HYDRAULIC LABORATORY SUMMARY REPORT FISCAL YEAR 1961

BUREAU OF RECLAMATION
ENGINEERING LABORATORIES
DENVER, COLORADO

Of course, the researcher would still have the work of secondary searching, followed by plenty of good solid study of primary sources, just as he now has. As we go about this task, the only solace we will ever have is that it could be much more difficult. Sir Lawrence Bragg expresses the idea with English candour: "I confess sometimes to having a feeling of despair when I see the library tabls groaning under all the periodicals and journals, a doubt as to whether it really is all worthwhile, and I expect many may well have the same feeling. We ought perhaps to take comfort from the prodigality of nature which showers such masses of papery seeds from the elm each year, and reflect what a small portion of these will ever become young trees. So many of these papers will fall on stony ground, so few will be absorbed into the growing body of science. Here we must recognize, it seems to me, that the solution for successful assimilation does not lie alone in better systems of abstracts, valuable though such schemes are. It lies in that faithful body of devoted workers who read and digest the stupendous mass of literature, and use their judgment to discard what is unimportant and present us with reports, reviews, and summaries which indicate what is valuable in a clear way. It is a tremendous task, like that of extracting the gold from the quarts reefs of the Rand * * *."

---

*The Trend In Engineering, October 1960

CONTENTS

CONTENTS---Continued

HYDRAULIC LABORATORY
Division of Engineering Laboratories
Office of Assistant Commissioner and Chief Engineer
Denver, Colorado

SECTION I--INTRODUCTION

General

The staff of the Hydraulic Laboratory witnessed an increase in the number of design studies for new projects, an emphasis on research conducted with nonreimbursable funds and an increase in staff duty for special activities of the Engineering Laboratories Division. Technical aspects of the work required ever wider reading of current literature in the field of hydraulics and correspondence with authorities in fluid mechanics by all members of the staff. Improvement of instrumentation for observation and recording of transient hydraulic phenomena continued.

Eight major research reports and eleven reports on design studies were published during the year.

The challenging canal capacity study was pursued with increased effort through field tests and laboratory research.

The laboratory was host to a meeting of Hydraulic Research Engineers of the Corps of Engineers, Tennessee Valley Authority, U.S. Navy David Taylor Model Basin, and the Bureau of Reclamation for discussions of methods of improving hydraulic investigations and data analyses through an exchange of ideas and information. The meeting was the third of a series started by the Corps of Engineers in 1956. The conference was considered timely and beneficial by the participants. Seventeen engineers from the other agencies attended.

One of the most important special assignments of the year, was that of assisting the Planning Committee for the Symposium on Basic Research in Civil Engineering Fields Related to Water Resources, held at Fort Collins, Colorado, June 12 to 15, 1961. J.W. Ball, as alternate member of the Planning Committee contributed significantly in coordinating the arrangements for the Symposium. The Chief of the Hydraulic Laboratory participated in the 4-day Symposium as a member of the panel on "Hydraulics of Water Conveyances;" E. J. Carlson contributed to the panel on "Fluvial Hydraulics."

Twelve hydraulic research projects were prepared as proposals for performance in foreign countries under the Special Foreign Currency Program budgeted for FY62. Five projects would be conducted in

Yugoslavia, two in Poland, two in Israel, one in Egypt, one in Pakistan, and one in both India and Pakistan. Foreign currency research was disallowed in FY61 program. Coordination of preparation of research projects for the entire division was handled by the Head, Hydraulic Structures and Equipment Section.

The Chief of the Hydraulic Laboratory attended a Symposium on Basic Science in France and United States at New York University, October 17-19, 1960. The Symposium, limited to about 150 persons from university, Government, and industrial laboratories, was held to provide an exchange of information among scientists and engineers in several diverse fields, including hydraulics. It was underwritten by the Sloan Foundation with the cooperation of the French Government.

Assistance was rendered the Iowa Institute of Hydraulic Research in its NSF Project of making a series of 16 mm, color and sound films to be used as visual aids in explaining and teaching hydraulics and fluid mechanics to engineering students. Several hundred feet of film was taken of the hydraulic action of water flowing through representative Bureau structure models to demonstrate the many types of flow encountered in the dam fields. The photography was performed by Iowa University personnel.

Forty-seven Hydraulic Laboratory studies of the Bureau of Reclamation were reported to the National Bureau of Standards for publication in the 1961 Edition of the annual "Hydraulic Research in the United States" which will be a guide to projects conducted by various hydraulic laboratories in the United States and Canada.

Under the auspices of the Hydraulic Division, ASCE and the Engineers Joint Council, Mr. J. B. Schijf, Chief Engineer and Director of Water Resources Development and Hydraulic Research, Rijkswaterstaat, The Hague, Netherlands, presented a lecture to Bureau engineers on "Salinity Problems in Tidal Estuaries and Harbors," April 11, 1961. Mr. Schijf visited the Hydraulic Laboratory and discussed a number of hydraulic topics with the staff.

An unprecendented number (30) of rotation training engineers were assigned to the Hydraulic Laboratory, each for a 3-month period during the year. These assignments were made mainly at the request of career advisors in the Division of Design, since it is felt that training in the Hydraulic Laboratory is helpful to trainees later in their design experience. The large number of such assignments created budget problems and sometimes taxed the ability to provide proper supervision. The latter problem will undoubtedly be alleviated with the return of four rotation engineers to full-time service in the Hydraulic Laboratory.

James W. Ball and Charles W. Thomas completed 30 years' service during the year and were given service pins by Assistant Commissioner and Chief Engineer Grant Bloodgood. Mr. Ball's entire service has been in the Hydraulic Laboratory. Mr. Thomas' service in the Laboratory was interrupted by over 5 years of military service. E. J. Carlson and G. L. Beichley completed 20 years' service. A. J. Peterka completed a 2-year assignment as Assistant to the Board of Civil Service Examiners in examining applications for engineering and subprofessional positions. Glen L. Beichley continued as Director, Denver Reclamation Employees Association.

Six members of the staff, W. E. Wagner; H. M. Martin; C. W. Thomas; P. F. Enger; Donald Colgate; and T. J. Rhone were invited through letters to the Assistant Commissioner and Chief Engineer to prepare and present papers in specific hydraulic research topics at national and international hydraulic meetings and conferences.

A record of papers, discussions and publications is found in Section VI of this report which also lists other professional attainments and affiliations. Professional writings have contributed significantly to the engineering profession and credit to the Bureau.

The Branch Chief visited eight colleges and universities to present lectures to various types of student bodies such as ASCE student chapters, and graduate seminars. Schools visited were: Iowa State, Michigan State, Michigan School of Mining and Technology, State University of Iowa, Georgia Institute of Technology, University of South Carolina, the Citadel, and Clemson College.

The Laboratory was honored on the election of Alvin J. Peterka to full membership in the Colorado University Chapter of the Society of the Sigma Xi, national society devoted to the promotion of research in science.

Among the significant developments in the staff was the addition of four young hydraulic research engineers to the regular staff; Henry T. Falvey who received his BS in civil engineering at Georgia Institute of Technology, and his MS at California Institute of Technology; Danny L. King who graduated with a BS in civil engineering at University of Idaho; David R. Basco and James M. Bergmann both of whom graduated from the University of Wisconsin with the BSCE degree. All entered the rotation training program the summer of 1960 and will return to the Hydraulic Laboratory for full-time service in mid 1961.

C. W. Thomas transferred to the United Nations for assignment to the Water Resources Planning Commission, 2 East Ningpo Street,

Taipei, Taiwan, China, April 16, 1961, for a 1-year period. He is serving on an international 8-man team studying the island's water resources.

Revision of the Water Measurement Manual was started. The supply of the first edition, published in 1953, is nearly exhausted. The second edition will include additional information derived from laboratory and field studies completed in recent years.

Favorable progress was made in classifying electrical and mechanical instrumentation. Excess and obsolete instruments, components and parts obtained from war surplus were transferred to the Property Branch for disposition. In the interest of maximum efficiency a plan of replacing old equipment with new and more effective instruments has been started.

In addition to the meeting on Hydraulic Laboratory Techniques, two 1-hour seminars were held within the Branch: (1) Safety; and (2) Canal Capacity Studies.

Facility Requirements

The Hydraulic Laboratory has made favorable advances in the instrumentation used in experimental work; plans are developed for further improvement of observation and recording of transient hydraulic phenomena. Two important aspects of the laboratory facilities require improvement and advancement: (1) office space rearrangement for optimum efficiency and (2) acquisition of a desk-type digital computer for day-to-day data processing.

SECTION II--STUDIES FOR BUREAU PROJECTS

The Hydraulic Laboratory staff was requested to solve hydraulic problems of complex nature. Many were studied by hydraulic models; others were solved by analysis supported by data available in the laboratory files.

In addition to the regular Hydraulic Laboratory reports, papers and publications issued this year, over 400 pages of notes on daily occurrences were dictated by the staff as a record of the activities throughout the year. These notes are on file in the Division office, as well as in the Branch and Sections.

The major studies described in this section are:

Fontenelle Dam Spillway
Fontenelle Dam Outlet Works
Yellowtail Dam Spillway
Yellowtail Dam Outlet Works
Whiskeytown Dam Spillway
Fish collecting facilities, Tracy Pumping Plant
Willard Canal Pumping Plant No. 1
San Acacia Diversion Dam
Twin Buttes Dam
El Dorado Distribution System
Green Springs Powerplant
Glen Canyon Dam Diversion
Glen Canyon Dam Tunnel Plug Outlet Works and Flip Bucket
Eklutna Tunnel
Figarden Reservoir Beaching Studies
Trinity Dam Jet Flow Gate
Central Valley Project Canal Capacity Studies
East Bench Canal, Missouri River Project, Montana
Sediment Tests on Prototype Diversion Dams, Nebraska and Kansas

Fontenelle Dam Spillway

The hydraulic model (Scale 1:30) investigations of the Fontenelle Dam Spillway indicated that the structure operated satisfactorily for discharge up to 15,000 second-feet, but for the maximum discharge of 20,000 second-feet there was some asymmetry in the flow in the spillway. The tests showed that this asymmetry could be relieved by placing a deflector wall along the floor of the spillway and streamlining the side piers at the entrance to the chute, Figure 1. However, it was decided that, due to the infrequency of operation at flows greater than 15,000 second-feet, the cost of the deflector wall could not be justified. Instead of correcting the asymmetry, which caused a concentration of flow along the right

A. Overall view of Fontenelle Dam spillway 1:30 scale model. Discharge = 20,000 cfs.

B. Closeup of flow in Fontenelle Dam spillway. U-shape spillway showing submergence and flow concentration on right side. Discharge = 20,000 cfs.

Figure 1. Fontenelle Dam spillway model studies.

wall, an 18-inch wide overhang was placed along the top of the chute walls. Water tending to overtop the walls was thereby effectively contained in the chute. The solution was satisfactory and economical. Pressure measurements, made on the downstream face of the eyebrow cover for the underdrain portal on the spillway chute, indicated that severe subatmospheric pressures might occur at discharges greater than 10,000 second-feet. It was recommended that an air vent be provided to alleviate this condition.

Dynamic pressure measurements on the stilling basin training walls were obtained with pressure cells and the 6-channel Sanborn recorder. These measurements show simultaneous pressure fluctuations at six locations either vertically or longitudinally along the wall or at similar locations on the walls on each side of the basin. The pressures obtained will be used to aid in the structural design of the stilling basin walls. Discharge capacity calibration tests on the spillway showed that the maximum discharge can be obtained at reservoir elevation 6512.9, the same as used for design purposes. Tests made for different possible approach depths showed that a 2-foot greater depth reduced the required reservoir elevations to 6512.8. Riprap placed over the excavated approach had little if any effect on the maximum reservoir elevation.

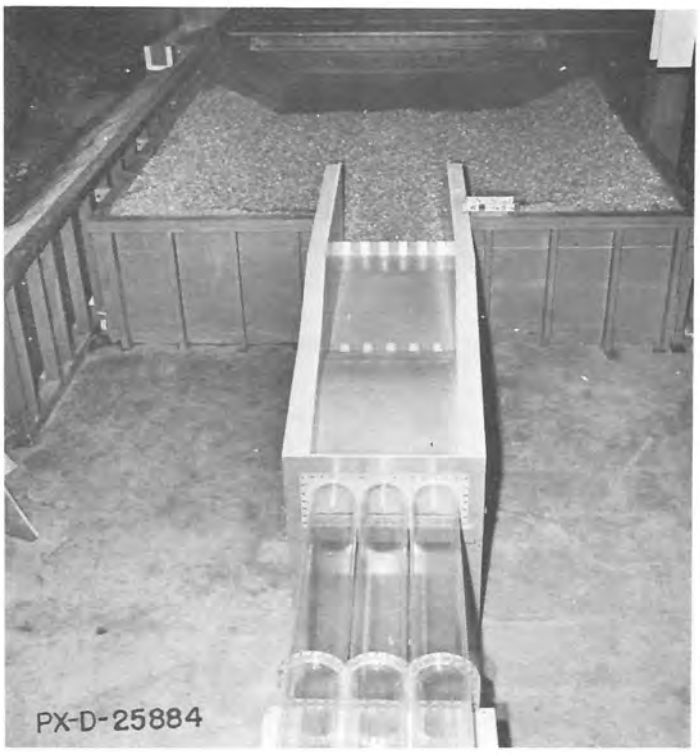
Tests on the stilling basin, patterned after the laboratory-developed "Basin II," showed that it would perform satisfactorily over the entire expected range of discharges and tailwater elevation. These tests also demonstrated that in placing the riprap downstream from the stilling basin, the larger material should be reserved for use on the right bank.

Fontenelle Dam Outlet Works

Tests on the 1:24.7 scale model of the outlet works (Type Basin II) stilling basin, were made to determine the adequacy of the basin for unsymmetrical operation, and to evaluate the riprap protection in the channel downstream from the stilling basin.

The stilling basin performance was excellent for both high and low tailwater conditions with all three conduits operating, with the center and either outside conduit operating, and with the center conduit only operating. Figure 2 shows the flow appearance when the three conduits are operating at the maximum discharge. With only one outside conduit operating the stilling basin, performance was satisfactory at the low tailwater elevation; however, at the high tailwater elevation, the performance was poor. The jet did not penetrate the water surface but produced large surface waves which overtopped the basin sidewalls. The waves are reduced in size before they enter the downstream channel, however, and do not cause any excessive erosion of the sideslopes.

A. Flow appearance with three conduits operating at 19,000 second-feet maximum discharge.



B. Riprap protection in channel below stilling basin.

Figure 2. Hydraulic studies of Fontenelle Dam outlet-works stilling basin, 1:24.7 scale.

Riprap evaluation tests were made to determine whether the 12- to 15-inch nominal size rocks available at the damsite would be adequate, or whether larger riprap would have to be transported from a source 80 miles from the damsite. In the model, the 12- to 15-inch riprap was represented by 1/4-and 3/8-inch gravel, Figure 2. Tests at the maximum discharge with high and low tailwater conditions indicated that the 12- to 15-inch riprap would provide adequate channel bank protection.

Yellowtail Dam Spillway

Two hydraulic models were required to solve the many problems on this project, a spillway model and an outlet works model. The spillway model, constructed to a scale of 1:50 included the spillway crest structure and adjacent reservoir area, the inclined spillway tunnel, the vertical bend, 750 feet of horizontal tunnel, the combination spillway stilling basin and flip bucket, the outlet works stilling basin, the powerplant draft tube outlets, and a 3,000-foot length of river channel downstream from the powerplant. The outlet works model was a larger and more accurate version of the structure contained in the spillway model.

The preliminary spillway stilling basin was found to be longer than necessary for the design flow of 12,000 cubic feet per second. Therefore, the basin was shortened approximately 80 feet. Numerous combinations of basin length, depth and end sill configuration were tested: (1) to maintain the hydraulic jump in the basin for flows up to 12,000 cubic feet per second, and (2) to direct a smooth-arched jet out of the basin for flows ranging from 12,000 cubic feet per second to 92,000 cubic feet per second.

Pressures along the tunnel invert vertical curve joining the upstream end of the spillway basin were measured and found to be more than 20 feet of water below atmospheric pressure for flows near maximum. A revised vertical curve was, therefore, developed to eliminate excessive subatmospheric pressures which would, in the prototype, result in cavitation and possible structure damage.

The revised trajectory was designed for a velocity of 160 feet per second, which was the maximum measured velocity in the velocity profile at the upstream end of the curve. Subatmospheric pressures along the invert of this trajectory curve do not exceed 5 feet of water, and this occurs only for the design flow of 92,000 cubic feet per second.

The outlet works, powerplant, and spillway portions of the model were used to determine tailwater elevations, including surges and drawdown, in the powerplant afterbay area. Drawdown occurs when

the spillway is operating and, by ejector action, lowers the tailwater upstream from the spillway jet.

Flow over the spillway crest, through the tunnel transition, the inclined tunnel, the vertical bend, and the horizontal tunnel was satisfactory. Subatmospheric pressures recorded in the tunnel did not exceed 5 feet of water, and flow throughout the tunnel was smooth and uniform. The spillway crest shape was found to be satisfactory for all discharges and no significant subatmospheric pressures were found, even for small gate openings and highheads. The approach channel, Figure 3B, was found to be wider than necessary and was reshaped to reduce excavation costs and improve performance. The entrance to the channel was flared to provide smoother entrance flow.

The tunnel and stilling basin, Figures 3B and 3C, were tested for diversion flows of 20,000 and 31,000 cubic feet per second. For these tests, the horizontal tunnel was connected directly to the supply line so that the flow bypassed the spillway crest, inclined tunnel, and vertical bend as is the case in the prototype structure. As a result, a 12-inch-inside-diameter air vent was found to be necessary in the crown of the tunnel trajectory section to prevent the tunnel from alternately closing and opening for flows near 20,000 cubic feet per second, and to prevent the control from shifting from the gate section to the tailwater surface when the tunnel was full.

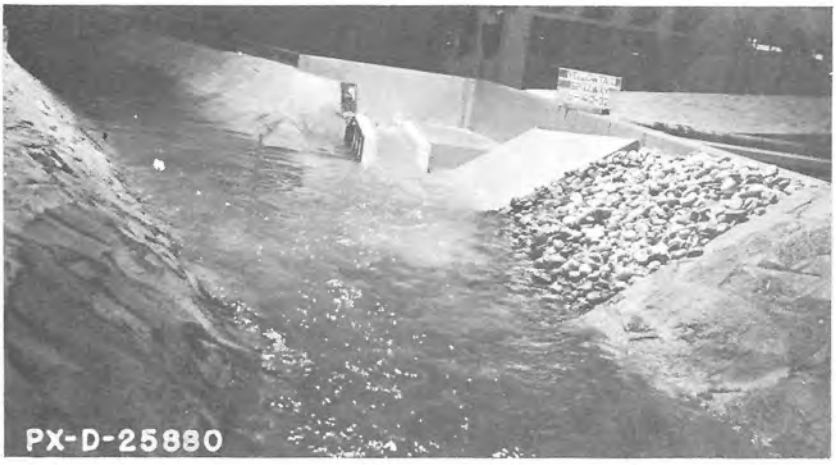
Yellowtail Dam Outlet Works

The second model was a larger reproduction, Scale 1:28, of the hollow-jet valve outlet works stilling basin. This model was used to study basin hydraulics resulting from extreme variations in tailwater elevations which occur during normal operation. The outlet works basin developed from hydraulic model tests for general use, Basin VIII, was modified to operate satisfactorily for the high tailwater resulting from filling the afterbay reservoir and for minimum tailwater which occurs when the afterbay reservoir is empty.

During operation at the maximum discharge, the turbulent action of flow on the riprap sideslopes downstream from the basin dislodged an occasional stone. The roller action of the jump at the end of the basin moved these stones into the basin where they remained, moving back and forth with considerable grinding action. The model tests showed that a retaining wall should be placed along the right bank at the foot of the riprap to prevent any dislodged stones from falling into the basin. The retaining wall also reduced the flow velocity and wave and eddy action along the riprapped slopes, permitting a reduction in the size of riprap from 3 feet to 2 feet.

A. Reservoir area and spillway entrance structure.

B. Tunnel-to-stilling basin trajectory--
20, 000-cfs diversion flow.



C. Stilling basin performance and riverflow conditions
for a diversion flow of 20, 000 cfs.

Figure 3. Yellowtail Dam spillway hydraulic model studies,
1:50 scale.

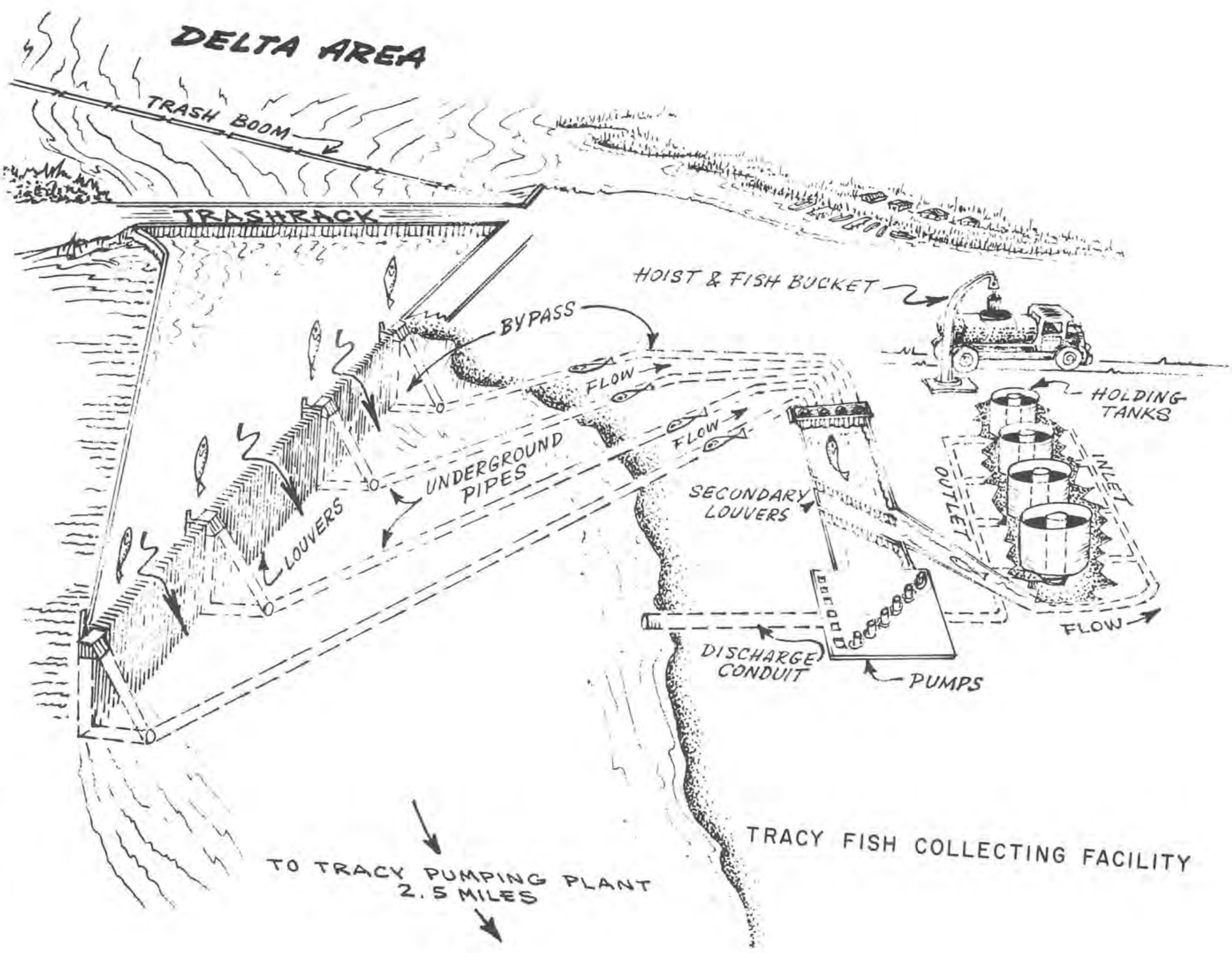
Whiskeytown Dam Spillway

Hydraulic model studies to develop the size, shape, and arrangement of spillway features, including the morning-glory inlet, tunnel, flip bucket, and river discharge channel were conducted on a 1:32.76 scale model. The spillway was tested to determine the capacity for a complete range of reservoir elevations, to determine the flow characteristics through the tunnel, and to determine pressures on the crest. Results of these tests indicated a need for a deflector and an air vent on the crown of the tunnel bend near the throat of the morning-glory. The location, shape, and size of the air-intake pier at the morning-glory crest were developed. The primary function of the vent and deflector is to insure that the tunnel will never flow full. In the prototype, air is supplied to the vent through an air pier located on the spillway crest. The tests showed need for guide vanes on the crest profile for straightening the flow through the tunnel and for increasing the maximum discharge at design reservoir elevation. The location and dimensions for six vanes on the spillway profile were determined. Pressures over the crest profile on the vanes and deflector were found to be satisfactory. All pressures are near atmospheric or above.

Fish Collecting Facilities, Tracy Pumping Plant

Extensive fish collecting and handling facilities have been constructed upstream of California's Tracy Pumping Plant (Figure 4) to prevent the entrance and subsequent death of thousands of small fish in the plant. Fish in the inlet channel are guided into four bypass intake pipes by means of currents induced through a line of louvers. Instinctively, they orient themselves with the current and drift along the face of the louvers to the bypasses. The fish, in maximum flow of about 100 cubic feet per second, are then conducted through pipelines into a secondary louver system for further concentration by reducing the rate of water flow that carries them into holding tanks. After a recuperative period in the tanks, the fish are loaded into trucks, carried downriver, and released beyond the influence of the pumping plant.

Operation of these fish collecting and handling facilities has shown generally excellent performance, with high fish collection efficiency. A possible exception is in the secondary louver structure where turbulence causes delay in fish movement and some unnecessary mortalities. Corrective studies of the structure were made by means of a 1.6 model. Preliminary tests of the as-built design, Figure 5, showed considerable turbulence in some parts of the structure and a rollback of water in the wide entrance above the entering water streams. This rollback circulated sluggishly and suspended material tended to remain trapped for a considerable time. Thus, small fish



TRACY FISH COLLECTING FACILITY

Figure 4

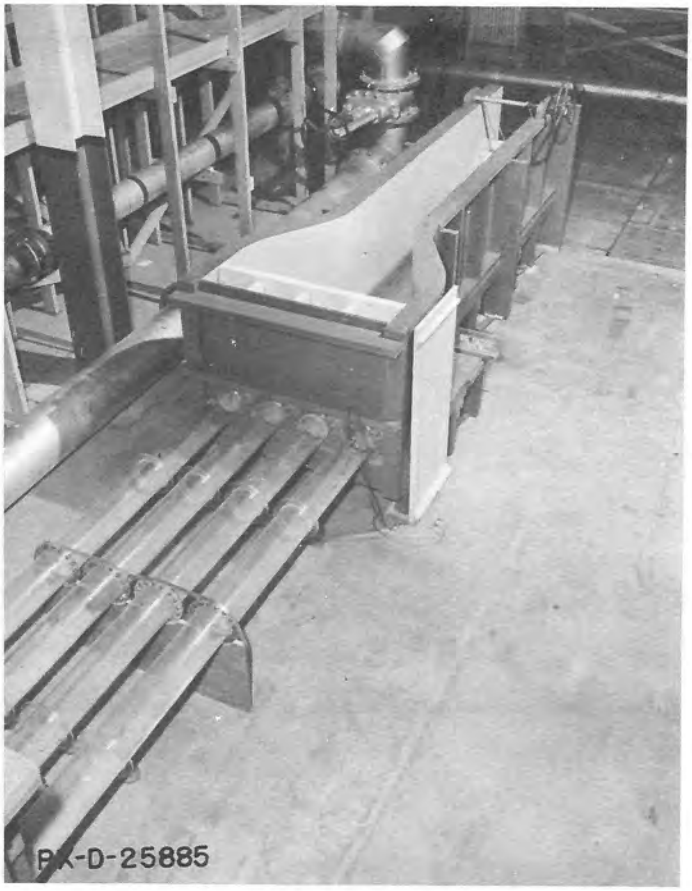


Figure 5. Model of secondary louver structure, fish collecting facilities, Tracy Pumping Plant, California, 1:6 scale.

may become disoriented and remain in the rollback area until exhausted, and then be swept through the louvers like inert debris. Normally, they should be able to exert themselves sufficiently to avoid the louvers and, thereby, be directed into the collection and folding facilities.

When the rates of flow were equal in the four entering pipelines, the flow pattern in the louver structure was symmetrical and the rollback was appreciable. When the rates of flow were unequal, an unsymmetrical, but similar flow pattern existed. Although equal rates of flow are desirable in the pipelines, such symmetry did not solve the problem of fish holdup, and other means were investigated. Expanding round to rectangular transitions were fitted into the pipelines just ahead of the structure to reduce the flow velocities. This change resulted in less severe turbulence in the structure, but did not materially alter the pattern of flow and its large eddies and rollbacks. Great improvement in flow pattern and almost complete elimination of rollback were achieved by placing a cover inside the structure to form a closed-conduit expanding section from the transition outlets to the water surface farther downstream. Straight guide walls at the sides of the structure also improved the flow. Visual examination of the water movement proved the generally good flow characteristics.

The recommended design uses the concept of gradually and continuously expanding closed-conduit transitions. Transitioning starts in the conduits 13 feet upstream from their junction with the structure headwall. It continues inside the structure between piers added downstream from the headwall and beneath a gradually upward sloping roof or cover. This cover continues to rise until it reaches an elevation a little greater than maximum tailwater.

Studies of the flow paths were made by injecting dyes into the water and noting the path, velocity, and turbulence indicated by the colored fluid. Tests were made with equal flows and various degrees of unbalanced flows among the four inlet lines. Excellent flow conditions prevailed for all reasonable distributions of flows. Acceptable conditions prevailed whenever the minimum flow in any line was at least 50 percent of that in the maximum flow line. This performance insured maximum effectiveness in screening out and collecting the fish in the secondary structure. It thereby increases the efficiency of the overall screening operation and further reduces the already small mortality rate of fish.

Willard Canal Pumping Plant No. 1

Baffled Apron for Gravity-flow Bypass

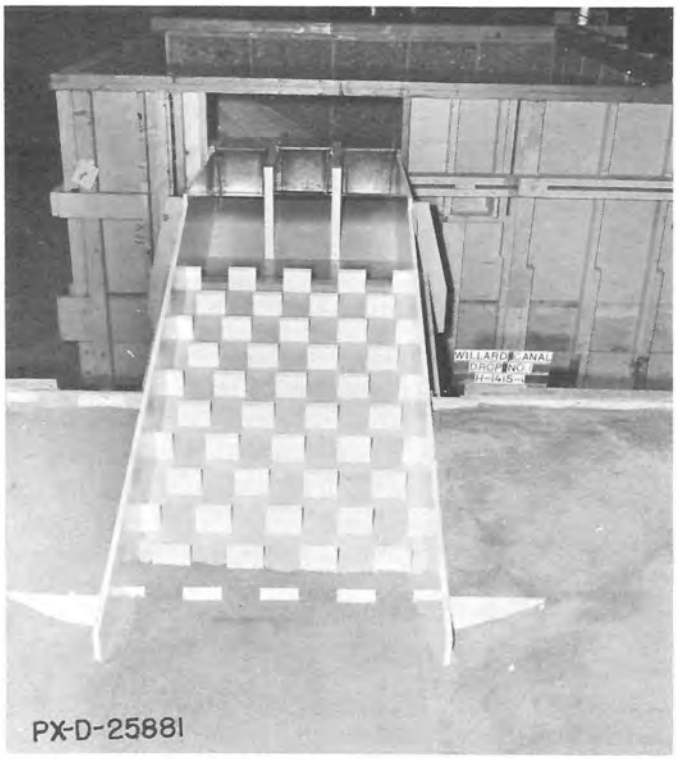
Hydraulic model studies were made to develop baffled aprons constructed on 4-1/2:1 and 3:1 slopes rather than the usual 2:1 slope. The flat slope is required because the earth material in this area is not stable for steeper slopes. Preliminary designs called for both drops to be on 5-1/2:1 slopes; however, later modifications called for Drop No. 1, Figure 6A, to be on a 3:1 slope and Drop No. 2 to be on a 1/2:1 slope.

The baffled apron is a chute studded with baffle piers of a height and arrangement to maintain nonaccelerating water flow from an upper to a lower level. Since no stilling pool is used at the downstream end of the chute, the height and placement entrance characteristics of the flow are critical factors in the design of a satisfactory apron. Generalized hydraulic design data are available for chutes on a 2:1 slope, but no information exists for flatter slopes.

A 1:10 model was constructed to study alternate designs. The first had a radial gate-controlled entrance section followed by a sloping apron 121 feet long and 33 feet wide. The second had an uncontrolled entrance section followed by a sloping apron 151 feet long and 27 feet wide.

The tests on Drop No. 1 showed that the spacing between rows of baffle blocks could be increased from 6 to 9 feet without resulting in excessive splashing or channel bed erosion. Figure 6B shows the appearance of the flow with the 9-foot spacing between rows of baffles. When the spacing was increased to 12 feet, the erosion at the foot of the structure was still moderate; however, there was considerable splashing and the flow frequently overtopped the sidewalls of the chute. Impact tubes placed in the faces of the blocks indicated that with the 6- and 9-foot spacing, the flow velocity did not increase as it progressed down the chute; with the 12-foot spacing, the velocity increased about 50 percent between the upstream and downstream end of the chute.

