HYDRAULICS, FLUID MECHANICS, AND HYDROLOGY AT COLORADO STATE UNIVERSITY

EDITED BY

HUNTER ROUSE

Engineering Research Center
Colorado State University
Fort Collins

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EDITOR'S PREFACE

During the several decades since Dean Nephi Christensen asked me to give a course in fluid mechanics at Colorado State in the summer of 1940, three parallel occurrences have taken place: I have watched with respect the exponential growth that the institution has exhibited. I have become convinced that the various influences which lead to the effectiveness of any prominent institution should be properly documented. And, with the continued passage of time, I have seen the evidence on which such documentation must be based steadily disappear.

As a result, when Dean Simons invited me to spend my summers at Fort Collins as visiting professor following retirement from the University of Iowa, I suggested that part of my new duties be the production of a booklet telling the story of how hydraulics, fluid mechanics, hydrology, and related fields achieved the position they now hold at CSU. The preparation of such booklets at my own institution, not to mention my great interest in the history of my profession, had already given me an appreciable amount of momentum in this direction. Beyond a certain point in time, however, those actively engaged at CSU in research administration were logically far better versed in the recent and current aspects of the story, and I have hence acted as editor rather than author of the latter portion of the text - stimulating assembly of the material by others and then seeking to bring it to uniformity.

The eventual usefulness of such a booklet as a historical record of accomplishment need hardly be emphasized. Other uses, however, are manifold. Prospective students, in particular postgraduate, will be able to see in detail the advantages that the institution has to offer. Engineering organizations will have the opportunity to judge from past accomplishments and present staff and facilities the suitability of the Engineering Research Center for developmental studies. And, to counteract the elimination of perspective by proximity, workers in the different divisions will have a clearer view of what is going on around them.

Many individuals in addition to the senior staff have assisted in making this material available. Special acknowledgment is due Barbara Burke, Tamra McFall, John Newman, Carol Stafford, Jean Steinhoff, and Eve

Vanderweit, all of CSU; Maxwell Parshall, retired from CSU; Danny King, of the Water and Power Resources Service, and Carl Nordin, of the U.S. Geological Survey.

For historical material not within the recall of those still alive, reference has been made to Ansel Watrous, History of Larimer County, Colorado, Courier Printing & Publishing Company, Fort Collins, 1911; Victor M. Cone, Engineering News, Vol. 70, No. 14, 1913; Ruth J. Wattles, The Mile High College, The History of the Colorado A & M, 1946 (unpublished); Faye J. Anderson, History, Department of Civil Engineering, 1970 (unpublished); Hunter Rouse, Hydraulics in the United States 1776-1976, Iowa Institute of Hydraulic Research, Iowa City, 1976; and above all to James E. Hansen II, Democracy's College in the Centennial State, Colorado State University, Fort Collins, 1977.

Fort Collins, 1980 Hunter Rouse

HISTORICAL SKETCH

In 1862 the United States Congress passed the Morrill Act granting land to each state in the amount of 30,000 acres for every senator and representative. The receipts from the sale of this land were to form a perpetual fund, the interest from which was to support "at least one college where the leading object shall be, without excluding other scientific and classical studies and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts, in such manner as the legislatures of the states may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life."

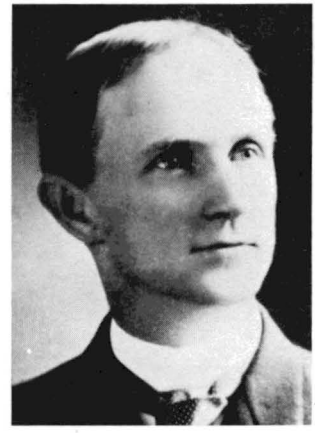
This act was passed fourteen years before Colorado was admitted to statehood in 1876, and an even longer period was to elapse before the act was properly implemented. Hence, to what extent the Territorial Legislature was influenced by the act can only be surmised. In any event, in 1870 the governor signed a Territorial Bill establishing at Fort Collins the Agricultural College of Colorado, to be governed by a Board of Agriculture of eight men, at least four of whom had to be practicing farmers. During the following three years, 240 acres of land were donated locally, and a year thereafter the first building - a mere 24x16 feet in plan - was constructed. Not till 1878 were funds for the College actually appropriated, whereupon the cornerstone of a permanent building was laid; this later came to be known as Old Main. The following fall the

Old Main, no longer in existence

General Assembly finally accepted land-grant income, and the initial classes were held. The enrollment rapidly grew from five to nineteen students, with a faculty of three: the president and two instructors. In 1881 the first dormitory was erected just north of the main building, and the first catalog was issued.

The earliest classes were necessarily preparatory, for the primary and secondary training of the students proved to be meager at best. Subsequent classes, moreover, were largely practical farming - though at least one member of

James Lawrence



Elwood Mead

the government was even against teaching agriculture in a state so ill-suited to it! In such circumstances it was to be expected that the prescribed mechanic arts would receive little attention indeed. Even the cataloged course in mechanics and drawing was intended, in the words of its first instructor, merely to provide the "much needed ability of caring for the machinery and buildings on a farm." It is therefore surprising that in 1882 a former MIT student from New England, James W. Lawrence (1858-1933), was employed to head that department. Not only did Lawrence gradually develop a course in mechanical engineering, but he eventually served as acting president and finally as dean of the faculty. It is equally noteworthy that the staff member who was to play the initial role in hydraulics was originally employed by the College - in 1882 - as an instructor in mathematics. This was Elwood Mead (1858-1936), a Hoosier by birth, who had studied civil engineering at Purdue and Iowa State. In 1883 Mead received approval of his proposal

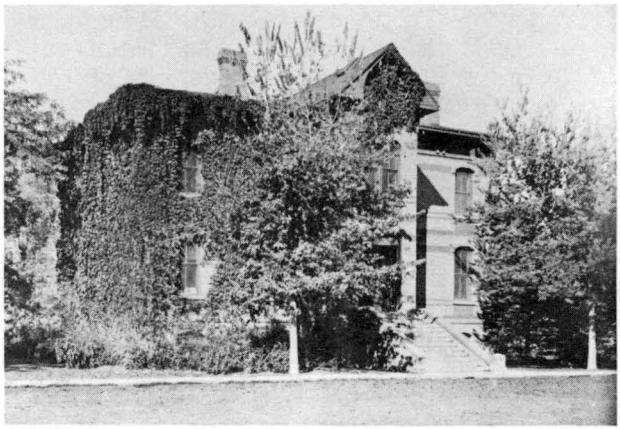
to teach a two-term senior course on irrigation, one term to be "devoted to the pressure and flow of water, and methods of determining the same;" and the other "to the survey and construction of canals and reservoirs." That year Mead also became assistant state engineer doing practical field work in irrigation.

After a two-year interval, during which he obtained an M.S. degree from Purdue, Mead was appointed to a full professorship in irrigation engineering. His perceptive remarks in this regard are significant: "In establishing the chair of Irrigation Engineering, the College has taken the initiative in what must soon be an important branch of industrial training in all technical schools of the arid region ....In this State the rapidity with which our agricultural possibilities are being developed, and the peculiar difficulties in the way of the promotion of better laws and practices, make the need of educated farmers greater than that of highly trained engineers, though both are essential." Unfortunately for the College, Mead was impossible to hold very long, and in 1888 he left for Wyoming, where he wrote the first irrigation code. He was subsequently employed by the U.S. Department of Agriculture, the Australian Water Supply Commission, the University of California, and finally the U.S. Bureau of Reclamation, with which he served a dozen years as commissioner. The lake above Hoover Dam now bears his name - not to mention the chair of water resources at CSU.

Barely a year before Mead's departure, Congressional passage of the Hatch Act provided financial incentive for establishing the Agricultural Research Station and instituting a graduate program at the College. Study toward the master's degree was initially restricted to research at the Station. However, the first M.S. in engineering was awarded in 1893, and the catalog of that year indicated that the advanced degrees of Civil Engineer and Mechanical Engineer could also be earned.

Mead's replacement at Fort Collins was Louis G. Carpenter (1861-1935), a Michigander by both birth and education, who had substituted for Mead during the latter's absence from the campus, and established a weather station as well as observations of evaporation. His influence on irrigation instruction and practice was just as effective as Mead's but of far longer duration. He headed the new Department of Civil and Irrigation Engineering (which was housed from 1893 on in the original dormitory building

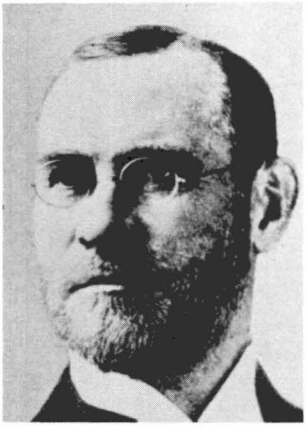
north of Old Main, now Spruce Hall), founded the American Society of Irrigation Engineers, twice declined the presidency of the College, assumed the directorship of the College Agricultural Station, designed the Greeley-Poudre irrigation system, became an authority on the legal aspects of irrigation, and finally resigned in 1911 (unfortunately under pressure) to form a consulting firm with a brother, "Delph" Carpenter of Greeley.



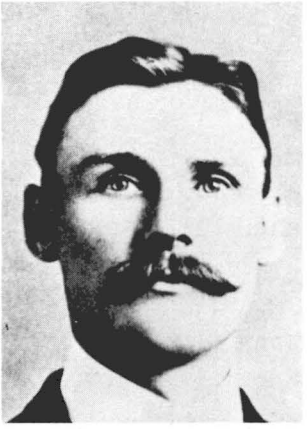
Spruce hall - see site plan on page 19 for location

In view of earlier opposition to the teaching of the mechanic arts (if not of agriculture itself), it is refreshing to note that the president of the College in 1906 declared that the institution rested on "four cornerstones," agriculture, civil engineering, mechanical engineering, and domestic science, each of which shared "equable support." At the same time, however, there was continued dissention between those who favored the trade-school level and those who believed in a truly high-level institution; this was reflected to some degree in Carpenter's resignation. It is hence noteworthy that in 1907 a degree program in electrical engineering was permanently established; in fact, Charles A. Lory (1872-1969), who had come up from Boulder to head the department of physics and applied electricity, became president of the College only two years later - a physical scientist rather than an agriculturist!

Just a year before Carpenter's resignation, a new Civil and Irrigation Engineering Building had been

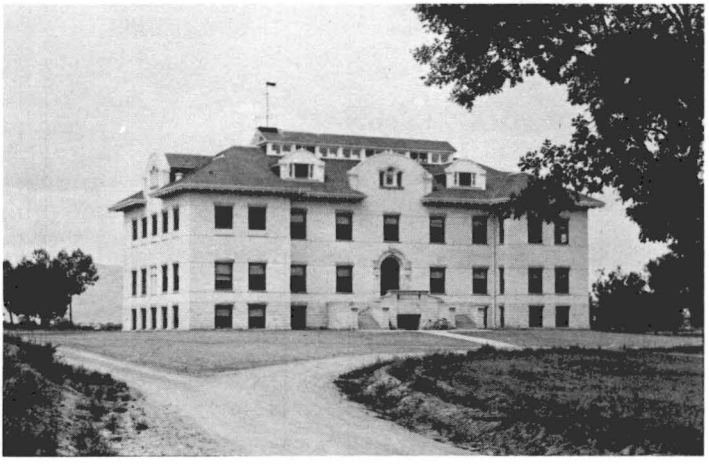


Louis Carpenter



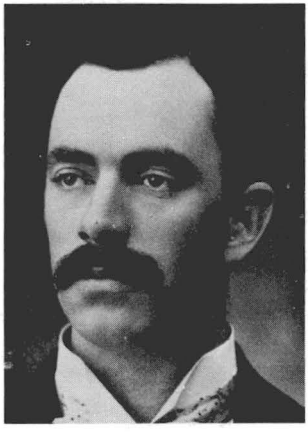
Charles Lory

completed (later used for Economics, it currently furnishes office space for the university Computer Center, Information Systems, and Math, Statistics, and Business Departments). Begun in 1904, its construction was continued as money became available, the walls going up in 1906 and the roof the year following. Not till 1909 was the appropriation paid in full. Equipment formerly housed in the original engineering building - including basement tanks and scales used in teaching hydraulics - was soon moved to its new quarters by two members of the staff.



Civil and Irrigation Engineering Building

Carpenter's replacement as head of Civil and Irrigation Engineering, the somewhat flamboyant Edward B. House (1872-1944), was born in Greeley and educated at Michigan in electrical engineering. He had joined the staff at Fort Collins soon after graduation, and like Mead he had initially taught mathematics. Eventually developing an interest in irrigation, he obtained his M.S. degree in that field in 1905, and was ultimately to become the first Dean of Engineering in 1933. A graduate of the Class of 1904, Ralph L. Parshall (1881-1959) of Golden had had a hand in laying out the foundation of the new C&IE Building while still a student. On receiving his degree, he first taught physics and then became an instructor in the C&IE department (and was one of the equipment movers already mentioned).



Edward House

Ralph Parshall

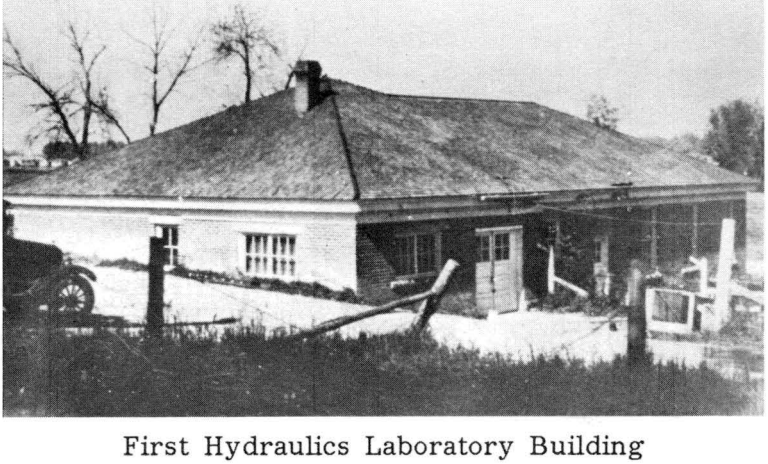
In 1910 the U.S. Department of Agriculture stationed Victor M. Cone (1883-1970) at Fort Collins to take charge of U.S. Irrigation Investigations, Bureau of Public Roads. This agency (forerunner of the Agricultural Research Service) in cooperation with the Colorado Agricultural Experiment Station was instrumental in building the new hydraulics laboratory of the C&IE department, and in 1912 Cone and Parshall were involved in its design. The next year Parshall was promoted to assistant professor, but then he resigned from the College to accept a position with the USDA - remaining in residence, however, in the C&IE building. He was replaced on the college staff by Oliver P. Pennock (1879-1968), a rather reserved 1902 graduate who 40 years later was to head the department (see page 13).

In 1914 Carl H. Rohwer (1890-1958) of Nebraska and Cornell was transferred to Fort Collins by the USDA, whereafter Cone, Parshall, and Rohwer proceeded to make the region - and vicariously the College - well recognized for irrigation research.

Victor Cone

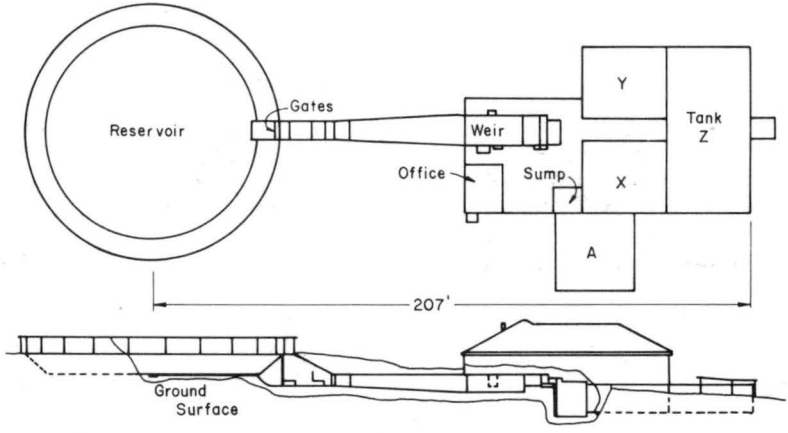
Carl Rohwer

The laboratory of that period included an upper reservoir about 85 feet in diameter and 7 feet deep on a low hill. Three gates controlled the flow to a channel provided with weirs and other devices, a portion of the flow being diverted to an auxiliary tank (A) for constancy during

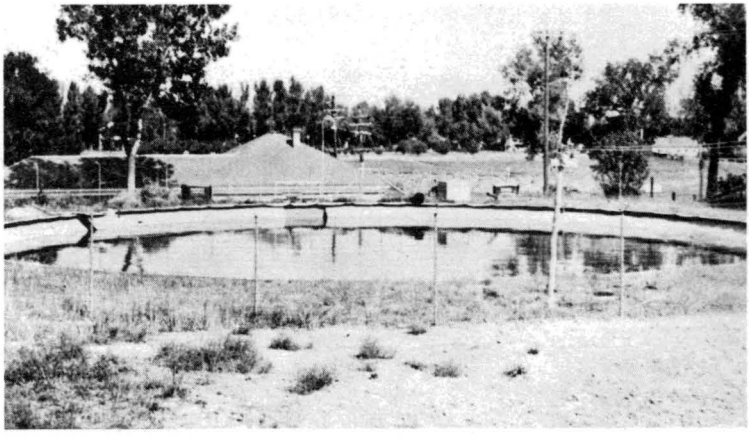


First Hydraulics Laboratory Building

adjustment of head. Pumps returned the flow to the upper reservoir. Two additional concrete tanks (X and Y) 9x24x27 feet, below floor level within the building, and a third (Z), 9x27x55 feet, just outside, were carefully calibrated for volumetric measurement against time. The year 1916 saw the construction of a 4x5x150-foot current-meter rating tank with semi-automatic recording instrumentation designed by Parshall; it was later extended to 250 feet in length. The upper reservoir was lined with copper in 1925 for Parshall's study of evaporation, which he had begun at an earlier date in one of the concrete tanks.



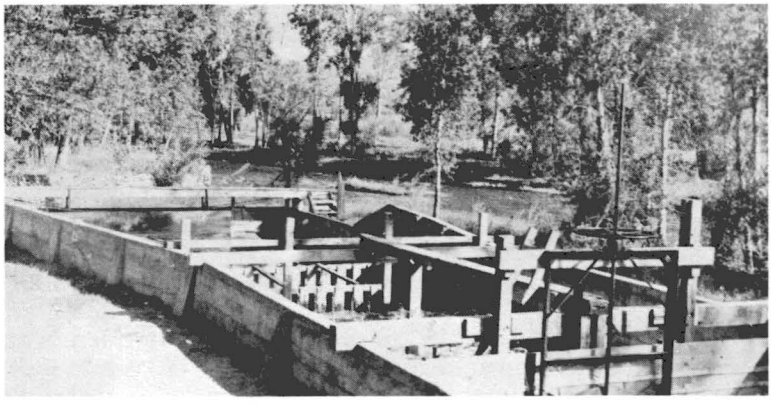
Laboratory plan and elevation



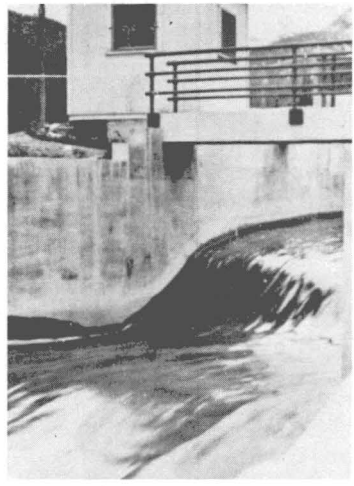
Reservoir and evaporation tank

Rating tank with recording instrumentation

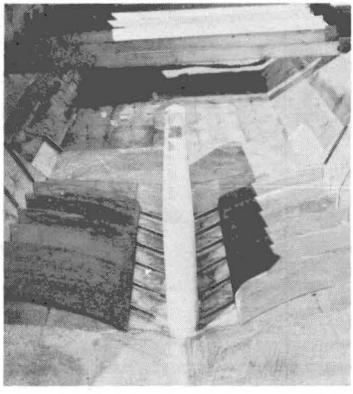
In 1920 a search was made by Parshall and Rohwer for an outdoor laboratory site, not too far from the city and with an ample supply of water. The waste gate on Jackson Ditch, leading from a branch of the Cache La Poudre River near Bellvue, northwest of Fort Collins, was found to meet their requirements, and a concrete channel 7x14x75 feet, tapering over another 50 feet to an outlet width of 25 feet, was connected to the gate. The latter permitted some adjustment to the flow, and a 15-foot weir was used for discharge measurement. It was in this channel that Parshall developed his adaptation of the Venturi flume for discharge measurement; patented about 1925, it became widely known under his name and used around the world.



Bellvue laboratory channel



Parshall and two of his flumes

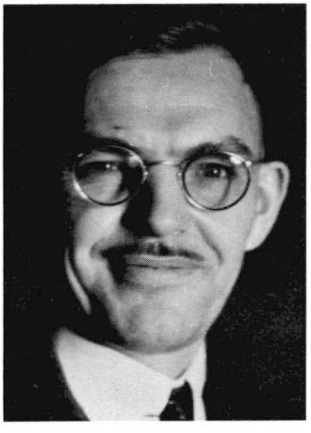


Sand trap model

Maxwell Parshall

He also devised a vortex method for eliminating sand from irrigation canals. Though Rohwer eventually took over Parshall's evaporation project, his interests lay rather in the direction of wells, seepage losses, and canal linings. Parshall's son Maxwell (1907-...), who had watched construction of the original laboratory at the age of 6, worked as a youth with his father and engineering colleagues on many local irrigation projects. In 1929 he returned from MIT with a degree in chemistry, and by 1937 had settled down to running the local weather station and assisting in the hydraulics laboratory.

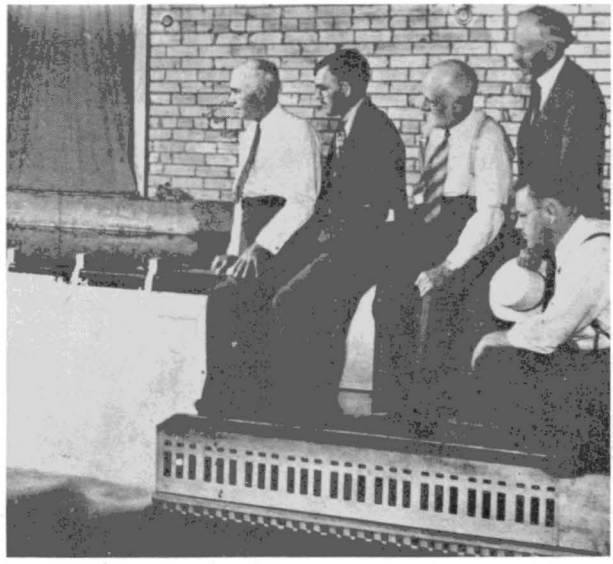
In August 1930 the Bureau of Reclamation sent a dozen engineers, technicians, and shop people from Denver to Fort Collins to work in the laboratory which had been designed by Cone and Parshall for the USDA. The Bureau program began with a study of proposed shaft spillways for Hoover Dam; as a result of these tests, a change was made from the shaft to the side-channel type of structure. Thereafter many other studies were undertaken, in particular for the Bureau's Grand Coulee and Imperial Dams and for the Tennessee Valley Authority's Wheeler and Norris Dams. Emory W. Lane (1891-1963), a Hoosier who had studied at Purdue and Cornell and then seen considerable experience both in the States and in China, was administrative head of the Fort Collins operation. This involved two shifts during the Hoover spillway tests, under Charles W. Thomas (1906-1978) and James W. Ball (1905-...), both Coloradoans educated at Fort Collins. Lane later went back to Denver, turning the Fort Collins work over to Jacob E. Warnock (1903-1949), a Hoosier with degrees from Purdue and Colorado. Upon Warnock's move to Denver, Ball was left in charge. By 1936 the laboratory had undergone a fourfold expansion, but for political and financial reasons the Bureau brought its work there to a close only two years later and withdrew to its Denver quarters in the New Customhouse.



