The St. Anthony Falls Laboratory: A Rich History and A Bright Future

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Abstract

A sketch of the history of the St. Anthony Falls Hydraulic Laboratory at the University of Minnesota is presented.

Introduction

The St. Anthony Falls Hydraulic Laboratory was dedicated on November 17, 1938. To reflect the growing diversity of laboratory activities beyond hydraulics, the name was changed in 1995 to St. Anthony Falls Laboratory: Engineering, Environmental and Geophysical Fluid Dynamics. Often called SAFL, the laboratory has been dedicated to water resources research, education and technology transfer since its beginning. A detailed early history of the Laboratory and its personnel may be found in a book by Mary Marsh, The St. Anthony Falls Hydraulic Laboratory, the First Fifty Years (Marsh, 1987). Rouse (1976) also provides information on SAFL. In 2003 several of the Laboratory's former directors wrote The St. Anthony Falls Laboratory in History (Silberman et al., 2003), which gives an up-date of Marsh's account. In this brief paper, information is excerpted from Silberman et al. (2003), and supplemented to describe how the Laboratory came to exist, how it developed and what was accomplished. We also delineate the current and envisioned future course of SAFL.

The Idea of a Laboratory on the Mississippi River

St. Anthony Falls on the Mississippi River was first suggested as a laboratory site in 1908. The city of Minneapolis water supply plant located on Hennepin Island at the Falls had been abandoned a few years earlier (following a typhoid epidemic). The head of the city's engineering department wrote to the Dean of the College of Engineering at the University of Minnesota that this would be an excellent place to develop a hydraulic laboratory. It was noted that water rights would be acquired with the site, which was located just two miles from the University's Engineering building. Nothing was produced by this letter or early reports which emphasized that a laboratory would be used to study pumps and turbines, and that support could be expected from manufacturers of those machines as well as from a potential hydropower industry in Minnesota.

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Also noted was the potential for developing and calibrating instruments and making river models. In 1938 a laboratory building was completed at the Falls of St. Anthony across from downtown Minneapolis, Minnesota (Figure 1). There is a natural drop of about 15 meters of hydraulic head available, and over 8 m^3/s (300 cfs) of water may be drawn through the building and distributed to pipes, flumes and tanks for experimental research. Today's laboratory is quite different from its original. The evolution will be described in the following pages.

The Role of Lorenz G. Straub (1930 to 1963)

The St. Anthony Falls Hydraulic Laboratory was designed and built under the direction of Dr. Lorenz G. Straub, a native of Kansas City, Missouri, who had obtained degrees, including a Ph.D. in 1927, in Civil Engineering from the University of Illinois. As a Freeman Fellow, Straub had the opportunity to observe hydraulic laboratories in Germany and Holland during a two-year period. After his return he was employed briefly by the U.S. Army Corps of Engineers and came to the University of Minnesota in 1930. Straub's position was created with the intent that the University would build a hydraulic laboratory and form a department to teach and do research in hydraulic engineering and related areas of fluid mechanics. Building a laboratory was rendered difficult by the Great Depression. A Works Progress Administration (WPA) grant facilitated the beginning of construction of the laboratory in 1936. With the help of an early associate, John F. Ripken, Straub designed the laboratory and the equipment that went into it at the time. The laboratory was built, and the dedication was held in 1938. Straub was not officially named its Director until 1942.

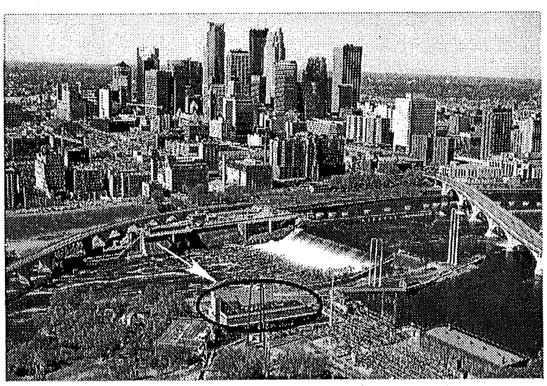

Figure 1: **St. Anthony Falls on the Mississippi River at Minneapolis and location of the St. Anthony Falls Laboratory.**

