe so the size may be kept to a minimum. Since the friction head loss and velocity of flow are a function of the physical characteristics of a conduit surface, the resistance coefficient can be readily determined from measurement of these factors at operating conduits. Losses in bends are equally as important as losses in straight reaches. Forming for the bends becomes an economic consideration during construction. A collection of data from tests made in various parts of the world, contained in Engineering Monograph No. 7, fulfills only a small part of the requirements.

Accomplished FY59. A draft of a report that includes friction loss data for the Elkutna Tunnel, Weber Coulee Siphon, and for tunnels in the New York City water supply was completed. It is planned to add data for the San Diego Aqueduct measurements to this report before publication.

Material, that makes use of the Colebrook-White resistance equations and Darcy-Weisbach coefficient, obtained from the Department of Scientific and Industrial Research, Hydraulics Research Station, England, and the Massachusetts Institute of Technology, was reviewed to determine its usefulness. The methods proposed by these two organizations offer a rational approach to the use of the Darcy-Weisbach coefficient for both closed conduit and open channel flow and thus may be very useful for design.

During the year, a study was made of a large diameter tunnel to determine the effects on the hydraulics of bends formed on a radius or with short tangent sections. From the literature available, it was concluded that the hydraulics for the size of tunnel considered was not the prime consideration. The question thus became one of economics of construction.

Plans were made for installation of test facilities for head loss measurements in the Fremont Canyon Power Conduit, Missouri River Basin Project. Locations for two rings of piezometers were proposed. Acceptance tests of the turbines will offer opportunity to obtain friction loss information.

Plans were made to locate piezometers in one of the river outlets in Glen Canyon Dam. The piezometers will measure entrance, bend, and friction losses for enameled steel pipe.

Literature was searched during the year to evaluate the various methods used for establishing the surface roughness of materials and to determine if any were suitable for use in this program.

Arrangements were made with the Design Division for coordinating the inclusion of necessary test equipment in tunnels during the design stage to determine hydraulic losses in straight sections and in bends in tunnels of various types of construction. A file on each installation was set up for necessary followup scheduling of tests.

<u>Scheduled FY60</u>. A progress report on the resistance coefficient values compiled in the past 4 years will be published.

Further search will be made for a technique suitable for measuring the surface roughness of construction materials normally used in conduits.

Plans for facilities for measuring friction losses in straight sections and in bends of conduits during the design period will be prepared in cooperation with the designers.

14. <u>Specifications, Finishes, and Tolerances for Irregularities and Misalinements in Concrete Surfaces Subjected to High Velocity Flow</u>

Many Bureau spillway and outlet works structures have concrete surfaces over which water flows at high velocities. Certain irregularities and misalinements, if permitted in these surfaces, cause regions of low pressure which will cause cavitation-erosion when vapor pressure is reached. It is therefore necessary that offsets, bulges, grooves, joints, misalinements, and other surface irregularities be adequately controlled.

The lack of information concerning the cavitation tendencies of these various surface irregularities and the uncertainties regarding the application of test data to predict the point of incipient cavitation for the prototype structures have resulted in the adoption of rather stringent specifications regarding the construction finishes and tolerances for these flow surfaces.

The treatment of these surfaces to make them comply with these stringent specifications often proves quite costly. Much of this extra cost could be eliminated by a relaxation of the specifications. A thorough knowledge of the cavitation tendencies of the various irregularities is needed to ascertain whether or not a relaxation is possible. This knowledge can be obtained through hydraulic tests using available water tunnel facilities. Representative joints, bumps, offsets, depressions, etc., would be placed in the test apparatus where they would be subjected to high velocities and low pressures. Pressure and velocity conditions for incipient cavitation would be determined and the critical cavitation index obtained for each of several sizes of the various irregularities.

Tests have been made to study the pressure conditions and cavitation potential of abrupt offsets in surfaces of flow passages. These tests emphasized the necessity of eliminating this type of irregularity when surfaces are subjected to various velocities and pressures. The test results have been presented in Hydraulic Laboratory Report No. Hyd-448. A limited number of tests have been made to evaluate pressure conditions and cavitation potential of abrupt offsets away from the flow. Considerable testing of various types of irregularities which are likely to be encountered in construction is needed to establish design and specification criteria.

Accomplished FY59. An attempt was made to study the cavitation potential of offsets away from the flow, but the laboratory facilities proved to be inadequate for this type of testing. Some improvements were made in the test facilities for the study of surface irregularities, but further improvements are still required.

Scheduled FY60. Efforts will be directed toward developing satisfactory test facilities for away-from-the-flow offsets and making a limited number of tests to determine the cavitation potential of a chamfered surface, construction joints, and small damaged areas.

15. Side Spillways

Requests for information necessary in the design of side spillways have been received in the laboratory from the Design Division periodically for a number of years. Although there is considerable information available on the subject, correlation is lacking. The usual procedure has been to make the best use of the material available and complete a design, or to rely on hydraulic models to resolve the immediate questions pertinent to the specific structure.

The purpose of the study would be to develop basic design data utilizing an analytical approach and hydraulic models. The study should be considered in two very closely associated parts: (a) a study of the parameters involved in the flow characteristics in the channel upstream from the side spillway and in the spillway proper (this type of structure is generally termed a side spillway and serves as an emergency structure to release excess flows from canals); and (b) a similar study of the hydraulics of a channel downstream from the spillway with relation to the overflow weir. (This type of structure is generally termed a side channel spillway and is normally used in connection with reservoirs. The flow may enter the channel from one or both sides, or from one or both sides and one end.)

In regard to Part (a), available information needs to be extended and reduced to a form readily usable by designing engineers by: (1) an analysis of all available technical literature on the subject; (2) correlation of data previously obtained in the laboratory; and (3) studies on hydraulic models.

The requirements in Part (b) would be similar to those outlined for Part (a). Hydraulic model studies would be directed toward developing a crest-channel relationship using existing models.

Accomplished FY59. The file of information and references has been kept up-to-date by adding material gathered from the technical literature. One report of work done in Yugoslavia on a labyrinth-type crest may add considerably to the data on this subject. During the year, Japanese engineers in training were encouraged to undertake intensive studies of side channel spillways which are used extensively.

Scheduled FY60. The project will be kept up-to-date by adding references and pertinent material to the files. As time permits, the material will be indexed and summarized.

16. <u>Air Requirements for Tunnels, Control Devices, Siphons, and Outlets</u>

There is a need for the determination of the mechanics of the escape of air absorbed in water when the ambient pressure is changed and for criteria to determine the quantity of air required by ejector action to prevent the formation of pressures conducive to cavitation or vibration.

In the case of siphons, for instance, air entrained in the water by natural means, together with the larger volume resulting from agitation by pumps or energy-dissipating devices, will collect at a high point in the conduit, preventing continued operation of the siphon or decreasing its capacity. Should the accumulation of the air be sufficient to adversely affect the capacity of the hydraulic carrier, the obstruction in the form of an air pocket can only be removed by mechanical means such as an air pump. With existing knowledge, the designer is forced to estimate the quantity of air to be released from the flow; and if it is assumed that a vent or mechanical means of removing the air is required, a second estimate must be made to determine the size needed. Obviously, these estimates must be on the side of safety, resulting in a costly structure.

The other phase of the problem stemming from those designs necessarily introducing air to prevent the formation of excessively low pressures requires a knowledge presently insufficient to evaluate the quantity of rarefied air in terms of the size of duct connecting to the atmosphere. A determination of the data from a hydraulic model does not permit transference with certainty to the prototype structures because of the introduction of unknown factors such as the effect of the increased velocity of the water jet involved or the action of the rough contour of the water stream compared to a smooth surface obtained in the laboratory.

The program includes laboratory investigations to determine the basic principles governing the rate of separation of air from solution and the flow of air in the rarefied state; the selection of instrumentation for laboratory and field measurements; and prototype observations to simplify and confirm laboratory studies permitting an analysis usable by the design engineer.

<u>Accomplished FY59</u>. In the past year, the file of information has been kept up-to-date by the addition of references and pertinent data. Considerable assistance was provided to members of the Design Division, particularly in regard to tunnel freeboard, water collection systems for powerplants, and rate of air ejection from pipes in irrigation systems.

The significance of air entrainment in pipe chutes, pipe drops, and siphons was given consideration. Of particular concern was the variable locations of the hydraulic jump in the pipe; bends in the horizontal or vertical alinement; and large variations in velocity, head loss, and capacity for possible combinations of submerged and free flow.

Structures suitable for study were sought, but no conclusions were drawn.

Scheduled FY60. No laboratory studies are contemplated. The file will be maintained by addition of references and pertinent data. As time permits, the material will be indexed and summarized. In cooperation with the designers, locations for field tests will be considered.

Discharge Coefficients for Radial Gates

This item transferred to "Water Measurement for FY60."

17. Crest and Transition Section for Morning-glory Spillway

The best available design principles for morning-glory spillways are applicable to structures which are so located that all circumferential flow is radial in approach and the maximum design discharge is required to obtain acceptable profile pressures.

Information for determining the morning-glory shape for ideal flow conditions was obtained from tests made in the early 1950's. The results, conclusions, and design criteria for the ideal case are contained in a technical journal.

Since few locations conform to that of the ideal standard, there is need for information which can be used to modify analytically spillway shapes for safe operation throughout the discharge ranges of structures in particular locations.

Accomplished FY59. Previously available technical literature was analyzed along with new material that was published during the year. The designs were compared for the purpose of generalizing such features as profile, diameter, aeration, operating head, and discharge curves. The majority of designs recognize the difficulties inherent in the morning-glory type spillway and to different degrees avoid them by overdesigning the structures. Specifically, the diameter is frequently made large to allow a conservative downstream profile and a low discharge head. So doing prevents the spillway from submerging and the development of a siphon head in the shaft. Thus, the designs are rationalized without attempts being made to derive analytically correct ones. A new crest and transition were designed and tested.

Scheduled FY60. The test results obtained in fiscal year 1959 will be analyzed for comparison with earlier data from five profiles used in the Trinity studies. It is planned to relocate the spillway within the model box to obtain radial flow over the entire crest. This will place the structure in the position most conducive to proper operation and similar to that of the circular weir from which profile coordinates were derived. The new crest and transition, and the preliminary and final Trinity designs, will be tested in the relocated position within the model box. Data from these tests will be compared to that obtained in the original tests.

18. Carrying Capacity of Large Concrete-lined Conveyances

Tests made on a number of large concrete-lined canals show a deficiency in the capacity compared to the design value. The deficiency may be caused by (1) roughness of the boundary, (2) the piers of structures such as bridges, overchutes, pipeline, crossings, etc., (3) conveyance structures such as drops, (4) bends, and (5) combination of bends and structures.

Design engineers are concerned in view of impending design of a number of large conveyances and have recommended research and investigations which will alleviate the shortage of competent design data.

Scheduled FY60. Research for the year would include a review of the literature and all available information which can be derived from Bureau projects and other sources. The second phase would be the analysis of such data and formulation of a series of field studies directed to certain areas in which design data are lacking. Laboratory studies of bridge piers are contemplated. The major portion of this study would be directed toward the development of pier studies with minimum head loss.

OTHER RESEARCH PROJECTS NOT PRESENTLY SCHEDULED

Hydraulics of Flow and Maximum Depth of Scour at Constrictions in Natural and Artificial Water Conveyances

The economics of civil engineering works crossing natural or artificial water conveyances are very closely interrelated with the hydraulic conditions before construction and those conditions that will prevail as a result of changes in flow regimen caused by the construction. Specifically, whether it be a highway or railroad bridge, a flume or inverted siphon, a pipeline or other structure crossing, for instance a natural watercourse, the limits to which the approaches may encroach on the natural flood plain of the stream without causing excessive backwater, are important economically. The cross sectional area of the normal flood channel obstructed by the approaches can be compensated by: (1) increasing the depth of the section passing through the structure; (2) streamlining; or (3) other possible means. In the case of an inverted siphon, it is necessary to know the amount of channel deepening that will occur immediately over the siphon barrel in order to safely locate the structure in elevation. If this depth is great, hydrostatic forces become high, and adverse effects on economics result. Therefore, the need is to develop information to establish relationships between variables for design of an adequate cross section for a stable channel through the construction to minimize backwater, and the protection necessary to maintain this channel in a state of stability at the structure and upstream. This would include lateral restriction necessary for stability.

Preliminary economic studies show that considerable savings might result from more balanced designs of approach and structure in building inverted siphons, bridges, and other crossings. If the studies yield the results which might normally be expected, the relationships developed could be used, at least in part, immediately in design practice. It is probable that considerable savings would accrue in a short time.

The proposed research would be conducted on a movable-bed hydraulic model so constructed to permit adequate flexibility to study the relationship between variables affecting the general solution of the problem. This research would involve study in the model of the relationship between original channel width, restricted channel width, and maximum depth of scour as related to a range of physical conditions which might exist at a specific site.

Capacity and freeboard for open chutes. This item was included in the January 22, 1959 memorandum from Chief, Canals Branch, to the Chief Designing Engineer and was stated as follows: "Chutes have been designed and constructed using different criteria for establishing freeboard because of the lack of reliable prototype data. Some of these chutes undoubtedly have excess freeboard and some possibly do not have enough. Construction practice, flow, velocity, grades, air entrainment, alinement, age of structure, and particularly the tendency for flow to surge or slug in some chutes are factors influencing capacity and freeboard. As far as we know, the question of why surging flow occurs in some chutes and not in others has not been answered to everyone's satisfaction. Since open chutes are usually a major item in any canal system, field studies to obtain more firm design criteria are desirable."

This idea includes two projects that have been considered by the Hydraulic Laboratory previously; aerated flow and slug flow. We have, in the past, done work on aerated flow and reports are available. However, this project was dropped in favor of more urgent problems. It could be revived easily by reviewing past writings.

The subject of slug flow has been studied on a limited scale both in the field and in the laboratory. A very good file is maintained on this subject. Probably the most thorough analysis was made by a graduate student at Cornell and reported in a thesis. The results of this study are available in our files and a project could be written up and started when circumstances permit.

Free fall drops. This study was also suggested in the January 22, 1959 memorandum from the Canals Branch, and stated as follows: "There are many instances of free falling drops used in canal structures such as stoplog checks, overchutes, vertical drops and weirs. A better prototype knowledge of the characteristics of these hydraulic jumps would benefit design."

