Pakistan-United States Science and Technology Cooperation Program
(ESP-A-00-05-00001-00)
Annual Report 2009

Summary of National Academies Activities, January 1, 2009 – December 31, 2009

This reporting period was the fourth year in which the program was managed on the U.S. side by the National Academies (NAS). Of the 11 grants initiated under the 2005 program cycle (Phase 1), 7 were still active during this reporting period, with 4 of those being completed by the end of 2009. Of the 16 new grants awarded in the 2006 cycle (Phase 2)—13 under the regular Science and Technology Cooperation Program and 3 under the special Cooperative Program in Earthquake-Related Research—all were continuing with the exception of one one-year project that was closed out in August 2008. In addition, all 11 projects from the 2007 cycle (Phase 3) continued their activities during 2009, making a total of 33 projects supported with USAID funds in operation as of the end of the reporting period. (This report does not cover the 8 projects selected for funding in Phase 3 that are supported with funds from the Department of State.)

The financial problems and political turmoil that in 2008 nearly paralyzed the Pakistani side were relieved somewhat in 2009 for our program counterparts at the Higher Education Commission (HEC), although the other Pakistani co-sponsor, the Ministry of Science and Technology (MoST) continued to fail to meet its grant commitments. The long delays that prevented announcement of the expected 2008 cycle (Phase 4) were finally resolved in July 2009, and deadline was announced for October 31, subsequently extended to November 16. On October 7-8, 2009, a meeting was held in Dubai for all representatives of all program stakeholders (USAID, the Department of State, HEC, MoST, the Pakistani Planning Commission, and NAS) to discuss program management issues. At the meeting, the Pakistani officials expressed their strong support for the program and noted that the program had been evaluated very favorably in internal reviews they had conducted, including visits to project sites and interviews with Pakistani principal investigators. At this point (April 2010), no commitment from USAID as to support for Phase 4 has been received, so the program is proceeding with funds from two different units at the Department of State.

Despite the financial problems, security-related issues, and the at-times delicate political relationship between the two countries, U.S. and Pakistani participants in the projects supported by the program worked with great dedication on their project objectives during 2009. The new individual and institutional capacities developed and new linkages formed and strengthened as a result of these projects are reflected in the following overviews of all active projects supported with USAID funds during this reporting period.

Comprehensive Summaries of Activities on S&T Projects Funded in Phase 1 (2005 Cycle) and Active in this Reporting Period

Following are updated comprehensive summaries of the seven projects funded under the Pakistan-U.S. Science and Technology Cooperation Program in 2005 that were still active during this reporting period. Of these seven, four were completed during the past year, and the others have been granted no-cost extensions, as noted below. All grantees were required to submit annual progress reports by January 31, 2010, although a few have missed this deadline. Copies of those reports will be submitted to the mission separately as soon as all of them have been

received. Please note that the Pakistani funding amounts listed are those provided by the Pakistani funders at the time the awards were made. There has been no independent verification that these amounts have in fact been provided (and, as noted on page 58 of this report, MoST has admitted that it has fallen short of meeting its funding commitments).

Development of a Strategic Model for Improvement of Construction Project Management Education, Research, and Practice in Pakistan
(2006-2008) (Extended through June 30, 2009 – Completed)
Syed Mahmood Ahmed, Florida International University, Miami
Sarosh Hashmat Lodi, NED University of Engineering and Technology, Karachi
Pakistani Funding (HEC): $275,000
U.S. Funding: $130,000

According to these researchers, the absence of an integrated system of construction management education, research, and practice in Pakistan has resulted in low output by the country's construction industry, which is the second largest sector in the Pakistani economy after agriculture. To address this problem, Drs. Ahmed and Lodi designed their project to

- Investigate the current state of the construction industry in Pakistan;
- Develop a strategic model for improving construction management education, research, and practice in Pakistan;
- Devise a framework to standardize construction industry practices for achieving improved performance on cost, time, quality, risk response, aesthetics, reliability, and safety; and
- Build the construction management capacity of academia, industry, and government.