Straub's early research was largely on sediment transport in open channels, flow in porous media and stability of earthen dams. He encouraged several of his graduate students to undertake experimental theses in areas of fluid mechanics such as viscous flow in channels. He also succeeded in bringing sponsored experimental research to support the Laboratory. He encouraged one of his doctoral students to undertake experiments on surface air entrainment in high velocity free surface flow. This continued as an important research area well into the 1950s and resulted in publication of a prize-winning paper (Straub and Anderson, 1958). Another student of that period, John S. McNown, who obtained his Ph.D. in 1942, later wrote a very perceptive article about Straub (McNown, 1992).

Before a fully developed program could be established at the Laboratory, Straub and most of his assistants were called to participate in civilian activities related to World War II. Straub went to New York City to serve on the National Defense Research Committee. He returned in January of 1945 and negotiated an almost autonomous Laboratory and a European type "chair" within the University's Institute of Technology. He agreed to become head of the newly created Department of Civil and Hydraulic Engineering. He also brought back to the Laboratory three of his former graduate students (Alvin G.

Anderson, John F. Ripken, and Edward Silberman) to lead the research program and to do much of the teaching, all under his close supervision. A picture of the faculty and principal research team at SAFL in 1958 is shown in Figure 2.

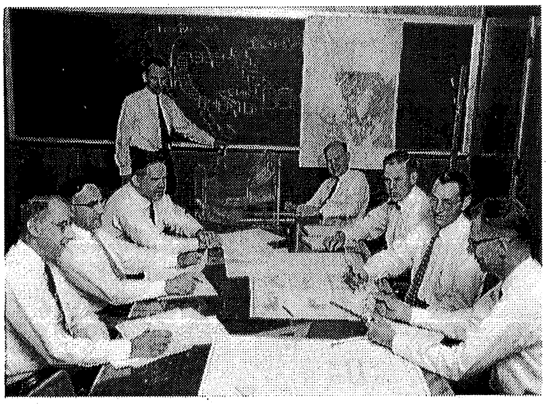

Figure 2: **Meeting of faculty and principal researchers at SAFL in 1958 (clockwise from left: C. Edward Bowers, Edward Silberman, Alvin G. Anderson, Al Mercer standing, Lorenz G. Straub under map of Passamaquoddy Bay, a projected tidal power plant site, John F. Ripken, Loyal Johnson and Sigurd Anderson).**

Straub carried on an intensive consulting practice, often in cooperation with Harza Engineering Company in Chicago, and brought in many hydraulic model studies that supported the laboratory financially. Many of these studies were for very large water resources development projects, e.g. on the Missouri river or abroad. Straub became recognized internationally for his ability to diagnose and recommend solutions to hydraulic engineering problems and was dubbed the "River Doctor" by a national magazine. His diabetes and intense work regime caught up with him, and he was found dead at his desk early Monday morning, October 28, 1963. Two memorials exist in his name at the Laboratory: The Lorenz G. Straub Memorial Library at SAFL, and the Lorenz G. Straub Award, established by contributions from his colleagues and industrial contacts. The award is made annually to the author of an outstanding Ph.D. thesis in hydraulics or a closely related area.

The legacy left by Straub is more than just a laboratory building and the equipment it contains. His vision of a university laboratory advancing pioneering methods in water resources engineering while serving as an educational tool lives on. Today SAFL explores cutting edge research on environmental and geophysical fluid dynamics and continues to apply state-of-the-art knowledge to a wide variety of water-, air- and sediment-related problems.

