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ENGINEERING RESEARCH

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CIVIL ENGINEERING SECTION  
COLORADO AGRICULTURAL EXPERIMENT STATION

ANNUAL REPORT

April 25, 1959.

By

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CER 59 ARC 12

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COLORADO AGRICULTURAL EXPERIMENT STATION  
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I. ACCOMPLISHMENTS BY PROJECTS

Regular Experiment Station

103 - Laboratory and Field Study of the Vortex Tube Sand Trap: -

Tests will be continued on methods and designs of sand traps. Tests have been completed on full scale Vortex tubes using laboratory facilities. Efficiencies of trapping sediment under various operating conditions are being computed. Tubes of different shapes and sizes were tested. Field evaluations of existing sand trap installations are being planned.

Tubes of different shapes seem to operate equally well. The critical points of design seem to be the size and length of tube. The efficiency of trapping varies with the velocity of flow and the size of material being moved.

104 - Meteorological Observations: - The work is being done to obtain a precise long time record of climatological elements. The elements observed are: maximum, minimum and current air temperature, wet and dry bulb temperatures for dew point temperature and relative humidity, soil temperatures at 3, 6, 12, 24, 36, and 72 inches, wind direction and velocity at 65 ft. and 15 in. above surface, barometric pressure, evaporation from a free water surface, water temperature at surface (maximum, minimum and current), precipitation, cloud cover, dew and frost.



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New extreme values of temperature have been recorded recently. The long time mean temperature is increasing. Precipitation varies widely with no long time trend apparent.

105 - Groundwater Fluctuations and Their Relation to Pumping: -

Semi-annual measurements of water table levels were again taken in the South Platte and Arkansas River Valleys and their major tributaries, continuing the work begun by the Experiment Station in 1929. Water levels are, in general, back to elevations common before the 1950-1956 drouth period. Exceptions occur in tributary valleys which have no surface water for irrigation, such as Kiowa, Bijou, and Beaver Creeks in which water table levels are still on the decline.

106 - Development and Improvement of Water Measuring Devices: -

The present phases of this project are concerned with the development and calibration of trapezoidal measuring flumes. It is anticipated that flumes of this design will find wide use for both irrigation and general hydrologic measurements.

Preliminary tests have shown that these flumes may be superior to those with rectangular cross-sections. They will operate under higher degrees of submergence without connections to the free-flow relationships being necessary. The general shape tends to more closely fit that of a natural or irrigation channel so that construction problems are simplified.

107 - Hydraulic Laboratory: - Significant progress has been made on two fundamental studies: a) the analysis and experimental verification of the hydraulic jump in shaping circular conduits, and b) the fall velocity of particles in extremely viscous fluids. Both studies will be reported in the form of Master's Theses in June 1959.

108 - Sealing of Irrigation Canals by Bentonite Sedimenting: -

The research and development investigations are being carried on at five field sites in operating canals: (1) Twin Lakes (Colo.) site in fractured rock; (2) Coors Farm (Colo.) site in sand and gravel; (3) Coachella Canal (Calif.) site in dune sand; (4) Lateral 1 (Wyo.) site in dune sand; (5) Lateral 19.3 (Nebr.) site in loessial soil. Purpose of research and development activities is to develop practical and effective canal sealing methods for irrigation canals in a representative range of pervious materials and operational conditions.

As a result of development work to date, two methods for sealing irrigation canals have been developed. The two methods are: (1) for fractured rock -- multiple dam method involving use of bentonite and saw-dust, and (2) for sand and loessial soils -- Wyoming method involving use of bentonite-water mixture with harrowing of canal bottom and sides during the bentonite ponding and sealing procedure.

109 - Snow Course Measurements and Forecast Analysis: - Systematic measurements of depth and water content of snow at high elevations in Colorado mountain areas for the purpose of forecasting the runoff of the principal rivers of the state in the interest of irrigation, power, domestic supplies, and other uses. The use of electrical resistance soil moisture units is being tested to determine a factor of soil moisture deficiency for water supply forecast purposes.

Snow measurement data are correlated with runoff. Once the relationship is established, the snow measurement data are used to predict the runoff for the coming season.