In the first phase of their project, the researchers designed and conducted detailed, structured surveys with contractors, consultants, suppliers, owners, government agencies, educational institutions, and other industry stakeholders. They collected data on general construction project management practices, causes of delays, delay mitigation practices, risk and safety management, and the business environment and regulatory framework. In the succeeding years of the project they compiled and analyzed the survey data and worked to develop a strategic model for improving the construction industry in Pakistan. To this end, Dr. Lodi made a two-week visit to Florida in April 2007 and Dr. Ahmed spent much of the summers of 2007 and 2008 in Karachi. In 2007 alone, a total of three workshops and five training sessions were organized in Pakistan in 2007 for more than 360 industry professionals and academics. An international conference to further work on developing and implementing the strategic model was held in Karachi August 4-5, 2008, and August 11-14 Dr. Ahmed led a week-long hands-on workshop for 48 project management trainees on mastering Microsoft Project Professional. December 14-15, 2008, Dr. Ahmed led a workshop at NED entitled "Total Quality Management and Risk Management," which attracted 40 engineers and allied professionals from public and private sector institutions.

Beyond its research and professional outreach aspects, the project also involved training of graduate students. In 2007 Mr. Rizwan Ul Haque Farooqui, an assistant professor at NED University, continued his PhD studies in construction engineering and management at Florida International University, having arrived there in the fall semester of 2006. He is expected to

receive his PhD by the end of 2010. Another NED assistant professor, Mr. Farhan Saleem, began his master's degree studies at FIU in January 2007, receiving his degree in the spring of 2008 and returning home to his position at NED. In addition, NED lecturer Mr. Muhammad Saqib began an on-line master's program in 2007 through FIU's distance learning program.

The last year of the project in 2009 was devoted primarily to data analysis and preparation of an extensive final report. This project is among the leaders in all phases of the program in terms of the number of Pakistanis who have received training or otherwise participated by attending conferences or taking part in stakeholders' meetings convened by the project organizers. The project directors have successfully reached out to involve not only members of the academic community but also representatives of the construction industry and relevant government agencies. The project has also been extremely productive in terms of research output. All told, the project has resulted in 42 publications in refereed journals or conference proceedings and has provided training to approximately 680 Pakistanis. Beyond fostering bilateral ties, this effort also enabled FIU and NED to establish new linkages with several Pakistani professional societies involved in engineering and construction and to foster capacity building at another Pakistani institution, the University of Engineering and Technology Taxila. A new course on innovation and entrepreneurship has been initiated there and a proposal has been developed to launch a master's degree program in construction management at that university. Although much has been accomplished, the partners involved hope to continue working together to study additional macro-level issues affecting the Pakistani construction industry, and they recognize that much more work is needed to disseminate their findings and recommendations to industry stakeholders. They are currently working to identify sources of funding to support their continued cooperative activities.

Development of Guidelines for Asphalt Pavement Recycling in Pakistan (2006-2008) (Extended through December 31, 2009 – Completed)

Gilbert Y. Baladi, Michigan State University, East Lansing
Tayyeb Akram, National University of Sciences and Technology (NUST), National Institute of Transportation (NIT), Risalpur
Pakistani Funding (HEC): $500,000
U.S. Funding: $350,000