Original Laboratory Building and Facilities

The Laboratory layout is described by Straub as follows: "The main experimental laboratory is approximately 300 feet long and 45 feet wide. It is two stories high and contains three large channels extending the entire length of the structure. One is an overhead of flume 8 feet wide and 9 feet deep, connected directly to the headwater above the falls, and is provided with numerous off-takes to supply water for the various experimental projects. The others are low-level channels below the level of the main floor. Of these, one is a wasteway and the other an experimental flume arranged for a wide variety of experiments. It is 9 feet wide and 6 feet deep, and is supplied directly from the upper pool of the river through a pressure tunnel. A towing car will make it possible to pull current meters, model ships, and the like through the flume with the water either at rest or in motion." With the later additions of mezzanines below, and a wind tunnel above, the laboratory now has six floors for research, teaching and administrative activities. The volumetric measuring basins just outside the Laboratory are the largest in the country and can handle a continuous flow up to 300cfs ($8.1 m^3/s$). They are so located that the flow from all but the lowest levels of the laboratory can be measured. This discharge measuring arrangement is used in large scale experiments and for calibrating large flow meters. For flow rates up to 15cfs, a pair of weighing tanks is available.

Straub was a perceptive observer, photographer and moviemaker. Flow visualization in laboratory experiments was one of his tools to show students and research sponsors particular flow phenomena and designs. An exceptionally large facility for flow visualization was in his original plans, but ultimately smaller flumes for flow visualization were built. A well-equipped dark room and movie-making lab were available and staffed by a full-time photographer throughout his lifetime.

Much was added to the Laboratory over the years under Straub's direction. Both John F. Ripken and C. Edward Bowers were assistants in the design of building additions and major facilities. Just before Straub's death, a new floor was completed. One end of this new wing was used to house the Lorenz G. Straub Memorial Library. Previously, the main experimental hall below had been divided in height by a new experimental floor. The upper level was called the River Model floor. Over the years, this space has been the location of a great number of model studies.

Research on cavitation and hydrofoil design for the Navy resulted in construction of a six-inch water tunnel, which was originally designed as a model for a sixty-inch tunnel for the David Taylor Model Basin of the U.S. Department of the Navy. Also added were a ten-inch free jet gravity-flow water tunnel (Silberman and Ripken, 1959) and a towing carriage for the nine-foot wide main channel. Both a mechanical and a pneumatic wave maker were designed for this channel to support research in the wave making process, as well as to test structures (both rigid and erodible) in waves. The channel and towing carriage were used to test hydrofoils and watercraft in waves. A larger tilting flume replaced the original one used in the air entrainment research (Straub and Anderson, 1958) but was later dismantled. Considerable effort was given to instrument development for use in these facilities. John M. Killen, a research fellow, and later Frank R. Schiebe led this effort. An acoustic wave sensor and an air concentration meter were early examples of such instrumentation.

Early Accomplishments

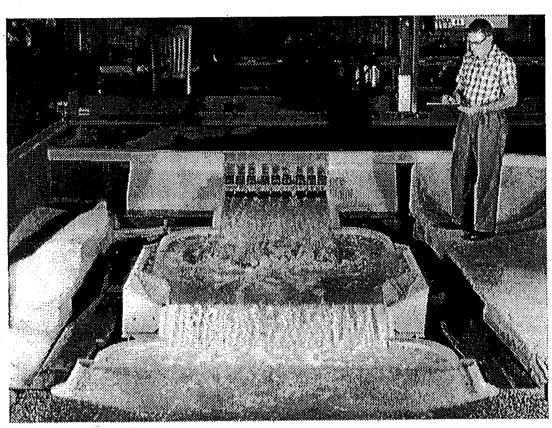

Figure 3: **Hydraulic scale model of the Mangla Dam spillway on the Jhelum River in Pakistan.**

Under Straub's leadership, SAFL became a laboratory for the study of some of the largest hydraulic structures in the world, among them the spillway and stilling basins for Mangla Dam on the Jhelum River in Pakistan (Figure 3) and Guri Dam in Venezuela.

