The Utah Water Journal

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Drought

(Map, courtesy of the Utah Division of Water Resources)

"When the well is dry, we learn the worth of water"
-- Ben Franklin

UWRL Memorial Scholarship

Contributors

Mr. Bob Morgan - Utah Department of Natural Res.
Ryan Anderson, MS Student, USU, CEE Department
Jan Urroz - Historical Highlight and Graduate Students 1969 and 1970 -- UWRL Administrative Assistant
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Dr. Ronald C. Sims, UWRL Director

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I teach a physical education class at Utah State University that is based on and directly related to my professional career in water, and helps participants to become more flexible, increase body strength and stamina, and dissipate physical stress and pressure in ways that improve their health and well-being. Through a series of body movements, stretches, turns, and rolls, students learn how to physically behave and act like water in its various pathways. The physical exercises and techniques represent a "hands-on" simulation of the way water moves through paths and around objects, sometimes like laminar flow in ground water systems and sometimes like turbulent flow in surface water systems. Through this class, based on the martial art of Aikido, I teach students how they can remain flexible and fluid in the long term as a life-long skill using water as their preceptor.

Taking water as my preceptor, I am making a change in my career path at USU that I hope will improve the professional health and well-being of myself, the College of Engineering, and USU. I will continue to teach PE 1500 and to be involved in research and coursework related to water. However, as of April 8, 2003, I am doing this from the administrative position of Interim Head of the Department of Biological and Irrigation Engineering (BIE), and Interim Associate Director of the Utah Water Research Laboratory. In this capacity, I am working to facilitate new pathways through joint research, teaching, and outreach opportunities between the UWRL and the BIE Department. Dean Scott Hinton offered me the opportunity to help establish stronger linkages in the water areas of the BIE Department and the UWRL, and also to help build the relatively new academic program in Biological Engineering within the BIE Department. My terminal degree (PhD) is in Biological and Agricultural Engineering and I, like many others within the Civil and Environmental Engineering (CEE) and BIE Departments, would be technically appropriate in either/both department(s).

Mac McKee, formerly the UWRL Associate Director, is currently Interim Director and is also working with the BIE Department. Mac is interested in working with faculty to develop new international projects in the water area, and there are many opportunities to open up new dialogue between the UWRL and the International Irrigation Center (IIC) and other faculty in the BIE Department to pursue large-scale multidisciplinary joint water projects. Also, there is a need in the BIE Department to increase the number of faculty with life science backgrounds to work with new faculty in the areas of biomedical, biosensor, biomechanical, and bioreactor engineering. Therefore, in addition to myself, UWRL-associated faculty including Thom Hardy, Darwin Sorensen, Joan McLean, and Judy Sims now have primary appointments in the BIE Department. This group will remain within the UWRL and Division of Environmental Engineering in the Civil and Environmental Engineering (CEE) Department, and will work with the BIE faculty in both the irrigation/water area and the biological engineering area. So we are establishing BIE linkages in the water resources, fluid mechanics, and water quality areas.

Under this arrangement, I will be operating from the UWRL/BIE perspective and Mac McKee will be operating from the UWRL/CEE perspective. We plan to take advantage of this opportunity to support engineering water-related program development and student recruitment, and to support research growth and international project development to make our water engineering programs even more robust and healthier than they are now. As a result we hope to improve the vitality and quality of programs in a manner similar to the conjunctive use of water resources.

I have very much enjoyed and appreciated the opportunity to function as Director of the UWRL since November, 1996, and to work with and support the faculty, staff, students, and USU administrators who have been a part of my career path during this time. I value the support and trust of the faculty, staff, students, and administration over the past 6 years.

Together we have increased the annual research-based support from approximately $4.5 million to nearly $10 million. This growth has been accompanied by an increase in programs, staff, publications, and efficiency with approximately the same number of faculty that we had in 1996. I look forward to continuing to work with the same excellent people as we continue to develop new and stronger pathways together within the College of Engineering in water research, education, and outreach at USU.

By the way, in my PE class I also encourage students to drink lots of water, as it also promotes internal health and well-being! I invite you to join me this Fall Semester in PE 1500, Introduction to Aikido to learn more about water as a preceptor.

The UWJ is sponsored and supported by the Utah Water Research Laboratory (UWRL) at Utah State University (USU).