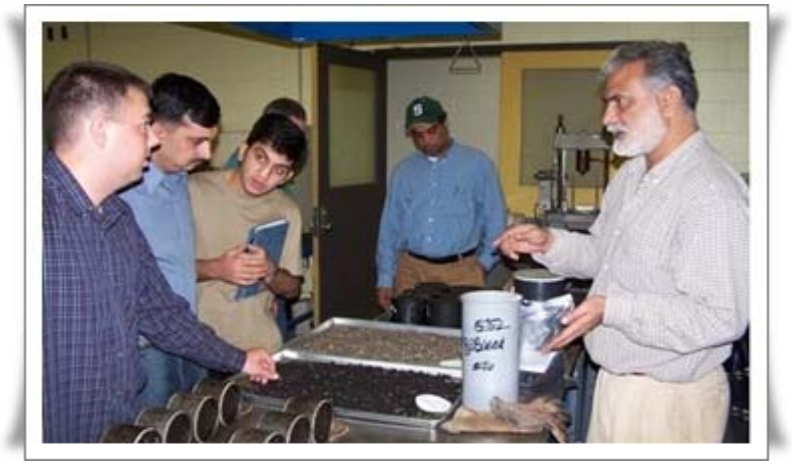
Tremendous increases in vehicle traffic over the past two decades have led to high rates of pavement deterioration on the Pakistani road system. This project addressed this problem by introducing asphalt recycling technologies to Pakistan and developing guidelines for their use. Recycling involves the reuse of existing roadway materials in the cost-effective reconstruction or rehabilitation of pavements. The price of asphalt, a product of petroleum refining, has increased many times over in recent years, so finding a way to reuse it makes economic sense. There are environmental benefits as well, as recycling pavement reduces the amount of waste that must be sent to landfills. This project, which involved several collaborating researchers at each partner institution as well as linkages with industry and government, included both technical studies of asphalt materials and policy studies that analyzed the potential savings to be realized from recycling and proposed implementation plans for Pakistan.

Following up on a two-week training visit to Michigan State and the National Center for Asphalt Technology at Auburn University by Dr. Tayyeb Akram and three graduate students in August 2006, Dr. Gilbert Baladi and MSU co-investigator Dr. Syed Waqar Haider spent two

weeks in Pakistan in December 2006 working with their colleagues at NIT as well as meeting with officials from the National Highway Administration and the local asphalt manufacturing industry. The research team also made site visits to an asphalt mixing plant and both hot and cold in-place recycling sites. The centerpiece of the visit was a three-day highway engineering workshop held December 16-18, which covered pavement design and analysis, pavement preservation and rehabilitation, road safety issues, and pavement recycling techniques. Drs. Baladi and Hyder summarized their findings and recommendations resulting from their visit and circulated them to the workshop attendees

In addition to the training aspects, the Pakistani counterparts at NIT have received and installed more than $660,000 worth of research equipment, half funded by HEC funds awarded under this grant and half supported by NIT's parent organization NUST as a demonstration of the institution's strong support for the project. Thanks to this equipment, the investigators worked intensively in 2008 and 2009 on surface distress data collection and in-situ testing of selected pavement sections.

In March 2008 the U.S. team again visited Pakistan to conduct a two-day workshop on construction and rehabilitation of asphalt and concrete pavements, consult with their colleagues on on-going testing and analyses, and meet with officials from the National Highway Authorities regarding the development and introduction of asphalt recycling guidelines. After participating in the August 2008 Pakistan-U.S. S&T conference in Islamabad, U.S. co-PI Dr. Haider also visited Risalpur again to discuss research results and help plan future activities. Over the course of 2008 this joint research team worked on pavement evaluation at dozens of selected sites in Pakistan, assessment of current pavement recycling practices, and materials characterization. Their annual report notes that "for the first time in Pakistan, the local construction materials are being characterized by using state-of-the-art equipment and state-of-the-practice testing protocols. This was only possible because of equipment procurement under this grant."



Dr. Tayyeb Akram (right) and his students visit an asphalt testing lab in Michigan in 2006.

These researchers have already presented their findings at seven international conferences, and more than a dozen joint papers are expected. In addition, in the summer of 2009 one American and three Pakistani graduate students submitted master's degree theses on research conducted as part of this project, and two more Pakistani students are expected to submit their theses in the spring of 2010. Although the security situation prevented Drs. Baladi and Haider from making a planned final visit to Pakistan on the project in 2009, they instead hosted their colleague Dr. Akram at Michigan State for one week in November 2009 to demonstrate testing procedures, work on their joint final report, and complete plans for implementation of their findings. Additional training of Pakistani graduate students was carried out in the fall of 2009 via videoconferencing.

Now that the project has been completed, the partners plan to remain in contact as they prepare their joint publications and work to disseminate their findings and recommendations for implementation by the Pakistani highway authorities and road construction industry. As noted above, this project has resulted in major improvements in the research infrastructure at NIT in the form of hundreds of thousands of dollars worth of new equipment. The U.S. partners have also provided training and guidance both in the United States and during their visits to Pakistan. The two sides appear to have an excellent working relationship and have built important linkages with the Pakistani highway authorities, who have expressed great interest in implementing the new paving and recycling techniques they are studying.

