

WINTER 1995

PROTECTING THE EARTH A SPECIAL ISSUE



WPI Journal

FEATURE

18 STEWARDS FOR A SMALL PLANET

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It's been more than three decades since Rachel Carson's *Silent Spring* awakened the world's environmental consciousness. In that time, hundreds of alumni have used their WPI education as a stepping-stone to rewarding careers in environmental management and protection. Here are some of their stories.





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> Cover: Illustration by Robert G. Cuoco. Story on page 18. Opposite: By good fortune, a great deal of this winter's sparse snowfall arrived in time for the 1995 Winter Carnival, held recently. The WPI community enjoyed such wintry activities as snow sculpting and frozen turkey bowling (seen here). Photo by Jason Philbrook '97.

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ADVANCE WORD

Environmental Education Covers the Academic Spectrum at WPI

BY MICHAEL DORSEY

n this special issue of the *WPI Journal* we look at the field of environmental science and engineering. Starting on page 9, we report on four projects with environmental themes completed by WPI undergraduates at the far corners of the globe. Beginning on page 12, you'll find profiles of five current research projects that revolve around ecology, environmental engineering and environmental psychology. Finally, starting on page 18, we present eight stories of WPI graduates who have built interesting careers in the environmental arena.

There is, of course, another side to the environmental field at WPI-environmental education. Since the dawn of the WPI Plan in the early 1970s, students have been able to take courses, pursue undergraduate majors, and complete projects in environmental studies. In the early days of the Plan, most of the courses and majors were pursued through the Interdisciplinary Studies Division (now the Interdisciplinary and Global Studies Division). Since then, the environment has become the focus for programs centered in eight academic departments and programs (including Interdisciplinary and Global Studies), and opportunities for students to concentrate their course and project work in an environmental discipline have grown dramatically.

WPI's 1995-96 undergraduate catalog devotes two pages to describing the range of

environmental offerings available at the undergraduate level. Emphasis areas in environmental engineering exist in the Chemical Engineering Department, the Manufacturing Engineering Program, the Mechanical Engineering Department, and the recently renamed Civil and Environmental Engineering Department.

The civil and environmental program focuses on water quality control systems related to water supply and waste treatment. The chemical engineering program introduces students to areas like pollution prevention, environmentally friendly packaging, and the abatement of air, water and soil pollution. In manufacturing engineering and mechanical engineering, the emphasis is on designing products to minimize environmental impact and on environmentally conscious manufacturing. Other emphasis areas have been created in the departments of Biology and Biotechnology, Humanities and Arts, and Social Science and Policy Studies. The focus areas in biology and biotechnology include ecology and environmental biology. In humanities and arts, students may pursue a degree in literature, history, or philosophy and religion with an environmental orientation, preparing for careers in such fields as law, business, government service, environmental activism and journalism.

In social science and policy studies, students can focus on environmental issues as part of any of the department's three existing degree programs: economics, economics and technology, and society, technology and policy. Currently in development is a new degree program called environmental policy and development.



Sustainable development will be a theme that permeates the new major program, says Michael J. Radzicki, associate professor of social science and policy studies and one of the creators of the new major. "The philosophy of sustainable development is: don't use renewable resources faster than they can be substituted for; don't create any more pollution than can be assimilated by the environment; and don't encourage more growth than the environment can support. In essence, the idea is to tie your standard of living to the carrying capacity of the environment."

Students will explore the requirements for and difficulties of sustainable development in a number of ways. For example, they will use a computer simulation being developed by an Interactive Qualifying Project team. In the game, players attempt to run a nation on a sustainable basis, deciding how much of the country's labor resources to allocate to things like manufacturing and renewable resource stewardship. Through projects like this one, students at WPI can explore real-world environmental problems and issues and get valuable insight into the kinds of social, technological and political interactions they are likely to encounter in their careers.

Each year, dozens of students complete IQPs, Sufficiencies and Major Qualifying Projects with environmental themes. Most are students who do not intend to pursue an environmental degree program or emphasis, but who have a strong interest in understanding the potential ramifications of the environment in their careers and lives.

The topics for these projects are farranging. Of the 12 broad thematic divisions in which IQPs are categorized, four touch directly on environmental issues: Environment and Technology; Energy and Resources; Regional Studies and Planning; and Economic Growth, Stability and Planning. Project teams working in these divisions in recent years have looked at the effectiveness of automobile recycling, studied atmospheric pollution in Athens, and prepared environmental curricular materials for local public schools.

Through WPI's corporate project centers, MQP teams have tackled many environmental problems of concern to managers at companies like Norton, Raytheon, Polaroid, Wyman-Gordon and Monsanto. At Norton, students have helped the company experiment with converting its fleet of vehicles to run on natural gas and helped find ways to reclaim and reuse abrasives used to make grinding wheels. At Raytheon, students have helped find alternatives to the ozone-depleting chemicals used in metal cleaning and finishing processes.

"These projects are very popular," notes Richard D. Sisson Jr., professor and head of the Manufacturing Engineering Program.

"These projects are very popular. That's a reflection of the interest students have in the environment. They want to do some good for society and they feel this is something to which an engineer can make an important contribution."

— Richard D. Sisson Jr.

"That's a reflection of the interest students have in the environment. They want to do some good for society and they feel this is something to which an engineer can make an important contribution."

Increasingly, students are traveling overseas to complete such projects. The stories starting on page 9 provide just a few examples. Some of WPI's international project centers, including the Ecuador Project Center in Guayaquil and the Venice Project Center, were created, in part, to address environmental issues, but opportunities to pursue projects with environmental themes exist around the world.

A recent grant from the Fund for the Improvement of Post-Secondary Education is making it easier for students to do environmentally related projects overseas—and for students from overseas to complete environmental studies in this country, according to Lance Schachterle, assistant provost for academic initiatives and principal investigator on the grant. The grant supported the creation of the United States/European Community Environmental Projects Coalition, which is being run by WPI in cooperation with Howard University, the Technical University in Darmstadt, Germany, the Eindhoven University of Technology in Holland, and the University of Limerick in Ireland.

> WPI students who travel to Europe are likely to learn about some of the most comprehensive environmental laws in the world, Sisson says. "A few European nations, including Germany, essentially say that a company owns its products for the entire life of those products. If you buy a computer, the company has to take it back when you are done with it and recycle or reuse it. This is something our engineers need to become familiar with."

> Funding from the AT&T Foundation is supporting an innovative effort to teach students about the importance of multidisciplinary teams in manufacturing enterprises through the use of case studies (*WPI Journal*, Spring 1994). One of the studies, developed by Sharon Johnson, associate professor of management, James O'Shaughnessy, professor of civil engineering, and Sisson, looked at a waste elimination program developed by Hyde Manufacturing Co. in Southbridge, Mass., a maker of household tools and knives.

Not all of the environmentally

related course and project work takes place at the undergraduate level, of course. WPI currently offers master's and Ph.D. programs in environmental engineering through the Civil and Environmental Engineering Department (in fact, about half of the department's graduate students are pursuing environmental degrees). Students also frequently complete master's theses and doctoral dissertations on environmental topics in many other departments. In addition, courses that delve into environmental issues are offered in a number of disciplines. In Manufacturing Engineering, for example, a new course developed and taught by Sisson and O'Shaughnessy introduces students to environmental issues in manufacturing.

"This course is quite timely," O'Shaughnessy says, "because we are seeing great changes in manufacturing and environmental engineering. The chemical industry has said

that in the 1990s, the cost of environmental compliance will exceed the cost of raw materials in manufacturing. But even more, industry is coming to see that minimizing waste and pollution makes good business sense. When you recover a waste and reuse it, you spend less on raw materials and on equipment to treat waste."

O'Shaughnessy, who has served as chairman of the American Society of Civil Engineers Task Force on Pollution Prevention, obtained funding from the Massachusetts Toxic Use Reduction Institute at the University of Massachusetts to teach courses on toxic use reduction through WPI's Continuing Education Office. Also participating in the courses, which help companies comply with the Massachusetts Toxic Use Reduction Act, were Sharon Johnson and Raymond Lizotte, an engineer at Texas Instruments.

At the undergraduate level, O'Shaughnessy is team leader for environmental course and project materials being developed by the Realization Consortium, which is pioneering a new approach to engineering education with a major grant from the federal Technology Reinvestment Program (*WPI Journal*, Spring 1994). Led by WPI, the consortium also includes Cornell, MIT, North Carolina A&T and Tuskegee.

"I'll be focusing on pollution prevention and waste minimization in the materials I'll be developing," O'Shaughnessy says. "The idea is to put together course modules that can be used at any of the participating schools—in fact, at any school that teaches engineering and design. We eventually hope to put these materials on the World Wide Web (see page 6) to make them widely available."

With topics like waste minimization, pollution prevention and design for the environment to ignite students' interest, O'Shaughnessy says the job of getting students excited about environmental issues is becoming easier. It's a change he says he's seen in his own career as an environmental educator and consultant.

"Until recently, I was always reactive, working at the end of the pipe to clean up the waste generated by manufacturers," he says. "When you talked to industry about waste treatment, they became defensive. Now we can be proactive. We talk about reducing waste and saving money, and industry gets excited. That gets me excited too. Now our job is to pass that excitement on to our students."

A Disappointing Celebration

TO THE EDITOR:

Upon receiving the Spring 1994 *WPI Journal*, 1 looked forward to reading "Memories of a Quarter Century: Celebrating 25 Years of Women at WPI." When my husband, Paul '68, attended WPl, there were no women students. As the parent of two daughters, Jaime (Yale '98) and Erin (a high school junior), it was interesting to look at the history of women at WPI.

However, I was upset to note that in your "celebration" of 25 years of women's accomplishments, you were unable to highlight the accomplishments of any women in any of the accompanying articles. I counted 12 separate articles about men and 31 pictures of successful men (along with a photo of one lone woman). Were no women graduates in 25 years worthy of mention? Have no women been successful enough to highlight, especially in this celebration issue? What kind of message are we sending our daughters. female students and female alumni-that their accomplishments just don't rate? What a disappointment!

Susan Arruda Wilmington, Del.

Marietta Fletcher Also a Sinclair

TO THE EDITOR:

What a wonderful surprise it was to see the picture of my great-grandmother, Marietta Fletcher, at the top of page 12 in the Spring 1994 *WPI Journal*. My mother, still alive in her 90s, remembers her grandmother with loving affection.

Marietta S. Fletcher was indeed one of the first female members of the WPI faculty. Her education included an extended visit in the home of a German family, where she gained a deep sense of familiarity with Germany and its people. She taught English, French and German at WPI (then the Worcester Free Institute). In 1870, only a few years after the founding of the Institute, she married Professor John E. Sinclair, who taught mathematics at WPI. While Marietta's tenure as a teacher lasted only a few years, her husband remained with WPI for nearly four decades as head of





the Mathematics Department.

It is unfortunate that your article did not mention Marietta Fletcher's married name of Sinclair. I believe she married during the period when she was teaching. The arrival of her first child, my grandmother Luise Sinclair, caused her to leave her teaching post.

Incidentally, Marietta's (and John Sinclair's) descendants have maintained a close relationship with WPI. They include myself, Louis C. Smith (WPI Class of 1872), David S. Cummings '72 and Stephen J. Cummings '76. I serve on the President's Advisory Council. The present John E. Sinclair Professorship at WPI was funded by Professor Sinclair's life insurance, the beneficiary of which was Marietta, until her death. Also, the manufacturing company started by Professor Sinclair, now called Lowell Corp., has created the John E. Sinclair Scholarship Fund at WPI.

Thank you for the article "O Pioneers," which put the highlight on my great-grandmother. May her memory be preserved for years to come.

> HENRY S. "PETE" CUMMINGS '50 HOLDEN, MASS.

Thanks for the Internet Story

TO THE EDITOR:

Thank you for your excellent article on the Internet in the Summer 1994 *WPI Journal*. 1 am a member of the "slide-rule generation" who is trying to educate myself in the ways of computers. Any help I can get is very welcome.

While I have always enjoyed reading WPI publications, this article is the most personally useful one I have read in the *Journal* during the past 39 years. Please include more of this type of article in the future.

PHILIP C. JONES '55 CHARLESTOWN, R.I.

Promote, But Don't Mandate, the F.E.

TO THE EDITOR:

l read with great interest Morton Fine's article in the Summer 1994 *WPI Journal* suggesting that the ABET accreditation process for engineering curriculums include a mandate that all seniors sit for the Fundamentals of Engineering (F.E.) examination ("Academia is Shortchanging New Engineers"). While I understand the arguments advanced by the author, I disagree with his conclusions.

The thrust of the article is that practicing engineers should see that new graduates are required to take the first step toward registration, whether they wish to or not. The article stresses the difficulties imposed by waiting beyond graduation to start the process and appears to define registration as a prerequisite to a successful career.

Having waited until 12 years after graduation to take the F.E. exam, I will admit that it is made more difficult by the passage of time. In my case, the delay was not due to trepidation about taking the exam. Rather, it reflected the reality that, as an engineer and manager in a large manufacturing company, there was no benefit at all to my being registered. Only after 1 decided to redirect my career toward consulting did any benefits arise. While the delay did not enhance my taking the exam, it did not prevent me from preparing for and passing it, nor would it do so to others.

In fact, a greater impediment to registration for individuals in a manufacturing environment is obtaining the letters of recommendation from P.E.s familiar with the individual's work, which must be submitted as part of the application process. I know several individuals who have avoided applying because of this requirement, and not because of examination issues.

Admittedly, it would have been more convenient had I taken the exam while in school. However, the end of a student's

> "The end of a student's senior year is not necessarily the best time to include an additional mandated requirement."

"More effort should be devoted to this subject in order to inform WPI students about the importance of engineering registration."

senior year is not necessarily the best time to include an additional mandated requirement, especially one as stress-laden and requiring as much preparation as the F.E. exam. Coupled with the costs of taking the exam (fees for registering with the state for the exam, fees to the testing company for taking the exam, and more fees for completing registering with the state after passing the exam), it can be argued that the immediate benefits to the student do not outweigh the cost. While there are some professional drawbacks to not being registered, the list is not as extensive as implied by Mr. Fine. I'm not sure which professional societies restrict full membership to P.E.s (certainly not AlChE), but the lack of registration has little or no effect on most careers. The great majority of registered engineers practice in consulting roles. Certainly, a P.E. is necessary if one wishes to open a one-engineer shop, but for most engineers practicing as employees there is no pressing need.

Regarding the ability of a physician to use the title M.D. without having to be licensed to practice, an engineer is just as free to use the titles B.S., M.S. and Ph.D. after his or her name. Many Ph.D. recipients freely use the honorific "Doctor" prior to their names. Achieving registration has no bearing on the use of these titles, nor on the prestige and respect that is or is not granted to them. More commonly, nonengineers either question the meaning of the initials P.E. or have no idea of their significance. Even among engineers, the title is sometimes seen as an achievement worthy of merit, but not one of consequence.

Perhaps before those of us in practice impose another requirement upon graduating seniors, we may want to become better educated about professional registration ourselves. Once we have defined the benefits of registration and reached agreement as to the value thereof, we can consider requiring seniors to join us. Until that time, a more aggressive informational campaign, using such resources as student society chapters, may be our best means to promote the initiation of the registration process.

George A. Dainis '79 P.E. Mansfield, Mass.