A file is maintained on these types of structures and some work has been done in the past. A work project could be outlined if and when time and circumstances permit.

Gate discharge coefficients. The January 22, 1959 memorandum states: "Additional data toward determination of reliable prototype discharge coefficients for flow under gates particularly the submerged condition, would be valuable."

This project is carried under the water measurement program. At the present time, emphasis is being placed on radial gates and square leaf turnout gates. A report of the progress and future proposals is outlined in the report of progress on the water measurement program.

Control notches. The January 22, 1959 memorandum states: "Multiple and single notch controls have been installed in numerous canals for various purposes. Observations of these controls should be made to determine if operation is satisfactory. Possibly the notches could be used to measure flow in some cases if accurate rating data were available."

The notches are normally used to control water surface whether it be in the conveyance or at the end of a hydraulic jump pool. In at least one instance, the notches were installed for a measuring section. There is now available considerable information on these notches, but it has never been assembled and put in usable form. Laboratory ratings of different types of notches, field ratings of others and some pictures and observations are readily available and some design data could be developed with a minimum of effort.

Other comments. E. R. Schultz in his comments of September 15, 1958, on the memorandum "Hydraulic Data Derived from Bureau Structures" states: "It would be desirable to have verification of friction losses and velocities in high head tunnels and overflow spillways. Our computations are borne out by model tests, but action of prototype would be most valuable. Possibilities of spray and swelling from entrained air could be examined much more closely in an attempt to prevent costly remedial measures, such as raising the training walls at Grand Coulee Dam. Apparatus for measuring velocities were installed at Grand Coulee Dam and at Shasta Dam but very little if any information on tests has been made available to the designers." (Velocity plates were also installed in Friant Dam. We have done nothing except exploratory tests on the plates at Shasta and Grand Coulee and nothing at Friant because of failure to gain approval for the necessary field testing. At Grand Coulee, there is a damaged portion of bucket below the plates and operation is restricted. At Shasta, the water is too valuable for power generation to permit flows over the spillway for testing.)

"Studies of crest shapes downstream of spillway gates to determine most economical design consistent with safe pressures would be helpful. We have recently designed crests on high dams with arbitrary minimum gate openings. On high dams with overfall spillways with gates, considerable economy could be effected if the crests could be safely steepened. The Army Engineers recently published some results of prototype tests on gated spillways and outlet works (see Volume 84, Journal of the Hydraulics Division, February 1958). A discussion of these conclusions by the Hydraulic Laboratory would be helpful.

Present available formulae for losses in pipe bends are based on experiments on very small diameter pipes. Data acceptable to all design groups presently seem nonexistent. The outlet at Glen Canyon Dam in order to pass the machine shop requires a large number of bends. It appears that here would be an excellent opportunity to study bend losses in large diameter pipes by installing a small amount of test apparatus."

There are a few other comments from individuals in the design branches, but the main items have been included.

SEDIMENTATION

1. Sediment Control at Diversions

Various types of sediment control structures have been developed for specific Bureau projects. There is a need for data which can be applied for a wide variety of conditions. Accordingly, hydraulic model and analytical studies are being made to improve methods of control of sediment at diversions.

Accomplished FY59. A testing program on the use of surface guide vanes to control bed sediment at canal intakes was started. Nine tests were completed before it was necessary to release the facilities for a project study.

Scheduled FY60. Tests on surface guide vanes will be resumed. Bottom guide vanes will be tested also. Location, number, and spacing of the vanes will be varied to cover a wide variety of conditions.

To check the effectiveness of two types of sediment control arrangements at diversions in the field with results obtained on hydraulic model studies of these diversions, it is proposed to make three field studies. Milburn Diversion and Bartley Diversion Dams, both in Nebraska, have a short tunnel and curved guide walls, respectively, for sediment control arrangements. Woodston Diversion in Kansas has curved guide walls and an overhanging sill. The studies would include a field trip to each diversion to sample the sediment loads passing through the sluiceways and that going into the headworks. These values would be compared with values obtained from model studies and thereby check similarity of action.

2. Stable Channel Shapes

Studies to improve design of unlined and earth-lined canals have been made over several years. Results have been utilized in the design of canals in noncohesive materials. During recent years, in coordination with the Lower-cost Canal Lining Program, the studies have been concentrated on canals constructed in cohesive materials. Field tests have been made on selected test reaches in six regions to determine erosion characteristics and the tractive forces or shear that produced the erosion.

Undisturbed and sack samples from each test reach were returned to the laboratory. Shear tests in a hydraulic shear testing tank were made, as well as the standard Atterberg soils tests. Vane shear tests were also made in the field and on the undisturbed samples brought to the laboratory. The purpose of the field and laboratory tests is to correlate standard or other soils tests with critical or starting erosion values so they can be used in designing future canals in cohesive material.

Reports that have been prepared to date and issued generally or on a limited basis are Hyd-352, General Report 21, and General Report 22. The latter two reports include data reported in Hyd-435 and Hyd-443 and are progress reports of the tests and data to date.

Accomplished FY59. During the year, laboratory tests were completed on the soil samples obtained from the many test reaches in the field. Over 100 samples were tested. A method of analyzing the data was developed to determine correlation between the dependent variable and the independent variables, the dependent variable being the critical shear or tractive force value for each sample or test reach. The other variables are considered independent. Ezekiel's method of deviations was adapted to determine correlations of variables. Several plots were made and coefficients of correlation determined.

To try various correlations of different groupings of variables, the services of the electronic data processing section were used. The data are being processed at present.

The work was accomplished partially under the LCCL Program and partially under the Sediment Research Program. Progress was made on a draft report of the work accomplished to date.

During the year, observations were made and data kept on curves on a reach of Cambridge Canal, Nebraska, in the vicinity of Station 1240. Recommendations for shaping these curves to reduce erosion on the outside of curves and reduce silt deposition on the inside of curves were made approximately 4 years ago. A recent travel report from an Irrigation Operations engineer reported the curves shaped with a 4:1 slope on the outside of the curve and a 1:1 slope on the inside of the curve gave less scour and deposition than other curves that were left with the regular trapezoidal canal shape.

Preliminary drawings for a general model study of canal curves were made.

Scheduled FY60. Analysis of the data obtained on the program for improving the design of canals in cohesive materials will be completed. The report of the findings to date will be finished. This will include the results of the multiple correlation analysis made by use of the IBM-650 electronic data processing machine.

To obtain data on earth materials in the fat clay range, it is proposed to select a few test reaches on canals constructed in this type of material. Field data will be obtained including velocity distribution, vane shear, water surface slope, and sediment concentration measurements. Laboratory tests will be made on undisturbed and sack samples.

A model for study of velocity distribution and shear forces in canal curves will be constructed and tested to determine the shape best suited for minimum erosion and deposition on curves.

3. Channelization and Bank Protection

The use of steel jacks and jetties for bank protection and channelization has been studied in the laboratory during the past few years. Through the use of two hydraulic model studies, formulas and graphs have been developed which will assist designers to choose economical layouts for jetty fields. These studies have been supported mainly by project funds from the Middle Rio Grande Project. One of the hydraulic model studies was made simulating a prototype layout of Casa Colorada area on the Middle Rio Grande.

Accomplished FY59. Tests were continued on the movable bed model to verify data obtained in the field and to extend the range of discharges and determine the deposition and scour characteristics of the jetty field setup.

After completing the series of tests on the Casa Colorado model installation, the movable bed distorted model was modified. The walls of the model were changed to give almost constant jetty field, channel, and flood-plain widths. The jetty fields were varied to make a general study, including runs made with 250-foot spacing and 500-foot spacing and a range of discharges from 5,000 to 15,000 cfs.

Scheduled FY60. The tests on the movable bed model will be finished and a report covering all the tests on both the movable and fixed bed models will be finished. A few tests extending the data already obtained in the fixed bed model will be made to fill in gaps in data where analysis has shown more measurements are required.

4. Weed Control by Shading With Sediment

A study has been carried on in coordination with Weed Control Research to determine the effectiveness of suspended sediment in water on reducing growth of water weeds. The study was started after reports had been received of jetting sediment from Angostura Reservoir for the purpose of reducing weed growth in Angostura Canal.

In several published reports, there have been statements indicating suspended sediment in canal systems has been the cause of reduced water weed growth. These statements have not given details as to concentration and type of sediment, or type of weeds. The subject study is designed to answer some of the questions concerning control of water weeds. There have been inquiries from various sources, particularly connected with jetting or injecting sediment into canals from outside sources.

Accomplished FY59. Tests were made on three types of pondweeds at three different concentrations of sodium-base bentonite. The sediment suspension was circulated by pumps mounted on the sides of 55-gallon drums. Two sets of pondweeds were grown during the summer and measurements made to determine amount of growth reduction. In general, the concentrations of bentonite from 50 to 800 ppm had no effect on growth of the weeds. Sediment was then obtained from Angostura Reservoir and tests started to compare effectiveness of this sediment with the commercial bentonite. Light measurements indicated the Angostura sediment has a much greater shading value than the bentonite.

A draft report was completed giving details and results of the bentonite studies.

Scheduled FY60. The tests will be completed using commercial sodium-base bentonite and Angostura Reservoir sediment. The measurements will determine the effectiveness of the two types of sediment. The first tests will determine how high the concentrations must be to completely stop pondweed growth.

A limnophotometer is being used to determine light values. Blue and red transmitted light are measured, as well as white light. Results of the 1959-1960 tests will be combined with data in the 1958-1959 draft report for a complete report.

5. Waves in Canals

Wave erosion on canals has always been a maintenance problem because it creates unsightly and inefficient canals and requires considerable cost to keep them in shape. Field measurements have been made of wave heights, wind velocities, and canal characteristics by use of 16-mm cameras, anemometers, staff gages, and other needed equipment. Measurements have been made on four projects in coordination with the Lower-cost Canal Lining Program.

Accomplished FY59. The data obtained from the four canal systems in the field were assembled and analyzed. A 2-foot by 8-foot by 72-foot rectangular flume was converted to a wave flume. A flap-type wave machine was installed and a 1-1/2 to 1 side slope was constructed on one side to simulate one side of a canal. The wave machine was calibrated to produce waves in the same range as those photographed on field projects.

A material from Driftwood Canal, Nebraska, was used in the tests. Rate of erosion by typical surface waves was measured and plotted. In general, the conclusions were:

1. Erosion of a homogeneous embankment by a uniform wave train tends to continue as a geometric progression of time.

2. The rate of erosion is dependent primarily on the wave height and density to which the soil has been compacted. Compaction above 95 percent of the Proctor maximum density greatly reduces the erosion rate.

3. Wetting and drying cycles have a deteriorating effect on the resistance of embankment to erosion due to the disruptive effect of slaking on the soil structure which occurs when dried soil is subjected to immersion. Freezing and thawing cycles seem to have a similar, though not as severe, an effect.

A report of the wave flume study and field tests was compiled and will soon be printed.

Arrangements were started to install field equipment on Driftwood Canal, Nebraska, to measure wind velocity and direction, wave heights and frequency, and rate and total amount of erosion. This test would correlate the model study with field measurements of erosion on the same soil.

Scheduled FY60. Three different types of earth materials will be obtained from the field and tests made in the laboratory wave flume. The materials will be chosen to cover a range of earth material characteristics. Tests similar to those conducted on Driftwood Canal material will be made.

A test reach will be chosen on Driftwood Canal; equipment will be installed, and data will be recorded to correlate erosion in the field with that measured in the laboratory wave flume.

6. Hydraulic Model Study to Determine Parameters Related to Suspension and Scour of Sediment

There is a need in sedimentation studies to be able to predict the size of sediment that will go into suspension when hydraulic characteristics of channels are known. This information is needed particularly in connection with sediment control arrangements at diversions, but would also be used in other problems where scour and deposition of sediment are involved.

Scheduled FY60. This is a new research project, and no work has been done on it in previous years.

The first part of the study will include a search and compilation of field data which are available. Data collected by Geological Survey for streams are available in the water supply papers. The size and concentration of sediment found in suspension will be related to functions of the velocity and shear.

The second part of the study will be the construction and operation of a flume to determine definite parameters relating maximum sediment size and concentration. The depth of scour in an unobstructed flow will also be related to parameters of velocity and shear.

WATER MEASUREMENT

1. Constant Head Orifice Turnout

Continued design and construction of this type of turnout have produced changes that seriously affect the discharge coefficient. The study purpose is to establish the effect of the changes and to supply revised discharge tables.

Accomplished FY59. Two additional studies affecting the coefficient of discharge of the turnout were completed. The first concerned the effect of changes in the entrance floor configuration, and the second the shape of the lower edge of the head wall that separates the entrance section and stilling compartment. The entrance floor configuration has a major effect on the coefficient, but the head wall shape has only a minor effect.

At the request of Design Division, a side outlet to the stilling compartment was studied in place of the end outlet normally used. This side outlet produced only a minor change in the coefficient and may be adaptable for design.

Results of each study of the turnout investigation were briefly summarized for inclusion in the final report.

Scheduled FY60. Foreseeable additional study of the turnout will be completed and a report written containing all results and the new discharge tables.

2. <u>Critical Depth Measuring Device</u>

Standardization and calibration of a critical depth measuring device with a section more closely related to the cross section of the water conveyance is needed.

<u>Accomplished FY59</u>. Progress in the study of such devices for use in water distribution was surveyed. An Agricultural Research Service paper "Trapezoidal Flumes for Open Channel Flow Measurement," A. R. Robinson and A. R. Chamberlain, was reviewed for possible application to Bureau problems. Current and past literature describing methods of measuring irrigation water by devices of this nature was read to obtain references that would assist in the standardization.

<u>Scheduled FY60</u>. Liaison will be maintained with the ARS project being conducted at Fort Collins. Maintenance of the files and review of literature will continue.

3. <u>Weirs Having Velocity of Approach</u>

Accuracy of measurement with weirs depends upon a number of factors, including the depth of water and velocity distribution in the pool upstream of the weir. As the velocity of approach to the weir notch increases with a decrease in water depth caused by filling of the pool with sediment, serious errors are incurred in determining the discharge. The purpose of this research is to rationalize the probable effect of the increased velocity on the discharge and recommend corrective measures.