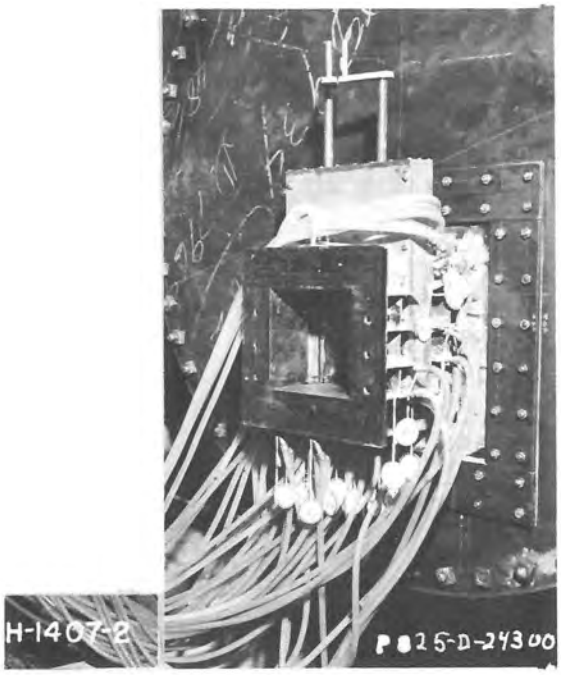
As a result of the tests, it was recommended that the spacing between the rows of baffles for Drop No. 1 be increased to 9 feet, which reduces the number of baffles by one-third. Also, the row spacing for Drop No. 2 has been increased to 13.5 feet instead of the 6 feet called for in the preliminary drawings. Tests showed that these spacings provided flow conditions and scour patterns for the flatter slopes which were similar to those previously determined as satisfactory for 2:1 slopes. It is recommended, therefore, that future designs take advantage of the allowable increase in row spacing for



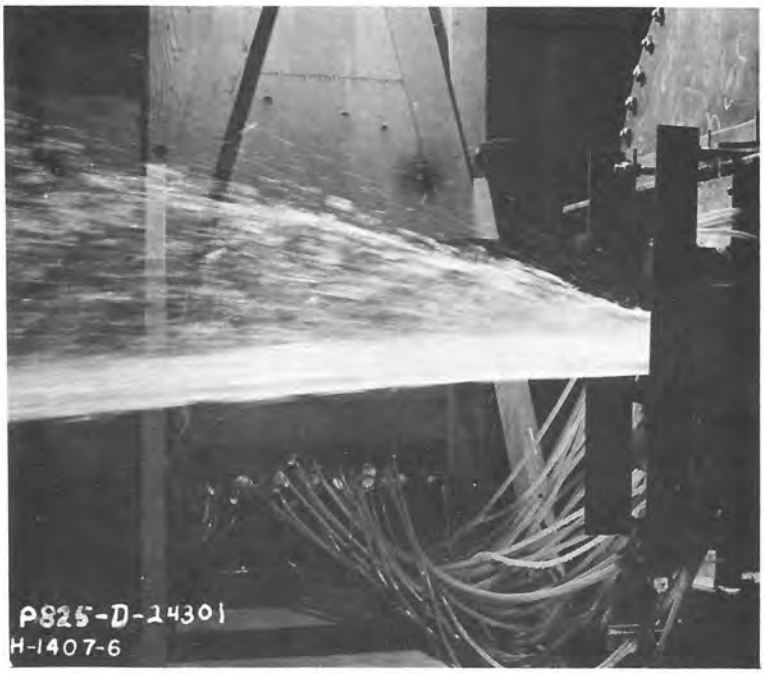
A. Chute on 3:1 slope with 6-foot spacing between baffle block rows.

B. Flow appearance at 500 second-feet with 9-foot spacing between baffle block rows.

Figure 6. Hydraulic studies of Willard Canal baffled apron drop structure No. 1, 1:10 scale.



A. Downstream face of auxiliary gate. 100% open.



B. Discharge at max. reservoir elev. Gate 30% open.

Figure 7. Hydraulic model tests of auxiliary regulating gate, Twin Buttes Dam.

slopes as flat as 4.5:1. Other chute dimensions may be obtained from the "Design Procedure," given in Hydraulic Laboratory Report No. Hyd-445.

Hydraulic Model Studies of a Sediment Control Structure, San Acacia Diversion Dam, Middle Rio Grande Project

A general study of San Acacia Diversion Dam and Headworks Structure using a 1:20 scale hydraulic model was conducted to determine an effective means of reducing concentrations of coarse sediment entering the Socorro Main Canal Headworks. The study was divided into three main parts. The first part was conducted with the canal headworks in its present prototype location. A system of bottom guide vanes was evolved which materially reduced the amount of bed sediments entering Socorro Main Canal by creating local secondary currents. The second part was conducted with the canal headworks moved to its previous prototype location in the sluiceway with the connection to the canal being made with an inverted siphon constructed under the low-flow channel. The third part of the study was conducted with the canal headworks moved to its previous prototype location in the sluiceway with a connecting flume constructed over the low-flow channel.

For discharges of 174 cubic feet per second in the canal and 8,760 cubic feet per second in the river, the concentration ratio of sediment entering the canal headworks to sediment in the river water was reduced from 2.65 to 0.09 by use of the bottom guide vanes. For 200 cubic feet per second in the canal and 480 cubic feet per second in the low-flow channel, the bottom guide vanes reduced the concentration ratio from 2.40 to 0.42.

With the siphon and flume in place, the concentration ratios were approximately 1.00 during the flood stage, and could be reduced to approximately 0.25 by intermittent sluicing operations. For low-flow stage, the ratios were approximately 0.25 without sluicing.

A number of tests conducted with the flume crossing the low-flow channel indicated that the sediment intake was satisfactory for the model discharges tested. A sluicing arrangement may be needed, however, to reduce sediment concentrations entering Socorro Main Canal, either by continuous or intermittent sluicing into the low-flow channel.

Twin Buttes Dam

Tests were made on a 1:5 scale model, Figure 7, of one of three 2- by 2-foot auxiliary regulating gates. These gates have two unusual features. First, they are mounted within each of three 12- by 15-foot fixed-wheel guard gates. Secondly, the gates seat

on the curved portion of the bellmouth entrance. The purpose of the 2- by 2-foot gates is to release low flows up to 600 cubic feet per second. For flows greater than 600 cubic feet per second, the 12- by 15-foot fixed-wheel gates will be opened, and outlet releases will be made through three 12- by 15-foot radial gates.

These studies were required to develop a satisfactory shape for the bellmouth which must be fitted within the relatively short distance between upstream and downstream skinplates of the fixed-wheel gate. In addition, flow conditions in the conduit downstream from the auxiliary gate leaf were studied, and head-discharge curves for various gate openings were determined.

Tests showed the discharge coefficient to be slightly greater than was expected in the preliminary plans. Observed pressures in the bellmouth and in the conduit downstream from the auxiliary gate leaf were only slightly subatmospheric. Pressure and coefficient data for the entire range of gate openings at heads greater than those used in design were also obtained.

El Dorado Distribution System

The El Dorado Distribution System in Central Valley Project, California, is a comprehensive closed conduit system that transports treated water for a variety of uses. Water is delivered from El Dorado Irrigation Ditch, treated for domestic use, and then placed in Reservoir No. 1 of the system. From there it is carried by gravity through a pipeline with a vertical drop of 630 feet to Reservoir No. 2. Similarly, this water and other treated water introduced into Reservoir No. 2 from Camino Conduit, travels through a total of four reservoirs and their connecting pipelines with a total vertical drop of 1,700 feet. Water is diverted at turnouts along the conduits to satisfy domestic users, the town of Placerville, and certain irrigation demands.

The problem of controls in such a system is complicated. First, the rate of flow must not exceed certain preset values in individual lines to prevent unbalancing the system. Too much flow from Reservoir No. 1, for example, could result in excessive drawdown of the pool. Second, regulated pressures must not exceed safe values for domestic facilities and to allow the use of more economical thin-walled pipe. Certain minimum pressures must be maintained simultaneously to permit adequate deliveries from the pipelines. Additional pressure regulation with manually operated, square-bottom gate valves is required for maintaining back pressure on the automatic valves at the reservoirs to prevent cavitation, vibration, and resultant damage. Third, maximum reservoir elevations must not be exceeded. Elevation control is accomplished by float-operated valves reducing or shutting off incoming flows to the

reservoirs, and by limiting the amount of outflow in the succeeding lines. When the reservoir elevations drop below the maximum, the automatic valves open to again pass water. Finally, all regulation, and most particularly the automatic part, must be accomplished in such a way that destructive water-jammer forces are controlled within safe limits.

The unusually stringent regulations requirements necessitated a thorough knowledge of typical automatic valve operating characteristics. A suitable representative 6-inch automatic regulating valve, complete with controls, was obtained and tested in the laboratory. Data obtained included the relationship between discharge coefficient and valve opening, and the performance and response times of the valve when signalled into action by the rate of flow controller, the pressure controller, and/or the reservoir elevation controller. The response of the valve was too rapid, creating excessive water-hammer forces in the long pipe system and modifications in the controller unit were studied. Additional data obtained included the cavitation characteristics of the valve and the relation of upstream to downstream pressures that must be maintained to prevent cavitation.

Green Springs Powerplant, Rogue River Basin Project, Oregon

A representative of the Hydraulic Laboratory Branch assisted the Hydraulic Machinery Branch in the salt-velocity measurements during turbine evaluation tests. This assistance entailed supervision of the electrode installation and wiring according to a brochure provided by Hydraulic Machinery personnel and installation of electrical recording equipment. During the evaluation tests, the laboratory representative was delegated the responsibility for salt-velocity measurements and the interpretation of several recordings to assure the reliability of the records.

Glen Canyon Dam Diversion

Diversion flows through the right tunnel undercut the canyon wall downstream from the tunnel portal. Investigations were made on the hydraulic model to determine what protective measures should be taken to prevent further damage.

The area 70 feet downstream from the tunnel portal will eventually be occupied by the spillway flip bucket; consequently, a concrete apron and wall were constructed in the model to represent the foundation for the permanent bucket. A deflector was added to the end of the wall to deflect the flow away from the downstream canyon wall.

In order to evaluate the protective value of these structures, the right canyon wall in the model was molded in a weak, easily erodible,

sand-cement mixture to the outline of the eroded canyon wall. Tests on this arrangement showed that the deflector wall was not sufficiently long to direct the water into the river. Flow impinging on the already eroded area, Figure 8A, would tend to increase the erosion downstream from the presently eroded area.

The right wall was then revised so that it was parallel with the tunnel center line and 70 feet longer. The new wall provided slightly better protection for the canyon wall, but a design analysis showed that it would be quite expensive and difficult to install. Therefore, it was decided to install a shorter superelevated deflector downstream from the concrete slab. After several trials, a deflector was developed that turned the flow away from the canyon wall, Figure 8B. Although this structure was satisfactory, it was decided that since the depth of the channel bed erosion in this area of the prototype was not known, an alternate scheme should be developed. The choice of schemes would be made after the cofferdam had been unwatered.

For the alternate scheme, a 30-foot high and 250-foot long wall was constructed along the curve of the canyon wall, Figure 8C. In general, this wall was very satisfactory for all flows. However, for certain tailwater elevations and discharges above 35,000 second-feet, an unstable region was found which caused the water over the entire width of the river to fluctuate in a harmonic motion. The resulting surges were about 15 feet high and had a period of about 30 seconds. Action of this type on the cofferdam would probably cause considerable damage or require extensive maintenance.

Further testing showed that a spur dike placed about 150 feet from the canyon wall with its long axis parallel to the diversion tunnel center line and extending about 150 feet downstream from the existing cofferdam prevented unstable flow and resulted in satisfactory operation for the entire range of discharges. The spur dike in the prototype would be the remains of the cofferdam used during construction of the curved wall. In other words, only a portion of the cofferdam would be removed and the remainder would be left in place to prevent the unstable flow during the diversion period.

The curved wall, Figure 8C, was constructed in the field and has performed satisfactorily as predicted. The spur dike was left in place as recommended during the model tests, but diversion flows have not been sufficiently great as yet to test the value of the dike.

Glen Canyon Left Diversion Tunnel Outlet Works and Flip Bucket

Tests were made on the 1:24 scale model to determine the bucket sidewall shape needed to prevent possible damaging water impact on

A. Right diversion tunnel with deflector wall downstream from portal, Q = 50,000 cfs.

B. Right diversion tunnel with superelevated deflector downstream from portal, Q = 50,000 cfs.

C. Right diversion tunnel with low, curved, wall protecting canyon wall, Q = 50,000 cfs.

Figure 8. Hydraulic model of Glen Canyon Dam Diversion Tunnel

the left canyon wall during outlet releases. A partial bucket utilizing only the lower portion of the upwardly curved invert was considered. This represented the first stage of a proposed 2-stage type of construction. The remainder of the bucket invert was to be installed after the tunnel outlet works was no longer needed, and the full bucket would then be available for ultimate spillway use.

At discharges below 10,200 cfs, a hydraulic jump occurred in the tunnel and water passed quietly over the bucket lip. At higher flows, the jump swept out of the tunnel and supercritical flows occurred over the lip. The "lift" imparted to the water by the partial bucket was small, and no water struck the canyon wall until flows reached 19,800 cfs. However, at flows of 28,000 and 32,700 cfs, part of the main jet directly struck the lower canyon wall. This direct impact and probable damage at high discharges were undesirable and it was concluded that the relatively expensive 2-stage-type bucket should not be used in the prototype structure.

Analyses of the performance data obtained in the bucket tests showed that the best compromise of outlet works performance, spillway performance, and cost was achieved with the single-stage bucket originally developed for spillway flows. Studies showed that some water impact occurred on the canyon wall with this design if severely unsymmetrical outlet works releases were made. However, this impact took place near the flip bucket at only relatively low velocities and moved farther downstream as the velocities increased. Thus, no significant damage is expected in the bucket area. Furthermore, unsymmetrical releases will seldom occur, and under emergency conditions only. The flip bucket, originally developed for spillway flows, was, therefore, chosen for prototype use with diversion tunnel outlet works flows.

The above-mentioned test program completed the model studies of the tunnel outlets. A final laboratory report on the studies is being prepared.

Tunnel Inspection and Friction Tests, Eklutna Project, Alaska

The Eklutna Tunnel was drained for the first inspection since it was put into operation in 1955. While the powerplant was shut down, equipment was installed in the plant for performance of tunnel friction coefficient tests. A laboratory engineer supervised the friction tests and an engineer from the Canals Branch participated in the tunnel inspection.

The concrete tunnel lining was found to be in excellent condition and the inlet drains were operating normally. Approximately 9 second-feet

of water was flowing into the tunnel through the drains. Two casts of typical tunnel flow surfaces were obtained and actual tunnel diameter measurements were made.

After the inspection, 15 test runs were made to obtain friction coefficient data. Preliminary calculations indicated that satisfactory test results were obtained.

Figarden Reservoir Beaching Studies, Central Valley Project

A beaching study was performed on a simulated Figarden Reservoir soil prepared in the laboratory. The soil having the same gradation as Figarden soil with a mean diameter of 0.6 mm was placed on a 1:1-1/2 slope in a 1-foot wide test section in the 70-foot laboratory wave-generating flume to represent directly approaching onshore waves.

Erosion characteristics of the soil were determined by subjecting the test section to a wave height (crest to trough) of 0.15 foot with a steepness ratio (wave height over wave length) of 0.035 foot and a period of 0.93 second. This wave eroded the slope to an equilibrium beach slope of 1:10.

After reforming the test section to its initial shape, the wave machine was set to produce a wave height of 0.30 foot and a steepness factor the same as the first wave.

The equilibrium beach profiles for both waves when plotted in dimensionless terms were coincident for ratios of horizontal distances to wave lengths ranging from -0.12 to +0.28. The horizontal distances were measured from the intersection of stillwater surface and the beach. The wave runup distance amounted to one-third of the total preceding ratio range. The equilibrium beaching slope was 1 to 10 for both waves.

Trinity Dam Jet Flow Gate

Studies continued on the 1:15 scale Trinity jet flow gate model in an effort to establish a correlation between model indications and actual prototype air requirements. In spite of recent strides in the science of testing and interpreting hydraulic models, very little is yet known about converting model air-demand measurements to the full size structures. Various correlating relationships have been proposed, such as a function of the Froude number at some significant or critical location in the system. However, to date, the relationship has not been established because the extensive model and field correlation studies have not been made.

In the model tests, air quantities were measured at the gate during operation with various gate openings and lengths of downstream conduit, various air system restrictions, and various operating heads. Gate openings ranged from 20 through 100 percent, and conduit lengths ranged from 2 to 10 feet. Air system restrictions consisted of 1- to 2-3/4-inch-diameter orifices at the entrance to a 3-inch pipe. The operating heads ranged from 10 to 50 feet.

The final correlation must await prototype data from the field structure. Fortunately, the gate is suitably situated for making such tests, and when water is available, efforts will be made to conduct them. When prototype data have been obtained, it is expected that a suitable and well-founded correlation factor will be developed. The factor will be valuable in evaluating air demands for other similar installations, and will insure that adequate, safe, and economical vents can be provided. In time, it is hoped that correlation factors will be available for all gate and valve types used extensively by the Bureau so that optimum designs can be assured.

Central Valley Project Canal Capacity Studies

The coordinated laboratory and field studies have three objectives: (1) to develop explanations of the observed hydraulic behavior of Central Valley Project canals and practical methods of increasing capacities; (2) to develop hydraulic design procedures for interim use while field and laboratory studies are being conducted; and (3) to acquire data which will provide a basis for refinement of future design procedures.

Measurements of head losses for models of 16-foot timber and 380-foot concrete bridge piers were completed. Head losses were measured for a model of a timber bent shown in Delta-Mendota Canal specifications, Figure 9. The bracing placed as an "X" on one side of the bent differed from field construction of a single brace on each side. Bracing on both sides increases the contraction of the canal flow area by less than 1 percent. The effect of this small quantity at model scale was considered negligible. A 2-caliber ogival pier nose was used on both the upstream and downstream ends of a smooth pier representing 3/4-inch sheathing on a prototype bent with the braces removed. The pier noses were fitted between the cap and sill of the bent, Figure 9. Head loss measured for a set of three smooth piers was approximately 1/10 of the 0.01-foot prototype equivalent measured for the models of three timber bents at the Froude number of the prototype.

Head loss measurements were made for two 38-foot-long articulated piers with 32-inch spacing between sections for a 24-foot county highway bridge at a 49 degree 32 minute angle. Measurements were made with and without closure of the spaces between pier sections.

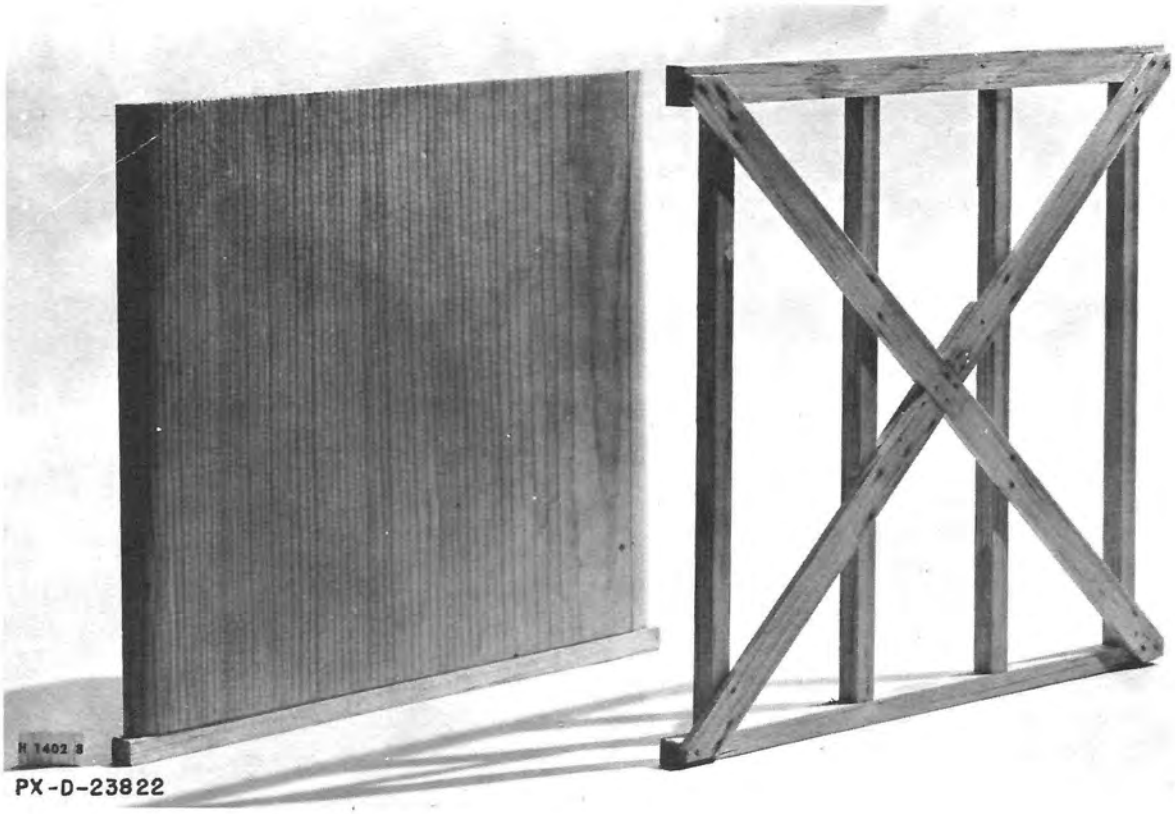


Figure 9. 1:24 scale model of a 16-foot sheathed and unsheathed timber bent.

Prototype loss for the open piers at the corresponding Froude number was approximately 0.01 foot. Closure of the spaces with 3-inch-thick walls on the pier center lines reduced the head loss by approximately 10 percent of the value for the open piers.

A trapezoidal canal section with a 2-foot bottom width was used for a 1:24 scale study of the articulated piers. These piers in prototype operation have produced waves that travel both upstream and downstream of the bridge and caused, at some locations, 2-foot fluctuations of the water surface on the side slopes. Model waves showed good similarity to the prototype wave frequency and amplitude. These studies have tentatively shown that a filling of the spaces between pier sections greatly reduces and possibly will eliminate the extraneous waves.

Head losses caused by 4-column timber bents were measured on 1:24 scale models in a 30-inch wide flume. These initial measurements were preparatory to a determination of the effectiveness of sheathing the bents to reduce the head loss. Preliminary measurements on the unsheathed model bents indicated prototype head loss was predictable from the 1:24 scale model. Studies in the 30-inch flume were extended to measure the head loss caused by the articulated piers, but representative wave action could not be reproduced in a rectangular channel.

A computer program was completed for the shear distribution analysis of velocities measured in the Main and East Low Canals of the Columbia Basin Project. Completion of the program will permit computations using 28 sets of discharge measurements. Results of the computations will be used for correlation of shear distribution with head loss and canal flow conditions that prevailed during the velocity measurements.

Initial phases of the bridge pier head loss studies were completed, and a report of the results is being prepared. Studies have been confined to bridge piers typical of those constructed in the Central Valley Project, and include modifications to improve hydraulic efficiency.

Concurrent with analysis of data from field and laboratory measurements of structure and boundary surface resistance losses in large concrete-lined canals, a laboratory test facility was developed for evaluating surface resistance coefficients of concrete linings. The primary purpose of the evaluation is practical application of the derived coefficients instead of a generalized solution for all conditions of roughness patterns.

The test facility consists of a 1.8-foot by 0.3-foot rectangular plastic conduit 24 feet long with bellmouth entrance, a rectangular

test section of the same dimensions, a surge chamber, and a centrifugal air pump, Figure 10. The pump draws air through the plastic entrance section to develop a turbulent velocity distribution and then through the test section where the floor is a reproduction of a concrete lining.

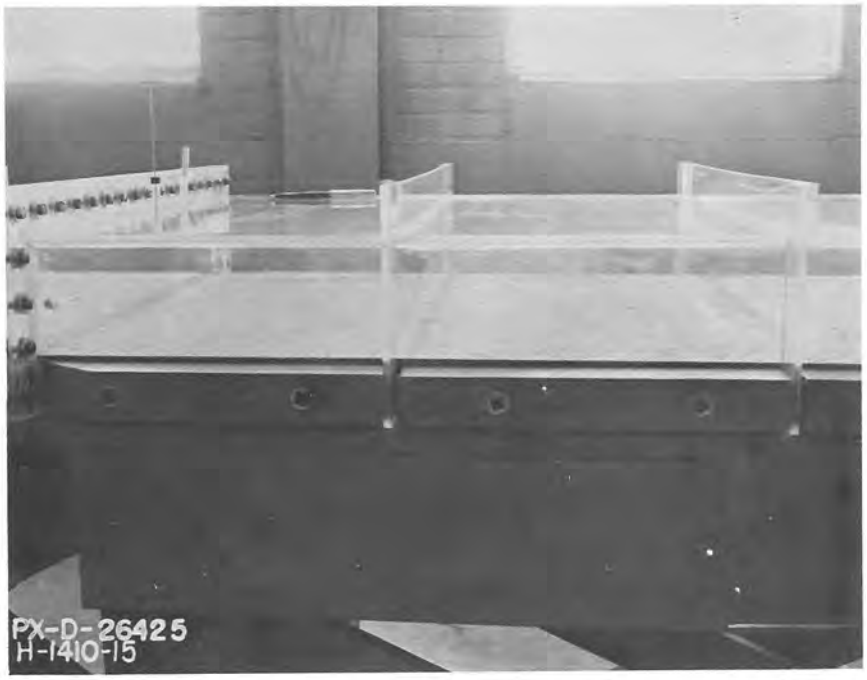
Velocity traverses have been taken at the downstream end of the entrance sections and at three stations in the test section. Figure 11 shows a typical concrete surface in the test conduit and velocity profiles at the downstream end of the plastic entrance section and at the downstream end of the concrete test section. From the relation between velocity change and change in distance from the test surface, computations of boundary shear and friction factors can be made.

In December 1960, representatives of the Hydraulic Laboratory and Canals Branch discussed the test program with personnel of Region 2 and inspected the canals in the Central Valley Project from which data are being derived for the canal capacities studies. The upper 30 miles of Delta-Mendota Canal had been unwatered for the first time since 1953 to permit construction for improvement of the hydraulic efficiency of the bridge piers, overchutes, and pipe crossings. Inspection of the unwatered reach revealed numerous clam-silt bars in the bottom and extensive animalcule growth on the concrete lining. The extent to which the extraneous deposits and growth contribute to retardation of flow cannot be determined readily. Capacity tests proposed for the near future will aid in understanding this and other problems.

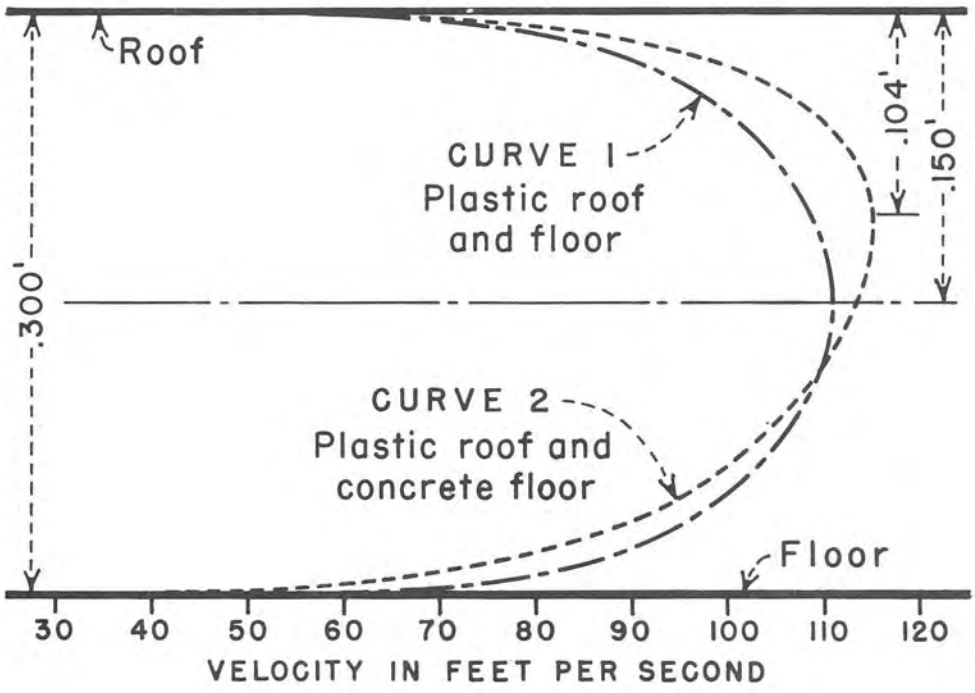
A program for obtaining data on the geometry and other characteristics in the unwatered reach of Delta-Mendota Canal, pertinent to the test program, was completed during the trip. Proposals for further testing of canals in the Central Valley were discussed, and a tentative program was outlined.

Instrumentation: A multiple current-meter system was purchased for simultaneous measurement of vertical velocity profiles in large canals. As purchased, the system included eight propeller-type current meters; a total of 35 feet of airfoil-shaped current-meter mounting rod; a mobile winch assembly for holding, raising, and lowering the rod; and a 12-pen chronograph. The chronograph contains a timer that employs 1 of the 12 pens to produce 1-second pips on a strip chart. All current meters are connected to a low-voltage direct-current circuit so each meter will operate 1 chronograph pen to record every 10 or 20 revolutions of the meter propeller. The time and revolution pips on the strip chart permit determination of simultaneous propeller speeds, in revolutions per second, for all meters. Calibration relationships furnished with the meters enable direct conversion from propeller revolutions per second to corresponding water velocities.

Figure 10 Air test facility for study of boundary surface resistance coefficients.



A. Typical concrete surface in test conduit.



B. Velocity profiles in plastic entrance conduit and in test section.

Figure 81 Canal capacity studies.

An auxiliary bracing frame to provide additional support for the meter mounting rod has been fabricated. This frame will be necessary to hold the rod in deep or high-velocity water. To minimize setup and disassembly times, a plug-in-type electrical system has been completed.

Operation of the system in the Hydraulic Laboratory revealed that minor modifications of the winch assembly and chronograph are required for satisfactory operation of these components.

Drawdown Tests, East Bench Canal, Missouri River Basin Project, Montana

A test of the stability of cover material placed over an asphalt canal membrane was conducted by the Hydraulic and Bituminous Laboratories. The test flume containing a simulated canal side slope supported by plywood was 24 feet long, 3 feet wide, and 6 feet deep. A 1/4-inch thick catalytically-blown asphalt membrane was placed on the plywood, and covered both the 13 feet of the 2:1 sloping bank and the simulated canal bottom. Seven and onehalf feet of canal bottom from the toe of the side slope were included in the test flume.

The cover material was mixed in the laboratory. The gradation was based on the criterion that the fraction 25 percent larger than No. 10 sieve would be erosion resistant at the computed tractive force for East Bench Canal, and that the fraction 95 percent larger than No. 200 sieve would be free draining. This resulted in a mixture with a geometric mean diameter of 0.500 millimeter, and 12.2 percent larger than No. 4 screen. The material had a gradation similar to that of material furnished from East Bench Canal.

The flume was filled slowly with water to a depth 5.83 feet above the bottom asphalt membrane, or 4.5 feet above the 16-inch thick cover material. The first test consisted of drawing the water down at a normal rate 1 foot per 24 hours. This rate is a suggested average for unwatering a canal after an irrigation season. The cover material for this rate was stable. The cover material was subjected to successively increasing rates of water surface drawdown. At a down rate of 2 feet per hour, the sloping bank developed surface cracks that were parallel to the falling waterline. This rate of drawdown was greater than any expected in the field, under normal conditions.

To increase the value of the tests, the cover material was tested for sensitivity to wave damage. The cover material was subjected to 8 minutes of waves having heights equal to 0.2 foot and less, and a frequency of 1 wave per second. During these tests, 0.33 cubic foot of soil was eroded per linear foot of canal per bank.

Sediment Tests on Prototype Diversion Dams, Nebraska and Kansas

During the first week in August, representatives from the Hydraulic Laboratory and the Hydrology Branch of the Assistant Commissioner and Chief Engineer's Office, accompanied by representatives of Region 7 and McCook offices, made tests on the sediment removal structures at Woodston, Bartley, Superior-Courtland, and Cambridge Diversion Dams. Suspended sediment samples were taken at the entrance to the guide walls, downstream from the headworks gates, and upstream from the sluice gates. The project office had previously arranged to release water from storage dams to give discharges in the headworks and sluiceways similar to the ratios of discharges tested in hydraulic model studies. Hydraulic models have been tested with sediment control arrangements simulating Woodston, Bartley, and Superior-Courtland headworks and sluiceways. Tests were made at Cambridge Diversion Dam at the request of project personnel.

In order to compute total sediment load approaching the diversions, water discharge measurements, suspended and bed material sediment samples, and water surface slopes were obtained on reaches of the rivers a short distance upstream from each diversion dam. The sediment samples and data have been analyzed in the Hydraulic Laboratory. A report will be prepared comparing the results of the field tests with results obtained during hydraulic model tests.

SECTION III--COOPERATION WITH OUTSIDE AGENCIES

Cooperation and assistance were rendered other Government agencies for several special problems. The most important are described briefly in the following paragraphs.

Bureau of Public Roads, Drain Tests

Hydraulic investigations were performed on a highway embankment rundown drain for the Bureau of Public Roads. The drain is used to collect storm runoff from a highway and conduct it to a lower elevation without causing erosion to the highway embankment. The drain, composed of standard corrugated metal pipe components, consists of a sheetmetal end section and transition at the intake and exit with a sloping section of corrugated metal pipe between. The laboratory rundown drain consists of 12-inch end sections and 6-inch pipe placed on a 1-1/2:1 slope. The vertical fall is about 15 feet.

The studies were concerned with determining the capacity of the structure, and in developing either a satisfactory energy dissipator or other device to provide protection against erosion at the exit. The initial tests showed that the capacity is approximately twice the capacity that is used in present design practice, indicating that it would be possible to space the drains at twice the distance now being used.

Tests made to determine the protection necessary to prevent erosion at the exit showed that riprap blanket composed of 1-1/2- to 3-inch rock placed around and downstream from the end section will prevent excessive erosion at all discharges.

The investigations of various types of energy dissipators showed that baffle plates installed in the downstream transition and end section were not effective. A vertical stilling well, constructed from a 2-foot-long section of 30-inch-diameter corrugated metal pipe standing on end, did not sufficiently dissipate the energy. The high-velocity flow entering the well caused extreme turbulence and bubbling action in the well with considerable splashing over the sides. In addition, the capacity of the structure was reduced from 3-1/2 second-feet to about 2 second-feet.

Bureau of Public Roads--Hydraulic Seminar

Alvin J. Peterka, Hydraulic Engineer, presented a paper at the Hydraulics Seminar January 31-February 2, 1961, in Denver, Colorado, sponsored by the Bureau of Public Roads and the Colorado, New Mexico, Utah, and Wyoming State Highway Departments. The paper, "Hydraulic

Models--Indispensable Tools of the Designing Engineer," was aimed to demonstrate the many benefits to Reclamation Engineering resulting from hydraulic testing and indicate the benefits which could be gained by model-testing highway engineering hydraulic problems. A condensed printed version of the oral presentation is on file in the Hydraulic Laboratory as PAP-148 and will be printed by the Bureau of Public Roads as part of the proceedings of this seminar.

Motion Picture Film--Iowa Institute of Hydraulic Research

The University of Iowa, working through the National Science Foundation, is presently engaged in making a series of six films, 16 mm, color and sound, to be used as visual aids in explaining and teaching hydraulics and fluid mechanics to engineering students. The first of the series is an orientation and summary film which will show the ultimate uses and applications of the hydraulic principles depicted in the other five films. Sources for this first film will be hydraulic laboratories and operating prototype structures in various parts of the United States.

On March 6 and 7, 1961, Mr. Lucien M. Bush, Jr., Research Engineer, Iowa Institute of Hydraulic Research, and a cameraman, Mr. Marsh Lovrien, with the help of the Hydraulic Laboratory staff, photographed the performance of a group of hydraulic models in the Bureau of Reclamation's Hydraulic Laboratory in Denver, Colorado. Several hundred feet of color film was taken of the hydraulic action of water flowing through representative structures to demonstrate the many types of flow encountered in the dams field.