110 - Calibration of Current Meters in Rating Flume: - Current meters have been rated for many municipalities, counties, consulting engineers, and state and federal agencies during the year. This is a service performed at no cost to the Station. A charge of twenty dollars is made for each calibration.

111 - Determination of Proper Irrigation Well Construction Materials and Maintenance Practices for Obtaining Maximum Economical Life and Performance: - A survey of drillers indicates that the failure of irrigation wells due to the collapse of casings is generally due to negligence upon the part of those placing the gravel-pack material rather than the use of too light of casings. Either bridging, segregation or a combination of both allows sand pumping and ultimate collapse of the formation about the well.

The principal problems of irrigation well failures seem to be connected with incrustation of screens or corrosion of casings and screens. Preliminary conclusions indicate that research work should be directed towards:

- (1) Developing methods of predicting incrustation and corrosion problems from chemical analysis of the water.
- (2) Developing recommendations for casing and screen materials for various corrosive water conditions in Colorado.
- (3) Determining best treatment materials and methods for various incrustation conditions.

124 - Laboratory Study of Gravel Filter Design for Irrigation Wells: - Laboratory studies are being conducted to: (1) determine the relationship of pack-aquifer ratios and pack and aquifer gradations for stable conditions, and (2) develop generalized criteria for the selection and placement of gravel pack materials.

Preliminary results indicate pack-aquifer ratios ranging from 4 to 12 are satisfactory for uniform materials. Non-uniform gravel pack makes it possible to use larger pack-aquifer ratios.

**125 - Development of Drainage Design Criteria for Irrigated Lands: -**

The field study on evaluation of interceptor drains has shown that there is not a significant correlation between only the hydraulic conductivity and the yield of flow per unit length of drain. Many other factors need to be considered such as the source of ground water, distance to this source, general slope, depth of saturated strata and degree of stratification. For the general area in which this study was conducted, the degree of stratification seemed to be most important. The degree of stratification was defined as the ratio in percent of depth of unlike materials to the predominate soil texture. A good correlation was noted between the percent stratification, the hydraulic conductivity and the yield for the field situations studied.

**227 - Study of Evaporation from Soil Surfaces in Terms of Soil and Micrometeorological Factors: -** The project is a comprehensive study of moisture transfer from soil by evaporation from the soil surface. The immediate objectives of this investigation are to evaluate the variables known to affect evaporation from soil in order to determine those that are most important in the field, and secondly to search for relationships among the pertinent variables which will permit quantitative estimates of evaporation from a given soil under prevailing ambient conditions.

- (1) There is a critical water-table depth for soils. When the water-table is below this depth, the rate of upward movement of the water is greatly reduced and is only slightly affected by ambient variables. The critical depth can be related to moisture characteristics of the soil.



- (2) When the surface of the soil becomes dry (for any reason), the rate of evaporation is only slightly affected by ambient variables and may even be inversely related to the corresponding evaporation rates from a free water surface.
- (3) The rate of water loss from a soil profile can be reduced by any surface treatment that reduces the capillarity of the surface pores. One effective treatment is a gravel mulch, another is an application of some types of surfactants.

At present no economical treatment for large scale use has been found.

236 - Economic Effect of Groundwater Laws and Related Institution on Groundwater Use in the Lower Bijou Basin, Morgan County, Colo.:-

The Engineering phase of this study has as its purpose the determination of the interrelationships of ground water and surface water in an area where both are used for irrigation. An area in the South Platte Valley has been chosen for this study. The economic phase will be concerned with the implications of various types of legislative controls which may be applied to the situation.

Investigation of surface rights and pumping plants indicates that the potential capacity of all irrigation pumps in the study area is considerably greater than allowable surface water diversions from the river. These pumps all draw upon underground water that would otherwise contribute to river flow, and under previous court decisions are therefore subject to injunction if surface rights are injured. Nearly all wells were drilled at least 50 years after the most junior surface right.

Colorado State University Research Foundation Projects

707 - Diffusion of Heat and Gases into an Atmosphere with Various Degrees of Stability: - This project is technically closed as was reported last year. However, administrative details still remain, it is anticipated that at least another year will be required to close this project at the rate the Air Force moves. At the present time the sponsors are still withholding one percent of the contract.