Fine's Article "Timely and Necessary"

TO THE EDITOR:

I read Morton Fine's article "Academia is Shortchanging New Engineers" (Summer 1994) with great interest. It was timely and necessary. It also reflects my sentiment on the subject. I wrote similar articles myself more than 20 years ago for professional publications. I believe more effort should be devoted to this subject in order to inform WPI students about the importance of engineering registration.

> VICTOR (VUNG) K. CHUN '51 P.E. Los Angeles, Calif.

INGENUITIES

Another Spin on the Information Highway

Editor's Note: In the Summer 1994 issue, we brought WPI Journal readers up to speed on the vast and constantly growing Internet ("Net Assets"). The response to that story has been quite positive, and we've received a number of requests to provide readers with similar information on a regular basis. (It should be noted that many of those requests arrived by e-mail, at least a few sent by readers who were enticed into taking their first steps into cyberspace after reading the Journal).

In that spirit, we introduce this new department. We'll use this corner of the Journal to talk about new developments in science and technology and to define and demystify some of the buzzwords you may find yourself reading about in newspapers and magazines (and, perhaps, online). In this first installment we'll continue our dialogue on the Internet and tell you how alumni may soon be able to venture into cyberspace courtesy of the WPI Alumni Association.

The World Wide Web: Future Shock Meets the Internet

Illustrations by Laura Tedas

In an article in *Harper's Magazine* in 1965, author Alvin Toffler defined future shock as "the dizzying disorientation brought on by the premature arrival of the future." Over the past three decades, the future has been arriving with greater and greater speed. In 1995, it seems that what's hot today can turn cold in the blink of an eye and today's emerging technology can become tomorrow's household tool.

The World Wide Web is a good case in point. Last summer, when we mentioned the Web in the *Journal*, this Internet service was still coming into its own. Since then, the Web has exploded, with thousands of new sites having come on-line and many more being added every day. Having broken through the informal ban on the use of the Internet for blatant advertising, the Web is becoming an almost mandatory storefront for companies and corporations of all sizes. And with its ease of use, potential for dazzling and creative graphics, and its ability to speed text, pictures, sound and video to computers all over the world, the World Wide Web is quickly eclipsing Gopher, yesterday's hot Internet tool.

A good indicator of the Web's growing popularity is its increasing presence in the media. Stories on the Web abound in newspapers and magazines. The national newsweeklies *Time* and *Newsweek* now have columns on electronic resources that regularly feature Web sites, as do frequent articles and columns in major newspapers.

The Web was conceived in 1989 by scientists at the CERN in Geneva and developed over the course of the next few years. It employs a concept called hypermedia, which means that the documents one retrieves through the Web may contain links that, when clicked with a mouse, will transport a user to other information, often located on another computer in some other corner of the world.

The first Web browsers (software needed to take advantage of the Web's hypermedia format) were text-based. In 1993 the first multimedia browsers appeared. The most popular is Mosaic,

created by the National Center for Supercomputer Applications. By the end of 1993 the first versions of Mosaic written for personal computers were released, setting the stage for the popularization of the Web.

To use the Web, you'll first need access to the Internet. See the Summer 1994 Journal for some tips for

getting connected or pick up one of the books mentioned in that issue or any of a slew of other Internet books now at bookstores. For personal use, you'll need a recent generation Macintosh or an IBM-compatible computer with enough power and memory to run Microsoft Windows 3.1.

You'll also need a browser. You can retrieve Mosaic by ftp from ftp.ncsa.uiuc.edu (the directories are /PC/Mosaic and /Mac/ Mosaic). Netscape is a commercial product that can be obtained free by ftp for evaluation purposes (be sure to read the license that comes with the package for details on long-term usage restrictions.) It's at ftp. mcom.com in the /netscape/mac and /netscape/windows directories.

To use these programs you will likely need other software (MacTCP for the Mac and a Winsock.dll and a windows 32-bit upgrade for Windows). The installation instructions that come with the software will explain these requirements and may point you to shareware versions of the packages. Things will get easier for Windows users this year when Windows 95 is finally released with its built-in Internet software. IBM's new Warp version of OS/2 already provides this function. Also, commercial Internet software is available that makes using the Web much easier (one popular package is called Internet-in-a-Box). Internet service providers often equip users with Web software, and if you belong to an on-line service like CompuServe or America On-Line, you should get Web access later this year. (Users of Prodigy already have it.)

OK, you've got your browser installed and working. So where do you go? Here are a few interesting places I've found. The first three are actually useful lists that will link you to many, many other sites. Try these to start with. In no time, you'll find yourself ranging far and wide around the Web as you follow the links. To travel to the following sites, you'll need to learn how to type in a URL (Universal Resource Locator—a fancy name for an Internet address) with your browser. In the examples below, the URLs are in **bold type**.

<u>Yahoo:</u> A Guide to the WWW: http:// akebono.stanford.edu/users/www_server/

<u>The Whole Internet Catalog:</u> http:// www.digital.com/gnn/wic/

ElNet Galaxy: http://galaxy.einet.net/

Library of Congress: http://lcweb.loc. gov/homepage/ A wealth of information; the Global Electronic Library has links to federal government Web servers, including the White House, as well as many World Wide Web guides; Thomas has the full text of bills before the House of Representatives and a guide to how laws are made.

<u>National Public Radio:</u> http://www.npr. org/ Story lineups, recipes and other information from a host of NPR news programs.

<u>The Virtual Tourist:</u> http://wings.buffalo. edu/world/ You start with a map of the world, select a region and ultimately work your way down to clickable maps of World Wide Web sites in specific states or nations.

Zarf Guide to Interactive Games: http:// www.cs.cmu.edu:8001/afs/cs.cmu.edu/ user/zarf/www/games.html These are games and other unusual diversions accessible through the Web, including chess, a tarot card reader and the Magic 8-Ball. Also check out http://www.yahoo.com/Computers/ Internet/Interesting_Devices_Connected_to _the_Net/ to see some of the strange things people have hooked up to the Net, including cameras continually trained on offices, doors and aquariums.

Building a New Home on the Web

One of the sites you can visit on your Web excursions is WPl (http://www.wpi.edu/). Recognizing how easy the Web makes it to access and retrieve information, WPI late last year formed a committee, led by Helen Shuster, director of the Gordon Library, to design a new Web server that would offer visitors a more comprehensive, useful and easy-to-navigate bundle of information about the university.

The result of the committee's work recently went on-line. Visitors arrive first at the WPl home page, a concise, attractive and simply organized departure point. A **Visitors Center** provides newcomers with information about WPl and even a virtual tour of the campus. An on-line **Admissions Office** (still in development) will cater to the interests and needs of potential undergraduate and graduate students and will even allow students to apply through the Internet.

Other buttons on the main menu lead to, among other things, home pages for academic and administrative departments and campus organizations (a selction of the Gordon Library's on-line services can be reached through the Web), WPI publications (including the undergraduate and graduate catalogs), news releases and calendars, periodicals (including the *Journal*), information about WPI educational programs (including, eventually, courses offered through the Web), a campus phone book, and personal home pages maintained by members of the WPl community. There is even a guest book to "sign" and a place where visitors can leave suggestions or request more information about what they find on our Web site.

The WPI Web pages will always be under construction, as Web page builders are fond of saying, with new information being added all the time. We hope Net browsers (people, not software, that is) will find many reasons to stop back often.

--MD

New WPI Network Aims to Get Alumni On the Internet

The wealth of information now being made available on the WPI World Wide Web server should be of special interest to alumni who want to stay in touch with goings-on at their alma mater. But to get at this treasure trove, one needs access to the Internet, something

-MICHAEL DORSEY



that can cost at least \$20 per month—a sum that may seem a bit steep for many.

All that may soon change. Currently an ad-hoc committee of the Alumni Council, spurred by a suggestion from WPI's College Computer Center (CCC), is exploring ways to give alumni who have their own computers and modems an inexpensive and easy route not only to WPI's on-line offerings, but to the Internet at large. The committee is chaired by Harlan Williams '50 and is being assisted by Margaret Riley of the Gordon Library and the staff of the CCC.

The committee has taken a look at other universities that offer this service to their alumni, including RPI. Rensselaer Alumni Network News (RANN) employs a dedicated computer on campus that alumni can reach through their modems. Users are charged a \$40 monthly service fee. For that they get access to the Internet and to alumni and campus newsgroups and information.

One drawback to the RPI arrangement is the fact that alumni outside of the local calling area must pay long-distance charges on top of the monthly fee. In addition, if WPI were to implement such a system, issues such as the cost of the necessary equipment, the responsibility for maintaining it, controlling access to the network, and the potential for the network to strain computers also used by faculty, students and staff would have to be addressed.

The cost of dialing into the network could be reduced by linking alumni to WPI's computers through a data communications service such as Infopath, a service of NYNEX. Through Infopath, callers in Eastern Massachusetts would dial a local NYNEX modem bank, rather than calling long-distance to Worcester. Their call would be routed to WPI through NYNEX data communications paths and callers would be billed by NYNEX based on the quantity of data transmitted over the telephone lines.

Williams College is trying an entirely different approach. Its alumni network will be accessed through a commercial on-line service, most likely America Online or Compu-Serve. By paying a monthly fee as low as \$10, participating alumni will get full Internet access, will be able to use all of the offerings of the on-line service, and will be able to puruse special services available only to Williams alumni. Both CompuServe and America Online services can be reached via a local phone call from much of the country.

Harlan Williams says the committee would appreciate feedback from alumni concerning how they might use the proposed network and what information they would like to have made available to them. Questions, comments and suggestions can be addressed to Williams through the Alumni Office (100 Institute Road, Worcester, MA 01609-2280) or c/o mwdorsey@ wpi.wpi.edu.

-JOAN KILLOUGH-MILLER

A Vital Connection for Job Hunters

As you browse through WPl's Web service, you're likely to come across Margaret Riley's constantly growing guide to job hunting and career resources on the Internet (it's in the Gordon Library section and on

Margaret's own home page-http:// www.wpi.edu/~mfriley/jobguide. html). The list developed by the Gordon Library circulation librarian has grown considerably since it was mentioned in the Summer 1994 Journal—and not just in length. It has also added thousands of new users and won growing recognition.

Riley and her expertise in Internet job hunting have been featured in stories in the Scientist, Boston Business Journal and Working Woman, among other publications. She has also been a consultant for a new book on Internet job-hunting tips by Joyce Lane Kennedy, who writes a syndicated column on career-related topics.



Riley says the list, which is part of a large set of subject-oriented Internet guides housed at the University of Michigan, is still the most comprehensive on the Net. She continues to update it monthly, a task that grows more and more time-consuming as use of the Net for job hunting and recruitment escalates.

"As people realize that other people are using the Internet as a job-hunting and recruiting resource, more and more people and organizations are setting up services," Riley says. "Many companies, as they join the World Wide Web, are including their job opportunities. Corporate recruiters are joining. The Internet in general (and especially the Web) is becoming the new place to look for a job.'

Riley says she finds the information in her guide by personally scouring the Net and by subscribing to Internet mailing lists that announce new services. She also receives electronic mail from people who are creating new services and want to get into the guide. (She says she will not add companies that charge for job hunters to read their listings unless they make a reasonable amount of information available at no charge.)

She says she also receives many e-mail messages from around the world sent by users of her guide. While many people write

> to thank her for creating the listing, a great deal of the mail is from people who need help using basic Internet tools to find the information. "People are still learning the basics," she says. "Contrary to what many people think, most people are not Internet literate."

> > But it's

not just individuals who are coming to grips with the vast sprawl of the Net, as Riley recently discovered. Governments, too, sometimes need to catch up. "I got a call from someone at the federal Office of Personnel Management," she says. "The committee that runs the federal job list has convinced OPM to change their procedures based on the amount of recruiting going on through the Internet.

"It was in large part because of my guide that they realized how far behind the federal government is. Because of that the OPM will be incorporating the use of the Internet in its application procedure, its recruiting procedure and several other of its practices."

EXPLORATIONS

Projects From Around the World Focus on Environmental Issues

BY ANGELA INNAMORATI

Helping Solve a Garbage Disposal Problem in a Thai Slum

Dealing with garbage is a major problem in the Klong Toey slums of Bangkok. With infrequent municipal waste collection, residents are left to pile trash in huge mounds on roads and to dump it into the canals and drainage system. The result is water contamination, the proliferation of rats and cockroaches, and the rapid spread of disease.

"The problem is so bad, it takes less than a week for a recently cleaned water source to refill with trash," says Jason Anderson '95, who with Sandra Davis '95 spent seven weeks in Thailand last year examining the waste problem in Klong Toey and developing ways to help residents clean up their community.

The Interactive Qualifying Project, a finalist in the 1994-95 President's IQP Awards competition, was sponsored by the Duang Prateep Foundation, which is dedicated to helping improve the quality of life for slum residents. It was advised by John F. Zeugner, professor of history at WPI and director of the Institute's Bangkok Project Center.

Before traveling to Bangkok, the students did a literature search on solid waste management and learned about life in the slums. Once in Thailand they observed the daily activities of more than 1,000 families and talked to three influential nongovernment organizations to learn about potential strategies for getting slum residents involved in improving their surroundings.

Part of the garbage problem in Klong Toey can be traced to the inefficient city trash collection service for the slum area. The service consists of six people who must walk several miles each day carrying up to three tons of trash in wheelbarrows. Low morale among the collectors results in a high rate of absenteeism and poor service. In fact, Davis says, the government collects garbage in the slums an average of just two to three times a year. "They do it if an important person is scheduled to visit," she says.

Anderson and Davis say they believe the lack of interest in the garbage problem contributes to a general feeling of indifference and hopelessness on the part of slum residents. The students say residents respond to virtually any problem, from mounting garbage to AIDS, with the phase "Mai ben rai" ("It's no problem/It's O.K.")

The students set out to attack the garbage problem from a number of directions. For example, they mathematically analyzed the current garbage collection system and suggested ways it could be improved. They pointed out potential new disposal sites and mapped out a more efficient collection pattern.

They designed educational materials to encourage residents to play a more active role in cleaning up their community. The materials included posters that highlight proper garbage disposal methods and the importance of recycling, among other topics. They also created brochures and Tshirts that illustrate the connection between improper waste disposal and disease.

The students also made recommendations for a variety of low-cost clean-up methods aimed at reducing the improper disposal of garbage. These included the purchase of trash barrels and the fencing of proposed dump sites. They emphasized that these are the minimum steps that must be taken to begin turning the trash problem around.

"Although we would have liked to solve the problem completely, we had to be realistic," Davis says. "We hope we started the ball rolling and that the people who inhabit the slums will take a proactive stance in making theirs a better community." Anderson says the project was "intense, intriguing and exciting. Not only did we develop and improve our presentation skills, we learned about tolerance and cultural diversity," he says. Davis says her experience in Thailand changed the way she interacts with the international students at WPI. "Everyone in Bangkok was so helpful and attentive," she says. "They went out of their way to help me get acclimated. I want to do the same for students who come to WPI from overseas. It's so important and takes so little effort, but it makes such a big difference."

"Cross-cultural encounters are the most vivid learning experiences," says Zeugner. "Watching Jason and Sandy grapple with their astonishment, frustration, confusion and elation was an educational experience for me."

Will Biogas Be a Viable Alternative to Firewood In Botswana?