Scenes included the Whiskeytown Dam morning-glory spillway both submerged and flowing freely; the Yellowtail Dam Outlet Works stilling basin and hollow-jet valve discharging the design flow; detailed views of a 6-inch transparent model hollow-jet valve; the Glen Canyon Dam tunnel plug outlet works flip bucket discharging adjacent to the carefully modeled left canyon wall; a baffled apron which uses the cascade principle to dissipate energy in water flowing down an inclined chute (Willard Canal); the Flaming Gorge Dam Spillway, flip bucket, powerplant, and hollow-jet valves; a sediment study model of the San Acacia Diversion Dam.

Scenes showing the performance of Bureau dams will be taken from the Bureau film, "By Their Deeds." Arrangements for showing the completed first film of the series in Denver will be made as soon as it is available.

State of California--Oroville Dam Model Studies

In response to a request from the Director, State of California, Department of Water Resources, an estimate was prepared of cost and a tentative time schedule for performance of hydraulic laboratory studies for the Oroville Project. Four studies were considered as follows: (1) Oroville Dam diversion tunnels operating both under construction conditions with river diversion flows and under postproject conditions as powerplant tailrace channels; (2) energy dissipator for the river outlets installed in the tunnel plug in the left diversion tunnel; (3) final hydraulic model check of the penstock intake structure and control gate; (4) and the spillway structure and channel for the Oroville Dam including both the spillway crest gates and the low-level flood control outlets.

Preliminary plans were made for the first two studies late in the fiscal year.

SECTION IV---ASSISTANCE TO FOREIGN GOVERNMENTS

The volume of work for foreign countries continued to decline this year. A small amount of consultation service was rendered for the Snowy Mountains Hydro-Electric Authority, Australia, and the Yanhee Project, Thailand. Six engineering trainees from other countries were assigned to the laboratory for training periods ranging from 2 days to 7 months. In addition, six observers from foreign countries were assigned to the Hydraulic Laboratory. More than 58 foreign engineers visited the laboratory on an official basis during the year.

Foreign Observers

Eduardo Basso	Chile	8-25-60	1 day
Ton That Thieu	Vietnam	9- 6-60	5 days
Dr. Robert Levy	Grenoble,France	9-20-60	1 day
Abdel-Aziz Saeed	Khartoum, Sudan	6- 5-61	1 day
Mostafa Mozayeny	Iran	6- 6-61	1 day
P. Henry Perera	Ceylon	6- 8-61 to	6-16-61

Foreign Trainees

Evani S. Sastri	Andhra Pradesh, India	1- 9-61 to	1-23-61
Jer-Yann Wu	Taiwan, China	1-17-61 to	3-10-61
Ayyad R. Ghobrial	Egypt	2-22-61	2 days
Francisco Aguerrevere (Frank)	Caracas, Venezuela	4- 4-61	2 weeks
		4-24-61	1 week
Thomas H. Kopp	Cooma, N.S. Wales, Australia	5- 1-61 to	7-7-61
Taweesak Mahasandana	Bangkok, Thailand	5- 4-61 to	12-61

Foreign Visitors

German Rodriquez	Lima, Peru	7-25-60	1 day
W. T. Norris	England	7-26-60	1 day
Stephan C. Hunter	England	7-26-60	1 day
Dr. Ludwig Rue	Leverkusco, Germany	8-11-60	1 day
Prof. Ahmed Shukry	Egypt	8-24,25-60	2 days
Helmi Bakr	Egypt	8-24,25-60	2 days
K. G. Macoun	Sydney, Australia	9- 2-60	1 day
K. K. Rao	Waldair, India	9- 2-60	1 day
I. V. Nayak	Chandigar, India	9- 2-60	1 day
M. K. Kuehl	Vancouver, British Columbia	9- 6-60	1 day
C. P. Vivian	Nairobi, Kenya	9-14-60	1 day
Lawrence Cruttenden	Southern Rhodesia	9-26-60	1 day
Mr. C. Beauchene	Sogreah, Algeria	10-10-60	1 day

Mrs. C. Beauchene	Sogreah, Algeria	10-10-60	1 day
Armando C. Lencastre	Lisbon, Portugal	10-21-60	1 day
J. Raja Rao	India	11- 7-60	1 day
Jijjarapu Rajarao	Andhra Pradesh, India	11- 8-60	1 day
Nahum Treiger)	Sanitaria, Brasil	11-28-60	1 day
Juvencio F. De Campos)			
Roberto Sanchez	Mexico	11-28-60	1 day
Dong Yol Shin)			
Kwan Woo Lee)	Korea	11-28-60	1 day
Wol Dong Joo)			
Mr. Victor Ostolaza	Peru	12-30-60	1 day
Mr. D. B. Sugden	Tasmania	2- 3-61	1 day
Mr. Yaacov Vardi	Israel	2-15-61	1 day
Arnold Boettcher	Peru	2-23-61	1 day
Captain Ray Frias)	University of Colorado	2-23-61	1 day
Shigeki Nakajima)			
Siang-Yun Tung	Taiwan, China	3- 2-61	1 day
H. G. Sweet)	Australia	3-20-61	1 day
R. M. West)			
Captain Ray Frias)	University of Colorado	2-23-61	1 day
Shigeki Nakajima)			
Mr. and Mrs. Parker H. Perera	Ceylon	3-28-61	1 day
Khalie Taleghani)	Tehran, Iran	4- 8-61	1 day
A. R. Ansari)			
Dall Won Goh	Korea	4-10-61	1 day
Yong Tai Kim	South Korea	4-10-61	1 day
Suk Lee	Seoul, Korea	4-10-61	1 day
Ibrahim A. Dinsel	Ankara, Turkey	4-10-61	1 day
Major Jose L. de Carvalho	Brazil	4-10-61	1 day
Kenji Awano	Japan	5- 9-61	1 day
H. T. Wolbeer	Saskatchewan, Canada	5-15-61	1 day
John R. Burton	Australia	5-16-61	1 day
Nathan Buras	Israel	5-16-61	1 day
Gordon Cole	London, England	6- 1-61	1 day
Colin Gunn	New Zealand	6- 2-61	1 day
Derek Judd	England	6- 2-61	1 day
Ake Sundborg	Sweden	6- 5-61	1 day
B. S. Ramappa	Mysore, India	6- 5-61	1 day
M. Chickannayappa	Mysore, India	6- 5-61	1 day
A. D. Therianos	Athens, Greece	6- 9-61	1 day
P. G. Michaelidis	Athens, Greece	6- 9-61	1 day
Ramaseshan S.	India	6-12-61	1 day
M. Anisfeld	Tahal, Israel	6-26-61	1 day
Dr. Takanobu Takata	Japan	6-26-61	1 day

SECTION V--HYDRAULIC LABORATORY INVESTIGATIONS

Research activities of the Hydraulic Laboratory received increased emphasis in fiscal year 1960. The program was accelerated and broadened in scope. Various aspects of hydraulic research are described in some detail by category in this section.

A. Hydraulic investigations--general
B. Sedimentation
C. Water measurement
D Lower-cost canal lining
E. Table of research fund sources
F. Demineralization research
G. Proposed research with foreign currency
H. Hydraulic Laboratory Techniques Conference
I. Civil Engineering Research Symposium

Categories A to D inclusive comprise the principal portion of the programed research in the Hydraulic Laboratory. Table E indicates the distribution of sources of funds in this year of transition from Project Services General funds to nonreimbursable funds.

Saline water demineralization research, F, is a principal project of the Chemical Engineering Laboratory Branch. The work performed by the Hydraulic Laboratory Branch deals with special phases of that project concerning problems in fluid mechanics and related technical fields.

In the previous year, the Hydraulic Laboratory developed twelve proposals for hydraulic research which would be useful to the Bureau and could be pursued by foreign laboratories with foreign currency credit in those countries. Descriptions of these proposed studies, suggested institutions, and their personnel and pertinent literature references are presented in Subsection G.

The Hydraulic Laboratory was host to a meeting on Hydraulic Laboratory Techniques, August 9 and 10, 1960. An outline of the technical topics discussed at this interagency meeting is presented in Subsection H.

The Hydraulic Laboratory participated in two panels of the Symposium on Basic Research in Civil Engineering Fields as related to Water Resources, held at Fort Collins, Colorado, June 12-15, 1961. An account of this participation is presented in Subsection I.

G. I.--

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-energy content, such as unwatering certain structures which contain water under high pressure or supplying irrigation water to earth ditches from high-pressure conduits. Investigations of particular structures and operation of completed field structures have established the feasibility of the stilling well.

Area, depth, and shape of well for various discharges and entrance velocities are needed in generalized form to establish design criteria for wells square and circular in cross section. A limited number of tests has been conducted to determine the relationships between well area, well depth, and amount and velocity of flow for wells of circular cross section. Some tests pertaining to wells of square cross section with regulated flow have been made but many gaps in the data do not permit its general use.

Stilling well structures developed for particular projects are discussed in Hydraulic Laboratory Reports No. Hyd-237, 244, and 277. Developments to date, however, permit only limited use of the stilling well principle in design considerations.

Accomplished FY61

Project Services--General. Study was not pursued because of more urgent work.

Scheduled FY62

G. I.--

All test results obtained to date will be consolidated and evaluated. A suitable model will be constructed and tested to obtain additional data on the flow characteristics of square wells. The study will be extended to include an evaluation of circular stilling wells. Design charts and tables will be prepared for presentation in a progress report.

Hydraulic Jump and Energy Dissipators

One of the greatest areas of uncertainty in the hydraulic design of water conveyance structures is the stilling basin, energy dissipator, flip bucket, or other device used to reduce or distribute the excess

energy in the flowing water before it is discharged into the downstream channel. Until research into these structures began to produce usable results, there was insufficient backgound experience to design an energy dissipator with sufficient accuracy to estimate the ultimate cost of the structure. The objective of this research is to develop the many possible types of energy dissipators including hydraulic jump and impact-type stilling basins, flip buckets, and baffled aprons for general use so that laboratory development work for each individual structure will be a minimum.

Of primary need were hydraulic jump stilling basins for overfall spillways or canal drops. Five types have now been developed and generalized so that they may be designed for most combinations of head, height of fall, and unit discharge. Also needed were roller buckets, impact-type basins, flip buckets, and baffled aprons used when hydraulic jumps are not feasible, and special purpose stilling basins such as used on outlet works controlled by valves.

A series of progress reports has been issued on the completed parts of the overall program. Hydraulic Laboratory Report No. Hyd-399 covers the five hydraulic jump basins and an impact basin. Report No. Hyd-415 covers "Slotted Buckets for High, Medium, and Low Dam Spillways* * *." The above material has been published by ASCE and is also available as Engineering Monograph No. 25. Report No. Hyd-446 covers the hydraulic design of a special purpose stilling basin for outlet works utilizing the hollow-jet valve for flow control. Report No. Hyd-445 (ready for duplicating and distribution) covers the hydraulic design of baffled aprons or chutes which may be used where stilling basins are not feasible. A paper, "Improved Tunnel Spillway Flip Buckets," published by ASCE covers a partial study of the buckets used at the end of high-velocity tunnels flowing partially full.

Miscellaneous data pertaining to the above studies have been obtained from laboratory tests and field performance of the recommended structures for the purpose of clarifying certain design procedures and proving that the proposed structures operate satisfactorily and perform to the degreee intended.

Research of the type discussed above is continuing although results have been published and used for a period of years. Modifications, additions, or deletions of the general rules and limits are periodically required as experience is gained in using the material as a guide in hydraulic design. The continuing program will, therefore, be directed toward completion of Items (a) and (c) below, modification where necessary of Item (b) and starting or planning of Items (d) and (e).

(a) Baffled aprons or chutes
(b) Hydraulic jump stilling basins, flip buckets, impact basins
(c) Stilling basins for outlet works utilizing the hollow-jet valve for flow control
(d) Energy dissipators in a tunnel
(e) Stilling basin for submerged spillways.

Accomplished FY61

G. I. Report No. Hyd-445 covering the hydraulic design of baffled apron energy dissipators on 2:1 slopes, Item (a) above, was completed and is being duplicated and issued. This report also contains a photographic record of prototype experiences with this type of energy dissipator. Performance records and comments by field operating personnel prove that structures designed according to the rules given in Hyd-445 may be expected to perform satisfactorily. Two baffled aprons on slopes flatter than 2:1 (not covered in Hyd-445) were investigated to determine the baffle pier spacing required. Some data were obtained which indicate that the spacing may be increased. Data are incomplete, however, and the findings will be reported as a separate study.

Testing was continued to obtain dynamic pressure data on stilling basin appurtenances which are apt to produce cavitation and structure damage and on training walls subjected to impact forces. (These tests are a continuation of the material reported in Hyd-339, above.) Preliminary tests using piezometers to measure pressures were made on a typical chute block for a range of flow depths and discharges. The effect of tail-water depth for a given flow condition was also investigated. These tests indicate that incipient cavitation may occur at lower velocities and unit discharges than first anticipated. More data are required, however, to establish the limiting conditions for the use of chute blocks and baffle piers.

There is a recent trend (based on recommendations from hydraulic model tests) to eliminate right-angle wing walls used as a lateral support for the training walls at the end of a stilling basin. Eliminating the wing walls allows the tail water to form behind the training walls and results in better hydraulic performance and lower structure cost but increases the need for a better understanding of the dynamic forces acting on the training walls. Large instantaneous unbalanced forces may cause an improperly designed wall to vibrate or deflect sufficiently to cause failure. Several model stilling basins being tested primarily for other reasons were equipped with pressure cells and the instantaneous forces on as many as six points were recorded simultaneously on a six-channel direct writing electronic recorder. The data obtained

were analyzed and used to provide training wall design forces. Data from the several basins have been inspected and it appears that general design rules may be developed. More data will be required, however, before accurate general conclusions may be drawn.

A testing flume 3 feet wide by 3 feet deep and 15 feet long, having a glass observation panel 8 feet long, was constructed to study Item (c) above. Two 4-3/4-inch wide slide gates (one of which is an exact model and the other a good approximation of the Palisades-type gate) have been installed in the flume to provide flow controls for the side-by-side stilling basins to be developed. The gates discharge onto a sloping floor and the issuing jets are confined between diverging walls. Testing and development work has been started. Water surface profiles have been obtained for 25 and 50 percent gate openings for heads up to 12 feet, which represent a good start on the data needed. (Heads up to 50 feet and gate openings of 75 and 100 percent will be investigated.) Measuring techniques and a plan for evaluating the necessary variables have been developed but will probably require modification as the testing progresses.

During the testing of the Yellowtail Dam spillway flip bucket, hydraulically designed from the publication "Improved Tunnel Spillway Flip Buckets" and described above as an incomplete study, it was found that the method of introducing the flow into the bucket had some effect on the shape of the jet leaving the bucket and in the number of water particles (of considerable size) which became detached in midair from the main jet. Investigation and improvement of the entrance flow conditions provided additional design considerations necessary for supplying satisfactory flip buckets for use on tunnel spillways. More data than can be obtained from this single model will be required, however, to define limiting entrance conditions.

The impact-type stilling basin, a rectangular box-like structure discussed in Report No. Hyd-399 and usually constructed of concrete, was modified by hydraulic laboratory tests so that the rectangular concrete box could be replaced by a length of corrugated metal pipe. This made the basin suitable for use at the end of a highway drain pipe to prevent erosion of the earth embankment. Standard prefabricated stilling basins low in initial and maintenance cost therefore become practical for installation in many locations other than highways. Although only one basin, capacity 2 cubic feet per second, was tested and developed, the research points the way to future tests to develop a variety of basin sizes which can be prefabricated and installed at less cost than the rectangular concrete basins.

Scheduled FY62

G. I.--$

Testing and development will be continued on all subjects reported for FY61, assuming that time, opportunity, and funds permit. The data obtained for baffled aprons on slopes of 3:1 and 4-1/2:1 will be analyzed and recommendations made for baffle pier spacing on slopes flatter than 2:1. Further testing on an existing apron may be necessary before general rules can be formulated. Testing of chute blocks and baffle piers for incipient cavitation pressures will be continued, probably using pressure cells and the 6-channel recorder to obtain a continuous record of instantaneous pressure fluctuations. Data will be analyzed as it is taken to define more precisely the course of future testing. Pressure fluctuation on cantilevered stilling basin walls and the effects of entrance flow conditions on bucket jets will be continued if the opportunity arises on existing project models. Attempts will be made to generalize the data on hand and to correlate any new data with those on hand. Development of the stilling basin utilizing slide gate controls will be continued. Tests will first be conducted to correlate the Froude number of the gate discharge with gate opening and operating head. A basin type will then be developed and generalized.

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. Inconsistencies had been noted in regard to the heads and times required for priming in identical designs, and discharges often differed from design values by as much as 30 percent.

Two siphon spillways of conventional Bureau design were built to 1:4 scale. Extensive observations were made of pressures throughout the barrel, heads and times to prime, and the influence of different forebay rates of rise on general operation. Concurrently, a detailed study was made of technical literature to discover the progress of siphon development and to develop an improved design for testing. Earlier results were published in Hydraulic Laboratory Reports No. Hyd-108 and 335.

Following many attempts to improve the conventional design and the analysis of data from a prototype test, an improved design embodying principles of French and Italian structures was constructed and tested. Test data were anlyzed to formulate general design procedures for the improved siphon spillway.

The results of studies on both conventional and improved designs were reported in a technical paper published by ASCE. Field structures were reviewed for adaptability to prototype testing.

Accomplished FY61

Project Services--General. Test equipment was designed, fabricated, and shipped to the Hammond Project for permanent installation in an improved design siphon spillway on the Hammond Canal. Contacts were maintained with design engineers to make provisions on design drawings for installation of this equipment during contruction. Future field tests will include measurements of discharge, pressure, and priming times of the siphon.

Scheduled FY62

G. I.--$ None

Hydraulic Characteristics of Pipeline Distribution Systems and Related Structures

Pipeline distribution systems are being used more extensively in localities where cost of right-of-way acquisition is high and where the usual canal losses by seepage and evaporation make irrigation costly or infeasible. Often these systems operate under heads of more than 125 feet. The regulation of flow from the high-head systems introduces problems of dissipating the energy of high velocity jets before releasing the flow to the land; protecting the system components from cavitation, vibration, and water hammer; controlling surging; regulating pressure to obtain constant turnout deliveries; developing suitable and simple automatic regulators; determining hydraulic losses; and establishing entrance condition requirements. The information now available is scattered and inadequate for effective resolution of the problems.

Tests on small and moderate size waterworks valves have established operation and cavitation characteristics for moderate heads when the valves discharge into sudden enlargements. This information is presented in Report No. Hyd-337. Limited studies have been made using sudden enlargements for energy dissipation downstream from a valve operating with heads up to 400 feet. More general studies have been made with 3 orifices and a flow nozzle placed singly in a 3-inch pipeline and operating at heads up to 150 feet. The latter data were analyzed and published as a technical discussion in the Journal of Basic Engineering, ASME, March 1960.

Accomplished FY61

G. I.--Detailed studies at heads up to 550 feet were made of flow conditions near and downstream from 3 circular concentric orifices placed singly in a 3-inch-diameter pipeline. The orifice-to-pipeline diameter ratios were 0.327, 0.530, and 0.857. The cavitation indices, K, where cavitation was first audibly detected, were determined for three orifice-to-pipeline diameter ratios. A significant finding was that the K value for incipient cavitation for any tested diameter ratio remained constant regardless of changes in upstream head from low values up to 550 feet of water. Thus, cavitation indices established at normally available heads may be confidently applied to similar systems operating at very much higher heads.

Severity of cavitation directly affected pressure distribution along the pipeline downstream from the orifices. With incipient or very light cavitation, the pressure distribution was about the same as with no cavitation. However, as cavitation was intensified, the flow pattern changed and recovery of head did not begin until the flow had moved farther downstream in the pipeline. The amount of head recovery eventually achieved progressively decreased as cavitation increased and the energy losses, therefore, increased with more severe cavitation.

The coefficients of discharge for the three orifice-to-pipeline diameter ratios were not affected by cavitation when the coefficients were based upon downstream flange tap pressure measurements. The coefficients based upon pipeline pressures measured farther downstream changed appreciably as the cavitation increased. This phenomenon was directly related to the change in pressure distribution noted when cavitation became severe.

The velocity distributions in the pipeline at Stations 1, 2, 3, 4, 5, and 9 diameters downstream from the orifices were not greatly affected by slight or moderate cavitation. Further increases in cavitation severity caused a progressively delayed redistribution of the orifice jet into uniform flow in the pipeline. Most of this redistribution was accomplished in the relatively short distance of 4 to 5 pipeline diameters for all but the most severe cavitating conditions.

Attempts were made to determine the nature and frequency of the instantaneous variations of pressure on the pipe walls when cavitation was occurring within the fluid stream. This information would be invaluable in economically designing structures where these conditions will be occurring. Difficulties encountered with pump-induced vibrations in the laboratory system prevented obtaining

usable data. The transient pressure studies were deferred until tests can be made from a high-head water source, such as at Estes Powerplant, where the head is obtained by free fall from a reservoir.

Special instruments were needed to make velocity studies across the pipe passage downstream from the orifice and to make the transient pressure studies. A three-hole, cylindrical Pitot-static tube was constructed of 1/8-inch-outside-diameter and 0.017-inch-outside-diameter stainless steel hypodermic needle tubing. Suitable mounts and special bosses and seals were installed on the pipe to receive the tube. No electronic pressure cells suitable for the high heads and rapid pressure fluctuations of the flow system were available in the Denver Laboratories for measuring the transient pressure conditions. Three commercially produced cells of appropriate pressure ranges, frequency response, physical size and type of signal were purchased for the purpose.

The test data were analyzed, plotted, and readied for eventual use in publications.

Scheduled FY62

G. I.--$

A heavy-walled transparent plastic pipeline will be placed immediately downstream from the orifices so that the flow pattern with and without cavitation may be observed visually. Strobe-light still photographs and high-speed motion pictures with cyclic rates up to 3,000 frames per second will be taken to obtain permanent records suitable for publishing.

Studies will be made to determine the operation conditions when cavitation in the flowing stream causes no damage to the pipe walls. The studies will be extended to determine the nature and severity of cavitation erosion when wall damage begins to occur. The data obtained for the three specific orifice-to-pipe diameter ratios will be directly useful for design purposes for a range of diameter ratios.

A comprehensive report will be prepared on the studies of high-head orifices used in pressure conduits.

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 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.

Locations were established for piezometer orifices in the liner plates of the center rectangular bellmouth entrance of the Glen Canyon tunnel plug outlet works.

Accomplished FY61

Project Services--General. Translation from the German article, "Resistance to Flow in Branch Pipes," by Grass and Liith was reviewed, and the results were compared to previously published Bureau and British head-loss coefficients. This review showed wide disagreement in the magnitude of the coefficients. Since all were based on relatively small scale models and pipes and test data were not available for the translation, no definite reasons for the disagreement could be established.

Pipe designs for various structures proposed for construction by the Bureau were studied for possible installation of piezometers for measurement of head loss for design purposes.

Scheduled FY62

G. I.--$ None

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 any 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 published by ASCE. Further laboratory and field investigations are necessary to establish the effect of the physical characteristics of the gate setting on downpull force.

Downpull force data have been obtained on two of the service gates in the Palisades Dam outlet works. These results were analyzed, and a report is being prepared, including a summary of prototype tests made to date.

Limited data obtained from one model gate were analyzed and are contained in a discussion of a paper published by ASCE.

Accomplished FY61

Project Services--General. Preparations for prototype tests on the Navajo Dam auxiliary outlet and Glen Canyon Dam tunnel plug outlet gates were continued by making arrangements with designers to provide fittings in the control systems for connecting test equipment. Review of technical articles was continued and pertinent references on this subject were added to the file.

Scheduled FY62

G. I.--$ None

Air Demand of Gates and Valves in Outlets

The use of gates and valves for "in line" regulation of flow in closed conduits requires admission of air downstream from the controls to prevent severe subatmospheric pressures, cavitation, and vibration. Empirical relationships are currently used to determine the air-vent

size or the free air space needed above the flow to prevent these adverse conditions. The use of these present empirical relationships does not assure adequate aeration or the most economical design. Thus, further coordinated model and prototype testing is needed to develop and verify generally applicable and more realistic relations. Data obtained and analyzed by the Corps of Engineers are a help in this direction, but a wider scope of material is needed. To obtain part of these data, provisions have been made to install, during construction, a Pitot tube in the air duct of the Navajo Dam auxiliary outlet works.

Accomplished FY61

Project Services--General. Air demand studies were conducted on a laboratory model of the Trinity Dam auxiliary outlet works jet flow gate and a portion of its downstream conduit. Tests were made at heads of 10, 25, and 40 feet to provide data over a range of Froude numbers likely to occur on the prototype structure. Downstream conduit lengths of 3.7, 7.4, 11.2, 14.9, and 18.6 times the width were tested to determine their effect upon the air demand. In general, the demand increased rapidly with head, rapidly at first and then to a lesser degree with conduit length, and erratically with gate opening. The greatest demand occurred at 100 percent gate opening. The data were analyzed and expressed in dimensionless parameters and published in Laboratory Report No. Hyd-472.

Installation drawings of the prototype Trinity gate were studied and means were tentatively developed for installing air measuring facilities at the structure. When reservoir and downstream channel conditions permit, prototype tests can be made. Such prototype tests are an essential feature in the program to establish a correlation between model and prototype results. This relationship has not yet been established because of inadequate opportunity to obtain detailed model and prototype data on the same structure. After satisfactory relationships have been established, accurate air demand predictions can be made confidently from model studies of prototype designs.

Scheduled FY62

G. I.--$

Field conditions permitting, studies will be made of air demand at the Trinity Dam auxiliary outlet works and at the Navajo Dam auxiliary outlet. As soon as the Trinity prototype data become available, correlations can be attempted with the existing laboratory model data. In the case of the Navajo slide gate, piezometers and other flow measurement provisions have been

included in the construction of the facility. When prototype data from this structure becomes available, a detailed model will be installed to obtain laboratory data for the slide gate installation. Prototype data, presently on hand, of the air demand at the Shasta Dam jet flow gates will be evaluated. The existing laboratory model will be rehabilitated and tested to obtain parallel model data. Model prototype correlation of air demand at these structures will then be attempted.

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.

Laboratory studies have indicated that practical cavitation-free slot shapes can be provided for gates discharging at partial openings under high heads. These results were used in the slot designs of various outlet works gates and were published by ASCE.

Although a cavitation-free gate slot has been developed, additional prototype studies are necessary to confirm present design criteria for various slot sizes and gate settings. The data should be extended to permit the use of slide gates in high-head installations where danger of cavitation has thus far prohibited their use.

Information for piezometer orifices was prepared for specifications drawings of the tandem slide gates to be installed in the Navajo Dam auxiliary outlet and in the Glen Canyon Dam tunnel plug center outlet.

Accomplished FY61

Project Services--General. Delivery and installation schedules for the Navajo Dam auxiliary outlet gates have been followed, and plans were formulated for specially preparing the flow surfaces around the piezometer openings. Treatment of the flow surface has been delayed by late delivery and installation of the gates.

Scheduled FY62

G. I.--$ None

Instrumentation for Acquiring and Recording Hydraulic Data

Instrumentation for fluid mechanics research requires continual study to provide increased precision and detail of measurements. Many

instruments are developed by industry and research organizations, some of new principle and others new adaptations of well-known equipment. Many measurements are still curtailed by lack of adequate instrumentation and insufficient time to find methods of application to specific problems. The objective of this program is to provide at reasonable cost modern instrumentation for improving the quality and quantity of data obtained from laboratory and field studies.

Accomplished FY61

Project Services--General. Selection of 7 pressure transducers ranging in capacity from 2.5 to 500 pounds per square inch were made from specifications surveys. These and other available tranducers were used for dynamic pressure measurements in the Twin Butte outlet works, Fontenelle outlet works, Fontenelle spillway, surface irregularities and energy dissipation studies of sudden enlargements. Pressure transducers in the 0.1- and 0.5-psi differential range were used in the measurement of head loss caused by bridge piers and the velocity distribution in the air test facility for surface resistance coefficients of concrete surfaces. A small amount of information was obtained on the capabilities of the shear tube from surface resistance studies in the air test facility of the canal capacity studies.

Considerable literature was reviewed to assist in the evaluation of tape recording systems and new equipment developed by private concerns or offered by manufacturers.

G. I. Facilities developed for the evaluation of the dynamic response of pressure transducer and connecting systems were used to evaluate the pressure leads of project and research studies. These facilities and operating models in the laboratory were also used to extend knowledge of system response to cover normal laboratory pressure studies. A progress report draft of these studies was prepared and included curves and tables for interpretation of records.

A towing facility for rating and study of the performance of low velocity measuring equipment was installed and operated in the 30-inch laboratory flume. The usable velocity of the carriage ranges from a few hundredths of a foot to 2 feet per second although 5 fps is possible.

Study of the high frequency response total head tube disclosed the possibility of its use as a miniature hydrophone for pressure fluctuation studies. Availability of small ceramic transducers increases the fruitfulness of endeavor in this field.

Studies of technical publications and commercial periodicals materially assisted in improving our methods and adapting them to engineering problems.

Scheduled FY62

G. I.--$

Study of the dynamic response characteristics of pressure cell systems will be continued to establish curves and tables for use in interpretation of oscillograph records from laboratory studies.

Development and calibration of the SR-4, linear variable differential transformer, and thermistor velocity meters will be continued. A recently developed propeller-type meter of variable reluctance will be studied for possible application to laboratory studies.

Search for a tape system fitting the needs of the laboratory for recording transients beyond the capabilities of our direct-writing oscillographs will be continued.

Development of pressure-head tubes for direct measurement of shear and for high-frequency response to fluctuations will be continued.

Technical publications and manufacturer's information will be reviewed to determine the usefulness and adaptation of new instruments to laboratory and design problems.

Determination of Minimum-size Riprap for Channels

A better method of determining minimum stone sizes for riprap protection of riverbed and banks downstream from stilling basins or other discharge structures is needed. Many maintenance reports indicate that a common fault of existing structures is undersized riprap which has been moved or carried away sufficiently to permit excessive scour of riverbanks, bed, or both.

To temporarily fill the need for a sound method of determining proper stone sizes, data have been collected and analyzed in terms of prototype performance and general laboratory experience. This material is contained in Hydraulic Laboratory Report No. Hyd-409. The report suggests that the submitted curve, stone diameter versus bottom velocity, be used to determine the minimum stone size. However, data are needed to establish the effect of interlocking pieces, the effect of stone shape, the optimum percentage of minimum stone sizes in the riprap mixture, the effect of method of placement, and other variables encountered in the field.

Accomplished FY61

Project Services--General. Tests on riprap protection of channels downstream from typical culvert exit transitions were deferred because of more urgent work.

Scheduled FY62

G. I.--$ None

Friction Losses in Large Conduits

The predominant size-controlling factor in the design of large diameter conduits and tunnels is the resistance offered to the flow by shear of the solid boundary on the fluid at the interface. An increase in surface roughness produces an increase in shear forces and the conduit must be larger for a given discharge capacity. Numerous relationships have been developed to correlate experimental and theoretical analysis of surface resistance head loss in both small and large diameter conduits. However, there are still many areas of investigation required for correlation over complete ranges of operating velocities and corresponding Reynold's numbers.

Measurements of head losses and velocities in large conduits are more easily obtained when preparations are made during design and construction stages. Satisfactory methods of measurement and classifications of surface roughness have, so far, escaped the efforts of engineers. Full understanding of surface resistance on large conduit capacity requires a firm correlation with a reliable classification of surface roughness. Until such a classification system is developed, data must be obtained to cover general ranges of surfaces roughness produced by various construction methods and materials.

Accomplished FY61

Project Services--General. Friction loss tests of the Eklutna Tunnel were performed. These tests covered a Reynold's number range from 4.4×10^5 to 5.9×10^6 for the 9-foot-diameter concrete-lined tunnel. The test results have been analyzed and furnished to the Division of Design. Two plaster casts of typical tunnel flow surfaces were obtained during an inspection of the tunnel.

Four casts, description, and photographs of typical flow surfaces in the concrete-lined Fremont Canyon power conduit were obtained. Piezometers were installed in this conduit during construction for friction loss tests. Equipment was purchased for these tests and preliminary planning for equipment installation was completed.

Sixteen sample flow surfaces from Clear Creek Tunnel were obtained from the ends of 6-inch-diameter concrete cores removed from the tunnel lining. Piezometers were installed in this tunnel for friction loss measurements at some future date.

A literature search has been maintained on the subjects of friction losses and methods of identifying surface roughness. Some of this material may be valuable for revision of Engineering Monograph No. 7 to include test results obtained since this monograph was published. Twenty-six sets of large conduit friction factor data, not included in the monograph, have been tabulated and plotted.

Scheduled FY62

G. I.--$

A test program and nessary equipment will be prepared for friction loss measurements on the Fremont Canyon power conduit. There is a possibility that a turbine acceptance test will not be performed at the Fremont Canyon Powerplant and a discharge calibration of the turbines will not be available. Revision of test plans and equipment requirements, therefore, may be required. If water is available and power operations of the plant can be satisfactorily scheduled, the friction loss tests will be performed. Other funds are scheduled to cover the cost of field tests. The test results will be analyzed and prepared for publications.

Information from current technical reports and periodicals will be analyzed and pertinent data compiled for a revision of Engineering Monograph No. 7. The search will be continued for suitable means of measuring and expressing the surface roughness of construction materials normally used in conduits. Plans and details for installation of test facilities for measuring friction losses in suitable conduits during the design period will be prepared in cooperation with the designers.

Specifications Finishes and Tolerances for Irregularities and Misalinements in Concrete Surfaces Subjected to High-velocity Flow

Many spillway and outlet works structures have concrete surfaces over which water flows at high velocities. Irregularities and misalinements, if permitted in these surfaces, may cause regions of vapor pressure which will produce cavitation damage to the flow surfaces. Adequate control of surface irregularities, therefore, is necessary.

The lack of information concerning the cavitation tendencies of these various surface irregularities has resulted in the adoption of close

tolerances and stringent specifications for concrete finishes. The surface treatment necessary to meet these specification requirements often proves costly. This costly treatment can be reduced substantially by a relaxation of the specifications. A thorough knowledge of the cavitation tendencies of various irregularities is needed to ascertain whether or not a relaxation is possible. This knowledge can be obtained in the laboratory using water tunnel test facilities. Representative joints, humps, offsets, depressions, etc., can be placed in the test apparatus and subjected to high velocity flows and low pressures. The pressure-velocity combinations producing incipient cavitation can be determined and the critical cavitation index obtained for each of several sizes of the various irregularities.

Preliminary tests on sharp 90° offsets, protruding into the high velocity stream, have been completed and are reported in Hydraulic Laboratory Report No. Hyd-448. Limited tests also were conducted on several beveled into-the-flow offsets to determine their cavitation characteristics.

Attempts have been made to study the cavitation potential of offsets away from the flow, but the existing laboratory water tunnel proved inadequate for this type of testing.