Emory Lane

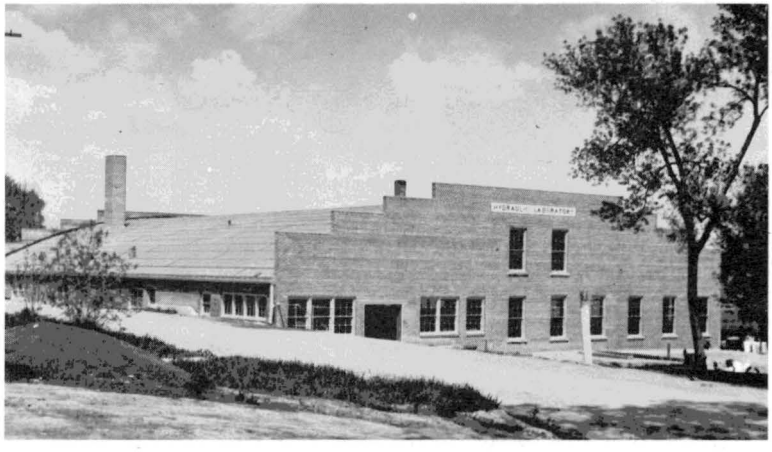
James Ball

The name of the Colorado Agricultural College was changed in 1935 to Colorado State College of Agriculture



J. L. Savage, E. W. Lane, W. E. Durand, C. P. Berkey, and J. E. Warnock at the Bureau of Reclamation model

and Mechanic Arts (only to change again to Colorado Agricultural and Mechanical College in 1944). Three years thereafter (1938) Pennock was replaced as department head and dean by Nephi A. Christensen (1903-...), a native of



View of laboratory extension

Bureau of Reclamation staff of 1931 included (back row) R. R. Randolph, E. W. Lane, V. C. Hammond, J. N. Bradley, C. W. Thomas, G. C. Wright, (front row) V. T. Bliss, R. A. Goodpasture, W. H. Price, J. W. Ball, R. J. Willson, W. O. Parker, W. M. Borland

Oliver Pennock

Nephi Christensen

Utah who had just obtained a Caltech doctorate under Theodor von Kármán and Robert T. Knapp. Christensen's first accomplishment was to gain accreditation (previously refused) of his three engineering departments by the Engineers Council for Professional Development. One of his former colleagues at Caltech was the Toledoan Hunter Rouse

(1906-...), who had just become a professor at the State University of Iowa when he was invited by Christensen to give a 1940 summer class at Fort Collins in the mechanics of fluids. This attracted some two dozen graduate students (among them J. C. Stevens, later president of the ASCE, and C. P. Vetter, sediment specialist of the Bureau of Reclamation), thus becoming the first of a continuing series of summer courses and conferences.

First special summer class 1) A. F. Saxton, 2) J. C. Carrigan, 3) W. S. Rassmussen, 4) C. J. McCash, 5) L. Larson, 6) Maxwell Parshall, 7) B. C. Goodell, 8) A. W. Zingg, 9) W. S. Hamilton, 10) G. E. Colborn, 11) Robert Lewis, 12) A. R. Davis, 13) Adrian Legault, 14) H. W. Richardson, 15) J. J. Idema, 16) D. F. Gunder, 17) W. J. Moore, 18) A. N. Vanderlip, 19) A. E. Everts, 20) P. H. Bliss, 21) C. P. Vetter, 22) N. A. Christensen, 23) Hunter Rouse, 24) J. C. Stevens, and 25) J. C. Harrold

As the United States became involved in World War II, some college laboratories undertook war-related research, while other staff members moved to federal laboratories for similar work. Christensen played an important part in the development of rocketry at the Army's Aberdeen Proving Grounds, taking with him a number of the College staff - in particular Dwight Gunder (1905-1964), a professor of engineering mathematics. At the same time, one who was to take a leading role in later developments at CSU, Maurice L. Albertson (1918-...), a Kansan with degrees from Iowa State College and the State University of Iowa, was called back from the TVA to the Iowa Institute of Hydraulic

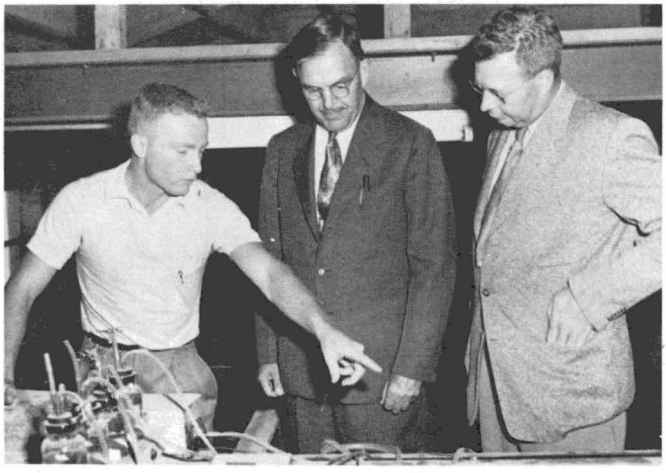
Research for war work under Rouse. This involved air-tunnel tests on fog dispersal, turbulence, and jet diffusion, in the course of which he completed a doctoral dissertation on boundary-layer evaporation. Since he had long hoped to take part in the irrigation research at Colorado State, between Rouse and Christensen a position for him there was arranged in 1947. With Christensen's backing, one of Albertson's first accomplishments at Fort Collins was to persuade the International Engineering Company to have the College conduct, in the laboratory previously abandoned by the Bureau of Reclamation, tests on dams and related structures which it had contracted to build in India. Maxwell Parshall took an active part in these and subsequent tests, but Christensen left for a position at Cornell at the end of the year.

Maurice Albertson

Jack Cermak

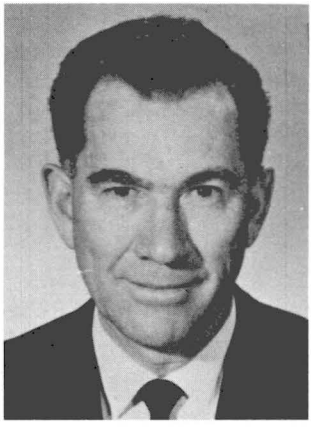
This overseas project was the first of many undertakings that resulted from Albertson's seemingly unlimited energy and initiative over the following three decades. The second was in effect a continuation of his wartime work at Iowa. Jack E. Cermak (1922-...), a native Coloradoan, had entered the College in 1940, but as a result of military service he completed his undergraduate studies just in time to become Albertson's first graduate student. Together they obtained a grant from the Office of Naval Research for the construction of the College's initial wind tunnel, located in the west half of what is now the Biochemistry and Radiation Building (see page 19). It was completed in 1949, and additional backing was obtained from

the ONR for the further study of evaporation. That same year Dean F. Peterson (1913-...) of Utah was appointed head of civil engineering; with his strong promotional aid, and the equally strong support of the ONR and the NSF, the organization began to display a remarkable rate of growth. Part of the reason was their practice of employing two or three men on one man's academic salary and utilizing income from contracts and grants to make up the difference. James R. Barton, one of Rouse's graduate students at Iowa, joined the staff in 1952, the year that also brought A. Ray Chamberlain (1929-...) a Michigander who became Albertson's (and the College's) first doctoral candidate and later chief of research. On his retirement from the Bureau of Reclamation in 1953, Emory Lane received a temporary appointment at Fort Collins, which he held until illness forced cessation of his activities in 1957; by then he was well along the road toward formulation of a general philosophy of sediment transport.



Ray Chamberlain, Emory Lane, and
Dean Peterson

In 1955 the Army Air Force granted funds for a meteorological wind tunnel, and this became operational alongside the first tunnel in 1963. Erich J. Plate (1929-...) of Germany, previously a graduate student, was recalled to the staff in 1959; at first involved in wind-tunnel design under Cermak, he later participated in atmospheric modeling and diffusion studies. The U.S. Geological Survey stationed Daryl B. Simons (1918-...) of Utah at Fort Collins in 1957 to collaborate in the growing



Daryl Simons

Everett Richardson

research program on river mechanics and sediment transport, to which the Nebraskan, Colorado State graduate Everett V. Richardson (1924-...), had been transferred from Iowa by the Survey in 1956. Simons not only supervised the USGS program but completed work toward the second engineering doctorate at CSU and then taught courses in civil engineering.

Vujica Yevjevich

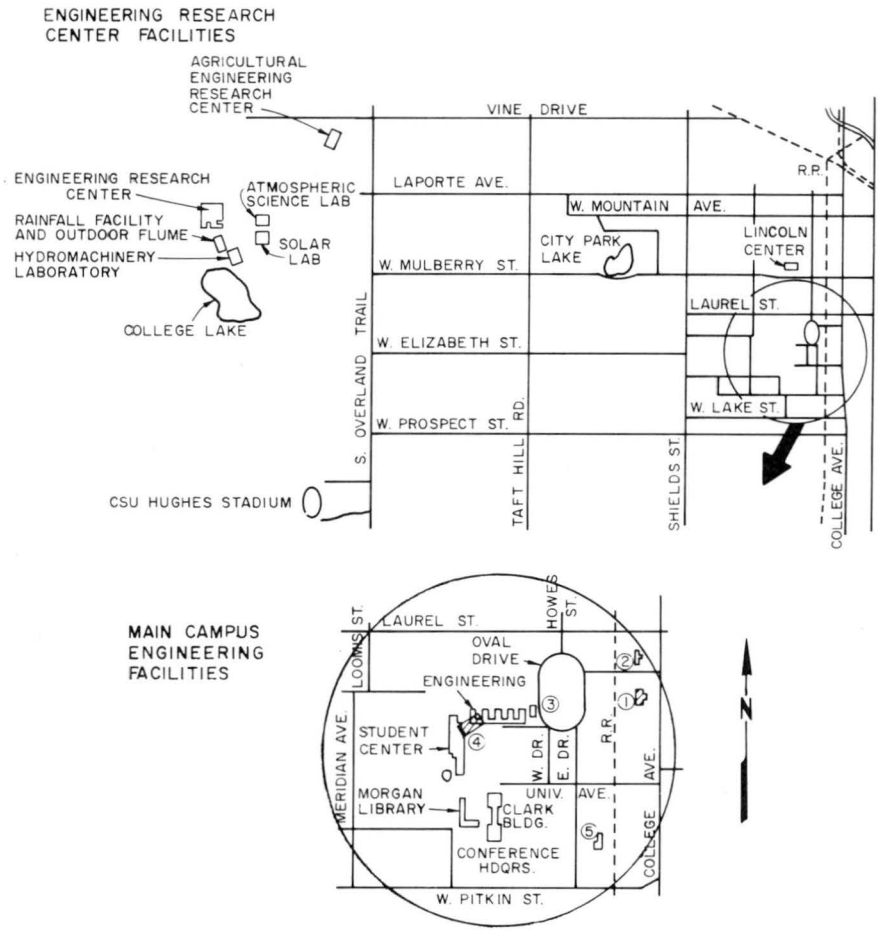
Lionel Baldwin

The year 1957 also saw the change in the institution's name to Colorado State University, not to mention the arrival of the hydrologist Vujica Yevjevich (1913-....), a native of Yugoslavia who had previously headed a research institute in his own country. The Texan Lionel Baldwin (1932-....) came to the campus in 1961, after experience with NACA-NASA; a chemical engineer, his specialty was fluid turbulence. William W. Sayre (1927-....) of New York and Princeton, initially a graduate student, became a member of the USGS staff in 1962, moving to Iowa in 1968 after receiving the doctorate; his particular interest was the mechanics of diffusion. Hsieh-Wen Shen (1931-....), a native of China who, after study at Michigan, had taken the doctorate in sediment transport under Einstein at Berkeley (and was to become an ASCE Freeman Scholar the following year), arrived at Fort Collins in 1964.

Hsieh-Wen Shen

Ray Chamberlain

With such a staff - not to mention the considerable support of various agencies - recirculating and tilting flumes, wave basins, and additional wind tunnels came into being, and graduate enrollment steadily rose. The pressure of growth inevitably prompted the construction in 1962 of a greatly enlarged facility in the foothills of the Rockies five miles west of the original Fort Collins campus, at about the same time that construction of the Engineering and Student Centers did away with the existing laboratories. By 1965 the new Engineering Research Center contained some 50,000 square feet of laboratory floor space, plus forty acres of



1. OLD MAIN SITE (FIRST PERMANENT BUILDING)
2. SPRUCE HALL (ORIGINAL DORMITORY BUILDING)
3. CIVIL AND IRRIGATION ENGINEERING BUILDING (NOW "OLD ECONOMICS")
4. SITE OF ORIGINAL HYDRAULICS LABORATORY
5. SITE OF INITIAL WIND TUNNEL (NOW WEST HALF OF BIOCHEMISTRY AND RADIATION BUILDING)

Plan of main campus and Engineering Research Center, showing location of engineering's early buildings

surrounding land for outdoor experiments, and much more equipment. Some of the new wind tunnels were provided with means of controlling the distribution of velocity and temperature, and one of the new flumes conceived by Albertson, Richardson, and Simons and constructed with USGS and NSF funds was claimed to be the largest tilting and recirculating facility in the country. Aside from the laboratory's very effective programs on wind dynamics, open-channel flow, hydrology, and fluid mechanics in general, the hydraulics and fluid mechanics staff actively promoted summer institutes on various aspects of fluid motion with the support of the NSF. Not only was Albertson himself behind the original developments, but he continued to take some part in subsequent activities and shared in the authorship of at least one prize-winning paper. However, he had many other irons in the fire, particularly of an international nature - such as the original formation of the Peace Corps, and the establishment of the Asian Institute of Technology at Bangkok.

In 1963 Daryl Simons left the USGS to become the head of Civil Engineering Research and in 1965 Simons accepted the position of Associate Dean for Research and as such became Director of the Engineering Research Center and Associate Director of the Agricultural Experiment Station. Lionel Baldwin was appointed Dean of Engineering in 1965; and in 1969 Ray Chamberlain - for several years Vice President - assumed the post of President as the University was preparing to celebrate its centennial year. Under Jack Cermak's direction, another environmental wind tunnel was added to the Fluid Dynamics and Diffusion Laboratory that year, and two more the year following. Continuous development of these wind-tunnel facilities and the science of atmospheric modeling through project THEMIS resulted in the laboratory becoming recognized as a world center for wind-engineering research. Erich Plate, who had been closely associated with the wind-tunnel investigations, left in 1970 to accept one of the chairs in hydraulic engineering at the University of Karlsruhe.

In the same period a large outdoor rainfall-runoff facility with an area of 25,000 square feet was constructed under Vujica Yevjevich's direction; fed by 400 irrigation sprinklers of variable capacity, rainfall and runoff measurements versus space and time are now reduced to their significant form by computer. Under Albertson, interest in water resources had gradually developed, and two specialists were finally added to the staff to strengthen that

Victor Koelzer

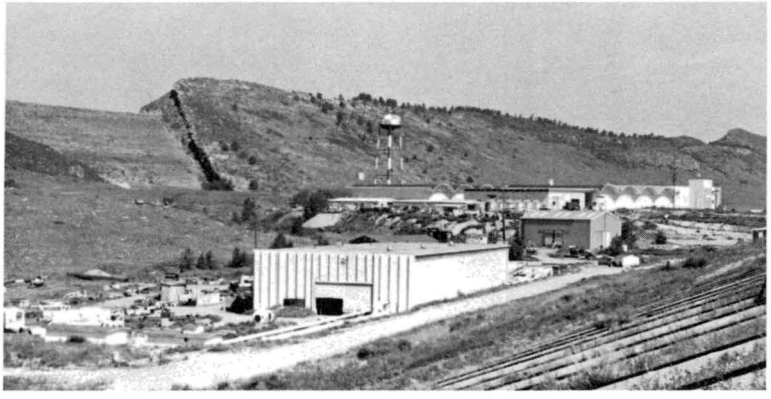
Warren Hall

particular field: Victor A. Koelzer (1914-...) of Kansas and Iowa, and Warren A. Hall (1919-...) of South Dakota and California, both of whom were broadly experienced in the field, including service with the government; Hall, it should be noted, became in 1973 the first to hold the newly endowed Elwood Mead Professorship. In 1963 Professor J. W. N. Fead (1923-...), a member of the Civil Engineering Department originally from Canada, succeeded Milton E. Bender (1916-...) as chairman when the latter assumed the presidency of the Asian Institute of Technology. The fall of 1979 saw the departure of Yevjevich for George Washington University, though he retained a quarter-time appointment at CSU.

As of September 1979 the staff of the combined hydraulics, fluid mechanics, and hydrology sections of the Civil Engineering Department has grown to a total membership of 125. Of these, 33 are of faculty rank, i.e., assistant professor or above, and 92 are graduate assistants. The hydraulics section is largest, with 69 members, and fluid mechanics next with 36. About 55% of all graduate students in the Department are employed part-time, with an annual turnover of some 40-50%.

PHYSICAL PLANT

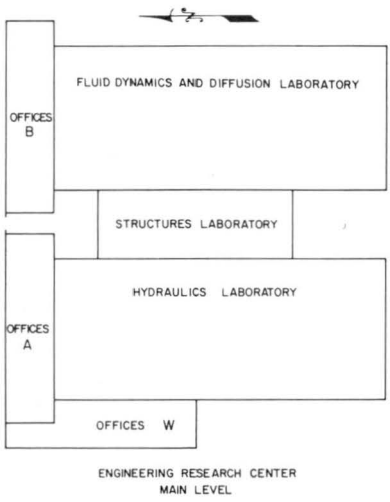
As seen from the accompanying figures, the Engineering Research Center occupies some 40 acres of the University Foothills Campus, the major part of which is devoted to experimental facilities for hydraulics, fluid mechanics, and hydrology. The primary structure consists of a multi-wing building: wings A and B include a basement and two stories, and provisions have been made for duplicating on A the third story already on B; wing W is a single story. The three wings together provide 69,000 square feet of



Looking over Hydro-machinery Laboratory toward Horsetooth Reservoir's Soldier Dam and the main Engineering Research Center buildings

space for offices, conference rooms, small laboratories and electronics shops, printing, drafting, and photographic quarters, two lecture rooms, and a cafeteria. Directly south of the main wings and connected to them are two large laboratories each roughly 120x280 feet in plan, with a minimum ceiling height of 22 feet, the one for hydraulics lying to the west and that for fluid mechanics to the east. A smaller hall between them is used for structural research. At the south end of the hydraulics section is a well-equipped machine and instrument shop some 40x120 feet in plan, serving the entire Research Center.

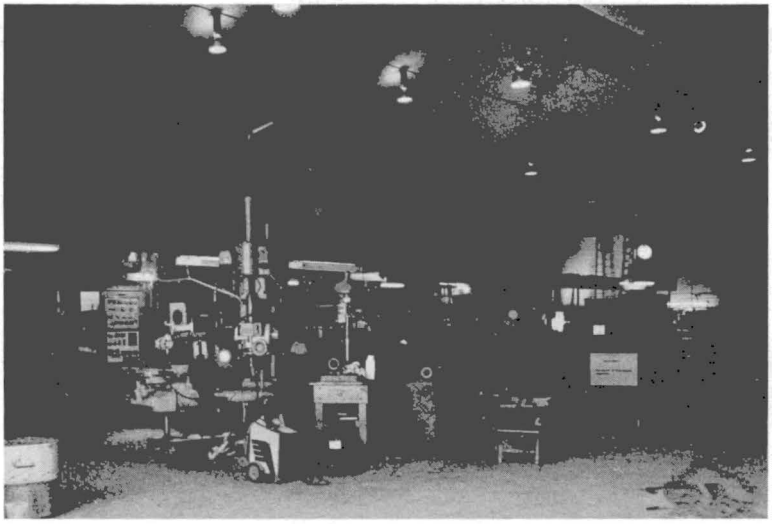
Permanent features of the Hydraulics Laboratory are a series of interconnected sumps 8 feet in depth and 5,400 square feet in surface area; 14 pumps ranging in capacity from 250 gallons per minute at 50-foot head to 23,000 gallons per minute at 19-foot head; a power-tilting



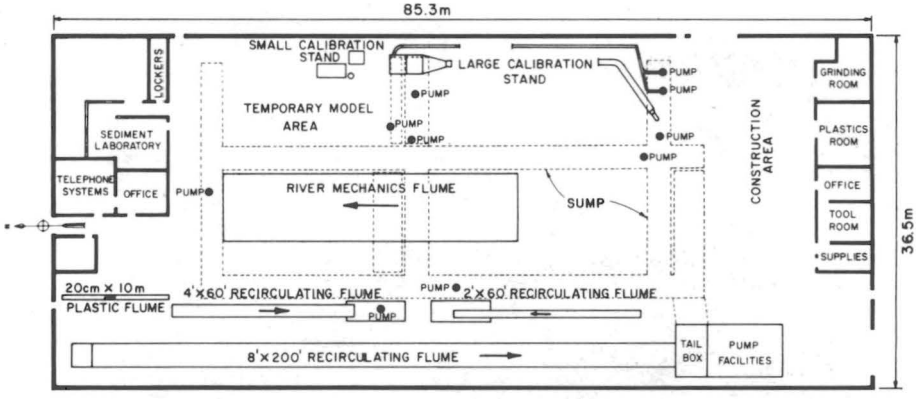
Layout of Engineering Research Center

Engineering Research Center facing east

flume 4x8x200 feet with a discharge capacity of 100 cubic feet per second; a 20x100 foot river-basin flume for meander, erosion, and control-structure studies; a large local-scour flume; three other tilting flumes; and ample space for temporary models.