<u>Accomplished FY59</u>. Investigation of this problem was postponed by the press of work in other programs. Literature reviews were made to keep our information current, but no laboratory or field investigations were made. Information and a bibliography were supplied to the Technical Information Branch for answer to an inquiry for information as part of the research necessary for preparation of a thesis on weirs with a velocity of approach.

<u>Scheduled FY60</u>. Because excessive velocity of approach causes errors in weirs used for water measurement, information sources should be continually reviewed and our knowledge increased. If the thesis, for which information was furnished, is published, a loan request will be made and the thesis reviewed to determine whether results are applicable to Bureau work.

4. <u>Turnout Gates</u>

In recent years, there has been an increase in interest in the use of single- and multiple-gate turnouts for both water control and measurement. Gates are plentiful, but an accurate knowledge of their discharge capacity for conditions under which they may control water has not been obtained. Past years of investigation have given information on the Denver screw lift gate, a meter gate, and those used in the constant head orifice turnout. Many other gates and uses are known for which no discharge data are available.

Accomplished FY59. A review of available calibration tables and curves for turnout gates was started for the purpose of filling some of the apparent gaps in information. Available information was used during the past year for assistance to Region 2 in the calibration of turnout gates for settlement of a claim involving handling of drainage waters. The calibration tests in progress by the Salt River Valley Water Users' Association were observed during the year. These tests include calibration of square-opening slide gates designed by the Association in sizes from 12 to 48 inches under both free-flow and submerged conditions.

Scheduled FY60. Because of the increased usage of these gates for control and measurement, an extensive review of publications and a compilation of the findings will be continued for the purpose of supplying information for design. Close liaison will be maintained with the Salt River Valley Water Users' Association for the purpose of obtaining maximum benefits from their tests.

5. Design Data Table

To simplify the selection of water measurement devices for use in distribution systems, the relative merits of each are being compared and presented in tabular form with a minimum of written material.

Accomplished FY59. Several investigations supplied useful data that were considered for preparation of the design data table. This information included discharge capacity of turnout gates, adjustable weirs, and compound weirs. A small amount of cost information on adjustable weirs was obtained.

Scheduled FY60. Information for continued preparation of the table will be acquired from available laboratory studies, field investigations, and literature.

6. Compound Wiers

Many water measurement devices are located in remote areas, must measure over a relatively large range of discharges, and do so with a known degree of reliability. Compound weirs may be used to extend the range of discharges over which a single measuring device will give accurate results. To assist in determining what devices are available and to relate their characteristics, a study of compound weirs was undertaken.

<u>Accomplished FY59</u>. Literature research disclosed very little information describing discharge relationships for compound weirs. From this search, it was concluded that a compound "V" notch weir might be the most readily adaptable device for measurement over a large flow range. Drawings for the weir and a box suitable for testing were prepared for construction, which was partially completed.

<u>Scheduled FY60</u>. Construction of the test facilities will be completed. An investigation of the discharge characteristics of the compound "V" notch will be undertaken for completion in the year.

7. <u>Adjustable Weirs</u>

Many adjustable weirs are in use in Bureau projects and more are being included at water division and terminal points in distribution systems. Requests originating in design and operation divisions are made for information on the discharge characteristics and placement of these weirs. To assist in answering a part of the questions, a limited investigation was undertaken.

<u>Accomplished FY59</u>. An adjustable weir was acquired on loan from Region 1 to assist in the investigation of the head discharge characteristics of the weir. Literature, correspondence, and specification files produced only a limited amount of detailed information which was assembled in report draft form. Testing of the weir in the laboratory 4-foot, glass-walled flume showed only a few percent deviation from the capacity of a standard Cippoletti weir. No attempt was made to test the weir in combination with one or two more weirs that are often used at a flow dividing point in the system. So many flow combinations are possible in the usual small confined space of the weir box that a test program seems impracticable.

<u>Scheduled FY60</u>. Results of the fiscal year 1959 literature search and laboratory investigation will be prepared in report form.

8. <u>Water Use and Measurement Records</u>

Importance of good measurements in an irrigation system may not be fully appreciated by all personnel responsible for water dispatching. Some may not be aware of what constitutes acceptable practice and steps necessary to improve accuracy for more equitable distribution. To improve measurement conditions, ultimately raise the quality of measurements, and to provide reliable water use figures, an educational and assistance program is indicated.

Accomplished FY59. Discussions were held with personnel concerned with the improvement of our water measurement methods. The discussions disclosed that a school might not produce as much benefit as actual measurement and recording of water use by improved methods with data converted to water use figures. Water use figures could be assembled and made available to various branches of the planning, design, and operation offices of the Bureau and other departments. The discussion resulted in a decision to plan a program for measurements to more accurately determine the distribution systems seepage loss and waste. This program would include determining the average consumptive use of water on representative farm units and a survey by questionnaire on the methods used by the projects for measuring water at points of diversion from streams and reservoirs. After analysis of questionnaire results against consumptive use figures, the need for further action would be determined.

Scheduled FY60. Plans will be extended through preparation and sending of questionnaires. Results will be analyzed. Tentative sites for installation of devices for improvement of measurement will be selected and details laid out. Should the results so indicate, a site will be selected and plans made for installation of improved measurement devices to provide accurate water use figures.

9. Summary of Available Information on Measurement of Irrigation Water

To quickly and accurately answer questions arising from correspondence or personal inquiry, a current and complete reference file on water-measurement methods is required. The laboratory file is maintained on this basis to reduce the time required to answer such questions.

Accomplished FY59. The water-measurement reference file was classified during the year into closely related methods. Several of the sections were abstracted for use in answering correspondence or design questions. Other reviews were made and used for parts of the water-measurement program, especially that of measuring small discharges of irrigation water, adjustable weirs, and weirs having a velocity of approach.

Scheduled FY60. The reference file will be further abstracted and simplified to provide additional bibliographies and usable resumes of progress for particular means of measurement.

10. Measuring Very Low Flows of Irrigation Water

Inquiries continued for means of measuring by simple and inexpensive means discharges that fall in a range considerably below our normal measurements.

Accomplished FY59. A library search was made during the year to ascertain the available information. The biliography and abstracted information indicate that little is presently known about the measurement of very small flows in the field and that a more intensive study should be made.

Scheduled FY60. A wider search for information will be undertaken, and the most promising indicated means studied for applicability to Bureau problems. Laboratory work is not anticipated, but a report of the findings will be completed.

11.* Control Notches

In recent years, multiple- and single-notch controls have been installed in numerous canals for various purposes. According to comments by designers, observations of these controls should be made to determine if operation is satisfactory. If the observations are made, determination should be made of the possibility of use of these devices for water measurement. Some information is available in the form of correspondence and laboratory and field calibrations. Additional information can be gained from letters to the regional offices and project offices where installations of the notch structures are known to exist.

Scheduled FY60. It is proposed that available information on notches be compiled, including both laboratory calibrations and field records of the operation for use by the Design Division and to determine need of further information.

12. U. S. Navy Underwater Log Equipment, Electromagnetic-type

A letter of November 26, 1958, from the Commissioner to the Assistant Commissioner and Chief Engineer, transmitted a technical manual describing the underwater log equipment. This letter contained a brief description of the equipment and the suggestion that the Denver Office might wish to make trials to determine the applicability to Bureau measurements. After review of the manual, characteristics of the equipment showed possibility of use as a control of valve opening, motor or pump speed control, an instrument to sense a change in velocity as a single unit, or

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*New item.

be capable of conjunctive use with other units to measure the differences between velocities at 2 or more points in a system. As a measuring device, discharges could be inferred from velocity measurement in the control section. Such installation would normally require a rating of the section for known positions of the log equipment. For determination of velocity and discharge in closed conduit flow, the rod meter could be used for traversing the pipe and determining the velocity distribution. With these apparent uses, it was requested that the log equipment be sent to Denver for study.

<u>Accomplished FY59</u>. The log meter was received and installed in the laboratory 2-1/2-foot-wide flume. Operation of the equipment was successful, but the range of velocity was limited by the small capacity of the flume. Sensitivity of the equipment was excellent for small changes in velocity to the extent that a traveling wave from one end of the flume to the other could be sensed. Results of the study were prepared in memorandum form.

<u>Scheduled FY60</u>. An attempt will be made to install the log equipment in facilities with a larger range of discharge and velocity. From this installation, specifications may be drawn to adapt this equipment more directly to Bureau use. This may include suggestions as to the modification to simplify both the sensing element and the control circuits from which the intelligence is transmitted.

13.* <u>Dethridge Meter</u>

The Dethridge Meter is a device for obtaining a positive self-integrating measurement of water delivered as a full-surface flow. It has a particular application for the measurement of deliveries of water from open channels for irrigation. The meter has been in use in Australia for over 40 years. It has been tested in the United States, but has never been accepted for general use. Periodically, the question arises as to why it is not more extensively used. The question has again been brought to the fore. Sufficient material immediately available from the files was used to show the limitations of the device.

<u>Scheduled FY60</u>. A literary search will be made to obtain additional references. The material will be indexed, correlated, and a summary in memorandum form will be prepared. This will provide an economical source of material for answering inquiries.

14. <u>Discharge Coefficients for Radial Gates</u>

Radial gates are used extensively in irrigation systems for rate of flow and water surface level control. Normal and flood

*New item.

releases from storage dams, and at diversion dams, and regulation and control in the conveyance systems, are affected by the use of these gates. Intelligent and orderly operation of the systems normally requires that the rate of flow passing the gated structures be known. The need for accuracy of measurement is dependent upon conditions existing at the site.

The radial gate is used to close an opening in a structure. Hence, the boundaries of the flow orifice are formed in part by the structure and in part by the gate. The wide variety of shapes which the structure may assume, together with the extensive choice of physical dimensions, shapes, and settings of the gate itself, combine to create an almost infinite number of combinations which affect the rate of flow. Therefore, determination of discharge coefficients through a structure utilizing radial gates for control is not readily solvable by analytical means. An empirical solution is thus indicated.

Needed information includes the effect on the discharge coefficient of: (1) the radius of curvature of the gate leaf; (2) the ratio of breadth to height; (3) the relative position of the hinge pins; (4) the submergence, both upstream and downstream; (5) the profile of the bottom of the structure adjacent to the gate; (6) the alinement of the sides of the structure (assuming that the structure has only one gate or that the gates are separated by piers. If there are no separating piers between gates, other questions arise.); and (7) orientation of the structure with respect to the approaching flow.

Many tests on model gates have been made over a period of several years. The test data have been analyzed and the results and conclusions presented in a paper published in a technical journal. Further testing and analyses are necessary to establish general design criteria.

Accomplished FY59. A followup was made of the findings contained in the paper "Problems Encountered in the Use of Low Head Radial Gates," prepared in fiscal year 1958. As a result of this review and for further simplification, it was decided to attack the problem of free flow gates first and defer the study of the effects of submergence until later.

A review was made of the existing information, including evaluation of published equations. The findings indicated the necessity for an analysis of available data in relation to available equations. This study resulted in a decision to attempt an analytical approach before initiating additional tests. This developed approach was applied to the available data and refinements were undertaken. The result of the study was development of an adjusted equation for determining discharge through the gate, taking into account the numerous variables. Use of this equation provided solutions that were in very close agreement with the results of calibrations. It was concluded from the study that further verification of the formula should be obtained over a range of variables studied in a hydraulic model.

Drawings of a model of a test radial gate to be installed in the large 4-foot flume in the Hydraulic Laboratory were completed.

Scheduled FY60. Construction of the model gate and installation in the 4-foot flume will be completed. Testing will be initiated to obtain data for checking the proposed formula and extending the scope of presently available information. A progress report will be prepared.

LOWER COST CANAL LINING

A total of $146,350 is programed for field offices and the Denver Office. The $45,500 indicated here is for the portion of the program to be performed by the Engineering Laboratories, labor, and additive only.

Complete details of accomplishments in fiscal year 1959 and the program scheduled for fiscal year 1960 are contained in the LCCL committee report dated June 1959.

LOWER COST CANAL LINING

Soil Sealants and Stabilizers

Chemical Treatment

During the current year, considerable emphasis has been placed on the use of chemical soil sealants, and much of the effort has been expended in laboratory tests on SS-13 with different canal soils. SS-13 is a commercial product designed especially for canal seepage reduction, and reports of initial tests indicated that it was a promising canal sealant. For this reason, more laboratory tests were conducted on this sealant than had been planned on chemicals for screening purposes only.

The SS-13 investigation started with a conference with Mr. J. Harlan Glenn of the Brunroy Corporation, Torrance, California, who produce the chemical sealant. We mutually agreed upon a laboratory program in which SS-13 would be tested on dune sand in small laboratory permeameters. This program was later extended to three other soils and a hydraulic laboratory flume study on a large sample of one of the soils.

SS-13 is a thick, viscous, light-colored liquid emulsion which mixes readily with water. It is a patented substance and, according to the manufacturer, the chemical consists of certain organic sodium salts and emulsifying agents in diesel fuel as a carrier. The manufacturer recommends using 500 to 1,000 ppm of the sealant in canal water, the amount required depending on the perviousness of the canal bed material. In an actual field installation, the chemical would be mixed with canal water and ponded in canal reaches for a 16- to 24-hour period, or allowed to flow as slowly as possible down the canal. After being carried at depth in the soil in seepage areas, the emulsion containing the sealant is designed to break, and the sodium salts are acted upon by calcium ions in the canal water and soils to form insoluble calcium salts of a resinous nature. These salts are believed to coat soil particles and fill soil voids, thus reducing soil permeability.

For the small scale laboratory permeameter tests, a specimen 1 inch in diameter by 1 foot long was compacted in a plastic tube and subjected to a constant waterhead (or slightly falling waterhead in some cases). The general procedure consisted of determining permeability of the soil specimen, introducing SS-13 of a definite concentration into the permeability equipment so the specimen could be treated with the sealant for a definite length of time, and then after the treatment and removal of the SS-13, a post-treatment determination of soil permeability. This would show the effectiveness of the chemical in reducing soil permeability. Subsequently, small increments of soil were removed from the specimen top at intervals and permeability tests made until the permeability rate approached that of the specimen prior to treatment with the sealant. This would show the effective depth of SS-13 in reducing permeability. Where the hardness of canal water was thought to be a factor in the effectiveness of the sealant, synthetic canal water, with compositions approximately those of canals where the soils were obtained, were used. This type of low head permeability test could be run in quantity, allowing a considerable variation in SS-13 concentration and treatment time.