Accomplished FY61

G. I. Tests were completed on various into-the-flow offsets with beveled or chamfered edges on slopes varying from 1:1 to 1:24. The studies were extended to determine the cavitation potential of various offsets with rounded corners. The height of offsets with beveled or rounded corners ranged from 1/8 to 1/2 inch. From these tests, tables or charts will be developed from which permissible tolerances for any particular pressure-velocity combination may be selected for most irregularities found in concrete surfaces of hydraulic structures.

A preliminary study was conducted to determine the relationship of offset shape and the maximum cavitation cloud size at which cavitation damage will not occur. These preliminary tests, although inconclusive, indicate that mild cavitation may be tolerated on some surface irregularities.

Preliminary tests also were conducted on shapes representing joint filler material protruding into the flow.

The above-mentioned studies were conducted in a water tunnel with a test section 3 inches in depth. The boundary layer thickness and degree of development of the turbulent boundary layer probably affects the pressure-velocity relationship for incipient cavitation. To minimize these boundary effects, a larger test facility having a 6-inch depth of water over the test surface is needed. Plans and shop drawings for this new test facility were completed.

Scheduled FY62

G. I.--$

The new test facility with a 6-inch test section will be fabricated and installed. Photographic records and visual evaluation of the cavitation cloud for various irregularities will be made through a large window in the side of the test section.

Test results on beveled and rounded offsets conducted during FY61 will be evaluated. Certain tests on square, beveled, and rounded offsets will be repeated in the 6-inch test facility to evaluate boundary effects and to confirm that the test results are applicable to prototype conditions.

Tests to determine the damage potential of mild cavitation for various irregularities will be continued. Tests on shapes representing protruding joint filler material will be completed.

The test program will be extended to include an evaluation of the cavitation potential of grooves or construction joints both parallel and normal to the direction of flow. These results will be included in a progress report.

Side Spillways

There have been demands in recent years for design information relating to side spillways. 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 to 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 would include 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).

Available information for both (a) and (b) needs to be extended and reduced to a form readily usable for design by (1) an analysis of all

available technical literature on the subject, (2) correlation of data previously obtained in the laboratory, and (3) extension of the available data by means of hydraulic model testing.

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.

Accomplished FY61

Project Services--General. Material from previous laboratory model studies was gathered for correlation studies, and pertinent references were added to the files. Additional data were obtained from a model study of Fontenelle Dam spillway.

Scheduled FY62

G. I.--$ None

Air Requirements for Tunnels and Siphons

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 to be exhausted from the system.

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, may collect under substmospheric pressure at the 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, it must 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. Obviously, the estimate must be on the side of safety and may result in a costly structure.

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 results for design use.

References and pertinent data have been reviewed, and assistance regarding tunnel freeboard and rate of air ejection from pipes in irrigation systems was given to designers.

Accomplished FY61

Project Services--General. Locations for field tests to measure rates of accumulation of air in siphons were studied. Since automatic pumping systems have been installed on the siphons at the ends of the Grand Coulee Pumping Plant discharge lines for removal of accumulation of air, this site was tentatively selected for field tests. A file on the subject was kept current by addition of new references.

Scheduled FY62

G. I.--$ None

Crest and Transition Section for Morning-glory Spillway

The best available hydraulic design information for morning-glory spillways is applicable only to structures which are so located in the reservoir that the approaching flow is radial with respect to the circular spillway crest. These design data were obtained from tests on a sharp-crested circular weir and have been published in the 1956 ASCE Transactions.

Seldom, if ever, are radial approach conditions encountered and information is needed to modify the ideal spillway shapes for safe and economic use on spillways where tangential rather than radial approach flows exist.

Spillway profiles used by others and published in the technical literature have been analyzed and the various features such as profile shape, diameter, air demand, operating head, and discharge capacity have been compared. In many instances, costly oversized crests have been used to prevent the spillway from submerging and/or forming an undesirable siphon head in the shaft with resulting cavitation pressures.

Laboratory research has been started to solve some of the design problems. One morning-glory crest was constructed and tested in an existing facility and the data used, along with data from five profiles investigated during the Trinity morning-glory spillway model studies, to gain further background as to the best method of attacking the problem.

Future research will be directed toward establishing design criteria which can be used to obtain a minimum spillway profile consistent with safe and satisfactory performance.

Accomplished FY61

Project Services--General. In constructing the Whiskeytown Dam morning-glory spillway model, now undergoing tests in the laboratory, provisions were made to study the effects of tangential flow as a research problem after the project tests had been completed. Twelve radial rows of piezometers, twelve to the row, were installed in the spillway crest to measure pressure differences caused by various combinations of radial and tangential approach flows.

Topography near the morning-glory crest was made removable so that tests may be made with truly radial and truly tangential flows to be compared with semitangential flows. Preliminary sketches were made of topographical features which affect the spillway approach, such as the sloping face of an earth dam or a hillside at various distances from the spillway. The investigation will include the effect of different approaches on the spillway discharge coefficients, the operating head to spillway diameter ratios, and the spillway profile pressures.

Scheduled FY62

G. I.--$

The existing morning-glory spillway used in the Whiskeytown Dam tests will be tested with various arrangements of topography to evaluate the effects of tangential approach flow. For various approach flow depths and typical obstructions to radial flow in the area adjacent to the spillway, the 144 piezometers in the spillway will be read to determine the pressure changes resulting from changes in approach flow characteristics; depth measurements over the crest line will be taken at intervals around the crest and correlated with the pressure measurements and the distance to the adjacent boundaries; and, if time permits, attempts will be made to generalize the findings for use in designing a morning-glory spillway.

Waves in Canals

Erosion of canal banks by wave action creates a costly maintenance problem. The canal becomes hydraulically inefficient and unsightly. Studies have been conducted in canals on four projects in coordination with the Lower-cost Canal Lining Program, using anenometers, staff gages, and camera equipment. Some phases of the testing program have been examined in the laboratory where control of variables is easily accomplished.

Accomplished FY61

G. I.--Hydraulic Laboratory Report No. Hyd-465, "Progress Report 1--Bank Erosion Due to Surface Waves in Canals," was completed and issued. This report included prototype wind and wave data from canals on four Bureau projects and the results of laboratory erosion tests of earth material from Driftwood Canal, Nebraska.

Similar laboratory tests of earth material from Kennewick Main Canal, Yakima Project, were conducted. These data were compiled and analyzed for inclusion in a future progress report.

Field equipment for measuring velocities and direction of wind and heights and frequencies of waves was installed on Driftwood Canal.

The amount of erosion on the banks due to waves was also measured. Because the wind velocity was insufficient during the FY61 tests to correlate the measured variables, the equipment will be reinstalled and the tests repeated during the 1961-1962 irrigation season. These tests will be conducted under the Lower-cost Canal Lining Program.

Scheduled FY62

G. I.--$ None

Discharge Coefficients for Radial Gates

Radial gates are used extensively on spillways and in irrigation systems to control rates of flow and water surface levels. Normal and flood regulation from storage and diversion dams are affected by the hydraulic characteristics of these gates. Intelligent and orderly operation of the systems normally requires that the rate of flow passing the gated structures be known to a relatively high degree of accuracy.

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, and an empirical solution is necessary.

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); and (7) orientation of the structure with respect to the approaching flow. If there are no separating piers between gates, other questions arise.

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 by ASCE in 1959. This paper indicates that progress has been made, but that further testing and analyses are necessary to establish general design criteria.

Further analytical studies of unsubmerged radial gates were made, utilizing the available data on gates, discharges, and gate-setting shapes. An equation was developed for determining discharges through a partially open gate taking into account the numerous variables. Use of this equation has provided discharge quantities which agree very closely with those obtained by laboratory calibration. Further verification of the formula is required, however, over a greater range of gate and structure shapes than is presently available. This can be accomplished by hydraulic model testing using a large radial gate. Drawings of a model of a test radial gate to be installed in the large 4-foot flume in the Hydraulic Laboratory are complete.

A thesis entitled "Discharge Characteristics of a Taintor Gate on a Spillway," by Zynowij Miroslav Glowiak, was obtained from the University of Iowa. Material in the thesis will assist in evaluating the importance of variables involved.

Accomplished FY61

Project Services--General. Model tests were deferred because of more urgent work.

Scheduled FY62

G. I.--$

Progress on this project will be dependent to some degree on completion of the baffle pier and chute block pressure study described in "Hydraulic Jump and Energy Dissipators," since both are scheduled for testing in the same glass-walled flume. Construction of the gate will be completed for installation in the 4-foot flume or another test flume. Testing will be initiated to obtain data for checking the proposed formula and extending the scope of presently available information.

Boundary Shear Studies

Problems concerning the design of noneroding channel embankments in a variety of soils are referred to the laboratory for study and recommendations. A laboratory method to quickly determine boundary shear values is greatly needed. It is proposed to design and construct a laboratory apparatus to readily obtain this type of information. The test facility will consist of a short recirculating flume in which velocities and depths can be varied. Velocity distributions will be measured in a straight reach and boundary shear values computed therefrom.

The flume will be calibrated in such a manner that boundary shear values can be determined quickly from hydraulic measurements.

Samples of prepared and undisturbed earth materials from canals and other channels will be tested at various moisture contents to determine their critical resistance to erosion.

Accomplished FY61

Project Services--General. A short recirculating flume was designed and constructed in the laboratory. Instruments and testing equipment were assembled or constructed in preparation for initial tests.

Scheduled FY62

G. I.--$

After the flume has been calibrated, tests will be conducted on soil samples from existing canals in the field. Samples will include various classes of cohesive materials to obtain test data on a range of typical soils. Test data will be plotted to develop general curves for correlation with prototype and other available data. General design criteria for earth canals will be developed.

Canal Capacity Studies

Designing large canals is a complex problem where the head loss is affected by the important factors of size, shape, and grade and the cumulative effects of lesser factors such as structures, crossings, inlets, turnouts, checks, and other local items. Although the specific quantitative effect of each factor is not accurately known, the design procedures developed over a number of years and applied by engineers with broad experience gave acceptable results.

Recent experience indicates design procedures used successfully for determining the capacity of small and medium sizes of canals are not adequate for large concrete-lined canals on comparatively flat grades.

Tests have demonstrated a capacity deficiency of approximately 20 percent. Consideration of the deficiencies led to a decision to review and evaluate the adequacy of current design practice and to consider the need for research and testing to develop improved methods of determining flow resistance. The program evolved has the following objectives:

1. Develop explanations of the observed hydraulic behavior of canals known to be deficient in capacity.

2. Develop hydraulic design procedures for interim use while field and laboratory studies are conducted.

3. Develop a comprehensive field and laboratory research effort to acquire data to provide a firm basis for refinement of design procedures.

Initial studies will be primarily concerned with concrete-lined canals with a later extension to include earth canals and closed conduits.

Accomplished FY61

Project Services--General. Technical assistance was provided project offices in Regions 1 and 2 for conducting prototype tests. Equipment was prepared and supplied for measurement of water surface levels and velocity distributions in test reaches of selected canals. Prototype data obtained from tests were analyzed to compute surface resistance and structure head loss coefficients. A propeller-type current meter system, including recorder, was purchased for making simultaneous velocity distribution measurements in vertical planes across prototype canal sections. This equipment was satisfactorily operated in the laboratory but has not yet been used in the field.

Laboratory investigations of the resistance coefficient for various bridge piers were carried out for use in design requirements. A laboratory test facility using air as the fluid was constructed and tested to obtain surface resistance coefficients of typical concrete surfaces. Velocity distributions and head loss measurements were used to evaluate the coefficients. One concrete surface of wood float finish was studied.

A letter of inquiry concerning current hydraulic design practices for large concrete lined channels was prepared jointly with the Canals Branch and sent to 29 organizations throughout the world. Information received in reply to this letter is being summarized and current literature was examined to learn of new developments in the field of open channel hydraulics.

Scheduled FY62

G. I.--$

Technical assistance and equipment will be provided for scheduled tests in Regions 1 and 2 for large concrete-lined canals. These tests will be directed toward evaluation of the first 30 miles of the Delta-Mendota Canal after the recent cleaning and the Trail Lake Reach of the Main Canal of Columbia Basin Project. Tests on the Madera Canal and the Friant-Kern Canal of the Central Valley Project will also require data analysis.

Laboratory studies of boundary surface resistance coefficients in the air test facility will be extended and correlated with analyzed results from the field. Laboratory pier loss tests will be completed and a report finished to summarize the results and compare them with field measured values.

As requested, assistance will be provided to the Central Valley Project in the measurement of structure losses of bridges on skews and curves. Data will be analyzed from the Delta-Mendota and Friant-Kern Canals as applicable to specific capacity deficiencies. Field measurements of skew-bridge waves for model prototype correlation will be requested. Development of equipment and techniques will be continued to supplement the slope and water surface gages presently being used in field measurements.

As information is derived from laboratory and field portions of the overall program, progress reports will be written for use of field and design division personnel in establishing tentative design criteria.

Standardization of Design of Small Canal Structures

Canal systems contain many small structures such as drops, turnouts, wasteways, overshoots, culverts, transitions, and bifurcations. Velocities of flow are usually low as compared with large structures, but efficient energy dissipation and proper flow distribution are essential to prevent undercutting at the structure and damage in the downstream canals. Head losses at most of the structures should be a minimum for economical operation. Proper design is important because the large number of structures involved in a system may mean that poorly operating or uneconomical designs are repeated many times.

Model studies have been made on a number of individual designs, but because the structures operate under such a wide range of conditions, standardization of designs is not yet possible. An orderly program of laboratory studies to achieve this standardization is progressing. Broken-back-type inlet and outlet transitions for connecting canals to

pipelines and culverts have been studied. Modified broken-back designs incorporating short closed-conduit expansion sections were also studied. Eventually, a field test program to verify the laboratory results will be included. A part of the data was published as a University of Colorado thesis for a Master's Degree for a Canals Branch engineer.

Accomplished FY61

Project Services--General. A transition structure consisting entirely of a closed conduit expanding section terminating in a headwall normal to the canal was constructed and tested in the laboratory. Tests with the structure serving as an outlet showed that the energy losses were reduced to a value of only one-tenth of the difference in velocity head from the pipeline to the canal. This loss is but one-sixth of the value measured with the more conventional open, broken-back-type transitions. Velocity distribution studies showed that the flow patterns were reasonably good at the transition outlet and additional tests showed that the scour in the unlined canal section was somewhat less than that found with open transitions.

Tests were also made with the structure serving as an inlet. The performance was entirely satisfactory and energy losses of about 0.4 of the velocity head difference were the same as those obtained for the conventional open transitions.

Data obtained in the velocity distribution studies with outlet flows indicated that the rate of sidewall expansion of the closed transition should be reduced from 6-1/2° relative to the centerline to about 5°. This change is expected to provide equally good retardation of the flow and recovery of head and to produce an even more economical structure. The less divergent transition was constructed and installed in the laboratory model and made ready for testing.

A progress report on the entire series of inlet and outlet transition studies was started.

Scheduled for FY62

G. I.--$

Detailed studies will be made of the revised transition operating as an inlet and outlet. Energy losses, scouring tendencies on the canal sideslopes and invert, and velocity distributions at the structure inlet and outlet will be determined. The first tests will be made with the pipeline approaching the transition horizontally. A second series of tests will be made with the pipeline approaching

on a 2 to 1 upward slope. After the comparative scouring tendencies of the transitions have been obtained and evaluated, tests will be conducted to determine minimum riprap sizes for a range of velocities in the transitions. The progress report on all the transition studies to date will be completed.

G.A.E.--$

Sediment Control at Diversions

Diversion of water from streams with alluvial beds into irrigation canals presents difficult problems. One important problem concerns the necessity of conducting the streambed sediment material through the dam structure and preventing its entry into canals to avoid costly removal by other means.

Designs of several diversion structures have been developed to cause the maximum amount of river bedload to pass through the sluiceways and bypass the canals. Both intermittent and continuous sluicing methods have been investigated. The types of sediment-excluding facilities developed and tested include: (1) curved guidewalls approaching the headworks and sluiceways, (2) short tunnels upstream from headworks and sluiceways, (3) overhanging sills and other specific devices at the entrance to headworks, (4) bottom and surface guide vanes, and (5) other sediment-control devices such as the vortex tube.

The development and hydraulic model testing of the headworks and sluiceways of some of the structures are reported in Hydraulic Laboratory Reports Hyd-275, -316, -384, -385, -419, and -451.

A paper on sediment control structures was published in the Proceedings, Minnesota International Hydraulics Convention, September 1953.

Accomplished FY61

Project Services--General. Tests using project funds were completed on the hydraulic model simulating the Socorro Main Canal headworks at San Acacia Diversion Dam. Three arrangements were tested: (1) bottom guide vanes upstream from the existing headworks; (2) a siphon with sediment blowoff under the low-flow channel; and (3) a flume over the low-flow channel with a sediment sluice into the channel. The third arrangement was constructed at San Acacia Diversion. Hydraulic Laboratory Report No. Hyd-479, describing these tests, was compiled.

Research was continued in the same test facility using surface guide vanes for sediment control at the headworks. Tests were made using 3 lengths of 4 vanes arranged at 5 depths below the water surface, at 3 angles with respect to the channel wall, and in 3 positions with respect to location of the canal headworks.

Field data were obtained on Woodston, Bartley, Superior-Courtland, and Cambridge Diversions showing total sediment transport and division of sediment load between headworks and sluiceway. Two diversions had curved guide walls, the third had curved guide walls with an overhanging sill, and Cambridge Diversion had no sediment control other than a sluiceway. Total sediment transport is being computed from data using the Modified Einstein Transport Formula and the IBM-650 Computer. Bedload is being computed using several bedload formulas. The results are being compiled in a report.

Scheduled FY62

G.A.E.--$

Tests will be continued to further develop the optimum shape, location, number, and spacing of bottom and surface guide vanes for use in controlling sediment at diversions. These data will be compiled and arranged in general form for application to future designs.

A field study is planned to check the effectiveness of a short-tunnel type of control arrangement. This study will include sampling of sediment loads passing through the sluiceways and those entering the headworks.

Stable Channel Shapes

Straight Channels. Research studies to improve design of unlined and earthlined canals have been made during the past several years. Data were collected from previous studies of field canals operating in noncohesive earth materials. These data were analyzed with other laboratory and field data to develop a theory utilizing critical tractive forces of noncohesive material combined with shape characteristics of canals to assist in design. Laboratory and field results and the development of the tractive force theory for design of canals are given in Hydraulic Laboratory Reports No. Hyd-325, -352, -358, -366, and -393. Two papers have been published, one in the Proceedings of Minnesota International Hydraulics Convention, 1953, and another in ASCE Transactions, 1955.

Studies have been concentrated in recent years on canals built in cohesive earth materials as a part of the Lower-cost Canal Lining Program. Field tests have been made on test reaches selected in five regions to determine erosion characteristics and the tractive forces (or shear) that produced erosion.

Undisturbed and sack samples obtained from each test reach were subjected to shear tests in a hydraulic shear testing tank and 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 soil tests with critical or starting erosion values for use in designing future canals in cohesive materials. General Laboratory Reports No. 21 and 22 have been issued and include data from Laboratory Reports No. Hyd-435, "Progress Report of Canal Erosion and Tractive Force Study--Lower-cost Canal Lining Program," February 1958.

Accomplished FY61

Project Services--General. Progress Report No. 3, "Canal Erosion and Tractive Force Study (Correlation of Laboratory Test Data)," was reviewed and issued as General Report No. Gen-26. This report was prepared in coordination with the Lower-cost Canal Lining Program and is also listed as Hydraulic Laboratory Report No. Hyd-464. The laboratory test data in the report included the critical tractive force as measured on a shear testing machine, the plasticity index, density, shrinkage limit, vane shear value, percent maximum density, and gradation analysis of the soil samples. Multiple linear correlations were made utilizing the IBM-650 Computer. One hundred and four correlations were made from the data plotted in zones parallel to the A line on the plasticity chart and by using various arrangements of the variables.

Possible test reaches were selected to establish a field test facility on Farwell Main Canal, Nebraska, which is currently being designed. From soil tests of samples obtained from the field, final selection of test reaches was made. Three test reaches (one designed to remain stable, one overdesigned, and one underdesigned to erode), will be built during regular construction of the new canal.

Scheduled FY62

G.A.E.--$

The three test reaches will be designed and built during regular construction of Farwell Main Canal, Nebraska. Instrumentation will be planned and assembled for tests when water is first delivered in the new canal. Data will be obtained to check laboratory results and to determine the correlation between field observations and laboratory results.

Curved Channels. Maintenance on curves of canals has been a problem for many years. In trapezoidal earth and earthlined canals, scour on the outside and deposition on the inside of curves have increased the cost of maintenance. Recommendations have been made to shape the canals in such a way as to reduce this scour and deposit. Research studies have been started, including collection of data from field canals and constructing a hydraulic model in the laboratory to determine the various forces involved as water moves around curves in canals, and to study the effects on scour and deposit by changing the canal shape or direction of the flow currents. Recent observations in the field have indicated that 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 symmetrical sideslopes of regular trapezoidal shape.

A trapezoidal test flume, 50 feet in length and with one to four curved sections, has been constructed for curved channel tests.

Accomplished FY61

Project Services--General. Because of priority work the hydraulic testing flume constructed for the curved channel tests was used for bridge pier tests. The flume was refurbished and instruments for measuring shear and velocity distributions were designed and partially fabricated. Additional literature was obtained and reviewed, including a recent study at a technical university. Additional information was obtained from operating projects concerning problems of scour and deposition on canal curves and maintenance being performed to keep channels in good condition.

Scheduled FY62

G.A.E.--$

Measurements of velocity and shear distribution will be continued in the hydraulic flume. Studies will be made to check results obtained from fixed-bed flume tests in another laboratory. After completing the fixed-bed model tests, the movable-bed material will be used to further study the mechanics of scour and deposition. Various changes in cross section and devices to direct the flow will be tested.

Channelization and Bank Protection

Use of steel jacks and jetties for bank protection and channelization has been studied during the past few years. Steel jacks and jetties have been installed in local areas on rivers to protect highways, bridges, railroads, etc. Through the use of two hydraulic model studies, formulas and graphs have been developed for use in choosing economical layouts for jetty fields. A fixed-bed, open-channel model was utilized to determine relationships between depth, Froude number, density, and number of lines of steel jacks, and velocity reduction and recovery downstream from the lines of steel jacks. Another hydraulic model study was made, simulating a prototype layout of Casa Colorada area on the Middle Rio Grande River. An unpublished paper gives results of the early model studies.

Tests have been made on the movable bed model to verify data obtained in the field, to extend the range of discharges, and to determine the deposition and scour characteristics of the jetty field. After completing the series of tests on the Casa Colorada model, the movable bed distorted model was modified. The walls of the model were changed to provide almost constant width of the jetty field channel and flood plain. To make the results more generally useful tests were made with steel jack tiebacks, spaced from 250 to 500 feet, and with the discharge ranging from 5,000 to 15,000 cfs.

Project Services--General. Data obtained from tests conducted on the hydraulic model and data furnished from the field were analyzed. Additional relationships were obtained from these data and a recommended procedure for designing jetty fields was developed. Hydraulic Laboratory Report No. Hyd-477, "Hydraulic Model and Prototype Studies of Casa Colorada Channelization," which includes the data obtained from the model studies and field measurements was reviewed and issued.

Scheduled FY62

G.A.E.--$

Additional data will be obtained from field installations on the Middle Rio Grande Project. The data will be correlated with the hydraulic model studies.

Weed Control by Shading with Sediment

A study has been conducted in coordination with the weed control research to determine the effectiveness of suspended sediment in reducing growth of water weeds. The study was started after reports had been received that sediment had been jetted from Angostura Reservoir for the purpose of reducing weed growth in Angostura Canal. In several published reports, statements indicate that suspended sediment in canal systems has reduced water weed growth. Details of concentration and type of sediment or types of weeds are not known. Research has been conducted to answer questions concerning control of water weeds.

Tests have been made on three types of pondweeds, using three different concentrations of commercial sodium-base bentonite and natural-occurring bentonite-type sediment obtained from Angostura Reservoir. The suspension was maintained by pumps mounted on the sides of 55-gallon drums, equipped with specially designed apparatus to maintain various concentrations of sediment in suspension.

To evaluate the growth response of the plants to shading by sediment in two different growth stages, both ungerminated plant propagules and established cultures were exposed to the environments of suspended sediment concentrations.

Solar radiation measurements made with a limnophotometer indicated that intensity and spectral quality of light were considerable in water containing suspended sediments. The reservoir sediment was more effective in reducing radiant energy levels at much lower concentrations than the commercial bentonite.

Data from this study indicate that low concentrations (50 to 100 ppm) of suspended sediment create sufficient shading to produce significant growth reductions of submersed aquatic plants. In general, however, the amount of growth reduction noted would not be considered critical to the survival ability of the plants. The data showed that sediment concentrations greater than 1,250 ppm would be necessary to affect their survival ability. Maintaining concentrations of fine sediment above 1,250 ppm, by weight, in most canals appears generally unfeasible.

Accomplished FY61

Project Services--General. Hydraulic Laboratory Report No. Hyd-450 (Gen-27), "Some Effects of Suspended Sediment on Growth of Submersed Pondweeds," was duplicated and distributed.

Scheduled FY62

G.A.E.--None

No further studies are contemplated during FY62.

Relating Suspension and Scour of Sediment to Channel Hydraulic Characteristics

It would be extremely useful to be able to predict the size of sediment that will go into suspension when the hydraulic characteristics of a water channel are known. This information is needed to solve problems of scour and deposition of sediment, particularly at diversions. The first part of the study is planned to include a search and compilation of field data such as can be found in the water supply papers of the Geological Survey. The size and concentration of sediment found in suspension will be related to functions of 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. Relationships which can be made from available field data will be checked in the flume study. The flume will be used to fill in areas where field data are lacking. One of the main points to be determined is the depth that a confined open channel will reach when water flows on an alluvial bed and when the size and gradation of the sediment and the hydraulic characteristics of the flowing fluid are known.

Accomplished FY61

Project Services--General. Data were obtained and analyzed from published sediment studies and from one unpublished study. The data were arranged and trial correlations were made.

A tilting flume was designed and plans drawn. The hydraulic system will be capable of recirculating water and sediment.

Scheduled FY62

G.A.E.--$

If preliminary correlations of existing data show promise of producing usable relationships, complete correlations will be made using the IBM-650 Computer.

The tilting flume will be constructed and tests will be started. The flume data will be related with correlations developed from existing data.

Equilibrium Beach Profile in Reservoirs with Noncohesive Earth Materials

Very often Bureau reservoirs are located in areas of noncohesive sandy materials. The equilibrium beaching slope of the reservoir banks becomes an important consideration in purchasing rights-of-way for the reservoir site. Such variables as height and frequency of waves and large fluctuations in water surface are determining factors in establishing the equilibrium slope of a beach. Considerable information on equilibrium profiles of ocean beaches is available in current literature. However, additional information is needed to adapt these data to the wide range of sandy materials found in reservoir banks.

Accomplished FY61

This is a new study to be started in FY62.

Scheduled FY62

G.A.E.--$

A study will be made in the Hydraulic Laboratory wave flume to determine the parameters from which equilibrium profiles of future reservoir beaches can be predicted. Four or five uniform sands will be tested at different wave heights and frequencies to obtain initial data.

G.A.E.--$

Constant Head Orifice Turnout

The constant head orifice turnout is used in place of the more common turnout-weir combination. This device has the advantage of not requiring the numerous adjustments and walking involved in using the gate-weir combination.

Questions concerning the effect of changes in physical features of the structures on the calibration have arisen repeatedly in recent years. Some questions have been answered, although with reservation and restriction, resulting in design changes which approached a new standard. Many questions remain to be answered.

A 1:2 scale model of a 24-inch slide gate turnout was constructed and testing has been completed.

Accomplished FY61

Project Services--General. Data analysis was continued in preparation for completion of the report. These test data formed a basis for answering numerous design questions.

Scheduled FY62

This study will be completed as a part of "Turnout Gates."

Critical Depth-measuring Device

The need for standardization and calibration of a critical depth-measuring device is evidenced by continued inquiries from design and field personnel. The Parshall flume has been calibrated and documented in use, but its rectangular cross section is not always readily adaptable to the trapezoidal section of canals and laterals without expensive transitions. This study is for the purpose of better defining the needs and exploring the development of a flume with a section shape compatible with canal design. Current and past literature describing methods of measuring irrigation water by devices of this nature was studied for application to current problems in water measurement. The Agricultural Research Service, using facilities of the Colorado State University Hydraulic Laboratory, is developing flumes for this purpose. One report "Trapezoidal Flumes for Open Channel Flow Measurement," dated in 1958, shows that progress is being made on this problem.

Accomplished FY61

Project Services--General. A paper "Unification of Parshall Flume Data," by Sydney Davis, Visiting Associate Professor, Cornell University, was obtained and reviewed. This paper appears to be a notable attempt to combine the individual flume calibrations under one series of graphs and equations. Further investigation of the effect of varying the side angles or bottom angle is suggested for perhaps not more than three flume sizes. Such an investigation may confirm the generalizing equation derived from the study. Search of literature sources was continued to provide references and to determine the necessity for a Bureau study of these devices.

Scheduled FY62

This study was transferred to "Study of Measurement Structures and Methods Producing Minimum Head Loss."

Weirs Having Velocity of Approach

Errors in water measurement with weirs are caused by a number of factors, including the depth of water and velocity distribution in the pool upstream from the weir. As the velocity of approach to the weir notch increases with a decrease in water depth caused by sediment filling the pool, serious inaccuracies are incurred in measuring the discharge. The purpose of this study is to rationalize the probable effect of the increased velocity and changed velocity distribution on the discharge.

Accomplished FY61

Project Services--General. Literature reviews were kept current and publications were used to assist in providing weirs for inflow-outflow discharge measurements of seepage losses. A 3.5-foot weir, 1-foot high with full contraction on the blade and partial contractions at the vertical sides, was rated in the laboratory 4-foot glass-sided flume. A memorandum report was prepared to compare the capacity curve of this weir with the head-discharge curves of standard suppressed weirs and fully contracted weirs..

Scheduled FY62

G.A.E.--$ None

Turnout Gates

In general, the measuring devices used in the irrigation systems in the United States do not control the flow. To accomplish measurement and control of the flow at a turnout from a water conveyance, a gate or similar control must be provided. If this control could also serve to measure the flow, economy would result. For this reason, there has been an increasing interest in the use of single- and multiple-gate turnouts, available commercially, but accurate knowledge of their measurement capabilities and operational limitations is lacking. Past years of investigation have yielded calibration and other pertinent data on meter gates, Hydraulic Laboratory Reports No. Hyd-314 and Hyd-471. The devices studied are only a minor part of such available equipment. General studies on the influence of headwall and approach channel design on capacity and performance of gated pipe entrances have been made and are reported in Hydraulic Laboratory Report No. Hyd-422.

References to a number of gate calibrations have been obtained, and analysis of the data will probably show important gaps that must be bridged by laboratory studies.

Accomplished FY61

Project Services--General. Hydraulic Laboratory Report No. Hyd-471, describing the results of capacity, accuracy, and operational limitations of one type of screw lift gate was issued. Results of the 36-inch gate calibration by the Salt River Valley Water Users' Association were not received, and thus incorporation of the results in general form with other available data was deferred.

Scheduled FY62

G.A.E.--$

Reporting of the constant head orifice turnout study, deferred because of more urgent work, will be completed. Search will be continued to obtain information on reliable gate calibrations for inclusion in a generalization of characteristics.

Analysis of Devices for Design

Experiences of the Bureau of Reclamation have shown an intense need for adequate measurement and accounting of irrigation water for the best utilization and conservation of this resource. In addition to accuracy, there is need for economical standardization with simplicity of design for construction and operation.

To simplify the selection of water measurement devices and bring about a standardization of the devices developed in the past with those now in prominence, the relative merits of each have been compared to form a source of information.

Accomplished FY61

Project Services--General. Turnout gate reports completed during the year and reports on adjustable and compound weirs were analyzed to determine their relative merits.

Scheduled FY62

G.A.E.--$

Information acquired from laboratory studies, field investigations, discussions with design branches, and from literature review will be used to assist design groups in determining the capabilities of measurement devices.

Compound Weirs

Many water measurement devices are located in remote areas; they must operate over a relatively large range of discharges with an acceptable degree of reliability. Weirs combining conventional and reliable shapes have been used to extend the range of discharges for which a single measuring device will give accurate measurements. Literature research disclosed very little information on discharge relationships for compound weirs. From the meager information of this search, it was concluded that a compound "V" notch weir might be the most readily adaptable device for measurement of a larger flow range.

Accomplished FY61

Project Services--General. Analysis of data from studies of five compound weirs was completed. The test weirs included a 1-foot deep, 90° V-notch weir combined with (1) vertical sides above the notch, (2) level crests 2 feet and 1 foot in length at the sides of the notch, and (3) 15° upward sloping crests 1 foot and 2 feet in length. A report draft of the investigation results was completed.

Scheduled FY62

G.A.E.--$

Change of discharge characteristics prevents extrapolation of the capacity curves for crest lengths larger than those tested. Further study will be made to find a method of extending the rating curves. The report will be finished and published on completion of the extrapolation analysis.

Adjustable Weirs

Many adjustable weirs are in use on irrigation projects, and more are being installed at water division and terminal points in distribution systems. These weirs having an adjustable crest height are used for raising surface levels for upstream water delivery and for measurement of water passing over them. In many instances, more than one adjustable weir is used at a division point. Under these circumstances, the placement of the weirs and the selection of the proper points for head measurement become important problems. Laboratory investigations were undertaken to better define the hydraulic conditions controlling the flow through single and multiple combinations of these weirs.

Accomplished FY61

Project Services--General. Analysis of test results on a 2-foot commercially produced adjustable weir were finished. A report draft was completed and will be published.

Scheduled FY62

G.A.E.--$

Study of Measurement Methods to Improve Water-loss Records

Importance of good measurements in an irrigation system may not be fully appreciated by all who are responsible for dispatching water. One must be aware of what constitutes acceptable practice and steps necessary to improve accuracy for more equitable distribution and conservation of water. To improve measurement conditions, ultimately raise the quality of measurements, and to provide reliable water use figures, an educational and assistance program is indicated. Preliminary discussions disclosed that a school might not produce as much benefit as actual measurement and recording of water use by improved methods. Water use figures would be assembled and made available to various planning, design, and operation offices.

This program plans for more accurate determination of system seepage loss and waste and for a compilation of water use figures. The 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 and consumptive use figures, the need for further action would be determined.

Accomplished FY61

Information was added to this phase of the program by application of our present knowledge to the inflow-outflow method of discharge measurement. Data furnished from two sites (one in the North Platte Project of Wyoming, and one in Kansas River Projects, Kansas) were used in determining the problems that arise from a study of losses on an extensive length of canal and lateral systems. Work on the preparation of information questionnaires was curtailed because of emphasis on other phases of the water measurement program.