Gene Pyramiding through Genetic Engineering for Increased Salt Tolerance in Wheat (2006-2008) (Extended through June 30, 2010)

Eduardo Blumwald, University of California, Davis
Anjuman Arif, National Institute for Biotechnology and Genetic Engineering, Faisalabad
Pakistani Funding (MoST): $ 47,880
U.S Funding: $350,000

This project was aimed at developing salt-tolerant wheat varieties that will grow and produce high yields in areas where the soils have high salt content or are irrigated with brackish ground water, conditions common in many parts of Pakistan. The researchers involved in this project worked to achieve their goals by pyramiding two well-characterized salt tolerance genes (the *Arabidopsis thaliana* vacuolar sodium proton antiporter AtNHX1 and a heat shock family-related transcription factor isolated from *Candida tropicalis* CtHSR1) introduced in wheat by Agrobacterium-mediated co- or stepwise transformation.

The project was somewhat delayed at its outset in 2006 because of difficulties the Pakistani partners encountered in obtaining visas to visit Dr. Eduardo Blumwald's lab, but Dr. Muhammad Arif and Dr. Anjuman Arif of the National Institute for Biotechnology and Genetic Engineering (NIBGE) successfully completed one-year working visits at UC Davis at the end of August 2007. In 2007, the transgenic rice plants created in 2006 were grown and tested in the greenhouse under various salinity and heat stress conditions. After overcoming some initial problems with the wheat constructs during the first year of their project, they produced T1 and T2 lines expressing NHX1, and T1 lines expressing HSR1. During 2008, efforts focused on propagating rice and wheat plants expressing AtNHX1 and ScHSR1, further characterizing transgenic plants expressing ScHSR1, and completing the characterization of the CtHSR1 plants (rice and wheat). This latter effort in particular should facilitate the development of transgenic material that will serve for the introduction of the traits into commercial varieties.

Following the visit by Anjuman and Muhammad Arif, two other Pakistani scientists made extended visits to UC Davis. Mr. Moddassir C. Ahmed from NIBGE, who arrived in late 2007, remained at Davis as of early 2009, and Mr. Ejaz Hussain Siddiqi of the University of Agriculture, Faisalabad, returned to Pakistan in December 2008. Another scientist from NIBGE, Mrs. Saima Iqbal, joined the group at UC Davis in 2009, with all costs for her visit being paid for by the Pakistani side. During 2009, this team worked to complete winter greenhouse experiments with wheat and rice and initiated field experiments in the summer of 2009 on those lines found to have performed best in the greenhouse trials.

Several additional linkages have been initiated as a result of this project, including with USDA-ARS in Albany, California, the International Rice Research Institute, the International

Maize and Wheat Improvement Center (CIMMYT), and Arcadia Biosciences, Inc. Dr. Blumwald reports that these collaborations will be useful not only in bringing additional expertise to bear but also in carrying out the necessary field trials for the plants being developed. Although this sort of research is time-consuming, it is hoped that it will soon result in new wheat varieties that can be successfully commercialized.

This team has been steadily pursuing their research objectives since the beginning of their project. They have not reported any major financial, technical, or visa-related problems (although it is not clear if the Pakistani side received all its grant funds), and both sides have expressed satisfaction with how things are going. The project does not involve training for large numbers of participants but has provided in-depth research experience for the five Pakistani scientists who have had the opportunity to make extended visits to the University of California. These scientists in turn have been able to apply their newly gained expertise and pass it on to colleagues and students back home in Pakistan.