Drought

by Bob Morgan**

**The Guest Editorial for this edition of the Water Journal is authored by Mr. Bob Morgan, Executive Director of the Utah Department of Natural Resources. Mr. Morgan, who is a former State Engineer, has served various posts in state government and has given several decades of service to the citizens of Utah in the water sector. His remarks here derive from a presentation he gave to the 2003 annual conference of the Utah Chapter of the American Water Resources Association, held in Salt Lake City on May 20, 2003.

"When the well is dry, we learn the worth of water."
-- Ben Franklin, from Poor Richard's Almanac, 1733.

I don't know if Ben Franklin ever came out West, but we all know that the well is getting dangerously low. Drought is a sneaky thing. For the first two or three years, we think things will change and then we finally realize that we have been set up and this drought thing is real.

To date, with the exception of one or two incidents in rural Utah, there have been no interruptions to culinary water supplies. Monticello has restricted outside watering to two hours per week and most Utah wholesalers and retailers of water have eliminated outside watering between 10:00 a.m. and 6:00 p.m. We are, though, in the fifth year of a drought and the agricultural industry has been hit hard. Alfalfa production is down and range conditions in most parts of the state are tough. Many cattle producers were forced to liquidate some of their herds last year.

Reservoir storage did get a little runoff during the first part of June but levels are dropping dramatically. Soil moisture is low and resulting levels and flows in springs has gone down. Ground water levels have dropped and many well owners have been forced to lower pumps.

Our watersheds are not looking great. The spruce beetle has killed approximately 1.8 million trees and others are being stressed by the lack of water, and grazing is at an all time low. We now see decreases in wildlife species, poor range health, reduced grazing and loss of revenues. Low water flows also are impacting fisheries and hatcheries that supply the fish. Isn't this great! It sounds like the ancient plagues.

So, what are we going to do? This has been a great educational opportunity and the public as well as the water community has learned from it. We are conserving and it is making a difference. Will we continue to conserve once the drought is over? Will we be prepared for the next million and a half people that are expected by 2025? Will we reverse the trends of our watersheds? Will open space and green areas be preserved to give us those experiences and clean air?

We must plan for the future. If there are to be water projects they will take time to develop and plan. We must be able to plan and implement the use of this finite amount of water into the infinite demands and uses that will compete for it in the future.

(Map, courtesy of the Utah Division of Water Resources)

UWRL Memorial Scholarship

In 1985 a Memorial Scholarship was started at the Utah Water Research Laboratory (UWRL) in memory of Barbara South and Duard S. Woffinden, who both passed away while employed at the UWRL. The scholarship is offered to UWRL staff and family of UWRL faculty and staff who are pursuing an education at Utah State University.

This is a wonderful opportunity for our staff and their family members to pursue their education and also a nice tribute to our past employees who served us well. The amount that is currently in the scholarship was attained through donations from UWRL employees. We would like to challenge all those who are not currently contributing to submit a payroll deduction form today or make a contribution and help make a difference.

If you would like to contribute to the UWRL Memorial Scholarship, please go to "Scholarship."

BARBARA SOUTH

April 16, 1983 has to be the saddest day in the history of the Utah Water Research Laboratory. Barbara South died that morning. She was our co-worker, our friend, and we loved her. Her career began with the water research program at Utah State and her contribution has shaped the Utah Water Research Laboratory from its beginning. She joined the Utah State University staff in February 1964 as a clerk typist in the engineering experiment station under the direction of Vaughn E. Hansen. At the completion of the UWRL facility, she moved into the new building, grew as the laboratory grew, and advanced to compositor typist coordinator and principal department clerk. But her imprints are not from titles. Her imprints are on the work she accomplished and the people she touched. Her imprints are deeply embedded in all that she touched because her work was her life--her family. She joyed as proposals she helped prepare, yes, more than just typed (always on hard deadlines and often into the wee hours and on weekends) gave birth to funded research. She tended the manuscript drafts that graduated into technical reports, some to be forgotten, some to contribute to improved water management, and some to awaken new research ideas. She transformed piles of scratchy notes into reports and papers and theses and dissertations that have made the careers of our researchers and have started countless students on roads to success. She lightened every else's load--students, co-workers, faculty, directors, and deans alike by unselfishly taking on the most tedious jobs. Her death is a personal loss to all she touched, and it leaves a tremendous void at the Utah Water Research Laboratory.