Scheduled FY62

G.A.E.--$

Results available from past application of principles involved in measuring continuous water loss from an operating canal-lateral system will be analyzed. Requests for copies of operating records will be made to assist in selection of a system where improved devices could be installed to evaluate the accuracy of water-loss measurements.

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 necessary to answer these questions.

Accomplished FY61

Project Services--General. Files were maintained and abstracted for use in bibliographies.

Scheduled FY62

G.A.E.--$ None

Small Flow Measurement Devices

Interest increased in devices for measuring discharges considerably smaller than normal flow rates as evidenced by writings of universities and Government organizations. From searches made during the year, there appears to be little information on the subject, but several studies are being pursued.

Accomplished FY61

Project Services--General. Additional information was obtained from a review of a progress report of studies by the California Agricultural Experiment Station, University of California, Davis, California. The studies covered the hydraulics of surface irrigation systems and the report briefly described progress in the study of the titration methods.

Scheduled FY62

G.A.E.--$

Studies will be extended and applied to specific project requirements as established. Development of measuring equipment to meet these requirements will follow.

Control Notches

In recent years, multiple- and single-notch controls have been installed in many canals for various purposes. Since the notches normally are designed to form a control in the conveyance, the possibility of using these devices for water measurement should be evaluated. Also, more information is needed to determine whether or not operation of these structures is satisfactory.

Accomplished FY61

Project Services--General. Work on the study was curtailed because of emphasis placed on other phases of the water measurement program.

Scheduled FY62

G.A.E.--$

Records of operation and calibration data will be requested for known installations of control notches, and report will be prepared.

Dethridge Meter

The Dethridge meter is a device for obtaining a positive self-integrating measurement of delivered water. It has particular application to measurement of deliveries of irrigation water from open channels. The meter consists of an undershot water wheel working with small clearances in a short, specially-shaped flume that forms the outlet for supply. The discharge rate is controlled by a sluice gate at the flume entrance, and the quantity of water discharged in any period is recorded directly in acre-feet by a specially-geared revolution counter linked to one end of the axle of the wheel.

Accomplished FY61

Project Services--General. A Hydraulic Laboratory Report summarizing available information on this device was prepared for duplication. The report will provide ready access to material for answering of questions.

Scheduled FY62

G.A.E.--$ None

Study of Measurement Structures and Methods Producing Minimum Head Loss

The need for measurement methods that produce accurate discharges and a minimum of head loss is evidenced by continued inquiries from design and operation personnel. The means of measurement may be a structure or a flow additive detected by equipment external to a sensing element in the canal prism. The Parshall and trapezoidal flumes are structures representative of devices producing a minimum of head loss. Although the Parshall flume is rated and documented in use, much remains to be done on the trapezoidal flumes.

Newer methods of using radioisotope tracers are in an experimental stage and possibly offer discharge measurements not obtainable with any other device. Sonic and electromagnetic devices offer fields of investigation to determine possible applications to open and closed conveyance discharge measurements.

Considerable interest was evident during the year in the capabilities of tracer methods of discharge measurement. Several papers on the total count method of measurement were acquired and reviewed in an effort to keep informed. References were also sought describing the "integrated sample" method of radioisotope measurement. This method is more closely associated with the chemical methods of measurement and may be subject to similar limitations of proper sampling.

Accomplished FY61

This new listing is a broader study combining "Critical Depth-Measuring Devices" with other methods of measurement including radioisotope, sonic, and electromagnetic devices.

Scheduled FY62

G.A.E.--$

Greater effort will be concentrated on understanding radioisotope, sonic, and electromagnetic methods of discharge measurement for application to Bureau structures. Continued contact will be maintained with organizations developing new approaches to the use of critical depth-measuring devices, such as trapezoidal and Parshall flumes.

D. LOWER-COST CANAL LINING PROGRAM

Canal Sealants

Chemical Sealants

During the period May 23 through June 4, 1960, a representative of the Engineering Laboratories observed procedures and assisted in the conducting of seepage control tests, using Chemical Sealant SS-13 in the flowing water of the Indian Bend pump lateral of the Salt River Project. The object of the tests was to evaluate, quantitatively, the effects of the seepage rate of applying the sealant to the 2-mile test reach. The test was conducted by the Bureau of Reclamation, the Salt River Valley Water Users' Association, and Arizona State University through cooperative agreements. During treatment, flow in the lateral was checked to obtain the approximate depth for the normal flow of about 20 cfs with a flow of 7 cfs. Treatment was for a 24-hour period, using an application rate of 1,000 ppm of SS-13. Post-application seepage rates were to be measured by the inflow-outflow and ponding methods.

On June 24, 1960, representatives of the Denver Office observed a field test of SS-13 in the Bowles Seep Canal near Hudson, Colorado. The work was accomplished by the Farmers Reservoir and Irrigation Company, with the Soil Conservation Service furnishing personnel to obtain engineering data. The canal in the test reach had about a 6-foot bottom width and a depth of flow of 30 cfs of some 2 feet. Throughout most of its length, the canal traverses sandy soil, much of it being blow sand. Operating records indicate about a 60 percent loss of water from the canal. Effects of the chemical sealant were determined by placement of two dikes to isolate a reach 1,350 feet in length and ponding between the dikes. Sufficient SS-13 was added to provide a concentration of about 1,000 ppm. The test was made under an agreement with the Tudor Equipment Company, Denver, who supplied the chemical, and the irrigation company. The agreement provided that if the chemical did not reduce the seepage by 60 percent, the irrigation district would not be billed for the chemical or the treatment expense. If 60 percent of the water was saved, the company was to pay about $2 per gallon for the 250 gallons of chemical used. From data furnished this office, it was reported that 7 hours after treatment, losses had been reduced by 56 percent, and 24 hours after treatment, the loss was further reduced to 64.3 percent. Additional tests are to be made in the spring of 1961 by the irrigation company to determine the effective life of the sealant. The cost of treating this relatively small section of canal (1,350 feet) was reported as 39.1 cents per linear foot. Gradation tests on samples of soil from the canal have been conducted,

and the information made available to the Farmers Reservoir and Irrigation Company, Hudson, Colorado, and to the Soil Conservation Service, Fort Lupton, Colorado.

A draft of the University of Idaho report on SS-13 tests, conducted last year near Notus, Idaho, was reviewed and returned with comments to Region 1. Although the results of these tests will be reported on more fully by the Region 1 or a University of Idaho representative at the annual meeting, the following brief summary of results is given.

The seepage rates determined by the University of Idaho during June of 1960, for Lateral 10.2 bypass were 1.09 cfd for Pond A and 1.39 cfd for Pond B. This compares with a rate of 0.99 cfd for Pond A and 1.86 cfd for Pond B during August of 1959 before SS-13 was applied. It shows a reduction in seepage of about 25 percent for Pond B and no reduction for Pond A after approximately 1 year had elapsed after initial SS-13 treatment. Before the June 1960 ponding tests were made, a thin layer of silt was removed by hand from both ponds and the surfaces were hand raked. Pond A had been treated with gypsum to increase the canal water hardness to approximately 1,000 ppm before initial treatment with SS-13. The gypsum did not seem to increase the sealing ability of the SS-13.

The seepage rates reduced to a low value of 0.61 cfd for Pond A and 0.81 cfd for Pond B during October of 1959. These values were measured during a period when a thin silt layer was on the perimeter of the canal. The seepage values before the silt layer accumulated, as measured in August of 1959, were 0.87 cfd for Pond A and 1.31 cfd for Pond B.

Hydraulic Laboratory flume tests were conducted with approximately 1 foot of head of water over fine sand placed to a depth of 12 inches on a 6-inch reverse filter in the flume, with the test section 12 inches wide and 6 feet long. Seepage measurements were conducted on the untreated sand. The cationic asphalt emulsion was then added and mixed with water. Penetration of the asphalt emulsion into the sand was observed through a glass-walled section of the flume. Seepage measurements were taken at various time intervals to establish sealing effectiveness of the asphalt emulsion. Flume tests, involving four different formulations of asphalt emulsion, were made under both static and flowing water conditions. Results of the tests indicated that, with an application rate of 1/2 gallon of asphalt emulsion per square yard, seepage was reduced as much as 93 percent. An average penetration depth of 7 inches was obtained. However, it was determined that most of the sealing developed in the first (top) inch of asphalt emulsion-penetrated soil. No erosion of the treated surface was observed, with water flowing at 3.6 feet per second velocity.

Waterborne Canal Sealant Tests, Eden Project, Wyoming

Representatives of the Chemical Engineering and Hydraulic Laboratory Branches assisted Eden Project personnel in the application of a chemical sealant and the measurement of seepage losses before and after the application in the West Side Lateral. The objectives of the tests were to demonstrate the feasibility of the application method and to determine the sealing effectiveness of the chemical.

Project personnel installed rectangular contracted weirs in six selected check structures over a 6.6-mile reach of the lateral. Each weir was provided with a staff gage and a water surface recorder. Distances between weirs varied from a minimum of approximately 3,000 feet to a maximum of approximately 12,000 feet according to canal stationing.

Chemical sealant was discharged from tank trucks directly into the canal flow in the stilling basin of the check structure containing the first weir. To obtain the maximum benefit from the sealant, the canal water surface had been checked to provide flow depths above design operating levels for maximum discharge in the various reaches between weirs. The sealant flowed with the water through the test reach and to the end of the lateral for a total distance of approximately 7.3 miles.

Seepage losses were measured for two conditions of flow. Before sealant was applied to the canal, discharges were measured at each of the six weirs to establish the loss in the selected reaches for depths near operating levels. The canal depth was then increased by placing stop logs in all check structures except the ones containing the first and last weirs. Overall water losses in the 6.6-mile test reach were then measured before and after application of the sealant. The canal was unchecked and measurements were repeated for depths near operating levels with flow over the six weirs.

Objectives of the tests were satisfactorily completed through the excellent cooperative efforts of project personnel. Data analysis is in progress and results indicate that the sealant used shows promise for future use. Seepage losses were reduced by more than 50 percent.

Seepage Measurements and Loss Detection

Improvement of Seepage Test Methods

During the period October 4-6, 1960, a representative of the Engineering Laboratories assisted Region 4 personnel in establishing a program of seepage loss measurements in Gateway Canal, Weber Basin

, and in conveyances on Eden Project, Wyoming For , canal, inflow-outflow tests at a reduced discharge, using weirs for flow measurements, were proposed for developing techniques and determining seepage loss rates. These tests were scheduled to be conducted during the past winter. Seepage measurements proposed for Eden Project will be deferred until next fiscal year in order that the LCCL Committee can complete and coordinate the program.

Portions of the Kirwin Main Canal in the Solomon Division, Missouri River Basin Project, Kansas, were selected for tests to improve the test procedure for increased accuracy of the inflow-outflow type of seepage tests. During the period September 28-29, 1960, a representative of the Hydraulic Laboratory inspected this canal to assist in selecting suitable test reaches for the inflow-outflow tests. He also conferred with personnel in the Kansas River Projects Office concerning seepage loss tests and electrical logging tests previously made on this canal and helped plan the test program. The tests included: (1) inflow-outflow tests at a reduced discharge, using weirs and check observations made with current meters; (2) ponding seepage tests in two reaches of the canal; and (3) seepage meter observations at about 12 locations, in addition to extensive seepage meter data available from previous observations. Regional personnel have been active in obtaining and reporting on the required seepage measurements, and this phase will be covered by the Region 7 LCCL representative.

For some time, there has been a need for standardization of procedures used in making tests by the commonly used methods to determine seepage losses from conveyances, quantitatively. During the year, a report, Hyd-459, "Measuring Seepage Loss in Irrigation Canals (Tentative Procedures for Ponding and Seepage Meter Tests)" was completed and reproduced. Adequate data are not presently available to write similar tentative standards for the inflow-outflow method.

Detection of Seepage by Electrical Logging Methods

Preliminary tests with the electrical logging equipment, modified for canal use, were made on a large soil sample which could be subjected to seepage conditions in a laboratory flume early in April 1960. The purpose of these tests was to try out electrodes and logging equipment designed for canal use and to obtain some idea of the changes in electrical logging records which would be obtained by varying seepage conditions in the flume. The tests also demonstrated that natural voltage measurements in logging are related to seepage. This was shown by the fact that when a petcock at the bottom of the laboratory flume was opened and water was seeping through the sand in the flume, a strong natural voltage was measured between electrodes on the surface of the sand by the logging equipment.

During the period from April 21 through 29, 1960, two Denver Office representatives traveled to the Central Valley Project, California, to conduct electrical logging tests on canals for seepage determinations. With the assistance of regional personnel, a total of 5,600 feet of canals was logged at the Madera Reservoir and on the Madera, Contra Costa, and Putah South Canals. On these tests, both resistivity and self-potential of canal bed materials were measured, with the Bureau-adapted bore-hole logger equipment acquired from the Atomic Energy Commission. As a result of these tests, it was concluded that self-potential can be measured in canals and that the quantity is known to be related to the movement of water through porous media. This, together with the potentialities of the methods for investigating and recording the resistivity characteristics of materials along a canal, which are affected by moisture, indicated that the method had promise of being effective for identifying seepage localities.

After a preliminary field trip on August 17 through 19, by a representative of the Denver Office to the Kirwin Main Canal in Kansas, it was decided that electrical logging tests on this canal would be coordinated with seepage measurement tests also planned for this canal. Therefore, during the period September 6 through 14, 1960, two representatives of the Denver Office, assisted by project personnel, conducted electrical logging tests on selected reaches of the Kirwin Main Canal. A total of 26 electrical logs was completed, which covered 9 different reaches of the canal in a total of 4-1/2 miles. A study of the electrical logs and data on conditions along the canal indicated that in a number of reaches, through both lined and unlined sections, there were only small variations in measured resistances and in self-potential. Evidence indicates that such reaches showed little leakage. Along three reaches, however, there were sections where the logs exhibited a very large and rapid change in self-potential from point to point. There is evidence that such large variations indicate leakage. Specifically, at 36 locations, comparisons with seepmeter meter readings and the interpretation of the electrical logs were possible. At these locations, the logs were interpreted as indicating tight reaches in 25 cases and these predictions were verified in 24 cases. The electrical logs were interpreted as showing seepage in 11 cases and the interpretation was verified at 9 locations.

The conducting of seepage measurements mentioned above and the electrical logging tests on the same canal reaches permitted valuable correlation and comparison of all these tests. The proposed program on Kirwin Canal, which is now virtually completed, yielded the most completed data that have been gathered from any one canal study thus far, under the Lower-cost Canal Lining Program.

The program this year, for detecting seepage by electrical logging methods, has been supported jointly by the Lower-cost Canal Lining and Soil and Moisture Conservation Funds. One field experiment, supported by funds mainly from the S&MC Program, is planned for the Tucumcari Project, Region 5 in May 1961. A representative of the Denver Office has made a preliminary trip to this project to prepare for the electrical logging tests that are to be made there.

Canal Silting

Supported by a Region 7 LCCL fund item, the Denver Office has assisted in the selection of test reaches and water evaluation measurements and in analysis of data for the canal silting work conducted on the North Platte Project in Wyoming. The silting is financed largely by Soil and Moisture Conservation Funds.

The selection of a test section was accomplished during April 18 through 23, 1960, by Region 7 representatives assisted by a representative of the Engineering Laboratories. As the result, in cooperation with regional personnel, a reach of the Interstate Canal, extending from the outlet of Rawhide Creek Siphon (Milepost 28.0) to a bridge near the Wyoming-Nebraska State Line (Milepost 50.8) was selected as the primary reach for the tests. A reach of the same canal from Mile 2.7 to 28.0 was selected as a secondary reach. Recommendations were made on the improvement of water-measuring devices to insure an adequate evaluation of water loss before and after proposed sediment runs. The procedures for obtaining the best water measurements were discussed. Also, the locations of sediment sampling sites were selected.

The methods and devices being used to obtain flow measurements in the test reach of canals and at numerous turnouts were inspected during the period July 6-8, 1960. A number of suggestions was made to insure accuracy of all discharge observations. These inspections were carried out during a period when clear water was flowing in the system. Sediment sampling procedures, selected stations, etc. were inspected during the same period by a representative of the region.

On July 14-15, a second inspection was made when reservoir water behind Guernsey Dam was drawn down to move reservoir sediment into the canal system. At this time, the technical aspects of the test program were explained to officials of the irrigation districts.

On August 16-17, a representative of the Hydraulic Laboratory again visited the North Platte Project to assist project and regional personnel in the selection of a reach of the Fort Laramie Canal for

investigation during the 1961 irrigation season for the silting and seepage investigations on this project.

Included in the analysis of silting and water measurement data was a comparison made between the bottom-withdrawal tube method and the Jackson turbidimeter method of determining concentrations of the sediment samples taken during the last season. The Jackson turbidimeter method was a rapid method used by project personnel on many samples. The bottom-withdrawal tube method was the method used in the laboratory here (laboratory testing done with S&MC Funds) on a few selected samples, where a more accurate determination could be made. The concentrations determined by the bottom-withdrawal tube method are generally lower than the concentrations determined by the turbidimeter. However, there was a definite trend of the two methods which seemed to be quite good, considering that the Jackson turbidimeter method is an approximate method for determining concentrations in parts per million by weight. The comparisons made of the two different methods will be of value in coordinating future field and laboratory procedures for silting operations on the North Platte Project.

Wave Erosion of Canal Soils

During June to October 1960, a representative of the Hydraulic Laboratory, assisted by Project personnel, set up wave and wind measuring equipment on the Driftwood Canal near McCook, Nebraska, in Region 7. The purpose of this field installation was to record the effect of wind waves on the silty loessial soil, a sample of which had been used in previous tests in the Hydraulic Laboratory flume containing wave generation equipment. This would permit an attempt to be made to correlate the tests of the laboratory flume and the field tests. The instruments installed were an anemometer, a weather vane, and a wave height and frequency recorder. Project personnel operated this equipment to record wind velocity, wind direction, and to sample wave heights recorded periodically. They also obtained cross sections of the canal bank in the vicinity of the wave measurements to periodically record the amount of soil erosion.

The data obtained from this field test have now been received and were analyzed to determine the relationships between wind velocity and direction, wave heights, and rate of erosion of the canal bank.

Wind direction and velocities were recorded from July 19 to September 13, 1960, except for 22 days during intermittent intervals when no recording was obtained because of technical difficulties with the recording equipment.

Sample recordings of surface waves were obtained on 10 different days during the 1960 irrigation season. These wave records varied in length from 9 to 25 minutes and will be used to correlate wind velocities and direction and wave heights. Significant wave heights (average height of highest one-third of the wave) have been determined and plotted with wind velocity for all the wave recordings. Because the canal water surface varied during the irrigation season and due to discrepancies in the rod and level and slope-board methods of measuring cross sections, difficulty is being experienced in determining rate of erosion. The amount of erosion is also rather small, due to the low wind velocities and short wind durations experienced during the season.

Erosion and Tractive Force Study

On the field and laboratory investigation to correlate the performance of soils in unlined and earth lined canals with the soil characteristics and the hydraulic conditions, a third progress report has been compiled and distributed. This report primarily consists of an analysis of laboratory test data. Since the report was written, some simple and some multiple correlations have been attempted between some of the soil properties and the soil resistances as measured in the laboratory erosion machine.

At this stage of the investigations, it is considered desirable to design some canal reaches with the erosion and tractive force investigation in mind in order to test the validity of the results gathered so far. For this, six reaches have been tentatively selected on the proposed Farwell Canal of the Missouri River Basin Project in Nebraska. Project personnel have been requested to submit soil samples from these reaches for laboratory tests. Based on the results of the soil tests, three of the six reaches will be selected and designed so one reach would be expected to remain stable, a second reach would be underdesigned, (expected to erode) and a third reach overdesigned.

E. TABLE OF RESEARCH FUND SOURCES FY61

Nonreimbursable Funds (GI)

Hydraulic jump and energy dissipator studies
Pipeline distribution system
Concrete surface irregularities
Instrumentation for hydraulic data
Erosion of earth slopes

Project Services General Funds

Hydraulic Laboratory investigations--general
Sedimentation studies
Water measurement studies
Canal capacity studies
Lower-cost canal lining studies

F. DEMINERALIZATION RESEARCH

Assistance to the Chemical Engineering Laboratory Branch in the Water Demineralization Program was composed of the design of an operating unit for installation of the Ionics Mark II-4 membrane stack. Design of the unit included a portable mounting platform suitable for transportation by truck trailer, a complete circulation system for the electrode and demineralization membrane cells, an instrument panel, description and purchase of equipment necessary for the installation and partial supervision of the construction. The installation of the membrane stack was essentially completed.

A limited amount of work was performed on the analysis of test data for cell development. This analysis was necessary for discussion with representatives of the Washington and Denver Office saline water group.

G. PROPOSED RESEARCH WITH FOREIGN CURRENCY

RESEARCH PROPOSAL H-2

Free Fall Drops in Open Channels

In canals or channels of irrigation systems, it is often necessary in steep terrain to lower the grade of the system. This is usually accomplished by means of free fall drops which lower the water in open channels to a lower elevation and dissipates its surplus energy. There is need for general criteria for designing these structures for different heights of fall, discharges, and shapes of conveyances.

This research study would be conducted to develop an economical drop designed to maintain normal water surface levels and velocity distribution in the upstream channel and to develop an effective energy dissipator at the base of the free fall drop. Variables to be considered in the study would include different sizes of rectangular, trapezoidal, and semicircular channels; vertical and sloping drops of various heights; and different energy-dissipating devices at the base of the drop. The energy dissipator may contain baffle piers, end sills, or other appurtenances to increase the effectiveness and reduce the length of the structure.

The research study would include a search of literature to determine present knowledge of the subject. An annotated bibliography with abstracts in English would be prepared. The literature search would be followed by hydraulic model tests which would be governed by the results of the literature survey.

The investigation would be directed toward defining the hydraulic losses in the structure and deriving relationships between critical dimensions of the drop structure and the energy dissipator. Various designs would be evaluated by measuring the velocity distribution at sections throughout the structure and the extent of erosion in the downstream channel. Dimensions of the structure and its appurtenances would be derived in a dimensionless form and related to height of fall, discharge, and Froude number or velocity. The data would be presented in a form that can be applied readily to design a structure for a given discharge and height of drop.

Facilities required for the laboratory study would include a pump or gravity water supply system; flow rate measuring devices for discharges up to 10 second-feet; suitable instrumentation to measure flow depths, velocity distribution, and channel bed erosion; and photographic equipment for still and moving pictures.

A comprehensive report of the studies, including the bibliography, would be prepared in English.

RESEARCH PROJECT H-2 (A)

Title: Free-fall Drops in Open Channels

Country: India

Institutions:

1. River Research Institute, West Bengal,
   Haringhata Central Laboratory,
   P. O. Mohanpur, District Nadia, West Bengal
2. Irrigation and Power Research Institute, Punjab
   (Laboratory at MalakpurPathankot)
   Amristar
3. Irrigation Research Institute
   Uttar Pradesh, Roorkee
4. Engineering Research Laboratories
   Government of Andhra Pradesh
   Red Hills, Hyderabad-Deccan
5. Mysore Engineering Research Station
   Krishnarajsagar, Mysore State
6. Irrigation Development Division
   Poona 1, Bombay
7. Central Water and Power Research Station,
   Bombay Road, Poona 3, Bombay
8. Irrigation Research Station
   Poondi (via Trivellore)
   Chlingleput District, Madras State
9. Indian Instute of Science
   Bangalore 3, Mysore State
10. Hirakud Research Station
    Ministry of Irrigation and Power
    Hirakud (Orissa)

Personnel:

For 1 above

1. B. Maitra, Director
2. Dr. N. K. Bose, Ex-Director and Advisor

3. Suresh Nath Sarkar, Assistant Research Officer

4. D. C Midha, Research Officer

5. G. Sinha, Engineer

6. P. B. Roy, Engineer

7. H. R Pramanik, Engineer

For 2 above

1. Dr. H. L Uppal, Director

2. Dr. C. L Dhawan, Physical Chemist

3. M. M. Lal Malhotra

4. Jagir Singh, Engineer

5. S. Singh, Engineer

6. T. D. Gulhati, Hydraulic Officer

For 3 above

1. Rameshwar Saran, Director

2. N. K Dwivedi, Research Officer

3. S. P. Garg, Research Officer

4. G. C. Agarwal, Research Officer

5. B. M. Seoni, Research Officer

For 4 above

1. R.K.V. Narasimham, Director

For 5 above

1. D. Doddiah, Research Officer
   S. D. Madai Gowda, Assistant Research Officer
   M. D. Shamanna, Assistant Research Officer

For 6 above

1. P. A. Joshi, Executive Engineer

For 7 above

1. M. G. Hiranandani, Director (spent period May-September 1957 as ICA observer in United States)
2. D. V. Joglekar, Retired Director and Advisor
   C. V. Gole, Chief Research Officer
3. S. V. Chitale, Chief Research Officer
4. Dr. G. T. Wadekar, Research Officer
5. S. D. Phansalkar, Research Officer
6. S. C. Desai, Research Officer
7. S T. Chotankar, Engineer
8. S. K. Guha, Engineer
9. S.D.L. Luthra, Engineer
10. P.M. Damle, Assistant Research Officer

For 8 above

1. P. K. Kandaswamy, Executive Engineer

For 9 above

1. N. S. Govinda Rao, Professor
2. K. Seetharamiah, Professor
3. N. V. Chandrasekhara Swamy, Professor
4. B. Prabhakar Pai, Professor
5. A. S. Rama Murthy
6. N. S. Lakshmana Rao
7. K. R. Pattabhiramiah
8. D. S. Srinivasa
9. A. Thiruvengadam

10. B. P. Singhal

11. H. C. Radhakrishna

12. D. N. Contractor

13. N. Dwarkanath

For 10 above

1. S. N. Buru Rau, Research Officer

References:

For 2 above

1. H. L. Uppal and S. Singh, A new method of recording instantaneous pressures and forces, Proceedings of the Sixth General Meeting, The Hague, 1955, International Association for Hydraulic Research, Vol. 2, Paper B1

For 3 above

1. Designing downstream protection works below tail falls of Sarda Sagar Feeder Canal for increased discharge of 5,000 cu sec

2. Design of downstream works below fall at mile 5-0-330 of Jani Escape

3. Design of downstream protection works below four falls of Hardoi Branch

4. Design of downstream protection works below falls at miles 4-0-234, 6-2-299, and 8-5-196 of Harder Branch

5. Design of downstream protection works below Babail Fall on Eastern Yamuna Canal

6. Design of downstream protection works below Bailka Fall on Eastern Yamuna Canal

7. Sarda type canal falls (vertical drops)

1 to 7 above Pages 185-187, Hydraulic Research, 1956, Vol 14, International Association for Hydraulic Research

For 5 above

1. D. Doddiah, Design of a combined relieving weir and silt ejector for irrigation and drainage systems, Proceedings Third Congress on Irrigation and Drainage, San Francisco, 1957, International Commission on Irrigation and Drainage, Question 9, Part II, Paper R21

For 7 above

1. D. V. Joglekar and S. D Phansalkar, Hydraulic structures on irrigation and drainage systems for measurement of water, Proceedings Third Congress on Irrigation and Drainage, San Francisco, 1957, International Commission on Irrigation and Drainage, Question 9, Part II, Paper R19

2. Anonymous, A comparative study of the working of the canal fall designs (Montague and baffle types) sent by the Damodar Valley Corporation, Annual Bulletin, 1955, International Commission on Irrigation and Drainage, page 106

3. Protective works and flow conditions in spill channel. (Experiments on single and double fall design.) Hydraulic Research, 1958, Vol. 14, page 209, International Association for Hydraulic Research

RESEARCH PROPOSAL H-2 (B)

Title: Free-fall Drops in Open Channels

Country: Pakistan

Institution: 1. Irrigation Research Institute, Punjab, Lahore

2. Hydraulic Research Laboratory East Pakistan, Tejgaon, Dacca

Personnel:

For 1 above

1. Mian Muzaffar Ahmad, Director

2. Nazir Ahmad, Physicist

3. S. L. Shah, Assistant Research Officer (Physics)

4. Mushtaq Ahmad, Research Officer (Hydraulics)

5. Sh. Vadood Ahmad, Research Officer (Hydraulics)

6. S. A. Awan, Research Officer

7. Mohammad Abdul Hamid

8. R.F.T. Farrant

For 2 above

1. M. A. Rahman, Officer in Charge

References:

For 1 above

1. Nasir Ahmad, Mechanism of erosion below hydraulic works, Proceedings Minnesota International Hydraulics Convention, 1953, Minneapolis, Minnesota, A joint meeting of the International Association for Hydraulic Research and Hydraulics Division, ASCE, page 133

2. Mohammad Abdul Hamid, R.F.T. Farrant, and Mushtaq Ahmad, Air entraining devices and their use in correcting flow conditions at weirs and canal falls, Proceedings Minnesota International Hydraulics Convention, 1953, Minneapolis, Minnesota, A joint meeting of the International Association for Hydraulic Research and Hydraulics Division, ASCE, page 519

3. Mushtaq Ahmad, Effect of scale distortion, size of model bed material and time scale on the geometrical similarity of local bed scour, Proceedings Sixth General Meeting, The Hague, 1955, IAHR, Vol. 4, Paper D4

4. Mushtaq Ahmad, Mian Muzaffar Ahmad and S. A. Awan, Automatic regulator to obtain constant discharge in a channel for a widely varying income flow. Proceedings Third Congress on Irrigation and Drainage, San Francisco, 1957, International Commission on Irrigation and Drainage, Question 9, Part II, Paper R5

RESEARCH PROPOSAL H-3

Sediment Exclusion at Diversions

Numerous devices, such as guide walls, vortex tubes, short tunnels, headworks sills, bottom and surface guide vanes, and artificial islands, have been used to exclude sediment from canal intakes at diversion dams on alluvial streams. The type and arrangement of devices are usually determined from hydraulic model studies of a specific structure. Some model studies have been combined and analyzed, but a general analysis of all studies has never been attempted. More knowledge is needed to evaluate and design efficient devices for reducing the amount of sediment entering a given structure.

The research study would include the analysis and compilation of data in published reports on sediment-exclusion devices, to determine gaps and limiting criteria, and to develop general criteria for designing sediment-exclusion devices at canal intakes.

Following the literature search and analysis of existing data, one of the most promising sediment-excluding devices would be chosen for laboratory testing to establish its basic relationships and characteristics. For example, the vortex tube could be studied to determine optimum shear conditions to establish the vortex, range of bottom sediments for which the tube is most efficient, and discharge ratio as a function of efficiency and sediment size.

Studies would be conducted for various shapes and sizes of vortex tubes to establish efficient depths and velocities of flows over the tubes. Sediment with a uniform gradation from fine sand to gravel would be added to the flow, and efficiency of the vortex tube would be determined by measuring concentrations and gradations of materials bypassing or entering the tube. Basic relationships of flow conditions, tube size and shape, and sediment size and concentration would be developed.

Facilities required for such a laboratory study would include a water supply system with a discharge potential of 8 second-feet, a sediment-feeding device, a flume (minimum length of 100 feet) for conducting tests, sampling equipment to obtain water and sediment discharge, equipment for determining mechanical analysis of sediments, accurate discharge measuring devices, and photographic equipment.

A comprehensive report, including a bibliography and covering theoretical analyses and laboratory studies, would be prepared in English.

RESEARCH PROPOSAL H-3

Title: Sediment Exclusion at Diversions

Country: Israel

Institution: Technion, Israel Institute of Technology
Division of Hydraulic Engineering,
Haifa, Israel

Personnel:
1. A. de Leeuw, Head, Division of Hydraulic Engineering
2. S. Davis, previous Head, Division of Hydraulic Engineering
(On leave of absence for academic year 1959-60.
Visiting professor, School of Civil Engineering,
Cornell University, Ithaca, New York)
3. Shragga Irmay, Professor
Technion, Division of Hydraulic Engineering,
Haifa, Israel
4. N. Geffen, Engineer

References: Theories of sediment transportation (Project No. 9)
Technion, "Hydraulic Research 1957," IAHR, Vol 13

Institution: Weismann Institute of Science, Rehovoth, Israel

Personnel: 1. Messrs. I. R. Miller and A. Bavil

RESEARCH PROPOSAL H-4

Sediment Transport Theory

The movement of sediment in flowing water presents design problems that can be resolved only with a better understanding of the phenomena and the development of new theories of sediment transport. The application of the theory of negative acceleration to the transportation of sediment, which has been proposed by Professor S. Irmay of Israel, offers a possible explanation of the very complex process of sediment transport as well as scour and deposit in channels. A research study is desired to determine if this theory explains more clearly the phenomena of sediment transport.

The research study would include a search of literature, a theoretical study to show how the theory of negative acceleration in hydraulic flow in channels applies to the transport of sediment materials, checking the theory by application of data from tests that have been run in flumes and natural channels, and verifying the theory and its application to sediment transport by means of a hydraulic model study.

The literature search would be made for articles pertinent to the study and published in various languages. Tabulations would be made of all data used and a brief abstract of references prepared in English.

Velocity distribution data from experiments by other scientists have been applied to this theory of negative acceleration with encouraging results. There are numerous other experiments where sediment materials have been measured as well as water velocities. The theory proposed would be applied to these data and correlations made to determine its relation to sediment transport.

Following the literature search and theoretical study, laboratory tests would be made in an open-channel flume adequate to make measurements of velocity distribution and sediment transportation. Tests would be made at several discharges and velocities with different sizes of sediment to obtain data covering a sufficiently wide range to check the theory and its application to sediment transport. Data obtained from the model would include velocity profiles, sediment transport characteristics and other hydraulic factors required to analyze and verify the theory. Relationships would be developed for computing sediment transport in various types of channels.

Facilities required for the laboratory study would include an adequate water supply system; a sediment-feeding device for controlling sediment concentrations; a flume of sufficient length to provide fully developed and uniform flow conditions; suitable instrumentation for measuring water and sediment discharge, velocity distribution, and water slopes; and equipment for making sediment size analysis.

A comprehensive report covering the theoretical analysis and results of the laboratory study, including the bibliography, would be prepared in English.

RESEARCH PROPOSAL H-4

Title: Sediment Transport Theory (The application of a theory of negative acceleration to the transportation of sediment in hydraulic channels and to determine if this theory explains the phenomena of sediment transport more clearly)

Country: Israel

Institution: Technion, Israel Institute of Technology,
Division of Hydraulic Engineering,
Haifa, Israel

Personnel: 1. A de Leeuw, Head, Division of Hydraulic Engineering

2. S. Davis, previous Head, Division of Hydraulic Engineering (On leave of absence for academic year 1959-60. Visiting professor, School of Civil Engineering, Cornell University, Ithaca, New York)

3. Shragga Irmay, Professor
Technion, Division of Hydraulic Engineering,
Haifa, Israel

4. N. Geffen, Engineer

References: 1. S. Irmay, On three layers of turbulent flow, Bulletin Research Council of Israel, Vol. 6C, No. 1, page 71, Abstract 1957

2. S. Irmay, On the mean accelerations of fluid particles in turbulent flow, Bulletin Research Council of Israel, Vol. 6C, No. 1, page 90

3. S. Irmay, on the mean accelerations of particles in turbulent incompressible channel flow, Mimeo Technion, Division of Hydraulic Engineering, 11 pages, 4 figures, 1957

Institution: Weismann Institute of Science, Rehovoth, Israel

Personnel: 1. Messrs. I. R. Miller and A. Bavil

RESEARCH PROPOSAL H-5

Artificial Islands for Diversion Intakes

The control of sediment inflow to canal intakes upstream from diversion dams has been accomplished occasionally by the use of artificial islands. An island, if properly shaped and located in the river, will cause curvature of the approaching river flow and minimize the amount of coarse sediment entering the canal. This method of sediment control has been used effectively in Pakistan and India. It is believed, however, that no attempt has been made to develop general design criteria by analyzing and correlating performance data from these structures.