708 - Behavior of Seaplane Hulls in a Simple Sea: - The final report has been accepted by the Navy. This project is, therefore, technically complete and only administrative closure must still be done. The results of the project indicate that a high length-beam ratio for seaplanes is favorable in improving seaworthiness. High speed performance of seaplanes can best be carried out either parallel to the crests of waves or in the direction of wave travel.

713 - Behavior of a Ship in an Oblique Sea: - The final technical report has been accepted by the sponsors in fulfillment of that aspect of the contract. Administrative closure must still be completed. The results of the research indicate that the greatest heaving and pitching of a ship occur in the  $135^{\circ}$  and  $180^{\circ}$  headings with respect to the direction of wave travel. The ship motions tended to be a maximum when the wave length of the sea in which the ship was running was approximately twice the hull length.

723 - Interaction of Ships and Waves: - Classified Project.

724 - Investigations of Contracted Openings in an Open Channel:- The study is divided into two stages, the first stage, which has been finished, was to study the backwater caused by the construction of a channel constriction in a tilting flume having a rigid bottom. The second stage of the study, which is in progress, is to study the effect of an alluvial bed on the backwater and also the maximum scour around the model highway abutments making up the constriction. The experimental work is conducted in a 150 foot long, 8 foot wide flume. Both the sediment and the water are recirculated in this system. A uniform flow is established before the abutments



are placed in the system. The change of water surface configuration and the change of bed configuration are measured throughout the testing period. The degree of contraction caused by the abutments varies from 0.5 to 0.1.

The hydraulics of open channel flow through constrictions has been classified as a result of this research. The energy loss has been subdivided into three parts: normal, mixing and excess. The distribution of these three losses is known. Empirical curves were derived for estimating the maximum backwater found in the laboratory. A practical method for estimating the maximum backwater for prototype conditions is presented. The maximum scour depends primarily upon the degree of contraction, the Froude number and the normal depth of the unobstructed flow and the geometry of the abutments.

**726 - Flow Patterns on Landing Impact of a Seaplane Hull:** - The final report has been submitted to the Navy Department and has been accepted. The purpose of the project was to determine flow patterns underneath two-dimensional draft such as seaplanes during landing. The second purpose of the project was to find a way to make the flow patterns which result from the impact of wedges or hulls visible to an observer. The only scheme which proved satisfactory was one using zero buoyancy bubbles immersed in water. The resultant visible flow pattern was correlated to the force-time history of impact for wedges of various included angles. The project is now technically completed and the business matters are being finalized.

**735 - Scour at Base of Cantilever Outlets:** - This study consists of several phases. The first phase, which has been completed, was development of generalized design criteria for stilling basins for cantilevered pipe flow. The stilling basin is a pre-shaped scour hole in an alluvial bed armorplated with well graded riprap. The second phase of the study, which is in progress, is to investigate the efficiency of the armorplated, pre-shaped stilling basin in scour control for different boundary geometry.

Scour in alluvial beds increases with an increase in channel width. Significant factors contributing to the increased rate of scour are the vortex action of secondary currents transverse to the direction of jet flow and the action of waves on the channel banks. Armorplating of channel banks is essential to stability of alluvial channels. Decreasing the slope of the channel banks increases the effectiveness in scour control of the armor-plated, pre-shaped stilling basin and banks.

736 - Methods of Creating a Complex Seaway for Model Studies: - The research is directed toward the development of ways and means to produce in a wave basin seas which will permit the testing of model ships under conditions representing those encountered by ships on the ocean under storm conditions.

A new type of wave generator was developed which promises to have the ability to produce a replica of an actual storm sea in a circular or rectangular wave basin. The replica sea would cover essentially the entire area of the wave basin.

738 - Research Directed Toward the Study of Low Level Turbulence: - Measurements of mean velocity, mean temperatures, turbulence intensities and turbulent shear stress profiles were made for turbulent air flow over a plane, rough boundary which was heated. A new wind tunnel with low ambient turbulence level and a test section 6 x 6 x 72 ft was designed and partially completed.