Ahmed Al-Baiti '95 of Tanzania, William Herron (who has since transfered to the University of Alabama), and Corey Lewis '95 of Bloomfield, Conn., shared a common desire when they enrolled at WPI: they wanted to go to southern Africa to do one of their required projects. When they decided to travel together to the Republic of Botswana to do an IQP focused on that nation's energy problems, they found that they would first need to solve a more immediate problem raising the money for the trip.

The students hoped to look for renew-



This page: Jason Anderson and Sandra Davis (in foreground) in the Klong Toey slum; Ahmed Al-Baiti, left, and William Herron in Botswana. Next page: from left, Antonio Delgado, Corinne Kachlert, Gail Concannon, Michael Conklin, Philipp Herget, Hanna Herharter of the Innichen Tourist Association, Kimberley Scofield and Dean Emeritus William Grogan in Innichen; from left, biologist Eduardo Cintron, Rafael Chavez and Susan Moriera prepare to fly with their pilot to Isla de Mona.

able energy resources Botswana might turn to in order to end its reliance on wood for cooking and heating and its dependence on imported oil and gas for diesel engines, appliances and lamps. The heavy use of wood is a special concern, because (coupled with a growing population) it is leading to the depletion of the nation's forests and endangering its land and water.

The students estimated that their expenses for the seven-week trip would run about \$13,000 more than what the Institute could contribute. Seeking to raise the needed funds, they contacted local congressmen, small business owners, black organizations and energy groups. They also approached the U.S. and Botswana embassies. "It was a lot more difficult than we imagined to raise the money," Lewis says. "We found that people were interested in making contributions, but were skeptical because nobody else had yet done so. It was a vicious cycle."

The students also turned to friends and relatives for help. They even contemplated selling their stereo systems and cars to finance the venture. "It wasn't until then that people realized how serious we were and that we'd do it at any cost," Lewis adds.

To reduce their financial needs, the students reworked their expenses, cutting meals down to the bare essentials and asking J. Raheem Hosseini '89, director and general manager of Kgalagadi Resources Development Co. Ltd in Gaborone, Botswana, for

help in finding inexpensive lodging.

It was then that the students received their first contributions. They came from W.A. Bland Addison Jr., associate professor of history, who co-advised the project with Tom Hartvig Thomsen, associate dean of student life and international student advisor, and Edward Clarke, professor emeritus of engineering and science.

"They started the ball rolling," says Al-Baiti. "After that, we called everyone back and asked again if they would help out. The response was quite a bit different this time." Among the contributions the students received were several corporate gifts, including nearly \$2,000 from United Technologies.

Once they reached Botswana, the students learned more about the nation's disappearing firewood supply. They estimated that within a decade the country (78 percent of which is now covered by desert) would run out of fuel. "The people of Botswana were only addressing the problem with short-term solutions," Herron says. "For example, they were planting eucalyptus trees to use as firewood because they grow so fast."

After researching potential alternatives, the students recommended that Botswana use biogas as a cooking fuel and as a replacement for petroleum products (importing these products costs Botswana millions of dollars each year). Biogas, a mixture of methane, carbon dioxide and other gases, is produced by fermenting animal and human waste and vegetable matter.

The students say the waste from the nation's four million head of cattle alone could generate enough biogas to fill all of Botswana's energy needs. "Biogas is the most affordable renewable energy resource, and it can be readily produced in Botswana," Lewis says. "In addition, it is not harmful to the environment."

The project won the 1994-95 President's IQP Award. Despite the thoroughness of the student's research and recommendations, the Botswanian government is unsure about

making the switch to biogas, Herron says. "They just aren't looking at the long-term effects of what they are doing. After all, why should they pay for biogas when they can get firewood for free? Still, the increasing ecological and energy problems the nation faces may change their attitudes."

Balancing Tourism and Cultural Preservation in the Tyrol

lnnichen (San Candido), an isolated region of the southern Tyrol on the border between ltaly and Austria, is known for its beauty and its skiing. Thanks to the work of six WPl juniors, it may also be known as the newest addition to WPI's growing global network of project sites. Last summer, Estado Aragua, Gail Concannon, Michael Conklin, Antonio Delgado, Philipp Herget, Corinne Kachlert and Kimberley Scofield traveled to Innichen to examine the feasibility of establishing a WPI project center there and to study the impact of tourism on the local economy.

The idea of establishing a project site in Innichen grew from a conversation in the summer of 1993 between William R. Grogan '45, dean emeritus of undergraduate studies, and Fabio Carrera '84, coordinator of WPI's Venice Project Center. The topics for the first two projects were suggested by David B. Dollenmayer, associate professor of German and coordinator of WPI's foreign language Sufficiency program.

"The area is extremely interesting historically," Grogan says. "Innichen was part of Austria until after World War I, when it was annexed by Italy. All of the town's 3,000 residents speak both Italian and German." Advance work by Grogan, Dollenmayer and Carrera led to an agreement by the town to provide the students and their advisors with housing at no cost. An office, complete with



photocopy and fax machines (not to mention a spectacular view), was also made available.

As part of their "bootstrap" project, Concannon, Conklin and Kachler set out to identify potential student projects in Innichen and to learn all they could about the region's history, culture and geography. They did extensive library research, conducted telephone interviews, and went doorto-door to talk to townspeople about their concerns. The result was a list of 29 potential projects, most of which would focus on environmental issues in the region.

"The town is interested in determining how growing traffic from tourists, whether hikers or mountain bikers, is affecting the local environment," Concannon says. Innichen's majestic hills have long been a lure for skiers. In recent years, interest in hiking and other outdoor activities has drawn vacationers to the region year-round.

For their project, Delgado, Herget and Scofield took an initial step toward addressing those concerns. They surveyed farmers, tourists and town officials to find out how these groups viewed the importance of the growing tourist industry and its potential impact on the 26 mountain farms that line the lnnichberg (the slope above the town). They found that while residents and town officials believe tourism is beneficial to lnnichen's economy, they fear that it may diminish the traditional Tyrolean culture.

"The attractiveness and uniqueness of the Alpine farms, if they are preserved, will provide an attraction for tourists and income for the Tyrolean town," the students noted during their presentation to the town. They recommended a number of ways to achieve a balance between tourism and cultural preservation, including running guided tours of a few farms combined with exhibits of traditional methods of farming, baking and craft-making, and developing a program that would enable visitors to live on a farm and participate in farm life for a period of time in exchange for a fee. The team members made their presentations in German; most had completed a Sufficiency in the language to prepare for the projects. Delgado, a resident of Venezuela, presented his portion in Italian. The invitations to the event were printed in both languages, while the students' final reports were written in German and English. One of the projects, "Farming on the Innichberg: Preserving a Unique Culture," was a finalist in the President's IQP Awards Competition.

"These projects were among the best I've ever seen," Grogan says. Innichen mayor Edgar Passler also gave the students high marks. "We don't get many Americans here and sometimes they are not so nice," he says. "Your students have completely changed the opinion of the people here about Americans."

Solar Energy May Make a Puerto Rican Paradise More Livable

For the six biologists who spend their days studying rare fish, iguanas, sea turtles, stingrays, sharks, octopuses and other exotic animals, Isla de Mona, an island off of Puerto Rico, is a paradise. But it is a paradise that comes at a cost. Living conditions on the island are primitive. In part, that is because financial and environmental restrictions prevent the operation of the diesel generators that provide electricity for the biologists and two maintenance people for more than 10 hours a day.

Although the Puerto Rican government would like to improve the accommodations on Isla de Mona and provide electricity around the clock, their primary concern is the welfare of the island's nonhuman inhabitants. That's why the Departamento de Recursos Naturales y Ambientales asked Rafael Chavez '95 and Susan Moreira '95 to study the situation and recommend an inexpensive, waste-free and environmentally sound alternative to the diesel generators.

In addition to producing air pollution and creating the potential for a fuel spill, the generators are costly to operate and maintain. "It costs \$600 for fuel and \$1,200 to transport that fuel every two weeks," says Wilhelm Eggimann, professor of electrical and computer engineering, who advised the project with Anita Sheperd-Mendez, a co-advisor at WPI's Puerto Rico Project Center in San Juan.

To learn more about the problem, the students met with representatives of the Departamento de Recursos Naturales y Ambientales and with the researchers and staff on Isla de Mona. "They also spent several days at the research station to see firsthand how the biologists have to live and work," Eggimann says. "The facilities were rather primitive."

The students recommended that the island's electricity be generated with photovoltaics. "PV is versatile, economically feasible and ecologically safe in many applications," Moreira says. "It is a great way to generate power in geographic locations like the Isla de Mona, where the only free energy source is the sun."

The students developed four economic models that compared the cost of the diesel generators to three possible ways of implementing a solar-energy system. They found that although the initial installation costs of a PV system are high, the system would cost about a third of the amount spent on the diesel generators over a 20-year period.

"The solution they proposed made perfect sense. It considered economic, technological and environmental issues," Eggimann says. "There is a good chance that the Departamento of Recursos Naturales will actually install one of the proposed systems." The project was a finalist in the 1994-95 President's IQP Awards competition.

—Innamorati served as acting assistant director of the News Service during part of 1994.

INVESTIGATIONS

Flushing Soils Clean of Metals

Among the most difficult problems environmental engineers face is treating hazardous waste that has been spilled onto, leached into, or buried under the ground. Once released into the earth, wastes like organic solvents and heavy metals can become

bound to the soil or slowly disperse until they contaminate groundwater. Often the only way to recover the waste and treat the soil is to dig up huge quantities of earth and cart it off to treatment sites or dumps, an expensive proposition.

With funding from the Environmental Protection Agency, Robert A. D'Andrea, associate professor of civil engineering, and James C. O'Shaughnessy, professor of civil engineering, have been conducting laboratory tests of a technique they've developed for removing metal wastes from soils on-site by flushing them out with solutions containing chelating agents. These are chemicals, like citric acid and EDTA, that can bind tightly to metals and keep them in solution. Some of these agents are also used by physicians to treat heavy-metal poisoning.

"The EPA is interested in our technique because it is a possible remediation method for the Lipari Landfill in New Jersey, a major Superfund site," D'Andrea says. "It may also prove useful at a number of other Superfund sites in Northern industrialized states that have similar soils and long histories of manufacturing and disposing of metal wastes."

The permeability, or hydraulic conductivity, of the soil is a critical factor in determining whether or not the technique will work. D'Andrea says the conductivity of soil can vary by more than 10 orders of magnitude, from dense clays that are almost impermeable to loose gravel that is highly permeable. "That's more variance than you will find in just about any other engineering parameter," he says.

The soils that are most likely candidates for flushing are mixtures of mainly sand and gravel, with small amounts of fines, a grainsize distribution that is often the result of glacial deposition. These soils are reasonably permeable to water and are also capable of latching onto heavy metals before they wash down into the groundwater.

To conduct their tests, D'Andrea and O'Shaughnessy gathered numerous samples of this type of soil from various sites around New England. After preliminary evaluation, a soil deemed to have the greatest potential



SPRAY OR TRICKLE IRRIGATION SYSTEM



O'Shaughnessy, left, and D'Andrea with some of the permeameters they used to test their technique for flushing heavy metals from soil. The diagram by graduate student Alton Day Stone shows how a chelating agent solution would be sprayed onto contaminated soil and allowed to percolate down to drains.

for successful treatment was chosen. The soil, obtained from a site in Worcester, was artificially contaminated by treatment with solutions containing varying concentrations of metal salts. It was then placed into tall plexiglass columns. Because previous research had shown that columns filled with soil were prone to clogging when repeatedly flushed with water, the researchers also conducted tests with similar soil packed into small plexiglass cubes. The cubical containers, called multidirectional hard-walled permeameters, permitted the direction of the flow of water to be varied by 90 degrees to reduce the chance of

> clogging and to enable the researchers to investigate metal precipitation. The permeameters and an associated piping system were based on an apparatus designed as part of a Major Qualifying Project by John T. Germain '76, now a principal research associate at MIT.

> In tests with the columns and cubes, D'Andrea and O'Shaughnessy flushed the soil multiple times with plain tap water and with solutions containing various chelating agents. They found that each of the six metals they tested (cadmium, copper, chromium, lead, nickel and zinc) reacted differently to the flushing.

> Copper, for example, was unaffected by the water rinses, but could be completely removed from the soil with repeated rinses with an EDTA solution. Up to 80 percent of chromium was removed in some trials with tap water rinses alone, while the addition of the EDTA solution removed only an additional 1.5 percent.

To put this technique into practice in the field, D'Andrea says, a temporary barrier would be constructed to surround the contaminated soil. A solution of chelating agents would be trickled onto the soil surface while wells would pump the water collected from

underdrains beneath the ground, drawing the chelating agent solution through the soil.

For his thesis, master's degree candidate Alton Day Stone proposed the use of this method to treat contaminated soil at a site in Cambridge, Mass. "In this study, Stone applied the laboratory results to show that more than 50 percent of the metals in the soil could be recovered," D'Andrea says. "Though we wouldn't achieve complete removal for all metals, it should be possible to reduce the metal concentrations to safe levels—and levels that meet state standards—in a relatively cost-effective way."

Evolutionary Trick May Provide an Economical Heavy Metal Treatment

Within the cells of all living things are tiny quantities of heavy metals. Elements like iron, copper, selenium and zinc are critical components of enzymes that enable organisms to carry out such life-sustaining functions as the transport and storage of oxygen and the metabolism of food. To keep these valuable substances from washing away into the lower reaches of the earth, fungi, molds and bacteria in the top layers of soil capture them and keep them in circulation.

Research by Ted Crusberg, associate professor of biology and biotechnology at WPl, has shown that the same physiological processes that enable these organisms to absorb small quantities of metals may also protect them from the toxicity of much larger concentrations of these elements. This previously unknown defense mechanism, in turn, may become the basis for a simple, effective and economical way of treating heavy metal waste.

For several years, Crusberg has been studying the ability of a *Penicillium* mold to entrap heavy metals. Initially, the work focused on beads made from the cell walls of microbes from which the living matter had been chemically removed (*WPI Journal*, Winter 1990). More recently, Crusberg has started experimenting with living cells. "I've found that the living organisms are easier to work with," he says. "But more important, they are also 12 times more effective at absorbing heavy metals."

Using various analytical techniques, including electron microscopy, Crusberg and his team (which currently includes eight undergraduates and two graduate students) have shown that *Penicillium* uses an enzyme secreted through its cell membrane to create an environment in which metal ions bind to phosphate ions. The resulting metal phosphates are trapped within the periplasm, a fluid layer that lies between the cell membrane and cell wall in fungi. The process, called biomineralization, is similar to the way coral cells build their protective shells and to the way bones are formed.

Tackling the Scourge of Heavy Metals

The first three stories in this edition of "Investigations" profile WPI teams that are developing three guite different ways of dealing with the problem of heavy metals in the environment. Unlike the many manmade pollutants that have contaminated the Earth, heavy metals are naturally occurring substances. Many, such as chromium, nickel, cobalt and copper, are actually necessary in small quantities to sustain life. But when these same metals are released into the environment in large quantities as waste from manufacturing and metal-plating plants, as components of agricultural pesticides, in sludge from sewage treatment plants, in products like batteries, paint and electrical equipment, and in the exhaust from gasoline- and diesel-fueled vehicles, they can become a serious threat to health, causing acute and chronic toxicity and even cancer.