The research study would develop this criteria and include collecting reports of hydraulic model studies and data from prototype installations, correlating and analyzing the data to develop relationships that can

...d for design of artificial islands, and performing laboratory ...sts to extend and broaden the available data.

A literature search would be made to determine the extent of existing knowledge and to compile published data in English on the use of artificial islands.

Pertinent data obtained in the literature search would be analyzed to evaluate the effectiveness of artificial islands and to determine if a correlation among variables can be made. Variables such as curvature of flow surfaces; depths and widths of flow channels; velocities and unit discharges of flow; size, gradation, and quantity of sediment transport would be included in the study. A comparison between the effectiveness of artificial islands and other methods of controlling sediment inflow to canal headworks would be made.

A hydraulic model study of a typical installation would be conducted to supply data lacking in existing literature and to develop suitable relationships from the data. The number and details of the tests would depend on the model and available facilities.

Facilities for conducting the laboratory study would include an adequate water supply system; a testing box large enough to minimize distortion; a suitable sediment feed system; instruments for measuring velocities, sediment concentrations, size analysis, and sediment and water discharges; and photographic equipment.

A comprehensive report, including the bibliography and covering the analytical and laboratory studies, would be prepared in English.

RESEARCH PROPOSAL H-5

Title: Artificial Islands for Diversion Intakes
(The Use of Artificial Islands Upstream from Diversion Intakes to Control Sediment Inflow into Canals)

Country: Pakistan

Institution: Irrigation Research Institute,
Punjab, Lahore, West Pakistan

Personnel: 1. Mian Muzaffar Ahmad, Director

2. Dr. Mushtaq Ahmad, Research Officer (Hydraulics)

3. Sh. Vadood Ahmad, Research Officer (Hydraulics)

4. Nazir Ahmad, Head, Physics Department

5. S. L. Shah, Assistant Research Officer (Physics)

6. S. A. Awan, Research Officer

7. Mohammad Abdul Hamid

8. R.F.T. Farrant

References: 1. Mustaq Ahmad, Effect of scale distortion, size of model bed material and time scale on the geometrical similarity of localised scour, Proceedings of the Sixth General Meeting, The Hague, 1955, International Association for Hydraulic Research, Vol. 4, Paper D4, pages D4-1 to -16

2. Nasir Ahmad, Mechanism of erosion below hydraulic works, Proceedings Minnesota International Hydraulics Convention, September 1-4, 1953, Minneapolis, Minnesota (Joint meeting IAHR and Hydraulics Division, ASCE), page 133

3. Mustaq Ahmad, Experiments on design and behavior of spur dikes, Proceedings Minnesota International Hydraulics Convention, September 1-4, 1953, Minneapolis, Minnesota (Joint meeting IAHR and Hydraulics Division, ASCE), page 145

RESEARCH PROPOSAL H-5

Artificial Islands for Diversion Intakes

Institutions in Pakistan (continued)

Institution: Hydraulic Research Laboratory, E. Bengal, Tejgon, Dacca

Personnel: M. A. Rahman, Officer-In-Charge

Institution: Scientific and Industrial Research Organization, Karachi, W. Pakistan

Personnel: Dr. Salimuzzaman Siddiqui, Director

RESEARCH PROPOSAL H-6

Stream Regimen and Sediment Transport

The movement of sediment in open-channel flow presents problems in design that can be resolved only with an increased knowledge and

analysis of sediment transport. A better quantitative understanding of the relations of river discharge, sediment transport, ripple formations, and bed soil and sediment characteristics on hydraulic roughness will enable the engineer to make better predictions for river control and design of earth canals. Numerous studies of sediment transport have been made, but most have been presented in qualitative form or in terms of a parameter that contains a questionable variable.

The research study on the effects of sediment transport and bed forms on channel roughness and stream regimen would include a search of literature to obtain a complete background of information on studies conducted to date. A theoretical analysis of existing information would be made. Based on the literature search and theoretical analysis, a laboratory test program will be formulated to augment the existing knowledge on the subject. Field data would be obtained from rivers and earth canals and used to correlate and verify the results of the theoretical and laboratory investigations. New parameters should be developed to present the data in a quantitative form that can be readily used by the design engineer.

Facilities for conducting the laboratory investigations would include an adequate water supply system with an accurate flow-measuring device; a sediment feeding device for controlling sediment concentrations; a sampling system for measuring sediment concentrations; a flume of adequate width, depth, and length; and provisions for obtaining grain analysis of the soil.

A comprehensive report, including the annotated bibliography and covering the theoretical analyses and results of the laboratory and field studies, would be prepared in English.

RESEARCH PROPOSAL H-6

Title: Stream Regimen and Sediment Transport
(The Effect of Sediment Transport and Bed Forms on Channel Roughness and Stream Regimen)

Country: Poland

Institution: Kierownk Centralengo Laboratorium
Wodnego Warszoirie
Warszawa, Poland

Personnel: 1. Walenty Jarocki

2. A. Reniger (believed to be at this hydraulic laboratory)

References: 1. Walenty Jarocki, A book "Ruch Rumowiska W Ciekach (Alluvium Movement in Rivers and Streams)" Gdynia 1957

2. Walenty Jarocki, Empirical Method of the Determination of the Quantity of Sediment Transport, Archiwum Hydrotechniki, Vol. 5, No. 2, 1958

3. Walenty Jarocki, A book, Obliczanie Otworow Mostov i Przepustow (Calculation of Bridge and Culvert Openings and Outlets), Warszawa 1955

RESEARCH PROPOSAL H-7

Transport in Pipes (Sediment)

Suspended sediment affects the flow characteristics of fluids in pipes and creates design problems that can be resolved only with a better understanding of the phenomena of sediment transport. Considerable research has been done in certain phases of the phenomena, such as the head losses resulting from the transport of suspended sediment. The results, however, are usually expressed in terms of velocity and concentration which are not readily adaptable to pipe design. A better quantitative understanding of head losses caused by sediment transport will lead to more exact designs.

The research study on sediment transport in pipes would include a search of literature to obtain a complete background of information on studies conducted to date. A theoretical analysis of this information would be made to determine the extent of the existing knowledge. Based on the literature search and the theoretical analyses, a laboratory study will be formulated to obtain data that are lacking in the literature and to broaden the existing knowledge on the subject. Suitable parameters should be developed to determine the carrying capacities of pipes. These parameters might be expressed as functions of the log normal sediment characteristics for both uniform and graded sediments, velocities, heads, and slope of the energy gradient. Artificial roughness and the amount of blockage from sediment deposition could be studied in terms of these same variables.

Facilities for conducting the laboratory study would include a water supply system of adequate capacity with an accurate flow-measuring device, a sediment-feeding device for controlling concentrations, a sampling system for determining sediment concentration, transparent pipe--6 inches or larger in diameter, and provisions for obtaining grain analyses of the soil.

A comprehensive report in English, including the annotated bibliography, would be prepared in a manner that the data can be readily used by the design engineer.

RESEARCH PROPOSAL H-7

Title: Sediment Transport in Pipes

Country: Poland

Institution: Kierownk Centralengo Laboratorium
Wodnego Warezoirie
Warszawa, Poland

Personnel: 1. Walenty Jarocki

2. A Reniger (believed to be at this hydraulic laboratory)

References:

1. Walenty Jarocki, Water Flow Through Drowned Conduits, Proceedings Seventh General Meeting, IAHR, Lisbon, Portugal, 1957, Vol. II, Paper D29

2. Walenty Jarocki, A book "Obliczanie Otworow Mostov i Przepustow (Calculation of Bridge and Culvert Openings and Outlets)," Warszawa 1955

3. Walenty Jarocki, Ruch Rumowiska W Ciekach (Movement of Sediment in Rivers) Gdynia 1957

RESEARCH PROPOSAL H-8

Energy of Submerged Water Jets

Energy in jets of high-velocity water can be dissipated by directing the jet into a body of water. A sudden enlargement in a flow passage, such as downstream from an orifice in a pipeline or downstream from a control valve, is an economical means of dissipating such energy.

Although much progress has been made in recent years in determining the size and arrangement of sudden enlargements to prevent the formation of vapor pockets and cavitation, additional studies are required to obtain fundamental data on the pressure distribution and fluctuation on the boundaries of various sized sudden enlargements and make the results available for general design purposes.

The research study of sudden enlargements would be directed toward establishing the basic relationships and characteristics for various jet-to-enlargement diameter ratios at low, moderate, and high heads, and would include a study of the hydraulic characteristics of single and multihole orifice plates, singly and in series in pipelines.

An analytical study would be made of the flow conditions, transient pressures, vapor pressure formations and hydraulic losses for single and multiple high-velocity water jets discharging concentrically and eccentrically into abrupt enlargements in flow passages.

Laboratory tests would then be made by discharging water through concentrically placed circular orifices, through various arrangements and spacings of multihole orifice plates, and through eccentrically placed single openings. The jets from these openings would enter enlarged pipe sections about 2 to 20 times the diameter of the openings under heads of at least 400 feet. Heads up to 2,000 feet are desirable. The enlargement section would be about 6 inches in diameter.

The test facilities would be constructed to permit measurement of the discharges, the upstream head, and the mean and transient pressures on the surfaces of the enlarged sections. Records would be made of transient pressures and vibration intensity at selected points. Velocity traverses would be made in the enlarged sections.

The vapor pressure conditions, as measured by the cavitation index K, would be determined and the critical values defined as the condition where erosion of the enlargement walls just begins. Concrete-lined enlargement sections would be used for this determination. Also, the index would be determined for incipient cavitation based on audible measurements by hydrophone.

A search of technical literature and the preparation of a complete bibliography with abstracts in English would be a part of the study. A comprehensive report in English on this research study would be required.

RESEARCH PROPOSAL H-8

Title: Entrainment of Air in Conduit Flows

Country: Yugoslavia

Institutions: I. Vodogradbeni Laboratorij pri Tehniski Fakulteti Univerze v Ljubljani, Hadrihova Ulica 26, Ljubljana

II. Hidrotehnicki Institut, "Ing. Jaroslav Cerni," Bulevar Vojvode Misica 43, Beograd VII

III. Hidravlichka Laboratorija "Avala" (The Hydraulic Laboratory "Avala") Beli Potok, Suburb of Belgrade

Personnel: I-1. Janko Bleiweis, Director
2. Dr. Ing. Josip Greic
3. Ante Frankovic
4. O. Colaric
5. M. Goljevscek
6. D. Legisa
7. F Krainer
8. M. Milovanovic

II-1. Zivko Vladisavljevic, Director
2. Vujica M. Yevdjevich (Has been director of the Hydraulic Laboratory. At present working with Water Resources Division, U.S. Geological Survey, Washington 25, D.C.)
3. Geza L. Bata, Engineer
4. Leon Levin, Engineer
5. M. Boreli
6. Michailo Vojinovic
7. B. Knezevich
8. S. Bruk
9. K. Djomin, Engineer
10. D. Miculic, Engineer
11. M. Vukovic, Hydraulic Engineer
12. P. Popovic
13. D. Jovasevic
14. V. Todorovic
15. D Maksimovic
16. M. Mitic
17. I. Bartos
18. B. Matic
19. N. Siljanovic
20. D. Brkic
21. M. Ridjanovic
22. V. Miloradov
23. G. Hajdin
24. V Antic
25. M. Milojevic
26. B. Damnjanovic
27. Dj. Dobrasinovic
28. Z. Jesin

III--1. Eng. D. Jasimovich, Director

References: I-1. Janko Bleiweis, Ecoulement et pressions dans une galerie muni d'un retrecissement a la sortie, Transactions Seventh General Meeting, Lisbon, 1957, International Association for Hydraulic Research, Vol. 1, pages C8-1 to -7

2. Methode aproximative de dimensionnement des tuyaux d'aeration des conduites d'evacuation fermees, Hydraulic Research 1958, Vol. 14, page 347, IAHR

II-1. Vujica M Yevdjevich and Leon Levin, Entrainment of Air in Flowing Water and Technical Problems Connected with It, Proceedings Minnesota International Hydraulics Convention, 1953, Minneapolis, Minnesota (A joint meeting of International Association for Hydraulic Research and Hydraulics Division, ASCE), page 439

2. V. Polhovsky and D. Nicolic--An Electrical Device for the Measurement of Concentration and Velocities of a Mixture, Proceedings of the Sixth General Meeting, The Hague, 1955, International Association for Hydraulic Research, Vol. 2, Paper B9

3. Vujica M. Yevdjevich, On the use of diffusers on the downstream end of diversion tunnels, Proceedings of the Sixth General Meeting, The Hague, 1955, International Association for Hydraulic Research, Vol. 3, Paper C13

4. M. Boreli, Stability of Aerated Siphons, Proceedings of the Sixth General Meeting, The Hague, 1955, International Association for Hydraulic Research, Vol. 3, Paper C12

RESEARCH PROPOSAL H-9

Sediment Exclusion by Guide Vanes

The exclusion of sediment from canal intakes is a problem continually facing the design engineer at diversion dams on alluvial streams. Numerous methods have been used successfully to prevent large quantities of river sediment from entering canals. Guide vanes, for example, have been used in Russia, India, Africa, and Algeria. Their use, however, has been limited to particular intakes, and no attempt has been made to generalize the design for use on other structures.

This research study would include a search of literature, compilation and analyses of existing data on the use of guide vanes as sediment-excluding devices, conducting laboratory tests to extend the existing knowledge, and the development of general criteria for the design of guide vanes. Knowledge obtained from this study will enable the evaluation and design of efficient sediment-excluding guide vanes for any given structure.

Technical papers and articles in various languages would be searched to compile and evaluate available information on the use of guide vanes. Abstracts would be prepared on all pertinent publications with translations in English of all important data.

Following the literature survey, a theoretical analysis of available information would be made to determine gaps in the current knowledge and to establish the extent of laboratory tests that are needed to complete the study. The laboratory tests would be directed toward establishing basic relationships and characteristics of surface and bottom guide vanes. The optimum elevation of vanes with regard to discharge and bedload conditions, the size of sediments deflected by the vanes, the strength of secondary currents established from various vane arrangements, effect of number of vanes, discharge necessary to establish secondary currents, comparative efficiency of surface and bottom vanes, and other data necessary for design purposes would be determined.

Facilities for the laboratory study would include a pump or gravity system with a discharge capacity to 8 second-feet, a sediment-feeding device for controlling concentrations, measuring devices for water and sediment, sampling system for determining sediment concentration, provisions for making mechanical analysis of sediments, and photographic equipment.

A comprehensive report, including a bibliography and covering the theoretical and laboratory studies, would be prepared in English.

RESEARCH PROPOSAL H-9

Title: Sediment Exclusion by Guide Vanes

Country: Egypt (U.A.R.)

Institution: The Hydraulic Experiment and Research Station, Delta Barrage, Egypt, U.A.R.

Personnel:
1. Dr. M. Gamal Mostafa, Director
2. Dr. Ahmed M. Yassin
3. Ahmed Ali El-Darwish
4. Mohamed Gaser
5. H. El-Sherbini
6. O. A. El-Ghamry

References: 1. Dr. M. Gamal Mostafa, Analytical and Experimental Study of the Effect of Flow Characteristics and Fluid Viscosity Upon the Movement of Bed Load in Open Channels, unpublished Doctor's thesis, University of Minnesota, 1949

2. Dr. Ahmed M. Yassin, Mean Roughness Coefficient in Open Channels with Different Roughnesses of Bed and Side Walls, Doctor's thesis, Swiss Federal Institute of Technology, Zurich, Switzerland, 1953

3. Effect of submerged weirs at the entrance of branch canals, Hydraulic Research, 1958, Vol. 14, IAHR, page 309

4. Sereawia Canal Intake, Hydraulic Research, 1958, Vol. 14, IAHR, page 309

5. O.A El-Ghamry, Effect of submerged weirs at the entrance of branch canals, Master of Science thesis, University of Cairo, 1959

Institution: National Research Center of Egypt, al Tahrir, Dokki, Cairo

Institution: Cairo University, Bulkeley, Ramleh, Cairo

RESEARCH PROPOSAL H-10

Density Flows

Many phases of the effects of density currents or stratified flows have been investigated in the past 10 years. The problem is diversified in that only a few aspects of selective withdrawal have been investigated. These studies have been performed in various parts of the world and need to be correlated and extended for engineering application. Selective withdrawal from a reservoir to control evaporation, temperature of water for irrigation or wildlife propagation, and quality of water is recognized as desirable by engineers responsible for water and wildlife conservation.

The research study would include a survey and review of existing technical literature on density currents. An analytical and laboratory test program would be undertaken to define flow pattern of selective withdrawal through relationship of velocity distribution and shear stress; to determine withdrawal levels of flow patterns that affect water evaporation, temperature, and quality; and to establish limiting factors from test facilities sufficiently large to indicate applicability to reservoir and rivers. The investigation

and analysis would be conducted and presented in a form such that the data would be applicable to other problems, including problems in sedimentation, chemical processes, salt intrusions in estuaries, heat dissipation, and thermal powerplants.

The experimental facilities should be designed to reduce scale effects to a minimum and provide results that can be readily extended to conditions of the prototype. Instrumentation to measure the quantities necessary to describe the statics and dynamics of the system would be developed concurrently with the experimental investigation. These may include small velocity meters for expected low velocities, chemical samplers for determination of withdrawal relationships, indicators of turbulence or eddy formation, and indicators of shear distribution along the interface of stratified layers. The literature search no doubt will reveal the need for other special instruments and equipment.

A comprehensive report covering all phases of this study, and including a bibliography, would be prepared in English.

RESEARCH PROPOSAL H-10

Title: Density Currents

Country: Yugoslavia

Institution: Hidrotechnicki Institut, Ing.
"Jaroslav Cerni," Bulevar Vojvode
Misica 43, Beograd VII, Jugoslavija

Personnel:
1. Zivko Vladisavljevic, Director
2. Vujica J. Yevdjevich
(Has been director of the Hydraulic Laboratory. At present working with Water Resources Division, U.S. Geological Survey, Washington 25, D.C.)
3. Gesa L Bata, Engineer
4. Leon Levin, Engineer
5. Michailo Vojinovic
6. M. Boreli
7. B. Knezevich
8. S. Bruk
9. K. Djonin, Engineer
10. D. Nicolic, Engineer
11. M. Vukovic, Hydraulic Engineer
12. P. Popovic
13. D. Jovasevic
14. V Todorovic
15. D. Maksimovic
16. M. Mitic

17. I. Bartos
18. B. Matic
19. N. Siljanovic
20. D. Brkic
21. M. Ridjanovic
22. V. Miloradov
23. G. Majdin
24. V. Antic
25. M. Milojevic
26. B. Damnjanovic
27. Dj. Dobrasinovic
28. Z. Jesin

References: 1. Geza L. Bata and Knezevich Bogich, Some Observations on Density Currents in the Laboratory and in the Field, Proceedings Minnesota International Hydraulics Convention, September 1-4, 1953, Minneapolis, Minnesota (Joint meeting of International Association for Hydraulic Research and Hydraulics Division, ASCE), page 387

2. Geza L. Bata, Recirculation of Cooling Water in Rivers and Canals, Journal of the Hydraulics Division, ASCE, Vol. 83, June 1957. (The work reported in this paper was done at the Iowa Institute of Hydraulic Research, State University of Iowa, under the direction of Dr. Hunter Rouse and Dr. Chia-Shun Yih while Mr. Bata was studying at that institution)

3. Geza L. Bata, Frictional Resistance at the Interface of Density Currents, Paper 12-C, 8th Congress, Montreal, 1959, International Association for Hydraulic Research

4. Geza L. Bata, Propagation of Gasoline Wave Through Water in Inclined Circular Annulus, Paper 13-C, 8th Congress, Montreal, 1959, International Association for Hydraulic Research

5. Circulation de l'eau dans le Lac De Belgrade, Hydraulic Research 1958, Vol. 14, IAHR, page 338

Institution: Hidraulichka Laboratorija "Avala"
(The Hydraulic Laboratory "Avala")
Beli Potok, suburb of Belgrade

Personnel: Eng. D. Josimovich, Director

Institution: Vodogradbeni Laboratorij pri Tehnichki Fakulteti
Universe u Ljubljani
(The Hydrotechnical Laboratory of the Technical
Faculty, Ljubljana University)
28 Hajdrihova, Ljubljana

Personnel: Janko Bleiweiss, Director

RESEARCH PROPOSAL H-11

Entrainment of Air in Conduit Flows

The entrainment of air presents design and operation problems, in closed conduit flows, such as pipeline distribution systems, vertical shafts, inverted siphons, energy-dissipating devices and pump discharge lines. Entrainment and accumulation of air in these systems have caused large air releases that induce structural vibrations and disrupt the normal flow of water.

Considerable research work has been done on the mechanics of air bubbles rising in still water. Some experiments have been reported on air-water mixtures in hydraulic jumps and entrainment of air by vortex action in vertical shafts, but little data are available on the effect of velocity and turbulence on the rate of bubble rise.

The research study on air entrainment would include a search of literature to determine the extent of knowledge on this subject. A complete bibliography of pertinent work would be required. Publications with data significant to the study would be translated and abstracts of the remaining articles would be prepared in English.

Laboratory tests would be performed to determine the rate of rise of bubbles in water flowing at different velocities. The influence of velocity distribution and turbulence would be evaluated. Methods of collecting and removing the entrained air would be developed. From these test data, parameters expressing the relationships among conduit diameter, velocity, slope, length, and bubble size would be evolved.

Two models would be required for the investigation. One would include a transparent pipe, 6 inches or larger in diameter, mounted for varying the slope to study the rise of bubbles in flowing water. The second model would be used to study the mixing of air and water in the hydraulic jump in pipe distribution systems and inverted siphons. Instrumentation and measuring equipment for defining velocity, velocity distribution, air concentration, and air injection would be required.

Upon completion of the literature search and laboratory study, the data would be analyzed and a comprehensive report, including the bibliography,

would be prepared in English. The data would be presented in a form readily adaptable for use by the design engineer.

RESEARCH PROPOSAL H-11

Title: Entrainment of Air in Conduit Flows

Country: Yugoslavia

Institutions:

I. Vodogradbeni Laboratorij pri Tehniski Fakulteti Universe v Ljubljani, Hadrihova Ulica 28, Ljubljana

II. Hidrotechnicki Institut, "Ing. Jaroslav Cerni," Bulevar Vojvode Misica 43, Beograd VII

III. Hidraulichka Laboratorija "Avala" (The Hydraulic Laboratory "Avala") Beli Potok, Suburb of Belgrade

Personnel:

I-1. Janko Bleiweis, Director
2. Dr. Ing. Josip Grcic
3. Ante Frankovic
4. O. Colaric
5. M. Goljevscek
6. D. Legisa
7. F. Krainer
8. M. Milovanovic

II-1. Zivko Vladisavljevic, Director
2. Vujica M. Yevdjevich (Has been director of the Hydraulic Laboratory. At present working with Water Resources Division, U.S. Geological Survey, Washington 25, D.C.)
3. Geza L. Bata, Engineer
4. Leon Levin, Engineer
5. Michailo Vojinovic
6. M. Boreli
7. B. Knezevich
8. S. Bruk
9. K. Djonin, Engineer
10. D. Nicolic, Engineer
11. M. Vukovic, Hydraulic Engineer
12. P. Popovic
13. D. Jovasevic
14. V. Todorovic
15. D. Maksimovic

16. M. Mitic
17. I. Bartos
18. B. Matic
19. N. Siljanovic
20. D. Brkic
21. M. Ridjanovic
22. V. Milcradov
23. G. Majdin
24. V. Antic
25. M. Milojevic
26. B. Damnjanovic
27. Dj. Dobrasinovic
28. Z. Jesin

III-1. Eng. D. Jasimovich, Director

References:

I-1. Janko Bleiweis, Ecoulement et pressions dans une galeri muni d'un retrecissement a la sortie, Transactions Seventh General Meeting, Lisbon, 1957, International Association for Hydraulic Research, Vol. 1, pages C8-1 to -7

2. Methode aproximative de dimensionnement des tuyaux d'aeration des conduites d'evacuation fermees, Hydraulic Research 1958, Vol. 14, page 347, IAHR

II-1. Vujica M. Yevdjevich and Leon Levin, Entrainment of Air in Flowing Water and Technical Problems Connected with It, Proceedings Minnesota International Hydraulics Convention, 1953, Minneapolis, Minnesota (A joint meeting of International Association for Hydraulic Research and Hydraulics Division, ASCE), page 439

2. V. Polhovsky and D. Nicolic--An Electrical Device for the Measurement of Concentration and Velocities of a Mixture, Proceedings of the Sixth General Meeting, The Hague, 1955, International Association for Hydraulic Research, Vol. 2, Paper B9

3. Vujica M. Yevdjevich, On the use of diffusers on the downstream end of diversion tunnels, Proceedings of the Sixth General Meeting, The Hague, 1955, International Association for Hydraulic Research, Vol. 3, Paper C13

4. M. Boreli, Stability of Aerated Siphons, Proceedings of the Sixth General Meeting, The Hague, 1955, International Association for Hydraulic Research, Vol. 3, Paper C12

RESEARCH PROPOSAL R-12

Entrainment of Air in Open-channel Flow

Air entrainment in open-channel flow presents problems that must be considered in designing irrigation structures. Design allowances must be made for bulking of high-velocity flow from air entrainment. A better understanding of the mechanics of these phenomena would result in construction economies.

The research study on air entrainment would include a search of literature to determine the status of present knowledge. Laboratory tests would be performed to discover the mechanics by which air is entrained in channels of various widths, depths, and slopes. Data from existing knowledge and the laboratory tests would be analyzed and relationships developed to permit application of the results to prototype structures. Field tests would be conducted to correlate and verify the results from the laboratory and analytical studies.

Facilities for the study would include an open channel, variable in slope, and sufficiently wide and deep to minimize the effects of viscous forces and to prevent the sidewall boundary layer and the entrained air at the sides from interfering with the main cross-sectional flow. The channel length should be sufficient to form the velocity distribution in a fully-developed boundary layer.

Suitable instrumentation including depth gages, velocity-measuring devices, and recording equipment for rapid fluctuations in data should be available to determine the variation of air concentration with depth, velocity, distance along the channel, and channel slope.

Considerable study of techniques to obtain prototype data would be necessary. Many laboratory instruments may be adapted to prototype use, but new techniques and devices should be developed for obtaining data from prototype structures.

A comprehensive report, covering the analytical and laboratory test results and conclusions, would be prepared in English. The data would be presented in a form that can be readily used by the design engineer. A bibliography with abstracts in English would be included in the report. Those publications containing high-quality, significant data would be translated in their entirety.

RESEARCH PAPER H-12

Title: Entrainment of Air in Open Channel Flow

Country: Yugoslavia

Institutions:

I. Vodogradbeni Laboratorij pri Tehniski Fakulteti Universe v Ljubljani, Hadrihova Ulica 28, Ljubljana

II. Hidrotehnicki Institut, "Ing. Jaroslav Cerni," Boulevar Vojvode Misica 43, Beograd VII

III. Hidraulichka Laboratorija "Avala" (The Hydraulic Laboratory "Avala") Beli Potok, Suburb of Belgrade

Personnel:

I-1. Janko Bleiweis, Director
2. Dr. Ing. Josip Grcic
3. Ante Frankovic
4. O. Colaric
5. M. Goljevscek
6. D. Legisa
7. F. Krainer
8. M. Milovanovic

II-1. Zivko Vladisavljevic, Director
2. Vukica M. Yevdjevich (Has been director of the Hydraulic Laboratory. At present working with Water Resources Division, U.S. Geological Survey, Washington 25, D.C.)
3. Geza L. Bata, Engineer
4. Leon Levin, Engineer
5. Michailo Vojinovic
6. M. Boreli
7. B. Knezevich
8. S. Bruk
9. K. Djunin, Engineer
10. D. Nicolic, Engineer
11. M. Vukovic, Hydraulic Engineer
12. P. Popovic
13. D. Jovasevic
14. V. Todorovic
15. D Maksimovic
16. M. Mitic
17. I. Bartos
18. B. Matic
19. N. Siljanovic
20. D Brkic

21. M. Ridjanovic
22. V. Miloradov
23. G. Hajdin
24. V. Antic
25. M. Milojevic
26. B. Dammjanovic
27. Dj. Dobrasinovic
28. Z. Jesin

III-1. Eng. D. Josimovich, Director

References: I-1. Ante Frankovic, Head Loss and Air Entrainment by Flowing Water in Steep Chutes, Proceedings Minnesota International Hydraulics Convention, 1953, Minneapolis, Minnesota (A joint meeting of the International Association for Hydraulic Research and Hydraulics Division, ASCE), page 467

II-1. Vujica M. Yevdjevich and Leon Levin, Entrainment of Air in Flowing Water and Technical Problems Connected with It, Proceedings Minnesota International Hydraulics Convention, 1953, Minneapolis, Minnesota (A joint meeting of International Association for Hydraulic Research and Hydraulics Division, ASCE), page 439

2. V. Polhovsky and D. Nicolic--An Electrical Device for the Measurement of Concentration and Velocities of a Mixture, Proceedings of the Sixth General Meeting, The Hague, 1955, International Association for Hydraulic Research, Vol. 2, Paper B9

3. Vujica M. Yevdjevich, On the Use of Diffusers on the Downstream End of Diversion Tunnels, Proceedings of the Sixth General Meeting, The Hague, 1955, International Association for Hydraulic Research, Vol. 3, Paper C13

4. Deversoir et canal a forte pente Glasanj, Hydraulic Research, 1958, Vol. 14, page 343, IAHR

RESEARCH PROPOSAL H-13

Aeration in Shaft Flows

The entrainment of air by water flowing in tunnel shafts has been known to result in blowback causing extensive damage to structures

placed near the shaft intakes. Although most of the known occurrences were with early hydraulic air compressors, they have caused a reluctance of designers to use shafts in which there is air entrainment. However, in recent years attention has been directed toward the problem of air entrainment and transport at primary and secondary inlets to water-filled tunnel systems and some of these are reported to be operating satisfactorily. Most of the recent investigation and exploratory work on flow in tunnel shafts has been done in countries outside the United States. Some of this work has been published in journals of wide circulation and thus is available to the American engineering profession. There is no doubt a great deal more information of real value that has not been published. Informal reports from abroad are that several vertical intake shafts have been operating satisfactorily even though considerable amounts of air are entrained. This indicates a need for research.

This proposed research study on aeration in shaft flows would require a search of technical literature, the preparation of a complete bibliography with abstracts in English, an appraisal of the information obtained, and laboratory tests and field observations to integrate and extend the data to make them useful for design.

The laboratory tests and field observations would be directed toward obtaining basic information regarding the mechanism of air entrainment, bubble size, bubble history, rate of rise in turbulent flows, effects on hydraulic equipment, methods and requirements for separation and venting, and methods of reducing air entrainment.

An analytical study would be made to correlate the findings of this research program. The knowledge derived from this program will enable a more factual evaluation of the extent and nature of probable air entrainment in proposed structures, the deleterious effects, if any, of the entrained air, and methods for entrainment control and air-water separation. A comprehensive report in English would be required for this research project.

RESEARCH PROPOSAL N-13

Title: Aeration in Shaft Flows

Country: Yugoslavia

Institutions: I. Vodogradbeni Laboratorij pri Tehniski Fakulteti Univerze v Ljubljani, Hadrihova Ulica 28, Ljubljana

II. Hidrotehnicki Institut, "Ing. Jaroslav Cerni," Bulevar Vojvode Misica 43, Beograd VII

III. Hidraulichka Laboratorija "Avala" (The Hydraulic Laboratory "Avala") Beli Potok, suburb of Belgrade

Personnel:

I-1. Janko Bleiweis, Director
2. Dr. Ing. Josip Greic
3. Ante Frankovic
4. O. Colaric
5. M. Goljevscek
6. D. Legisa
7. F. Krainer
8. M. Milovanovic

II-1. Zivko Vladisavljevic, Director
2. Vujica M. Yevdjevich (Has been director of the Hydraulic Laboratory. At present working with Water Resources Division, U.S Geological Survey, Washington 25, D.C.)
3. Geza L. Bata, Engineer
4. Leon Levin, Engineer
5. Michailo Vojinovic
6. M. Boreli
7. B. Knezevich
8. S. Bruk
9. K. Djunin, Engineer
10. D. Nicolic, Engineer
11. M. Vukovic, Hydraulic Engineer
12. P. Popovic
13. D Jovasevic
14. V. Todorovic
15. D. Maksimovic
16. M. Mitic
17. I. Bartos
18. B. Matic
19. N. Siljanovic
20. D. Brkic
21. M. Ridjanovic
22. V. Miloradov
23. G. Hajdin
24. V. Antic
25. M. Milojevic
26. B. Damjanovic
27. Dj. Dobrasinovic
28. Z. Jesin

III-1. Eng. D. Josimovich, Director

References:

I-1. Josip Greic, The Surge Tank with Air Cushion, Eighth General Meeting, Montreal, 1959, International Association for Hydraulic Research, Paper 14D

II-1. Vujica M. Yevdjevich and Leon Levin, Entrainment of Air in Flowing Water and Technical Problems Connected With It, Proceedings Minnesota International Hydraulics Convention, 1953, Minneapolis, Minnesota (A joint meeting of International Association for Hydraulic Research and Hydraulics Division, ASCE), page 439

2. V. Polhovsky and D. Nicolic--An Electrical Device for the Measurement of Concentration and Velocities of a Mixture, Proceedings of the Sixth General Meeting, The Hague, 1955, International Association for Hydraulic Research, Vol. 2, Paper B9

3. Vujica M. Yevdjevich, On the Use of Diffusers on the Downstream End of Diversion Tunnels, Proceedings of the Sixth General Meeting, The Hague, 1955, International Association for Hydraulic Research, Vol. 3, Paper C13

4. Vujica M. Yevdjevich, Recovery of Energy After Introduction of the Water From Small Water Courses Into Pressure Tunnels, Proceedings of the Sixth General Meeting, The Hague, 1955, International Association for Hydraulic Research, Vol. 3, Paper C11

H. MEETING ON HYDRAULIC LABORATORY TECHNIQUES

The Hydraulic Laboratory was host to a meeting of hydraulic research engineers held August 9-10, 1960, to discuss laboratory techniques. Agencies represented were the Corps of Engineers, Tennessee Valley Authority, and the U.S. Navy David Taylor Model Basin. A brief outline of the topics covered in the meeting together with a roster of participants follows:

Program Outline

Hydraulic Structures

- Hydraulic Measurement of the Effect of High Velocity Flows at Surface Irregularities
- Vortex Flow and Model-prototype Similitude
- Protective Materials Studies in Model and Prototype--Structures, Conveyances, Shorelines, Riprap, and Other Means
- Hydraulics of Large Conveyances--Basic Fluid Mechanics Concepts--Instrumentation

Hydraulic Equipment and Closed Conduits

- Energy Dissipation in Closed Conduits--Laboratory Studies of Sudden Enlargements; Other
- Application of Air Testing to Hydraulic Model Studies
- Similitude Problems of Aeration in Closed Conduits

Sediment Research

- Materials and Measurements in Movable Bed Hydraulic Model and Prototype Studies
- Use of Radioisotopes in Sediment Studies
- Representing Sediment Transport in Intermittent Streams

Instrumentation, Analogs, and Data Processing

- Instrumentation for Prototype Measurements and Methods of Recording and Processing Data

Special Tests and Summary

- Special Tests Performed by Participating Laboratories--Wave Studies, Seepage, and Seepage Control

Roster of Attendants

Corps of Engineers

Office of Chief of Engineers

Mr. Jacob H. Douma, Chief, Hydraulic Design Branch

Waterways Experiment Station, Vicksburg, Mississippi

Colonel Edmund H. Lang, Director
Mr. Eugene P Fortson, Jr., Chief, Hydraulics Division
Mr. George B. Fenwick, Chief, Rivers and Harbors Branch
Mr. Frank B. Campbell, Chief, Hydraulic Analysis Branch
Mr. Thomas E. Murphy, Chief, Structures Section, Hydrodynamics Branch

Beach Erosion Board, Washington, D.C.