DUARD S. WOFFINDEN

Duard S. Woffinden, Senior Research Engineer when he was formal, which was hardly ever, and friend to everyone all the time, died suddenly at the Utah Water Research Laboratory on July 5, 1984 at the young age of 62. He was born at Garden City, Utah, and graduated from North Rich High School and from Utah State University with BS and MS degrees.

Every modern research laboratory requires electronic expertise, someone who goes beyond the theory and knows how boards and chips can be made to work right, that practical body who knows by instinct what is wrong, and how it can be fixed. Duard was the grandmaster, the man who would confidently see past the dead keyboard, flash-

ing screen, or smoldering wire and go to the heart of a problem when everyone else felt helpless, exasperated, and irritable. Duard is remembered with fondness for the cheerfulness that he brought into the room, the energy that he put into the assignment, and the joy with which he filled a gloomy day. He was never too busy to help, even if it required working on his own time, which if often did. He was a man whose words said and whose every joke emphasized that he didn't know anyone that he did not like.

Duard contributed greatly to the success of the research program at the UWRL since the lab's construction in 1965. Prior to that time, he worked at the Sandia Atomic Energy Laboratory in Albuquerque, New Mexico; at the Supersonic Research Test Site in Hurricane, Utah; and the Electro Dynamics Laboratory at Utah State University. His technical competence, creative skills, and quiet unassuming attitude contributed immeasurably to the numerous research projects that were conducted at the laboratory.

Above everything and everyone, Duard loved his wife, Rose Marie, and his four sons and three daughters. He enjoyed being with them and was proud of their accomplishments. All of us at the UWRL pay tribute to Duard. He enhanced the growth and prestige of the UWRL, enriched our lives, and will long be remembered among us with love and respect.

Field Measurement Methods for Arsenic in Drinking Water

by Ryan Anderson

The Problem

The U.S. Environmental Protection Agency (USEPA) Office of Water in 2002 lowered the maximum contaminant level (MCL) for allowable levels of arsenic in drinking water from 50 micrograms per liter (µg/L) to 10 µg/L (USEPA, 2001). Long-term exposure to arsenic via drinking-water has been shown to cause cancer of the skin, lungs, urinary bladder, and kidney, as well as other skin changes such as pigmentation changes and thickening (hyperkeratosis).

With the implementation of the new rule, approximately 4,000 water utilities in the United States will be affected. As a result, these water utilities will need to reduce the level of arsenic in their drinking waters by implementing one or more of a number of available technologies or by mixing different source waters.

To optimize these treatment technologies, water utilities will need to monitor for arsenic. There are various arsenic measurement techniques used in the laboratory that have detection limits of 1 µg/L or less, but these instruments are costly and require a high degree of operator training. Many water treatment utilities, especially the smaller utilities that will be most impacted by the new MCL, do not own one of these instruments and must send samples off-site to a contract or state laboratory for analysis.

The goal of this project was to develop a fast, safe, easy-to-use, and relatively inexpensive portable field method that can accurately quantify arsenic in drinking water samples at the low µg/L level. Water utilities will be able to use this instrument to measure arsenic concentrations in the influent water and during treatment processes to optimize arsenic removal to aid in compliance with the new MCL.

Results

The method involves adding acid (hydrochloric acid, HCl) and a strong reducing agent (sodium borohydride, NaBH4) to a water sample, which causes arsenic present in the sample to evolve in the form of arsine gas (AsH3). A portable paper-tape arsine gas monitor is then used to measure the concentration of arsine that evolves from the sample (Figure 1).

Figure 1. Portable paper-tape monitor used to measure arsine gas

By relating the measured arsine gas concentrations from water samples with known arsenic concentrations, unknown arsenic concentrations can be determined (Figure 2). The method is capable of quantifying arsenic at concentrations from 0.5 µg/L to 20 µg/L.

Using this relationship, measurements of arsine gas concentrations were taken in the field at different utilities to determine the arsenic concentrations at those utilities. The results for the field method were compared to accepted two laboratory methods, Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and Hydride Generation Atomic Absorption (HGAA) (Figure 3).

At two of the sites (Utilities B and D), results were statistically the same as a proven laboratory method (HGAA), given a 95% confidence interval. The method was statistically similar for the two sites using ICP-MS, given a 99% confidence interval. At Utility C, the concentration measured by the field method was below the estimated Practical Quantification Level (PQL) of the method (2.5 µg/L) and within 2 µg/L of the concentration measured by HGAA and ICP-MS.