Federal environmental laws and regulations now prohibit the wholesale release of metal wastes into the environment and make manufacturers liable for the safe and responsible disposal of any waste they generate. These laws, plus a growing awareness that treating waste and recovering the metals can often be more cost-effective than buying new raw materials, has focused attention on finding more effective and economical ways to extract metals from the waste stream.

But even as industry works to keep heavy metals out of the environment, vast quantities of waste, the legacy of more than a century of industrial activity in this country, lie buried in thousands of underground sites, slowly releasing metals into the soil and groundwater. Recovering these wastes and treating contaminated soils—a major focus of the federal Superfund program—is proving to be a difficult and extremely expensive undertaking.

"This is really an interesting protective mechanism," Crusberg says. "The metals never reach the interior of the cell, so the organism is in no danger. The only problem is that as the cells growing in culture trap more and more of the metal, they get very large and heavy and will ultimately settle to the bottom. Then, getting adequate oxygen and nutrients to the cells becomes a problem."

Studies in Crusberg's lab have shown that the *Penicillium* mold is highly effective at absorbing virtually any heavy metal. It also survives well in even highly concentrated metal solutions. In addition, the mold is easy to grow in a continuous process.

The cells tend to cluster into pea-sized

beads that can be freeze-dried and later revived. The beads are easy to keep suspended in solution, thus eliminating the need to immobilize the cells in columns or grow them into mats, techniques that are required for other types of biological agents used in waste treatment.

"It should be possible to send a small quantity of freeze-dried *Penicillium* beads to an industrial site," Crusberg says. "The beads would be placed in a bioreactor, and from that initial supply, the company could grow all the fungus they need. That's another major advantage of living cells over dried cell walls."

The fungal beads, which Crusberg calls biotraps, should prove an effective and low-cost method for treating industrial waste streams containing heavy metals. The beads, once they become saturated with metal ions, could be removed from solution and burned in a kiln. The only thing left behind would be the metals, which could be recovered and reused.

Another possible application for the biotraps is the treatment of water contaminated with radioactive metals (including uranium and plutonium) from nuclear reactors and nuclear weapons plants. "These wastes are now very difficult to treat," Crusberg says. "I've already had some preliminary talks with people at some of the national nuclear laboratories about testing this application."

Crusberg has also had discussions with engineers at the Worcester wastewater treatment plant about testing the organism's ability to remove copper from the treated water before it is discharged into the environment. "Copper

leaching from water pipes in the home is a major problem in the Northeast, where the leaching is significantly enhanced by acid rain," he says. "The copper eventually finds its way into municipal wastewater. There are EPA regulations in the works that may require municipalities to remove that copper during wastewater treatment, before it is discharged. Biotraps may prove to be an economical way of doing that."

In addition to studying how the *Penicillium* mold goes about trapping heavy metals, Crusberg has been working to give that ability to other microorganisms. He and his team have obtained the gene that produces the enzyme responsible for heavy metal bio-

mineralization. The next step will be to use genetic engineering methods to transfer the gene to other bacteria, fungi or molds. "We should be able to give this resistance to almost any microorganism," he says.

Pillared Clays May Stack Up Against Heavy Metals

Clay is a component of soil made up almost exclusively of very fine particles. These tiny shards of mineral matter bind readily to metallic ions, making them good candidates for filtering heavy metals from industrial waste streams. But the fine grain structure of clays also renders much of their interior surfaces inaccessible for adsorption. To

polymeric cations (positively charged ions capable of linking together to form a poly-

mer). The clay particles are allowed to settle out of solution, forming layers. When the clay samples are baked at a high temperature, the polymeric ions form pillars that become chemically bound to the clay particles, pushing the clay layers apart.

Once they have created pillared clays, the research-

ers use a variety of techniques, including electron microscopy and x-ray diffraction, to study their physical properties. These include the size of the channels created by the

clays with a solution containing inorganic ium, making it possible to regenerate the clay beds and recover and reuse the metals.

> As part of their research, the team will develop computer models to simulate the processes that occur when the clays adsorb and release the met-



utility for waste treatment.

With a grant from the **Environmental Projection** Agency's Risk Reduction Engineering Laboratory in Cincinnati, Yi Hua Ma, professor of chemical engineer-

ing, and Alfred A. Scala, professor of chemistry, are experimenting with a technique that may overcome this shortcoming. The technique involves creating tiny pillars that force apart the layers in clay, creating channels through which wastewater can flow. Working with Ma and Scala on the project is Danyan Li, a postdoctoral researcher whose Ph.D. dissertation at Michigan State University focused on pillared clays.

To create a pillared clay, the researchers mix natural or synthetic montmorillonite

pillars and the total surface area available for adsorbing heavy metals. "Our two departments have many years of experience using these techniques to study other porous

materials, most notably zeolites, that can be used as ion exchangers," Ma says. "It was this expertise that led us to realize that pillared clays may prove effective as exchange agents for heavy metals."

In addition to the structural characterization, Ma, Scala and Li will use fixed beds of pillared clays to measure their effectiveness in removing a range of heavy metals from water. They will also determine whether they can get the clays to release the heavy metals in exchange for benign ions like sodAbove left, a photomicrograph of a pillared clay. Inset, from left, Ma, Li and Scala. Center, a 40-micrometer sphere of copper phosphate that has

formed in the mycelia of a Penicillium fungal bead. Inset, Crusberg. Far right, a scanning laser beam captures dye as it disperses in a simulated ocean environment. Inset, from left, Baird, Johari and Jumper.

als. The models will help the researchers determine how to optimize the adsorption of the pillared clay systems. "These models should be generally useful in evaluating and optimizing processes involving absorbents," Ma says.

"If they prove successful," Scala says, "pillared clays could be used to treat concentrated metal wastes produced by manufacturers like metal platers, lowering or eliminating the cost of disposing of these materials. By enabling companies to recover metals they

now dispose of, the technique should reduce their raw material costs and make their operations more efficient and competitive."

Finding Out How Deep-Sea Fishes Follow Their Noses

Hundreds of meters beneath the surface of the ocean lies a strange, alien world. Here, in a still, cold, pitch-black realm, live exotic species of fish well-suited for life in a watery desert where the main sources of food are ultimately derived from more fertile waters far above, and where encounters with other creatures—including others of one's own species—may be few and far between.

In this environment, a fish's most valuable asset may be its nose, says Ronald C. Baird, director of corporate relations at WPI and an affiliate associate professor of biolo-

gy and biotechnology. "It has long been known that a number of fishes use pheromones to attract mates and that the chemical sense is important to them," Baird says. "I have been interested in deepsea ecosystems, and it is



hatchetfish and other deep-sea fishes. he decided that to understand how these fish use their noses to locate food and mates, he would first need to better appreciate how chemicals disperse in the open ocean. After developing some rudimentary mathematical models, he realized that he would need the help of someone versed in fluid dynamics and computational techniques.

That someone was George Y. Jumper,

then associate professor of mechanical engineering at WPI and now senior aerospace engineer in the Aerospace Engineering Division of the U.S. Air Force Phillips Laboratory at Hanscom Air Force Base in Mass-



clear that in those environments, chemical reception must play a very important role in the life of many of the species found there."

Baird, who holds a B.S. in zoology from Yale, an M.A. in zoology from the University of Texas, Austin, and a Ph.D. in biological oceanography from Harvard, has taught and written extensively on deep-sea fishes, oceanic ecosystems and natural resources management. He is currently a courtesy professor of marine science at the University of South Florida's Marine Sciences Institute, where he taught for eight years, a member and past chairman of the National Sea Grant Review Panel, and the National Oceanic and Atmospheric Administration (NOAA) representative to the Gulf of Maine Regional Research Board.

In the mid-1980s, when Baird became interested in the olfactory sense in the

achusetts. Jumper brought to the table a broad technical background ranging from chemical engineering and physical gas dynamics to target acquisition and system optimization theory honed in his work for the Air Force.

"I had originally asked George to improve the modeling of the pheromone dispersion in the ocean, which alone did not seem to yield meaningful results," Baird says. Jumper says he found himself haunted by the inability of the model to explain the obvious ability of the hatchetfish to find mates.

"Finally, one night I began to dream about spherical molecules moving about in space, hitting each other and the walls of their container," Jumper says. "The spheres then turned into hatchetfish and I awoke with a start. I realized that pheromone dispersion alone could not explain the problem, because the fish were also moving—a lot faster than the pheromones. The next day l applied the equations for the collision of molecules against a wall to the problem of fish swimming into a patch of pheromones, and it cracked the problem."

In their work, Baird and Jumper also made use of encounter theory, which attempts to explain how organisms come in contact with each other. "We thought this would be a good starting point for a theoretical analysis of the problem," Baird says, "since fish have to not only detect an odor, but to

locate its source. In the deep midocean, there are no local currents to move pheromones in a linear fashion,

creating a scent trail. So we had to develop a new theory about how an organism might locate the source of

an odor in the absence of directional information from currents."

The model developed by Baird and Jumper incorporates an understanding of how deep-sea fishes detect chemicals in the water, gained through knowledge of the physiology of fish olfactory systems; estimates of the abundance and vertical distribution of a number of these species, derived from trawl studies conducted by Baird and others; and data on how chemicals disperse in deep water, derived, in part, from diffusion theory and studies that tracked the movement of dye released hundreds of meters deep in the ocean. The model was enhanced with the help of Hamid Johari, assistant professor of mechanical engineering, who joined the research team in 1993. He brought a wealth of knowledge about diffusion processes and experimental techniques to the mix.

The analysis revealed that one of the most critical factors in determining whether a fish is likely to locate a potential mate or meal (and whether, in turn, a species is likely to survive) is a variable they call the perception distance. This is the distance at which a fish is able to first recognize and locate a target organism. The probability of successful encounters with such targets increases exponentially as the perception distance increases.

"Any factor that can change the perception distance can have a profound effect on the probability of encounter," Baird says. "To enhance reproductive success, for example, females of some species release pheromones into the water, while the males have developed inordinately elaborate olfactory organs to increase their ability to pick up the pheromone scent.

"Animals encounter things in real-time and 3-D," Baird says, "so the physics of realtime, 3-D encounter is a critical dimension in understanding aquatic ecosystems. It begins to explain why organisms look the way they do—why, for example, some male deep-sea fish have very large noses, or why the larva of pelagic species are often as clear as glass."

> A model that accounts for the many variables that can influence perception distance and encounter probabilities can be e x t r e m e l y complex and require considerable computer power to run, Baird says. For this reason,

The hatchetfish Sternoptyx diaphana, resident of a strange deep-sea world.

with funding from the Advanced Research Projects Agency, Baird, Jumper, Johari and mechanical engineering graduate student Michael J. Rider are adapting encounter algorithms to run on high-performance, massively parallel computers in collaboration with the Enterprise Computing Institute (formerly WPI's Center for High Performance Computing).

In other work, the researchers plan to begin gathering new data on chemical dispersal in simulated aquatic environments using a sophisticated water tunnel and other equipment in the Fluid Dynamics Laboratory in Higgins Laboratories.

The research on deep-sea encounter theory is just one aspect of a multidisciplinary program in ecological engineering at WPI that began in 1989 when the Institute received a multiyear grant from the Rodney Hunt Co., a maker of water- and sewage-control equipment in Orange, Mass. The grant has supported educational and research programs that apply the tools and techniques of engineering and computer science to environmental and ecological problems.

"This program grew from the recognition that there are a host of problems in these fields that are so complex they don't lend themselves to one-discipline solutions," Baird says. "Ecologists are generally not well-versed in engineering and computer science. At the same time, engineers and scientists have skills, exciting technology and computational methods that can be applied to ecological problems. As an oceanographer and ecologist, 1 saw all of this expertise around me at WPI and 1 thought, 'Let's see if we can bring these people together to work on a problem of real ecological interest."

To date, more than 10 graduate and undergraduate students have worked on research projects through the ecological engineering program. Their work has contributed to four papers in top ecological and oceanographic journals and to several invited presentations at national scientific meetings.

"These are not, by and large, students who intend to pursue careers in the environmental field," Baird says. "Rather, they are using engineering theory and tools they will eventually employ in their careers and applying them to real problems that just happen to have an ecological thrust. In the process, they're gaining a new appreciation for the environment. That's the real goal of this program—to expose engineering students to ecological issues.

"In the next century, the environment may surpass the economy as our principal national concern. Clearly, all engineers and scientists will find themselves dealing with issues that relate to the environment and the global environmental implications of technology. Just as important, future engineers and scientists must understand that they will be called upon to play important roles in solving the environmental problems we face."

How Poor Decisions Can Add Up to Global Problems

In 1982, James K. Doyle, assistant professor of social science and policy studies, earned a bachelor's degree in environmental sciences at the University of California, Berkeley, and set out to help solve the world's environmental problems. But he soon made a fundamental discovery that would change the course of his career.

"I realized that the primary cause of these problems is human behavior," he says. "I had thought I could have a fine career fixing environmental problems, but each time a problem was fixed, people would turn around and create a new one. So I decided to go to the source and find out how people think about the environment and how they make the decisions in their daily lives that contribute to environmental problems."

Doyle went back to school and earned a Ph.D. in social psychology at the University of Colorado in 1991. Since then he has been studying judgement and decision making, particularly the kinds of decisions individuals make that concern risk to themselves and risk to the environment. As an example, Doyle points to the risk people face from exposure to radon gas in their homes.

Working with the Environmental Protection Agency, Doyle studied the results of a campaign in the Washington, D.C., area to encourage people to purchase and use reduced-price test kits. "We found that about half of the people who went to the trouble of buying the kits never sent them in for testing," he says. "Of those who did, only



Doyle: going to the source.

about half retested, which is recommended. Those whose kits measured more than 50 picocuries per liter were sent a free kit for retesting. Half of those never came back. Only a few percent of people with a radon problem followed through to correct it.

"Before this study, the EPA had focused a lot of its efforts on getting people concerned about the risk of radon. But that's not enough. Dealing with a radon problem is such a long and technical process, most people just can't make it all the way through. So we suggested to the EPA that the time to get people involved is when houses turn over, because then there are brokers and other professionals to make "The environmental movement would like us to think globally, but as a social and cognitive psychologist, I don't think we now have or will soon develop the capacity to do that."

sure things get done. With that approach, more than half the people with radon problems correct them."

In another study, Doyle tried to assess whether people are accurate judges of the way some risks, like those tied to radon exposure, accumulate over time. "For example," he says, "if you live in a flood plain, the chance of a hundred-year flood occurring in any one year is one in a hundred. If you live there 25 years, the odds of at least one such flood rise to 22 in a hundred. If people don't understand that, it might explain why so few buy heavily subsidized flood insurance.

"Previous studies had concluded that people don't buy the insurance because they greatly underestimate how risk accumulates. We found that people are better at making such estimates than they'd been given credit for, but they don't buy the insurance anyway. They understand the risk and they worry about it, but these feelings get lost in the complications of everyday life. If they're having trouble getting jobs or feeding their families, flood insurance simply goes to the bottom of the priority list."

While people can sometimes think rationally about how risk accumulates, they are less clearheaded when it comes to quantifying how much they value the environment, Doyle has found. "It is easy to get people to say they value the environment, but it is much more difficult to get them to say exactly how much they value it," he says.