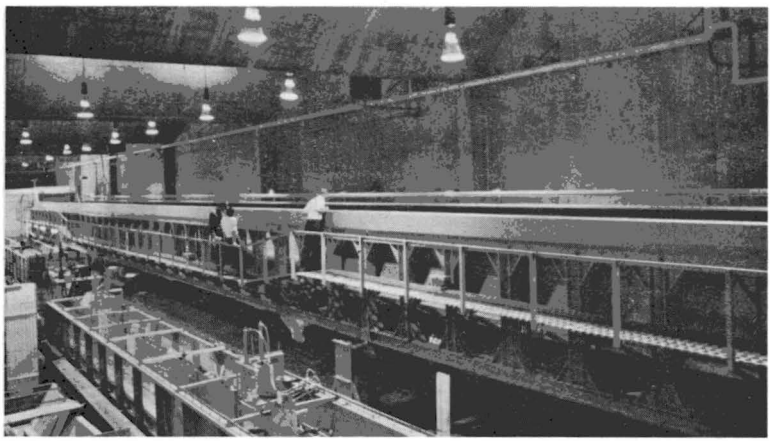


A portion of Engineering Research Center Shop



Plan of Hydraulics Laboratory

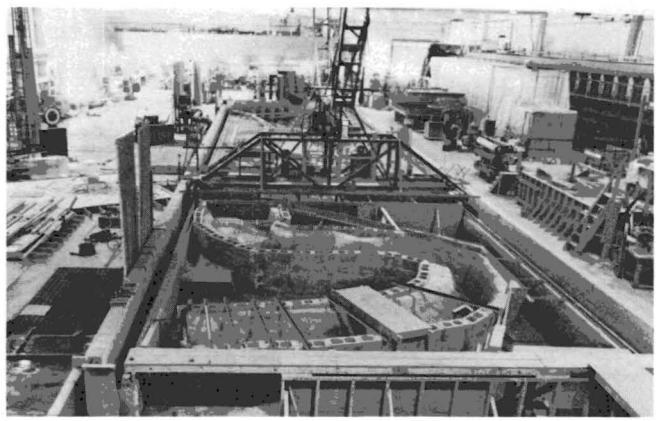
A 100-acre outdoor laboratory adjoins the building, making possible large-scale model and full-scale prototype studies. A concrete flume 8x20x180 feet with a recessed section 10 feet deep provides a facility for large-scale tests. A 3-foot-diameter variable-slope pipe 825 feet long is also available. A hydro-machinery facility is housed in a 70x192-foot prestressed-concrete building. The concrete



View of large tilting flume

floor slab was made 3 feet thick to eliminate vibration during testing.

Water for both the indoor and outdoor laboratories comes from the U.S. Bureau of Reclamation's Horsetooth Reservoir just uphill to the west of the Research Center.



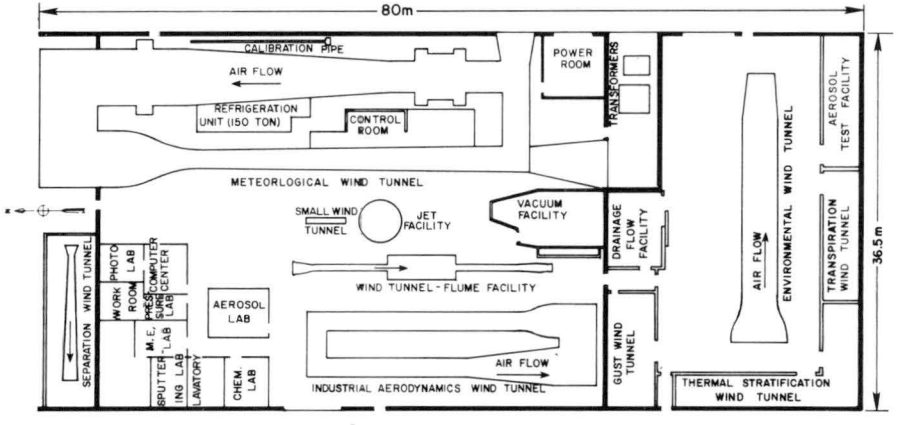
Temporary flume with models

A maximum head and discharge on the order of 200 feet and 300 cubic feet per second are available. Modifications are currently underway that will increase the maximum available discharge to 500 cubic feet per second. In addition, large

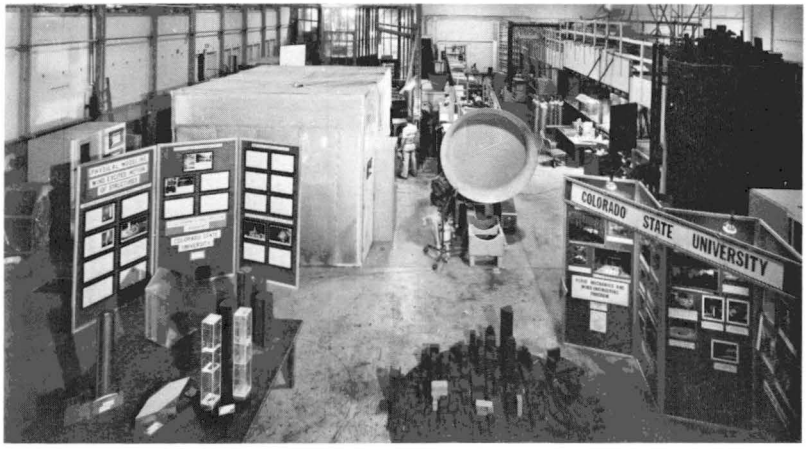
stationary and movable pumps are used to recirculate water from sumps and to increase the operating head. Waste water is led south to College Lake, which also serves as a secondary supply reservoir.

The ample water supply, large head, and extensive working area offer a unique opportunity to study problems requiring large discharges and heads, such as certain types of model tests, geomorphological studies, flume and pipe experiments on roughness, sediment transport, turbulence, diffusion, hydraulic machinery, valves, and related problems. In addition, a ready comparison of field and laboratory conditions can be made, because in the vicinity of Fort Collins are steep mountain streams, sand-bearing rivers of the plains, lined supply channels, and large storage reservoirs.

The Fluid Dynamics and Diffusion Laboratory, shown in plan, houses eight air-flow facilities of various sizes and capabilities. The meteorological wind tunnel has an overall length of 200 feet with a 6x6-foot test section 100 feet long. Heating and/or cooling of the air in the 18x18-foot return-flow section provides extreme flexibility for simulating a wide range of atmospheric thermal stratification. Wind speeds from 0.5 to 100 miles per hour permit boundary-layer flows similar to those of the real atmosphere to be modeled with accuracy.

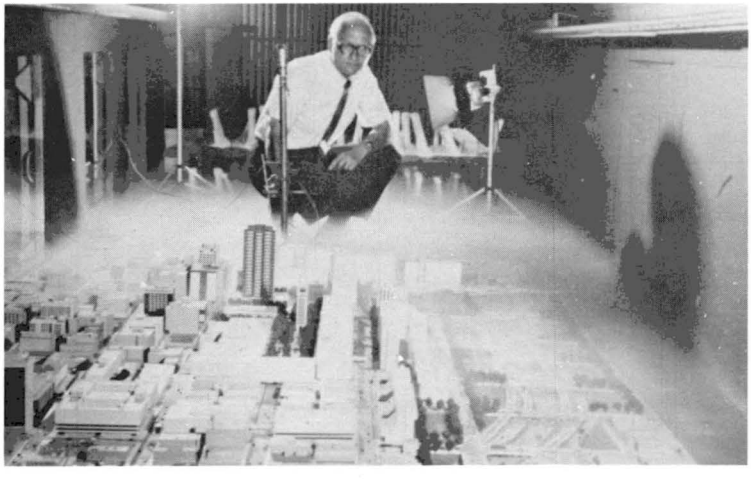


Plan of the Fluid Dynamics and Diffusion Laboratory



Fluid Dynamics and Diffusion Laboratory

An environmental wind tunnel has a test section 60 feet long and a 12x8 cross section. With air speeds up to 27 miles per hour, this facility is used for investigation of wind effects on large areas. An industrial-aerodynamics wind tunnel, with a test section 60 feet long and 6x6 feet in cross section and an air speed up to 60 miles per hour, provides additional capabilities for boundary-layer studies such as evaporation from soil and water surfaces, wind pressures on model buildings, ventilation, and the movement of soil and snow by wind.

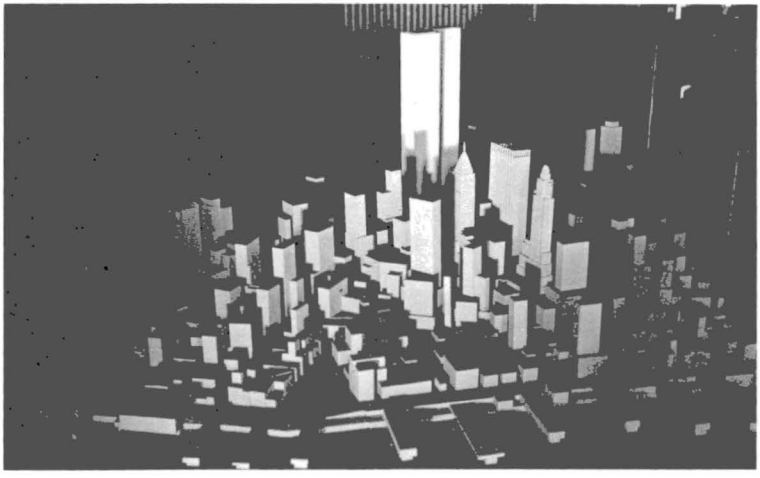


Inversion conditions over Denver model in meteorological wind tunnel

Studies of water waves generated by wind, and mass transport across an air-sea interface are made possible by a wind-water channel. This facility has a length of 60 feet and provision for flow of water with or against the air-stream in the 2x3-foot test section. Wind speeds up to 40 miles per hour can be developed, and water waves of selected amplitude and frequency can be created by a mechanical generator.

Model of Yerba Buena Center, San Francisco, in environmental wind tunnel (1:240 scale)

Several facilities for specialized research augment the larger test facilities, including a separated-flow facility, which has a working section 2 feet wide with a flexible floor that can be adjusted over a length of 10 feet to provide a wide range of pressure variation in the flow direction. A thermal-stratification facility 2x3x12 feet in size with air speeds up to 10 miles per hour provides opportunities for basic research. Studies of flow control over airfoils and turbine blades are conducted in a transpiration wind tunnel, which is provided with a porous floor in the 1x2-foot test section to permit withdrawal from or injection in the boundary layer formed over the porous surface. An air-jet facility permits the study of boundary-layer development of an impinging jet on a normal plate; 1-inch-jet velocities of 250 feet per second against a 12-foot-diameter plate can be realized. Aerosol dispersion can be studied in an aerosol test



Model of World Trade Center, New York, in meteorological wind tunnel (1:500 scale)

facility with a 2x2-foot test section 15 feet long capable of producing air speeds up to 170 feet per second and equipped with a remote-sensing laser-powered particle spectrometer. Studies of large-scale turbulence are made in a gust tunnel with a 3x3-foot test section equipped with two banks of airfoils whose pitch may be varied randomly by an electromechanical servo-system. A drainage-flow facility consisting of a 20x20x8-foot isolated chamber with provisions for cooling of surfaces placed within the chamber is used to study free-connection flow over models of complex land forms.

Instrumentation for measurement of flow variables and tracer-gas concentrations is available to support either the most advanced studies on turbulence and diffusion or the applied investigations of wind engineering. This instrumentation includes hot-wire-anemometer systems; electronic pressure transducers and meters; aerosol, radioactive-gas, and helium and carbon concentration-measurement systems; optical systems; and strain-gage balances. Data-processing equipment includes an analog-to-digital converter and a Hewlett-Packard data processor, spectral analyzers, probability-density analyzers, and a variety of special-purpose systems.

CSU's Hydrology Laboratory consists primarily of an outdoor rainfall-runoff facility covering 25,000 square feet of land sloping gently toward the point of outflow.

Characteristics of the ground such as roughness, permeability, and geometry can be varied to represent a wide range of natural catchments. The simulated rainfall is generated by 277 sprinklers, each located on top of a 10-foot vertical pipe. Water is supplied to the sprinkler risers by aluminum feeder lines running in parallel across the watershed. These lines are approximately 17½ feet apart, and each line has 20 risers 10 feet on center. Various rainfall intensities are produced by operating different combinations of sprinklers controlled by electric solenoid valves at the side of the facility. When all sprinklers are running simultaneously, approximately 100 millimeters of rainfall per hour is being generated. The size of the facility is evidently such that it represents an intermediate step between laboratory models and natural watersheds.

Data-processing equipment available to the Engineering Research Center includes the following: A CYBER 171 digital computer with 131K of 60-bit words, an NOS operating system, 5-607 7-track tape drives, and 1 billion 400 million characters of on-line storage. A CYBER 172 digital computer with 131K of 60-bit words, an NOS operating system, 2-669 9-track tape drives, 3-667 7-track tape drives, 2-607 7-track tape drives and 1 billion 600 million characters of on-line storage. These computers can be accessed in either batch or interactive mode. Also located at the Research Center is a DATA 100 high-speed batch terminal consisting of a card reader and printer.

There are 5 DEKWRITER interactive terminals located in an interactive laboratory with a TEKTRONIX 4014-1 graphics terminal that has a dual-floppy disc unit, a hard-copy unit, and a pen plotter. Several other interactive terminals are located throughout the building and on campus. Support equipment such as keypunches and a hard-copy plotter is also available. Recently, a Hewlett-Packard 1000 minicomputer with 200K of 16-bit words, one 9-track, 1600 bpi tape drive, a 600 line per minute printer and 140 million characters of on-line storage and a multiplexor capable of handling up to 16 interactive terminals was installed at the Research Center.

A remote-sensing laboratory with the capability of digitizing maps, strip charts, etc., is likewise available to the various research programs. Recording facilities include three analog tape recorders of 14 FM channels each and an analog-to-digital digitizer with 8 channels. The possibility exists of connecting to any cooperating computer center in either batch or interactive mode.

CURRENT RESEARCH

HYDRAULICS

Dr. D. B. Simons, Professor in Charge and Associate Dean for Research

Senior Staff: M. L. Albertson (Emeritus), J. W. Ball, Y. H. Chen, J. Gessler, S. Karaki, H. J. Koloseus, R. M. Li, E. V. Richardson, J. F. Ruff, H. W. Shen

The Hydraulics Section engages in broad theoretical and applied activities that are coordinated with the graduate-study program to provide the students with research experience as well as formal instruction. A significant portion of the research is interdisciplinary, involving other programs, departments, colleges, external agencies, and governments, both American and foreign. Thus the scope of the research extends well beyond the area of classical hydraulics.

Major emphasis is on research related to hydraulic, geomorphic, hydrologic, water-resource, and environmental problems. Primary areas of concentration include river mechanics, bridge-pier and culvert scour, erosion, and sedimentation; diffusion and turbulence in closed- and open-channel flow; cavitation, noise, and vibration; transport of solids through pipelines, and viscous drag reduction; design and performance of hydraulic structures and of water-conveyance systems; energy development and conservation; physical modeling and mathematical modeling of complex one- and two-dimensional systems; flow measurement; and river-system remote sensing.

Information Transfer

The program is significantly involved in both standard and innovative forms of information transfer. It specializes in the development of specific information for presentation as regular course work, in special short courses (page 51), in seminars, and on videotape. The Section serves the specialized training needs of federal agencies, industry, state agencies, and foreign agencies or governments. Special courses have been offered in river mechanics, geomorphology, transportation in river environment, remote sensing techniques, nonuniform unsteady water and sediment flow,

river training, erosion and sedimentation, hydromachinery, turbulence, diffusion, dispersion, and related processes. The work may involve training with or without credit.

River Mechanics

A major area of concentration in hydraulic research at Colorado State University is the behavior of alluvial channels. Much of this work is done in association with the Agricultural Research Service, the Corps of Engineers, the Bureau of Sports Fisheries, the U.S. Forest Service, the Environmental Protection Agency, engineering consulting firms, and foreign governments. The number and complexity of the variables affecting flow in such channels require highly sophisticated techniques if useful relationships are to be developed. The work is supported by investigations of basic flow phenomena.

These basic investigations include studies of flow conditions in the laboratory and in the field that are designed to develop sound principles for evaluating resistance to flow, for computing sediment transport, for analyzing channel stability, and for designing both rigid and alluvial channels. Related studies investigating such phenomena as turbulent shear flow will enable engineers to better understand the processes of energy dissipation and dispersion in open channels.

Specific projects are concerned with the effect of surface forces on the stability of alluvial channels and the analysis of ripples, dunes, antidunes, bar formations, and other aspects of the movement of sediment particles in alluvial channels. A study of the effects of different variables on alluvial-channel flow is in progress; as a consequence, it will be possible to make better use of the results of small-scale flume and laboratory work. There is currently research in progress on meandering and braiding in alluvial channels, the hydraulics of steep channels, secondary currents, and bridge-pier and general scour.

Colorado State University engineers are conducting studies aimed at the development of a method for the design of stable alluvial channels carrying a certain flow and sediment load. Hydraulic engineers are working with geomorphologists and biologists toward a realistic solution of this problem.

Sediment transport rates under various simulated vegetative and hydraulic conditions are being investigated both theoretically and experimentally in a laboratory flume by the stochastic approach. The distributions of the step lengths and rest periods of single sediment particles are obtained with the aid of radioactive tracer techniques.

Studies of the interaction between wind and water in open-channel flow are expected to yield results that will make possible the modification of open-channel design parameters to include the effects of wind. Wind-generated waves in shallow water are also being studied.

Delta-formation studies involve the effect of groundwater flow through porous stream banks and the phenomena of delta development above flood-water and debris-storage structures.

Research on the development of low-cost methods for sealing leaky ponds and irrigation canals has evaluated a series of Colorado clays as sealants and is now directed toward studying various chemical sealants.

Hydromechanics

Research in the area of cavitation has been directed toward providing the hydraulic engineer with information on the cavitation performance of valves and other control devices. Design limits of incipient, critical, incipient-damage, and choking cavitation have been defined and experimentally determined, and scale-effect adjustments associated with size and operating pressure have been proposed. Fundamental studies are under way to uncover the mechanics of cavitation damage and the cause of scale effects.

The unique head and discharge capacities of the Hydromachinery Laboratory have enabled a considerable amount of testing of full-scale hydraulic systems to be conducted. The torque, cavitation, transient vibration, and steady-state performance of large valves have been studied. Flow-distribution, resistance, and flow-induced vibration studies have been conducted on large piping systems for nuclear power plants.

Hydraulic transients caused by filling and operating pipelines and by closing check valves have been and are being investigated. Guidelines for allowable filling

velocities, selection and location of air relief valves, and identification of factors affecting transient pressure rise caused by pipe filling have been proposed.

Drag reduction caused by the addition of polyethylene oxide to water flowing through pipes has produced decreases in wall shear stress in excess of 80 percent. The influence of the additive on the boundary-layer growth, velocity profiles, and turbulence is being studied to uncover the reason for the profound influence of the additive.

Turbulence and Diffusion

Both theoretical and experimental studies of turbulence and diffusion are being conducted under the hydraulics program. These studies are being carried out in pipes and open channels in both the laboratory and the field. The theoretical studies are devoted to the development and study of mathematical models of turbulence-shear flows; diffusion and dispersion processes; turbulent mixing; and the transport of mass, momentum, and heat. The experimental program is developing methods and instruments for the measurement of the fluctuating time and space variables that constitute the flow field. It is also experimentally examining the theoretical postulates to determine their validity. The research is leading to better practical methods of solving such engineering problems as energy loss in fluid flow, transport of sediment, time of travel and dilution of pollutants in rivers, and mixing in chemical processes.

Physical and Mathematical Modeling

Colorado State University engineers have tested models of high-head radial and roller-type gates, considering special problems in seal design, hydraulic loading, aeration, and cavitation prevention. Other models of spillways, outlet works, penstocks, pipe networks, and diversion works have been investigated. The research has also included the study of flow-measuring structures and river interaction with hydraulic structures. The interaction study has entailed both physical and mathematical modeling.

Many studies involve the detailed mathematical modeling of watersheds, sediments of rivers, hydraulic structures, and river systems. Mathematical modeling involving the routing of both water and sediment including sediment by

size enables the engineer to study channel response, the effect of hydraulic structures, flood routing, and in particular the response of watersheds and river systems to development. Extensive modeling work is being done that relates to the response of the Rio Grande and the Mississippi Rivers to flood control, navigation, and specific environmental considerations.

Moreover, mathematical-modeling activity includes the routing of pesticides, herbicides, organic matter, and heat. The present goal is to extend the modeling applications to include identification of feasible development alternatives; continued investigation of process and stochastic models; and the production of simplified models for field application where simplification is justified.

Unsteady Flow in Open Channels

Analyses of unsteady flow are concerned with developing theoretical equations that relate to the actual phenomena and the corresponding numerical analysis of the partial differential equations. Attention is being given to the analysis of errors and error propagation as a result of the computational procedures. Areas of interest include surges produced by flood waves in both natural channels and at hydroelectric power generating stations where a sudden change in power requirement may produce a corresponding surge in the forebay or in the tailrace. In the arid regions of the west, a knowledge of flash floods, which occur in natural channels as a result of high-intensity precipitation, is important in predicting the effects of changing discharge in dry-bed channels. Continuing work includes both theoretical and experimental observations of rapidly varied unsteady flow. Results of research in this area of study are being incorporated into other research activites, such as mathematical modeling of various hydrologic and hydraulic problems. A major effort currently involves the development of two-dimensional mathematical models of special river problems.

Fluvial Geometronics

New and effective techniques for collecting spatial and spectral information about river systems have been developed over the past few years in the Civil Engineering Department at Colorado State University. The new procedures, which involve analytical photogrammetry and remote

sensing, provide data at a rapid rate over extensive reaches of river systems. Interpretation involves state-of-the-art, manual, analog, and analytical procedures. Graduate-study programs may be tailored to meet the individual student's requirements, varying from supplemental to total utilization of these new techniques for specific problem areas.

Particular emphasis has been put upon the utilization of both color infrared photography and thermal infrared imagery for many aspects of river studies, including flow patterns, vegetation mapping, environmental-impact assessment, snow surveys, and sediment-transport processes.

Irrigation Engineering

The lack of food production and the need for better nutrition in the developing countries is reaching disastrous proportions, creating world problems. Yet improved water management in conjunction with soil management and improved seeds can significantly increase food production, even without additional fertilizer.

Irrigation engineering is involved with all aspects of the hydrologic cycle as it relates to food production - the watershed, water delivery and removal systems, and related institutional development and on-farm water management. Research is both basic and adaptive and involves legal and administrative rules for water delivery and removal; hydraulic structures for delivery, measurement, and control of water and sediment; water-storage systems; conjunctive use of surface and groundwater; water quality; soil, water, and crop interaction; soil-erosion magnitude and control; management of water delivery systems; on-farm water management; and the planning and design of irrigation systems.

The irrigation engineering program is interdisciplinary and involves departments in the Colleges of Agriculture, Humanities and Social Sciences, and Natural Sciences, in addition to the Agricultural Engineering and Civil Engineering Departments. The program also cooperates extensively with similar programs at the University of Arizona, Tucson; University of California, Davis; University of California, Riverside; University of Idaho, Moscow; New Mexico State University, Las Cruces; Oregon State University, Corvallis; Texas Tech University, Lubbock; Utah State University, Logan and Washington State University, Pullman. These

universities, along with Colorado State, have formed a "Consortium for International Development" (CID) to apply and coordinate their expertise in the fields of water management to world production of food and fiber. A dynamic intra- and inter-member university program has developed that provides expertise in irrigation engineering to AID, the World Bank, private consulting firms, and foreign governments.

FLUID MECHANICS AND WIND ENGINEERING

Dr. J. E. Cermak, Professor-in-Charge and Director, Fluid Dynamics and Diffusion Laboratory

Senior Staff: L. V. Baldwin, J. A. Garrison, R. N. Meroney, J. A. Peterka, W. Z. Sadeh, V. A. Sandborn, J. B. Wedding

The Fluid Mechanics and Wind Engineering Program treats motions of gases and liquids as a scientific discipline that is structured to support and stimulate many applications in engineering, architecture, agriculture, meteorology, oceanography, and biology. Through emphasis on application of fluid mechanics to investigation of atmospheric motion, the Program has pioneered in development of laboratory facilities to study low-level wind and its effects on heat, mass, and momentum transfer. Theoretical and applied research, professional activities, and formal lecture courses are integrated to form a well-balanced graduate program. Graduates of the Program serve with engineering faculties in universities throughout the world and are employed by consulting firms, industries, and governmental agencies.