Straub built and studied models of river sections, hydraulic structures, such as the failed spillway section of the Karnafuli Dam, gates of many types, fish ladders and coffer dams, e.g. for the Columbia River (Wanapum). Numerous other areas of fluid mechanics and hydraulics, both basic and applied, were addressed at SAFL: air-water mixture flow, non-Newtonian fluid flow, and boundary layers. The Navy used the Laboratory as a pilot research facility to study hydrofoil design and operation, and skin friction drag reduction. Information on flow in concrete culverts generated for the Minnesota Highway Department and the U.S. Public Roads Administration (C.L. Larson and H.M. Morris, 1948) found wide-spread use. Educational movies were produced at SAFL, and even today "Fluid Mechanics - The Boundary Layer" (Film No. 56) and "Flow in Culverts" (Film No. 4) are being requested, and are now available in VHS format. The Laboratory's Circular No. 3 (SAFL 1981) gives a complete list of publications from the broad research program during that time (**www.safl.umn.edu**).

A federal research group, the hydraulic structures research arm of the Soil Conservation Service, which later became the Agricultural Research Service (ARS), was also transferred to the Laboratory at that time. The lead researcher was Fred W. Blaisdell, well-known around the world for the generic design of small hydraulic structures for water conveyance and energy dissipation, including the "SAFL Stilling Basin" (Blaisdell, 1948). This group remained until the 1980s when it was integrated with another ARS group in Stillwater, Oklahoma. Later, the Federal Interagency Sedimentation Project was established at the Laboratory with personnel from the U.S. Geological Survey and the U.S. Army Corps of Engineers. It developed the currently used U.S. standard equipment and protocol for suspended sediment sampling in streams.

Results of studies conducted at the Laboratory were documented in a series of publications (SAFL, 1981). Project Reports were limited distribution publications, giving complete details of each project or study, and were intended for the sponsor and as a permanent record of the project. There were Technical Papers A which were reprints from peer-reviewed publications and papers presented at conferences and elsewhere. Technical Papers B were reviewed within the Laboratory and described research not published or presented elsewhere.

The Silberman/Anderson Years (1964 to 1974)

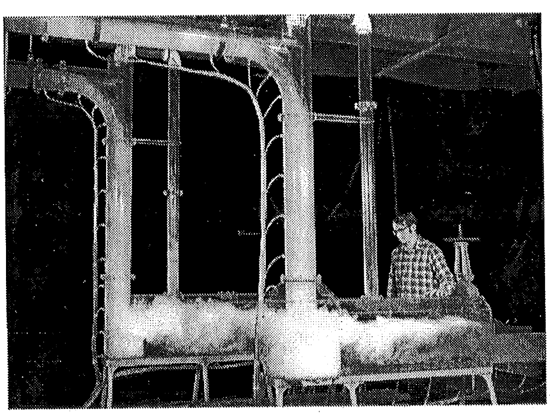

Figure 4: **Hydraulic scale models of two storm water drop shafts for the City of Chicago.**

After Straub's death, Edward Silberman, Professor of Civil Engineering, was appointed Director. Ed had been a student of Straub's and had conducted research on two-phase flow, hydrofoils, and basic fluid mechanics at SAFL. Under Silberman's leadership SAFL continued to flourish. Ongoing studies were continued or expanded; a second Guri Dam spillway model was built in Venezuela.

A federal mandate required control of water pollution from urban storm water discharges, and large underground drop structures were studied at SAFL in physical models for the city of Chicago (Figure 4). Alvin G. Anderson, also a Professor of Civil Engineering, assisted by fulltime laboratory staff, took charge of these applied studies and produced a number of movies for documentation and education. Ed Silberman edited and narrated a 16mm movie that summarized typical hydraulic model studies conducted at SAFL from 1950 to 1965 (Film No. 2, 1967 Edition).