Antimicrobial Resistance in Pakistan: a Program to Develop and Strengthen Capacity for Surveillance, Containment, and Diagnosis through Public-Private Sector Partnership (2006-2008) (Extended through March 31, 2010 – Completed, final report pending)
Mary Brandt, Centers for Disease Control and Prevention, Atlanta
Rumina Hasan, The Aga Khan Medical University (AKU), Karachi
Pakistani Funding (HEC): $500,000
U.S. Funding: $ 75,000

The rising infectious disease burden in Pakistan is a major source of concern, and efforts to control such diseases are hampered by the incessant increase in antimicrobial resistance (AMR) in the country. This project has initiated a data collection and compilation system to assess the prevalence of AMR and conduct molecular typing on selected bacterial strains. Information on AMR is being disseminated to healthcare providers and professional organizations to help promote data-driven programs for the containment of AMR. Infection control measures are also being promoted as important intervention strategies. The principal investigators have assembled a diverse multidisciplinary team with strengths in clinical microbiology, infectious diseases, epidemiology, and infection control with linkages to key national and international institutions, including major Pakistani hospitals, research centers, and government agencies.

Continuing their project after a very active year in which nearly 500 participants were trained in 2006, the Pakistani partners on this effort launched the Pakistan Antimicrobial Resistance Network (PARN) in 2007. To extend surveillance for antimicrobial resistance beyond Karachi and increase awareness about antimicrobial usage and surveillance for resistance, a national-level meeting was also held in Karachi in March 2007. Participants included clinical microbiologists and infectious diseases experts from Lahore, Islamabad, and various Armed Forces hospitals in addition to representatives from the National Institutes of Health and Pakistan Medical Research Council. A follow-up meeting was held in Islamabad on June 26, 2007, to discuss extending awareness about antimicrobial stewardship and surveillance to a larger number of public sector health facilities in the country. The aim of the meeting was to establish a network of hospitals in which systems could be developed for monitoring antimicrobial resistance and where resistance information could be utilized to institute appropriate antimicrobial policies. Issues of antibiotic misuse, surveillance for antimicrobial resistance, as

well as educational programs to encourage good antibiotic prescribing practices and to develop strategies for appropriate antimicrobial usage were discussed.

Five training sessions on infection control practices were also held during 2007, providing training to approximately 250 medical personnel and hospital auxiliary staff, and a five-day workshop was held in May 2007 focusing on smear microscopy for tuberculosis diagnostics, following up on a similar workshop in 2006. On the U.S. side, CDC hosted two AKU staff members, Ms. Shahida Qureshi and Ms. Maqboola Dojki, for a BSL-3 laboratory safety training course at Emory University in November 2006, and Ms. Quereshi stayed on for an additional two weeks gaining practical experience in the clinical microbiology laboratories at Emory. In 2007, Noureen Saeed of AKU, who had visited in the summer of 2006, returned to CDC for three more months of mycology training and analytical work on fungal samples (June-September 2007), and three other AKU researchers received training at CDC and elsewhere. To disseminate and share the information learned during these visits, mycology, parasitology, infection control and biosafety workshops were planned for 2008, although the Pakistani partner has not forwarded the details as of this date. In addition, CDC sent more than $12,000 worth of supplies and materials to AKU in 2008 to facilitate establishment of an antifungals testing laboratory.

Dr. Brandt was able to travel to Islamabad in August 2008 to participate in the S&T conference, which gave her the opportunity to meet with Dr. Hasan, who was also in attendance. However, she was unable to travel to AKU, and in view of the increased restrictions on travel by government personnel that were instituted in September 2008, it now very appears unlikely that she could receive clearance to visit Karachi. The travel funds were reprogrammed to support a two-month training visit by a young researcher from AKU, Dr. Joveria Farooqi, who visited the Mycotic Diseases Branch at CDC from June 7 to July 31, 2009. Her research project was to describe the species distribution and prevalence of antifungal resistance in hospital-related fungal infections in the AKU hospital. She brought with her a set of fungal isolates collected at AKU through sentinel surveillance for serious yeast infections. At CDC, Dr. Farooqi received training in reference identification and antifungal susceptibility testing of these isolates. In addition to standard morphologic methods, she was able to employ a novel DNA-based technology called the Luminex xMAP multianalyte profiling system, which allows rapid and specific identification of unknown yeast isolates. She also learned to conduct DNA sequencing of isolates that could not be identified using any other method. She received preliminary training in two methods of antifungal susceptibility testing, so that the prevalence of antifungal resistance in these infections could be determined. Unfortunately a family emergency necessitated her premature return to Pakistan after a stay of seven weeks. CDC personnel completed the study and returned the data to Dr Farooqi so that a manuscript describing the prevalence of fungal infections in AKU could be written.