The laboratory tests described in the preceding paragraph were conducted on representative soil samples from the following prospective sites for field trials with SS-13:

1. Lateral 1 of Interstate Canal on North Platte Project, Wyoming

2. Lateral 10.2 of the Black Canyon Irrigation District, Idaho

3. Lateral R-41 of the Heart Mountain Division, Shoshone Project, Wyoming

4. Coachella Canal, Imperial Irrigation District, Arizona

No. 4 above was somewhat different from the other three, because the tests were made on undisturbed samples of untreated soil adjacent to an SS-13 treated reach of Coachella Canal.

The results of these permeameter tests indicated that where soil permeability was reduced, it was being caused by the formation of a surface seal which was broken when a fraction of an inch of the soil was removed from the top of the specimen. For some of the soil specimens having permeabilities lower than 200 or 300 feet per year, the permeability reduction for treated specimens was no higher than that for untreated control specimens, some of which had a marked tendency for seepage reduction with water alone as the permeability tests progressed. Samples of soil from the Idaho and Wyoming Canal sites were sent to the Bramey Corporation for tests with SS-13 in their laboratory. To date, we have received only a brief comment on their preliminary tests, which was that they had obtained seepage reductions in the soil after treatment with SS-13, but that the seepage rate increased when top portions of the soil specimens were removed. At that time, they were not satisfied that the removal of the soil did not unduly disturb the "packing" of the soil.

Early in the calendar year 1958, Region 1 had made arrangements, in cooperation with Dr. Warnick of the University of Idaho, to conduct a field trial with SS-13 on Lateral 10.2 of the Black Canyon Irrigation District. When the laboratory tests did not show that the chemical was sealing the soil to an effective depth, the plan for the field installation was abandoned for the time being.

Another factor in the discontinuance of plans for the field trial was that the degree of toxicity of SS-13, used in a canal sealing operation, was in question. Samples of SS-13 have been submitted to the U. S. Public Health Service, so that agency could pass upon the toxicity of the material for use in canal water. At first, the Health Service did not know the composition of SS-13, except that diesel fuel as a carrier made up a large proportion of the material. They, therefore, only passed upon the use of diesel fuel in water, and stated that diesel fuel would be detrimental to fish and fish food organisms, and to human and animal consumption. Later, the Bromroy Corporation revealed to the Public Health Service the general nature of the other ingredients in SS-13. At this writing, we have had no additional report from the Health Service, but an attempt is being made to have an answer from them on this matter before the annual meeting.

The permeameter tests on soils from Lateral 10.2 of the Black Canyon Irrigation District were followed by two larger scale tests in a hydraulic flume. The study was conducted in a 1- by 1-1/2- by 30-foot recirculating flume in the Hydraulic Laboratory using both ponded and flowing water. A soil sample with a 6-foot-square surface area and a 1-foot depth was treated with SS-13, and the permeability characteristics of the soil determined before, during, and after the chemical treatment.

Test data recorded for ponded water showed the SS-13 had only minor effects when used in concentrations of 0.1 percent by volume and ponded for 24 and 48 hours. The results of the test generally confirmed those of small scale permeameter tests.

When calcium carbonate hardness was increased to approximately 385 parts per million and flowing water treated for 48 hours with an 0.1 percent by volume concentration of SS-13, a surface seal resulted. The permeability coefficient decreased from approximately 2,000 to 165 feet per year. However, when 3/4 inch of soil was removed from the soil surface, the permeability coefficient immediately increased to approximately 7,200 feet per year. The sudden increase indicated the surface seal which had occurred was easily destroyed when the soil surface was removed.

A report is being prepared covering these tests.

In addition to the work with SS-13, three proposed soil sealants, made up by the Chemical Analysis Section, were tested in the small scale permeameters by procedures similar to those described above for these tests. These consisted of an emulsified diesel fuel in water and two different paraffin emulsions in water. The tests showed that these materials produced a surface seal on the soil, some of them even better than SS-13. The seal was, however, broken when as little as 1/4 inch of soil was removed from the top of the specimen.

In addition to the laboratory testing on soil sealants, a review of the literature has been conducted on the subject of soil stabilizers and sealants. A report and bibliography on this review are now being compiled.

Soil Modification

Representatives of the Engineering Laboratories traveled to McCook, Nebraska, to assist project personnel in the installation of cement and asphalt stabilized compacted earth lining. The purpose of the stabilization was to increase the resistance of the earth lining to water erosion. This investigation will be described by the Region 7 report compiled for the annual LCCL meeting.

SPECIAL STUDIES

Erosion and Tractive Force

Shrinkage limit tests on 102 soil specimens from the field test sites were conducted to find possible correlations between this test and the laboratory erosion results and computed tractive force values. After a limited comparison of these data, no apparent correlation has been found to date.

Field and laboratory erosion and tractive force data have only been partially analyzed at this time. In this analysis, several different approaches have been tried, but the most promising approach still appears to be that presented in General Report No. 22, distributed about a year ago. The laboratory and field data collected to date are insufficient to extend graphical representations into the area of soil with relatively high plastic indices. This extension would be desirable from the standpoint of having information on a more complete range of soil types. A report on this overall subject, including all the data now available, is being prepared.

Wave Erosion of Canal Soils

The laboratory hydraulic wave equipment for studying the effect of canal wind waves on soils has been completed, calibrated, and used on silty soils of the Driftwood Canal, Missouri River Basin Project. This apparatus consists of a wave generator, a wave absorber, and a 70-foot flume with a test section into which a test embankment of soil can be placed. Calibration consisted of measuring wave heights, lengths, and velocities for each of five different waves to be used in testing soils. These waves have the essential characteristics of average waves in canals.

Two large shipments of soil were obtained from the Driftwood Canal, Frenchman-Cambridge Construction Field Division, Nebraska, for use in the wave tests. Observations and measurements of the effect of the five basic waves on the soil required the placement of a separate large specimen for each test.

In these tests, erosion of the soil occurred at the waterline, primarily, and the rate of erosion decreased approximately with the logarithm of time. The experiments also demonstrated that the erosion rate is greatly increased with a decrease in soil density and also after periods of drying.

For canal reaches on the four Bureau projects where wave heights and frequencies have been measured, additional information on canal dimensions and alinement was obtained from project and irrigation district offices. From this information, fetch lengths (lengths of water exposed to and in the direction of wind) have been determined. Such information has supplemented wind and wave data obtained on other studies and will help make all the data usable for Bureau canal design purposes. With the wind direction and velocities known for a proposed canal of certain alinement and dimensions, wave characteristics which will result in the completed canal can be estimated.

The report titled "Progress Report on Bank Erosion Due to Surface Waves in Canals" has been drafted and is being reviewed and finalized. The studies discussed and analyzed in this report include the measurement of surface waves, wind velocities, and wind direction and canal data made on canals of four USBR projects, and the laboratory study of surface wave erosion. The field data were analyzed on the basis of Sverdrup, Munk and Bretschneider methods. By making corrections for fetch width, wind direction, and flow velocity in the canals tested, the field data fell in line with the Sverdrup, Munk and Bretschneider curves.

As a result of the laboratory study, the following general conclusions are made. These conclusions apply to inorganic clays and silts of a type similar to the Driftwood Canal soil.

1. When started, the erosion of a homogeneous embankment by a uniform wave train tends to continue as a geometric progression of time.

2. The rate of erosion is dependent primarily on the wave height and the density to which the soil has been compacted. Compaction above 95 percent of the Proctor maximum density greatly reduces the erosion rate.

3. Wetting and drying cycles have a deteriorating effect on the resistance of the embankment to erosion due to the disruptive effect of slaking on the soil structure when dry soil is subjected to immersion. Freezing and thawing cycles seem to have a similar, though not as severe, an effect.

Seepage

A representative from this office assisted Region 7 personnel in conducting ponding tests on Franklin Canal to evaluate two reaches of compacted earth lining. This canal was selected for such tests because our study of density changes in compacted earth canal linings has indicated that the silty loessial soil of Franklin Canal has generally shown a greater decrease in density over a period of years after compaction than have other soil types.

One pond extended from Station 116 to Station 130. The compacted lining in the bottom was 18 inches thick. On the sides, the lining had been placed on a 3:1 slope in 18-inch depth and then covered with uncompacted soils; the canal sides were then shaped to 1-1/2:1 slope.

The second pond was built between Stations 548 and 562. The bottom lining was again 18 inches thick. Lining on the sides was placed horizontally in 6-inch lifts on paths 6 feet wide. The sides were bladed to 1-1/2:1 slope.

The seepage rate for the pond between Stations 116 and 130 was 0.03 cubic foot per square foot per day, and the corresponding rate for the pond between Stations 548 and 562 was 0.09.

Seepage losses were computed by two methods in the upstream pond, Stations 116 to 130. Using the canal survey notes, the average cross sectional areas for small increments of depth were determined by combined planimetry and proportional adjustment. Wetted perimeters were scaled from the plotted sections. Seepage rates were computed from measured rates of drop in the water surface and decreases in pond volume.

In the second method, water surface widths at incremental depths were scaled from the cross sections. Average widths were applied to the time rate of water surface drop in computing volumes of water lost. These latter values were processed with appropriate wetted perimeters to compute seepage rates.

Since the second method involves less office work, it was desirable to learn how the rates derived from it compared to those of the first method. No significant differences in the computed seepage rates are apparent. A maximum difference in lost volumes computed was 2-1/2 percent, an amount which is possibly less than experimental error.

Seepage rates in the downstream pond were computed by the second method only.

SECTION VI--HYDRAULIC LABORATORY BRANCH
GENERAL DISTRIBUTIVE WORK

A. General Description and Identification

Costs of this office consist of two principal elements, direct project charges and indirect costs. Direct project charges are administered through the program process while indirect costs are administered by means of the Office Budget. Collectively, indirect costs are referred to as General Distributive Expense and cover essential activities whose benefits cannot reasonably be identified with individual projects or separately financed activities. General Distributive Expense accounts used in the Hydraulic Laboratory are as follows:

GENERAL DISTRIBUTIVE EXPENSE

General Operating Expense

Benefits and Welfare--Employee Recognition

Equipment Maintenance
Auditorium sound system
Office equipment repair

Miscellaneous Administrative Expense--Laboratory and Office Tours

Indirect Engineering Expense

Administrative

Staff Development--Student Engineer Training
Rotation Engineer Training

Meetings and Conferences--Professional and Scientific
Papers and Cooperation (nonattendance)
Civic, Government, and private groups (with Bureau personnel)

Technical Information, Denver--Domestic Visitors
Engineering Monographs
Technical Memoranda

Technical Staff Service--Laboratories

Technical Standards and Procedures (Standardization specifications)

Bureau-wide Expense

Field Training--Field Engineer Laboratory Training
  Construction Engineers' Conference

Manuals and Publications--Reclamation Instructions
  Water Measurement Manual
  Low Dams Manual

Technical Information, Bureau-wide--Preparation and
  Display of Exhibits
    Foreign visitors
    Technical inquiries
    Articles and papers

Laboratory Investigations--Hydraulic

B. Special Activities

1. PROFESSIONAL ACTIVITIES OF PERSONNEL OF HYDRAULIC LABORATORY
Membership in Technical Organizations, Registrations, Etc.

Name	Membership in founder societies	Membership in other technical organizations	Registered professional engineer	Other
Martin	Fellow, ASCE	Member, International Association for Hydraulic Research Member, Colorado Chapter Society of the Sigma Xi	Colorado	Member, Executive Committee, Hydraulics Division, ASCE
Ball	Member, ASCE	Member, International Association for Hydraulic Research Member, U. S. Commission on Large Dams Member, Society of Sigma Xi	Colorado	Member, Task Force on Gates and Valves, ASCE Hydraulics Division Chairman, Publications Committee, ASCE Hydraulics Division Reviewed several papers for Publications Committee, Hydraulics Division, ASCE
Wagner	Fellow, ASCE	5002 Research and Development Unit	Colorado	Task Force on Hydraulic Design and Operation of Spillways
Peterka	Fellow, ASCE	Reclamation Technical Club	Colorado	Member, ASCE Committee on Hydraulic Structures Member, ASCE Task Force on Energy Dissipators for Spillways and Outlet Works
Rhone	Member, ASCE		Colorado	Member, ASCE Task Force on Flow in Large Conduits Reviewed one technical paper for Hydraulics Division, ASCE
Simmons	Member, ASCE		Colorado	Secretary-Treasurer, Hydraulics Division, Colorado Section, ASCE Reviewed one technical paper for Hydraulics Division, ASCE

Name	Membership in founder societies	Membership in other technical organizations	Registered professional engineer	Other
Colgate	Member, ASCE		Colorado	Member, ASCE Task Force on Aerated Flow Member, ASCE Task Force on Cavitation
Beichley	Member, ASCE	Reclamation Technical Club U. S. Naval Reserve, Civil Engineer Corps, Unit CB9-150	Colorado	Reviewed one paper for Hydraulics Division, ASCE
Thomas	Fellow, ASCE Member, ASAE	Member, International Association for Hydraulic Research Member, U. S. Committee, International Commission on Irrigation and Drainage Member, U. S. Committee on Large Dams of the International Commission on Large Dams Member, Reclamation Technical Club Member, Four States Irrigation Club Member, Society of the Sigma Xi	Colorado	Chairman, Technical Activities Committee, U. S. National Committee, International Commission on Irrigation and Drainage Reviewed a number of papers to be published in technical outlets
arlson	Fellow, ASCE	Reclamation Technical Club 5002 Research and Development Unit Four States Irrigation Council	Colorado (Engineer and Land Surveyor)	Member, Committee on Sedimentation, Hydraulic Division; arranged 1/2-day session for Hydraulics Division ASCE Conference July 1959, Fort Collins Two weeks' Military Tour of Duty at Missouri River Division Office, C.E. Reviewed engineering manuals and design specifications and inspected drainage facilities and erosion on three military airfields Wrote report on tour of duty Continued Russian language class
chuster	Member, ASME	Reclamation Technical Club	Colorado	Chairman, Agenda Committee, Rocky Mountain Section, ASME
McBirney	Associate Member ASCE	Reclamation Technical Club International Association for Hydraulic Research		