Experimental research, a strongly emphasized element of the Program, is centered in the Fluid Dynamics and Diffusion Laboratory (FDDL). Special boundary-layer wind tunnels for simulation of atmospheric motion provide a unique capability for basic research and investigation of wind engineering and environmental problems of state, national, and international concern. Modern instrumentation, data-processing systems, and a variety of flow facilities support basic and applied investigations on boundary layers, turbulence, and turbulent diffusion. Because the laboratory provides unusual opportunities for research, many cooperative investigations with visiting scientists,

research teams from other universities, and industrial research groups have evolved.

Research developed during the last three decades is sponsored primarily by the National Science Foundation, the Office of Naval Research, the National Aeronautics and Space Administration, the Energy Research and Development Administration, the Nuclear Regulatory Commission, the Environmental Protection Agency, the Department of Energy, the Air Force, the Army, and the Navy. The Program is complemented by a wide variety of laboratory investigations of wind forces on structures, atmospheric diffusion, and other wind-engineering problems associated with maintenance of air quality, development of new energy-production systems, and the design and planning of major engineering projects. These investigations, sponsored by leading consulting and industrial firms throughout the country, utilize many of the research results obtained by the program staff and students and help identify areas that will be productive for new research. In addition to providing support for program faculty, laboratory technicians, 30 graduate research assistants, and 28 under-graduate laboratory assistants, contract funds permit operation, maintenance, and development of the FDDL without cost to the State of Colorado.

Turbulent-Boundary-Layer and Turbulence Studies

Boundary-layer investigations have been and continue to be the primary research area of the Program. Three decades ago the research began on two-dimensional boundary layers. The effects of surface roughness and thermal stratification on mean flow properties and turbulence were investigated for uniform surfaces corresponding to a wide range of natural surface conditions. Current research focuses on the definition of flow characteristics over non-uniform surfaces for which surface roughness and/or temperature vary in either two-dimensional or circular areal patterns. These surface conditions correspond closely to natural conditions found on Earth's surface. Through analysis and comparison of boundary-layer data measured in the FDDL meteorological wind tunnel with micrometerorological data measured in the atmospheric boundary layer, similarity for the boundary-layer characteristics was confirmed in 1963. Thus, a rational basis for use of boundary-layer wind tunnels to study natural wind characteristics and their effects on heat, mass, and momentum transfer was

established. Accordingly, information on turbulence distributions, lateral and vertical mean-flow development, and longitudinal vorticity obtained in the meteorological and environmental wind tunnels provides direct information on atmospheric motion over cities, agricultural areas, airport runways, lakes, and many other local surface irregularities. This knowledge is useful in determining the circulation of air pollutants in urban areas, carbon-dioxide transport to plants, dispersal of insecticides by aircraft, and evaporation of water from land and water surfaces as well as frictional drag on various types of surfaces.

Experimental evaluations of the properties of compressible turbulent boundary layers for both subsonic and supersonic flow have been made using facilities of the NASA Ames Research Center, since the FDDL specializes in low-speed wind-tunnel facilities. Evaluation of turbulent shear stress for a wide range of flow conditions has been made. This is aiding in development of a computer code that will be employed directly in design of new aircraft.

Fundamental boundary-layer phenomenon currently being studied both theoretically and experimentally include the following topics:

1. vorticity amplification in boundary layers near stagnation regions,

2. thermally induced flow reversal in flat-plate boundary layers,

3. boundary-layer interaction with a tornado-like vortex that is attached normal to the flow boundary, and

4. perturbations in boundary-layer characteristics resulting from flow over hill-like surface obstacles.

Systems for generation of large-scale turbulence in wind-tunnel test sections have been studied in the FDDL. The need for such a system, in addition to determining the basic properties of large-scale turbulence, is to enable aerodynamic stability of suspension-bridge decks to be investigated in flows that adequately simulate atmospheric turbulence. A promising system consisting of sets of airfoils with random pitch fluctuations activated by hydraulically driven electro-mechanical servo-systems has been constructed.

Turbulent Diffusion Studies

Basic research on turbulent diffusion and transport has been and continues to be a fundamental effort of the Fluid Dynamics and Wind Engineering Program. Initially studies were confined to diffusion from steady point or line sources of passive material into turbulent boundary layers with and without thermal stratification established over a plane surface of uniform roughness and temperature. Current studies emphasize investigation of turbulent transport over nonuniform surfaces corresponding, in local regions, to individual buildings, hills, and city canyons. These studies include basic research on dispersion of dense gases such as may result from a liquid natural gas spill and dispersion in drainage flows generated by surface cooling of complex terrain models. The investigations are being extended to include unsteady flow conditions, dispersion of aerosols as well as gases, and measurement of concentration fluctuations in addition to mean concentrations. Basic information on dispersion rates is being used in formulating environmental-impact evaluations either directly or through incorporation as input for numerical models.

Wake Studies

Interaction of a turbulent circular jet with a turbulent boundary layer formed on a flat plate normal to the jet axis has been studied in detail. Both the mean-flow and turbulence characteristics within the jet-wake region are under study.

Wakes downwind from isolated surface obstacles immersed in a boundary-layer flow contain a pair of vortices trailing behind the obstacle for a wide range of wind directions. The wake characteristics - mean flow, turbulence, and vorticity - are being studied for a hemispherical obstacle and for box-like obstacles. Since similar wakes are found in the atmosphere downwind from buildings, the research is being done to determine effects that buildings near airports might have upon flight safety during takeoff and landing, to determine how upwind structures affect wind pressures on buildings in their wake, and to evaluate dispersion characteristics for air pollutants emitted in a building wake.

The vortex-shedding properties of circular cylinders, although established for uniform flow, are not known for

flow in which the mean speed varies along the length of the cylinder. A basic study in which the flow speed varies at a constant rate has been initiated in support of a program to investigate "strumming" of long underwater cables.

Studies of Wind Effects on Buildings and Structures

A program of systematic experimental and analytical studies to develop a basic understanding of interactions between wind and bluff bodies such as buildings, towers, and bridges has been active for the last decade. Local flow phenomena (separation, reattachment, vortex formation, and shedding), local wind pressures and heat-transfer rates on building surfaces, and integral wind effects (mean forces and moments; dynamic excitation by buffeting, vortex shedding, and galloping) are being investigated for a variety of surrounding urban environments and topography. The fundings are being related to building design and construction practices, with the long-range objective of improving building codes in an effort to reduce the nearly three-billion-dollar annual wind damage to buildings now being experienced in the United States. This program supported by the National Science Foundation is complemented by wind-engineering investigations for the design of many new structures that are conducted for architectural and structural engineering firms.

As a result of these pioneering studies on wind-effects, the Program was selected to serve as headquarters for the Wind Engineering Research Council, Inc., and to serve as host for the Fifth International Conference on Wind Engineering in 1979.

Air-Pollution Control Studies

The capability to physically model atmospheric transport of air pollutants for a wide range of meteorological conditions grew out of Program research on turbulent diffusion and development of the meteorological wind tunnel. Determination of good-engineering-practice stack heights for power plants and smelters, safety evaluation in the event of ruptured liquid-natural-gas storage tanks, pollution levels during loading and unloading of toxic chemicals, potential pollutant concentrations in and near parking garages, arrangement of buildings and air exhaust-intake vents to minimize recirculation of pollutants into buildings, and dispersion-control measures to minimize transport of odors

from sewage-treatment-plant sludge ponds are among the services provided utilities, governmental agencies, and urban developers.

The primary endeavors of the Fluid Mechanics and Wind Engineering Program in this area of study have two goals:

1. To develop basic knowledge about winds and dispersion in complex boundary conditions that defy solution by numerical and mathematical analysis.

2. To utilize the capabilities for physical modeling in the FDDL to serve the needs of society in achieving environmental control for existing and proposed urban and industrial developments.

The singular success of these efforts continues to provide quantitive data to engineers, architects, urban planners, and owners that permit decisions on environmental questions to be made with confidence. Program staff serve as advisors to governmental regulatory agencies and utility advisory groups in the development of air-pollution regulations as a result of these pioneering efforts.

HYDROLOGY

Dr. H. W. Shen, Professor in Charge

Senior Staff: H. J. Morel-Seytoux, J. D. Salas, T. G. Sanders, Vujica Yevjevich (Emeritus)

The broad objectives of this program are to obtain a more complete understanding of the physical and statistical characteristics of the hydrologic system and to develop better methods of applying this understanding to the more effective management of our water resources.

Application of Statistical and Stochastic Methods

This work deals with the analysis of stochastic processes in hydrology and water resources. It concerns especially the variations of hydrologic variables in time and space and their effect on the output variables of water-resource systems. These processes are analyzed by the

most up-to-date methods of probability theory, mathematical statistics, and stochastic theory. Special emphasis is placed upon new methods of solving water-regulation problems in the planning, design, and operation of storage-reservoir capacities. The study of the stochastic aspects of floods in developing methods for selecting flood-control measures, and the use of stochastic techniques for estimating drought possibilities and developing methods for drought-control measures, are also important aspects of this area of study. Because of the complexities of hydrologic systems, it is often desirable to consider the functions of the watershed to be a stochastic process and then to deal with the hydrologic behavior in statistical terms.

General Hydrology

The overall objective of this research is to study water and air movement in soils and to develop a mathematical model of infiltration and drainage able to respond to any spatial and temporal pattern of rainfall, including drought. In this form the model can be readily integrated into a general model simulating the hydrologic response of a watershed.

The problem of predicting the onset of the flood hydrograph after the beginning of storm rainfall is associated with many problems in operational hydrology. Initially, losses from the storm rainfall occur before the flood runoff begins. These losses are largely related to the losses to soil-moisture storage that have taken place since the last time the watershed was fully saturated. Such losses are largely evapotranspirational. Using given climatic measurements in the watershed, better methods for predicting the evapotranspiration losses are being developed.

Under a cooperative agreement, a U.S.-Yugoslavia research project on the hydrology and water resources of karsified areas involves various methods of determining the water budget of large underground or surface karst areas. The response of karst aquifers to inputs in the form of the outflow of karst springs has been given particular attention, as have several particular engineering and economic problems of karst areas. A method of solving the problem of conjunctive use of surface storage and interconnected underground storage has been developed.

Droughts

The project to study droughts has been organized in three fundamental parts. The first is an analysis of the probability of occurrence of droughts covering different areas for prolonged times. The second part is an analysis of the predictability of large droughts by examining various interrelationships and attempting to provide a physical explanation of the droughts. And the third part is a study of the engineering and socio-economic aspects of droughts with particular emphasis on drought-control measures. It is hoped that this project will lead to procedures which can be used to help alleviate the hardship and suffering which are caused by prolonged droughts.

Snow and Ice in the Hydrologic System

The objective of this research is to develop an optimal strategy of operations for an overall water-resource development, taking into account the interrelations of the hydrology, the characteristics of power-production and distribution units, the effect of energy prices and demand, and the acceptability of various risk factors.

Additional projects have as their objective the development of procedures to describe the evolution of the water content of the soil under natural hydrologic boundary conditions. This is a problem of identifying the relevant physical phenomena producing the necessary mathematical model for the computer solution of the physical problem. The compatibility of the final product with existing models and actual field conditions will then be tested.

Since snow and ice are significant features of the hydrologic cycle, research work in snow hydrology is expected to yield a more complete understanding of the migration of the water through the snow phase of the hydrologic cycle.

Water Quality Hydrology

The primary objective of this research is to develop a water-quality model to predict the characteristics of runoff from a small watershed. This will require the determination of the relationships between the runoff hydrograph and a water-quality hydrograph, and an evaluation of the sensitivity of the pertinent model parameters to error or uncertainty in the data.

Using the rainfall-runoff facility at the Engineering Research Center, it is proposed to model the water-quality concentration resulting from a small watershed subjected to controlled rainfall. Both surface runoff and the combination of surface and subsurface runoff will be investigated. The runoff hydrograph and the water-quality hydrograph from the small watershed will be studied to determine fundamental interrelationships so that the feasibility of estimating runoff water-quality concentrations by utilizing the runoff hydrograph can be investigated.

Sanitary Engineering

The project objective is to investigate the potential for water reuse and to compare the costs and side effects of water reuse to the development of new water in meeting the demands at least cost.

The methodology is a planning matrix. In this matrix all categories of inputs are displayed as rows. These inputs include such things as base stream flow, groundwater, stream reach, stored water, industrial effluents, a treatment-plant effluent, agricultural return flows, and others. The destinations of these inputs are either a water-treatment plant, or another stream reach. Thus, the matrix can display any relationship desired between each possible source, displayed as a row on the matrix, and each possible destination, displayed as a column. Optimization can be in terms of maximizing net benefits or minimizing costs within the constraints of the system.

Flood Hydrology

Small watersheds are of great economic importance because there are so many of them and because the aggregate economic investment in them is great. In spite of this, there is a paucity of actual records of runoff from small watersheds. Research work is now concentrated upon developing new scientific methods for solving problems in predicting floods from small watersheds.

This research has resulted in the collection of flood and rainfall data from small experimental watersheds distributed over the United States. These data are being assembled on magnetic tape. The data can then be used to test various theoretical methods of predicting the flood response for small watersheds. In addition, controlled and

reproducible experiments using the one-half-acre outdoor rainfall-runoff facility are being carried out to provide additional input and testing of the models. The analysis is being developed to include a numerical solution to the overland-flow equations, the watershed as a means of storage, and the effects of land use on the various elements in the hydrologic system.

Recent research has shown that the progressive urbanization of a region results in large changes in its flood potential. There is a need for measurements in an urban environment, and several metropolitan areas have networks of small watersheds that are instrumented with stream-gaging stations and recording rain gages. Data from these watersheds are recorded on magnetic tape in the CSU flood-data file. Also recorded are pertinent physical features of the watershed. With urbanization, some of these physical features are rapidly changing, and the research which is being carried out will provide means for predicting the alteration to be anticipated in the flood hydrograph as these watersheds become urbanized.

Obviously, any improvement which can be made in the prediction of floods and the development of cost-effective flood-control measures would be of great benefit to society.

GROUNDWATER

Dr. D. K. Sunada: Professor in Charge

Senior Staff: J. W. Labadie, R. A. Longenbaugh, D. B. McWhorter, N. V. Ortiz, H. J. Morel-Seytoux

Groundwater research projects encompass both basic and applied research directly related to the fields of hydraulics, hydrology, geology, and geotechnical engineering.

Historically, most work at Colorado State University has been on applied problems requiring field investigations in Colorado with the cooperation of both state and local agencies. The Colorado Division of Water Resources is currently utilizing several computer programs developed specifically to help analyze groundwater-management problems. Conjunctive-use studies for the combined management of both ground and surface water have direct applicability to the management of many of the stream-aquifer systems

within Colorado and throughout the world. The need to conserve available water resources has placed additional emphasis on the use of artificial recharge and the storing of excess flows for later groundwater withdrawal.

A large and well-equipped laboratory is available to make detailed studies of aquifer samples and to evaluate the phenomena that control flow through porous media. In addition, the computer facilities at the University are extensively used in developing computer models and optimization techniques to evaluate operational policies for the beneficial use of both ground and surface waters. Computer and physical models for predicting changes in groundwater quality have been developed and additional work is under way.

Artificial Recharge

Currently storm runoff and some winter stream flows pass into adjoining states and are not available for use in Colorado. Demonstration projects have been conducted indicating that benefits could be obtained from the artificial recharge of groundwater aquifers with excess surface flows. Projects have been conducted at Olds Reservoir in Prospect Valley, on the Arikaree River near Cope, on properties of the South Platte Ditch Company near Sterling, and at Haxtun, Colorado. These demonstrations have shown the feasibility of spreading water or using available leaky canals and reservoirs to recharge excess surface water to the underlying aquifer.

Proper management of a groundwater aquifer necessitates the determination of the areal and time distribution of the natural recharge. The amount of water reaching the water table is a function of soil and aquifer properties, rainfall intensities, topography, and depth to the water table. Current research seeks to develop a model that will consider these variables in estimating the natural recharge and allow development of better management policies for administration of withdrawals from aquifers such as the Ogallala formation in eastern Colorado.

Groundwater Management

Digital computer models have been developed and are currently being used by water administrators in evaluating complex groundwater systems. These models assist water

administrators in evaluating the effect of various pumping patterns, natural recharge, artificial recharge, and water exchange with overlying streams or reservoirs.

Development of techniques that can be used to design optimal operational policies is under way. Application of these techniques to existing water-distribution systems is also under way and should demonstrate to water administrators their usefulness in developing optimal operational policies.

Groundwater Quality Studies

Current concern for water quality and, specifically, the need to protect our groundwater from pollution is responsible for the development of several projects evaluating the physical interaction between soil and water systems and the possible contamination of groundwater by fertilizers. Pollution may also occur by percolation of water through sanitary land fills and through fills in strip-mine operations; studies are under way to determine the usefulness of existing groundwater models in evaluating the ability of various reclamation procedures to intercept the pollutants and extract them for processing, thus minimizing the pollution. Development of digital-computer models for the treatment of hydrodynamic dispersion in porous media is being continued. Laboratory studies of the physical phenomena that control groundwater pollution are being conducted.

A groundwater quantity-quality simulation model has been combined with an optimizing model for managing groundwater salinity in irrigated stream-aquifer systems. The management model has been applied to the San Luis Rey River Basin in San Diego County, California, enabling forecasts to be made of the impact of various innovative salinity-management strategies.

A physical model to study the precipitation of humic acid at the interface between a humic-acid solution and an aluminum-potassium-sulfate solution was developed to gain an insight into the deposition of Colorado-Plateau-type uranium deposits. A numerical model was also developed to predict the potential location of these deposits. Currently, the model is being modified to simulate actual field conditions.

Pumping Plant Systems

Many of the irrigation and municipal wells that pump water from underlying aquifers operate at very low efficiencies. Recent studies have discovered the causes of the low efficiencies, and extensive educational programs have been developed with the Cooperative Extension Service to encourage individual pump owners to improve their respective plant efficiencies to save both money and energy. Part of this study has included analysis of pumping-plant costs, operation and maintenance procedures, the effects of declining water levels, and the economies associated with rising fuel and power costs. The results of this research have been directly applied and presented at public meetings; many individual contacts have been made with pump owners to encourage them to improve their pumping plants.

WATER RESROUCES PLANNING AND MANAGEMENT

Dr. Warren A. Hall: Professor in Charge

Senior Staff: Maurice L. Albertson (Emeritus), Victor A. Koelzer, J. W. Labadie

Recent years have seen a great increase in the systems approach to water resources. This has been due, to a great extent, to the development of new mathematical techniques and tools, including the computer, simulation techniques, and mathematical programming. Although the use of these tools is still in its infancy, it is already evident that great improvements can be made in planning, design, construction, operation, and management of water-resource systems.

Developments in such systems depend in an indispensable way on a sound knowledge of the basic aspects of water-resources development, such as hydrology, hydraulics, fluid mechanics, atmospheric science, groundwater, and flow in open channels; the socio-economic aspects are important as well. The purpose of the program in water-resource systems is to integrate the different areas of specialization to optimize the use of water resources through the new techniques and tools now available.

Among the various elements that are important in water-resource systems are hydropower, irrigation, water

pollution, flood control, municipal and industrial water, navigation, coastal engineering, and recreation.

Research in water-resource systems involves consideration of subsystems as well as overall systems. It also involves the selection and analysis of decision variables, constraints, state variables, objective functions, optimal-policy analysis, cost-benefit analysis, water conveyance and distribution systems, water-supply reservoir systems, and the decomposition and recomposition of large-scale, complex, multi-purpose water-resource systems.

The overall objective of the research is to design rules for the conjunctive development, management, use, and protection of surface and groundwater resources that both satisfy the law and maximize the beneficial use of the waters. To achieve this overall objective, a major objective is a realistic analysis of the simultaneous behavior of river flow and groundwater movement. An important specification for this analysis is that it be usable in any economic regional analysis immediately and without modification. The maximization of the human regional economic and social objective will determine a worthy set of rules for management within present law. Another objective is to find out whether limited changes in the law or other constraints might not result in great benefits.

The research employs a broad array of techniques in the analysis of the physical system, among which are removal of singularities, Green's functions, finite-difference method, finite-element method, and Galerkin's method, as well as various processes of statistical analysis. Techniques employed in the optimization study are stochastic one-stage and multi-stage analysis and differential-algorithm programming, involving both single- and multi-objective programs.

SOME SPECIAL COURSES OFFERED AT CSU

1975	
6/22-25	Wind Engineering Research
6/30 - 7/11	Stochastic Approaches to Water Resources
7/8-11	ASCE Specialty Conference - Water Resources Planning and Management
----	Institute on Unsteady Flow in Open Channels
----	Highways in the River Environment
1976	
3/18-19	Regional Workshop for Remote Sensing & Photogrammetry
7/19-22	Remote Sensing, ASCE Specialty Conference
8/9-12	Symposium on Inland Waterways for Navigation, Flood Control & Water Diversions (Rivers '76)
----	Highways in the River Environment
1977	
4/25-27	Bio-Engineering Symposium
5/16-19	Improving Irrigation Return Flow Quality
6/27-29	3rd International Symposium in Hydrology
6/30 - 7/1	Second International Conference on Transfer of Water Resources Knowledge
7/5-15	River Mechanics Institute
7/10 - 8/5	Experimental Solar Engineering Course
8/9-11	Colorado Aerial Photography Workshop
12/12-16	Drought Research Needs
----	Analysis of River Systems and Hydraulic Structures presented to Venezuelan & Brazilian Governmental Agencies
----	Highways in the River Environment
1978	
3/6-17	Hydrology for Transportation Engineers
5/22 - 6/2	Hydrology for Transportation Engineers
6/9	Short Course on Hydraulics of Cooling Water Systems
6/12-14	Joint Symposium on Design & Operation of Fluid Machinery
7/5-7	Water Resources Management I
7/10-14	Water Resources Management II
7/17-21	Computer Workshop in Statistical Hydrology
8/9-11	Mid-Continent R&D Council - High Plains Irrigation
11/5-9	Instream Flow - Environmental Resources
----	Highways in the River Environment

1979	
4/16-18	Water Resources Management
5/28 - 6/1	Analysis of Watersheds & River Systems
6/4-8	Analysis of Watersheds & River Systems
7/8-13	Fifth International Conference on Wind Engineering
7/23-27	Design of Water Quality Monitoring Networks
8/12-24	Soil Conservation Service - Stream Mechanics
----	Highways in the River Environment
----	Joint CSU - USDA Sedimentation Laboratory Workshop
1980	
2/11-22	Soil Conservation Service - Stream Mechanics
6/2-6	Subsurface Hydrology
6/9-13	Groundwater Modeling for Management
6/9-13	Closed-Conduit Flow
6/16-20	Unsteady Flow in Open Channels
6/23-27	Application of Dynamic Programming to Water Resources Management
7/7-11	Institute on River Mechanics
7/21-25	Design of Water Quality Monitoring Networks
7/28 - 8/1	Statistical Computer Techniques in Hydrology and Water Resources
8/27 - 8/29	Fish & Wildlife - Stream Morphology
1981	
3/2-13	Soil Conservation Service - Stream Mechanics
4/6-11	Turf Irrigation
6/29 - 7/10	Hydromachinery
7/6-17	Analysis of Watersheds & River Systems
7/20-24	Water Quality Monitoring Networks
8/10-14	Multi-Objective Optimization
1982	
6/21 - 7/2	River Mechanics Institute
1984	
5/22 - 6/4	International Congress on Irrigation & Drainage

PUBLICATIONS

Research necessarily remains uncompleted until the results are brought to the dissemination stage, usually in the form of lectures and published papers. In the 32 years since the hydraulics section of Civil Engineering actively engaged in contract and other investigations, the number of staff writings has exceeded 2613, some 1205 of which were refereed papers and 1408 contract reports. In addition to these must be counted the 645 graduate theses and dissertations, 275 of which were for the Ph.D. degree.