Conclusions

This new method is capable of measuring arsenic in water samples on-site, instead of requiring that sam-

ples be sent to a laboratory for analysis. Further work is required, however, to make this method even more accurate and reliable.

Knowing the arsenic concentrations in the influent water and during treatment processes at water treatment plants will help to optimize arsenic removal to aid in compliance with the new MCL requirement.

References

USEPA. 2001. National Primary Drinking Water Regulation; Arsenic and Clarifications to Compliance and New Source Contaminants Monitoring; Final Rule. Federal Register(66:14):6976-7066.

For more information please contact Dr. Laurie McNeill, (435) 797-1522 - Lmcneill@cc.usu.edu

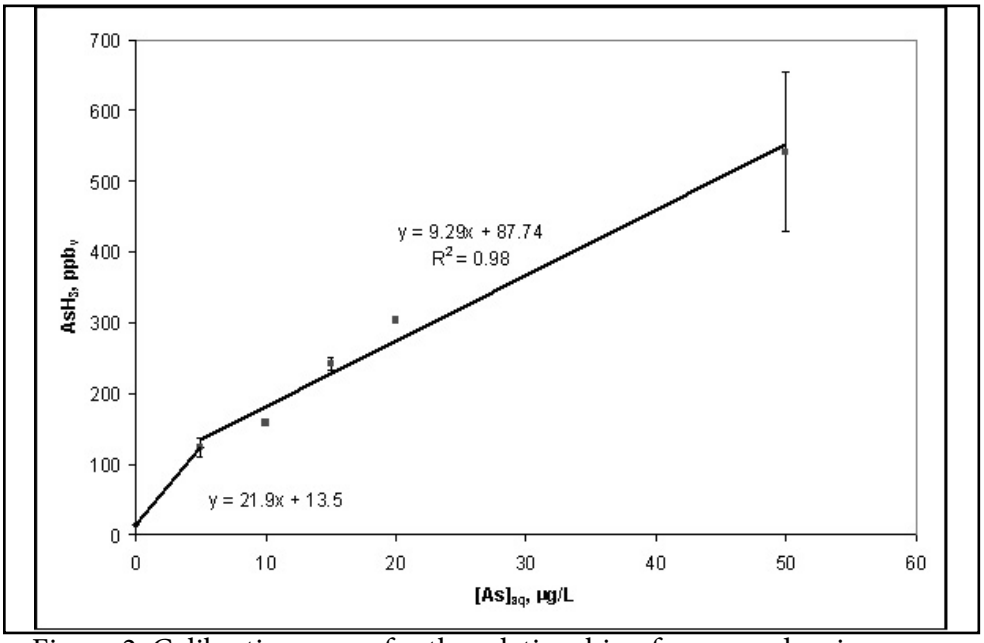

Figure 2: Calibration curve for the relationship of measured arsine gas concentration (AsH3, ppbv) using the paper-tape monitor to water samples with known arsenic concentrations ([As]aq, µg/L)