Name	Membership in founder societies	Membership in other technical organizations	Registered professional engineer	Other
Dexter		5002 Research and Development Unit U. S. Army		
Enger	Applied for transfer to member, ASCE	Reclamation Technical Club	Colorado	Completed classwork and now working on thesis toward advanced degree. University of Colorado; additional graduate work in mathematics; continued study of Russian; Chairman of Nominating Committee, Hydraulics Division, Colorado Section, ASCE, 1959
Dodge		National Society of Professional Engineers Reclamation Technical Club	Engineer in Training, Michigan	
Kusmich		Instrument Society of America Reclamation Technical Club		Member, Educational Committee, ISA

2. PROFESSIONAL ACTIVITIES OF HYDRAULIC LABORATORY PERSONNEL

Professional Papers and Lectures Prepared, Presented and/or Published During FY59 or in Preparation

Author	Title of paper	Meeting (place and date)	Paper published
Ball	Cavitation and Vibration Studies for a Cylinder Gate Designed for High Heads	Eighth Congress, International Association for Hydraulic Research, Montreal, Canada, August 1959	To be published in Proceedings 8th Congress, IAHR
	Discussion on ASME paper "Cavitation Effect on Discharge Coefficient of the Sharp-edged Orifice Plate"		To be published in ASME Transactions
	Hydraulic Characteristics of Gate Slots	Portland ASCE Convention, 1958	Submitted and approved for publication in Journal, Hydraulics Division, ASCE
Peterka	The Hydraulic Design of Slotted Spillway Bucket Energy Dissipators (coauthored with G. L. Beichley)	Los Angeles Convention ASCE February 9-13, 1959	Submitted and approved for publication in Journal, Hydraulics Division, ASCE
	Improved Tunnel-Spillway Flip Buckets (coauthored with T. J. Rhone)	8th National Conference, Hydraulic Division, ASCE, Fort Collins, Colorado, July 1-3, 1959	Will be submitted to ASCE for publication in Journal, Hydraulics Division
Rhone	Problems Concerning Use of Low Head Radial Gates		Published in Journal, Hydraulics Division, ASCE, Vol 85, No. Hy 2, February 1959, Part 1
	Improved Tunnel-Spillway Flip Buckets (coauthored with A. J. Peterka)	8th National Conference, Hydraulics Division, ASCE, Fort Collins, Colorado, July 1-3, 1959	Will be submitted to ASCE for publication in Journal, Hydraulics Division
Simmons	Air Model Studies of Hydraulic Downpull on Large Gates		Published in Journal, Hydraulics Division, ASCE, January 1959
	Model Studies with Reynolds Number as a Main Concern	To be presented at Washington D. C. Convention, ASCE, October 1959	Will be submitted to ASCE for publication in Journal, Hydraulics Division
Colgate	Method of Determining Hydraulic Downpull Forces on High Head Gates		Submitted and approved for publication in Journal, Hydraulics Division, ASCE

Author	Title of paper	Meeting (place and date)	Paper published
Beichley	The Hydraulic Design of Slotted Spillway Bucket Energy Dissipator (coauthored with A. J. Peterka)	Los Angeles Convention, ASCE, February 9-13, 1959	Submitted and approved for publication in Journal, Hydraulics Division, ASCE
	The Hollow Jet Valve Stilling Basin		Paper is in preparation for ASCE, Hydraulics Division Journal
Thomas	Common Errors in Measurement of Irrigation Water		Accepted for publication in Transactions, ASCE Edited and reviewed to conform to Transactions Standards--Reprints with discussions now available
	Hydraulic Performance of 96-inch Regulating Gates in Closed Conduits	Eighth Congress, IAHR, Montreal, Canada, August 1959	Will appear in 8th Congress proceedings
	World Practice in Water Measurement and Control at the Farm Turnout	Being prepared for presentation at annual meeting ASCE, Washington D. C. October 1959	
Carlson	Gravel Blanket Required to Prevent Wave Erosion		Published, Journal, Hydraulics Division ASCE, May 1959
	Hydraulic Studies to Develop Design Criteria for Use of Steel Jack and Jetty Fields for Channelization in Rivers	For seminar "Transportation of Material in Water" Eighth Congress, IAHR, August 1959, Montreal, Canada	
	Talk--Sediment Problems of the Bureau of Reclamation	For foreign engineer trainees, Bureau of Reclamation, Denver; December 1958	
	Talk--Bank Erosion Due to Surface Waves in Canals	Eighth Annual Meeting of the Four States Irrigation Council, Denver, Colorado, January 1959	A short resumé was published in the proceedings of the meeting

Author	Title of paper	Meeting (Place and date)	Paper published
McBirney	Some Experiments with Emergency Siphon Spillways	ASCE--Annual Meeting, New York, New York, October 1957	Closure to discussion of this paper prepared and submitted for Hy Hydraulics Division Journal
Dexter and Lancaster	Hydraulic Characteristics of Hollow Jet Valves		Submitted to ASCE for publication in Journal, Hydraulics Division
Martin	Talks--"Glen Canyon Dam" and "Hydraulic Laboratory Practice in the Bureau of Reclamation"	University of Missouri; Missouri School of Mines; University of Tennessee; University of South Carolina; The Citadel; North Carolina State; University of Kentucky; Rose Polytechnic Institute; Purdue University; University of Illinois	

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3. Special Records and Publications

Motion pictures are used to record significant developments in testing, research, and studies in the laboratory and in the field. The following films were taken during the year. Sufficient editing was done in most cases to properly identify the films and indicate the important aspects of the tests.

Middle Rio Grande Project

200 feet of 16-mm Kodachrome of prototype structures of San Acacia Diversion Dam and Socorro Main Canal--Silent--24 frames per second--Not edited

400 feet of 16-mm Kodachrome of San Acacia Diversion Dam model study--Silent--Not edited--16 frames per second

Casa Colorada model--200 feet of black and white--Silent film--16 frames per second--Not edited

Glendo Dam Outlet Works

300 feet of 16-mm Kodacolor--Silent film showing prototype operation of Glendo Dam outlet works stilling basin with releases through Gate 2 (center) operating singly and Gates 1 and 2 operating simultaneously at discharges from 1,850 to 4,000 second feet

200 feet of Kodachrome 16-mm silent film of Glendo chute block in cavitation apparatus--1,000 frames per second

Snowy Mountains Hydro-Electric Authority

225 feet of 16-mm colored silent film of preliminary design and of recommended design of Tantangara outlet works--Murrumbidgee-Eucumbene Diversion Project--Not edited

Prineville Dam Spillway and Outlet Works

1,000 feet, silent, colored film--About 40 percent of flow scenes taken at 64 frames per second to approximate prototype time scale--The film shows the flow of spillway and outlet works and performance of the single stilling basin that receives their flow

Trinity Morning-glory Spillway

The recommended spillway design was filmed from two locations for several steps in the discharge range, including the maximum of 24,000 second-feet--Confetti on the water surface was used to define flow paths--Approximately 200 feet of film was taken--Color--16 frames per second--Not edited

Palisades Dam Outlet Works Stilling Basin

Motion pictures--16-mm Kodachrome--16 frames per second--Silent--Taken with flows of 8,000, 11,000, 13,000 second-feet into the basin--Not edited

Flaming Gorge Dam Model Spillway Studies

300 feet of colored silent film--Not edited

Navajo Dam Spillway Model Study

100 feet of colored silent film--Not edited

Navajo Diversion Works Model Study

50 feet of colored silent film--Not edited

Navajo Dam Outlet Works Model Study

200 feet of colored silent film--16 frames per second--Not edited

4. Model Shopwork

Glen Canyon Dam Structural Model

Continued from last fiscal year to assist and advise in the construction of test models for the Concrete Laboratory. Our obligation on this assignment has now been completed.

17 Western States Relief Map

The concrete cast of this map on display in the Concrete Laboratory was revised to include features built and under construction since the map was originally painted.

Texas Relief Map

J. C. Douglas and H. P. Burleigh of Region 5 were furnished at their request an outline and cost estimate for a relief map of Texas and vicinity. The 1:500,000 scale map suggested was estimated to cost $5,000 for the original plus $600 per finished copy.

Upper Colorado River Basin Model

A completed copy of this model was prepared for shipment and sent to the Governor's office in Santa Fe, New Mexico in September 1958.

The copy on display in the lobby of Building 56 was rehabilitated and shipped to the Regional Director, Salt Lake City, at his request for a copy to be used by the Upper Colorado River Commission.

A second copy of the model (previously reserved for the Governor of Wyoming) was sent to the Governor of New Mexico at the Commissioner's request in December 1958. (The first copy, sent last September, was subsequently presented to the Navajo Tribal Council.) A new copy of the model was then fabricated and shipped to the Governor's office in Cheyenne, Wyoming. Later a trip was made to Cheyenne to correct a few errors on that copy.

The copy on display in the lobby of Building 53 was temporarily returned to the model shop where it was cleaned and sprayed with a new type of protective coating.

Two requests were also received during the year from, and estimates sent to, the Plateau Oil and Gas Company of Salt Lake City for both finished and unfinished copies of the model.

Rainbow Bridge National Monument Relief Map

Started last fiscal year, the original of this model was completed, and three copies were cast in plastic. As completed, the copies were sent to (1) Regional Director, Salt Lake City; (2) Regional Director, National Park Service, Santa Fe; (3) Commissioner's Office.

Note: For 12 weeks of this fiscal year the model maker was absent from the model shop due to a service-connected injury.

SECTION VII--LABORATORY REPORTS, MONOGRAPHS, PAPERS, PUBLICATIONS, AND TRAVEL REPORTS ISSUED DURING FY59

Laboratory Reports

Hyd-441 — Hydraulic Model Studies of Tantangara Dam outlet works--Murrumbidgee-Eucumbene Diversion Project--Snowy Mountains Hydro-Electric Authority, Australia
September 23, 1958 — D. Colgate

Hyd-442 — Hydraulic Model Studies of the Davis Aqueduct Turnouts at Stations 15.4 and 11.7--Weber Basin Project, Utah
September 15, 1958 — J. C. Schuster, W. P. Simmons, Jr.

Hyd-448 — Importance of Smooth Surfaces on Flow Boundaries Downstream from Outlet Works Control Gates
July 15, 1958 — J. W. Ball

R-Hyd-6 — Progress Report No. II--Preliminary Investigations in Hydraulic Laboratory of Flocculating Agents
November 3, 1958 — T. J. Rhone

R-Hyd-7 — Laboratory Tests of Antiblast Valves for the Federal Civil Defense Administration
February 13, 1959 — D. Colgate

Monographs

Engineering Monograph No. 25
Hydraulic Design of Stilling Basins and Bucket Energy Dissipators
September 1958 — J. N. Bradley, A. J. Peterka, G. L. Beichley

Travel Reports

Field trip to North Fork of South Platte River to obtain water surface elevations to verify the model study
June 27, 1958 — P. F. Enger, W. W. Sayre

Field trip to North Fork of South Platte River to obtain water surface elevations to verify the model study
June 30, 1958 — P. F. Enger, R. N. Johnson

Attendance at Seventh Hydraulics Conference--Iowa Institute of Hydraulic Research--State University of Iowa, Iowa City, Iowa
July 7, 1958 — J. W. Ball

Attendance at the American Society of Civil Engineers' Convention in Portland, Oregon
June 23-27, 1958

July 7, 1958 — T. J. Rhone

Attendance at Hydraulics Division Conference--American Society of Civil Engineers--Atlanta, Georgia
August 19-22, 1958

September 10, 1958 — H. M. Martin

Seepage Tests--Franklin Canal--Lower-cost Canal Lining Program--Bostwick Division, Kansas-Nebraska--Missouri River Basin Project
October 27, 1958 — W. B. McBirney

Inspection and measurements of raw water Venturi meter--Lake Hefner Water Plant--Oklahoma City, Oklahoma
September 29, 1958 — R. B. Dexter

Volumetric calibration of north raw water Venturi meter--Lake Hefner water treatment plant--Oklahoma City, Oklahoma
November 6, 1958 — R. B. Dexter, J. C. Schuster

Review in Australia of Snowy Mountains Hydro-Electric Authority's hydraulic laboratory work and proposed designs on the Adaminaby-Snowy Project
November 21, 1958 — H. K. Brickey, J. W. Ball

Attendance at business meeting of Executive Committee, Hydraulics Division, ASCE--St. Louis, Missouri
November 3-4, 1958

November 25, 1958 — H. M. Martin

Detail to Colorado River Front Work and Levee System Office, Needles, California
January 23, 1959 — R. A. Dodge, Jr.