As electric power production by coal- and nuclear-fuelled generating plants was expanded in the 1960s and 1970s, large amounts of waste heat had to be disposed of, primarily via cooling water. The mixing and recirculation of cooling water discharges in rivers, reservoirs and coastal regions posed a threat to licensing and operation of power plants. Physical model studies were used to find solutions. The first such study was conducted at SAFL in 1964 for Northern States Power Co. and involved the use of salt and freshwater to simulate thermally induced buoyancy. This was the birth of "Environmental Hydraulics" at SAFL. Heinz Stefan, who conducted the study together with Ed Silberman, was hired later (1967) as a faculty member to replace the deceased Loyal Johnson. Cooling water model studies (Figure 5) in the decade that followed used warm and cold water. Generic experimental studies conducted for the Federal Water Pollution Control Administration (FWPCA, later renamed EPA) provided basic information for the "Industrial Waste Guide on Thermal Pollution" and for integral numerical models of thermal plumes.

Straub had been a co-founder of the International Association of Hydraulic Research (IAHR), and membership records for that organization were kept at SAFL until they were transferred to Delft in the 1980s. During Silberman's tenure the American Water Resources Association (AWRA) was born, and Ed became an early president. In 1974 Ed Silberman stepped down and Alvin G. Anderson became SAFL Director with Heinz Stefan as Associate Director. Anderson, who was well known for his fundamental studies on air-entrainment and sediment transport (Figure 6), passed away in 1975. A memorial award, the Alvin G. Anderson Award, is made every year to a graduate student pursuing graduate studies at the University of Minnesota in the area of Hydraulic Engineering and/or Water Resources.

The Arndt Years (1977 to 1993)

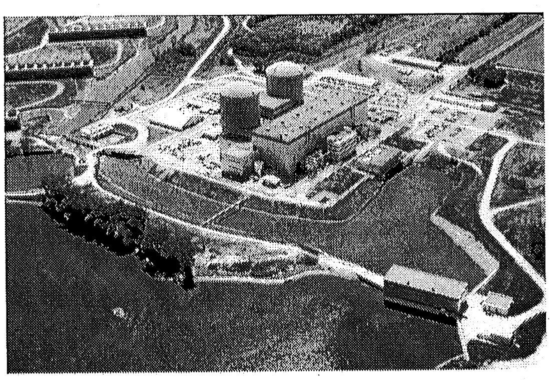

Figure 5: **Aerial view of cooling water recirculation, intake and discharge canals of the Prairie Island electric power generating plant that were modeled at SAFL.**

After an administrative interim of two years, with John F. Ripken serving as Acting Director, Roger Arndt was hired to lead the Laboratory. Roger had been the third recipient of the prestigious Straub Award after Hugo Fischer and William Sayre and brought a new focus to the laboratory. Fluid Mechanics had always been the foundation of the research at SAFL, but Roger moved it further into the limelight. He chose Fluid Mechanics Research as the theme of the SAFL 40th anniversary symposium in 1979 (Arndt and Marsh, 1981) and organized a national conference on Advances in Fluid Mechanics for ASCE (Arndt et al., 1986). The Laboratory had built its reputation on the use of hydraulic models for solution of hydraulic and river engineering problems, the development of specialized instrumentation, and naval hydrodynamics research. This activity was expanded to include topics such as computer simulation of water quality dynamics, aeration, fluid transients in large pipe networks, slurry transport and acoustic radiation from bubbly flows. Charles C. S. Song, who had been a student of Silberman's and held a faculty position in Civil Engineering, developed numerical flow-simulation techniques which to this date are being used to analyze transient flows in large urban storm sewer systems, supercritical flows in channels, and 3-dimensional flows through turbines.

Arndt also reinvigorated cavitation research at SAFL and initiated a program in hydropower research. The latter included a very successful series of professional development courses for hydropower practitioners and developers (Gulliver and Arndt, 1991), an inventory of Minnesota's hydropower potential, research on hydroturbine dynamics and aeration, as well as physical modeling and field studies of several small hydropower schemes in Minnesota.

During this time, the Legislative Commission for Minnesota Resources (LCMR) funded SAFL for state-related water resources and energy research. Support from the LCMR was significant over this period averaging roughly one-third of the budget for several years. LCMR-funded research projects addressed a host of environmental and energy-related issues of importance to the State. The Governor, Rudy Perpich, held a press conference on Energy Initiatives at the Laboratory.