For the rough, heated surface the velocity defect law for the outer regime of the boundary layer follows the same law for a smooth boundary provided the displacement thickness includes the variation of density with temperature. The temperature distribution can be expressed by a wall law and a temperature-defect law analogous to the velocity-distribution laws.

740 - Study of Resistance to Flow and Sediment Transport in Alluvial Channels: - This investigation consists of a laboratory study which will be followed by a field study of (a) resistance to flow in alluvial channels, (b) sediment transport theory, including the effect of very fine sediment on



resistance to flow and sediment transport, and (c) the theory of rapid flow phenomenon in alluvial channels.

Relationships describing alluvial channel flow phenomenon and the regimes of flow and forms of bed roughness have been developed based on flume data. The effect of small concentrations of very fine sediment on resistance to flow and silt-sand sediment transport has been and is being investigated. An equation for bed load transport, applicable when ripples or dunes exist, of the form  $q_b = (1 - \lambda) V_g h / 2$  has been developed and verified in which:  $q_b$  is the bed load,  $\lambda$  is the porosity of bed material,  $V_g$  is the average velocity of the ripples and/or dunes, and  $h$  is the average amplitude of ripples and/or dunes.

**740C - Distribution and Concentration of Radioactive Waste in Alluvial Streams :** - The purpose of the study is to bring together knowledge from the fields of diffusion of heat, mass and momentum, adsorption and absorption of radioactive materials to sediments in streams, and alluvial channel hydraulics. The results of these studies will be used in developing a program of experimental and theoretical research on the relationships of fluvial hydraulics to the movement of radioactive materials in alluvial channels.

**747 - Water and Sediment Measuring Equipment for Ephemeral Streams:-** The continuing phases are to further develop measuring flumes of trapezoidal shapes for the purpose of measurement on steep slopes and for a large range of flow. Test results from models are being compared with prototype behavior.

Very good correlation of model prototype results have been obtained. Examination of prototype data reveals that the approach velocities change from super-critical to sub-critical for increasing discharges. The relationship of depth in the contracted section to discharge does not change for the different approach conditions.

**749 - Analytical Study of Alluvial Channel Roughness:-** Excellent experimental results have been obtained and an empirical equation on the beginning of ripples on a sand bed has been established. Analysis of numerous

data on alluvial channel flow has shown a promise of finding a new formula for estimating the mean velocity of flow in an alluvial channel.

If the mean velocity in a channel can be accurately estimated by knowing the depth of flow, channel slope, and bed material, the design of irrigation canals and the control of natural waterways can be improved.

The results have been presented for publication by the American Society of Civil Engineers. The project is now technically and administratively closed.

**752 - Model Studies for Bocono Dam:** - The purpose of the model studies was to obtain information concerning the action of water flowing over and through the proposed dam and appurtenant works. Preliminary studies of the stilling basin were made in a 2-ft wide glass-walled flume and over-all performance of the spillway examined on a general model; both models were constructed to a scale of 1:49.2. For the river-outlet studies a separate model was built to a scale of 1:20 with a transparent plastic end section for the elbow.

**Results:**

- (1) A suitable stilling basin was developed for spillway flows up to 10,000m<sup>3</sup>/s.
- (2) The piers on the spillway crest were modified to minimize fin information on the spillway face, and a rating curve was obtained for free and gate controlled flows.
- (3) The flow characteristics and pressure distribution in the vicinity of the downstream end of the river outlets were examined and found satisfactory.
- (4) An evaluation was made of the effect of stilling basin operation on pressures within draft tubes which discharge directly into the stilling basin.

This project is now technically and administratively closed.



759 - Interaction Waves and Hydrofoils: - Classified Project.

760 - Design and Construction of a Tilting Flume: - A 2-ft wide, 2 1/2-ft deep, by 60-ft long steel-frame flume has been designed and constructed. The flume is supported so that any slope from horizontal to a maximum of about 6 percent can be easily obtained. Flow is recirculated through a 4,000 gpm centrifugal pump. The walls of the flume are clear plastic the full length of the flume and the floor is 1/4-inch stainless steel plate.

The design and construction are completed. The project is now technically and administratively closed.

761 - Calibration of Flowmeters for the Martin Company, Denver Division: - Calibration of turbine type flowmeters which range in size from 3/16 in. to 12 in. for the Titan ICBM program is being done on a routine basis.