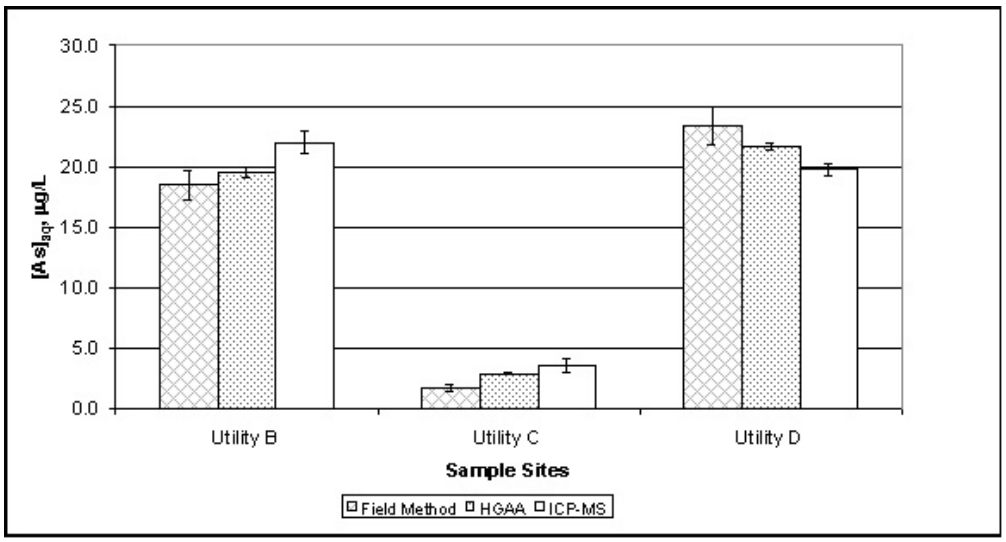

Figure 3: Comparison of results for the developed field method to hydride generation atomic absorption (HGAA) and inductively coupled plasma mass spectrometry (ICP-MS)

1969 Degrees from the College of Engineering

Doctorate Degrees 1969:

Amisal, Roger A. Gabriel
Port-au-Prince, Haiti
M.S.: Colorado State University, 1965
Major: Civil Engineering
Major Professor: Dr. J. Paul Riley
Dissertation: Analog Computer Solution of the Unsteady Flow Equations and its Use in Modeling the Surface Runoff Process

Devries, Richard Norman
Lincoln, Nebraska
M.S.: University of Nebraska, 1963
Major: Civil Engineering
Major Professor: Dr. Calvin G. Clyde
Dissertation: An Application of Optimization in Planning the Use of Multiple Water Sources that Supply Municipal Water Demands

Hoggan, Daniel H.
Logan, UT
M.S.: Stanford University, 1953
Major: Civil Engineering
Major Professor: Dr. Jay M. Bagley
Dissertation: State Organization Patterns for Comprehensive Planning of Water Resources Development

Manam, Pandurangarao Venkata
Mandras, India
M.S.: Indian Institute of Technology, 1960
Major: Civil Engineering
Major Professor: Dr. Gary Z. Watters
Dissertation: Effects of Effluent and Influent Seepage on the Hydrodynamic Forces Acting on a Noncohesive Sediment Particle

Milligan, James Homer
Logan, Utah
M.S.: Utah State University, 1963
Major: Civil Engineering
Major Professor: Dr. Calvin G. Clyde
Dissertation: Optimizing Conjunctive Use of Groundwater and Surface Water

Narayana, V.V. Dhruva
Gunter, India
M.S.: Utah State University, 1967
Major: Civil Engineering
Major Professor: Dr. Jay M. Bagley
Dissertation: Application of an Electronic Analog Computer Technique for the Evaluation of the Effects of Urbanization on the Runoff Characteristics of Small Watersheds

Packer, Murland Ray
Ririe, Idaho
M.S.: Utah State University, 1967
Major: Civil Engineering
Major Professor: Dr. J. Paul Riley
Dissertation: Simulation of the Hydrologic-Economic Flow System

Masters Degrees 1969:

Ballif, James Douglas
Preston, Idaho
B.S.: Utah State University
Major: Civil Engineering
Major Professor: Dr. Calvin G. Clyde
Thesis: A Conceptual Model of San Pitch River Basin

Bennion, David K.
Vernal, Utah
B.S.: Utah State University, 1968
Major: Civil Engineering
Major Professor: Dr. Winfred O. Carter
Thesis: A Computer Based Algorithm for the Analysis of Three Dimensional Frames

Chang, Tsing-Yuan
Hsin-Chu, Taiwan, China
B.S.: Taiwan University, 1953
Major: Civil Engineering
Major Professor: Professor Joel E. Fletcher
Thesis: Some Precipitation Characteristics for Utah

Chen, Yung-Kuang
Tou Fen Miaoli, Taiwan, Republic of China
B.S.: National Taiwan University, 1963
Major: Civil Engineering
Major Professor: Professor Vance T. Christiansen
Thesis: Applications of Numerical Methods to the Solution of Plates

Desai, Thakorbhai C.
Palsana, India
B.S.: M.S. University, Baroda, India, 1965
Major: Civil Engineering
Major Professor: Professor Vance T. Christiansen
Thesis: Cable Roof Structures

Hamid, Akhtar
Lahore, Pakistan
BS: Engineering University of Pakistan, 1965
Major: Irrigation Engineering
Major Professor: Dr. J. Lamar Anderson
Thesis: Plan B