Environmental topics were also addressed in a large interdisciplinary symposium on surface water reservoirs (Stefan, 1980), in lake restoration projects (Stefan, 1994) and in a research program on potential global warming effects on lakes and streams funded by the USEPA and USDA. Numerical modeling of lake processes led to the development of the MINLAKE model. A research program was conducted to develop a passive water intake screen, a technology now widely used by water and electric power utilities.

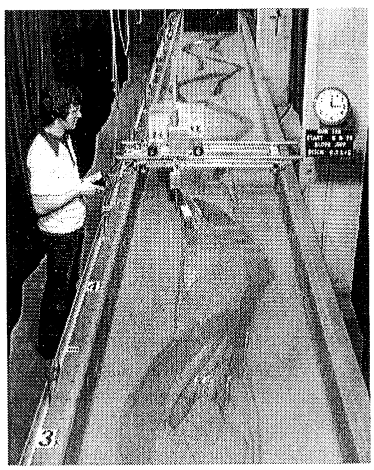

Figure 6: **Model of a meandering gravel river in SAFL's tilting flume.**

At this time the laboratory was selected by the U.S. Navy to develop hydrodynamic design of the Large Cavitation Channel (LCC), which is now the world's largest water tunnel. This large project permitted the laboratory to expand further into the field of computational fluid dynamics as a supplement to experimental research. The Laboratory's linkage with the University's new Supercomputer Institute provided the opportunity to meet the challenges during this period of expansion. The instrumentation capabilities at the Laboratory were vastly updated to include computer-based data acquisition. The US Office of Naval Research made a significant grant to the Laboratory for hydroacoustic research. Faculty from the Departments of Electrical Engineering and Aerospace Engineering and Mechanics collaborated in this research.

Several new faculty were appointed during this period. Vacancies were created by the retirements of Professors Ripken, Silberman and Bowers, and the death of Professor Anderson. The new faculty were Cesar Farell in 1978, Gary Parker and John Gulliver in 1980, Peter Kitanidis in 1984, and Efi Foufoula-Georgiou in 1989. Farell brought expertise in wind engineering and fluid mechanics. With NSF support he designed and built a boundary layer wind tunnel for studies in wind engineering and environmental mass transport. Parker was key to revitalizing research in river mechanics and fluvial hydraulics. Gulliver added engineering solutions as part of the water quality research program. He also played an active role in all phases of hydropower research. Kitanidis (who was hired to replace Edward Bowers in hydrology) remained at Minnesota only briefly and left to assume a faculty position at Stanford. Efi Foufoula-Georgiou replaced him, and developed a research program in space-time rainfall modeling, geomorphology and scaling in hydrologic processes utilizing sophisticated mathematical tools.

In spite of significant growth of the Laboratory during the 1980s, newly inaugurated President Keller recommended closure of SAFL along with other major University units as a cost-saving measure. The Lab's closure was averted as a result, in part, of a strong recommendation by an external review committee and the support of the LCMR. The receipt of the Outstanding Water Achievement Award from the American Water Resources Association in 1989 greatly encouraged all at the laboratory. Arndt stepped down as Director in June 1993 and went to the National Science Foundation in Washington DC from 1995-98. The Head of the Department of Civil Engineering, Steven Crouch, filled in as Acting Director of the Laboratory from June 1993 to February 1995. A Steering Committee managed the Laboratory. Gary Parker served as the committee head, and Heinz Stefan and Rick Voigt as members. Voigt was a research fellow who had succeeded Joseph Wetzel as Assistant Director for Applied Research in 1992.