763 - Consequences of Restraint on Motions of a Model Ship: - The purpose of this project is to obtain experimental data on the influence of restraint on the model motions resulting from wave trains acting on a model ship. Initially the model motions will be restrained and the forces and moments on the model caused by the waves will be measured. A new type wave probe will be used to measure the wave field in the vicinity of the model.

Activity to date has been confined to development of instrumentation. These include the improvement of a capacitance probe which does not touch or disturb the water surface. Six transistorized probe units will be used to measure the waves in the vicinity of the model. Comparison of the records with a record of the undisturbed wave will yield information on the influence of the ship on the waves. A six component balance has been constructed to measure the forces and moments on the restrained model.

768 - U. S. Bureau of Public Roads - Educational Film: - The project involves the making of a color film on open channel flow in connection with highway drainage problems for educational purposes. The film is seventy percent complete.

769 - Model Studies of the Cumbaya Project Tunnel By-Pass: - The by-pass is a unique underground structure which conveys water around a

powerhouse into a tunnel 74 meters below for use at such times as the powerhouse units may not operate. The model study is to check adequacy of original design of manifold stilling basin, a basin which dissipates kinetic energy of flow by diffusion of submerged jets.

The stilling basin as designed would perform satisfactorily. However, modifications are necessary in the conduit approaching the stilling basin.

770 - Evaluation of Flowmeters for the Martin Company. - The purpose of the project is to carry out tests on the dynamic, kinematic and general performance characteristics of various types of flowmeters to be inserted in pipelines. The flowmeters to be considered are the Gulton, Gentile Tube, and Maxson Ultrasonic, impact strain gauge, turbine and rotameters. The fluids under consideration are water, liquid oxygen, liquid nitrogen, JP-4 fuel, RP-1 fuel and MIL-0-5606 hydraulic fluid. Work is continuing on a fairly fast rate.

771 - Determination of Shear Stress by Measurement of the Electrokinetic Potential: - Electrokinetic potentials between two electrodes placed in the wall of a precision glass pipe are amplified after passing through an electrometer tube circuit and displayed on an oscilloscope. The displayed signal frequencies are being studied for the cases in which the water flowing through the tube is in a laminar state, transition state, and turbulent state.

773 - Distribution of a Wetting and a Non-Wetting Fluid Phase in a Porous Solid: - The first part of this study has been completed. A differential equation was derived to describe the pressure distribution during steady two-phase flow through porous solids. The equation was solved and tested experimentally for the case of a static non-wetting phase. Experiments were run in which the wetting-phase flow passed through stratified columns of sand as well as columns of uniform sands. Other experiments included flow through sections of a sand having two different slopes and situations in which the sand contained sources and sinks for the wetting phase. In every case, the derived equation described the pressure distribution with satisfactory precision.



Another part of the study which will deal with the situation in which the non-wetting phase flows in the presence of a static wetting phase is just getting started as far as the experimental testing is concerned.

775 - The Longitudinal Distribution of Forces and Moments on a Restrained Model in Waves: - The primary objective of this project is to impose pitching and heaving displacements (separately) varying sinusoidally in time upon a model ship and to measure the forces and moments as a function of time. The models are segmented and attached to an oscillating strongback by means of a stiff spring. The force on each end of a segment is sensed by means of an SR4 strain gage. The simultaneous records of the forces on the seven segments may be used to construct a longitudinal shear curve. The longitudinal bending moment is found by graphical integration.

The pitching and heaving experiments on a five foot model of a T2-SE-A1 tanker have been completed. The model was oscillated at seven frequencies at rest and at three speeds of advance. The results are being analyzed and will be compared with the analytical findings of Haskind, Havelock and Grimm.

778 - Study of Atmospheric Surface Layer Phenomena in a Wind Tunnel: - Measurements of mean velocities and mean temperatures together with turbulence intensities and correlations have been made over a smooth, plane, heated or unheated surface. The objective of the program is to relate the turbulent boundary layer structure to the thermal stratification obtained by heating.

Heating of the turbulent boundary layer at low Reynolds number has been found to produce the following effects: (1) increase the coefficient of drag (2) increase the eddy viscosity (3) increase the correlation between vertical and horizontal velocity fluctuations.