All such writings are listed in the following series of publications:

Research Reports, Papers, Bulletins, and Theses, 1948 through 1963; Civil Engineering Section, Colorado State University, December 1963:

259 Reports for Sponsored Projects
206 Papers, Published or Presented
43 Discussions and Closures
25 Bulletins and Circulars
113 Theses, Dissertations, and Master's Reports

Biennial Catalog of Research Reports, Papers, Bulletins, and Theses, for the period ending December 1965; College of Engineering, CSU, December 1965:

125 Publications
44 Theses

Catalog of Research Reports, Papers, Bulletins, and Theses (Hydraulics), for the period Janury 1, 1966, through June 30, 1969; College of Engineering, CSU, July 1, 1969:

329 Publications
134 Theses

Catalog of Research Reports, Papers, Bulletins, and Theses, for the period July 1, 1969, through June 30, 1971; College of Engineering, CSU, July 1, 1971:

337 Publications (Hydraulics)
10 ECOM Technical Reports
23 Research Memoranda (Fluid Mechanics Program)
51 Hydrology Papers
17 Hydro-Machinery Laboratory Reports
10 THEMIS Technical Reports
11 Water Management Technical Reports
47 Theses and Dissertations

Catalog of Research Reports, Papers, Bulletins, and Theses for the period July 1, 1971, through June 30, 1974; College of Engineering, CSU, July 1, 1974:

443 Publications (Hydraulics)
102 Theses
1 Research Memorandum (Fluid Mechanics Program)
17 Hydrology Papers (52-68)
20 Hydro-Machinery Laboratory Reports (18-37)
18 THEMIS Technical Reports (11-28)
21 Water Management Technical Reports (12-32)

Catalog of Research Reports, Papers, Bulletins, and Theses, for the period July 1, 1974, through June 30, 1977; College of Engineering, CSU, July 1, 1977:

557 Publications (Hydraulics)
107 Theses
2 Research Memoranda (Fluid Mechanics Program)
26 Hydrology Papers
42 Hydro-Machinery Laboratory Reports (38-79)
13 Water Management Technical Reports (33-45)

Publications from July 1, 1977 to August 1980:

218 Reports for Sponsored Projects
139 Papers, Published or Presented
98 Theses and Dissertations, of which 36 are for Ph.D. degree

ROSTER OF GRADUATE STUDENTS TO DATE

ROSTER OF GRADUATE STUDENTS TO DATE

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
MASTER OF SCIENCE, 1893			
Beach, Frank	USA	Soil moisture.	
Benson, Clarence V.	USA		
MASTER OF SCIENCE, 1906			
House, Edward B.	USA		
MASTER OF SCIENCE, 1909			
Balcomb, J. B.			
MASTER OF SCIENCE, 1924			
Ogle, Alfred L.	USA	Nebraska Federal Aid Project number 88-C.	
MASTER OF SCIENCE, 1947			
Lin, Kuo C.		A systematic approach to the hydraulic and structural principles involved in the design of lowhead radial gate.	
Yang, Fang Y.		A critical study of factors involved in the economical design of pipe systems for pumping plants.	
MASTER OF SCIENCE, 1948			
Serr, Eugene F. III	USA	A comparison of the sedimentation diameter and the sieve diameter for various types of natural sands.	N. Christensen
MASTER OF SCIENCE, 1949			
Cermak, Jack E.	USA	Energy losses through conical diffusers.	M. L. Albertson
Corey, Gilbert L., Jr.	USA	Hydraulic properties of well screens.	R. L. Lewis
Garstka, Walter U.	USA	Forecasting seasonal water yield in the Upper Snake River Basin Idaho-Wyoming.	M. L. Albertson
Gerhardt, Burrell B.		Practical effect of the small particles in a soil on its compacted strength.	
MASTER OF SCIENCE, 1950			
Corey, Arthur T.	USA	Influence of shape on the fall velocity of sand grains.	M. L. Albertson
Doddiah, Doddiah		Comparison of scour caused by hollow and solid jets of water.	M. L. Albertson
Koonsmen, George L.	USA	Efficiency of a vortex-tube sand trap.	R. L. Lewis
Matejka, Donald Q.	USA	Effect of pier shape on backwater, total head loss, and water-surface profile.	M. L. Albertson

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
MASTER OF IRRIGATION ENGINEERING, 1951			
Walter, Jesudasan		Comparison of flood routing methods as applied to the Osage River Basin.	
MASTER OF SCIENCE, 1951			
Lane, Delbert E.	USA		
Peterson, Jack S.	USA	Effect of well screens on flow into wells.	M. L. Albertson
MASTER OF SCIENCE, 1952			
Lleras, Eduardo	Colombia	Possibility of effecting economies in construction of gravity type concrete dams by reduction of pore pressure.	H. W. Collins
MASTER OF SCIENCE, 1952			
Farmanfarma, Ali D.	Iran	Laminar flow between a stationary disk and a rotating disk.	M. L. Albertson
Koloseus, Herman J.	USA	Discharge characteristics of submerged spillways.	M. L. Albertson
Leatherwood, Frank N.	USA	Hydraulic head loss at the interface between porous media of different sizes.	D. F. Peterson
Navon, D.	Israel	Triaxial compression tests of a remodeled partially-saturated clay.	D. F. Peterson
Schweizer, Herbert H.	USA	Turbine for use in integrating flow meter.	H. W. Collins
Van't Hul, Arthur W.	USA	Natural roughness in open channels.	M. L. Albertson
Wilde, Robert H.	Canada	Effect of shape on the fall velocity of gravel sized particles.	M. L. Albertson
MASTER OF IRRIGATION ENGINEERING, 1953			
Malik, Sarfraz K.	Pakistan	S inity and alkalinity problems in the Punjab.	N. A. Evans
Al-Ali, Saiid M.	Iraq	Some aspects of roughness in alluvial channels.	M. L. Alberston
Kiefer, Fred W., Jr.	USA	Reynolds number for flow through porous media.	D. F. Peterson
Schulz, Edmund F.	USA	Influence of shape factor on the fall velocity of small sand grains.	M. L. Albertson
Thomas, Robert K.	USA	Scour in a gravel bed at the base of a free overfall.	M. L. Albertson
MASTER OF IRRIGATION ENGINEERING, 1954			
Al-Badry, Mowafag M.	Iraq	Development of plan a for utilization of water resources of the Upper Tigris River within the boundaries of Iraq.	H. W. Collins

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
MASTER OF SCIENCE, 1954			
Karaki, Susumu	Canada	Model study of seepage flow from a canal to a shallow water table.	D. F. Peterson
Lochman, John R.	USA	Selection of gravel pack for water wells in fine, uniform, unconsolidated aquifers.	D. F. Peterson
Shen, Richard T. H.	China	Longitudinally prestressed concrete pipeline bridge.	H. W. Collins
Unhanand, Komain	Thailand	Analysis of unsteady flow in open channels.	P. N. Lin
MASTER OF IRRIGATION ENGINEERING, 1955			
Furtun, Haluk B.	Turkey	Water spreading for groundwater replenishment and recommendations for its adoption to Anamur Valley.	W. E. Code
Raju, Basavaraju C.	India	Lining of irrigation channels; and correlation of regime theory and tractive force theories of stable channel design.	E. W. Lane
MASTER OF SCIENCE, 1955			
Caparas, Jorge T.	Phillippines	Basic methods of irrigating greenhouses.	N. A. Evans
Djanjigian, Papken V.	Lebanon	Seepage flow from a canal to a shallow water table by electrical analogue.	D. F. Peterson
Halderman, Allen D.	USA	Design of gravel filters for water wells in fine, unconsolidated aquifers.	N. A. Evans
Hallmark, Dasel E.	USA	Influence of particle size gradation on scour at base of free over-fall.	M. L. Albertson
Morris, Wallace V.	Canada	Forecasting snowmelt runoff.	P. N. Lin
Sadar, Donald J.	USA	Preliminary study of sediment sampling efficiency.	J. E. Cermak
Thorson, Donald A.	USA	Nappe characteristics for flow over sharp-crested weirs.	M. L. Albertson
DOCTOR OF PHILOSOPHY, 1955			
Chamberlain, A. R.	USA	Effect of boundary form on fine sand transport in twelve-inch pipes.	M. L. Albertson
MASTER OF CIVIL ENGINEERING, 1956			
Fonken, David W.	USA	No thesis.	D. F. Peterson
MASTER OF IRRIGATION ENGINEERING, 1956			
Sanghavi, Ramniklal S.	India	Piping under masonry dams on earth foundations.	E. W. Lane
MASTER OF SCIENCE, 1956			
Al-Khafaji, Abbas N.	Iraq	The potential drainability of Grand Valley, Colorado.	N. A. Evans
Bender, Donald L.	USA	Suspended sediment transport in alluvial irrigation channels.	E. W. Lane

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
MASTER OF SCIENCE, 1956 (Cont.)			
Keller, Jack	USA	Model study of interceptor drains.	D. F. Peterson
McFarland, William W.	USA	Effect of rim height on the rate of evaporation from pans.	M. L. Albertson
Newman, E. C.	United Kingdom	The penetration and sealing effects of dispersed and floccu-lated bentonite suspensions in a dune sand.	D. F. Peterson
MASTER OF IRRIGATION ENGINEERING, 1957			
Athaullah, Muhammad	India	Multi-purpose project planning for undeveloped regions.	H. W. Collins
Davar, Kersi S.	India	Role of forecasting in flood control.	E. W. Lane
Donabedian, Christopher S.	Lebanon	Methods of energy dissipation.	D. F. Peterson
Soliman, Mostafa M.	Egypt	No thesis.	G. L. Corey
MASTER OF SCIENCE, 1957			
d'Utruy, Bernard	France	Deceleration during impact of seaplane hulls on a water surface.	A. R. Chamberlain
Fiala, Gene R.	USA	Laboratory study of a manifold stilling basin.	M. L. Albertson
Garde, Ramachanara J.	India	Sediment transport through pipes.	M. L. Albertson
Hastings, Maurice M.	USA	Some characteristics of an artesian aquifer in the Grand Valley of Colorado.	H. W. Collins
Makarechian, A. H.	Iran	Effect of wash load on suspension of bed material load.	M. L. Albertson
Nelson, Duane F.	USA	The effect of shape of a plane, smooth, saturated surface on evaporation rate.	J. E. Cermak
Plate, Erich J. O. F.	Germany	Laboratory studies on the beginning of sediment ripple formation in an alluvial channel.	H. K. Liu
Sayre, William W.	USA	Artificial roughness in open channels.	M. L. Albertson
Smith, George L.	USA	An analysis of scour below culvert outlines.	M. L. Albertson
Williams, Theodore T.	USA	Stabilization of Thompson Lake outlet channel.	D. F. Peterson
DOCTOR OF PHILOSOPHY, 1957			
Simons, Daryl B.	USA	Theory and design of stable channels in alluvial materials.	M. L. Albertson
MASTER OF IRRIGATION ENGINEERING, 1958			
Malhotra, Ramesh C.	India	Forecasting seasonal snowmelt runoff.	J. R. Barton
Mohanty, Prasanta K.	India	Drilled water wells for Indian villages.	N. A. Evans
Quebral, Ricardo T.	Phillippines	Drainage of small farms in central Iowa.	
Stainern, Arnulf P.	Austria	Bank protection by vegetation.	J. R. Barton

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
MASTER OF SCIENCE, 1958			
Hwang, Shoi Y.	Taiwan	Analytical study of the roughness of alluvial channels.	H. K. Liu
Nagabhushanaiah, Halevoor S.	India	Meandering characteristics of alluvial rivers.	M. L. Albertson
DOCTOR OF PHILOSOPHY, 1958			
Chanda, Benoyendra	India	Turbulent boundary layer over heated and unheated, plane, rough surface.	M. L. Albertson
Barton, James R.	USA	A study of roughness in alluvial channels.	M. L. Albertson
Schleusener, Richard A.	USA	Factors affecting evaporation from soils in contact with a water table.	G. L. Corey
MASTER OF CIVIL ENGINEERING, 1959			
Chang, Feng-Ming	Taiwan	No thesis.	V. Yevdjevich
MASTER OF SCIENCE, 1959			
Nelson, Rasmus W.	USA	The measurement of permeability in non-homogeneous media through an analysis of the steady potential distribution.	J. E. Cermak
Poreh, Michael	Israel	Flow characteristics of a circular submerged jet impinging normally on a smooth boundary.	J. E. Cermak
Ayoub, Suleiman A. I.	Jordon	Properties of the hydraulic jump in sloping circular conduits.	J. R. Barton
DOCTOR OF PHILOSOPHY, 1959			
Garde, Ramachandra J.	India	Total sediment transport in alluvial channels.	M. L. Albertson
Scott, Verne H.	USA	Pressure distribution in porous media during unsaturated flow.	G. L. Corey
MASTER OF CIVIL ENGINEERING, 1960			
Bobo, Bobo G.	Iraq	No thesis.	I. S. Dunn
Brooks, Royal H.	USA	No thesis.	A. T. Corey
Bryner, Bailey H.	USA	No thesis.	E. F. Schulz
Fan, Shou S.	Taiwan	Backwater effects at channel constrictions.	H. K. Liu
Murarappa, Koratagere B.	India	No thesis.	J. R. Barton
Tsuei, Yeong G.	Taiwan	No thesis.	I. S. Dunn
Videon, Fred F.	USA	No thesis.	I. S. Dunn
MASTER OF IRRIGATION ENGINEERING, 1960			
Price, William A.	USA	No thesis.	J. R. Barton
MASTER OF SCIENCE, 1960			
Chen, Ming C.	Taiwan	Effect of watershed characteristics on peak rates of runoff in Eastern Colorado.	R. A. Schleusener

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
MASTER OF SCIENCE, 1960 (Cont.)			
Earle, Edward N.	USA	Mean velocity profiles for flow over a plane, smooth, heated boundary.	J. E. Cermak
Haushild, William L.	USA	The effect of fine sediment on the mechanics of flow in alluvial channels.	D. B. Simons
Richardson, Everett V.	USA	Sediment transport in alluvial channels (examination of Bagnold's 1956 hypothesis).	D. B. Simons
MASTER OF CIVIL ENGINEERING, 1961			
Abdelsalam, Mohamed W.	Egypt	No thesis.	J. R. Barton
Chuyen, Nguyen Q.	Vietnam	No thesis.	I. S. Dunn
Danielson, Jeris A.	USA	No thesis.	M. E. Bender
El-Kateb, Mohamed H. M.	Egypt	No thesis.	J. R. Barton
Hayman, Robert W.	USA	No thesis.	M. E. Bender
Phukan, Samudradev	India	No thesis.	E. F. Schulz
MASTER OF IRRIGATION ENGINEERING, 1961			
Zayed, Mostafa M.	Egypt	No thesis.	M. E. Bender
MASTER OF SCIENCE, 1961			
Al-Shaikh Ali, Khalid S.	Iraq	Influence of temperature on sediment transport and roughness in alluvial channels.	D. B. Simons
Trelease, Frank J., III	USA	Effects and benefits of artificial recharge in Fountain Creek Valley, Colorado.	M. W. Bittinger
DOCTOR OF PHILOSOPHY, 1961			
Binder, Gilbert J.	France	Electrokinetic potential fluctuations by turbulence at a solid-liquid interface.	G. Binder
Bishop, Avery A.	USA	Sediment transport in alluvial channels, a critical examinaton of Einstein's theory.	D. B. Simons
Daver, Kersi S.	India	Diffusion from a point source within a turbulent boundary layer.	J. E. Cermak
Nielsen, John P.	USA	Unified consolidation theory.	I. S. Dunn
MASTER OF SCIENCE, 1962			
Leaf, Charles F.	USA	Snow measurement in mountainous regions.	R. A. Schleusener
DOCTOR OF PHILOSOPHY, 1962			
Chuang, Hsing	Taiwan	Electrokinetic-potential fluctuations produced by turbulent liquid flow in tubes.	J. E. Cermak
Daranandana, Niwat	Thailand	The effect of gradation of bed materials on flow phenomena in alluvial channels.	D. B. Simons
Duckstein, Lucien	France	Electrokinetic-potential at a solid liquid interface.	J. E. Cermak

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
DOCTOR OF PHILOSOPHY, 1962 (Cont.)			
Gardi, Omar R.	Iraq	Analysis of arch dams by slope deflection equations.	J. W. N. Fead
Kruse, Ernest G.	USA	Effects of boundary roughness and channel slope on resistance to flow of water in very small open channels.	I. S. Dunn
Malhotra, Ramesh C.	India	Diffusion from a point source into a turbulent boundary layer with unstable density stratification.	J. E. Cermak
Nagabhushanaiah, Halevoor S.	India	Effects of geometric distortion upon fluid dynamics models.	J. E. Cermak
Poreh, Michael	Israel	Diffusion from a line source in a turbulent boundary layer.	J. E. Cermak
Reich, Brian M.	South Africa	Design hydrographs for very small watersheds from rainfall.	V. Yevdjevich
Yotsukura, Nobuhiro	Japan	Some effects of bentonite suspensions on sand transport in a smooth four-inch pipe.	D. B. Simons
MASTER OF SCIENCE, 1963			
Bajsarowicz, Janusz	Poland	Plan B - Hydraulics and hydrology.	E. J. Plate
Braun, Harry Z.	Peru	Plan B - Hydraulics and hydrology.	H. J. Koloseus
Cecil, Edward A.	USA	Plan B - Hydraulics and hydrology.	I. S. Dunn
Hill, John M.	USA	Plan B - Structures and fluid mechanics.	J. W. N. Fead
Holahan, Edward P.	USA	Plan B - Hydraulics.	M. E. Bender
Kandala, Abdulahad S.	Iraq	Plan B - Hydraulics and hydrology.	H. J. Koloseus
Kemp, Bennett L.	USA	Plan B - Fluid mechanics and structures.	J. E. Cermak
Liu, Henry	Taiwan	Plan B - Hydraulics and fluid mechanics.	A. R. Robinson J. E. Cermak
McQuivey, Raul S.	USA	Plan B - Hydraulics and fluid mechanics.	D. B. Simons
Rowe, Lloyd A.	USA	Plan B - Irrigation engineering.	J. R. Barton M. E. Bender J. W. N. Fead
Shahjahan, Muhammad	Pakistan	Depth-of-flow correction for rough boundaries.	H. J. Koloseus
Shaikh, Sanaullah	Pakistan	Flow in the bend of a concrete trapezoidal channel.	D. B. Simons
Stepanich, Frederick C.	USA	Control structures in alluvial channels.	D. B. Simons
Yano, Motoaki	Japan	Plan B - Hydraulics and fluid mechanics.	D. B. Simons
Zorich, Theodore M.	USA	Plan B - Hydraulics and hydrology.	N. A. Evans

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
DOCTOR OF PHILOSOPHY, 1963			
Bhaduri, Sachindranarayan	India	Mass diffusion from a point source in a turbulent boundary layer over a rough surface.	J. E. Cermak
Chang, Feng-Ming	Taiwan	Mechanics of scour and sedimentation.	D. B. Simons
Evans, Norman A.	USA	Osmotic flow.	G. L. Corey
Teerawong, Pairoje	Thailand	Consolidation of unsaturated clay soils.	J. R. Barton
Tsuei, Yeong-ging	Taiwan	Axisymmetric boundary-layer of a jet impinging on a smooth plate.	J. E. Cermak
Unhanand, Komain	Thailand	Fall velocity of artificial porous particles.	I. S. Dunn
MASTER OF SCIENCE, 1964			
Bole, James B.	USA	A flume study of velocity distribution with the suspension wind problem.	D. B. Simons
Eshett, Ali	Israel	Plan B - Hydrology.	M. W. Bittinger
Filmer, Robert W.	USA	Plan B - Soil mechanics and hydraulics.	J. W. N. Fead
Inglessis, Constantine J.	Lebanon	Plan B - Hydraulics and hydrology.	J. W. N. Fead
Kao, Kai	Taiwan	Plan B - Fluid mechanics.	H. J. Koloseus
Kolzow, William C.	USA	Plan B - Hydraulics and hydrology.	E. J. Plate
Markovic, Radmilo D.	Yugoslavia	Theoretical frequency functions of best fit to distributions of annual precipitations and mean annual river flows.	V. Yevdjevich
Rodeman, Ronald	USA	Plan B - Fluid Mechanics.	J. E. Cermak
Watts, Frederick J.	USA	Variation of A and B values in lined open channels.	D. B. Simons
Wetter, Lawrence H.	USA	Plan B - Hydraulics and hydrology.	V. Yevdjevich
DOCTOR OF PHILOSOPHY, 1964			
Alger, George R.	USA	A study of fall velocity of irregular shaped particles.	D. B. Simons
Al-Shaikh Ali, Khalid S.	Turkey	A field study of energy loss in bends in rigid boundary trapezoidal channels.	D. B. Simons
Bloomsburg, George L.	USA	Diffusion of entrapped air from porous media.	G. L. Corey
Danielson, Jeris A.	USA	Consolidation of unsaturated clay-soils.	M. E. Bender
Haynie, Richard M.	USA	Design of stable channels in alluvial material.	D. B. Simons
Quraishi, Ali A.	Pakistan	Effects of flexible roughness elements on diffusion in a turbulent boundary layer.	J. E. Cermak