"If you ask them how much they'd be willing to pay on their water bill to clean up a toxic landfill leaking chemicals into the groundwater, they might say \$10 a month. If you ask them how much they'd pay to clean up five landfills, they'd still say \$10 a month. In your methodology, you have to be able to deal with problems like these. You also have to be wary of trying to get a value out of people when there is no value to be gotten until you ask the question."

Often, people's impressions about the environment and about risk are shaped by their own biases. For example, a recent IQP advised by Doyle showed that people tend to believe that larger animals, animals that are the most similar to humans, and animals unlike those they see every day, are the most likely to be endangered. "People have trouble imagining that an insect can be endangered," he says.

Often, biases are shaped or fueled by reporting in the media, Doyle says. For example, people tend to overestimate their risk of dying from causes that are heavily reported (murder, car accidents) and underestimate the risk from lesser-reported causes (diabetes, cancer). A current lQP is looking at whether people's concern over global warming is shaped by the impressions they get from the media concerning how much disagreement there is among climatology experts.

"There is substantial disagreement over minor points, such as which countries will be most affected, but there is almost complete agreement that global warming will happen over the next century," Doyle says. "But do people mistake the quibbling over details for disagreement on the big picture?"

Given the limitations of the human mind, are people up to the task of managing the global environment? "I'm certain that right now, we are not up to the task," Doyle says. "We have limits on our working memory, limits on the ways in which we can perceive the world, and limits on our judgement and problem-solving abilities that make it difficult for us to comprehend complicated, massively interconnected systems, let alone manage them. The environmental movement would like us to think globally, but as a social and cognitive psychologist, I don't think we now have or will soon develop the capacity to do that."

Is there an alternative? Doyle says rather than trying to manage the environment on a global scale, environmental scientists should focus on trying to get people to make better decisions in their own lives—to help them see that their actions, while seemingly inconsequential, help contribute to problems on a global scale. "It's the idiosyncrasies of our minds and the way we think that cause us to make bad decisions," he says, "and all these little everyday decisions add up to things like global warming, ozone depletion and species extinction."

-MICHAEL DORSEY

STEWARDS FOR A

Many WPI graduates have found that helping protect the environment can make for an exciting and rewarding career.

By David Brooks, Allison Chisolm, Diane Benison, Michael Dorsey, Joan Killough-Miller and Ruth Trask Illustration by Robert G. Cuoco

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n the few short decades since the modern environmental movement began, some major achievements have been recorded. In this country, these include the creation of the Environmental Protection Agency and a host of other federal, state and local government bodies dedicated to environmental preservation; the passage of myriad laws and regulations governing water quality, land use, and the release of hazardous materials into the environment; and a sea change in public attitudes about the value of protecting the natural world.

As a result, today we live in a cleaner and safer world. But the battle to protect the environment is far from over. Important threats remain to our air, water and land. Huge quantities of toxic materials still lie buried underground all over the country, a threat to human health and the fiscal health of those who may unwittingly purchase polluted land. And industry must still grapple with the best and safest ways to deal with the hazardous byproducts of manufacturing.

None of this is news to the several hundred WPI alumni who have built careers in various aspects of the environmental field. In the pages that follow, we invite you to meet just a few of these talented men and women.

These eight stories were reported by staff writers Michael Dorsey, Joan Killough-Miller and Ruth Trask, and by David Brooks, a photographer and writer who lives in Warren, N.H., Allison Chisolm, a Worcester-based freelance writer, and Diane Benison, a former newspaper editor who writes regularly for the WPI Journal.

Small Planet

Hank and Paula Nowick Help Companies Save Money and Protect the Environment

n 1959, when Henry ("Hank") Nowick '56 began his career as a process engineer at Monsanto Chemical Co., protecting the environment was not a major focus for the chemical industry. Few environmental laws and regulations were yet in effect, and the impact of pollution on the environment and human health was not well understood. But all that would soon begin to change.

The publication of Rachel Carson's Silent Spring in 1962 alerted the world to the dangers of environmental pollution by pesticides, and in the process launched the international environmental movement. The first Earth Day in 1970 demonstrated the growing popular concern over pollution and environmental degradation, a concern that helped fuel the creation of the Environmental Protection Agency and the subsequent passage of landmark environmental protection laws, such as the Resource Conservation and Recovery Act and the Clean Air and Water acts, over the following two decades.

Today, a different sort of environmental revolution is taking place. Where the environmental movement of the 1970s and 1980s grew primarily from a desire to clean up the world's air, water and soil, and to find safer and more reliable ways to dispose of the products of our industrialized society, today there is a growing realization that protecting the environment can be good business.

More and more, companies are looking for ways to reduce their production of waste and to reuse hazardous materials—strategies that not only reduce the need to dispose of chemicals, but lessen the risks involved in storing and handling these materials. The potential for significant savings and improved safety are motivating many companies to accelerate their environmental efforts. Nowick says his 35-year career in chemical engineering has been greatly influenced by the environmental movement. When he joined Monsanto in 1959, he was a technology specialist whose primary responsibilities were improving the manufacturing processes for existing products and bringing new products developed in Monsanto's laboratories into full-scale industrial production. He also became involved in starting up new chemical production units in Mexico, Spain, Italy, Germany and England.

In recognition of his contributions to the company, Nowick in 1979 was one of a handful of employees offered a full-year academic assignment at a university and in a field of his choice. He elected to study the emerging field of environmental engineering at the University of California at Berkeley.

"My years of varied industry experience gave me a perspective that many political-action environmentalists didn't share," Nowick says, "namely, that American industry was run by intelligent, well-meaning and caring citizens, like me, who had been unaware of the long-term impacts that new products and their by-products might have on the land, air and water. The solutions to these problems required intensive study and strategic planning, not sloganeering and name-calling."

When he returned to Monsanto, he was assigned to develop a coordinated hazardous waste management program for the company's Springfield, Mass., plant. In that job he developed training programs, conducted environmental audits for several Monsanto plants, and designed programs that enabled the company to meet environmental regulations in a cost-effective manner.

He also became corporate Monsanto's leading public speaker, concentrating primarily on environmental issues and industry compliance with government regulations. And he was a charter member of the Massachusetts Hazardous Waste Facility Site Safety Council, one of several boards on which he has served over the years.

At the many national conferences Nowick attended, he was introduced to the new revolu-



Hank and Paula Nowick, founders of Nowick Environmental Associates. After a 35-year career with Monsanto, Hank Nowick set out on his own. The firm he and Paula created helps companies comply with environmental regulations and reduce their production of hazardous wastes.

"My years of varied industry experience gave me a perspective that many political-action environmentalists didn't share, namely, that American industry was run by intelligent, well-meaning and caring citizens."

tion in environmental engineering. He learned that the most effective—and economical—way to tackle hazardous waste is to produce as little as possible. "The idea was," he says, "wherever possible, to reengineer your product and processes so as to minimize hazardous materials. Engineers were being asked to design more efficient processes, substitute materials, recover, recycle, and create new uses for by-products."

At Monsanto, for example, Nowick decided there had to be an alternative to paying between \$50 and \$300 per 50-gallon drum to dispose of waste resins generated at the plant. Drawing on his contacts at other chemical plants, he discovered that Polaroid was faced with similar costs for disposing of waste solvents. By commingling Monsanto's waste resins with Polaroid's waste solvents, Nowick was able to generate a fuel that could be sold to companies that produce concrete shale aggregate, replacing the more expensive petroleum-based fuels they were using. "That initiative produced hundreds of thousands of dollars of savings for everyone," Nowick says.

After taking early retirement from Monsanto, Nowick entered the consulting business in environmental engineering and founded his own company, Nowick Environmental Associates, in January 1994. His wife, Paula, is vice president of the firm. A major objective of the company is to help industries that process or handle hazardous chemicals, or that create hazardous by-products, comply with complicated state and federal regulations.

"I read the Federal Register every day," Nowick says. "It enables me to keep my clients abreast of amendments to environmental regulations, pending legislation, pertinent legal interpretations and current laws that may affect them. This is an ever-changing, ever-challenging field."

Because each state can add more stringent amendments to the federal law, companies doing interstate business must comply with many variations. "We recently trained workers in an Arizona-based company on the mandates they must follow to avoid violating federal, Massachusetts and Arizona environmental regulations," Nowick says. "The sessions took eight hours, including certifying exams."

Nowick presents training and certification programs in a wide variety of environmental topics. His largest training group included 993 Air National Guard reservists at Westover Air Reserve Base in Chicopee, Mass. "It took 32 sessions to train everyone," Nowick says. "I also produced a video to train absentees or newcomers. By the end of that assignment, I could give a five-hour training session with no notes."

In its first year of operation, Nowick Associates has developed toxic use reduction plans for 15 industries in Massachusetts. One such company is a printing plate producer that uses concentrated nitric acid in its photoengraving etching process. For years the firm had been disposing of the spent acid in its wastewater discharge after first neutralizing it with sodium hydroxide.

Nowick was asked to investigate whether it was possible for the company to reduce its use of nitric acid and sodium hydroxide, both of which are expensive and potentially hazardous to workers and the environment. Nowick proposed the use of a recently developed acid recycling system that uses diffusion dialysis. Trials in the plant demonstrated that 95 percent of the spent nitric acid could be recovered and purified for reuse.

"Not only was the nitric acid discharge cut significantly," Nowick says, "but the need for sodium hydroxide was drastically reduced. The company was able to realize its goal of producing high-quality etched products while producing as little waste as possible. This strategy not only significantly lowered the risk associated with the storage and handling of hazardous chemicals, but it will have financial benefits by reducing the need to purchase raw materials, as well as lowering operating and waste-disposal costs."

"We have found that many companies do not have the resources to research alternatives like this," Paula Nowick says. "Larger companies have downsized their research and development staffs, and smaller companies, especially in New England, have to focus their energies on surviving in fiercely competitive markets. Given strict environmental regulations and today's economic climate, the environmental consultant has become a vital asset for many industries."

Public conservation efforts can also frequently benefit from the types of services that Nowick Environmental Associates offers. For example, a consortium of 20 high schools in Western Massachusetts needed help in finding the most costeffective way of disposing of small quantities of the many spent and out-of-date chemicals purchased for use in classroom demonstrations and experiments. Since only licensed hazardous waste disposers are authorized to deal with these potentially dangerous chemicals, each school was looking at costs ranging from \$2,000 to \$5,000 for disposing of less than a 50-gallon drum of waste.

"First, we compiled a master list of the chemicals from all 20 schools," Nowick says. "Through the industrial contacts I have made over the years, we found companies that could use many of these chemicals in their operations. We even found a roofing contractor to take some excess asphaltic materials from one of the schools."

Currently, Hank and Paula are gearing up to help companies comply with regulations being prepared by the Occupational Safety and Health Administration and the Environmental Protection Agency that will require manufacturing companies to review and improve their operations to ensure the health and safety of employees and neighboring communities.

"Part of the process of complying with these Process Safety Management regulations will require the application of the concepts of total quality management, making sure everyone in the company—from managers on down to line workers—becomes involved in the decision making about processes that employ hazardous materials," Paula says.

While Nowick Environmental Associates is their first joint business venture, Hank and Paula Nowick have been partners since first meeting at WPI in 1958, becoming engaged in Paris in 1961, and marrying in 1963.

"Given strict environmental regulations and today's economic climate, the environmental consultant has become a vital asset for many industries."

"It's fascinating to look back at the changes in environmental awareness that have occurred over that time," Paula says. "It's just as fascinating to think about how much our life together has deepened our appreciation of the loving care that needs to be given to all evolving things—especially relationships. All beautiful things need protection and reverence."

- Michael Dorsey and David Brooks

NANCY CONVARD HELPS KEEP THE SPIRIT OF EARTH DAY ALIVE IN THE PACIFIC RIM

ver the past two decades, the annual celebration of Earth Day has lost much of its original excitement and visibility. But in the late 1970s, when Nancy S. Convard '80 was in high school, it was still a new and powerful idea, one that influenced her choice of college and helped shape her career.

When Convard decided she wanted a career that combined her budding concern for the environment with her knack for math and science, she went looking for colleges that would enable her to merge these interests. At the time, WPI was one of the few universities offering an undergraduate degree in environmental engineering. That, plus the WPI Plan, with its project-based approach to education, led her to enroll at WPI in 1976.

What she didn't realize then was how her choice of career and college would help her achieve another of her goals: seeing the world. For the first 20 months after she graduated from WPI, Convard worked in Massachusetts for the U.S. Environmental Protection Agency. But since then she's pursued her career entirely in the Pacific Rim, working in Southeast Asia, for a small Pacific island republic and, most recently, in Hawaii.

Her life in the Pacific region began in 1982 when she left the EPA to join the Peace Corps as an environmental engineer. She was sent to Thailand to work with the provincial government in Roi-Et on water resource projects. She helped plan, design and build small dams, spillways and rain catchment tanks. She also spent a great deal of time in the village of Ban Payamnom Noi helping out with a variety of environmental projects.

When her two-year hitch in the Peace Corps was over, she signed on for a third year and was given the freedom to design her own assignment. She decided to go to Chiang Mai University in northern Thailand, where she worked as a researcher and instructor in the environmental engineering program. Fluent in Thai, she taught courses in environmental engineering and industrial wastewater treatment to Thai students. She also helped conduct water quality surveys in northern Thailand.

"I liked working in Thailand," she says, "and I liked the fact that my work made a clear difference in the lives of people." She realized that to remain in the environmental field she would need an advanced degree. She was accepted by several universities, but chose the Master of Public Health Program at the University of Hawaii.

She attended the university with a prestigious scholarship from the East-West Center for Intercultural and Technical Exchanges. Funded by the U.S. government, the East-West Center has a staff of full-time researchers, fellows and associates and sponsors a cadre of graduate students at the University of Hawaii. Of the 150 to 200 students who conduct research through the center each year, about 25 percent are from the U.S. and the balance come from various Asian and Pacific island nations.

Convard says her work through the East-West Center gave her valuable international professional ties. But the public health program focused more on identifying and managing environmental risks, and less on treating and mitigating them, which were her interests. To learn more about the practical, hands-on side of environmental work, she stayed on to earn a second master's degree in civil engineering in 1987.

With her graduate work complete, she took a job as executive director of the Environmental



Early in her career, Nancy Convard worked as an environmental engineer in Thailand, where the local fauna includes elephants. She has remained in the Pacific Rim since then, running an environmental agency for an island nation and working for several consulting firms in Hawaii.

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"I believe it is important to balance environmental and public health concerns with real-world needs, such as housing, economic development and so on. Sustainable development and assessing risks to the environment and human health are both key to 'environmental management."



David Ploss, right, and H. Robert Nyce of Ploss Associates. The firm, founded by Ploss in 1985, provides a range of environmental services and also offers an on-line information service that keeps clients up to speed on the latest news on environmental laws and regulations. Quality Protection Board of the Republic of Palau. Palau was then part of the United Nations Trust Territory of the Pacific Islands and was administered by the U.S. Located about 800 miles southwest of Guam, Palau is made up of some 340 islands in the Caroline chain, many of which are uninhabited. Its 15,000 citizens live in an area roughly twice the size of Washington, D.C.

The Republic of Palau gained its independence last October, the last U.N. Trust Territory in the Pacific to do so. When Convard went to Palau in the late 1980s, the U.S. EPA was working with local officials to help them prepare to manage their own environmental programs after independence came.