781 - Scour Below Culvert Outlets: - The experimental study on the initial phase has been completed. Four zones have been defined for a submerged jet impinging normally on a smooth boundary. The velocity profile for each zone was measured, as well as the pressure distribution along the deflecting boundary. The integration of the Reynolds equations for axially symmetric flow near a plane boundary accomplished as a part of this study provides a basis for further analysis of flow in the boundary layer region and evaluation of the boundary shear. Knowledge of boundary shear is of fundamental importance to the knowledge of the phenomenon of scour or erosion of sediment particles and of its control. This project is suspended until additional funds can be found.

782 - Makio Dam Spillway: - The purpose of the model study of the Makio Dam Spillway, to be constructed in Japan, is to check the hydraulic performances of an original and alternate spillway design and to introduce changes as required. The spillway is for a reservoir impounded by a rockfall dam 80 meters high; located on the left bank of the river.

Modifications to the spillway approach and chute have been made. The choice of stilling basin has been made with modifications thereto. The technical report has been submitted to the sponsor.

785 - Study of the Spur Dikes for Highway Bridge Openings: - Spur dikes in connection with highway bridge openings are used to eliminate scour adjacent to abutments and piers. The flow which would normally cause an eddy near the abutment is made to approach the bridge opening as normal as possible. The purpose of this phase of the study is to determine the best shape and location as well as length of spur dike for a given set of conditions which might prevail at a bridge opening.

An apparent shape and location has been determined for one set of conditions in the testing flume.



1400 - Weather Data Cards: - Weather data from fifteen (15) stations in eastern Colorado have been placed on IBM punched cards. Cards for six (6) stations have been processed for accuracy and duplicate decks of cards have been sent to the National Weather Records Center at Asheville, N. C. The remainder of the cards have processed for accuracy and duplicate decks will be sent to the National Weather Records Center before 1 June 1959.

2002 - Model of the Dillon Dam Morning-Glory Spillway: - The model of the spillway and necessary sections of the outlet works has been constructed to test hydraulic characteristics of the various structures as designed and to modify them as necessary on the basis of results obtained. Significant areas of study include; local excavation effects on the spillway crest; Pressures on the spillway crest; negative pressures in the vertical shaft; flow control through the deflector; flow control at the junction with the outlet tunnel; flip bucket design at the outlet and downstream erosion control. The model was constructed to a scale of 1:31.31. The size of the model is 12 feet high, 8 feet wide and 60 feet long.

2003 - Flow in Porous Media: - The study began April 1, 1959, under the auspices of the Petroleum Research Corporation.

2004 - Accuracy in Surveyor's Instruments: -The study began April 1, 1959, under the sponsorship of a manufacturing firm making surveying instruments.

2200 - Structural Consulting Service to the Martin Company: - Analytic investigation of the possible utilization of flexible conduit type underground structures for atomic shelter purposes. Single and double wall corrugated metal structures have been investigated in the elastic range including elastic stability problems. Comparison of three independent theories has yielded approximately the same results, i.e. the underground structure works as a cylindrical thin shell.

... can be used to design double-skin structures to support expected static loads. The stress distribution can be well approximated by utilizing the membrane theory.

2201 - Evaluation of Flowmeters for the Martin Company: - This is a study of performance of various types of flowmeters used in missiles. Evaluation of some turbine meters, flow tubes and ultrasonic meters have been made and reported. The studies include determination of accuracy and reliability of the various meters; linearity and flow range; effects of fluid dynamic viscosity and temperature; effects of approach tubing and cavitation.

Work is being done at the present time on turbine type meters. The study is an extension of project 770.

2400 - Magnitude and Frequency of Floods in Arid and Semi-Arid Areas: - The purpose of the study is to develop procedures for estimating the frequency and magnitude of peak rates of runoff from watersheds in arid and semi-arid areas.

Basic data have been collected and analysis is being continued to delimit the basic factors that control flood events in arid and semi-arid areas.