Correcting relief map in Governor's office in Cheyenne
February 11, 1959 — H. R. Schroeder

Field measurements of pier losses--Delta-Mendota Canal--Central Valley Project, California, and review of draft of report on Sand Deposits in Canals, University of California, Berkeley
September 20, 1958 — C. W. Thomas

Performance tests and inspection of pump-turbine units--Thomas Point Hydraulic Pumping Plant--Lower Yellowstone Project
February 20, 1959 — R. B. Dexter

Attendance at the ASCE Los Angeles Convention
February 9-13, 1959

March 6, 1959 — G. L. Beichley

Inspection of Glendo Dam outlet works stilling basin--Missouri River Basin Project, Wyoming
August 7, 1958 — H. W. Whinnerah, W. E. Wagner

Tests on concrete pipe drain installation--Coachella Valley Drainage System--All-American Canal System--Boulder Canyon Project
January 28 to February 26, 1958

March 23, 1959 — W. B. McBirney

Second hydrostatic test of outlet pipe manifold--Delivery C--Specifications No. DC-3675--Palisades Project
March 18, 1959 — R. B. Dexter, R. H. Kuemmich

Operating studies--San Acacia Diversion Dam--Socorro Canal Headworks--Middle Rio Grande Project, New Mexico
March 24, 1959 — P. F. Enger

College recruitment
March 2-13, 1959

March 30, 1959 — H. M. Martin

Papers and Publications

PAP-115 — Discharge Curve for Modified Lower Outlets, Grand Coulee Dam
September 10, 1958

(A memorandum to J. B. Kirkwood, Project Investigations, through Chief, Division of Engineering Laboratories, from Chief, Hydraulic Laboratory Branch)
W. B. McBirney

PAP-116 Hydraulic Laboratory
A collection of Laboratory Facts

PAP-117 Report to the Government of Japan on the Hydraulic Design of Spillways--FAO Report No. 917--Food and Agriculture Organization of the United Nations
Rome 1958 — C. W. Thomas

PAP-118 The Hydraulic Design of Slotted Spillway Bucket Energy Dissipators

(A paper presented at the ASCE Los Angeles Convention, Los Angeles, California, February 9-13, 1959)
G. L. Beichley, A. J. Peterka

PAP-119 Some aspects of Reservoir Sedimentation--Published in Irrigation and Power Journal--Vol X, No. 2 and 3
April and July 1953 — E. W. Lane

PAP-120 Interim report of hydraulic model studies, Glendo Dam Outlet Works
February 9, 1959

(A memorandum to Chief Designing Engineer from Chief, Division of Engineering Laboratories)

PAP-121 Discussion on paper "Cavitation Effect on Discharge Coefficient of the Sharp-Edged Orifice Plate"

(Prepared March 1, 1959, for the ASME Transactions)
J. W. Ball

PAP-122 Hydraulic Performance of 96-inch Regulating Gates in closed conduits

(A paper to be presented at the Eighth Congress of the International Association for Hydraulic Research, Montreal, Canada, August 24-29, 1959)
C. W. Thomas

PAP-123 Hydraulic Model Studies of Grand Valley Diversion Dam
April 2, 1959

(A memorandum to Chief Designing Engineer, Attention: Chief, Dams Branch, from Chief, Division of Engineering Laboratories)
T. J. Rhone

PAP-124 Cavitation and Vibration Studies for a Cylinder Gate Designed for High Heads

(A paper to be presented at the Eighth Congress of the International Association for Hydraulic Research, Montreal, Canada, August 24-29, 1959)

J. W. Ball

PAP-126 Glendo Chute Blocks--Cavitation Apparatus Study October 9, 1958

(Memorandum to H. M. Martin)

D. Colgate

SECTION VIII--PERSONNEL

Regular Staff--Hydraulic Laboratory

Harold M. Martin, BSCE, MSCE	Chief of Hydraulic Laboratory
James W. Ball, BSME, MSCE	Head of Section
Charles W. Thomas, BSME, MSCE	Head of Section
Alvin J. Peterka, BSCE	Head of Unit
Enos J. Carlson, BSCE, MSCE	Head of Unit
William E. Wagner, BSCE, MSCE	Head of Unit
Jack C. Schuster, BSME, MSME	Head of Unit
Glenn L. Beichley, BSCE, MSCE	Hydraulic Research Engineer
Robert B. Dexter, BSME	Hydraulic Research Engineer
D. Colgate, BSCE	Hydraulic Research Engineer
Phillip F. Enger, BSCE	Hydraulic Research Engineer
Warren B. McBirney, BSCE, MSCE	Hydraulic Research Engineer
Thomas J. Rhone, BSCE	Hydraulic Research Engineer
William P. Simmons, BSME	Hydraulic Research Engineer
Russell A. Dodge, Jr., BSCE	Hydraulic Research Engineer
Robert E. Kuzmich	Electronic Development Technician
Howard R. Schroeder	Visual Information Specialist
James E. Fay	Hydraulic Engineering Aid
J. P. Ambrusch	Exhibits Technician
Laura Hawthorn	Secretary

Summer Trainees

1958

Robert N. Johnson Engineering Trainee, GS-4 CU

No engineers from university faculties were employed during the summers of 1958 and 1959 as in former years.

No student trainees were assigned to the Hydraulic Laboratory during the summer of 1959.

Rotation Engineers

The following rotation engineers received training in the Hydraulic Laboratory during fiscal year 1959:

Donald Wolfgram	Jimmy J. Straughan
Bernard J. Peter	Darrel Nash
John A. Symonds	Donald R. McKeon
David M. Evans	Donald G. Blunk
Eugene R. Zeigler	Duane Nelson
Stanley S. Larsen	Oscar J. Rohrer
Everett L. Conner	Alden D. Whitmer
Philip F. Enberg	Bruce Blanchard

Recapitulation of Staff Statistics

Date	Permanent employees	Total annual salaries	Temporary employees	Military furlough	Trainees	On detail
1-1-51	47	211,805	--	1	6	--
1-1-52	41	219,035	--	2	1	1
1-1-53	39	219,445	--	1	1	--
1-1-54	30	178,145	--	1	3	--
7-1-54	25	162,170	--	1	--	2
7-1-55	21	127,000	--	2	--	--
7-1-56	20	134,595	*1	2	3+	--
7-1-57	22	153,735	*1	0	3+	1
7-1-58	21	173,505	*2	0	1+	1
7-1-59	20	167,410	--	0	--	--

+Engineering students working during summer months.
*University faculty members employed during summer months.

SECTION IX--TIME AND COST DISTRIBUTION BY CLASSIFICATION OF WORK--SUMMARY FOR FY59

This section consists of four parts, as follows:

(a) Percentage of Labor Distribution for FY59 (July 1, 1958, to June 30, 1959)

(b) Labor and Leave Expenditures--FY59--Hydraulic Laboratory Branch by feature and job number

(c) Engineering Laboratories Division Time Distribution Record for Hydraulic Laboratory FY59

(d) List of Accumulated Shelved Work Items

DIVISION OF ENGINEERING LABORATORIES

(a) Percentage of labor distribution July 1, 1958, through June 30, 1959

Feature	Division office	Conc	Chem	Hydr	Earth	Lab Services	Division Actual	Division Budget	Rate of expend
Bureau Project Work	56.8	58.9	43.7	33.4	51.9	42.5	48.2	44.5	
Outside Agencies	--	1.8	2.1	1.9	2.9	1.1	1.9	2.5	
Foreign Activities	0.8	5.4	2.5	9.2	1.8	3.9	5.8	5.1	
Special Studies	0.1	0.2	11.3	19.6	6.7	2.0	7.0	7.5	
Fabrication Orders	--	0.3	--	--	--	8.8	1.1	0.8	
Network Analyzer	--	0.3	--	--	--	0.1	0.1	0.1	
Direct Charge Total	57.7	70.9	59.6	64.1	63.3	58.4	64.1	60.5	
Employee Benefits and Welfare	--	--	0.1	0.2	--	0.3	0.1	0.1	
Equipment Maintenance	--	2.6	1.1	2.0	2.3	24.4	4.7	6.4	
Building Maintenance and Alteration	--	--	--	0.1	--	0.4	0.1	0.1	
Miscellaneous Admin Expense	1.0	0.3	0.3	0.3	0.3	--	0.3	0.3	
General Operating Expense--Total	1.0	2.9	1.5	2.6	2.6	25.1	5.2	6.9	
Administration	13.7	3.2	2.9	3.4	5.2	2.4	3.7	3.7	
Staff Development	1.3	0.6	0.6	1.5	0.4	--	0.7	0.4	
Meeting and Conferences	9.8	3.4	1.7	4.2	3.0	0.3	3.0	3.6	
Tech Info Service--Denver	2.8	2.5	2.4	1.7	1.2	--	1.9	1.0	
Tech Staff Services--Laboratories	1.5	1.1	2.2	2.6	1.1	0.1	1.5	2.4	
Tech Stds and Procedures	--	0.2	0.3	--	0.2	--	0.2	0.2	
Indirect Engineering Expense--Total	29.1	11.0	10.1	13.4	11.1	2.8	11.0	11.3	

DIVISION OF ENGINEERING LABORATORIES

(a) Percentage of labor distribution July 1, 1958, through June 30, 1959

Feature	Division office	Conc	Chem	Hydr	Earth	Lab Services	Division Actual	Division Budget	Rate of expend
Property Management	--	--	--	--	0.1	--	--	--	---
Manuals & Publications	--	0.1	0.3	--	4.2	--	0.7	0.9	
Tech Information Service--Bureauwide	3.5	0.9	2.1	5.5	1.8	0.2	2.1	2.9	
Technical Studies	0.1	--	--	--	0.3	--	--	0.2	
Laboratory Investigations	8.3	14.3	26.3	13.6	16.3	13.4	16.8	17.4	
Personnel Activities and Services	0.2	--	--	0.8	0.2	--	0.2	0.2	
Bureau-wide expense--Total	12.1	15.3	28.7	19.9	22.9	13.6	19.8	21.6	
General Distributive Expense--Total	24.2	29.2	40.3	35.9	36.6	41.5	36.0	39.8	

(b) LABOR AND ADDITIVE EXPENDITURES—FISCAL YEAR

Hydraulic Laboratory Branch, Cost Center 830. Date of this report June 30, 1959

Feature	Job Number	Labor & additive: Annual budget	Labor & additive: Expended to date	% Spent in 100% of time: Branch	% Spent in 100% of time: Division	Rate of exp
Bureau Project Work		54,350	69,327.55			
Outside Agencies		8,000	3,984.09			
Foreign Activities		11,000	19,129.35			
Fabrication Orders	32-8900-0-					
Special Studies						
Sedimentation	32-8001-0-0-1	19,700	16,717.05			
Weed Control	32-8008-0-0-1					
Water Meas Devices	32-8009-0-0-1	15,000	13,098.01			
LCCL	32-8030-0-0-1	10,850	10,994.50			
		45,550	40,809.56			
Network Analyzer	32-8200-0-0-1					
Employee Benefits and Welfare						
Employee recognition	21-3301-0-0-5	--	339.16			
Civil Defense participation	21-3301-0-0-6					
Equipment Maintenance						
Laboratories	21-3302-0-0-3	3,500	3,958.37			
Auditorium, Building 56	21-3302-0-0-4	275	17.27			
Photoelastic Laboratory	21-3302-0-0-5					
Electric load analyzer	21-3302-0-0-6					
Office equipment repair	21-3302-0-0-7	150	851.48			
		3,925	4,061.12			
Building Maintenance and Alterations	21-3303-0-0-2	300	224.44			
Miscellaneous Admin Expense						
Laboratory and office tours	21-3306-0-0-10	800	622.01			
Office moves	21-3306-0-0-11					
Administration, general	22-4400-0-0-1	7,000	7,017.28			

Cost Center 830
Date of this report June 30, 1959

Feature	Job Number	Labor & additive: Annual budget	Labor & additive: Expended to date	% Spent in 100% of time: Branch	% Spent in 100% of time: Division	Rate of exp
Staff Development						
Student engineer training	22-4401-0-0-1	400	220.55			
Rotation engineer program	22-4401-0-0-2	600	2,906.67			
Engr Utilization Survey	22-4401-0-0-5	--	23.87			
		1,000	3,151.09			
Meeting and Conferences						
Prof & Scientific	22-4403-0-0-1	2,200	1,158.58			
Papers & cooperation	22-4403-0-0-2	5,000	3,882.04			
Gov't and private groups	22-4403-0-0-3	4,300	3,775.67			
		11,500	8,816.29			
Tech Staff Services--Labs	22-4405-0-0-7	5,800	5,030.31			
Exam of existing struct	22-4405-0-0-12	--	432.09			
		5,800	5,462.40			
Tech Info Services--Denver						
Domestic visitors	22-4404-0-0-1	2,100	1,933.20			
Technical inquiries	22-4404-0-0-2		549.81			
Statistical compilations	22-4404-0-0-3		73.02			
Articles & papers	22-4404-0-0-4		326.31			
Engineering monographs	22-4404-0-0-5	1,200	153.88			
Technical memoranda	22-4404-0-0-6	550	284.67			
Other technical publications	22-4404-0-0-7		149.56			
		3,850	3,470.45			
Tech Standards & Procedures						
Standard specifications	22-4406-0-0-2	500	--			
Field Training, Conf & Reviews						
Field engr lab training	23-5500-0-0-1					
Construction engr conf	23-5500-0-0-2					
Safety engineering	23-5500-0-0-3					
Prep of Manuals and Publications						
Reclamation Instructions	23-5501-0-0-1	225	--			
Concrete Manual	23-5501-0-0-2					
Earth Manual	23-5501-0-0-3					
Paint Manual	23-5501-0-0-4	225	48.58			
Water Measurement Manual	23-5501-0-0-5	225	--			
Low Dams Manual	23-5501-0-0-11	675	48.58			

Cost Center 830
Date of this report June 30, 1959

Feature	Job Number	Labor and additive: Annual budget	Labor and additive: Expended to date	% spent in 100% of time: Branch	% spent in 100% of time: Division	Rate of exp
Tech Info Service (Bureauwide)						
Prep & display of exhibits	23-5502-0-0-1	1,100	821.27			
Foreign visitors	23-5502-0-0-2	1,600	1,753.78			
Technical inquiries	23-5502-0-0-3	4,000	3,358.18			
Statistical compilations	23-5502-0-0-4		3,136.51			
Articles & papers	23-5502-0-0-5	4,200	2,306.56			
		10,900	11,376.30			
Tech Studies						
Data analysis--Earth Dams	23-5503-0-0-2					
Laboratory Investigations						
Concrete	23-5504-0-0-1	30	29.43			
Cement and pozzolan	23-5504-0-0-2					
Earth	23-5504-0-0-3		33.70			
Hydraulic	23-5504-0-0-4	27,200	24,621.14			
Structural and materials	23-5504-0-0-5					
Bituminous	23-5504-0-0-6					
Special techniques	23-5504-0-0-7					
Paint and corrosion	23-5504-0-0-8					
Rock foundations	23-5504-0-0-9					
Riprap	23-5504-0-0-10					
Evaporation reduction	23-5504-0-0-11	1,200	1,168.63			
Plastics	23-5504-0-0-13					
Lake Hefner Studies	23-5504-0-0-15	2,000	2,391.85			
		30,430	28,244.75			
Personnel Activities and Services						
Recruitment--College contact	23-5506-0-0-1	1,300	1,256.40			
Board of Examiners	23-5506-0-0-2	450	447.54			
		1,750	1,703.94			
Total		$197,130	$207,788.36			