Convard says the nation's early environmental program focused primarily on sanitation and rural environmental health. But the newly established Environmental Quality Protection Board was charged with addressing other environmental issues and creating new programs for the country, whose small economy was built primarily on tourism, subsistence agriculture and fishing. The tourist industry is considered to be of great importance to the nation's economic future.

"When I arrived, the board was not very active," she says. "Its staff was implementing the program through other government departments. My role as executive director was to manage the technical staff. I reported to an appointed board that made policy decisions based on the staff's technical analysis and recommendations."

For nearly three years, she helped set the new agency's scope and agenda. She and her staff reviewed the nation's existing environmental regulations, drafted new regulations, and recommended others to meet unaddressed needs. Under her direction, the board became a quasi-independent government agency, no longer under the control of any other department or ministry. She said this helped the board remain objective as it reviewed the nation's development efforts, which were largely directed by the national government.

"The board had pretty much all of the program areas that the U.S. EPA has: water supply, marine water quality, solid waste and hazardous waste, which in Palau primarily meant pesticides, household hazardous waste, petroleum products, and so on," she says.

"Palau is a wonderful place. It has some of the best—if not the best—scuba diving in the world, and it has some terrific people. I had a great time there; it was the part of my career of which I'm most proud. But the time came for the Palauans to take over. Since I left, I've stayed in touch with many of the people I worked with there."

In the spring of 1990, Convard began a new job with PRC Environmental Management Inc., a consulting firm in Honolulu. A year later she was offered the opportunity to open a Honolulu office for EnviroSearch International, a small firm based in Salt Lake City.

"EnviroSearch wanted to do international work and I had contacts in the Pacific region that allowed me to get project work," she says. "I worked on projects for governments and agencies, particularly the American Samoan government and the South Pacific Regional Environment Program, a regional international environmental technical assistance organization with representatives from governments throughout the Pacific region. I also added another continent to my resumé when I was asked to conduct an assessment of hazardous waste management in Botswana."

After two years with EnviroSearch International, she joined Parametrix Inc., a 300-person consulting firm based in Washington state. While Parametrix is known in the mainland U.S. as a multidisciplinary environmental firm, its Honolulu office had focused largely on water/wastewater engineering. Convard was asked to expand the environmental practice in Hawaii and in the Pacific, which she did until late 1994, when the company decided to scale back its Hawaiian operation and focus on the Pacific Northwest.

In November 1994 she joined Barrett Consulting Group Inc., which has a 300-person staff that works in offices in California, Washington, Hawaii and Guam. As senior environmental engi-

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"Having the opportunity to tap into needed information with a few keystrokes puts an end to flipping and browsing through mountains of manuals and documents."

neer/project manager in Honolulu, she will continue to work with several clients she brought with her from her previous job and further develop her expertise in areas like toxic waste remediation and solid waste management—in Hawaii and in the international arena. "We're looking at potential projects in the Maldives, Southeast Asia and the Cook Islands, among other areas," she says. "A four-month assignment to develop improved solid-waste management and environmental agency strengthening should be completed by this fall."

Convard says her work as an environmental consultant has been quite varied. Her earlier assignments—including her Major Qualifying Project at WPI—dealt with water quality. The MQP, completed with Betsy Steigerwald Yingling '80 and Grace (Crooker) Levergood '80, was a study of the Muschopauge Reservoir watershed in Rutland, Mass. "That project was actually similar to some of the work I've done as a consultant, where the environmental impacts of development projects are considered in the planning process or management of water resources," she says.

Today, many of her assignments in Hawaii focus on the environmental assessment, environmental audit, investigation and remediation of hazardous waste sites. For the foreseeable future she says she will likely continue this work on an international scale, helping governments balance economic development with adequate environmental controls. For her industrial clients, she sees her work turning more and more to areas like pollution prevention and waste minimization.

She says her work on international environmental projects has been particularly exciting, "because it solves real problems and provides proactive environmental management. I believe it is important to balance environmental and public health concerns with real-world needs, such as housing, economic development and so on. Sustainable development and assessing risks to the environment and human health are both key to 'environmental management.""

— Diane Benison

PLOSS ASSOCIATES BRINGS Environmental Services to the Information Highway

hen companies need more solid footing as they slog through the quagmire of environmental health and safety regulations, they can log into an on-line service maintained by Ploss Associates, an environmental consulting firm in Northboro, Mass. The service can give them answers around the clock, seven days a week.

F. David Ploss '70, founder and president of Ploss Associates, designed the new service, called Ploss Environmental and Safety Information Service. "We wanted businesses that had been dependent upon trade journals or that found themselves swamped with regulatory data to be able to get the information they need from a central source in a concise form," Ploss says. "Having the opportunity to tap into needed information with a few keystrokes puts an end to flipping and browsing through mountains of manuals and documents."

Agencies such as the U.S Occupational Safety and Health Administration and the Environmental Protection Agency are going on-line, Ploss says, but it still takes companies too much time to wade through all the latest regulations. And smaller companies, which his firm serves, rarely have a full-time regulatory affairs employee to do the work. Ploss says he and his staff glean the information they offer on-line on their own forays into the Internet. "We get the information because we need it in our work with specific clients," he says.

He says he decided to start the unique service about a year ago when he was downloading information from OSHA and realized that his client needed the same information but might not know how to find it. Now he makes the information—including news about proposed legislation—available to clients for a small monthly feeIt can be accessed by modem or through the Internet. So far, more than two dozen companies have signed on.

Michael Alberts, director of corporate safety and security for Cabot Safety Corp. in Sturbridge, Mass., is one of the service's clients. "I find that if there's something hot going on, I can find it," he says. "It cuts right to the chase." Norman Faucher, owner of CAC Industries Inc., says such a service has long been needed. "Before I joined, I was often unable to easily access the latest regulations, so I'd follow the old ones and hope for the best," he says. "I'd sometimes find out later that many were outdated by at least a couple of months."

In addition to access to information, the monthly fee also gives clients on-line support and two hours of free phone consultations each quarter. For a higher fee, companies can set up a bulletin board system for their employees. "For example," Ploss says, "a firm with 10 manufacturing plants around the country might want its own internal memo system so staff managers can discuss the latest EPA and OSHA regulations among themselves. Our service could, if requested, then supply them with the names of key agency persons to contact about regulatory changes."

Although the budding on-line service is presently on the front burner at Ploss Associates, the firm also specializes in providing solutions to environmental, safety, industrial hygiene and regulatory problems at companies—small and large —around the country. It conducts environmental site audits, environmental due-diligence investigations, industrial hygiene sampling and safety audits, and industrial program development, among other services.

"We also develop and assist in the implementation of hazardous waste management programs, audit existing programs and provide required training for clients," Ploss says.

The firm has completed a wide variety of projects since Ploss founded it in 1985. For example, it evaluated how fly ash is handled at the incineration facilities of a large municipality, prepared a corporate safety manual for a large New England

"Liabilities that are not at first apparent in proposed mergers can cost a firm millions of dollars. We can evaluate the potential liabilities before the transaction is completed and can, possibly, prevent a firm from assuming significant financial responsibilities."

corporation, and prepared and implemented a "Worker's Right To Know" program at a small printing company.

Ploss Associates also has experience in making environmental risk assessments prior to business acquisition and mergers. Its clients currently include a leading private investment company in New York and a development company and law firm in New England. "Liabilities that are not at first apparent in proposed mergers can cost a firm millions of dollars," Ploss says. "We can evaluate the potential liabilities before the transaction is completed and can, possibly, prevent a firm from assuming significant financial responsibilities."

Ploss says he relies on networking to build his business. "When you work for yourself, you're your own salesman. You follow up on referrals. You make cold calls. You ask people if they have any problems that you can help solve. We've been fortunate in being able to get ahead on a lot of word-of-mouth and repeat business."

The "we" behind Ploss Associates is a WPI alumni duo. Working with Ploss as a project manager is H. Robert Nyce Jr. '93, who has 16 years of environmental experience, mostly in the construction and consulting field. He has managed air-quality, safety, industrial hygiene and regulatory projects for a number of firms, including an abrasives manufacturer, machine shops, construction businesses, printing facilities, and trashto-energy plants.

Ploss' own experience includes course work at the Harvard School of Public Health and nearly two decades at Norton Co., where he was corporate administrator of Environmental, Health and Safety Services. He has also worked as a chemical engineer for Factory Insurance Association, a fire protection insurance carrier in Detroit, and for Kemper Insurance Co. in Philadelphia.

He has served on committees to develop industrywide compliance procedures and has been retained as an expert witness in numerous environmental- and safety-related legal cases. An authority on Workers Right To Know legislation and OSHA compliance, he has been a consultant to the Grinding Wheel Institute, the Abrasive Grain Association, the Smaller Business Association of New England, the Risk and Insurance Managers Society, and the Associated Industries of Massachusetts. A registered environmental assessor, he is also certified as a safety professional, hazardous materials manager, environmental inspector and plant engineer.

"When necessary, we add the services of additional certified industrial hygienists and safety professionals, as well as toxicologists, biologists, hydrogeologists, geologists and surveyors," Ploss says. "But most of the time, it's just the two of us." And that's just how he likes it. "You know," he says with a grin, "I really do like being my own boss and calling the shots."

Calling the shots is something that comes naturally to an experienced rower, coxswain and crew coach who once made it to the finals of the Canadian Nationals in the singles event. For more than 13 years, beginning in 1972, Ploss coached the WPI Crew Club, a six-day-a-week job. Under his guidance, the team won numerous titles, including the Four With Coxswain title at the National Championships in 1978, the City of Worcester Championship (for 12 years), and the New England Championships in 1979.

In 1982 he led the first alumni contingent and student crews to row in the Reading Regatta in England (a preliminary race to the famed Henley Regatta), where they won three trophies. Ploss' dedication as rowing coach, along with his work as a class secretary, a class agent, and chairman of the 15th Reunion of his WPI class, won him the 1985 John Boynton Young Alumni Award for service to WPI.

Like rowing, Ploss says he finds that being an entrepreneur has its rewards and its risks. "I'm in control of my career now," he says. "I didn't feel that way when I worked for a big company. On the other hand, I have to think about a lot of other things that I wouldn't have otherwise—like meeting a payroll."

— Ruth Trask

FORMER CHEMICAL ENGINEER IS A LAWYER FOR THE LAND, WATER AND SKY

n the mid-1980s, Paula (Green) Curry '82 dealt with dirty water. A chemical engineer, she designed industrial wastewater treatment systems to help companies meet clean water requirements. While her clients now had clean water, Curry discovered they didn't really understand the host of other environmental regulations their businesses faced. "They needed legal advice," she says. And the regulations fascinated her. So she decided to become a lawyer.

A native of Auburn, Mass., Curry graduated from Boston College Law School in 1990 and joined the 100-year-old Boston law firm Bingham, Dana & Gould as an associate. A national firm with more than 200 lawyers, Bingham, Dana & Gould offers its clients a full range of legal services. Curry is a member of a small group that offers counsel on environmental issues.

While she practices environmental law, Curry says she operates more as a businessperson. A large part of her work is providing environmental due diligence, she says, by arming businesspeople with the right information—both legal and technical—to make an acquisition decision.

For Curry, environmental issues are "not just for people who live in Cambridge and wear Birkenstock sandals. These are real business issues people have to deal with." On many cases, she reviews technical data on a piece of property, including groundwater and soil tests, and undertakes literature searches on the site and surrounding area.

"My goal is to get the best possible outcome for my clients," she says, "and help them work through all kinds of messes," from owning environmentally hazardous sites on the federal Superfund list, to lending money to companies who bought property discovered to have been a toxic dumping ground a generation ago.

"My goal is to get the best possible outcome for my clients and help them work through all kinds of messes."

"What my clients want to know is, "What is the likelihood I will have to pay for this?" Curry says. "I help them evaluate the risk." And the risks can be significant if a \$35 million to \$40 million transaction is at stake.

As for the potential price tag for cleaning up a hazardous waste site, Curry refers her clients to environmental consultants. "I try not to advise my clients whether or not to buy a property," she says. "The client picks a team and we approach the problems together."

Why should businesses worry about the environment? If they want to buy, sell or build on land, they have no choice—especially if the land is in densely developed New England. Several state and federal laws enacted over the last 20 years have changed the commercial real estate landscape, especially where ground or water contamination is suspected. If tests reveal contamination from hazardous waste, the federal Superfund Act imposes strict liability for cleanup costs on any person who ever owned or operated a business on the site, without regard to fault.

"Basically, the government can go after anybody in the chain of title," Curry explains, and ask them to clean up the mess. Other common statutes businesses wrestle to comply with are the revised federal Clean Air Act, Massachusetts' Chapter 21E (Massachusetts' Superfund statute), and local sewer regulations.

Since Curry first entered the field of environmental law, she says she has seen clients become more sophisticated about environmental laws and regulations. "These statutes have been around 20 years now," says Curry. "People have grown more comfortable with the laws and are more likely to evaluate the risks themselves."

So why switch from chemical engineering? As Curry has explained to WPI student audiences, law and engineering careers have different expectations. Engineering courses, she says, often lead students to solve a problem with one right answer. But law school professors want to see your reasoning, not your answers. Fewer clearcut solutions may bother engineers, she says, but she doesn't mind working through gray areas.

There are also more women in law, Curry notes, particularly in the first years of practice. "That's one less hurdle to overcome," she says. As an engineer, she often found herself the sole woman on a plant floor and had trouble conveying her competence to her male colleagues. "That made it difficult to do the job," she recalls.

In an environmental law practice, Curry is constantly challenged by a wide variety of tasks. Emergencies arise where she must evaluate material quickly. For example, a company on the verge of signing a deal may suddenly uncover a box of papers with environmental information. Inspectors from the Environmental Protection Agency may appear on a company's doorstep. At any one time, she may juggle eight to 10 different projects.

"You have to be up on a lot of various statutes," she says. "You've got to be a generalist within your specialty."

Curry and her husband, Scott Curry '82, recently acquired a new specialty—parenting. She took a five-month maternity leave last September to welcome their son, Davis, into the world—a world, she hopes, that will be a little cleaner for his generation.

— Allison Chisolm

PETER TUNNICLIFFE HAS BUILT A CAREER IN ENVIRONMENTAL PROJECT CONSTRUCTION

hen Peter W. Tunnicliffe '74 decided to enroll at WPI, the field of environmental engineering was new, as was the WPI Plan. He says he was willing to gamble on one, but not on both. As a member of one of the early Plan classes, he was free to choose the Plan or WPI's more traditional curriculum. Concerned that the Plan's lack of grades might hamper his ability to get a job, he opted for the traditional route to a degree in civil engineering with an environmental emphasis.



Paula Curry began her career as a chemical engineer specializing in wastewater treatment. In 1990 she earned a law degree and now is an associate at a Boston law firm, where she counsels clients on environmental issues, including those surrounding the purchase of real estate.

"We're going to see an awful lot of global environmental opportunities as more underdeveloped countries begin to get their water systems up to the current state of the art."



Having worked for a number of years in environmental construction for the firm of Camp Dresser & McKee, Peter Tunnicliffe was named head of a CDM subsidiary, CDM Engineers and Constructors, in 1993. The group specializes in undertaking environmental projects on a design-build basis.

Now president of CDM Engineers and Constructors, a subsidiary of Camp Dresser & McKee Inc., Tunnicliffe says environmental engineering appealed to him because it enabled him to blend his interests in chemistry, the life sciences, engineering and the environment. It also offered good prospects for employment.