During 2009, the participants in this project reported nine journal articles published or accepted, plus another seven poster presentations on their work. Although no large-scale training workshops or conferences were held this year, the project nevertheless helped foster the PhD studies of three Pakistani students and involved 20 other Pakistani researchers and technical personnel. A final report will be submitted now that the project has been completed as of the end of March 2010.

These researchers had to revise their original work plans due to Dr. Brandt's inability to obtain permission from CDC to travel to Karachi, but they managed to cope with the changes successfully. This project is by far the most productive of any funded in terms of the numbers of

people trained (approximately 1,000), which was possible thanks to the many training workshops organized by the AKU partners. Dr. Hasan and her team have also been very active in building a nationwide network of healthcare providers, researchers, and government health officials to raise awareness of antimicrobial resistance and to gather comprehensive data on the incidence of resistant strains. After a January 2008 visit to AKU, the National Academies program manager and a U.S. review panel member were very impressed by the lab facilities, the progress reported by Dr. Hasan and her team, and their obvious commitment to their work. The collaborative relationship between Dr. Brandt and Dr. Hasan appears well established, and they are reportedly pursuing additional funding that will support their work after the completion of this very successful project.

Capacity Building for Research, Education, and Training in Water Resources Management in Pakistan (2006-2008) (Extended through December 31, 2009 – Completed)
M. Hanif Chaudhry, University of South Carolina
Muhammad Latif, University of Engineering and Technology (UET), Lahore
Pakistani Funding (HEC): $500,000
U.S. Funding: $100,000

This project was aimed at building the capacity of the Center for Excellence in Water Resources Engineering (CEWRE) at UET Lahore by providing education and training to Pakistani graduate students through in-person and Internet-based courses, faculty exchanges, and basic and applied collaborative research activities. Beyond the educational aspects, the research goals of the project focused on providing engineering tools to Pakistani engineers and scientists so that they might better assess, implement, and monitor their water resources systems. Physical laboratory studies were being carried out and numerical models developed to plan and evaluate the performance of hydraulic structures and control channel erosion and sediment transport. Models were also developed to study water resources management for irrigation and drainage, and modeling tools were applied to evaluate flooding and draining system capacities at selected sites in Pakistan.

Due to a visa delay experienced by Dr. Latif during 2006, the partners communicated during the first year of their project by telephone and e-mail to work out the details for undertaking various project tasks. After waiting more than one year for his application to clear a security review, Dr. Latif finally received his U.S. visa in June 2007. He and a colleague, Dr. S.M. Saeed Shah, visited USC in August and September 2007, during which they met with all USC faculty and staff members involved in the project and also visited the university's audio-video facility for consultations on establishing the distance learning center at UET. Dr. Latif also had the opportunity to visit a farmer in eastern South Carolina to learn more about cotton irrigation using center pivot sprinklers. Dr. Latif also presented a seminar that was attended by the faculty and graduate students of Civil Engineering Department. Meanwhile, Dr. Shah worked with Dr. Michael Meadows from USC to plan activities in storm water management. Another UET researcher, Mr. Waqqas-ur-Rehman, visited South Carolina for two months beginning in January 2008. Part of his visit focused on the technical aspects of setting up the new distance learning infrastructure at UET. USC colleagues trained him on hardware installation and troubleshooting and helped him finalize the list of videoconferencing equipment that would be purchased by UET. After some procurement delays the equipment was installed and tested during the summer of 2009.