EL-4
(FEB 56)
BUREAU OF RECLAMATION

DIVISION OF ENGINEERING LABORATORIES

(c) TIME DISTRIBUTION RECORD

BRANCH Hydraulic Laboratory

SECTION

SHEET 1 OF 6
Fiscal Year 1959
DATE C.O.B. June 30, 1959
MONTH YEAR

REF. NO.	JOB NUMBER	PROJECT / FEATURE	SHOPS This FY Used	SHOPS This FY Allo	FISCAL YEAR 1959 BAL. FWD.	FISCAL YEAR 1959 THIS MONTH	FISCAL YEAR 1959 TOTAL	FISCAL YEAR 1959 ALLOCATION ORIG.	FISCAL YEAR 1959 ALLOCATION REV.	TOTAL JOB BAL. FWD.	TOTAL JOB TO DATE	TOTAL JOB ESTIMATE ORIG.	TOTAL JOB ESTIMATE REV.	DURATION MONTH / YEAR START	DURATION ESTM. END	REMARKS
	0-9100-00-01-02	Inspection Bureau Structures (Klamath)					7^{3}									See 22-4405-00-00-12
	1-33-11-01-01	Roza Powerplant Turbine		2			1	1								Complete
	1-113-01-01-01	Prineville Dam, Conf					2^{1}									
338	"	Prineville Spillway & Outlet Works	25^{1}	19^{1}			62^{5}		65		135			1-58		Report issued
	1-113-05-01-01	Diversion Canal, Crooked River P Conf					4									
	1-A162-73-60-15	Canyon Creek Power Canal--Snake Riv P					6									Complete
	1-222-00-76-01	Grand Coulee Dam Modification Rep, CBP					2									Complete
	1-222-03-25-01	Relay Test for Pumping Plant, CBP					2^{4}	12								Complete
	1-R222-22-26-01	P-4 Pump Bearing Failure, Grd Coulee D					2									
321	1-456-01-07-01	Palisades Dam, OW, Hydro Test					8^{3}				181^{3}			7-57		Completed Travel Report
365	"	Palisades Dam OW Losses and Dnpull	7	10			35^{6}	38								
270	1-456-11-01-01	Palisades Penstocks, Hydro Test					0				95			3-55		Hyd report draft comp
	1-566-05-10-01	Emergency Spwy Kennewick Main Canal					1	1								Review complete
341	1-811-01-01-01	Little Wood River Stilling Pool									12^{2}			2-58		Shelved
	1-818-00-02-01	Bridgeport Bar Unit, Chf Joseph P					7^{6}	11								Complete
	1-A866-73-60-10	Smiths Ferry					4	4								
	2-12-03-15-01	Klamath Pump. Pl "D" Testing Units					1^{4}	1^{4}			5					Complete, equip. shipped
	2-214-00-27-01	Delta-Mendota Canal Capacity Tests					11^{6}									
	2-214-05-51-01	Fish Protective Facilities					1^{3}	1^{3}								Complete
	2-214-05-61-02	Delta-Mendota Cap. Tests (Freeboard)					17									
	2-R214-22-59-01	Delta-Mendota Capacity Tests					3^{3}	4								
	2-368-01-01-01	Cachuma Automatic Gates					2^{7}	2^{2}								Complete
	2-416-01-01-01	Trinity Penstock Conference														
	"	Trinity Dam Spillway & OW Conf							110							
299	"	Trinity Spillway	12	9^{7}			82^{4}				635^{1}			4-56		Report in review
	2-416-05-01-02	Geophy Inv--Clear Creek Tunnel					41^{3}		42							Complete
286	2-575-01-01-01	Twitchell Dam OW (Vaquero)					31^{4}		35		255^{7}			12-55		Report in Review
	2-A650-73-40-01	Fresno-Chowchilla, CVP, Geophy Explor					3^{4}				17^{4}					Complete
	2-767-05-04-01	Rincon Facilities, Ventura River Proj					1									Complete
	3-212-00-05-01	Drain Tests--Coachella, Calif					19^{1}									Travel report completed Tests pending on another drain
	3-A788-73-60-03	Redesign Spwy--Marble Canyon Dam					4	4								
347	4-8-02-01-01	Grand Valley Spwy Apron Riprap	5^{4}	5^{4}			19^{6}	19^{6}			23					Ltr report written but not dup or distributed
	4-244-11-01-01	Deer Creek Powerplant					6		6							
	4-482-01-01-01	Vega Dam--Collbran Project					1	1								
	4-482-05-02-01	So Side Canal Tun Conf--Collbran Proj					1^{7}	1^{6}								
	4-482-05-03-01	Bonham Cottonwood Pipeline--Collbran					3		3							
	4-482-11-01-01	Upper Molina Powerplant Conf					5		10							
	"	U M Penstock & Engy Dis--Collbran					5^{3}									
	4-526-05-05-01	West Farmington Trunkline					2	2								
	4-526-05-08-01	Sand Ridge Trunk Line, Davis Aqueduct					1^{2}	1								
	4-526-05-09-01	Shepherd & Farmington Crks--Weber, Davis					1^{4}									

NOTES:

EL-4
(FEB 56)
BUREAU OF RECLAMATION

DIVISION OF ENGINEERING LABORATORIES
TIME DISTRIBUTION RECORD

BRANCH Hydraulic Laboratory
SECTION

SHEET 2 OF 6
Fiscal Year 1959
DATE C.O.B. June 30, 1959 (MONTH / YEAR)

TIME IN MAN DAYS →00⁰← AND HOURS

REF. NO.	JOB NUMBER	PROJECT / FEATURE	SHOPS This FY Used	SHOPS This FY Allo	FISCAL YEAR 1959 BAL. FWD.	FISCAL YEAR 1959 THIS MONTH	FISCAL YEAR 1959 TOTAL	ALLOCATION ORIG.	ALLOCATION REV.	TOTAL JOB BAL. FWD.	TOTAL JOB TO DATE	ESTIMATE ORIG.	ESTIMATE REV.	DURATION START	DURATION ESTM. END	REMARKS
	4-526-06-03-01	West Farmington Lateral--Weber Basin					1^{2}		4^{2}							
	4-526-06-04-01	Woods Cross Trunk Line--Weber Basin					7		2							
	4-526-06-05-01	Ricks Crk Laterals, Davis Aqu, Weber					2		2^{6}							
	4-526-11-01-01	Gateway Powerplant WM--Weber BP					6^{5}									
315	4-G551-01-01-01	Paonia Spillway & OW Model					33^{7}		34		133^{5}			4-57		Report in Duplicating
303	4-557-00-01-01	Upper Colorado River Basin Relief Map	6	6			1									Complete
	4-G557-01-01-01	Glen Canyon Dam & Spwy Conf					7^{2}	5								
	4-G557-01-01-02	Glen Canyon Tunnel & OW Conf					9^{6}	5								
364	"	--Pump Runner Coatings--Sed Eros	4^{2}				1^{4}									
301	"	Glen Canyon Div Tunnel									77^{2}			6-56 -		
319	"	Glen Canyon Tunnel Plug OW	20^{7}	25			27^{2}		82		190			6-57		
343	"	Glen Canyon Control Gates					5^{2}	20			6^{2}			4-58		See Snowy Mtn
	"	G C River OW Conduit Piezometers					5	3								Complete
	"	G C Tunnel Plug Gate Piezometers					9^{4}									Hyd Invest. completed
302	4-G557-01-01-03	Glen Canyon Spillway	12	19^{2}			131^{6}	193			611			6-56		
	4-G557-01-01-07	Glen Canyon Dam, Structural Model					46^{2}				56^{9}					Hyd work complete
	"	Three-Dimensional & Sect. Mod--GCD					2									
345	4-G557-01-05-03	Rainbow Bridge Relief Model	2				38^{7}				49^{3}			6-58		Complete
	4-G557-11-01-01	G C Powerplant--Cavitation Tests					5^{1}									
318	4-G591-01-01-01	Flaming Gorge Spillway	123^{3}	126^{3}			138^{6}		152^{6}		281^{5}			4-57		
	4-G591-01-01-07	Seismological Inv--Flaming Gorge D&R					6	1								Completed (Shpmt not reqd)
	4-G711-01-01-01	Navajo Dam and Res Conf					4									
	"	Navajo Spillway Conf					3^{2}	180								
336	"	Navajo Spillway & Aux OW	82^{6}	82^{2}			119^{1}				193^{3}			12-57		
337	"	Navajo Outlet Works	12	19			46^{5}				84			12-57		
348	5-163-02-03-02	San Acacia Diver. Dam Rehab--MRioG	100^{9}	98			136^{1}		130							
277	5-163-09-05-01	Casa Colorada Channelization	8^{4}	12			149^{6}		158		670^{3}					Report being compiled
	5-825-01-01-01	Twin Buttes Dam Conf					3	10								
367	"	Twin Buttes OW Water Model	15	25			10^{6}	182								
368	"	Twin Buttes OW Air Model					2									
	5-830-01-02-01	Foss Dam, Washita Proj, Okla--Conf					1							1-58		Report being compiled
340	"	Foss Outlet Stilling Basin					28^{1}		31^{2}		102^{7}					
	6-R14-22-01-01	Thomas Point Pmp P--Lower Yellowstone	P				16^{7}									Comp. Trav rep issued
261	6-R15-22-01-01	Sherburne Lakes Dam					15^{9}		16^{4}							Report in Duplicating
	6-26-01-01-01	Buffalo Bill Dam OW					5^{3}		6							Complete
360	6-276-01-01-01	Shadehill Dam OW Still. Basin	59	65			61^{6}		69							
	6-339-01-01-01	Anchor Dam, MRB					4		2^{4}							Complete
	6-605-03-04-01	Bluff Pumping Plant No. 1					1		1							Complete
	7-271-00-04-01	Ponding Tests--Franklin Canal					11									Comp TR Oct. 27, 1958 Memo to LCCL Comm 2-27-59
	7-271-00-05-01	Bostwick Division Equip. req					9	5								
	7-328-05-08-01	Culbertson Canal--MRBP					4	1								Complete
	7-328-05-11-01	Meeker Canal-Seepage Meters, Shpmt	4								4			6-58		Complete

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REF. NO.	JOB NUMBER	PROJECT / FEATURE	SHOPS This FY Used	SHOPS This FY Allo	FISCAL YEAR 1959 BAL. FWD.	FISCAL YEAR 1959 THIS MONTH	FISCAL YEAR 1959 TOTAL	FISCAL YEAR 1959 ALLOCATION ORIG.	FISCAL YEAR 1959 ALLOCATION REV.	TOTAL JOB BAL. FWD.	TOTAL JOB TO DATE	TOTAL JOB ESTIMATE ORIG.	TOTAL JOB ESTIMATE REV.	DURATION MONTH / YEAR START	DURATION MONTH / YEAR ESTM. END	REMARKS
	7-449-01-01-01	Glendo OW, Conf					18		18							
346	"	Glendo OW Proto Still. Basin (FT)					9^{4}									Complete
350	"	Glendo OW Stilling Basin Model	63^{5}	60			75^{1}		71^{5}							Interim report issued
	7-449-01-02-01	Gray Reef Dam--Glendo Unit, Oregon					1^{5}		1^{4}							
282	7-449-11-01-02	Glendo Hydrostatic Tests									152^{6}			3-55		Hyd report draft comp
	7-449-11-02-01	Fremont Canyon Tun (Piez Install.)					2	2								Complete
	"	Freemont Powerplant					$\underline{5}$	1								
314	7-468-02-01-01	Woodston Headworks & Sluiceway					17^{8}		25		128^{4}			2-57		Report in review Drawings being traced
362	7-707-01-01-01	Sherman OW Still. Basin	15	15			34^{5}	15								
	7-719-01-01-01	Merritt Dam OW Conf, Snake River							6							
363	"	Merritt Dam OW Still. Basin	37^{2}	40^{8}			3^{2}		9							
	7-A758-73-60-04	O'Neill Canal, Section 2					$\underline{2}$									Complete
	9-R000-31-10-10	Canal Logging					6^{2}	6								
361	9-800-00-01-01	Electrodialysis Res & Dev--Saline Wat					112^{7}	200								
361	9-800-00-01-06	Electrodialysis Res & Dev--Cells					0									Not used until FY60
		OUTSIDE AGENCIES														
280	11-6207-00-02-01	--Bur of Fed Supply--Matl & Parts Test									28^{4}					Shelved
	11-6215-00-01-01	--Bur of Mines Coal Test. Instru Repair					$\underline{4}$									Complete
349	11-6222-00-02-01	--Antiblast Valves, FCDA	51^{2}	52^{3}			96^{4}		85							Report issued
344	11-6243-00-03-01	--Fish & WL--So Platte Channel Studies					1^{4}	66^{2}			35^{3}			5-58		Shelved
	OUTSIDE AGENCIES	TOTALS					98^{4}									
		FOREIGN ACTIVITIES (12, 13- & 14-)														
	12-6195-00-72-01	--Foreign Trainees--Special funds					12^{7}									
	12-6195-00-73-01	--Foreign Observers--Special funds					6^{4}									
	13-6195-00-92-01	--Trainees--Japan, India					38^{4}									
	13-6301-00-01-03	--Snowy Mtn--Australia Trainees					56	59^{5}								
	13-6301-00-01-05	--General Technical Services					6^{7}									
	13-6301-00-01-09	--Australian Observer					1									
	13-6301-02-02-01	--T-2 Diversion Dam--Q curves					7^{2}	6						4-58		Also see Glen Canyon
343	13-6301-05-06-01	--Tooma-Tumut, Control Gates					4^{6}	23						4-58		Also see Glen Canyon
343	13-6301-05-06-03	--Tooma-Tumut, Control Gates					2^{6}	14^{2}						4-58		Also see Glen Canyon
	13-6301-05-07-01	--Murrum-Eucumbene Diversion (Conf)					0									
317	"	--Murrumbidgee-Eucumb Intake Control					24	26			189^{2}			4-57		See 13-6301-05-07-02
317	13-6301-05-07-02	--Murrumbidgee-Eucumbene Tunnel etc					1	1						4-57		Complete
	13-6301-05-08-02	--Island Bend Intake (Conf)					4^{7}									
343	"	--Island Bend Control Gates	64^{7}	64^{7}			33^{4}	33^{4}			37					
343	13-6301-05-08-07	--Island Bend Intake Structure (mod)	68^{2}	80^{2}			67^{4}		61					4-58		Also see Glen Canyon
	13-6301-20-01-19	--Australian Detail--Ball					4		10^{4}							Travel Report Completed
	13-6305-00-02-04	--Engineering Consultants, Inc--YanHee					1^{7}									