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
MASTER OF SCIENCE, 1965			
Ahmed, Nazeer	Pakistan	Plan B - Groundwater.	R. A. Longenbaugh
Algert, James H.	USA	Statistics of sand channel bed forms.	D. B. Simons
Amisial, Roger A. G.	Haiti	Plan B - Hydraulics.	H. J. Koloseus
Andrews, Anwiya S.	Haiti	Plan B - Hydraulics and structures.	H. J. Koloseus
Bhowmilk, Nani G.	Pakistan	Hydraulic design of concrete canals.	D. B. Simons
Chang, Hai-Yain	Taiwan	Plan B - Hydraulics.	D. B. Simons
Chou, I-Hui	Taiwan	Plan B - Fluid mechanics.	J. E. Cermak
Dominguez, Richard F.	USA	Plan B - Hydraulics.	H. J. Koloseus
Goodwin, Carl R.	USA	Wind drag effect on open channel flow.	E. J. Plate
Jeng, Ing-song	Taiwan	Time dependence in lake outflows.	V. Yevdjevich
Lin, Chi-Win	Taiwan	Plan B - Fluid mechanics.	E. J. Plate
Liu, Chang-Yu	Taiwan	Plan B - Fluid mechanics.	J. E. Cermak
Marwitz, John D.	USA	Correlation of summer rainfall.	R. A. Schleusener
Palos, Gyorgy	Hungary	Plan B - Groundwater.	M. W. Bittinger
Peterka, Jon A.	USA	Plan B - Fluid Mechanics.	J. E. Cermak
Rafay, Tariq	Pakistan	Particle size reduction along streams.	D. B. Simons
Roesner, Larry A.	USA	Rainfall and runoff sequences.	V. Yevdjevich
Roper, Alan T.	USA	Cylinder wake in boundary layer.	J. E. Cermak
Schneider, Verne R.	USA	Plan B - Hydraulics.	H. W. Shen
Sheih, Ching M.	Taiwan	Plan B - Fluid mechanics.	E. J. Plate
Shokouh, Hossein	Iran	Plan B - Fluid mechanics.	E. J. Plate
Signor, Donald C.	USA	Plan B - Hydrology.	V. Yevdjevich
Staley, Robert W.	USA	Effect of depth of water table on evaporation from fine sand.	D. B. Simons
Tan, Huey-ming	Taiwan	Plan B - Fluid mechanics.	J. E. Cermak
Tao, Men-cheh	Taiwan	Plan B - Fluid mechanics.	V. A. Sandborn
Thomas, Jimmy L.	USA	Pan B - Groundwater.	M. M. Skinner
Wu, Chein-Tsan	Taiwan	Plan B - Hydraulics.	D. B. Simons
Yang, Chi-sheng	Taiwan	Plan B - Fluid dynamics.	E. J. Plate
Yang, Tsung	Taiwan	Plan B - Hydraulics.	H. J. Koloseus
Yuen, Kwan	Hawaii	Plan B - Fluid dynamics.	J. E. Cermak
DOCTOR OF PHILOSOPHY, 1965			
Arbhabhirama, Anat	Thailand	Steady upward flow from water tables.	G. L. Corey
Barnes, Albert H.	USA	Steady non-uniform flow.	V. Yevdjevich
Brooks, Royal H.	USA	Hydraulic properties of porous media.	A. T. Corey
Caffey, James E.	USA	Correlation of river flow and precipitation.	V. Yevdjevich

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
DOCTOR OF PHILOSOPHY, 1965 (Cont.)			
Chao, Junn-Ling	Taiwan	Turbulent momentum transfer in a three-dimensional wall jet.	V. A. Sandborn
Corey, Gilbert L., Jr.	USA	Similitude for flow in porous media.	G. L. Corey
King, Larry G.	USA	Imbibition of fluids by porous solids.	G. L. Corey
Kuo, Yung-huang	Taiwan	Three-dimensional turbulent wakes.	L. V. Baldwin
Maasland, Dirk E. L.	Netherlands	Rate of quality change of drain effluent from a saline-water aquifer.	M. W. Bittinger
Melentijevich, Mirko J.	Yugoslavia	Characteristics of the range of water out-flow dependent upon reservoir volume and/or level.	V. Yevdjevich
Pinkayan, Subin	Thailand	Areal distribution of wet and dry years.	V. Yevdjevich
Richardson, Everett V.	USA	Resistance to flow in sand channels.	D. B. Simons
MASTER OF SCIENCE, 1966			
Anderson, Richard J.	USA	Plan B - Hydrology.	D. B. Simons
Bennett, James P.	USA	High pressure permeability test.	R. D. Dirmeyer
Boning, Charles W.	USA	Plan B - Hydraulics.	D. B. Simons
Chang, Shih-Cheng	Taiwan	Velocity field in separated flow.	E. J. Plate
Chowdhurry, Shamsuzzaman	Bangladesh	Turbulent boundary layer eddies.	V. A. Sandborn
Dragoun, Frank J.	USA	Volumetric erosion and deposition.	G. L. Kruse
Harrison, Lawrence J.	USA	Plan B - Hydraulics.	D. B. Simons
Komura, Saburo	Japan	Alternate scours in alluvial channels.	H. W. Shen
Lorah, William L.	USA	Energy losses in a 90° junction box.	G. L. Smith
Miller, Norman	USA	Plan B - Hydrology.	V. Yevdjevich
Rungrongtaanin, Sunthorn	Thailand	Plan B - Hydrology.	V. Yevdjevich
Siddiqi, Mohammad K.	India	Flood rainfall-runoff volume relationships.	D. B. Simons
Wang, Tsan W.	Taiwan	Plan B - Hydraulics.	H. J. Koloseus
Williams, George O.	USA	Plan B - Hydraulics.	H. J. Koloseus
Wong, Kea-Ling	Hong Kong	Plan B - Hydraulics.	H. J. Koloseus
Zimbelman, Darell D.	USA	Fall velocity in turbulence.	D. B. Simons
DOCTOR OF PHILOSOPHY, 1966			
Dowdell, Rodger B.	USA	Corner boundary layer.	J. E. Cermak
Filmer, Robert W.	USA	Transport of particles in porous media.	G. L. Corey
Giorgini, Aldo P. G.	Italy	Plane-homogeneous-isotropic turbulence.	J. E. Cermak
Hwang, N. Huan-Chang	Taiwan	Turbulence behind axisymmetric body.	L. V. Baldwin
Liu, Henry	Taiwan	Electrokinetic-potential fluctuation in turbulent water flow.	J. E. Cermak

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
DOCTOR OF PHILOSOPHY, 1966 (Cont.)			
Markovic, Radmilo D.	Yugoslavia	Evaluation of weather modification.	V. Yevdjevich
Quimpo, Rafael G.	Philippines	Daily flow sequences.	D. B. Simons
Stringham, Glen E.	USA	Fall velocity of geometric particles.	D. B. Simons
Yano, Motoaki	Japan	Turbulent diffusion.	J. E. Cermak
MASTER OF SCIENCE, 1967			
Ahmad, Daud	Pakistan	Circular hydraulic jump.	H. J. Koloseus
Assifi, Abdul T.	Afghanistan	Hydraulics and geometry of rivers.	D. B. Simons
Boyd, Marden B.	USA	Plan B - Hydraulics.	H. J. Koloseus
Cobb, Ernest D.	USA	Plan B - Hydrology.	J. W. N. Fead
Futrakul, Suvich	Thailand	Flood routing in a circular section.	A. H. Barnes
Gorove, Arpad	Hungary	Dynamics of pressure lines.	J. E. Cermak
Goswami, Atul C.	India	Geometric study of ripples and dunes.	E. V. Richardson
Ho, Yu-Bing	Taiwan	Hydrograph recessions.	J. M. Bell W. V. Garstka
Jennings, Marshall E.	USA	Plan B - Hydrology.	G. L. Smith
Julian, Robert W.	USA	Water yield-physiographic relationships.	V. Yevdjevich
Kesic, Dragoljub M.	Yugoslavia	Diffusion of heat in a boundary layer.	J. E. Cermak
Kung, Robin J.	Taiwan	Ultra-low-speed anemometry.	E. J. Plate
Liou, Yeuan-dong	Taiwan	Erosion of clay soils with chemicals.	R. D. Dirmeyer
Loyacano, Joseph N.	USA	Fall velocity in turbulent flume flow.	D. B. Simons
McWhorter, David B.	USA	Similitude for flow in porous media.	G. L. Corey
Mitchell, James S.	USA	Computed and observed wave attenuation.	A. H. Barnes
Om Kar, Songthara	Cambodia	Hydrograph rise times.	M. L. Albertson
Reid, Thomas A.	USA	Sediment size distribution in deltas.	D. B. Simons
Ruff, James F.	USA	Pressure fluctuations below valves.	D. B. Simons
Saulmon, Robert W.	USA	Flow into drains with gravel envelopes.	G. L. Kruse
Shih, Ching-chi	Taiwan	Diffusion in a turbulent shear layer.	R. N. Meroney
Su, Shih-tun	Taiwan	Circular free outfall.	A. H. Barnes
Vanikar, Suneel N.	India	Effects of chemical additives on clay.	R. D. Dirmeyer
Voytik, Andrew	USA	Runoff volumes for arid regions.	W. V. Garstka
DOCTOR OF PHILOSOPHY, 1967			
Ahmed, Nazeer	Pakistan	Turbulence in porous medium.	D. K. Sunada
Chandra, Suresh	India	Diffusion in turbulent boundary layer.	E. J. Plate
Chang, Hai-Yain	Taiwan	Hydraulics of rivers and deltas.	D. B. Simons

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
DOCTOR OF PHILOSOPHY, 1967 (Cont.)			
Dickinson, William T.	Canada	Accuracy of discharge determinations.	V. Yevdjevich
Drake, Ronald L.	USA	Wind generated waves on open channel flow.	E. J. Plate
Hill, William W., Jr.	USA	Ionization of shock-heated argon.	V. A. Sandborn
Kandala, Abdulahad S.	India	Velocity of spheres in open channels.	D. B. Simons
Koehler, Stanley B.	USA	Turbulent diffusion.	L. V. Baldwin
Kumar, Ashok	India	Fall behavior of rough objects.	D. B. Simons
Liu, Chang Y.	Taiwan	Boundary layer separation.	V. A. Sandborn
McQuivey, Raul S.	USA	Turbulence in open-channel flow.	E. V. Richardson
Rodriquez-Iturbe, Ignacio	Venezuela	Cross-spectrum applied in hydrology.	V. Yevdjevich
Roper, Alan T.	USA	A cylinder in a shear layer.	J. E. Cermak
Sayre, William W.	USA	Longitudinal mixing in open channels.	L. V. Baldwin
Sutabutra, Prathet	Thailand	Design of storage reservoirs.	V. Yevdjevich
MASTER OF SCIENCE, 1968			
Aiston, Stewart T.	USA	Drag coefficients for ocean platforms.	J. H. Nath
Anderson, Victor E.	USA	An analysis of cavitation in valves.	M. L. Albertson
Biggs, Michael W.	USA	Irrigation system consolidation.	M. E. Holland
Brustkern, Richard L.	USA	Plan B - Hydrology.	H. J. Morel-Seytoux
Cliff, William C.	USA	Visualization of turbulent mixing.	J. E. Cermak
Corrigan, John T.	USA	Plan B - Hydraulics.	D. B. Simons
Feline, Jacques J. R.	France	Stochastic variables in hydrologic series.	V. Yevdjevich
Groetsch, Siegmar F.	USA	Micromeasurements of water velocity.	D. K. Sunada
Jouini, Taoufik	Tunisia	Plan B - Hydraulics.	H. J. Koloseus
Kawatani, Takeshi	Japan	Structure of canopy flow field.	J. E. Cermak
Kolp, Donald A.	USA	Water hammer generated by air release.	M. L. Albertson
Lin, Jung-Tai	Taiwan	Simulated mountain lee-waves.	G. Binder
Mellema, Warren J.	USA	Plan B - Hydraulics.	D. B. Simons
Miller, Arthur C.	USA	Plan B - River mechanics.	J. W. N. Fead
Neuhauser, Christian H.	Austria	A method of analysis for stable channels.	D. B. Simons
Opie, Thomas R.	Australia	Scours at culvert outlets.	D. B. Simons
Patel, Jayantkumar P.	India	Plan B - Hydraulics.	H. J. Koloseus
Ramirez-Trujillo, Carlos A.	Colombia	Hydraulic equivalence of heavy minerals.	E. V. Richardson
Robertson, James A., Jr.	USA	Reducing seepage with sodium carbonate.	R. D. Dirmeyer

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
MASTER OF SCIENCE, 1968 (Cont.)			
Ross, John A.	Canada	Plan B - Hydraulics.	D. B. Simons
Salas-La Cruz, Jose D.	Peru	Plan B - Hydraulics.	D. B. Simons
Sapik, David B.	USA	Plan B - Groundwater.	D. K. Sunada
Scott, Cloyd H.	USA	Resistance to flow in sand channels.	E. V. Richardson
Sharp, Paul R.	USA	Plan B - Hydraulics.	D. B. Simons
Stephan, Roland K.	France	Geometry of expanding jet from culverts.	D. B. Simons
Timiyasathit, Pipat	Thailand	Plan B - Hydraulics.	D. B. Simons
Ulugur, Mustafa E.	Turkey	Plan B - Hydrology.	W. V. Garstka
Urbonas, Barnabas R.	USA	Forces on a bed particle.	D. B. Simons
Van Hoften, James D. A.	USA	Alternate bars in alluvial channels.	D. B. Simons
Weiss, Paul A.	USA	Plan B - Hydraulics.	H. J. Koloseus
Wend, Fred H.	USA	Stabilization of channels with gravel.	D. B. Simons
Zelenhasic, Emir F.	Yugoslavia	Particle shapes and some hydraulic properties.	J. W. N. Fead
DOCTOR OF PHILOSOPHY, 1968			
Athaullah, Muhammad	Pakistan	The prediction of alluvial bed forms.	D. B. Simons
Downer, Richard N.	USA	Hyetograph shape vs. small watershed floods.	V. Yevdjevich
Hiemstra, Lourens A. V.	South Africal	Frequency of runoff for small basins.	W. V. Garstka
Hsi, G. Chai-Lien	Taiwan	Wind drag of simulated forest canopies.	J. H. Nath
Jeng, R. Ing-song	Taiwan	Water storage problems.	M. M. Siddiqui
Marshall, Richard D.	USA	Turbulent stagnation flow.	J. E. Cermak
Nordin, Carl F.	USA	Statistical properties of dune profiles.	D. B. Simons
Steward, Willis G.	USA	Transient flow of cryogenic fluids.	J. E. Cermak
Tieleman, Henry W.	Canada	Viscous region of turbulent boundary layer.	V. A. Sandborn
Verschuren, Jacobus P.	Netherlands	A stochastic analysis of precipitation.	E. V. Richardson
Watts, Frederick J.	USA	Hydraulics of rigid boundary basins.	D. B. Simons
White, Nikolas F.	USA	Desaturation of porous materials.	J. W. N. Fead D. K. Sunada
Yang, Chih T.	Taiwan	Sand dispersion in a laboratory flume.	H. W. Shen
MASTER OF SCIENCE, 1969			
Arrigoni, Enrico L.	Italy	Effect of sample shape on shear strength.	J. M. Bell
Bibby, Robert	England	Flow between alluvium and bedrock.	D. K. Sunada

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
MASTER OF SCIENCE, 1969 (Cont.)			
Burgi, Philip H.	Chile	Seepage effect on channel bank stability.	S. Karaki
Dumas, Andre J.	France	Stochastic hydrology and cloud seeding.	H. J. Morel-Seytoux
Dyar, Lance P.	USA	Plan B - Hydraulics.	H. J. Koloseus
Hamilton, John M.	USA	Stabilization of gravel channels.	D. B. Simons
Hibbert, William V.	USA	Gas flow through porous media.	D. K. Sunada
Hogan, Raymond A.	USA	Characteristics of butterfly valves.	J. P. Tullis
Keefer, Thomas N.	USA	Plan B - Hydraulics.	E. V. Richardson
Lee, Baum-Koo	Korea	Constant depth alluvial channel flow.	E. V. Richardson
Lin, Hsin C.	Taiwan	Hydraulic measurement for surface area.	D. K. Sunada
Mejia, Jose M.	Colombia	Plan B - Hydraulics.	J. A. Gessler
Nakamichi, Hiroshi	Japan	Suitability to weather modification.	H. J. Morel-Seytoux
Navas, Andres	Colombia	Plan B - Hydrology.	M. E. Holland
Penel, Jacques G.	France	Plan B - Hydraulics.	D. B. Simons
Safai, Jamshid	India	Plan B - Hydrology.	A. H. Barnes
Simpson, Andrew A.	England	Plan B - Hydrology.	M. E. Holland
Simpson, Harold D.	USA	Laminar and turbulent dispersion of miscibile fluids in porous media.	D. K. Sunada
Stettner, Paul	USA	Aquifers: physical and analytical models.	D. K. Sunada
Su, Kuo-shyong	Taiwan	Filtered spacetime correlation.	E. J. Plate
Trawle, Michael J.	USA	Wind created waves in open channel flow.	E. J. Plate
Veenhuizen, Scott D.	USA	Secondary flow in a boundary layer.	R. N. Meroney
Wang, Jeng-Song	Taiwan	Hydraulic transport of solids in pipes.	H. W. Shen
Wu, Fang H.	Taiwan	Plan B - Hydraulics.	H. W. Shen
DOCTOR OF PHILOSOPHY, 1969			
Arya, Satya P. S.	India	Thermally stratified boundary layer.	E. J. Plate
Bennett, James P.	USA	Open channel turbulence measurement.	E. V. Richardson
Bhowmik, Nani G.	Pakistan	Stabilization of alluvial channels.	D. B. Simons
Bhuiya, Rezaul K.	Pakistan	Analysis of hydrologic time series.	M. M. Siddiqui
Chang, Po-cheng	Taiwan	Wind generated waves.	E. J. Plate
Eloubaidy, Aziz F.	Iraq	Reareation with wind waves.	E. J. Plate
Grigg, Neil S.	USA	Motion of single particles.	D. B. Simons
Hannan, Abdul	Pakistan	Study of Mississippi River bends.	D. B. Simons
Jobson, Harvey E.	USA	Diffusion of mass in open channel flow.	D. B. Simons
Kesic, Dragoljob M.	Yugoslavia	Energy spectrum in shear turbulence.	J. E. Cermak

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
DOCTOR OF PHILOSOPHY, 1969 (Cont.)			
Kibler, David F.	USA	A kinematic overland flow model.	D. A. Woolhiser
Lin, Jung-Tai	Taiwan	Turbulence spectra of stratified flow.	J. E. Cermak
Llamas, Jose	Spain	Deficit and surplus in precipitation series.	M. M. Siddiqui
Muir, Clifford D.	USA	Stability of slopes with seepage.	D. B. Simons
Nimmannit, Viboon	Thailand	Multivariate analysis of hydrologic changes.	H. J. Morel-Seytoux
Schiller, Robert E., Jr.	USA	A study of Indus basin canals.	D. B. Simons
Schneider, Verne R.	USA	Mechanics of local scour.	H. W. Shen
Stevens, Michael A.	Canada	Scour in rip rap at culvert outlets.	D. B. Simons
Suryanarayana, Bhamidipaty	India	Aggradation and degradation in open channels.	H. W. Shen
Ulugur, Mustafa E.	Turkey	Fluvial physiography in basin response.	J. W. N. Fead M. E. Holland
Zoric, Dusan L.	Yugoslavia	Turbulent boundary layer similarity.	V. A. Sandborn
MASTER OF SCIENCE, 1970			
Boyle, Walter S.	USA	Plan B - Hydrology.	E. F. Schulz
Chin, William Q.	Canada	Plan B - Hydrology.	E. F. Schulz
Chou, Fang-Kuo	Taiwan	Boundary layer separation.	V. A. Sandborn
Hung, Chung-ming	Taiwan	Plan B - Hydraulics.	E. V. Richardson
Kite, Geoffrey W.	England	A method of experimental statistical inference.	V. Yevdjevich
Laura, Della	USA	Plan B - Water resources.	M. L. Albertson
Lopez, Garcia L.	Spain	Dynamic programming in water resources.	E. A. Breitenbach
Montenegro, Carlos V.	El Salvador	Plan B - Hydrology.	V. Yevdjevich
Phuc, Le Van	France	General one-dimensional model of infiltration.	H. J. Morel-Seytoux
Shilling, Robert C.	USA	Punching shear behavior of slabs.	M. D. Vanderbilt
Tao, Pen-Chih	Taiwan	Surface profile of sudden release.	A. H. Barnes
Yang, Bing T.	Taiwan	Diffusion in the Wake regions.	R. N. Meroney
DOCTOR OF PHILOSOPHY, 1970			
Brustkern, Richard L.	USA	Infiltration study.	H. J. Morel-Seytoux
Chaudry, Fazal H.	Pakistan	Turbulent diffusion.	R. N. Meroney
Eshett, Ali	Israel	Groundwater systems analysis.	H. J. Koloseus
Kung, Robin J.	Taiwan	Boundary layer over fences.	E. J. Plate
Lai, Juey-rong R.	Taiwan	Evaporation from small wind waves.	E. J. Plate
Liou, Yeuan-dong	Taiwan	Hydraulic erodibility of clays.	J. A. Gessler
Petryk, Sylvester	Canada	Drag on cylinders in open channel.	H. W. Shen
Saldarriaga, Jaime	Colombia	Wet and dry years investigated by runs.	V. Yevdjevich
Sangvaree, Wiroj	Thailand	Land-use effect on flood peaks.	V. Yevdjevich

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
DOCTOR OF PHILOSOPHY, 1970 (Cont.)			
Smith, Roger E.	USA	Simulation of infiltrating watersheds.	D. A. Woolhiser
Su, Shih-tun	Taiwan	Dry-bed wave due to sudden releases.	A. H. Barnes
Subrahmanyam, Vedula	India	Morphology of a small alluvial channel.	H. W. Shen
Sundaram, Archivok V.	India	Modeling for stability of cohesive slopes.	J. M. Bell
Yeh, Fei-Fan	Taiwan	Air flow over roughness discontinuity.	E. J. Plate E. C. Nickerson
MASTER OF SCIENCE, 1971			
Andrews, James S.	USA	Waterhammer due to air exhaustion.	M. L. Albertson
Chen, Yung H.	Taiwan	Scour at outlets of box scours.	D. B. Simons
Gupta, Vijay K.	India	Transposition of storms.	V. Yevdjevich
Haque, Muhammad I.	W. Pakistan	Analytically determined ripple shapes.	A. G. Mercer
Hart, Ellis D.	USA	Plan B - Hydraulics.	J. P. Tullis
Karlinger, Michael R.	USA	Plan B - Hydraulics.	E. V. Richardson
Leelapattaranuruk, Adul	Thailand	Plan B - Hydraulics.	D. B. Simons
Medina, Jesus A. G.	Venezuala	Plan B - Hydraulics.	E. V. Richardson
Noblanc, Alain G.	France	Mathematical model of infiltration.	H. J. Morel-Seytoux
Oporto, Carlos F.	Equador	Open channel flow surface-dispersion.	J. A. Gessler
Perez, Jose M.	Venezuala	Plan B - Hydraulics.	E. V. Richardson
Rundquist, Larry A.	Canada	Plan B - Hydrology and water resources.	E. F. Schultz
Sanabria, Jose I.	Venezuala	Plan B - Hydraulics.	E. V. Richardson
Symes, Craig R.	Australia	Cone frustrums in a shear layer.	R. N. Meroney
Thaemert, Ronald L.	USA	Steep channel water surface profiles.	E. V. Richardson
Whittington, Newman C.	USA	Cavitation scale effects for orifices.	J. P. Tullis
Wu, Yao-Huang	Taiwan	Plan B - Hydraulics.	S. Karaki
DOCTOR OF PHILOSOPHY, 1971			
Ahmad, Daud	W. Pakistan	Forced repetitive oscillations.	H. J. Koloseus
Bibby, Robert	England	Error analysis of groundwater systems.	D. K. Sunada
Duke, James H.	USA	Maximum water delivery in irrigation.	E. V. Richardson
Esen, Ismail I.	Turkey	Probabilistic analysis of dissolved oxygen.	E. V. Richardson
Garcia-Martinez, Luis E.	Guatemala	Scarce data and water resource systems.	M. L. Albertson
Jolly, John P.	Canada	Amplification criteria for single peaked waves.	V. Yevdjevich
Kawatani, Takeshi	Japan	The flow over high roughness.	W. Z. Sadeh J. W. N. Fead