2402 - Theory of Consolidation Combining Primary and Secondary Consolidation: - The study consists of a mathematical analysis of the effect of visco-plastic resistance on the rate of pore pressure decrease and of an experimental program to verify the mathematical results and to investigate the effect of varied load increments on the time-consolidation relationship. The mathematical analysis will be carried out by adding visco-plastic resistance terms to the basic differential equation of consolidation developed by Terzaghi and solving the resulting equation either by standard methods or by analysis of a theoretical model. The solution of this system along with the laboratory consolidation curves will be used to produce the relationship between plastic resistance and related variables such as speed of deformation and percent of deformation.



2408 - Wind Tunnel Modeling of Atmospheric Diffusion: - This is a new research project initiated 1 March 1959, under the support of the National Institute of Health, for a three year period.

2409 - Development of Ultrasonic Stream Bed Analyzer to Both Laboratory and Field: - This project started 27 February 1959, under a contract with the USDA-ARS. The objective is to develop an instrument for alluvial channel research that will automatically record both the bed level and water surface level of an open channel stream.

2410 - Institute and Mathematics for Senior and Junior High School Teachers: - This project is to start 1 October 1959, This section is largely serving as the fiscal officer for the Department of Mathematics.

2411 - U.S.G.S. In-Service Training Course - Mechanics of Fluid Transport: - This is a new project, with the performance to take place in July of 1959 before some 25 high level engineers of the U.S. Geological Survey.

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### III. PUBLIC SERVICES.

Maxwell Parshall prepared local weather data for the two Fort Collins radio stations twice daily. He also transmitted weather data and forecasts of future weather data to the local newspaper and the Sugar Company once a day, and to the Public Service Company once a week. Details on unusual weather, precipitation and temperature data have been given to many private citizens. Adjustments on about a dozen home barometers were made. The sewage analyses for the City Plant were made weekly. Besides the above mentioned services, Mr. Parhsall gave several talks on weather.

In connection with Project 108 -- "Investigations of the Sedimenting Method of Sealing Canals", R. D. Dirmeyer answered an average of three to four requests per week for information on ways of controlling canal and farm pond seepage. To simplify answering the requests, a set of how-to-do booklets were prepared by R. T. Shen. Mr. Dirmeyer gave a talk at the January 1959 meeting of the Arkansas Valley Ditch Association in La Junta, on the bentonite sealing work at the University. Mr. Shen delivered a report on the same subject at the meeting of the Rocky Mountain Section of ASAE in Logan, Utah, April 3rd and 4th.

A. R. Robinson, as many others, has answered many inquiries concerning problems involving water measurement and conveyance, seepage measurement and drainage. He has also distributed, upon request, available information concerning irrigation and drainage. Mr. Robinson is a member of American Society of Civil Engineers, Irrigation and Drainage Division's Task Group on Water Reclamation. He is also serving on the American Society of Agricultural Engineer's Committee on Irrigation design, and the Colorado State University graduate faculty for thesis guidance. He is president of the Engineer's Club of Fort Collins.

E. F. Schulz is serving on the Board of Directors of the South Taft Hill Water Association.

Rudolph Szilard is a reviewer of German, Hungarian and Spanish technical periodicals for the Journal of American Concrete Institute.

Harry K. Liu furnished information on design of backwater caused by bridge constriction to the Anderson-Nichols and Company in Boston; on design of scour at siphon crossings to Whitney Borland of the Bureau of Reclamation in Denver; and scour depth at bridge abutments to John W. Smith of Washington, D. C. Dr. Liu reviewed the following for McGraw Hill Co.: "Hydraulics of Open Channel Flow" by V. T. Chow, and "Applied Hydrology" by Linsley, Kohler and Paulhus.

Morton W. Bittinger is working closely with the Colorado Ground Water Commission and the Colorado Well Contractors Association. At present he is helping plan a Well Drillers' short course to be held on the CSU Campus in June 1959. He is serving on the American Society of Agricultural Engineers' committee for developing a set of minimum standards for irrigation well construction.

A. T. Corey supplied miscellaneous information in connection with research findings to state and federal agencies as well as private individuals.

J. E. Cermak presented a program on Atmospheric Diffusion to the Denver Section of American Meteorological Society; appeared on a technical panel of Army Signal Corps Conference on Present Status of Micrometeorological Research; made several short tape recordings for use in C.S.U. radio programs; and reviewed research proposals for the National Science Foundation.