Hung, Eldon Jing-Nan
Taiwan, China
B.S.: Cheng Kung University, 1965
Major: Civil Engineering
Major Professor: Professor Vance. T Christiansen
Thesis: Plan B

Larsen, Virgil Jack
Preston, Idaho
B.S.: Utah State University, 1964
Major: Civil Engineering
Major Professor: Dr. I.S. Dunn
Thesis: Determination of an Equilibrium Void Ratio in the Consolidation of Clay Soils

Li, Chun
Taiwan, China
B.S.: National Taiwan University
Major: Civil Engineering
Major Professor: Professor Vance T. Christiansen
Thesis: Plan B

McKee, M. Lynn
Tridell, Utah
B.S.: Utah State University, 1968
Major: Civil Engineering
Major Professor: Dr. J. Paul Riley
Thesis: Design Principles for the Surveillance of Salinity in River Systems

Parmar, Yash Paul Singh
Panjab, India
B.S.: Panjab Engineering College, 1961
Major: Civil Engineering
Major Professor: Dr. Winfred O. Carter
Thesis: Elastic Stability of a Slender Bar

Pitkin, Jay Brown
Logan, Utah
B.S.: Utah State University, 1967
Major: Civil Engineering
Major Professor: Dr. Norman B. Jones
Thesis: Plan B

Santana, Barry Wayne
Spokane, Washington
B.S.: Gonzaga University, 1967
Major: Civil Engineering
Major Professor: Dr. Elliot Rich
Thesis: Plan B

Tu, Kuen-Chun
Taipei, Taiwan, China
B.S.: Taiwan Provincial Cheng Kung University, 1965
Major: Civil Engineering
Major Professor: Dr. Winfred O. Carter
Thesis: An Algorithm for the Analysis of Three-Dimensional Orthogonally Intersecting Truss Systems

Wei, Chi-Yuan
Taipei, Taiwan, China
B.S.: Taiwan Christian College, 1963
Major: Civil Engineering
Major Professor: Professor Gaylord Skogerboe
Thesis: Design Criteria for USU Stilling Basin Pipe Flow to Open Channels

Yu, Robert Pi-Chang
Taipei, Taiwan, China
B.S.: Taiwan Cheng-Kung University, 1964
Major: Civil Engineering
Major Professor: Dr. Calvin G. Clyde
Thesis: Two-Dimensional Flow Resistance Over a Bed of Spherical Roughness Elements

Yu, Yung Hoon
Seoul, Korea
B.S.: Seoul National University, 1966
Major: Civil Engineering
Major Professor: Dr. Winfred O. Carter
Thesis: Moment-Curvature-Deflection Relationships of a Simply Supported, Inelastic Wide-Flange Beam Column Subjected to End Moments

1970 Degrees from the College of Engineering

Doctorate Degrees 1970:

Cheng, Edmund Dah-Hu
Taipei, Taiwan, China
B.S.: National Taiwan University, 1961
Major: Civil Engineering
Major Professor: Dr. Calvin G. Clyde
Dissertation: The Incipient Motion of Large Roughness Elements in Turbulent Open Channel Flow

Dixon, Neal Perry
Gooding, Idaho
M.S.: Utah State University, 1968
Major: Civil Engineering
Major Professor: Dr. David W. Hendricks
Dissertation: Simulation of Spatial and Temporal Changes in Water Quality Within a Hydrologic Unit

Eggleston, Keith Otis
Grover, Wyoming
M.S.: Utah State University, 1967
Major: Civil Engineering
Major Professor: Dr. J. Paul Riley
Dissertation: Simulation of the Snowmelt Processes

Hyatt, Milton Leon
Cedar City, Utah
M.S.: Utah State University, 1965
Major: Civil Engineering
Major Professor: Dr. J. Paul Riley
Dissertation: Simulation of the Salinity Flow System Within the Upper Colorado River Basin

Wang, Bi-Huei
Taipei, Taiwan
B.S.: SEATP Graduate School of Engineering, 1967
Major: Civil Engineering
Major Professor: Dr. Roland W. Jeppson
Dissertation: Influence of Mountain Groundwater on Streamflow

Masters Degrees 1970:

Austin, Tom Al
Dalhart, Texas
B.S.: Texas Technological College, 1967
Major: Civil Engineering
Major Professor: Professor Frank W. Haws
Thesis: Water Management Potential of the Bear River Delta