The Parker/Foufoula Years (1995 to 2003)

Gary Parker was officially appointed to the Directorship of SAFL in February 1995 and immediately invited the participation of other University of Minnesota faculty at SAFL. Vaughan Voller in the Civil Engineering department, brought numerical modeling skills of great benefit to the Laboratory. Chris Paola, a professor in the Department of Geology and Geophysics, had long maintained a close relationship with Parker and SAFL. In the course of a project on the formation of an alluvial fan in the tailings basin of the Hibbing Taconite Mine in northern Minnesota, Paola proposed the idea of a unique experimental facility, one that could be used to study the morphodynamics of depositional basins, drainage basins and continental margins undergoing tectonic subsidence or uplift. A successful proposal by Paola and Parker to the National Science Foundation supported the construction of this facility, later dubbed the XES (eXperimental EarthScape) facility or "Jurassic Tank." The XES facility was designed and built with ingenuity and persistence by Jim Mullen and Chris Ellis at SAFL. The facility and a schematic of the mechanism for operation of this basin are illustrated in Figure 7. Featured in Science (Stokstad, 2000), it is the first system ever built capable of controlled physical experiments on the formation of large-scale stratigraphic patterns, which develop through the interplay of tectonic subsidence and sedimentation.

Parker developed a strong research program on turbidity currents and debris flows, using a variety of methodologies. In June 1999, Gary Parker stepped down, and was replaced by Efi Foufoula-Georgiou as the Director. Her research on stochastic hydrology and scaling theories of natural systems expanded the focus of SAFL's research to mathematical modeling of multiscale phenomena (see Foufoula-Georgiou and Kumar, 1994).

Two new faculty members were added to the Laboratory in 1999 to replace the retired Professors Charles Song and Cesar Farell. Miki Hondzo brought new expertise in eco-biological fluid dynamics (the interaction of water with biota), algae formation and biochemical processes in lakes, rivers and the coastal ocean. Fernando Porté-Agel brought expertise in atmospheric boundary layer turbulence, land-atmosphere interactions, field experimentation and large-eddy simulation modeling of boundary layer flows. Hondzo is currently building a new Eco-Fluids Laboratory, which features state-of-the-art equipment for biochemical analysis. Porté-Agel has rejuvenated SAFL's boundary layer wind tunnel use in combination with field and numerical studies of atmospheric boundary layers.

As the diversity of expertise within SAFL grew, researchers could address questions on turbulence, water quality, climate change, hydrometeorology, biochemistry, fluvial geomorphology, sedimentology and atmospheric transport, all in the same laboratory and by using a combination of experimental, computational and theoretical approaches (see **www.safl.umn.edu**). At the same time, SAFL's applied research program, headed by John Thene from 1999 to 2003 and Omid Mohseni after 2003, addressed old and new problems such as protection of fish at water intakes, scour protection for bridge piers, storm sewer system operation and environmental impacts of dam removal. SAFL is also developing better ways of predicting the geometry of potential oil reservoirs for the oil industry. Applied projects in recent years have been more diverse, smaller, and of shorter duration than in the laboratory's early years.

In 2002 SAFL's unique expertise in experimental, numerical and theoretical research in water and earth surface processes led to a successful proposal to the National Science Foundation for a new Science and Technology Center named *National Center for Earth-surface Dynamics* (NCED). NCED's (**www.nced.umn.edu**) vision is to identify and quantify the major physical, biological and chemical processes that shape the Earth's surface. The hallmark of NCED, as for all Science and Technology Centers, is integrative, multidisciplinary research with clear benefits for society. NCED involves the Departments of Civil Engineering, Geology & Geophysics, and Ecology, Evolution & Behavior at the University of Minnesota, as well as researchers from the University of California at Berkeley, Massachusetts Institute of Technology, Princeton University, and Fond du Lac Tribal and Community College. In addition, a strong partnership was formed with the Science Museum of Minnesota on educational programs including outdoor, hands-on exhibits on surface processes and engineering. The Science Museum partnership will bring some of the fascination of surface dynamics to the public along with its engineering challenges.