Mr. John C Fairchild, Research Division

Division Office, Omaha, Nebraska

Mr. N. L. Barbarossa, Chief, Hydraulic Section

District Office, St. Paul, Minnesota

Mr. Martin E. Nelson, Chief, Hydraulic Laboratory Branch

District Office, Portland, Oregon

Mr. Marvin J. Webster, Chief, Hydraulics Section
Mr. Harry P. Theus, Chief, Bonneville Hydraulic Laboratory

District Office, Los Angeles

Mr. A. P. Gildea, Chief, Hydraulic Section
Mr. D. A. Barela

United States Navy

David Taylor Model Basin, Washington, D.C.

Mr. W. F Brownell, Instrumentation Engineer, Hydromechanics Laboratory

Tennessee Valley Authority

Hydraulics Laboratory, Norris, Tennessee

Mr. Rex A. Elder, Head, Hydraulic Laboratory
Mr. James A. Dale, Instrumentation Specialist
Mr. Marvin N. Smith, Civil Engineer

Bureau of Reclamation

Office of Assistant Commissioner and Chief Engineer, Denver, Colorado

Division of Engineering Laboratories

Walter H. Price, Chief Research Engineer

Hydraulic Laboratory Branch

Harold M. Martin, Chief, Hydraulic Laboratory Branch
James W. Ball, Head, Hydraulic Structures and Equipment Section
Alvin J. Peterka, Supervising Hydraulic Research Engineer
Charles W. Thomas, Head, Hydraulic Investigations Section
Jack C. Schuster, Supervising Hydraulic Research Engineer
Enos J. Carlson, Supervising Hydraulic Research Engineer
Glenn L. Beichley, Hydraulic Research Engineer
Donald Colgate, Hydraulic Research Engineer
Robert B. Dexter, Hydraulic Research Engineer
Russell A. Dodge, Hydraulic Research Engineer
Phillip F. Enger, Hydraulic Research Engineer
Danny L. King, Hydraulic Research Engineer
Warren B. McBirney, Hydraulic Research Engineer
Thomas J. Rhone, Hydraulic Research Engineer
William P. Simmons, Hydraulic Research Engineer
Eugene R. Zeigler, Hydraulic Research Engineer
David R. Basco, Hydraulic Research Engineer
Robert H. Kuesmich, Electronic Development Technician

Chemical Engineering Laboratory Branch

Quentin L. Florey, Physicist

Division of Power Operations and General Engineering

Automatic Data Processing Branch

Francis E. Swain, Chief

Notes of the technical discussions were reproduced and distributed to all participants.

I. SYMPOSIUM ON BASIC RESEARCH IN CIVIL ENGINEERING FIELDS RELATED TO WATER RESOURCES

The Symposium, held at Colorado State University June 12-15, 1961, drew together leading engineers and scientists to explore the critical needs for basic research in selected scientific fields relating to water resources and to stimulate the interest of educational institutions and other organizations to accomplish this research. Two subjects were of direct interest to the Hydraulic Laboratory: Fluvial Hydraulics (Subject No. 4), and Hydraulics of Water Conveyances (Subject No. 5).

The panel for the subject Fluvial Hydraulics consisted of:

Dr. Arthur T. Ippen, Chairman
E. J. Carlson, Recorder
Dr. Hunter Rouse
J. F. Friedkin
D. C. Bondurant
Dr. E. M. Laursen
G. B. Fenwick
D. B. Simons
Dr. Norman H. Brooks

The panel used the following outline in discussing basic research needs:

I. General Problems of Water Flow in Alluvial Streams

   A. Boundary resistance for uniform flow
   B. Non-uniformities of boundaries and alignment
   C. Flood-wave propagation

II. General Problems of Sediment Movement

   A. Mechanics of transport for flows in equilibrium
   B. Non-equilibrium problem

III. Morphology of Alluvial Streams

   A. Channel geometry
   B. Sources of sediment
   C. Sedimentation pattern

IV. Engineering Works

   A. Channel stabilization and improvement methods
   B. Effects of weirs and dams
   C. Channel modification by other engineering structures

V. Estuaries

A. General tidal hydraulics
B. Diffusion in estuaries
C. Sedimentation problems

VI. Modern Methods of Measurement and Prediction

A. Measurement of hydraulic characteristics
B. Evaluation of erodibility of bed and banks
C. Measurement of sediment transport rates
D. Laboratory analysis of sediments
E. Model simulation of alluvial streams
F. Data processing and interpretation

The panel for the subject Hydraulics of Water Conveyances consisted of:

Dr. J. S. McNown, Chairman
W. W Sayre, Recorder
Dr. M. L. Albertson
Harold M. Martin
C. E. Kindsvater
Rex A. Elder
Dr. Ven Te Chow
F. B. Campbell
C. F. Izzard

The panel used the following outline in discussing basic research needs:

I. Preface---Consideration of purpose of Symposium (stimulation of research); nature of task; audience; devices; procedures

II. Crucial Problems in Water Conveyances (Striking Examples)

III. Governing Variables

IV. Flow Phenomena Resulting From Combinations of Variables

V. Design Criteria

The panel chairmen will file reports on the complete discussions and recommendations in the near future.

SECTION VI--HYDRAULIC LABORATORY BRANCH
GENERAL DISTRIBUTIVE WORK

A. General Description and Identification
B. Special Activities
   Membership in Technical Organizations
   Professional Papers
   Special Records and Publications
   Model Shopwork

A. General Description and Identification

Costs of this office consist of two principal elements, direct project charges and indirect costs. Direct projects 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 be reasonably 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
Equipment Maintenance
Miscellaneous Administrative Expense

Indirect Engineering Expense

Administrative
Staff Development
Meetings and Conferences
Technical Information, Denver
Technical Staff Service, Laboratories
Technical Standards and Procedures

Bureauwide Expense

Field Training
Manuals and Publications
Technical Information, Bureauwide
Laboratory Investigations, Hydraulic

B. Special Activities

1. MEMBERSHIP IN TECHNICAL ORGANIZATIONS, REGISTRATIONS, ETC. (FY61)

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 Member, U.S. Commission on Large Dams	Colorado	Member, Research Committee, Hydraulics Division, ASCE Member, Hydraulics Division, Colorado Section, ASCE
Ball	Member, ASCE	Member, International Association for Hydraulic Research Member, U.S. Commission on Large Dams Member, Society of Sigma Xi	Colorado	Reviewed one paper for Publications Committee, Hydraulics Division, ASCE Member, Hydraulics Division, Colorado Section, ASCE
Wagner	Fellow, ASCE	5002 Research and Development Unit, USA Attended 2 weeks seminar in Guided Missiles at Pasadena, California Reclamation Technical Club	Colorado	Member, Task Force on Hydraulic Design of Spillways, ASCE
Peterka	Fellow, ASCE	Reclamation Technical Club	Colorado	Member, Committee on Hydraulic Structures, ASCE
Rhone	Member, ASCE		Colorado	Member, Task Force on Flow in Large Conduits, ASCE; Member, Colorado Section Reviewed two technical papers for Hydraulics Division, ASCE
Simmons	Member, ASCE		Colorado	Chairman, Hydraulics Division, Colorado Section, ASCE Chairman, Task Force on Vibration in Hydraulic Structures, ASCE
Colgate	Member, ASCE	5002 Research and Development Unit, USA	Colorado	Member, Task Force on Aerated Flow, ASCE Member, Task Force on Cavitation, ASCE Reviewed two technical papers for Hydraulics Division, ASCE
Beichley	Member, ASCE	Reclamation Technical Club U.S. Naval Reserve, Civil Engineer Corps, Unit CB9-150	Colorado	Reviewed one technical paper for Hydraulics Division, ASCE

1. MEMBERSHIP IN TECHNICAL ORGANIZATIONS, REGISTRATIONS, ETC. (FY61)--Continued

Name	Membership in founder societies	Membership in other technical organizations	Registered professional engineer	Other
King	Associate Member, ASCE		Engineer in Training	
Falvey	Member, ASCE	5002 Research and Development Unit, USA	Engineer in Training	Studying German
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 Council Member, Society of the Sigma Xi	Colorado	Chairman, Technical Activities Committee, U.S. National Committee, International Commission on Irrigation and Drainage Reviewed several papers to be published in technical outlets
Carlson	Fellow, ASCE	Reclamation Technical Club 5002 Research and Development Unit, USA Four States Irrigation Council	Colorado (Engineer and Land Surveyor)	Member, Committee on Sedimentation, Hydraulics Division, ASCE Arranged for 4 papers and presided at 1/2-day session of Sedimentation, Hydraulics Division, ASCE Convention, Phoenix, Arizona, April 10-14, 1961 Two weeks' tour of Military Duty to office of Deputy Chief of Staff for Logistics, Construction Division, Pentagon, Washington, D.C. Continued Russian language class
Schuster	Member, ASME	Reclamation Technical Club Member, International Association for Hydraulic Research	Colorado	

1. MEMBERSHIP IN TECHNICAL ORGANIZATIONS, REGISTRATIONS, ETC. (FY61)--Continued

Name	Membership in founder societies	Membership in other technical organizations	Registered professional engineer	Other
McBirney	Member, ASCE	Director, Reclamation Technical Club Member, International Association for Hydraulic Research	Colorado	
Dexter		5002 Research and Development Unit, USA: Reclamation Technical Club		
Enger	Member, ASCE	Member, American Geophysical Union Member, International Association for Hydraulic Research Member, Reclamation Technical Club	Colorado	Member, Task Force on Erosion of Cohesive Materials, ASCE On Nominating Committee for Colorado Section, Hydraulics Division, ASCE Obtained Master's Degree; completed thesis
Dodge		National Society of Professional Engineers	Engineer in Training, Michigan	
Zeigler		Reclamation Technical Club		Attending classes at University of Colorado
Kuenmich		Instrument Society of America Reclamation Technical Club		Member, Educational Committee, ISA

B. Special Activities

2. PROFESSIONAL PAPERS AND LECTURES PREPARED, PRESENTED AND/OR PUBLISHED DURING FY61, OR IN PREPARATION

Author	Title of paper	Meeting (place and date)	Paper published
Ball	Hydraulic Laboratory Practice in the Bureau of Reclamation	Lecture to about 35 foreign trainees, Bureau of Reclamation, Denver February 21, 1961	
Peterka	The Hydraulic Design of Hollow-Jet Valve Stilling Basins (coauthored with G.L. Beichley)	ASCE Summer Convention, Reno, Nevada, June 20-24, 1960	Paper presented by A.J. Peterka Accepted for ASCE publication
Rhone	Fish Protective Facilities at Tracy Pumping Plant (coauthored with Daniel W. Bates, Fish and Wildlife Service)	Hydraulics Conference, ASCE, Seattle, Washington, August 17-19, 1960	Paper presented by T.J. Rhone Submitted for publication in Hydraulics Division Journal, ASCE
Simmons	Closure for Proceedings Paper No. 2531, Hydraulics Division, ASCE, "Models Primarily Dependent on the Reynolds Number"		
Colgate	Research and Development, Military Training Program, Part II	5002 R&D Army Reserve Unit, April 11, 1961	One-hour lecture by D. Colgate
Beichley	The Hydraulic Design of Hollow-Jet Valve Stilling Basins (coauthored with A.J. Peterka)	ASCE summer convention, Reno, Nevada June 20-24, 1960	Paper presented by A.J. Peterka Accepted for ASCE publication
King	None		
Falvey	None		
Thomas	Closing discussion for Paper No. 2530, "World Practices in Water Measurement at Turnouts"		Journal of the Irrigation and Drainage Division, ASCE, June 1960
	Use of an Electronic Computer to Analyze Data from Studies of Critical Tractive Forces for Cohesive Soils (coauthored with P. F. Enger)	Ninth Convention, IAHR, Belgrade, Yugoslavia, September 3-7, 1961	To be presented
Dodge	Use of Steel Jacks and Jetties for Bank Protection and Channelization in Rivers	Annual Meeting of Rocky Mountain Hydraulic Laboratory, Allens Park, Colorado, August 13, 1960	Discussion presented by R.A. Dodge, Jr.

2. PROFESSIONAL PAPERS AND LECTURES PREPARED, PRESENTED AND/OR PUBLISHED DURING FY61, OR IN PREPARATION—Cont.

Author	Title of paper	Meeting (place and date)	Paper published
Carlson	Sediment Problems in the Bureau of Reclamation	Lecture to about 28 foreign trainees, Bureau of Reclamation, Denver, February 28, 1961	
	Correlation of Laboratory Test Data for Use in Stable Channel Design	Talk presented to Hydraulics and Irrigation and Drainage Divisions, Colorado Section, ASCE, April 26, 1961	
	Research and Development, Military Training Program, Part III	5002 R&D Army Reserve Unit, April 25, 1961	One-hour lecture by E.J. Carlson
Dexter	Navy Guided Missile Systems	Army Reserve, 5002 R&D Unit, March 28, 1961	One-hour lecture by R.B. Dexter
Enger	Use of an Electronic Computer to Analyze Data from Studies of Critical Tractive Forces for Cohesive Soils (coauthored with C. W. Thomas)	Ninth Convention, IAHR, Belgrade, Yugoslavia, September 3-7, 1961	To be presented
Zeigler	None		
Wagner	Experience in Turbulence in Hydraulic Structures (coauthored with H. M. Martin)	Ninth Convention, IAHR, Belgrade, Yugoslavia, September 3-7, 1961	To be presented
Martin	Talk, "Cavitation Problems in High Head Hydraulic Structures"	Iowa State University, Michigan State University, Michigan School of Mining and Technology, University of Iowa, Georgia Institute of Technology, University of South Carolina, Clemson College, The Citadel	
	Experience in Turbulence in Hydraulic Structures (coauthored with W.E. Wagner	Ninth Convention, IAHR, Belgrade, Yugoslavia, September 3-7, 1961	To be presented

2. PROFESSIONAL PAPERS AND LECTURES PREPARED, PRESENTED AND/OR PUBLISHED DURING FY61, OR IN PREPARATION--Cont.

Author	Title of paper	Meeting (place and date)	Paper published
Martin	Cavitation Erosion in Hydraulic Structures	Annual Meeting of Rocky Mountain Hydraulic Laboratory, Allens Park,	Talk presented by H. M. Martin
	Report on Attitude of Public Agencies Toward Activity of Public Engineers in Professional Societies	ASCE Summer Convention, Reno, Nevada, June 20-24, 1960	Reported by H. M. Martin

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.

Central Valley Project

Trinity Dam auxiliary outlet works, jet flow gate--1:14.87 scale model--300 feet, color film, 16 and 64 frames per second--edited and titled. (This film is not good quality; caused by mechanical faults in camera.)

Colorado River Storage Project

Flaming Gorge Dam--1:30 scale model of spillway--100 feet, color film, 32 frames per second--not edited.

Weber Basin Project

Willard Canal baffled apron bypass No. 1--1:10 scale model--100 feet, color film, 32 frames per second--not edited.

Central Valley Project

Whiskeytown Dam Spillway--1:32.76 scale model--500 feet, color film (incomplete)--not edited. (Completed portion includes preliminary design of entire structure plus the recommended design of flip bucket operating with the outlet works.)

Canal Capacity Studies

Wave action studies at bridge piers--1:24 scale model--100 feet of color film, various speeds--not edited.

4. Model Shopwork

Weir Measuring Devices Demonstration Model

The model was repaired and completely repainted and relabeled. During the year it was shipped for display at: (1) Lamar State College of Technology, Beaumont, Texas, for Engineer's Day; (2) Wyoming Engineering Society Conference, Casper, Wyoming; (3) Colorado State University, Fort Collins, Colorado, College Days; and (4) Michigan College of Mining and Technology, Houghton, Michigan, Engineering Show. Between shipments, the model was on display in the laboratory.

Glen Canyon Architectural Model

This 1:240 scale model was completed in October 1960. Work performed this fiscal year included the fabrication of metal replicas of 3 right rim towers and 1 switchyard approach tower, completing the downstream face of the dam and applying the final coat of paint to the entire model. The model was displayed at the Denver-Hilton Hotel during the annual convention of the National Society of Professional Engineers in October 1960. It was finally moved to the display area on the southwest mezzanine of Building 53. Later the upstream side of the model was enclosed and the cable duct between the powerhouse and the canyon wall was added. It is now being used as an aid to design studies and a public display. Photographs of the model have also been used to illustrate an article in Electrical World.

Irrigation Project Display Model, Region 6

At the request of Region 6, the laboratory model maker went (on May 14) to Billings, Montana, on a 30-day detail. The assignment was to complete a 3- by 5-foot diorama of a typical irrigation project started by a former employee of the Billings Office. The model is animated and depicts a representative distribution system conveying water from the reservoir to the farmers' land. Exemplary farm products are miniaturized in the fields in the foreground of the model. Also portrayed is the secondary benefit of power to the farm and the means of distribution from the hydroelectric powerplant at the storage dam.

SECTION VII--LABORATORY REPORTS, PAPERS, PUBLICATIONS AND TRAVEL REPORTS ISSUED DURING FY61

Laboratory Reports

Hyd-445	Progress Report V--Research Study on Stilling Basins, Energy Dissipators, and Associated Appurtenances--Section 9--Baffled Apron on 2:1 Slope for Canal or Spillway Drops (Basin IX)--April 26, 1961	A. J. Peterka
Hyd-447	Hydraulic Model Studies of the Trinity Dam Morning-glory Spillway--Trinity River Division--Central Valley Project, California--April 22, 1960	W. B. McBirney
Hyd-450	Some Effects of Suspended Sediment on Growth of Submersed Pondweeds--July 12, 1960 (Issued as General Report Gen-27)	P. F. Enger N. E. Otto
Hyd-457	Hydraulic Model Studies of Navajo Dam Diversion and Outlet Works Structure--August 15, 1960	G. L. Beichley
Hyd-459	Measuring Seepage Loss in Irrigation Canals (Tentative Procedures for Ponding and Seepage Meter Tests)--March 1961	W. B. McBirney
Hyd-461	Hydraulic Model Studies of Glendo Dam Outlet Works--Missouri River Basin Project, Wyoming--August 1, 1960	W. E. Wagner
Hyd-463	Hydraulic Model Studies of Twin Buttes Dam Outlet Works--San Angelo Project, Texas--May 25, 1960	T. J. Rhone
Hyd-464	Progress Report No. 3--Canal Erosion and Tractive Force Study (Correlation of Laboratory Test Data)--Lower-cost Canal Lining Program (Issued as General Report Gen-26, October 26, 1960)	P. F. Enger J. Merriman B. A. Prichard M. J. Ruffatti
Hyd-465	Progress Report No. 1--Canal Bank Erosion Due to Wind-generated Water Waves (January 9, 1961)	E. J. Carlson W. W. Sayre

Hyd-466	Hydraulic Model Studies of the Foss Dam River Outlet Works Stilling Basin--Foss Division--Washita Basin Project, Oklahoma--August 23, 1960	D. Colgate
Hyd-467	Hydraulic Model Studies of the Trinity Dam Spillway Flip Bucket--Central Valley Project, California--August 10, 1960	T. J. Rhone
Hyd-468	Air and Hydraulic Model Studies of the Left Diversion Tunnel Outlet Works for Glen Canyon Dam--Colorado River Storage Project, Arizona--September 28, 1960	W. P. Simmons, Jr.
Hyd-471	Flow Characteristics and Limitations of Screw Lift Vertical Metergates	J. W. Ball
Hyd-472	Hydraulic Model Studies of the Trinity Dam Auxiliary Outlet Works Jet Flow Gate--Central Valley Project, California--January 6, 1961	W. P. Simmons, Jr.
Hyd-473	Why Close Tolerances Are Necessary Under High-velocity Flow--October 20, 1960	J. W. Ball
Hyd-474	Calibration of Hollow-jet Valves and Vibration Studies of Outlet Works Y-Branch--Falcon Dam--October 25, 1960	J. W. Ball
Hyd-476	Hydraulic Model Studies of the 2- by 2-foot Twin Buttes Auxiliary Regulating Gate--San Angelo Project, Texas--January 30, 1961	Henry Falvey
Hyd-477	Hydraulic Model and Prototype Studies of Casa Colorada Channelization--Middle Rio Grande Project, New Mexico--May 1961	R. A. Dodge, Jr.
Hyd-478	Study of the Effects of Turnout Design on Registration Accuracy of Propeller Meters Placed in Downstream Ends of Turnout Pipes--April 10, 1961	J. W. Ball

Papers and Publications

Pap-137	Results of Hydraulic Laboratory Test to Determine Cause of Malfunctioning of Sparling Compound Meter Furnished under Specifications No. DC-4894 (A memorandum to Chief, Mechanical Branch, from Acting Chief Research Engineer, June 20, 1960)	R. B. Dexter
Pap-138	Fish Protective Facilities at the Tracy Pumping Plant--Central Valley Project, California (A paper presented at the Ninth Hydraulics Division Conference, ASCE, Seattle, Washington, August 17-19, 1960)	T. J. Rhone D. W. Bates
Pap-139	Why Close Tolerances are Necessary under High-velocity Flow (A paper presented at the Construction Engineers Conference, Denver, Colorado, January 25-29, 1960)	J. W. Ball
Pap-140	Closing Discussion--Hydraulic Characteristics of Gate Slots (See Pap-105 for subject paper)	J. W. Ball
Pap-141	Discussion on Paper, "Use of Model to Disclose Effects of Cavitation in Penstock Wye-Branch"	J. W. Ball
Pap-142	Discussion on Paper, "Torque and Cavitation Characteristics of Butterfly Valves"	J. W. Ball
Pap-143	A Closure for Paper, "Hydraulic Design of Spillway Buckets" (See Pap-118 for subject paper)	G. L. Beichley A. J. Peterka
Pap-144	Discussion on Paper, "Hydraulic Downpull Forces on High Head Gates"	W. P. Simmons, Jr.
Pap-145	A Closure for Paper, "Problems Encountered in the Use of Low Head Radial Gates" See Pap-103 for subject paper)	T. J. Rhone
Pap-146	Cableway for Current Meter Gaging and Sediment Sampling Stations which Permits Operation of the Current Meter or Sampler from the Bank of the Stream	C. W. Thomas

Pap-147	Notes of Meeting on Hydraulic Laboratory Techniques, November 28, 1960 (Bureau of Reclamation, Corps of Engineers, Tennessee Valley Authority, and U.S. Navy David Taylor Model Basin, August 9 and 10, 1960)	Hydraulic Laboratory Staff
Pap-148	Hydraulic Models--Indispensable Tools of the Designing Engineer (Paper presented at the Hydraulics Seminar, January 31-February 2, 1961, in Denver, Colorado, sponsored by the Bureau of Public Roads and the Colorado, New Mexico, Utah, and Wyoming State Highway Departments)	A. J. Peterka
Pap-149	Tractive Force Fluctuations Around an Open Channel Perimeter as Determined from Point Velocity Measurements (A paper presented at the ASCE Convention, Phoenix, Arizona, April 10-14, 1961)	P. F. Enger
Pap-151	Cylinder Pitot Tube and Supporting Mount for Studies in a High Head, High Velocity Closed Conduit Flow System (Memorandum to H. M. Martin, April 14, 1961)	W. P. Simmons, Jr.

Travel Reports

Discussion of proposed cosponsorship of basic research symposium with officials of Colorado State University--July 11, 1960 (July 14, 1960)	H. M. Martin
Wind velocity, direction, and wave height instrument installation and profile survey on Driftwood-Meeker Canal for the purpose of studying the erosion effect of wind-generated water waves on earth-lined canals--Missouri River Basin Project (July 13, 1960)	R. H. Kuenmich
Seepage control demonstration using the chemical, SS-13, as a sealant on a small canal near Hudson, Colorado--June 24, 1960 (July 15, 1960)	R. J. Willson C. W. Thomas
Chemical sealant tests on Indian Bend Pump Lateral--Salt River Project, Arizona--May-June 1960--Lower-cost Canal Lining Program (July 15, 1960)	C. W. Thomas
Field tests to develop data on conveyance capacities of large canals in the Columbia Basin Project (May 3, 1960)	C. W. Thomas
Silting investigations--Lower-cost Canal Lining Program--North Platte Project (May 10, 1960)	C. W. Thomas
Attendance and participation in ASCE and USCOLD Convention in Reno, Nevada, June 20 to 24, 1960 (July 19, 1960)	L. G. Puls W. H. Price Samuel Judd A. J. Peterka
Discussion meeting at Sacramento, California, June 27 to July 1, 1960, on conveyance capacities of large canals (August 1, 1960)	C. W. Thomas P. J. Tilp
Participation in the Ninth National Conference, Hydraulics Division, American Society of Civil Engineers--University of Washington--Seattle, Washington--August 17 through 19, 1960 (September 19, 1960)	T. J. Rhone H. S. Riesbol
Silting and seepage investigations--North Platte Project (August 17, 1960)	C. W. Thomas
Silting and seepage investigations--North Platte Project (September 8, 1960)	C. W. Thomas

Planning meeting for proposed Symposium on Basic Research in Civil Engineering Fields as Related to Water Resources in Reclamation (October 4, 1960)	W. H. Price J. W. Ball
Electrical logging field tests to detect seepage on the Kirwin Main Canal--Lower-cost Canal Lining Program--Solomon Division--Missouri River Basin Project, Kansas (October 19, 1960)	D. Wantland R. H. Kuenmich
Seepage loss studies--Kirwin Main Canal--Missouri River Basin Project--Lower-cost Canal Lining Program (October 21, 1960)	C. W. Thomas
Silting and seepage investigations--North Platte Project (September 20, 1960)	C. W. Thomas
Attendance at Symposium on Basic Science in France and United States--New York University--October 17-19, 1960 (November 16, 1960)	H. M. Martin
Seepage loss measurements--Eden Project, Wyoming, and Gateway Canal--Weber Basin Project, Utah--Lower-cost Canal Lining Program (November 9, 1960)	C. W. Thomas
Coordination of research and development work of the Corps of Engineers, Tennessee Valley Authority, and the Bureau of Reclamation--Meeting at Waterways Experiment Station, May 9 to 12, 1960 (June 10, 1960)	W. H. Price W. U. Garstka H. M. Martin W. G. Holtz E. C. Higginson
Turbine performance and CO_2 concentration tests on the unit at Green Springs Powerplant--Talent Division--Rogue River Basin Project (November 17, 1960)	R. E. Krueger R. H. Kuenmich
Inspection of Eklutna Tunnel and performance of hydraulic tests--Eklutna Project, Alaska (September 12, 1960)	W. E. Schneider R. B. Dexter
Sediment tests on prototype diversion dams--Kansas River Basin--Nebraska-Kansas (September 9, 1960)	E. J. Carlson E. L. Pemberton
Visit to Air Force Academy to obtain design and operational information concerning smoke tunnel test facility (February 13, 1961)	J. W. Ball
Seismic field tests in connection with foundation exploration--Causey Dam--Weber Basin Project, Utah (February 17, 1961)	Dart Wantland R. H. Kuenmich

Observation of the unwatered upper 30 miles of Delta-Mendota Canal and discussions with Central Valley Project personnel regarding canal capacity tests (February 2, 1961)	C. W. Thomas P. J. Tilp
College contact program (March 16, 1961)	H. M. Martin
College contact program (March 16, 1961)	H. M. Martin
Silting and seepage investigations--North Platte Project (March 15, 1961)	C. W. Thomas
Symposium on Basic Research in Civil Engineering Fields Related to Water Resources (May 8, 1961)	W. H. Price J. W. Ball
Movable bed flume tests using radioactive-labeled sand--Hydraulic Laboratory---Colorado State University (April 24, 1961)	E. J. Carlson
Attendance at American Society of Civil Engineers Convention--Phoenix, Arizona--April 10-14, 1961 (May 11, 1961)	P. F. Enger
Symposium on Basic Research in Civil Engineering Fields Related to Water Resources--Fort Collins, Colorado (June 22, 1961)	H. M. Martin J. W. Ball E. J. Carlson

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
Donald Colgate, BSCE	Hydraulic Research Engineer
Phillip F. Enger, BSCE, MSCE	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
Eugene R. Zeigler, BSCE	Hydraulic Research Engineer
Danny L. King, BSCE	Hydraulic Research Engineer
David R. Basco, BSCE	Hydraulic Research Engineer
James M. Bergmann, BSCE	Hydraulic Research Engineer
Henry T. Falvey, BSCE, MSCE	Hydraulic Research Engineer
Robert H. Kuemmich	Electronic Development Technician
Howard R. Schroeder	Visual Information Specialist
James E. Fay	Hydraulic Engineering Aid
Julius P. Ambrusch	Exhibits Technician
Laura S. Hawthorn	Secretary

*Transferred to Division Office.

Summer Trainees

1960
None

1961
None

No engineers from university faculties were employed during the summers of 1960 and 1961.