Basha, Mohammed Ameer
Cuddapah, India
B.S.: Unversity of Roorkee, 1961
Major: Civil Engineering
Major Professor: Dr. J. Paul Riley
Thesis: Plan B

Cahoon, Gary Roscoe
Pocatello, Idaho
B.S.: Utah State University, 1962
Major: Civil Engineering
Major Professor: Professor William A. Cordon
Thesis: The Relative Importance of the Past-Aggregate Ration on the Shrinkage of Concrete

Chang, Kuan Tao
Taipei, Taiwan
B.S.: Utah State University, 1968
Major: Civil Engineering
Major Professor: Professor Vance T. Christiansen
Thesis: Plan B

Dinsdale, Ramon Floyd
Ogden, Utah
B.S.: Utah State University, 1969
Major: Civil Engineering
Major Professor: Dr. Winfred O. Carter
Thesis: Plan B

Evelyn, Joseph B.
New York, New York
B.S.: Cooper Union, 1968
Major: Civil Engineering
Major Professor: Dr. J. Paul Riley
Thesis: Hydrograph Synthesis for Watershed Subzones

Gandhi, Atul N.
Ahmedabad, India
B.S.: L.D. College of Engineering, 1964
Major: Civil Engineering
Major Professor: Professor Vance T. Christiansen
Thesis: Plan B

Gold, Rick L.
Rexburg, Idaho
B.S.: Utah State University, 1968
Major: Civil Engineering
Major Professor: Dr. Calvin G. Clyde
Thesis: Plan B

Huang, Lie-Rong
Tainan, Taiwan
B.S.: Taiwan Cheng Kung University, 1967
Major: Civil Engineering
Major Professor: Vance T. Christiansen
Thesis: Plan B

Johnson, Frank Ralph, Jr.
Honolulu, Hawaii
B.S.: Utah State University, 1969
Major: Civil Engineering
Major Professor: Dr. Winfred O. Carter
Thesis: An Interactive Design Algorithm for Pre-stressed Concrete Bridge Girders

Lad, Prakash Shripad
Bombay, India
B.S.: Walchand College of Engineering, 1963
Major: Civil Engineering
Major Professor: Dr. Elliot Rich
Thesis: Plan B

Naik, Dilip T.
Amalsad, India
B.S.: University of Baroda, 1968
Major: Civil Engineering
Major Professor: Dr. Winfred O. Carter
Thesis: Plan B

Paluso, Joseph Thomas
B.S.: Utah State University, 1968
Major: Civil Engineering
Major Professor: Professor William A. Cordon
Thesis: The Comparison of Laboratory Freezing and Thawing Test of Concrete and the Magnesium Sulfate Test on Aggregates in Predicting the Freezing and Thawing Resistance of Concrete

Patel, Ishverbhai Muljibhai
Gujrat, India
B.S.: L.D. College of Engineering, 1959
Major: Civil Engineering
Major Professor: Professor Vance T. Christiansen
Thesis: Plan B

Sandhu, Inder Pal Singh
Chandigarh, India
B.S.: Punjab Engineering College, 1966
Major: Civil Engineering
Major Professor: Dr. J. Paul Riley
Thesis: Plan B

Seamone, Douglas Archibald
Bridgewater, Nova Scotia
B.S.: Nova Scotia Technical College, 1957
Major: Civil Engineering
Major Professor: Dr. Daniel H. Hoggan
Thesis: Evaluation and Study of a Surface and Ground-water Supply for the Town of Wolfville, Nova Scotia

Sial, Muhammad Akbar
Lyallpur, West Pakistan
B.S.: West Pakistan Agricultural University, 1967
Major: Civil Engineering
Major Professor: Dr. J. Paul Riley
Thesis: The Effects of Watershed and Storm Parameters on the Runoff Characteristics of Small Watersheds

Singh, Kuldip
Amritsar, India
B.S.: Punjab University, 1961
Major: Civil Engineering
Major Professor: Dr. Elliot Rich
Thesis: Plan B

Walker, Clive Hansen
Casper, Wyoming
B.S.: Utah State University, 1960
Major: Civil Engineering
Major Professor: Professor Joel E. Fletcher
Thesis: Estimating the Rainfall-Runoff Characteristics of Selected Small Utah Watersheds