George Smith presented, by means of a movie, the research findings of the project on scour at base of cantilever outlets to an open meeting of the committee on Surface Drainage of Highways at Colorado State University, September 1958. He was also a consultant engineer to the Division office of Bureau of Public Roads on problems involving scour at culvert outlets.



Richard A. Schleusener assisted in preparation of proposal for study of meteorological parameters in relation to stream flow in the Colorado River. He is a member of the Rocky Mountain Section A.S.A.E. membership committee.

A. R. Chamberlain has given talks and lectures to many civic groups during the last year. He is Director and President of the Rocky Mountain Cystic Fibrosis Association (Public Health oriented). He has been involved in the work and organization of ARMU, Industrial Development Council, Research Committee, Panel discussion groups, etc. He serves on an advisory committee for the USDA-Forest Service Unit serving the western states, and two professional task force research groups.

#### IV. OTHER RESEARCH ACTIVITIES

Those research activities which cannot be related to a specific research project are listed in this section.

A. R. Robinson is administratively and technically responsible for the A.R.S. unit to the Western Soil and Water Management Research Branch, A.R.S. Reported projects are cooperative with this agency. Unit consists of three professional grade A.R.S. employees as well as one full time and three part time sub-professionals.

E. F. Schulz is a member of the Physical Sciences Panel - Volunteer Research Reserve Unit 9-12 of the Naval Reserve, Mr. Schulz is also an advisor to the Rocky Mountain Forest and Range Experiment Station on hydrologic matters.

Rudolph Szilard presented a paper entitled, "Design of Underground Structures for Atomic Blast Load" at the meeting of A.S.T.M. in Salt Lake City, Utah. He also attended the joint convention of the A.S.C.D. and I.A.S.B.E. in New York, N. Y.

R. D. Dirmeyer served as a consultant for Wyoming Natural Resource Board in demonstration and development program of bentonite sealing trials in Wyoming during the summer of 1958. He prepared an "Evaluation Report on Recent Bentonite Sealing Work in Wyoming Canals", published by the Wyoming Natural Resource Board, and assisted several other irrigation companies in setting up canal sealing work.

A. T. Corey conducted research sponsored by Petroleum Research Corporation of Denver relating to oil-bearing aquifers under hydrodynamic conditions. He also served as a consultant for the petroleum industry on problems dealing with multi-phase flow in porous rocks.

J. E. Cermak acted as advisor to the U.S. Forest Service personnel on technical problems of heat, mass and momentum transfer; to the Soil Conservation personnel on design of plant growth chamber having humidity, temperature and air circulation control; and to the P.E.C. Corporation on several research problems. He spent two weeks at White Sands Missile Range in Job capacity of Research and Development Coordination.

## V. RECOMMENDATIONS

1) The principal recommendation as far as Civil Engineering is concerned is that every effort should be made to induce the State Legislature, private industry, and individuals to make available to the University more nearly adequate funds for expenses and capital investment in equipment and buildings. At the present time, with Experiment Station expense accounts essentially being held constant and no Station monies available for capital investment, it is impossible to conduct Station research in a satisfactory manner in the face of continually rising expense costs and the continuous aging of presently available equipment. As an absolute minimum, even if additional building space cannot be made available, funds should be found to offset the rising costs of expenses incurred in research and to replace worn out equipment. In addition to the needs for capital investment, funds are needed to employ additional semi-professional assistants. At the present time the output of our professional employees is considerably less than it could be if they had adequate semi-professional help.

2) It is felt that this section is in need of not only monies for the things mentioned above, but from the management viewpoint a redistribution of financial support. At the present time the Section obtains over 90 percent of its budget from non-experiment station sources. This is an dangerously high percentage; which should be reduced to not over 75 percent by increased allocation of station monies to the Section.

As a corollary recommendation, CSU engineers should be enrolled to work for Colorado, rather than California, Wyoming, Nebraska and the federal government as they now do during 90 percent of their time. This can only be made possible by more station funds being given to engineering.

Submitted by

A. R. Chamberlain, Chief  
Civil Engineering Station  
April 25, 1959