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
DOCTOR OF PHILOSOPHY, 1971 (Cont.)			
Keefer, Thomas N.	USA	Turbulent diffusion in an open channel.	E. V. Richardson
Khan, A. K. M. H. R.	Pakistan	Alluvial river morphology.	D. B. Simons
Knisel, Walter G., Jr.	USA	Response of Karst aquifers to recharge.	V. Yevdjevich
Mahmood, Khalid	Pakistan	Flow in sand-bed channels.	D. B. Simons
Orgill, Montie M.	USA	Transport and dispersion over mountains.	J. E. Cermak
Putta, Surya N.	India	Mass dispersion from a line source.	J. E. Cermak
Verma, Shasi B. P.	India	Mass transfer from rough surfaces.	J. E. Cermak
Yamada, Tetsuji	Japan	Wall perturbation of stratified flows.	R. N. Meroney
Zelenhasic, Emir F.	Yugoslavia	Stochastic model for floods.	V. Yevdjevich
MASTER OF SCIENCE, 1972			
Cass, Clyde P.	USA	Plan B - Hydraulics.	E. V. Richardson
Correia, Mario L. S.	Portugal	Plan B - Hydrology.	V. Yevdjevich
Deredec, Alain J.	France	Water supply planning for an urban area.	H. J. Morel-Seytoux
Diaz, Jose E.	Peru	Waterhammer during pipeline filling.	M. L. Albertson
Fatourechy, Hassan	Iran	Plan B - Hydraulics.	J. C. Ward
Fawkes, Patrick E.	England	Roughness in a model of overland flows.	E. F. Schultz
Forney, Guy W., Jr.	USA	Plan B - Hydraulics.	H. W. Shen
Garg, Mandan M.	India	River classification by photos and map.	D. B. Simons
Kavvas, Mustafa L.	Turkey	Unit hydrograph instability.	E. F. Schultz
Kraeger, Catherine E.	USA	Numerical model of groundwater contamination.	D. K. Sunada
Lawson, Elwin R.	England	Plan B - Hydrology.	E. S. Schultz
Li, Ruh-Ming	Taiwan	Sheet flow under simulated rainfall.	H. W. Shen
Lindeman, Lance F.	USA	Polymer injection for drag reduction.	J. P. Tullis
Mukherji, Sanjib K.	India	Wall jet interaction with a shear flow.	W. Z. Sadeh
Nambudripad, Kudallur D.	India	Flow over non-uniform surface roughness.	J. E. Cermak
Peterson, Charles R.	USA	Flood routing with a diffusion equation.	D. B. Simons
Quesada-Mateo, Carlos A.	Philippines	Plan B - Hydrology	E. F. Schultz
Rabot, Jacques	France	Turbulence measurements by a propeller.	E. V. Richardson
Rakha, Allah	Pakistan	Sediment conduction of turnouts.	A. G. Mercer

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
MASTER OF SCIENCE, 1972 (Cont.)			
Rana, Saeed A.	Pakistan	Sediment sorting in alluvial channels.	D. B. Simons
Wilson, Wallace A.	USA	Unit hydrograph response times.	E. F. Schultz
DOCTOR OF PHILOSOPHY, 1972			
Anyiwo, Joshua C.	Nigeria	A computer study of wall boundary layers.	R. N. Meroney
Beebe, Paul S.	USA	Turbulent flow over rough surfaces.	J. E. Cermak
Dellah, Abdellatif	Tunisia	Evaporation from swirl spray nozzles.	G. O. G. Lof
Dyhr-Nielsen, Mogens	Denmark	Loss of information by discretization.	V. Yevdjevich
Emmanuel, Constantinos B.	USA	Helmholtz waves in the atmosphere.	V. A. Sandborn
Huang, Chin-hua	Taiwan	Airflow over nonhomogeneous terrain.	J. W. N. Fead E. C. Nickerson
Kilinc, Mustafa Y.	Turkey	Mechanics of soil erosion.	E. V. Richardson
Lewis, Gary L.	USA	Riprap protection of bridge footings.	D. B. Simons
Liu, Hsien Ta	Taiwan	Mass diffusion over wind waves.	S. Karaki
Mejia, Jose M.	Colombia	Operational hydrology and Hurst's Law.	D. B. Simons
Millan, Jaime	Colombia	Droughts: An engineering-economic model.	V. Yevdjevich
Miller, Arthur C.	USA	Diffusion and dispersion in open channel.	E. V. Richardson
Moss, Marshall E.	USA	Correlation of discretized streamflow.	E. V. Richardson
Nalluswami, Marappagounder	India	Dispersion in ground water flow.	R. A. Longenbaugh
Salas-La Cruz, Jose D.	Peru	Range of periodic-hydrologic series.	V. Yevdjevich
Santos-Cayado, Julio	Santa Domingo	Stage determination for high discharge.	D. B. Simons
Su, Kuo-Shyong	Taiwan	Wind waves and diffusion in open channel.	J. A. Gessler
Torranin, Padoong	Thailand	Canonical correlation in hydrologic predictions.	V. Yevdjevich
Wang, Hua	Taiwan	Air flow over lateral surface discontinuities.	E. C. Nickerson
Wang, Jeng-Song	Taiwan	Turbulent flow in a pipe inlet region.	J. P. Tullis
MASTER OF SCIENCE, 1973			
Abreu-Burelli, Rafael E.	Venezuala	Plan B - Fluid Mechanics.	E. V. Richardson
Baker, Charles D.	USA	Plan B - Water resources.	E. V. Richardson
Church, David N.	USA	Plan B - Hydrology.	E. F. Schultz
Cress, Milo D.	USA	Stabilization of alluvial rivers.	D. B. Simons

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
MASTER OF SCIENCE, 1973 (Cont.)			
Degenhardt, Eugene A.	USA	Stabilization of middle Mississippi River.	D. B. Simons
Derickson, Russell G., Jr.	USA	Computational aspects of a cloud model.	E. C. Nickerson
Dreher, Karl J.	USA	Wind loads on the roof of a house.	J. E. Cermak
Ghiacy, Ghulam D.	Afghanistan	Plan B - Hydraulics.	E. V. Richardson
Hanson, Warren W.	USA	Plan B - Fluid mechanics.	J. A. Peterka
Hsieh, Juei L.	Taiwan	Plan B - Hydraulics.	D. B. Simons
Jawed, Khalid	Pakistan	Comparison of methods of deriving unit hydrograph.	E. F. Schultz
Kazemi, Mohamad J.	Afghanistan	Plan B - Hydraulics.	E. V. Richardson
Kincheloe, Thomas R.	USA	Plan B - Water resources.	E. V. Richardson
King, Shao-Hsing	Taiwan	Plan B - Hydrology and water resources.	E. F. Schultz
Ko, Meng-Fang	Taiwan	Layered beam systems with interlayered slip.	M. D. Vanderbilt
Laufer, Frederic	Switzerland	Flow changes in high mountain watersheds.	H. J. Morel-Seytoux
Maarfi, Mohamed A.	Libya	Plan B - Hydraulics.	J. A. Gessler
Makhdoom, Rashid A.	Pakistan	Plan B - Hydraulics.	D. B. Simons
McCain, Jerald F.	USA	Plan B - Water resources.	E. V. Richardson
Moore, Richard L.	USA	Plan B - Fluid mechanics.	V. A. Sandborn
Nazar, Atal M.	Afghanistan	Bed material withdrawal in farm turnouts.	M. L. Albertson
Nutter, Eddie W.	USA	Plan B - Water resources.	E. V. Richardson
Olson, Alan F.	USA	A digital stream-aquifer model.	R. A. Longenbaugh
Ortiz-Brennan, Diego	Equador	Local scour at river constrictions.	D. B. Simons
Pennino, Bruce J.	USA	Plan B - Hydraulics.	H. J. Koloseus
Raghavendran, R.	India	Plan B - Hydrology and water resources.	V. Yevdjevich
Sabol, George V.	USA	Intermittent river sediment sampling.	E. V. Richardson
Samuelson, Andrew L.	USA	Plan B - Hydraulics.	E. V. Richardson
Schiefer, Michael C.	USA	The organization of Thai irrigators.	M. L. Albertson
Sharify, Azizullah	Afghanistan	Plan B - Hydraulics.	E. V. Richardson
Sullivan, Charles H.	USA	Plan B - Water resources.	E. V. Richardson
Trujillo-Herrera, Hector A.	Venezuala	Plan B - Water resources.	E. V. Richardson
Tu, Chyuan-Gen S.	Taiwan	Plan B - Fluid mechanics.	J. E. Cermak
Zuberi, Farid-Uddin A.	Pakistan	Plan B - Groundwater.	R. A. Longenbaugh
DOCTOR OF PHILOSOPHY, 1973			
Chaudhry, Mohammed T.	Pakistan	Conjuctive use of Indus basin waters.	M. L. Albertson
Chen, Yung H.	Taiwan	Water and sediment routing in channels.	D. B. Simons

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
DOCTOR OF PHILOSOPHY, 1973 (Cont.)			
Cheong, Hin F.	Singapore	Stochastic analysis of sediment bedforms.	Y. H. Chen
Chieh, Sherman	Taiwan	Plane couette flow in stratified fluid.	E. C. Nickerson
Chin, William Q.	Canada	Stochasticity in climatic change.	V. Yevdjevich
Chou, Fang-Kuo	Taiwan	Prediction of turbulent separation.	V. A. Sandborn
Cliff, William C.	USA	Convective velocities in the turbulent boundary layer.	V. A. Sandborn
Croley, Thomas E.	USA	Sequential stochastic optimization.	V. Yevdjevich
Govindarajan, Rangachari	India	Cavitation size scale effects.	J. P. Tullis
Hendrick, John D.	USA	Effect of storage on river salinity.	V. Yevdjevich
Karplus, Alan K.	USA	Simulation of precipitation series.	V. Yevdjevich
Lee, Baum-Koo	Korea	Stochastic analysis of sand movement.	E. V. Richardson
Nayak, Shrinivas	India	Periodicity of combined heat transport.	V. A. Sandborn
Raman, S. Sethu	India	Flow over a rough heat island.	J. E. Cermak
Rousselle, Jean	Canada	On some problems of flood analysis.	P. Todorovic
Sagar, Bokkapatnam T. A.	India	Downpull in high head gate installations.	J. P. Tullis
Santefore, Henry S., Jr.	USA	Management of windblown alpine snows.	M. L. Albertson L. O. Grant
Sonu, Jungkeum	Korea	Water and air movement into bounded layered soil.	H. J. Morel-Seytoux
Tao, Pen-Chih	Taiwan	Distribution of residuals of hydrologic time series.	V. Yevdjevich
Tuffuor, Samuel	Ghana	Time variant simulated watershed model.	M. L. Albertson
Veenhuizen, Scott D.	USA	Turbulent air flow over wind excited laboratory water waves.	S. Karaki
Yang, Bing-Tsuen	Taiwan	Unsteady diffusion processes-puffs.	R. N. Meroney
MASTER OF SCIENCE, 1974			
Budeiri, Zafir M.	Egypt	Plan B - Water resources.	E. V. Richardson
Bullard, Kenneth L.	USA	Consequences of removal of time series harmonies.	V. Yevdjevich
Catchpole, Glenn J.	USA	Plan B - Water resource systems.	M. L. Albertson
Dorratcague, Dennis E.	USA	Digital processing of thermal infrared scanner data.	M. M. Skinner
Flug, Marshall	USA	Optimization of an urban water system.	J. Labadie
Frevert, Donald K.	USA	Prediction of unit hydrograph parameters.	V. Yevdjevich
Harleston, Alex E.	England	Plan B - Hydrology and water resources.	V. Yevdjevich
Laete, Jacob	USA	Plan B - Hydraulics.	J. W. Ball
Lefevre, Bernard	France	Experiments on a 2-phase flow in sand.	H. J. Morel-Seytoux

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
MASTER OF SCIENCE, 1974 (Cont.)			
Lopez, Oscar G.	USA	Reponse time in urban Colorado basins.	E. F. Schultz
Rowe, Garry M.	USA	Plan B - Water resources.	E. V. Richardson
Sweeney, Charles E.	USA	Cavitation damage in sudden enlargements.	J. P. Tullis
Theurer, Fred D.	USA	Plan B - Hydraulics.	E. V. Richardson
Vargas-Semprun, Douglas	Venezuala	Plan B - Hydrology and water resources.	V. Yevdjevich
Wacker, A. Mainard	USA	Highway impact on mountain streams.	D. B. Simons
Watt, Richard S.	USA	Plan B - Hydrology and water resources.	E. F. Schultz
Willard, Thomas A.	USA	Plan B - Hydrology and water resources.	E. F. Schultz
DOCTOR OF PHILOSOPHY, 1974			
Barnett, Kenneth M.	USA	Turbulence effect on vortex shedding.	J. E. Cermak
Bell, Peter W. W.	Canada	Optimal control of flow in combined sewer system.	M. L. Albertson
Blinco, Paul H.	USA	Spatial structure of viscous sublayer.	D. B. Simons
Edling, Bruce H.	USA	Turbulent boundary layer on roughness.	N. S. Grigg
Guerrero-Salazar, Pedro L. A.	Peru	Stochastic approach to the study of droughts.	V. Yevdjevich
Jacobi, Sven	Denmark	Worth of sediment data in a decision framework.	C. F. Nordin
Kahawita, Rene A.	Canada	Study of convective instabilities.	R. N. Meroney
Laura, Della	USA	Water resources decision evaluation model.	E. V. Richardson
Lemma, Wendim-Agegnehu	Russia	Selection and timing of water resources projects.	M. L. Albertson
Prakash, Anand	India	Galerkin simulation of hydrodynamic dispersion.	R. A. Longenbaugh J. W. N. Fead
Sabol, George V.	USA	Stochastic model of dispersion in a shear flow.	C. F. Nordin
Shieh, S. Chin-nan	Taiwan	Turbulence in pipe flows with polymer additives.	S. Karaki
Singh, Vijay P.	India	A kinematic wave model of surface runoff.	D. A. Woolhiser
Tamburi, Alfred J.	USA	Geology and water resource system of the Indus plains.	M. L. Albertson
Wu, Fang H.	Taiwan	Groundwater management-Pakistan.	A. G. Mercer E. V. Richardson R. A. Longenbaugh
MASTER OF SCIENCE, 1975			
Bader, Frederick R., Jr.	USA	Plan B - Water resources.	E. V. Richardson
Copeland, Ronald R.	USA	Plan B - Water resources.	E. V. Richardson

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MASTER OF SCIENCE, 1975 (Cont.)			
Demlow, Thomas C.	USA	Model study of pipeline scour.	C. F. Nordin
Drury, Roger M.	USA	Stability of earth covering overlying PVC membranes.	E. V. Richardson
Guillot, Elaine	France	Plan B - Water resource systems.	N. S. Grigg
Hill, William C.	USA	A shuntline metering system for irrigation wells.	J. F. Ruff
Huang, Fei-Dar	Taiwan	Plan B - Fluid mechanics.	R. N. Meroney
Jafar, Ata M.	Pakistan	Plan B - Hydrology and water resources.	V. Yevjevich
Jimenez, Ulate B.	Costa Rica	Plan B - Hydraulics.	J. A. Gessler
Kapple, Glenn	USA	Plan B - Groundwater.	R. A. Longenbaugh
Kemprasit, San	Thailand	Plan B - Hydrology and water resources.	V. Yevjevich
Lau, Daniel H.	USA	A preliminary comparison of the economics of two water supply alternatives for the city of Fort Collins.	H. J. Morel-Seytoux
Lokrou, Vincent P.	Africa	Plan B - Hydraulics.	D. B. Simons
Lopez, Antonio Y.	Colombia	Plan B - Hydrology and water resources.	V. Yevjevich
Malik, Tahir A.	Pakistan	Plan B - Hydraulics.	K. Mahmood
Melone, Anthony M.	USA	Exclusion and ejection of sediment from canals.	D. B. Simons
Mommandi, Amanullah	Afghanistan	Plan B - Water resources.	J. A. Gessler
Rahmeyer, William J.	USA	Cavitation pressure scale effects and damage for butterfly valves.	J. P. Tullis
Rios-Reategui, Emilio	Peru	Optimal conjuctive use of surface and groundwater, South Platte Ditch Company near Sterling, Colorado.	R. A. Longenbaugh
Rovey, Edward W.	USA	A kinematic model of upland watersheds.	D. A. Woolhiser
Smith, Lewis A.	USA	Plan B - Hydraulics.	E. V. Richardson
Trimmer, Walter L.	USA	Plan B - Water resource systems.	N. S. Grigg
Wahl, Kenneth L.	USA	Plan B - Hydraulics.	D. B. Simons
DOCTOR OF PHILOSOPHY, 1975			
Campbell, John R.	USA	A numerical simulation of a viscous water wave.	S. Karaki
Gomide, Francisco L. S.	Brazil	Range and deficit analysis using markov chains.	V. Yevjevich
Holly, Forrest M., Jr.	USA	Two-dimensional mass dispersion in rivers.	D. B. Simons
Koper, Chester A., Jr.	USA	An investigation of turbulent transport in the extreme lower atmosphere.	W. Z. Sadeh
Krishnamurthi, N.	India	Simulation of gravitational water movement in soil.	R. A. Longenbaugh J. W. N. Fead

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
DOCTOR OF PHILOSOPHY, 1975 (Cont.)			
Lagasse, Peter F.	USA	Interaction of river hydraulics and morphology with riverine dredging operations.	D. B. Simons
Lane, Leonard J.	USA	Influence of simplification of watershed geometry in simulation of surface runoff.	V. Yevjevich
Lane, William L.	USA	Extraction of information on inorganic water quality.	V. Yevjevich
Li, Ruh-Ming	Taiwan	Mathematical modeling response from small watersheds.	D. B. Simons
Ramu, Kikkeri L. V.	India	Inlet region flow with polymer additives.	J. P. Tullis
Rovey, Catherine E. K.	USA	Numerical model of flow in a stream-aquifer system.	E. V. Richardson
Rundquist, Larry A.	USA	A classification and analysis of natural rivers.	D. B. Simons
Stripling, Travis E.	USA	Cavitation damage scale effects: Sudden enlargements.	J. P. Tullis
Tai, Kon C.	Malaysia	Analysis and synthesis of flood-control measures.	V. Yevjevich
Theurer, Fred D.	USA	A solution for unsteady open channel flow.	E. V. Richardson
MASTER OF SCIENCE, 1976			
Acajabon, Arturo D.	Guatemala	Plan B - Hydrology and water resources.	V. Yevjevich
Ahmadi Karvigh, H.	Iran	Plan B - Hydraulics.	K. Mahmood
Ahmadzai, Ahmadshah	Afghanistan	Plan B - Water resources.	J. A. Gessler
Berryman, Alan D.	USA	Hydraulic characteristics of a small basin.	E. V. Richardson
Brazil, Larry E.	USA	A water quality model of overland flow.	T. G. Sanders J. W. N. Fead
Bredthauer, Stephan R.	USA	Plan B - Hydrology and water resources.	H. J. Morel-Seytoux
Brisbane, Thomas E.	USA	Plan B - Hydraulics.	S. Karaki
Casco, Mario I.	Honduras	Plan B - Hydrology and water resources.	V. A. Koelzer
Dang, Clement K. S.	USA	Rating of the broad-crested V-notch weir.	J. F. Ruff J. W. N. Fead
De Haan, Roger W.	USA	An input-output analysis of the total water system in a river basin.	D. W. Hendricks
Durnford, Deanna	USA	Effects of wind load requirements on design.	J. W. N. Fead
Eckhardt, John R.	USA	Simultaneous solution for distribution of head in a two aquifer system.	D. K. Sunada
Eyster, Gary L.	USA	Variation of suspended sediment in sand bed canals.	K. Mahmood
Ghooprasert, Wanchai	Thailand	Plan B - Groundwater.	R. A. Longenbaugh J. W. N. Fead

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
MASTER OF SCIENCE, 1976 (Cont.)			
Gronning, Lloyd J.	USA	Plan B - Water resource systems engineering.	J. Labadie
Holman, Kenneth L.	USA	Plan B - Water resources.	E. V. Richardson
Hooper, John A.	USA	Pipe-orifice flow with polymer additives.	J. P. Tullis
Hu, Wen-Jung	Taiwan	Method of irrigation scheduling with potential inputs from remote sensing.	L. D. Miller
Jolly, Wallace A.	Canada	Plan B - Water resource systems engineering.	M. L. Albertson
Knopp, John E.	USA	Plan B - Hydraulics.	E. V. Richardson
Liao, Tsung-shen	Taiwan	Plan B - Hydraulics.	H. W. Shen
Lopez, Jose L.	Venezuela	Plan B - Hydraulics.	E. V. Richardson
Mulhern, Patrick F.	USA	Form and pattern on the Gros Ventre River.	M. M. Skinner
Murthy, B. S. Krishna	India	Plan B - Groundwater.	R. A. Longenbaugh
Myers, Philip M.	USA	Plan B - Water resource systems engineering.	E. V. Richardson
Nunez Wietstruck, Juan J.	Venezuela	Plan B - Hydraulics.	H. W. Shen
Ozga, John P.	USA	Plan B - Hydrology and water resources	T. G. Sanders H. J. Morel-Seytoux
Park, Kyoung-Yoon	Korea	Remote estimation of diffusion coefficients.	W. Z. Sadeh
Pokrefke, Thomas J., Jr.	USA	Plan B - Hydraulics.	E. V. Richardson
Rao, Suvarna Dhananjaya	India	A laboratory study of effect of dikes on channels.	D. B. Simons
Smith, Peter E.	USA	Supercavitation in pipe flow.	J. P. Tullis
Svendsen, Mark T.	USA	Investigating agricultural water logging and salinity problems.	E. V. Richardson
Temple, Darrel M.	USA	Sediment stable canal systems.	E. V. Richardson
Walters, Wallace H.	USA	Regime changes of the lower Mississippi River.	D. B. Simons
Wood, Alan D.	USA	Water lifters and pumps for the developing world.	E. V. Richardson
DOCTOR OF PHILOSOPHY, 1976			
Blank, Herbert G.	USA	Optimal irrigation decisions with limited water.	M. L. Albertson
Carrigan, Philip H., Jr.	USA	Regional flood maxima.	E. V. Richardson
Dass, Purushottam	India	Water and sediment routing in natural channels.	D. B. Simons
Hansen, A. Craig	USA	Vortex-containing wakes of surface obstacles.	J. E. Cermak
Helweg, Otto J.	USA	A salinity management strategy for stream-aquifer system.	J. Labadie
Hung, Chesheng	Taiwan	Stochastic analysis of bedload particle movement.	H. W. Shen