Rotation Engineers

Gary Broetzman
Homer Jack Overton
Danny L. King
Bobby R. Maupin
David R. Basco
James M. Bergmann
Jackie E. Johnson
Kenneth D. Schoeman
Henry T. Falvey
Harley Warren
Albert Betters
William H. Thompson
Lorentz Haugseth
Dale Smith
Benjamin V. Wilkinson
David R. Osmundsen
David Gill
Stanley W. Cappa
Alexander H. Fraser
Gerald N. Hatton
David L. Wells
Fred J. Lasko
Orville B. Ridgley
Philip H. Nelson
J. (John) G. Anderson
Glenn DeGroot
Harold G. Budka
John Healy
Albert H. Miller
Kenneth E. Cudworth

Recapitulation of Staff Statistics

Date	Permanent employees	Total annual salaries	Temporary employees	Military furlough	Trainees	On detail
1-1-51	47	$211,885	--	1	6	--
1-1-52	41	219,035	--	2	1	1
1-1-53	39	219,445	--	1	1	--
1-1-54	30	176,145	--	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	--	**3	1
7-1-58	21	173,505	*2	--	**1	1
7-1-59	20	167,410	--	--	--	--
7-1-60	23	188,977	--	--	**1	--
7-1-61	24	205,660	--	--	--	--

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

SECTION IX--TIME AND COST DISTRIBUTION BY CLASSIFICATION OF WORK-SUMMARY FOR FY61

This section consists of three parts as follows:

(a) Percentage of labor distribution for FY61 (July 1, 1960 to June330, 1961)

(b) Labor and leave expenditures--FY61--Hydraulic Laboratory Branch by feature and job number

(c) Division of Engineering Laboratories time distribution record for Hydraulic Laboratory, FY61

EL-1
Rev. 9-60

DIVISION OF ENGINEERING LABORATORIES

Percentage of labor distribution July 1, 1960 through June 30, 1961

Feature	Division Office	Conc	Chem	Hyd	Earth	Lab Services	Division Actual	Division Budget	Expend.
DIRECT CHARGE - TOTAL	67.2	86.5	88.6	83.6	84.8	79.0	84.5	83.4	
Bureau Projects	62.8	74.6	69.1	74.7	75.2	59.4	71.2	69.9	
Individual Projects	35.9	69.6	48.8	37.2	57.6	47.0	53.7	49.8	
Project Services-General	26.9	5.0	20.3	37.5	17.6	12.4	17.5	20.2	
Manuals & Publications	0.4	1.1	0.4	1.0	0.4	0.1	0.7	1.2	
Tech. Info. Services	7.9	0.8	1.1	2.2	1.0	0.2	1.3	1.6	
Technical Studies	0.1	0.7	--	--	0.2	--	0.2	0.3	
Eng. Meth. & Matls Res.	18.5	2.3	18.8	33.4	15.3	12.1	14.0	16.7	
Personnel Act. & Serv.	--	0.1	--	0.9	0.3	--	0.2	0.3	
Property Mgt. Service	--	--	--	--	0.4	--	0.1	0.1	
Non-reimbursable research	3.8	8.5	17.8	6.7	7.1	4.0	9.5	10.1	
Outside Agencies	0.2	0.4	1.2	1.1	1.4	0.8	0.9	1.1	
Foreign Activities	0.4	3.0	0.5	1.1	1.1	0.9	1.4	1.4	
Fabrication Orders	--	--	--	--	--	13.9	1.5	0.9	
GENERAL DISTRIBUTIVE EXPENSE - TOTAL	32.7	13.5	11.4	16.4	15.2	21.1	15.4	16.6	
General Operating Expense	1.7	3.9	1.5	2.1	3.9	18.0	4.5	5.5	
Employee Benefits & Welf.	--	--	--	--	--	--	--	--	
Equipment Maintenance	0.1	3.3	1.2	1.6	3.0	17.8	4.0	5.0	
Bldg. Maint. & Alter.	--	--	--	0.2	0.3	0.2	0.1	0.1	
Misc. Admin. Expense	1.6	0.6	0.3	0.3	0.6	--	0.4	0.4	
Indirect Eng'g Expense	31.0	9.6	9.9	14.3	11.3	3.1	10.9	11.1	
Administration	18.3	2.3	3.5	4.2	3.6	2.8	3.8	3.8	
Staff Development	--	0.5	0.4	1.8	1.7	--	0.8	0.5	
Prof., Interagency Coop.	6.1	4.4	1.3	4.6	3.1	0.3	3.1	3.3	
Tech. Info. Serv.-Denver	2.5	0.8	2.3	1.8	1.1	--	1.4	1.5	
Tech. Staff Serv.-Labs	4.1	1.2	2.1	1.9	1.7	--	1.6	1.6	
Tech. Stds. & Procedures	--	0.4	0.3	--	0.1	--	0.2	0.4	

LABOR+ADDITIVE EXPENDITURES--FISCAL YEAR 1961

Hydraulics Lab Branch Cost Center P-0 Date of this report 6-30-61

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 Expenditure
Bureau Project Work		83450	92,372.39			
Outside Agencies		1500	2640.40			
Foreign Activities		4000	2819.67			
Fabrication Orders	32-8900-0-					
Employee Benefits & Welfare						
Employee recognition	21-3301-0-0-5	150	66.97			
Civil Defense participation	-6					
Equipment Maintenance						
Laboratories	21-3302-0-0-3	4000	3953.17			
Auditorium sound system	-4	100				
Photo-elastic Laboratory	-5					
Electric load analyzer	-6					
Office equipment repair	-7	275	31.82			
		4375	3984.99			
Building Maint.&Alterations	21-3303-0-0-		411.28			
Misc. Administrative Expense						
Laboratory & office tours	21-3306-0-0-10	900	804.94			
Office moves	-11					
Administration--General	22-4400-0-0-1	9800	10,509.82			
Staff Development						
Student engineer training	22-4401-0-0-1	100	106.78			
Rotation Engineer Program	-2	1400	4328.91			
Chromatography Course	-12					
Orientation for GS-12 Engr.	-14	15				
		1515	4435.69			
Professional, Interagency & Other Cooperation						
Attendance at meetings	22-4403-0-0-1	2500	1796.86			
Technical papers	-2	2000	1048.01			
Federal, state & civic groups	-3	2000	6835.01			
Technical group participation	-6	2000	1393.86			
Safety Mtgs.	-7	200	271.25			
		8700	11,344.99			

Cost Center 3 Date of this report 6-30-61

Feature	Job Number	Labor & Motive Annual Budget	Labor & Motive Expended to date	% spent in 60 % of time Branch	% spent in 60 % of time Division	Rate of expenditure
Tech. Info. Service--Denver						
Domestic visitors	22-4404-0-0-1	1800	1552.37			
Technical inquiries	-2	1500	1554.62			
Statistical compilations	-3	200	361.83			
Articles and papers	-4	500	601.18			
Engineering monographs & technical memoranda	-5	400	442.06			
		4400	4512.06			
Technical Staff Services--Lab	22-4405-0-0-7	5500	4819.03			
Tech. Stds. & Procedures						
Standard specifications	22-4406-0-0-2					
Federal Spec. for pipe	-4					
Prep. of Manuals & Publications						
Reclamation Instructions	23-5501-0-0-1					
Concrete Manual	-2					
Earth Manual	-3					
Paint Manual	-4					
Water Measurement Manual	-5	700	2407.26			
Tech. Info. Serv. (Project Serv.)						
Prep. & display of exhibits	23-5502-0-0-1	1000	790.33			
Foreign visitors	-2	2000	1309.95			
Technical inquiries	-3	2500	2284.84			
Statistical compilations	-4	900	690.79			
Articles and papers	-5	300	306.94			
Russian Tour	-16					
		6700	5382.85			
Technical Studies						
Data Analysis--Earth dams	23-5503-0-0-2					
European Dam Study Tour	-34					
Personnel Activities & Services						
Recruitment--College contact	23-5506-0-0-1	1500	1626.44			
Board of examiners	-2	950	564.80			
		2450	2191.24			
Property Management Services	23-5507-0-0-					

Cost Center 830 Date of this report 6-30-6

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 expenditure
Engrg. Methods & Matls. Res.						
Concrete	23-5504-0-0-1					
Cement and pozzolan	-2					
Earth	-3					
Hydraulic	-4	12,600	14,667.37			
Structural & materials	-5					
Bituminous	-6					
Special techniques	-7					
Protective coatings	-8					
Rock foundations	-9					
Riprap	-10	—	63.64			
Evaporation reduction	-11					
Plastics	-13					
Sedimentation studies	-16	16,700	22,523.32			
Weed control studies	-17		459.85			
Water measuring devices	-18	11,300	11,696.87			
Lower-cost canal lining	-19	11,160	11,922.78			
Oxygen content - water	-20					
Canal conveyance	-21	23,500	20,863.04			
Coordination - research	-22	1000	555.84			
		76,260	82,752.91			
Engrg. Methods & Matls. Res. (Non-reimb.)						
Concrete	9 F101-0-1-1					
Structural	1-2					
Cement, pozzolan & Admix.	-2-1					
Hydraulic	-3-1	17,000	16,514.02			
Oxygen content	-3-2					
Earth	4-1					
Rock foundations	4-2					
Bituminous material	-4-3					
Riprap	-4-4					
Evap. reduct. matls & method	-5-1					
Paint and corrosion	-6-1					
Plastics	-6-2					
Special techniques	-6-3					
		17,000	16,514.02			
		224,900	248,020.52			

DIVISION OF ENGINEERING LABORATORIES
TIME DISTRIBUTION RECORD

BRANCH: Hydraulic Laboratory
SECTION:

SHEET 1 OF 6
DATE: End of Fiscal Year 1961 (MONTH / YEAR)

‡ "B" No.	‡ REF NO	JOB NUMBER	PROJECT FEATURE	SHOPS This FY Used	SHOPS This FY Allo	TIME IN MAN DAYS FISCAL YEAR 1961 BAL. FWD.	THIS MONTH	TOTAL	ALLOCATION ORIG.	ALLOCATION REV.	*000* AND HOURS TOTAL JOB BAL. FWD.	TO DATE	ESTIMATE ORIG.	ESTIMATE REV.	DURATION MONTH / YEAR START	ESTM END	REMARKS
		1-A0-76-01-03	Equipment Shipment to Region 1			1	0	1	1								
		1-222-06-60-01	Block 23 Lateral System, CAP			1	0	1	1								
~~397~~		1-R222-22-35-01	Cavitation Damage--Outlet Cond--GCD			½	0	½									
~~X~~		1-415-11-01-01	Turbine Test--Grn Spgs Pplt--Rogue R	1		16	2	18		18							Completed
5721	377	2-214-00-30-01	Conveyance Capacity of Cen Val Canals	*43½	31	293	7	300	300								
5734	402	2-214-05-51-01	Delta-Mendota--Fish Protection--Tracy	80	80	60½	3	63½	140								
		2-214-06-60-01	Madera Extension Distribution Sys, CVP			½	0	½	½								
		2-R214-22-82-01	Shasta Dam Spwy Design			¼	0	¼	¼								
~~399~~		2-416-01-01-01	Trinity Spillway			4	0	4	0							4-56	Hyd-447 & -467 issued
~~376~~		"	Trinity Aux OW Gate Calibration			10½	0	10½	10								Hyd-472 issued--See Hyd Res 324
		2-416-01-04-01	Whiskeytown Dam Conf			0	0	0									
5381	381	"	Whiskeytown Spillway Model	23	86	176½	21½	197¾	200								
		2-416-05-01-01	Clear Creek Tunnel			¼	0	¼		12							
		2-416-05-02-01	Spring Creek Conf (Tunnel)			½	0	½	0								
		2-540-06-01-01	First Stage ElDorado Dist Sys Conf			1½	0	1½	0								
	384	"	ElDorado Distr Sys--Clayton Valve	13	13¼	65¼	2	67¼		53							
		2-H885-98-02-01	Santa Ynez River Water Cons District			¼	0	¼	½								
		2-00-00-03-01	San Luis Pumping Plant			0	2½	2½	5								
		4-G154-01-01-01	Fontenelle Dam Conf, Seedskadee Proj			3	0	3	5								
5752	403	"	Fontenelle Spillway Model	89	91	109½	14½	123½	124								
5757	404	"	Fontenelle Outlet Works Model	73¼	70	77	9½	86½		88¼							
		4-G343-02-01-01	Hammond Diversion Dam			3?	0	3?	4								
	~~382~~	4-G343-05-01-01	Hammond Main Canal, New Mexico			½	0	½	½								Completed
		4-482-01-02-01	Bonham Dam Rehabilitation			1½	0	1½									
		4-482-05-03-01	Colbran Canal, Bonham Cottonwood Conf			0	0	0									
		4-G517-01-01-01	Crawford Dam			0	0	0									
		4-G519-01-01-01	Lemon Dam, Florida Project--Conf			3¼	0	3¼	5								
	~~X~~	4-526-01-04-01	Causey Dam, Geological Invest.			14½	0	14½	19								
		4-526-03-01-01	Pump Plant No. 1--Willard Canal, Conf			3½	0	3½	2								
	401	"	Willard Canal Baffled Apron--Weber B	50¼	33	63	0	63	59								
	~~375~~	4-G557-01-01-01	Glen Canyon Architectural Model	16¼	15	10	0	10	10								Completed
		"	Glen Canyon Dam Epoxy Conf			4½	0	4½									
		"	Glen Canyon Dam Epoxy Tests			0	0	0									
		"	Glen Canyon Dam & Spwy Conf			7½	0	7½									
		4-G557-01-01-02	Glen Canyon Tunnel & OW Conf			0	0	0									
~~4426~~	~~319~~	"	Glen Canyon Tunnel Plug OW	16¼	29	23	0	23	140							6-57	Hyd-468 issued
4154	302	4-G557-01-01-03	Glen Canyon Spillway	15		97½	12½	109¾								6-56	Hyd-469 drafted
5641		4-G557-11-01-01	G C Powerplant--Cavitation Tests	1	2	2½	0	2½	10								
5642	318	4-G591-01-01-01	Flaming Gorge Spillway	3		30¾	16½	46¼	50							4-57	
		4-G711-01-01-01	Navajo Dam and Res Conf			0	0	0									
~~5710~~	336	"	Navajo Spillway & Aux OW	2	4	40½	5½	46		48						12-57	
	~~337~~	"	Navajo Outlet Works			2	0	2								12-57	Hyd-457 issued
		4-G514-74-60-03	Rifle Gap Dam--Silt Project			½	0	½		½							

NOTES
*Shop time--includes charges to other "B" numbers this FY.
*Hyd time--includes charges to discontinued assignments.
‡ Do not charge to shop number or assignment if crossed.

DIVISION OF ENGINEERING LABORATORIES
TIME DISTRIBUTION RECORD

BRANCH: Hydraulic Laboratory
SECTION:

DATE: End of Fiscal Year 1961

‡ "B" No.	‡ REF NO	JOB NUMBER	PROJECT FEATURE	SHOPS This FY Used	SHOPS This FY Allo	TIME IN MAN DAYS *000* AND HOURS FISCAL YEAR 1961 BAL. FWD.	THIS MONTH	TOTAL	ALLOCATION ORIG.	ALLOCATION REV.	TOTAL JOB BAL FWD	TOTAL JOB TO DATE	TOTAL JOB ESTIMATE ORIG	TOTAL JOB ESTIMATE REV	DURATION MONTH / YEAR STAN	DURATION MONTH / YEAR ESTM END	REMARKS
4873	348	5-163-02-03-04	Sedimentation Alleviation--San Acacia	8	8	148	6	154		154							Hyd-479 drafted
	348	5-163-09-05-01	Channelization Studies, San Acacia			3	1	4									See 5-163-02-03-04
3860	277	"	Channelization Studies, M Rio G Proj			34	0	34		39							Hyd-477 issued
		5-163-09-22-01	Channelization--Albuquerque Area--Ang			11	0	11		20							
		5-163-01-01-01	ElVado Dam--Butterfly Valve Repair			0	1	1	1								
		5-B662-01-01-01	Sanford Dam Conf, Canadian Riv Proj			1	2	3	5								
		5-825-01-01-01	Twin Buttes Dam Conf, San Angelo Proj			1	0	1									
	367	"	Twin Buttes OW Water Model			5	0	5		46							Hyd-463 issued
	368	"	Twin Buttes OW Air Model	37	35	28	11	39									Hyd-470 drafted
	398	"	Twin Buttes Aux Gate			54	0	54		45							Hyd-476 issued
		5-825-05-01-01	San Angelo Canal System, Twin Buttes			2	3	2	5								
	340	5-830-01-02-01	Foss Outlet Stilling Basin			8	0	8	10						1-58		Hyd-466 issued
		5-B135															
		6-0-31-22-01	Personnel Detail--J. P. Ambrusch			12	22	34									
		6-26-01-01-01	Buffalo Bill Dam--Shoshone Proj			3	0	3		3							
5967		6-459-01-01-01	Yellowtail Dam & Res--LBH--MRBP Conf	1	1	32	0	32									
5673	399	"	Yellowtail Spillway--Lower Big Horn	335	359	391	41	433		575							
5690	400	"	Yellowtail Outlet Works			71	0	71									
	405	6-699-05-01-01	East Bench Canal--Seepage Measurement			4	0	4	2								
5836	406	"	East Bench Canal--Drawdown Tests MRBP	5	8	11	4	15		15							
5892		7-00-31-31-01	Silting Invest.--LCCL--No. Platte		1	18	0	18		15							TR 8-17-, 9-8-, 9-20-60
		7-328-01-04-01	Red Willow Dam			0	0	0									
	**	7-372-05-01-01	Cedar Bluff Main Canal			2	0	2		3							
		7-449-11-02-01	Fremont Canyon Powerplant Test Equip.			1	0	1	1								
	**	7-492-01-01-02	Horton R. R. Relocation			1	0	1									Complete
		7-719-01-01-01	Merritt Dam OW Conf, Snake River			0	0	0									Hyd-456 drafted
	363	"	Merritt Dam OW Stilling Basin			19	9	29		30							
		8-R783-22-04-01	Obtain Conveyance Cap. Data--Eklutna			15	0	15		15							See Hyd Res 310
		9-F101-00-03-01	HYD LAB INVEST.--NONREIMBURSABLE														
	218	"	--Hyd Jump & Energy Dissipators	27		104	0	104	120								Hyd-445 issued
	221	"	--Pipeline Distribution System	31		131	0	131	104								
	322	"	--Conc Surface Irregularities	25		98	0	98	100								Hyd-473 issued
	225	"	--Instrumentation for Hyd Data	27		58	0	58	50								Chgs also 23-5504-0-0-4
	247	"	--Erosion of Earth Slopes	0		24	0	24	18								Also see LCCL--Hyd-465 issued
			NONREIMBURSABLE TOTALS	110				417	392								
		9-F801-76-30-07	Sediment Surveys of Existing Reservoirs			1		1									
		9-R000-31-10-10	Soil & Moisture Conservation--El Leg.			22	0	22	22								
5704	361	9-800-00-01-06	Electrodialysis Res & Dev--Cells (Sal)	16		113	0	113		115							
		9-800-00-01-01	Dalpra Farm (Field Test Site)--ER&D			0	1	1									
			OUTSIDE AGENCIES														
	385	11-6214-00-01-15	--B/Pub Rds--Hyd Inv Embankment Drain	25		12	0	12		12							Account closed

**Rotation Engineer detailed to finish uncompleted work in former assignment.

DIVISION OF ENGINEERING LABORATORIES
TIME DISTRIBUTION RECORD

BRANCH **Hydraulic Laboratory** SHEET 3 OF 6 Sheets

SECTION End of Fiscal Year 1961

‡ "B" No.	‡ REF NO	JOB NUMBER	PROJECT FEATURE	SHOPS This FY Used	SHOPS This FY Allo	TIME IN MAN DAYS .00 AND HOURS FISCAL YEAR 1961 BAL FWD.	THIS MONTH	TOTAL	ALLOCATION ORIG.	ALLOCATION REV.	TOTAL JOB BAL FWD.	TOTAL JOB TO DATE	TOTAL JOB ESTIMATE ORIG.	TOTAL JOB ESTIMATE REV.	DURATION MONTH / YEAR START	DURATION FINISH EST.
		12-6195-0-73-01	Foreign Observer (Iran)													
		12-624-00-01-02	**State of Calif, Dept of Water Resources**--Conf			13 2/5	7	20 2/5								
5959	407	"	Oroville Diversion Tunnels 1 & 2	15	60		17 1/5	17 1/5								
5960	408	"	Oroville Outlet Works		60		12 1/5	12 1/5								
		"	Oroville Power Intake													
		"	Oroville Spillway													
			FOREIGN ACTIVITIES													
		13-6195-00-92-01	--Trainees			46	0	46								
		13-6301-00-01-03	--Snowy Mtns--Australian Trainees			45	2	65								
		13-6301-00-01-05	--Gen Tech Services			94	0	94								
		13-6301-00-01-09	--Australian Observer			0	0	0								
		13-6301-05-01-01	--Adaminaby Junction Shaft			0	0	0								
		13-6305-00-02-04	--Engineering Consultants, Inc--Yan Hee			2/5	0	2/5								
		13-6305-00-02-11	--Foreign Trainee (Thailand)			5 2/5	4	9 2/5								
		14-6195-00-22-01	--Foreign Trainees			13 5/5	0	13 5/5								
		14-6195-00-23-01	--Foreign Observers--Tech Coop Prog			4 5/5	2	6 1/5								
		14-6195-20-00-01	--General Tech Services			5 3/5	0	5 3/5								
	~~380~~	"	--Korean Hydraulic Laboratory--ICA			3	0	3								
		14-6195-20-09-01	--"Backstopping" Mission to Ethiopia			2/5	0	2/5								
		14-6195-20-21-01	--Backstop--Gen Tech Info--Turkey			0	0	0								
		14-6195-28-01-01	--Engrg Advisory Services			0	0	0								
			FOREIGN ACTIVITIES TOTALS					59 1/5	80							
		21-3301-00-00-05	**BENEFITS & WELFARE**--Employee Recog			1 4/5	0	1 4/5	3							
5814		21-3302-00-00-03	**EQUIP. MAINT**--Lab, Meters	24 6/5												
2755		21-3302-00-00-03	**EQUIP. MAINT**--Laboratories	99 2/5		95 5/5	2	97 5/5	80							
		21-3302-00-00-04	--Auditorium sound system			1	0	1	2							
		21-3302-00-00-07	--Office equipment repair			1	0	1	5/5							
		21-3303-00-00-02	**BLDG MAINT & ALTERATIONS**--Bldg 56			10 5/5	0	10 5/5	3							
		21-3306-00-00-10	**MISC ADMIN EXP**--Lab & Office Tours			18 4/5	1	19 5/5	18							

NOTES

DIVISION OF ENGINEERING LABORATORIES
TIME DISTRIBUTION RECORD

BRANCH **Hydraulic Laboratory** SHEET 4 of 6
SECTION DATE End of Fiscal Year 1961
MON. YEAR

‡ REF NO	JOB NUMBER	PROJECT FEATURE	SHOPS This FY Used Allo	TIME IN MAN DAYS .00 AND HOURS FISCAL YEAR 1961 BAL. FWD.	THIS MONTH	TOTAL	ALLOCATION ORIG	REV	TOTAL JOB BAL FWD	TO DATE	ESTIMATE ORIG	REV	DURATION MONTH	YEAR START	FY	REMARKS
‡ "B" No.																
	22-4400-00-00-01	ADMINISTRATIVE		148 6	22 3	171 3	163									
	"	--Foreign Currency Research		8 4	0	8 4										
	22-4401-00-00-01	STAFF DEVELOP.--Student Engr Training		6 3	0	6 3	5									
	22-4401-00-00-02	--Rotation Engr Training		107 3	2 2	109 5	28									
	22-4403-00-00-01	PROFESSIONAL, INTERAGENCY & OTHER--Att. Meet.		20 4	12	32 4	60									
	22-4403-00-00-02	--Technical Papers		22 2	4	22 6	40									
	22-4403-00-00-03	--Other Participation in Fed, St, Civic Groups		79 2	0	79 1	40									
	"	--1961 Basic Research Symposium		61	0	61										
	22-4403-00-00-05	--Interagency Committee on Water Resources		0	0	0	0									
	22-4403-00-00-06	--Other Participation in Technical Groups		40 4	0	40 4	40									
	22-4403-00-00-07	--Safety Meetings--Laboratories		3 2	3 2	6 4										
	22-4404-00-00-01	TECH INFO, Denver--Domestic Visitors		33 2	1 3	34 5	36									
	22-4404-00-00-02	--Technical Inquiries		32 2	0	32 2	30									
	22-4404-00-00-03	--Statistical Compilations		11 2	0	11 2	4									
	22-4404-00-00-04	--Articles & Papers (except mtgs)		13 1	0	13 1	10									
	22-4404-00-00-05	--Monographs & Technical Memoranda		8 2	0	8 2	8									
	22-4405-00-00-07	TECH STAFF SERV--Laboratories		117 4	0	117 4	110									
	22-4405-00-00-12	--Examination of Operating Projects		1 2	0	1 2	2									
	23-5501-00-00-05	MANUALS & PUBL--Water Measurement		17 6	32 3	50 1										
	23-5502-00-00-01	TECH INFO, Bwide--Prep & Disp Exhibits		24	0	24 4	20									
	23-5502-00-00-02	--Foreign Visitors		29 1	1 3	30 4	40									
	23-5502-00-00-03	--Technical Inquiries		46 5	4	47 1	50									
	23-5502-00-00-04	--Statistical Compilations		18 2	0	18 2	18									
	23-5502-00-00-05	--Articles and Papers		3 2	4	7 2	6									

NOTES

DIVISION OF ENGINEERING LABORATORIES
TIME DISTRIBUTION RECORD

BRANCH: Hydraulic Laboratory
SECTION:
SHEET 5 of 6
DATE: End of Fiscal Year 1961 (MONTH, YEAR)

‡ "B" No.	‡ REF NO.	JOB NUMBER	PROJECT FEATURE	SHOPS This FY Used	SHOPS This FY Allo	TIME IN MAN DAYS (000) AND HOURS FISCAL YEAR 1961 BAL. FWD.	THIS MONTH	TOTAL	ALLOCATION ORIG.	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 FSTM END	REMARKS
4204	226	23-5504-00-00-04	HYD LAB INVESTIGATIONS--General	*23 6		79 7	0	79 7	0								
	240	"	--Vertical Stilling Wells			4	0	4	10								
	219	"	--Siphon Spillway			0	0	0	30								
	220	"	--Canals, Small Structures			10	0	10	120								
4265	251	"	--Pipe Exit & Ent Trans	25 4		71	0	71									
	309	"	--Cond & Penstock Br, Cav & Hd Loss			12 2	0	12 2	20								
	191	"	--Gates, Downpull			0	0	0	20								
	365	"	--Palisades-type Gate			0	0	0									
	222	"	--Air Demand, Gates & Valves			8	0	8	30								
	255	"	--Gate Slots			0 2	0	0 2	40								
5628	225	"	--Instrumentation for Hyd Data	20		59	0	59	20								Charges also in 9-F
	359	"	--Riprap sizes			4	0	4	10								
	310	"	--Friction--Large Conduit			75 6	0	75 6	40								
	323	"	--Side Channel Spillways			0	0	0	4								
	324	"	--Air Req Tunnels, Controls			40 1	0	40 1	4								See also Trinity 378
	326	"	--Morning-glory Spillway			2	0	2	10								
			HYDRAULIC LAB INVESTIGATIONS TOTALS					365	358								
	177	23-5504-00-00-16	SEDIMENTATION STUDIES--General			35 6	5 1	41 5	28								
	306	"	--Sediment Removal Structures	* 5		174	6 3	180 3	130								
	36	"	--Stable Channel Shapes			93	0	93	60								Report Gen-D issued
5161	331	"	--Curved Channel Sections	25		34 5	2	36 5									
	330	"	--Channelization & Bank Protection			104 4	1	105 4	90								
	372	"	--Suspension of Bed Sediment			54 1	20 3	74 4	58								
5865	393	"	--Boundary Shear	111 4		88 2	21 3	109 6	60								
			SEDIMENTATION TOTALS					557 6	426								
		23-5504-00-00-17	WEED CONTROL			2 4	9 2	12 3									
	184	23-5504-00-00-18	WATER MEASUREMENT--General			59 4	0	59 4	0								Hyd-478 issued
	320	"	--Constant-head Orifice Turnout			7	10	17	30								
	332	"	--Critical Depth Meas Device			1 2	0	1 2	4								
	351	"	--Weirs, Velocity of Approach			12 1	0	12 1	4								
	352	"	--Turnout Gates			51 3	9	60 2	30								Hyd-471 issued
	334	"	--Design Data Tables			4 4	0	4 4	30								
	353	"	--Compound Weirs			23 1	7	30 1	30								
	354	"	--Adjustable Weirs			15 3	0	15 3	20								
~~5643~~ 5887	355	"	--Water Use & Meas Records (continued next page)	*34 2		17	8 1	25 1	70								

NOTES

147

DIVISION OF ENGINEERING LABORATORIES
TIME DISTRIBUTION RECORD

BRANCH Hydraulic Laboratory
SECTION

SHEET 6 OF 6 End of
DATE Fiscal Year 1961 (MONTH / YEAR)

‡ "B" No.	‡ REF NO	JOB NUMBER	PROJECT / FEATURE	MOPS This FY Used	MOPS This FY Allo	TIME IN MAN DAYS *00* AND HOURS — FISCAL YEAR 1961 BAL. FWD.	THIS MONTH	TOTAL	ALLOCATION ORIG.	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
		23-5504-00-00-18	Water Measurement (cont'd)														
	356	"	--Bibliography and Classified File			4 6	0	4 6	20								
	357	"	--Very Low Flow Meas			1 1	0	1 1	10								
	370	"	--Control Notches			22 4	21 3	43 7	10								
	371	"	--Dethridge Meter			4 7	0	4 7	4								
	325	"	--Radial Gate Coefficients			12 0	11	23 5	52								
			WATER MEASUREMENT TOTALS					305 5	314								
5876	152	23-5504-00-00-19	LCCL PROGRAM--Gen (Chemical Sealant)	1		31 2	9 6	*41		16 2							
	328	"	--Earth-chem Stabilization			50 2	0	50 2	40								
	327	"	--Asphalt, Soil Stabilization			5 2	0	5 2		12							
	290	"	--Erosion & Tractive Force			48 6	4	49 2	284								
	247	"	--Wave Erosion in Canals			27 5	0	27 5	10								Gen Rep 26 & Hyd-464 ins
		"	--Seepage Detection & Meas			0	0	0	0								See 9-F101-00-03-01
	374	"	--Electric Log			47 4	0	47 4		37							
	394	"	--Inflow-outflow Method			37 6	0	37 6		116 2							
5808	395	"	--Meter Standard Procedure	4		5 5	0	5 6	10								TR 10-21- and 11-9-60
	396	"	--Ponding Tests Procedure			4 6	0	4 6	10								
			LOWER-COST CANAL LINING TOTALS			10 2	268 2		280								
		23-5504-00-00-21	CANAL CAPACITY STUDIES														
5740	385	"	--Hydraulic Tests on Canals	21		96 5	21 4	118 1	36								
	386	"	--Field Test Analysis			98 3	4	102 3	100								
	387	"	--Model-prototype Correlation			12	4	16	40								
	388	"	--Pier Losses, Model Tests			40 4	4	44 4	60								
5631	389	"	--Boundary Surface Texture	*91		204 7	18 3	223 3	102								
	390	"	--Engineering Literature			6	6	12	40								
	391	"	--Tentative Design Criteria			5	4 1	9 1	30								
	392	"	--Progress Report			6 4	4	10 4	20								
			CANAL CAPACITY TOTALS					534 4	428								
		23-5504-00-00-22	COORDINATION OF RESEARCH														
			--Hydraulic Research Conference			10 2	0	10 2									
			--Corps of Engrs Coordination			1 2	0	1 2									
		23-5506-00-00-01	PERSNL ACT. & SERV--Recruit, Col Cntct			27 4	0	27 6									
		23-5506-00-00-02	--Central Bd Civil Serv Examiner			10 7	0	10 7	18								
		28-4100-00-00-01	LEAVE--Annual			511 4	34 1	545 5									
		28-4100-00-00-02	--Sick			104 4	10 3	114 7									
		28-4100-00-00-03	--Holiday														
		28-4100-00-00-04	--Military			27	0	27									
		28-4100-00-00-05	--Court			2	0	2									
		28-4100-00-00-06	--Administrative			4	0	4									
		28-4100-00-00-07	--Civil Defense														

NOTES

HYDRAULIC LABORATORY

Feature	Labor + Additive D. L. + 30% FY61	FY62	
Bureau Project Work	$ 83,450	$100,000	Include Saline Water Res
Outside Agencies	1,500	32,000	California
Foreign Activities	4,000	2,000	
Employee Benefits and Welfare	150	150	
Equipment Maintenance	4,375	4,000	
Bldg Maint and Alt		150	
Misc Adm Expense	900	900	
Administrative--General	9,800	9,800	
Staff Development	1,515	4,500	
Prof, Interagency and other Coop.	8,700	10,000	
Tech Information Service:	4,400	5,500	
Tech Staff Services	5,500	4,000	
Prep of Manuals and Publ:	200	200	
Tech Info Serv (Pro Serv)	6,700	6,700	
Personnel Activities	2,450	1,500	
Hydraulic Research PSG	12,600	--	$95,000 Hyd Res (GI) (LL & OH)
Hydraulic Res Nonreim	17,000	67,800 G.I.	(Hyd Res 60,000 (Canal Cap 29,000 (Small Canal Str 6,000
Sedimentation Studies PSG	16,700	17,850 GAE	25,000 (LL & OH)
Water Meas Dev PSG	11,300	10,700 GAE	15,000 (LL & OH)
LCCL PSG	11,160	8,650	13,000 (LL & OH)
Canal Capacity Studies	23,500		See Hyd Res above
Coordination of Res	1,000	1,000	
TOTAL	$226,900	$287,600	

Approximate Salary Equivalent	$221,000	Direct Labor
Regular Staff Salaries	207,000	(24 in Hyd Lab)
Rotation Engineer Salaries	14,000	2 rotation engineers man-year

PROPOSED DEFINITION OF NONREIMBURSABLE WORK
Hydraulic Laboratory--FY62

Hydraulic Studies (Topics as noted in FY61 program)	Engineering Materials and Methods Research Nonreimbursable (GI Funds FY62, $390,000--Div $95,000 Hyd Studies Hydraulic Lab)	Development and Testing of Mat'ls and Procedures for General Application Proj Services General FY61 (Proposed GAE Funds FY62 $435,000--Division 53,000--Hyd Lab)
1. Hydraulic Characteristics of Vertical Stilling Wells	$ 6,600	
2. Hydraulic Jump and Energy Dissipators	9,000	
3. Operation and Design Characteristics of Siphon Spillways		
4. Standardization of Design of Small Canal Structures (Listed after Capacity Studies)		
5. Hydraulic Characteristics of Pipeline Distribution Systems and Related Structures	9,400	
6. Cavitation and Head Loss in Conduit and Penstock Branches		
7. Cavitation Erosion of Roughened Surfaces		
8. Downpull Forces on Coaster, Cylinder, and Fixed-wheel Gates		
9. Air Demand of Gates and Valves in Outlets	3,000	
10. Development of Cavitation-free Gate Slots		
11. Instrumentation for Acquiring and Recording Hydraulic Data	5,000	
12. Determination of Minimum-size Riprap for Channels		
13. Friction Loss Tests in Large Conduits	2,000	
14. Specifications Finishes and Tolerances for Irregularities and Misalinements in Concrete Surfaces Subjected to High-velocity Flow	4,200	

PROPOSED DEFINITION OF NONREIMBURSABLE WORK--Continued

Hydraulic Studies (Topics as noted in FY61 program)	Engineering Materials and Methods Research Nonreimbursable (GI Funds FY62, $390,000--Div $95,000 Hyd Studies --Hydraulid Lab)	Development and Testing of Mat'ls and Procedures for General Application Proj Services General FY61 (Proposed GAE Funds FY62 $435,000--Division 53,000--Hyd Lab)
15. Side Spillways		
16. Air Requirements for Tunnels and Siphons		
17. Crest and Transition Section for Morning-glory Spillway	$ 2,800	
18. Radial Gate Studies (new)	7,000	
19. Boundary Shear Studies (Related to sediment studies)	11,000	
SUBTOTAL	$50,000	

PROPOSED DEFINITION OF NONREIMBURSABLE WORK
Hydraulic Laboratory--FY62

	Engineering Materials and Methods Research Nonreimbursable (GI Funds FY62, $390,000--Div $95,000 Hyd Studies --Hydraulic Lab)	Development and Testing of Mat'ls and Procedures for General Application Proj Services General FY61 (Proposed GAE Funds FY62 $435,000--Division 53,000--Hyd Lab)
Canal Capacity Studies		
1. Hydraulic tests on large canals--technical assistance and equipment	$29,000	
2. Investigation of structure losses and resistance coefficients of boundary surface textures		
3. Analyses of field and laboratory data		
Development of Small Canal Structures	6,000	
1. Hydraulic tests on inlet and exit transitions to culverts and inverted siphons		
Subtotal for Hydraulic Laboratory:		
TOTAL	$95,000	

PROPOSED DEFINITION OF NONREIMBURSABLE WORK
Hydraulic Laboratory--FY62

	Engineering Materials and Methods Research Nonreimbursable (GI Funds FY62, $390,000--Div $95,000 Hyd studies--Hydraulic Lab)	Development and Testing of Mat'ls and Procedures for General Application Project Services General FY61 (Proposed GAK Funds FY62 $435,000-Division $3,000--Hyd Lab)
Sediment Studies		$ 25,000
1. Sediment control at diversions		3,500
2. Stable channel shapes--straight and curved channels		4,500
3. Channelization and bank protection		1,000
4. Relating suspension and scour of sediment to channel hydraulic characteristics		12,000
5. Boundary shear studies (listed under Hyd Res)		
6. Equilibrium beach profiles in reservoirs and non-cohesive earth materials		4,000
Development and Standardization of Water Measurement Devices		15,000
1. Constant-head orifice turnout study report; study of turnout gates		3,000
2. Study of radial gates for water measurement		
3. Compound weir study report		1,000
4. Study of notches for measurement purposes		2,000
5. Study of measurement structures with minimum head loss		4,000
6. Small measurement devices		1,000
7. Analysis of devices for design procedures		2,000
8. Study of measurement methods to improve water-loss records		2,000

PROPOSED DEFINITION OF NONREIMBURSABLE WORK
Hydraulic Laboratory--FY62

	Engineering Materials and Methods Research	Development and Testing of Mat'ls and Procedures for General Application
	Nonreimbursable (GI Funds FY62, $390,000--Div $95,000 Hyd Studies--Hydraulic Lab)	Proj Services General FY61 (Proposed GAE funds FY62 $435,000--Division 53,000--Hyd Lab)
Lower-cost Canal Lining Program		
1. Seepage Measurements and Loss Detection		--
Electrical logging		--
Inflow-outflow method		($ 4,000) prelim
Seepage meter and ponding test procedures		(1,750) prelim
Ponding tests of chemical installations in field		(6,800) prelim
2. Erosion and Tractive Force Studies		(3,500) prelim
3. Wave Studies in Canals		(1,200) prelim
4. Drawdown tests on Canal Bank Materials		(1,000) prelim
5. Canal Lining Flow Resistance		(1,000) prelim
		($19,250) prelim
ESTIMATED HYD LAB BUDGET		$13,000