At that time, the focus of environmental engineering was water quality and wastewater treatment. Under the Clean Water Act, the federal government was funneling large amounts of construction money into state and local government projects like sewer systems and water treatment plants. There was a growing need for engineers with expertise in design and construction.

Having received his degree in civil engineering, Tunnicliffe decided to take a job with Camp Dresser & McKee, one of several firms that made offers. He says the company's varied portfolio of environmental projects appealed to him. "Some of the other offers would have pigeonholed me," he says. "One company wanted me to be an ion exchange specialist. That seemed too limiting."

Starting in Camp Dresser's construction group, Tunnicliffe worked on a wide range of construction projects, including water treatment plants, wastewater plants, transmission mains, and sewer lines. "I learned an awful lot about construction very quickly," he says, "faster, in fact, than I could have in many alternate career paths. That exposure shaped the rest of my career."

In 1979 he was assigned to the company's New York City office, where he worked on some heavy construction projects designed by a firm acquired by Camp Dresser. "They had a lot of problems," he says. "I rolled up my sleeves, began to resolve them, and ended up relocating to New York and taking over the heavy construction group."

While in New York, he earned a law degree at Brooklyn Law School, something he felt would be an asset in his work in construction management. In 1981 he was named head of the reorganized New York office, which was working on major design jobs, including projects for wastewater plants and landfills. Over the next several years, as Camp Dresser became an important consultant and contractor in the field of hazardous waste, Tunnicliffe began managing projects in that area, as well, including work for the U.S. Environmental Protection Agency and industrial clients.

In 1991, as part of a companywide reorganization, Camp Dresser established several practice-oriented groups focused on national market trends. In 1993, one of those, created to meet a growing interest of industrial and municipal clients in design-build projects in the environmental field, became CDM Engineers and Constructors.

Traditionally, clients have contracted separately with designers and builders to get environmental projects constructed. But with designbuild, an approach now common in Europe, a single contractor is responsible for the entire project, which can often save money. Tunnicliffe says he believes this design-build concept will become prevalent throughout the environmental field.

CDM Engineers and Constructors' 14-member staff consists largely of construction project managers and superintendents. For specific projects, the subsidiary works with professionals from other Camp Dresser units, particularly people with design or construction experience.

"Our mission contemplates further growth in the areas of responsibility assigned to our project managers and superintendents," Tunnicliffe says. "It doesn't contemplate growing a series of redundant services that would compete with the parent. One of the core philosophies of Camp Dresser is to function as one team throughout all the operating units. We're not set up to compete among ourselves. That's different than many firms that are set up on a localized profit-center basis. Our goals are structured to promote teamwork between units."

Tunnicliffe says he is optimistic about the future of environmental engineering. In particular, he says the international market will provide a great deal of work for firms like his. "We're going to see an awful lot of global environmental

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"Business and industry are learning through experience that pollution prevention and the safe disposal of hazardous waste reduce the exposure of workers to toxic materials and help them stay healthy."

opportunities as more underdeveloped countries begin to get their water systems up to the current state of the art," he says.

"This is happening now on the Pacific Rim. Water system upgrades will be followed by wastewater treatment and, ultimately, by solid waste- and hazardous waste-related work. There are tremendous water treatment and wastewater needs in Eastern Europe because of uncontrolled industrialization. Drinking water is in trouble there and basic wastewater needs are not being met well. All around the world, there are tremendous environmental needs that will have to be addressed in the next decade or two."

— Diane Benison

STILL AN ACTIVIST AT HEART, FORCELLA HELPS CONNECTICUT MANAGE HAZARDOUS WASTE

he development of hazardous waste sites is controversial and unpopular, and even more so for low-level radioactive wastedisposal facilities," says Domenic Forcella '70. "But in this initiative, the community, not some outside agency, makes the decision as to whether or not it will participate in the selection of a local site."

Forcella is chairman and executive officer of the Connecticut Hazardous Waste Management Service (CHWMS) in Hartford, an independent, quasi-public agency created by the Connecticut Legislature in 1983 to promote the responsible management of hazardous waste to help safeguard the state's air, water and land. It also helps business operate more efficiently by providing technical assistance in pollution prevention.

In 1987 the agency's scope was broadened to include low-level radioactive waste. Through an innovative voluntary siting program, CHWMS hopes a community will volunteer to host a facility for the management of the low-level radioactive waste generated in the state. He says the new approach gives more control and bigger incentives to a community to establish a site than traditional state siting programs.

Under the program, local governments make the decision to begin discussions about hosting a facility. "It is not imposed on them as has traditionally been done," Forcella says. The community can design criteria for the site to meet its needs, and with the state it develops a "facility development agreement" that spells out the responsibilities of each party and carries the weight of contract law. For its participation, and to offset its costs, the community receives financial compensation from the state that it can use in any way it sees fit. Other states are studying the program, Forcella says.

The activities of CHWMS and its 20 employees are guided by a 10-member board of directors. Its members include Gerald R. Backlund '55, manager of regulatory affairs at the Stamford (Conn.) Research Laboratories of Cytec Industries Inc. Another WPI graduate, Joseph M. Amarello '82, is assistant manager for policy and regulation for CHWMS.

Forcella says that one of CHMWS's most important current missions is promoting waste minimization and pollution prevention among the state's industries. Through the Connecticut Technical Assistance Program (ConnTAP), it provides companies that wish to reduce their waste output with financial and technical assistance.

Attitudes about pollution prevention have changed over the last few years, Forcella says. Once thought of merely as "the right thing to do, environmentally," today it is seen as a more economical and efficient way to manage a manufacturing operation. "Business and industry are also learning through experience that pollution prevention and the safe disposal of hazardous waste reduce the exposure of workers to toxic materials and help them stay healthy," he says. "A healthy work force can mean increased production and profits."

Forcella says managing Connecticut's waste disposal problems is becoming more difficult all

the time as other states attempt to close their borders to out-of-state waste. The lack of adequate disposal sites for waste leaves Connecticut facing the potential for the loss of industry and jobs and increases the potential for irresponsible disposal and illegal dumping, he says.

All this makes the need for in-state waste disposal solutions more critical, although no less complex or controversial, he says. "While simple solutions are desirable, they are increasingly more unlikely. Solutions to the technical and environmental problems of waste disposal are within reach, but they will not come without some expense, and there will be complex political and social hurdles to surmount."

Forcella's interest in public service began when he was a student at WPI. He was instrumental in setting up a program called the Worcester Area Free University, which was open to anyone without age restrictions or residence requirements. "Our goal was to bring people from institutions of higher learning together with people from the community at large who were seeking solutions to problems," he says. "We placed more emphasis on practice than on theory."

He also became interested in environmental issues as a student, serving on the Worcester Chamber of Commerce's Beautification Council and Environmental Committee and helping organize the Institute's observance of the first Earth Day in 1970. After receiving his degree in civil engineering and starting a job in the Worcester City Planning Department, he began his graduate work in civil engineering and environmental planning at WPI and founded the Worcester Ecology Action Center, which used radio shows, political lobbying, speakers and advisors in its efforts to improve Worcester's environment.

In 1974 he interrupted his graduate work to become the first chairperson of the Inland Wetlands Commission in his hometown of Plainville, Conn. During the next several years he worked at a variety of jobs, including substitute teacher in the Plainville schools, instructor at

"Solutions to the technical and environmental problems of waste disposal are within reach, but they will not come without some expense, and there will be complex political and social hurdles to surmount."

Briarwood College in Southington, Conn., justice of the peace, photographer, feature writer for the *Plainville News*, and consultant for an environmental studies program at Central Connecticut State College in New Britain.

Long active in Connecticut politics (he is a past chairman of the Plainville Democratic Town Committee and a former vice president of the state's Young Democrats), he was nominated in 1978 to run (unsuccessfully, as it turned out) as the Democratic Party choice for the 22nd State Assembly District, which includes Plainville. He also worked on the political campaigns of his father, a former mayor of Plainville, and former WPI professor Carl H. Koontz, who served as a city councilor in Worcester.

"I started my first important post in 1979," he says, "when I was appointed by Connecticut Governor Ella Grasso as executive director of the Connecticut Council on Environmental Quality." For five years he served as an ombudsman for the state, overseeing environmental issues and legislation and addressing citizens' problems. Under his direction, the council became involved in such potentially thorny issues as hazardous waste siting, drinking water contamination and solid-waste disposal. It also investigated the impact of the construction of large shopping malls on the environment.

In 1983 he received a Mellon Fellowship for Academic Research and enrolled at Yale University's School of Forestry and Environmental Studies to complete work on a master's degree in environmental policy. Three years later he stepped down from his executive director's post to pursue a Ph.D. in environmental design and planning at Virginia Polytechnic Institute and State University under a Cunningham Fellowship for Dissertation Research.

"Dom's work with the Council on Environmental Quality has emphasized citizen concerns, and his efforts to solve problems that were varied and complicated have made us that much more effective," attorney Donald Mackie, then chairman of the council, said at the time. "His concern let the public know that the council is a unique government agency that has a mandate to follow through on citizen complaints."

At Virginia Polytechnic, Forcella conducted research on facility siting procedures, small-quantity waste generators, household hazardous waste, and emergency response. He prepared reports on hazardous waste issues for local officials in Virginia cities and towns. For two years he was a facility siting consultant to the National League of Cities.

In 1987 he was named a senior policy analyst for the Natural Resources Center of the National Governors' Association. In that post he directed a pollution prevention study, staffed the Governors' Task Force on Solid Waste, coordinated a Superfund policy forum, directed work for the Waste Capacity Assurance Project, and assisted in a survey of areas closed or restricted due to toxic contamination. This work required close collaboration with state environmental staffs, the EPA, industry representatives, and environmental groups.

Over the years, Forcella's know-how and creative approach to problem solving have made him a much-sought-after committee member and speaker. Among the many committees on which he serves are the U.S. Environmental Protection Agency/NGA Environmental Justice Work Group, the State and Territorial Solid Waste Management Officials Pollution Prevention Task Force, and the U.S. Department of Energy's Federal Facilities Compliance Act Task Force.

He has written extensively about environmental issues and has presented the results of the work of CHWMS at national conferences and to work groups at the National Governors' Association. He is listed in Who's Who in American Politics and Who's Who in Pollution Prevention.

Forcella was appointed to his current post at CHWMS in 1992 by Governor Lowell R. Weicker Jr. In this highly visible job he says he draws on the varied experience he has gained over the years. Particularly useful, he says, is the

political sensibility he began building more than 20 years ago while an undergraduate at WPI.

Active in a campus protest of the U.S. military invasion of Cambodia, he earlier had found himself, as a member of the Student Activities Board, voting against a motion to spend student government money to rent a bus to carry students to Washington, D.C., for a moratorium in late 1969. He says he opposed using general student funds to support the political views of one segment of the student body, "even though I may have agreed with those views.

"From that experience I learned the value of compromise," he says. "You have to push as far as you can for yourself, but you can't be inflexible. You need to work hard to get things done, especially in the environmental arena where so many people hold diverse views. Sometimes, such as with our voluntary community siting program, we win one."

- Ruth Trask

Monsanto Engineer Has a Message for Today's Students: Environmental Engineering Pays

dward Jamro '73 learned early on the value of environmentalism. He grew up in Central Falls, R.I., in the 1950s, long before recycling was fashionable. When his mother made Ed and his brothers bundle rags and newspapers and cart them to the junk dealer, he found out that there was money in conservation—often enough for a movie or a hot fudge sundae.

Now, as manager of environmental protection for Monsanto Co.'s Indian Orchard Plant in Springfield, Mass., he is in a good position to get that same message out to today's young people. Environmental engineering pays, he says, and not just for those who work in the discipline, but for companies and communities.

"Never lose sight of the fact that this really applies. Every time you help a worker do his or her job better, you are also helping the environment."

Jamro loves to talk about his work and to promote the field of environmental engineering to students at WPI, where he earned a bachelor's degree in chemistry, and at the University of Massachusetts, Amherst, where he earned a master's degree in environmental engineering in 1975. "In the late '60s and early '70s, when I got interested in this field, we had red rivers, white rivers, green rivers—rivers catching on fire," he says. "I know Institute Pond near campus isn't a good place to swim, but you should have seen it when I was a student."

The first Earth Day in 1970 had Jamro, then a freshman, on his hands and knees, picking up litter in Institute Park with some of his Sigma Alpha Epsilon fraternity brothers. As a junior, he got his feet wet in the environmental field by monitoring carbon monoxide levels in the streets of Worcester through WPI's Environmental Systems Study Program, a precursor of today's student projects. He says this work gave him credentials to break into his chosen career.

Jamro has spent the past 20 years working to minimize Monsanto's negative impact on rivers, groundwater, air quality and the environment in general. Since 1988 he has been responsible for compliance with federal, state and local regulations at the company's Indian Orchard Plant, the largest chemical plant in the state of Massachusetts, which produces resins and plastics. He played a leading role in the plant's voluntary waste-reduction effort, which halved total waste generation and cut toxic air emissions by 89.8 percent between 1987 and 1993. Two MQPs by WPI students have helped to further reduce waste generation at Monsanto; a third project is planned for 1995.

Jamro's professional accomplishments and his dedicated volunteer activism earned him a 1991 Environmental Award from the Springfield Conservation Commission and the 1994 Environmental Excellence Award from the National Association for Environmental Management. In his spare time, he mobilizes volunteer forces in the Greater Springfield community and among Monsanto employees. He helps organize Springfield's annual Earth Day Fair, and he helped found the nonprofit Local Emergency Planning Corporation to raise funds for local emergency needs.

Jamro has been recognized locally for starting a citizens' project to monitor water quality on the Chicopee River, and for sustaining a similar project on the Mill River, both in Western Massachusetts. On Saturday mornings he can be found with his 18-year-old son, Terry, dipping sample jars into the tea-colored water to assess dissolved oxygen levels, biochemical oxygen demand, phosphates, organic and total carbon levels, fecal coliform counts, and pH.

He predicts that the job of the environmental engineer will get tougher and tougher, as stronger environmental protection standards are passed and as the drama of burning rivers and pea-green lakes passes from the public consciousness. He acknowledges that the first steps in addressing an environmental problem are often the easiest; it's eliminating the last bits of pollutants that demands the most of an environmental engineer. That, he notes, accounts for the current focus on "source reduction," which seeks more efficient manufacturing processes that reduce the need for hazardous reactants and avoid the creation of toxic by-products in the first place.

The environmental engineer's most important charge, he stresses, is to make sure that environmental awareness trickles down. "If it's 3 a.m. and a scrubber stops working, what can you do?" he asks. "The operator has to have the motivation and the know-how to get it working or halt production."

He points to a diagram of the water cycle as he addresses a group of students at a recent WPI lecture. "Never lose sight of the fact that this really applies," he tells them. "Every time you help a worker do his or her job better, you are also helping the environment."

Jamro reminds skeptics that what was acceptable for industry just a generation ago is unthink-



Domenic Forcella, right, and Joseph Amarello '82 watch a videotape produced by the Connecticut Hazardous Waste Management Service for local communities. The agency, headed by Forcella, runs an innovative voluntary siting program for hazardous waste facilities in the state.