With the center came a major remodeling of the aging SAFL building. The laboratory now has renovated graduate student offices, a video conference center, a high-speed optic fiber data link to campus, and an updated electrical service capable of supplying adequate power to the facilities through the next century. Toward the end of providing the best research and educational experience to its graduate students, the laboratory's alumni funded the Graduate Student Fund in 1996. Today, SAFL houses eleven faculty members (a new faculty member, Lesley Perg from the Department of Geology and Geophysics has added expertise in biogeomorphology), approximately 60 graduate students and postdoctoral researchers, 20 undergraduate students and 10 full-time technical staff and research engineers and several support staff. Efi Foufoula-Georgiou stepped down as director in 2003, and John S. Gulliver, Head of the Department of Civil Engineering, is the current Director. Most of the active faculty are shown in Figure 8.

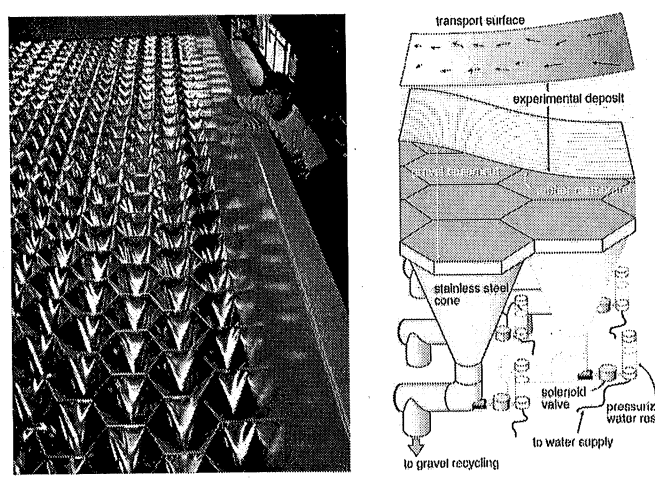

Figure 7: **eXperimental EarthScape (XES) Facility.**

Figure 8: **Faculty at SAFL in December 2003 (Back row from left to right: Miki Hondzo, Fernando Porté-Agel, Heinz Stefan, Efi Foufoula-Georgiou, John Gulliver, Lesley Perg, Roger Arndt. Front row from left to right: Gary Parker, Chris Paola, Edward Silberman. Vaughan Voller is not in the photo).**

SAFL has contributed to the education of more than 400 graduate students and numerous undergraduates. More than 100 visiting scholars and post-doctoral fellows from all over the world have spent up to two years in active collaboration with faculty and research staff. Hundreds of middle and high school students are given tours of the Lab annually to develop an appreciation of water resources research and associated career opportunities. In a typical year, roughly 10 M. S. and Ph.D. students graduate from the laboratory's programs with degrees in Civil Engineering, Water Resources Sciences, Mechanical or Aerospace Engineering, or in Geology and Geophysics. Researchers at SAFL have published over 700 refereed publications and close to 500 project reports in the last 65 years, in addition to books, book chapters, motion pictures and videos (see SAFL, 1981).

The Future

It has been recognized (NRC, 2001) that in the face of increasing water demand and stress on water resources, we have to take an integrated view of the water cycle and its part in society. Water has to be approached as the most important component of a complex environmental system. Water cannot be studied in isolation, but must be studied in conjunction with such interacting components as sediment, air, vegetation, chemical and biological agents, and humans.

We expect that experimental facilities will continue to be central to SAFL's mission, but our focus is on understanding processes. We expect to continue expanding our experimental capabilities with new facilities such as an Eco-Fluids Laboratory. Experiments and field work are most powerful when done in conjunction with theoretical analysis and modeling. Our theoretical research will continue to make use of in-house computing strength, backed by the University of Minnesota Digital Technology Center and the Minnesota Supercomputing Institute. SAFL's depth of research expertise, diversity in its faculty, and unique experimental facilities places it in a unique position to address significant problems related to water and land resource management in response to manmade or natural stresses.

Acknowledgments

Edward Silberman, Gary Parker, Chris Paola have contributed thoughts and text to this sketch of the SAFL history; Chris Ellis and Venugopal Vuruputur reviewed it. It was written during a week when Ed Silberman celebrated his 90th birthday, and Joseph Wetzel passed away. We are dedicating this brief paper to both of them.

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