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REF. NO.	JOB NUMBER	PROJECT / FEATURE	SHOPS This FY Used	SHOPS This FY Allo	FISCAL YEAR 1959 BAL. FWD.	FISCAL YEAR 1959 THIS MONTH	FISCAL YEAR 1959 TOTAL	ALLOCATION ORIG.	ALLOCATION REV.	TOTAL JOB BAL. FWD.	TOTAL JOB TO DATE	ESTIMATE ORIG.	ESTIMATE REV.	DURATION START	DURATION ESTM. END	REMARKS
		FOREIGN ACTIVITIES, cont'd														
	14-6195-00-22-01	--Foreign Trainees					129^{3}									
	14-6195-00-23-01	--Foreign Observers					11^{3}									
	14-6195-20-00-01	--General Technical Services					5									
	14-6195-20-21-01	--Backstop--Gen Tech Info--Turkey					10^{2}									
	14-6195-28-01-01	--Foreign Observers--Konya P--India					1									
	FOREIGN ACTIVITIES TOTALS						430^{2}									
	21-3301-00-00-05	BENEFITS & WELFARE--Employee Recog					6^{1}									
	21-3302-00-00-03	EQUIP. MAINT--Laboratories	95^{9}				108^{6}	85								
	21-3302-00-00-04	--Auditorium sound system					2^{2}	6^{8}								
	21-3302-00-00-07	--Office equipment repair					2^{4}	3^{4}								
	21-3303-00-00-02	BLDG MAINT & ALTERATIONS--Bldg 56					6^{4}									
	21-3306-00-00-10	MISC ADMIN EXP--Lab & Office Tours					17^{1}	19								
	22-4400-00-00-01	ADMINISTRATIVE					112	108								
	"	United Fund Campaign D O					2									Complete
	22-4401-00-00-01	STAFF DEVELOP--Student Engr Training					10^{7}	1^{6}								
	22-4401-00-00-02	--Rotation Engr Training					76^{3}	6								
	22-4401-00-00-05	--Personnel														
	22-4403-00-00-01	MTGS & CONF--Prof & Scientific					22	40								
	22-4403-00-00-02	--Papers & Coop. (non-attend)					10^{1}	111								
	22-4403-00-00-03	--Civic, Govt, & private groups					83^{1}	95^{9}								
	22-4404-00-00-01	TECH INFO, Denver--Domestic Visitors					48^{5}	51								
	22-4404-00-00-02	--Technical Inquiries					13^{3}									
	22-4404-00-00-03	--Statistical--Compilations					1^{4}									
	22-4404-00-00-04	--Articles & Papers (except Mtgs)					8^{4}									
	22-4404-00-00-05	--Engineering Monographs					3^{9}	44								
	22-4404-00-00-06	--Technical Memoranda					6^{3}	11								
	22-4404-00-00-07	--Other Technical Publications					3^{2}									
	22-4405-00-00-07	TECH STAFF SERV--Laboratories					130^{7}	116								
	22-4405-00-00-12	--Examination of Operating Projects					1^{1}									Was 0-9100-0-1-2
	22-4406-00-00-01	TECH STDS & PROCED--Std design & dwgs					0									
	22-4406-00-00-02	--Standard Specs					0	10								
	23-5500-00-00-01	FIELD TRAINING--Fld Engr Lab Training					0									
	23-5500-00-00-02	--Const Engr Conf					0	3								

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	23-5501-00-00-01	MANUALS & PUBL--Recl Instructions					0	4^{4}								
	23-5501-00-00-05	--Water Meas Manual					7	4^{4}								
	23-5501-00-00-06	--Hyd & Excavation Tables					0									
	23-5501-00-00-07	--Design Standards					0	4^{4}								
	23-5501-00-00-11	--Low Dams Manual					0									
	23-5502-00-00-01	TECH INFO, Bwide--Prep & Disp Exhibits	1				26^{2}	24^{3}								
	23-5502-00-00-02	--Foreign Visitors					38^{1}	35^{7}								
	23-5502-00-00-03	--Technical Inquiries					77	80								
	23-5502-00-00-04	--Statistical Compilations					78									
	23-5502-00-00-05	--Articles and Papers					57^{1}	93								
	23-5504-00-00-04	LAB INVEST.--Hydraulic Item No.														
226	"	--General	137^{6}				56^{2}	0						7-53		
218	"	--Hyd Jump & Energy Dissipators 2	38^{6}				278^{3}	53						7-53		
219	"	--Siphon Spillways 3	7^{4}				22^{3}	36						7-53		
220	"	--Canals, Small Structures 4					1^{4}	49						7-53		
251	"	--Pipe Exit & Ent Trans	57^{2}				24^{7}	50						5-54		
221	"	--Pipeline Distribution System 5					23^{4}	16^{4}						7-53		
309	"	--Cond & Penstock Br--Cav & Hd 6					15^{3}	26^{4}						7-56		
191	"	--Gates, Downpull 8					20^{1}	16^{4}						1-47		
255	"	--Gate Slots 10	15^{7}				18^{1}	63						7-54		
225	"	--Instrumentation for Hyd Data 11	11^{3}				80^{5}	41						7-53		
359	"	--Riprap Sizes 13						16^{4}								
310	"	--Friction--Large Conduit 14					29^{3}	25						7-56		Report in progress
322	"	--Conc Surface Irregularities 15	14				19^{6}	82						7-57		
323	"	--Side Channel Spillways 16						1^{4}								
324	"	--Air Req Tunnel Controls 17					1^{4}	1^{4}								
325	"	--Radial Gate Coef 18					50^{1}	33						7-57		
326	"	--Morning-glory Spwy 19	9^{4}				5^{5}	33								
	HYDRAULIC LAB INVESTIGATIONS TOTALS		292	157			647^{4}	544								
358	23-5504-00-00-15	EVAPORATION SUPPRESSION--Lake Hefner					81^{3}									Travel Reports issued
	23-5506-00-00-01	PERSNL ACT. & SERV--Recruit, Col Cntct					20									
	23-5506-00-00-02	--Central Bd Civil Serv Examiner					9^{3}									
	28-4100-00-00-01	LEAVE--Annual					491^{3}									
	28-4100-00-00-02	--Sick					178^{5}									
	28-4100-00-00-03	--Holiday					0									
	28-4100-00-00-04	--Military					49									
	28-4100-00-00-05	--Court					1									
	28-4100-00-00-06	--Administrative					^{4}									
	28-4100-00-00-07	--Civil Defense					0									

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177	32-8001-00-00-01	SEDIMENTATION--General	9^{3}				75	0								
306	"	--Sediment removal structures					96^{1}	97^{4}						7-56		
36	"	--Stable channel shapes					50^{4}	29^{3}						11-49		
331	"	--Curved Channel Sections					2	68^{2}						7-57		
330	"	--Channelization & bank protection					29^{3}	39						7-57		
342	"	--Weed Control by sediment shading	2^{4}	2^{4}			76^{4}	23^{4}						2-58		Progress report reviewed
	"	--Cohesive Matl eros, Drains & Wastwys						68^{2}						7-58		Progress report drafted
247	"	--Waves in canals, Protect. cover	12^{4}				110^{5}	68^{2}						3-54		See also 8030 below
	SEDIMENTATION TOTALS		24^{3}	86			440^{1}	394								
184	32-8009-00-00-01	WATER MEAS DEVICE--General	2				56^{6}	0								
320	"	--Constant-head orifice turnout					97	75						6-57		
332	"	--Critical depth meas device					5^{5}	19						7-57		
334	"	--Design data tables					2^{6}	25						7-57		
351	"	--Weirs, Velocity of approach					20^{4}	31						7-58		
352	"	--Turnout Gates					39^{6}	11						3-50		
353	"	--Compound Weirs	^{4}				19^{6}	13								
354	"	--Adjustable Weirs					59^{3}	11								
355	"	--School for Field Personnel					3^{2}		39							
356	"	--Bibliograph & Classify File					1	13								
357	"	--Very Low Flow Meas					10^{3}	13								
366	"	--Navy Log Meter					34^{3}	50								
	WATER MEASUREMENT TOTALS		2^{4}	28^{5}			350^{4}		300							
152	32-8030-00-00-01	LCCL--General	6^{2}				27^{5}	25								
308	"	--Qtr & annual reports					1^{5}							7-57		
290	"	--Erosion & tractive force					48^{7}	53						7-55		
247	"	--Waves in canals, Protect. cover					69		69					3-54		See also 8001 above
307	"	--Permeability & seepage	1				62^{4}	66						7-56		
328	"	--Earth-chem stabilization, (SS-13)	12				86		87					7-57		Hyd-453 drafted & reviewed
329	"	--Review canal lining report					5^{4}							7-57		
	LOWER-COST CANAL LINING TOTALS		19^{2}	5^{6}			301^{1}		300							

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2		Seepage Meter, Development of							49			1-47		(1)
7		Water Meas, Device Devel & Std							285			1-48		(19)
21		Spillway jet insufflation, Gr Coulee Dam, CBP							16	40		7-49		Hyd-368 to be written
22		Air demand studies, river outlets, Gr Coulee							35	60		7-49		
25		Spillway and diversion scheme, Davis Dam, DDP							17	107		8-49		Hyd-346 to be written
35		Calibration of 8-in. Sparling deflection meter							26	35		11-49		
40		Salinity Meters, Sacramento-San Joaquin Delta							8	15		1-49		
41		Vortex Tube Desilting Apparatus							54			1-50		
49		Spillway velocities, Shasta Dam, CVP							16	30		6-50		
52		Weir stands, Exeter & Saucelito Irr Dists, CVP							223	285		11-50		(6)
55		Yellowtail Spill. & Outlet Wks							1130			11-50		(611)
59		Spillway data, Falcon Dam, IB&WC							28	55		1-51		
63		Velocity distribu, Sparling deflection meter							67	80		2-51		
75		Stream-gaging devices (in coop. with USGS)							110	200		6-51		
76		Pump flow indicator, Tracy Pumping Plant, CVP							63	73		7-51		
77		Frequency response of pressure cells							23	40		7-51		Tests completed 3-53
80		Radio Report. Rain Gage, CVP							665			11-49		(112)
86		Sparling meter, Mohawk Canal turnouts							370	362		9-51		(11)
88		Calibration of 12-inch Sparling line meter							2	20		10-51		
89		Calibration of 8-inch Sparling line meter							2	20		10-51		
90		Calibration of 12-inch Spar. Deflection meter							1	20		10-51		
110		Sediment sampling, Cambridge Diver. Dam, MRBP							156	185		12-51		(16) Tests comp. 11-52
111		Sedimentation, Desilting Works, Data							45			1-49		
115		Kirwin Dam Spillway							293			2-52		(125)
125		Negative-pressure crest studies							38	54		12-51		
139		Spillway, river outlets & powerplant, Shasta Dam							0	100		1939		
140		Gila Pumping Plant flap gates, Gila Project							2	52		2-52		
141		Pump discharge siphon elbow, Grand Coulee, CBP							7	40		3-48		
143		Hyd characteristics, Shasta river outlets, lower							0	30		7-49		
151		Resloping tailraces & river channel, Gr Coulee							7	32		1945		
160		Spillways, Spreading of Jets							13			4-52		
180		Flow characteristics, Sparling open-flow meter							21	66		7-52		
198		LCCL, Prefab. Lining Tests							39			1-53		(22)
222		Gates & Valves, Air Demand							36			7-53		(1)
223		Cavitation Eros. Rough Surfaces							30			7-53		
224		Chem & Pressure disch meas in large conduits							148	254		7-53		(2)
240		Vertical Stilling Wells							32			7-53		
241		Red Bluff spillway model studies, CVP							14	18		11-53		Memo rpt to be written
270		Palisades Penstocks, Hydro Test							95			3-55		Hyd report draft comp.
273		Heated Precipitation Gage, Eklutna							27			2-55		(50)
279		Sedimentation, Flocculating Agents (Separan)							59			7-55		

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NOTES: Bracketed Nos. in Remarks Col. show Shop time.

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280		GSA Valve Acceptance Tests							32			8-55		
282		Glendo Hydrostatic Tests							152			3-55		Hyd report draft comp.
288		Baffled Apron, Energy Dissipators							28			7-55		(2)
296		Cippoletti Weir, Gage Position							6			4-56		(4)
305		Evaluation of Sediment Linings, LCCL							66			7-56		
321		Palisades Dam, OW, Hydro Test							181			7-57		
327		Asphalt Lining and Soil Stabilization, LCCL										1958		
341		Little Wood River, Stilling Pool							12	11		2-58		
344		So Platte River Channel Studies, Fish & Wildlife							35			5-58		

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SECTION X--BUDGET ESTIMATES, FY60

Labor plus additive expenditures

Feature	Job Number	Amount
Bureau Project Work		68,255
Outside Agencies		5,000
Foreign Activities		16,000
Fabrication Orders	32-8900-0-	200
Employee Benefits & Welfare		
Employee recognition	21-3301-0-0-5	200
Equipment Maintenance		
Laboratories	21-3302-0-0-3	3,500
Auditorium sound system	-4	50
Miscellaneous Adm Expense		
Laboratory & office tours	21-3306-0-0-10	700
Administration--general	22-4400-0-0-1	8,000
Staff Development		
Rotation engineer training	22-4401-0-0-2	1,250
Professional, Interagency & other cooperation		
Attendance at meetings	22-4403-0-0-1	1,200
Technical Papers	-2	2,250
Federal, state, and civic groups	-3	1,750
Technical group participation	-4	2,000
Technical Info Service--Denver		
Domestic visitors	22-4404-0-0-1	2,200
Technical inquiries	-2	2,100
Statistical compilations	-3	300
Articles and papers	-4	2,100
Engineering monographs	-5	700
Technical memoranda	-6	1,000
Technical Staff Services--Labs		
Laboratories Division	22-4405-0-0-7	5,600
Examination of existing structures	-12	300
Preparation of Manuals & Publications		
Water Measurement Manual	23-5501-0-0-1	125

Feature	Job Number	Amount
Technical Info Service (Project Service)		
Preparation and display of exhibits	23-5502-0-0-1	1,000
Foreign visitors	-2	1,750
Technical inquiries	-3	2,000
Statistical compilations	-4	800
Articles and papers	-5	2,800
Laboratory Investigations		
Hydraulic	23-5504-0-0-4	30,500
Evaporation-reduction	-11	300
Sedimentation Studies	-16	18,700
Water measuring devices	-18	12,700
Lower cost canal lining	-19	12,470
Personnel Activities & Services		
Board of examiners	23-5506-0-0-2	1,200
TOTAL		209,000