U.S. co-investigator Dr. Jasim Imran of USC visited Pakistan in January 2007 to take part in a workshop on hydraulics and sediment transport in streams. During his visit, Dr. Imran also presented seminars and assisted with the development of pilot Internet-based courses, physical laboratory-based modeling, and mathematical sediment transport modeling. Dr. Chaudhry's scheduled October 2008 visit to Lahore had to be postponed due to the security concerns, but he made the visit successfully in April 2009. During his stay he consulted with Dr. Latif on ongoing research projects, presented a workshop on modeling of free-surface and pressurized flows at UET Lahore, and led a seminar in at the Water and Power Development Authority (WAPDA) attended by about 30 leading engineers and senior officials, including the Member, WAPDA.

Dr. Latif made a second visit to USC from late November through late December 2009, and another UET researcher, Assistant Professor Ghulam Nabi, arrived in mid-October for a four-month visit. So far, this U.S.-Pakistani research team has had six joint papers published or accepted for publication, and three more were under review as of the end of 2009. Although their grant under this program has ended, they will be continuing their collaboration thanks to other funds they have secured from the U.S. National Science Foundation. During the spring 2010 semester, making use of the new distance learning capabilities established at UET, Dr. Chaudhry and Dr. Latif are co-directing a course for 10 graduate students from USC, 25 from UET, and another 25 from Cairo University.

Dr. Chaudhry (top left) leads a class in South Carolina with live video links to Lahore and Cairo (January 2010).

The focus of the project was rather broad in comparison with most others funded, and the earlier progress reports submitted by the U.S. partner were somewhat brief. However, based on their reported output of publications (this research team has had six joint papers published or accepted for publication, and one more is currently under review), it seems that the collaboration has been productive. They are also nearing completion on a joint research study entitled "Management of Groundwater to Overcome Dilemma of Inequitable Distribution of Canal Water in Selected Canal Command Areas in Pakistan," so additional papers are expected.

Understanding and Control of Plant Viral Disease Complexes in Pakistan (2006-2008) (Extended through December 15, 2009 – Completed, Final Report Pending)

Claude M. Fauquet, Donald Danforth Plant Science Center
Shahid Mansoor, National Institute for Biotechnology and Genetic Engineering (NIBGE), Faisalabad
Pakistani Funding (MoST): $142,000
U.S. Funding: $175,000

Plant viruses are becoming increasingly widespread and virulent in Pakistan, leading to reduced yields for food and fiber crops. This project aimed to enhance the laboratory infrastructure at NIBGE and improve the expertise of its researchers in molecular virology techniques to understand and control plant viruses. Specifically, the researchers worked on developing new diagnostic tools such as DNA chip technology for the detection of multiple plant viruses and their recombinants and on increasing their understanding of host-virus interactions and viral proteins that overcome host defense responses.

The Pakistani principal investigator, Dr. Shahid Mansoor, reported that the grant allowed him to attract several PhD students and researchers who became involved in working on project objectives. A young researcher from NIBGE, Dr. M. Shah Nawaz Khan, arrived in St. Louis is early February 2007, bringing with him plasmid DNA samples prepared at NIBGE for use in research at the Danforth Center. For this part of the work, he had surveyed fields in central Pakistan, an area that has been severely impacted by geminiviruses over the last two decades. During his survey visits to different fields, he worked in cooperation with experts from cotton-growing areas, including researchers from the Central Cotton Research Institute at Multan. Dr. Khan is completed his research stay in St. Louis in August 2009 before moving on to the University of Kentucky for some additional postdoctoral training. Meanwhile, another NIBGE researcher, Imran Amin, arrived at the Danforth Center in late November 2007 to study the interaction of geminiviruses and their encoded genes with developmental miRNA. He completed his visit and returned to Pakistan in September 2008.

U.S. principal investigator Dr. Claude Fauquet traveled to Faisalabad in November 2006 to participate in a training course on molecular virology at NIGBE and meet with Dr. Mansoor to review the project. This training course was funded by other sources, but as it dealt with complementary topics pertaining to viruses and gene silencing, Dr. Fauquet reports that it greatly benefited the project and the students who participated. He attended another conference in Pakistan in March 2008, during which he took the opportunity to visit NIBGE for consultations with his colleagues.