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
DOCTOR OF PHILOSOPHY, 1976 (Cont.)			
Isailovic, Dragoslav Z.	Yugoslavia	Optimal operation of coupled surface-underground storage.	V. Yevjevich
Larson, Harry	USA	An analysis of an irrigation venture.	E. V. Richardson
Liang, Wen-Sheng	Taiwan	The development of turbulent boundary layers in open-channel flows.	E. V. Richardson
Mutreja, Kedar N.	India	Reservoir capacity for periodic-stochastic input and periodic output.	V. Yevjevich
Rodriguez-Amaya, Carlos	Colombia	A decomposed aquifer model suitable for management.	H. J. Morel-Seytoux
Sentürk, Hüseyin A.	Turkey	Resistance to flow in sand-bed channels.	D. B. Simons
Thaemert, Ronald L.	USA	Mathematical model of water allocation methods.	E. V. Richardson
Trotta, Paul D.	USA	On-line adaptive control for combined sewer systems.	N. S. Grigg
van Hoften, James D. A.	USA	The interaction of gravity waves and turbulent channel flow.	S. Karaki
Ward, Timothy J.	USA	Factor of safety approach to landslide potential delineation.	D. B. Simons
MASTER OF SCIENCE, 1977			
Abt, Steven R.	USA	Managing runoff effects of urbanization with detention storage.	N. S. Grigg
Ahmed, Sajjad	Pakistan	Plan B - Water resources planning and management.	M. L. Albertson
Al-Kazzaz, Shifa'a A. M.	Iraq	Multi-objective optimization of farm irrigation systems.	W. A. Hall
Azizi, A. Hamid	Afghanistan	Plan B - Water resources.	M. L. Albertson
Baquero O., L. Francisco	Ecuador	Cavitation damage in elbows.	J. P. Tullis
Clyde, Eric S.	USA	Cavitation scale effects in pipe elbows.	J. P. Tullis
Edgar, Thomas V.	USA	Ground water recharge in the frenchman watershed.	D. K. Sunada
Eggert, Kenneth G.	USA	Modelling the unsteady infiltration process.	D. B. Simons
Fang, Tachung	Taiwan	Plan B - Hydraulics.	R. M. Li
Galuzzi, Michael R.	USA	Stabilization and control of alluvial channels.	D. B. Simons
Goldbach, Joseph C.	USA	Input-output modeling of water resources systems by digital computer.	D. W. Hendricks
Gruver, Shari M.	USA	Plan B - Hydraulics.	J. F. Ruff
Hatcher, Robert V.	USA	Dispersion in the wake of a model industrial complex.	R. N. Meroney
James, Christopher	South Africa	Plan B - Hydraulics.	E. V. Richardson

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
MASTER OF SCIENCE, 1977 (Cont.)			
Kuechster, Theodore E.	USA	Wave reflection in a moving current.	S. Karaki
Kuo, Chao-Hsiung	Taiwan	Plan B - Hydraulics.	D. B. Simons
Li, Lan-Yin	Taiwan	Data analysis on turbulent velocities and boundary shear stresses.	H. W. Shen
McKnight, Charles A.	USA	Plan B - Water resources.	N. S. Grigg
Marsh, G. Leonard	USA	Measurement of turbulent flows with a rotated hot-film anemometer.	J. A. Peterka
Masood, Tariq	Pakistan	Error analysis in measurements of alluvial channels.	K. Mahmood
Merkle, Lawrence O.	USA	Plan B - Hydrology and water resources.	E. V. Richardson
Mierau, Ronald L.	USA	Erosion of clays subjected to drying and addition of dispersants.	J. A. Gessler
Nadja, Abdul-Rahman S.	Russia	Plan B - Water resources.	E. V. Richardson
Patterson, James L.	USA	Water for industry in the South Platte basin.	D. W. Hendricks
Peterson, Roger J.	USA	Laboratory simulation of soil erosion.	T. G. Sanders
Price, Bradford S.	USA	Plan B - Hydrology and water resources.	E. V. Richardson
Pyle, William L.	USA	Equilibrium snowdrift geometry.	V. A. Sandborn
Rowe, Jerry W.	USA	Water quality hydrology of surface mined watersheds.	R. A. Longenbaugh
Simons, Robert K.	USA	A modified kinematic approximation for water and sediment routing.	R. M. Li
Subramaniam, Janakiram	India	Water resources institutions and development.	M. L. Albertson
Sukhsri, Chaiyuth	Thailand	Plan B - Water resources planning and management.	W. A. Hall
Sung, Quecheng	Taiwan	Taiwan land-use mapping by computer processing of landsat imagery.	L. D. Miller
Tejada, Sergio A.	Colombia	Plan B - Hydraulics.	H. W. Shen
Templin, Joseph T.	Canada	Wind pressures on buildings: effects of mullions.	J. E. Cermak
Vicente M., Caridad H.	Venezuala	Plan B - Water resources.	N. S. Grigg
Wray, Richard N.	USA	On the motion of autorotating elongated prismatic bodies.	J. E. Cermak M. Poreh
DOCTOR OF PHILOSOPHY, 1977			
Karvigh, Hassan A.	Iran	Diffusion in developing turbulent flow.	E. V. Richardson
Akins, Robert E.	USA	Wind pressures on buildings.	J. E. Cermak
Andrew, John W.	Australia	Economic optimization of water allocation systems.	E. V. Richardson
Cluff, Carwin B.	USA	The compartmented reservoir: A method of efficient water storage.	E. V. Richardson

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
DOCTOR OF PHILOSOPHY, 1977 (Cont.)			
Gonzalez, Don D.	USA	Hydraulic effects of underground nuclear explosions, Amchitka Island, Alaska.	E. V. Richardson
Kelman, Jerson	Brazil	Stochastic modeling of intermittent daily hydrologic series.	V. Yevjevich
Laufer, Frédéric	Switzerland	Weekly control of alpine seasonal reservoir.	H. J. Morel-Seytoux
Naas, Seddik L.	Libya	Flow behavior in alluvial channel bends.	E. V. Richardson
Ortiz, Nester V.	Canada	Artificial ground water recharge with capillary.	D. K. Sunada R. A. Longenbaugh
Ponce, Victor M.	Peru	Boundary-flow interaction in straight alluvial channels.	K. Mahmood
Richardson, Clarence W.	USA	A model of the stochastic structure of daily precipitation over an area.	V. Yevjevich
Semprum, Douglas V.	Venezuala	On the stochastic modeling of daily streamflows.	V. Yevjevich
Tase, Norio	Japan	Area-deficit-intensity characteristics of droughts.	V. Yevjevich
MASTER OF SCIENCE, 1978			
Abdelbary, Mohamed R.	Egypt	Flows with rapid sediment motions over flat bed.	H. W. Shen
Beckstead, Gary R. E.	Canada	Plan B - Hydraulics.	E. V. Richardson
Chen, Anthony T.	Taiwan	A study of reduction methods of reservoir sedimentation.	E. V. Richardson
De Luca, Sergio J.	Brazil	Plan B - Water resources planning and management.	D. W. Hendricks
Domenick, James V.	USA	System analysis of real-time water distribution management.	E. V. Richardson
Foley, Patrick M.	USA	Plan B - Hydraulics.	E. V. Richardson
Gerlek, Stephen	USA	Water supplies of the South Platte River basin.	D. W. Hendricks
Gonzalez, Oswaldo	Venezuela	Plan B - Hydraulics.	E. V. Richardson
Graham, Wayne J.	USA	Plan B - Water resource planning and management.	G. L. Smith
Herrin, Janet C.	USA	Peak flow prediction from small ungaged Colorado foothills watersheds.	V. Yevjevich
Ho, Nan-Hsuing J.	Taiwan	A nutrient cycle model for prediction of nutrient losses from watershed.	D. B. Simons
Lombardi, David J.	USA	Steady state pollutant concentration in an urban area.	J. E. Cermak
Lopez-Garcia, Jesus	Spain	Mathematical modeling of alluvial bed transients.	D. B. Simons
Machado, Humberto J.	Nicaragua	Plan B - Water resource planning and management.	J. Labadie
Neff, David E.	USA	Wind tunnel study of plume dispersion from liquid methane spills.	R. N. Meroney

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
MASTER OF SCIENCE, 1978 (Cont.)			
Owens, Emmet M., Jr.	USA	Sediment routing in rivers.	D. B. Simons
Perez-Ayala, Rafael	Venezuela	Plan B - Hydraulics.	E. V. Richardson
Pernia, Jose E.	Venezuela	Hydrologic parameters from landsat imagery for Williams Fork watershed.	A. H. Barnes
Peters, Greg G.	USA	Modeling aquifer return flows and non-equilibrium initial conditions.	H. J. Morel-Seytoux
Pittman, Leslie W.	USA	Numerical simulation for convection of contaminants in groundwater.	R. A. Longenbaugh
Playton, Stephen J.	USA	Plan B - Hydrology and water resources.	T. G. Sanders
Rector, Michael R.	USA	Plan B - Water resources planning and management.	J. Labadie
Reese, Andrew J.	USA	Simplified small watershed sediment and water yield modeling.	D. B. Simons
Reitano, Bartolomeo M.	Italy	An input-output model of the Cache La Poudre water system.	D. W. Hendricks
Restrepo-Mejia, Jorge I. de J.	Colombia	Plan B - Hydrology and water resources.	H. J. Morel-Seytoux
Rider, Michael A.	USA	Boundary layer turbulence over two-dimensional hills.	V. A. Sandborn
Rothwell, Edward D.	USA	Plan B - Hydraulics.	D. B. Simons
Sainz-Ossio, Victor H.	Bolivia	Plan B - Water resources planning and management.	W. A. Hall
Shah, Syed M.	Pakistan	Small scale hydroelectric power potential in rural northern areas of Pakistan.	M. L. Albertson
Sheng, Richard V. (Sze-van)	China	Statistical analysis of sediment particle movement on flat beds.	H. W. Shen
Smith-Quintero, Ricardo A.	Colombia	Plan B - Hydrology and water resources.	V. Yevjevich
Smith, Stephen W.	USA	Plan B - Water resources planning and management.	W. A. Hall
Spronk, Brent E.	USA	Simulation of rainfall runoff from a system of multiple watersheds.	R. M. Li
Steele, Kenneth A.	USA	Plan B - Hydraulics.	D. B. Simons
Stiehr, Patrick L.	USA	Plan B - Water resources planning and management.	J. Labadie
Ten Eyck, Gregg S.	USA	Plan B - Hydrology and water resources.	T. G. Sanders
Tung, Shih-Min	Taiwan	Effects of various year beginning on properties of annual series.	V. Yevjevich
Turbak, Abdulaziz S.	Saudi Arabia	Plan B - Hydrology and water resources.	V. Yevjevich
Vaca Vaca, Gil A.	Ecuador	Plan B - Hydraulics.	D. B. Simons
Waugaman, Dennis G.	USA	Remote sensing of turbidity.	J. F. Ruff
Wille, Sílvio A. de C.	Brazil	Plan B - Water resources planning and management.	W. A. Hall
Zambrano, Thomas	USA	Wind load interaction on an adjacent building.	J. A. Peterka

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
DOCTOR OF PHILOSOPHY, 1978			
Ahmed, Sajjad	Pakistan	Multiobjective optimization of water and power in the K-S-C River basin, Pakistan.	M. L. Albertson
Ghooprasert, Wanchai	Thailand	Salinity effects on soil consolidation.	J. D. Nelson D. K. Sunada
Jϕnch-Clausen, Torkil	Denmark	Optimal allocation of water resources in an input-output framework.	H. J. Morel-Seytoux
Khan, Irfan A.	Pakistan	A hierarchical approach to salinity management in river basins.	J. Labadie
Kia, Abdolrahim	Tabriz	Physico-social processes in hydraulic structures.	M. L. Albertson
Lopez S., Jose L.	Venezuela	Mathematical modeling of sediment deposition in reservoirs.	E. V. Richardson
Samad, Md. Abdus	Bangladesh	Analysis of riprap for channel stabilization.	D. B. Simons
Shiao, Larry Y.	Taiwan	Water and sediment yield from small watersheds.	D. B. Simons
Taesombut, Viraphol	Thailand	Use of partial flood series to estimate distribution of annual floods.	V. Yevjevich
Taylor, Donald C.	USA	Management for interdisciplinary effectiveness in research.	M. L. Albertson
Wu, Yao-Huang	Taiwan	Effect of roughness and its spatial variability on runoff hydrographs.	V. Yevjevich
MASTER OF SCIENCE, 1979			
Al-Dabakh, Abdulsattar	Iraq	Plan B - Hydrology and water resources.	V. Yevjevich
Buchberger, Steven G.	USA	The transport of soluble nonpoint source pollutants during the rising hydrograph.	T. G. Sanders
Cardenas, Robert L.	USA	Plan B - Hydraulics.	J. A. Gessler
Correia, Francisco C. da G. N.	Portugal	Plan B - Hydrology and water resources.	H. J. Morel-Seytoux
Delgadillo, Pablo A.	Mexico	Plan B - Hydraulics.	E. V. Richardson
Demery, Phillip M.	USA	Laboratory testing of plastic filters.	Y. H. Chen
Ellis, Sherman R.	USA	Plan B - Hydrology and water resources.	T. G. Sanders
Farber, Martin A.	USA	Use of reservoir selective withdrawal for water quality management.	J. Labadie
Ferentchak, James A.	USA	Investigation of the influence of groundwater on sandstone type uranium deposits.	N. V. Ortiz D. K. Sunada
Ghaheri, Abbas	Iran	Plan B - Hydrology and water resources.	H. J. Morel-Seytoux
Gomez, Jerry A.	USA	Plan B - Hydraulics.	R. M. Gutkowski

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
MASTER OF SCIENCE, 1979 (Cont.)			
Harada, Yukiharu	Japan	Plan B - Hydrology and water resources.	H. J. Morel-Seytoux
Hernandez, Ivan D. O.	Colombia	Properties and utility of extremal distributions in modeling hydrologic data.	H. W. Shen
Ingram, John J.	USA	Chemical transfer from a saturated soil into overland flow.	D. A. Woolhiser
Jarrett, Robert D.	USA	Plan B - Hydraulics.	E. V. Richardson
Khosrowpanah, Shahram	Iran	Plan B - Hydraulics.	J. A. Gessler
Kircher, James E.	USA	A case study on the Big Sandy River basin, Wyoming.	E. V. Richardson
Leonard, Gordon A.		Plan B - Hydraulics.	A. H. Barnes
Lindell, Laurel A.	USA	A comparison and sensitivity analysis of selected infiltration equations.	H. J. Morel-Seytoux
Linnane, William F.	USA	Plan B - Hydraulics.	E. V. Richardson
Lou, Wellington C.	Brazil	Plan B - Hydrology and hydraulics.	J. D. Salas
Lowham, Hugh W.	USA	An analysis of stream temperature, Green River basin, Wyoming.	D. B. Simons
Lu, Jau-Yau	Taiwan	A sediment transport equation from nonlinear regression analysis.	R. M. Li
Luvira, Somboon	Thailand	Plan B - Hydrology and water resources.	J. Labadie
Lux, Frederick, III	Canada	Rating of segmental orifices for use in an irrigation shunt line meter.	J. F. Ruff
Mefford, Brent W.	USA	Rating broad crested V-notch weirs for different appraoch channels.	J. F. Ruff
Pick, Thomas A.	USA	Plan B - Hydrology.	V. Yevjevich
Schall, James D.	USA	Spatial and time distribution of boundary shear stress in open channel flows.	R. M. Li
Scott, John F., III	USA	Precipitation management techniques to facilitate mine spoil reclamation.	W. A. Hall
Stoner, Jeffrey D.	USA	Plan B - Groundwater.	D. K. Sunada
Wana-Etyem, Charles	Uganda	Plan B - Hydrology and water resources.	V. Yevjevich
Wlaschin, Patrick D.	USA	Plan B - Hydrology and water resources.	T. G. Sanders
DOCTOR OF PHILOSOPHY, 1979			
Bouwmeester, Reinier J. B.	Netherlands	Wind characteristics over ridges.	R. N. Meroney
Daly, Charles J.	USA	Analytical/numerical methods for groundwater flow and quality problems.	H. J. Morel-Seytoux

NAME	COUNTRY	RESEARCH SUBJECT	ADVISOR
DOCTOR OF PHILOSOPHY, 1979 (Cont.)			
Illangasekare, Tissa H.	Ceylon	Influence coefficients generator suitable for stream-aquifer management.	H. J. Morel-Seytoux
Kareem, Ahsan	Pakistan	Wind excited motion of buildings.	J. E. Cermak
Kothari, Kirankumar M.	India	Stably stratified building wakes.	J. A. Peterka
Morrow, Dennis M.	USA	Optimal real-time computer control of unsteady flow in combined sewers.	J. Labadie
Nazar, Ata M.	Afghanistan	Risk avoidance in the operation of a water supply system (Qalagai Project in Afghanistan).	M. L. Albertson
Nualchawee, Kaew	Thailand	Spatial land cover inventory, modeling, and projection/Northern Thailand.	L. D. Miller
Park, John K.	Korea	Cluster analysis based on density estimate and its application to landsat imagery.	Y. H. Chen L. D. Miller
Petersen, Ronald L.	USA	Plume rise and dispersion for varying ambient turbulence, thermal stratification and stack exit conditions.	J. E. Cermak
Riordan, Eugene J.	USA	Development of a drainage and flood control management system for urbanizing communities.	W. A. Hall
Shafer, John M.	USA	An interactive river basin water management model: Synthesis and application.	J. Labadie
Tucci, Carlos E. M.	Brazil	Hydraulic and water quality model for a river network.	D. B. Simons
Vieira, Vicente de Paulo P. B.	Brazil	Risk assessment in the evaluation of water resources projects.	W. A. Hall
Wurbs, Ralph A.	USA	Flood damage reduction system optimization.	J. Labadie E. V. Richardson
MASTER OF SCIENCE, 1980			
Ballantine, Michael J.	USA	Methodology for estimating sediment and erosion yields using a digital computer for forest land use alternatives.	R. M. Li T. J. Ward
Bell, Gregory J.	USA	Turbulent boundary layer skin friction predictions.	V. A. Sandborn
Bergendahl, Bart S.	USA	Plan B - Hydraulics.	E. V. Richardson
Book, Dale E.	USA	A dynamic hydraulic model for simulation and evaluation of complex drainage systems.	J. W. Labadie
Bormann, Noel E.	USA	Plan B - Hydraulics.	A. H. Barnes
Bosley, Charles M.	USA	Computer-assisted water administration for the Poudre River system.	E. V. Richardson
Burow, Andrew M.	USA	Plan B - Groundwater.	R. A. Longenbaugh
Cadavid, Juan L.	Columbia	Plan B - Hydraulics.	D. B. Simons T. J. Ward

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MASTER OF SCIENCE, 1980 (Cont.)			
Caicedo, Nelson O. L.	Brazil	Plan B - Groundwater.	H. J. Morel-Seytoux
Coello, Mario L.	Honduras	Plan B - Water Resources Planning and Management.	W. A. Hall
Dixon, Michael J.	South Africa	Plan B - Hydrology and Water Resources.	T. G. Sanders
Dolanski, Darryl M.	USA	Plan B - Groundwater.	H. J. Morel-Seytoux
Eyck, Gregg, S. T.	USA	Plan B - Hydrology and water resources.	T. G. Sanders
Ghavam, Hamid R.	Iran	Plan B - Fluid Mechanics and Wind Engineering.	J. E. Cermak
Hartley, David M.	USA	Resistance to shallow flow through vegetation.	R. M. Li
Juinio, Editha B.	Philippines	Plan B - Water Resources Planning and Management.	W. A. Hall
Kiely, Gerard K.	Ireland	Plan B - Fluid Mechanics and Wind Engineering.	J. E. Cermak
Kimzey, Jan R.	USA	Flood control operations and optimization: a case study for Bonny Reservoir, Colorado.	J. D. Salas V. M. Yevjevich
Langhout, Cornelius	South Africa	Plan B - Water Resources Planning and Management.	W. A. Hall
Lopera, Eduardo	Colombia	Plan B - Hydraulics.	D. B. Simons T. J. Ward
Lovelace, Kenneth A., Jr.	USA	Hydrogeology of crystalline rocks in the Colorado Front Range.	D. K. Sunada J. P. Waltz
Marchegiani, Eric A.	USA	Plan B - Hydrology and Water Resources.	V. Yevjevich
Marco, Juan B.	Spain	A direct method for natural groundwater recharge estimation.	D. B. McWhorter
Mendoza-Cabrales, Cesar	Colombia	Headwall influence on scour at culvert outlets.	J. F. Ruff
Miller, Jeffrey E.	USA	Plan B - Hydraulics.	E. V. Richardson
Montgomery, Michael E.	USA	The uptake of monodisperse aerosals by plant canopies.	J. B. Wedding
Montgomery, Robert J.	USA	A data-based evaluation of the SCS curve number method for runoff prediction.	R. E. Smith
Morawski, Timothy E.	USA	Theory and design of irrigation pipe lines to minimize sediment deposition.	Y. H. Chen V. M. Ponce
Orvis, Curtis J.	USA	An analysis of steep channel control structures	R. M. Li D. B. Simons
Piatt, Jill E.	USA	Efficient estimation of flood peaks.	V. Yevjevich
Saez-Benito Godino, Jose M.	Spain	A one-dimensional water and sediment routing model of pools 5-8 in the Mississippi River system.	Y. H. Chen
Sant'ana, Ruy F.	Brazil	Plan B - Hydraulics.	R. M. Li

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MASTER OF SCIENCE, 1980 (Cont.)			
Santos, Emidio G.	Portugal	Plan B - Hydraulics.	V. M. Ponce
Sawatsky, Leslie F.	Canada	Plan B - Hydraulics.	D. B. Simons
Shaikh, Alaeddin	Iran	Scour in uniform and graded gravel at culvert outlets.	J. F. Ruff
Sinou, Jean M.	France	Plan B - Fluid Mechanics and Wind Engineering.	J. E. Cermak J. A. Peterka
Sunday, Ginger K.	USA	Role of rill development in Salt loading from hillslopes.	H. W. Shen
Templo, Pedro Tersol, Jr.	Philippines	Plan B - Groundwater.	H. J. Morel-Seytoux
Tilleard, John W.	Australia	Data requirements for analysis of river response and stability	R. M. Li D. B. Simons
Tsivoglou, Andrew J.	USA	Plan B - Hydraulics.	V. M. Ponce
Urias-Martinez, Adolfo	Mexico	Plan B - Groundwater.	R. A. Longenbaugh
Waimin-Ramos, Marco	Honduras	Plan B - Water Resources Planning and Management.	W. A. Hall
Webb, Jerry W.	USA	Plan B - Hydraulics.	E. V. Richardson
Yabusaki, Steven B.	USA	Mathematical modeling of circulation in open channels.	V. M. Ponce
DOCTOR OF PHILOSOPHY, 1980			
Abt, Steven R.	USA	Scour at culvert outlets in cohesive bed material	J. F. Ruff
Anderberg, Lars A. W.	Sweden	The anticipated decision influence period in real time reservoir operation.	W. A. Hall
Bazaraa, Abdallah S.	Egypt	Experimental/analytical investigation of the recharge rates to a groundwater table.	H. J. Morel-Seytoux
Coutinho, Miguel M. J. de Azevedo	Portugal	Simulation model for the design of alluvial canals.	D. B. Simons
Eggert, Kenneth G.	USA	Hydrologic simulation for predicting nonpoint source pollution.	D. B. Simons R. M. Li
Faris, Bashir M.	Libya	Alternative uses of water qualities in irrigation.	M. L. Albertson
Hazan, Nisim I.	Israel	Turbulent flow in a rectangular cavity.	J. E. Cermak W. Z. Sadeh
Hebaus, George G.	USA	Sloshing flow over two-way drop inlet crests.	M. L. Albertson
Layla, Rasheed I.	Saudi Arabia	Numerical analysis of transient salt/fresh-water interface in coastal aquifers.	N. V. Ortiz D. K. Sunada
Lokrou, Vincent P.	Ivory Coast	Characteristics of flow in channel abrupt expansion.	H. W. Shen
Quesado-Mateo, Carlos A.	Costa Rica	Effect of reservoir sedimentation and streamflow modification on firm power generation.	W. A. Hall