Edward Jamro with an Earth Day display about emergency planning and response projects in Springfield, Mass., in 1992. Jamro, who is manager of environmental protection for Monsanto's Springfield, Mass., plant, is also active in environmental organizations in the area. "A site may look like a deli or a hairdressing salon today, but you might find underground storage tanks that were paved over, or floor drains from a prior occupant that leaked industrial solvents or oils."



Lisa and Geoff Wadge look over site plans in the offices of EnviroAudit Ltd. and EnviroCheck Ltd., which they founded in Connecticut. EnviroAudit specializes in due diligence work, while EnviroCheck is a computerized resource that provides clients with copies of government records.

able today. As an example, he cites an environmental impact study from the 1960s that, in essence, concluded, "Discharge into this river is OK because the river is so polluted already, it won't know the difference.' You weren't brought up the way we were," Jamro tells today's students, who will be tomorrow's environmental engineers. "I think we need one more generation of dedicated environmentalists to really make things change."

- Joan Killough-Miller

GETTING ENVIRONMENTAL INFORMATION TO THE PEOPLE IS THE GOAL OF LISA AND GEOFF WADGE

f you were thinking about buying a \$5,000 used car, you might have a mechanic look it over to make sure you weren't about to get stuck with a lemon. If you were about to sink \$1 million into a piece of commercial real estate, you might want to hire a different kind of expert to save you from jumping into the purchase of an environmental nightmare—a sort of "environmental detective" who could dig up any dirt on the site's past, run background checks on its previous uses, and cross-reference the findings with data from local, state and federal agencies.

That's precisely what Lisa (Katz) Wadge '82 and Geoff Wadge '81 do. They are a husbandand-wife team of private environmental investigators with the scientific and legal know-how to evaluate the potential liabilities of any type of real estate—residential, commercial or industrial. Their clients may be prospective buyers or sellers and include businesses, hospitals and universities, as well as banks and investors. Their services are vital to those who need to know exactly what they're getting into before embarking on a real estate transaction.

The Wadges, who met at WPI and were

married on the lawn of Higgins House in 1982, have launched two successful businesses that work together to offer clients peace of mind. EnviroAudit Ltd., founded in 1988, is an environmental consulting firm that performs customized site assessments. These may range from looking up records at the local town hall, to testing soil and groundwater samples for contaminants, to locating and removing underground oil-storage tanks. "Our market niche is clearly the investigative side, as opposed to the cleanup and remediation sides," says Geoff.

The need for such services comes from recent "transfer trigger laws," such as Connecticut's 1985 Transfer and Superlien Act. "It's a kind of lemon law for real estate transactions," Lisa says. "If the seller doesn't disclose certain conditions, the new owner has the right to seek recompense from the previous owner.

"The intent is to encourage parties who are coming together in a purchase-and-sale environment to 'fess up' about environmental conditions. The transfer trigger regulations have encouraged all people to understand and clean up even the smallest environmental liabilities. Under the context of these provisions, we're able to short-circuit and resolve issues that the government has been unable to manage for years."

To date, 11 states have enacted similar regulations, including chapter 21E in Massachusetts and ECRA in New Jersey. The findings in some cases suggest that purchasers must show that they have performed "due diligence" and made "all appropriate inquiry" to determine if environmental factors might impact the value of the property or human health.

"EnviroAudit *is* due diligence," says Lisa. "If you can show that you made the proper inquiries, you may have the right to go back after the prior owner, should something new come up." The company offers customized services packages, with fees ranging from \$300 for a simple database search, to \$10,000 and up for soil and groundwater sampling using a large drilling rig. Although clients sometimes grumble at the initial "We believe that environmental information belongs to the people. The more people understand about what's happening in their community, the more real action we'll see in managing environmental issues."

expense, the value of the information can be priceless.

"A site may look like a deli or a hairdressing salon today," Lisa cautions, "but you might find underground storage tanks that were paved over, or floor drains from a prior occupant that leaked industrial solvents or oils." Other common findings include the presence of lead-based paint, asbestos or radon, as well as soil and groundwater contamination resulting from ancient septic systems.

"Not all problems spell total disaster," says Geoff. "The solution could be as simple as removing a leaking tank and some contaminated soil. On the other hand, a groundwater pollution problem that requires pumping and treating can cost hundreds of thousands of dollars to clean up." Armed with this kind of information, a buyer can outline cleanup actions and negotiate costs with the seller—before it's too late.

EnviroAudit grew out of Lisa's previous work in groundwater investigations for a small civil engineering firm. With her employer's encouragement, she struck out on her own, working out of a small room in the couple's Killingworth, Conn., home. Geoff was working as a mechanical engineer for Union Carbide Corp. at the time, a job he'd taken after graduating from WPI.

After seven months, EnviroAudit sales grew to the point where "things were too crazy around the house," he says. Geoff quit his job and the Wadges rented an office and hired their first two employees. Their dream of meeting a sales quota of \$30,000 in the first year was surpassed with a whopping \$90,000 worth of business.

In the course of running a consulting business with current annual sales of \$700,000 to \$1 million, the Wadges found that obtaining government records was a constant obstacle. "We started to copy the records and keep them in our office...never realizing what we were starting," recalls Lisa. "Six years and a half-million pages later, we created a database that grew into a second company."

EnviroCheck Ltd. is a computerized informa-

tion library that provides access to a database with hard copies of government records. Using a newly programmed search routine created under Geoff's guidance, the Wadges can type in the name and address of any location in New England and search for relevant environmental data. They can provide clients with hard copies of environmental regulations, historical documents and lists of hazardous waste sites.

How important is this type of information? Lisa relates the story of a state historical society that was planning an archaeological dig. "They put a Styrofoam cup into the water to get a sample, and the cup dissolved. We called the location up on the computer and found out they were working on a heavily contaminated Superfund site and didn't know it. We're trying to get data out to people who might not be aware that this type of information is important to them."

Tracking down information can consume more time and effort than many clients can spare. Environmental records are typically separated by environmental media (air, water, solid waste) and can be stored at numerous locations. Some government offices are only open a limited number of hours each week. Although one is often required to make an appointment in advance and wait on line, there's no guarantee of locating the needed information before closing time. The records may be misfiled, missing or filed under a previous owner. With their computerized search facility and in-house records, EnviroCheck can find information faster and more cost-effectively than a manual search though bulging file cabinets at state and local offices.

Clients of EnviroCheck might include a homeowner, the local dry cleaner, a *Fortune* 500 company, local planning and zoning authorities, or lawyers and engineers representing any of the above. One of EnviroCheck's best customers is EnviroAudit, which consults the database for advice every day.

In December 1994, the Wadges sold Enviro-Audit to a large New England utility company and retained ownership of EnviroCheck. Lisa remains as president of EnviroAudit and works one day a week for EnviroCheck; Geoff now works full time for EnviroCheck. Lisa describes herself as the "outside person," doing the marketing, obtaining records and responding to legal issues. Geoff is the "inside man," managing EnviroCheck. Until the recent transfer, he managed field activities, such as drilling and sampling, as vice president of EnviroAudit.

The Wadges say they enjoy their business partnership. "A lot of people shy away from working with their spouses," says Lisa, "but I think engineers are well-suited to work together, because we are pragmatic and problem-solving. We've had our tense moments, but I wouldn't trade working with Geoff for anything in the world." The flexibility of working together allows them to share in the care of 2 1/2-year-old son, Justin, as well. Both companies are located close to their home, in the scenic Connecticut River valley community of Centerbrook.

The uniqueness of EnviroCheck, and the wealth of the information the Wadges have acquired, offer exciting possibilities, such as linking up with on-line computer services, or plotting the data by location, so that it can be searched and displayed in map form, rather than by typing in words. They intend to maintain their database in Connecticut, Rhode Island and Massachusetts, while expanding into Maine, New Hampshire and Vermont.

"There are other private companies that broker federal data, but there's no one else in New England that has what we have," Lisa says. "There's no one else crazy enough to do what we did! It's very time-consuming. Everything that we have is available to the public (under the federal Freedom of Information Act), but it's more cost-effective for clients to get it through us.

"We believe that environmental information belongs to the people. The more people understand about what's happening in their community, the more real action we'll see in managing environmental issues."

- Joan Killough-Miller

WPI JOURNAL

FINAL WORD



The Search for Everett Leach

By Joan Killough-Miller

N THE SUMMER OF 1945,

a twin-engine plane fell from the sky and crashed at the edge of a cornfield on the lsle of Wight. The pilot, a young American major in the Army Air Force, was killed instantly. From the next field, a farmer watched in horror as the plane caught fire and exploded.

The news was relayed to the pilot's family. His civilian boss, Luther Martin '25, sent word to Alumni Secretary Herbert Taylor, who reported the death in the *WPI Journal*. "EVERETT W. LEACH, '38: Fourth graduate of the class to lose his life during the war, Ev Leach was its acknowledged leader. He was elected permanent class president after having served in that capacity during the senior year. He was also president of Skull...."

Leach was only one of many alumni of the 1930s and 1940s reported dead, missing or wounded during the war. In those days, the *Journal* devoted as many pages to a column called "From the War Theaters" as it did to "Around Boynton Hill." In 1950, Leach's photo appeared again in the *Journal*, when he was awarded a posthumous Distinguished Flying Cross.

His wife, the former Idella Muir, remarried and moved to the West Coast. Another classmate took on his duties as class president and agent. His alumni file was closed, and eventually came to rest in the archives in Gordon Library.

But one person could not forget Everett Leach. Nils Askman, who trained with Leach at Standard Oil (later ESSO, and now Exxon), was filled with questions about his friend's death. Where, exactly, did his plane go down? Why was he flying the training plane over the English Channel that day? What happened to his remains?

Askman and Leach became fast friends when they met in Standard Oil's student engineers training course and were later assigned to work in the same division. Both men enlisted in 1941. The Army split them up for training, but they were happily reunited at Turner Field in Georgia. In an amazing series of coincidences, Askman and Leach found themselves posted to the same locations over and over again through most of the war.

In 1945 Leach was sent to England to work on a jet engine for a newly developed fighter plane. Askman was awaiting overseas assignment, but got only as far as Long Island, N.Y., when the war ended. He was there when he got the call from Della Leach informing him of his best friend's death.

Askman's career with ESSO took him to Europe and Asia, including several assignments in England. It was there that he met his wife, Daphne, a nurse from New Forest, not far from the lsle of Wight. While living in England, the couple investigated Leach's death, but uncovered very little, since most information was still classified. After retirement in 1978, they returned to Askman's hometown of Beverly, Mass., and had more time to devote to their search. Time had soothed the grief, and the transcontinental research project became a hobby.

"It's been rather fun, really," says Daphne Askman of their long-distance detective work. A major breakthrough occurred several years ago, when the Askmans tracked down Leach's grave in Worcester. Through correspondence with the RAF's Ministry of Defence, they learned that Leach had been

One person could not forget Everett Leach. Nils Askman...was filled with questions about his friend's death.

buried in a small cemetery outside of London, but that the remains of all Americans buried there had been moved in 1948, some to the United States.

A fire had destroyed the relevant records, but on a hunch Askman wrote to the Worcester Department of Parks, Recreation and Cemeteries and struck gold. In 1993 he and Daphne received a map of the plot in Hope Cemetery and were able to pay their respects to Everett Leach.

It was the brother of an English friend who finally led them to the site of the plane crash. When Daphne's mother died, she inherited a cottage near her childhood home. Neighbors David and Mary Hall took Nils and Daphne on a tour of the Isle of Wight, led by Mary's brother, Canon John Bean, the retired pastor of a church on the island.

After lunch, the Canon drove them to Newport, Isle of Wight's capital city. Without explanation, he dispatched the ladies to a tea shop and led Askman across the street into the offices of the Isle of Wight County Press. They searched microfilm of the newspaper starting from July 1945. It wasn't long before Askman reeled to a brief report of the accident.

A one-inch story gave the time, date and street location of the crash. Of some consolation was the final sentence: "The Ryde ambulance and the N.F.S. were promptly on the scene, but the pilot was beyond all human aid and must have died instantly."

With those questions answered, a new one arose. How to commemo-

rate the big, good-looking guy, who didn't seem to have an enemy in the world? On a subsequent visit, Bean took Askman to Havenstreet Shrine, a monument erected in 1917 by a farmer who lost his son in World War I. Over time it had become a memorial to all the local war dead, including those lost in battle over the Falkland Islands near Argentina in 1982.

After viewing the shrine, relentless Askman stopped at a dairy farm across the street to ask if anyone remembered the plane crash. The farmer had been a baby during the war, but he directed the couple to 94-year-old Fred Aylett, a former owner. It was Aylett who had stood in his cornfield 50 years ago and watched Everett Leach's plane plummet and burn.

Aylett's eyewitness account confirms the RAF's report of the crash: Leach took off from Boscombe Down at 1130 hours to conduct stability trials on the Airspeed Oxford NM247 at an altitude of 5,000 feet. Askman remembers that Leach was always looking for something to do, and what he loved most was to take up planes with a "red-cross condition" (having just been repaired) to check them out. "He always had his nose in fly-



Above, Askman, left, and Canon Bean at the Havenstreet Shrine; right, the memorial to Leach.

ing—and the mechanics of it, the engineering, and the technology behind it."

Aylett had seen the plane flying over the area for a while before it suddenly started to act up. "He said Ev just fought it all the way down," Askman relates. "And the fact wasn't lost on him either, that Ev was up around 5,000 feet and could easily have bailed out...but he stayed with the plane." The young, life-loving engineer, with a wife and a promising career waiting for him back home, stayed with his plane and steered for the edge of the field, thus sparing the residents of the farm and village the fireball that took his life.

Askman says that while finding the clipping in the *County Press* morgue brought tears, it also brought peace. "When I went to that newspaper office and I ran across that thing on the screen...it was just like when I heard it back in '45, when Della called me," he says. "Now, the sadness of his death has pretty much healed, and the memories of his life are always pleasant."

Why did he search all these years? Like Don Quixote's loyal sidekick, Sancho Panza, Askman has a simple answer: "I liked him." Daphne elaborates: "My husband, being a hard-headed Swede, does not make many friends. And when he does, they really count."

Last fall, the Askmans visited WPI for the first time. They toured Ev's campus and shared their memories and the scrapbook of their quest. Leach's alumni folder was unearthed from the archives in Gordon Library so they could page through photographs, news clippings, and letters in his familiar handwriting.

Although Everett Leach was a WPI alumnus for only seven years, the fragile pages reveal a dedicated Tech man, who signed his class newsletters, "Your Humble Servant."

HIMMORY OF

MAJOR BYBLEFT WLEACH DEC U.S. ARM& AR CORPS

WHO DIED NEARBAILS RULY 1945

The wartime correspondence was posted from different bases, but Leach doggedly filed his class fund-drive reports. In one appeal, he chides his classmates for neglecting their alma mater: "Hell, man, I'm busy too. Seven days a week and flying from four to twelve hours a day, and these letters take everyone's time. Please give us a break, will you?"

It's been 50 years since Nils Askman lost his friend. He's found his grail and paid homage, with a bronze plaque dedicated to Leach's memory that was mounted at the Havenstreet Shrine in 1993. Canon Bean conducted a dedication ceremony with three prayers of friendship. Askman is at peace. "When a close friend or relative dies suddenly, you feel like you never had a chance to say good-bye. I figured this was kind of like saying good-bye to him."