So far, the researchers report that

Dr. Shah Nawaz Khan in the lab at the Danforth Center.

this project has produced a wealth of information on the viruses and their satellites that are related to cotton leaf curl virus disease, as well as on the function of some of the viral genes. It is important to note that the cotton leaf curl Burawalia virus (CLCuBuV) and its cognate betasatellite appeared on the newly resistant cotton variety cultivated in Pakistan for the last three years, and this and related viruses are seriously impacting cotton production in the country. However, before the present work, there had been no attempt to find, describe and understand this pool of diversity in reservoir plants. Although the work is not yet at the stage where it could be commercialized, Dr. Fauquet reports that his team's complete begomovirus survey on different cotton species that are not only grown in Pakistan but also are potential breeding material throughout the world is highly valuable to cotton breeders. This information should be helpful to all cotton breeders who are specifically using these species in developing disease resistant varieties.

This project has also provided an opportunity to train young Pakistani scientists and give them access to new technologies such as rolling circle amplification, which has been extremely important in accessing and cloning a wealth of new viruses and satellites. Dr. Fauquet indicates that he expects that at least four papers to be published as a result of the project, and the first, "Maintenance of an Old World betasatellite by a New World helper begomovirus and possible rapid adaptation of the betasatellite," was published in the *Journal of Virology* in July 2009. Ultimately the results of this research project will be made available to cotton breeders so that they can incorporate them in their efforts to create improved crop varieties.

Development of Computational Mechanics Infrastructure and Human Resources for Advancing Engineering Design Practices in Pakistani Industry
(2006-2008) (Extended through January 31, 2010 – Completed)

Arif Masud, University of Illinois at Urbana-Champaign (UIUC) and Ashfaq Khokhar, University of Illinoi at Chicago
Mohammad Abid and Abdullah Sadiq, Ghulam Ishaq Khan Institute (GIKI) of Engineering Science and Technology, Topi
Pakistani Funding (HEC): $302,000
U.S. Funding: $220,000

Computational mechanics supports simulation-based design leading to virtual prototyping of engineering devices, serving as a bridge between physical engineering design and theoretical and conceptual modeling. While other countries have invested in developing indigenous expertise in the field in order to enhance their industrial competitiveness, Pakistan's computational mechanics resources have up to now been limited. This project was designed to address the problem by developing both human resources and the technical infrastructure to promote the application of advanced engineering design methodologies in contemporary product development. It is hoped that the program created at GIKI under this now-completed project will continue as a self-sustaining center that will serve as a liaison with industry on emerging industrial design needs.

This project included organization of hands-on tutorials and workshops on computational methods and simulation techniques for faculty, students, and industry practitioners, development of an interdisciplinary computational mechanics curriculum at GIKI, and creation of a high-performance computing platform to support large-scale simulation needs. After consultations with the U.S. partners, the components for the Beowulf cluster were purchased and installed in

the fall of 2006. This 64-node Beowulf PC cluster connected via gigabit Ethernet is the centerpiece of the institute's new High Performance Computing Lab. Available for use by faculty and research staff as well students, this cluster provides the backbone for large-scale computational projects at GIKI.

In December 2006 Dr. Masud returned to Pakistan for a third visit on the project to review progress on the new course curriculum, help evaluate the performance of the new PhD candidates and master's degree students, and work with GIKI colleagues to install additional codes on the new Beowulf cluster. During the summer of 2007 Drs. Masud and Khokhar presented another short course at GIKI on nonlinear finite element methods June 4-8, 2007, and Dr. Masud and another UIUC colleague, Dr. Rizwan Uddin, presented seminars on related topics in mechanics that were well attended by GIKI staff, students, and representatives of other academic, industrial, and research institutions. A Web site on the project has also been established at www.giki.edu.pk/go/pakus/index.htm.

In June 2008 Dr. Masud and his Pakistani partners presented a short course on nonlinear finite element analysis at GIKI for 25 Pakistani students and advised other students and staff on high performance computing and advanced data structures. Meanwhile, a PhD student from GIKI, Mr. Masroor Hussain, arrived in Illinois in January 2008 for an one-year visit, during which he took courses on algorithms, parallel processing, data mining, and nonlinear finite element analysis.

In January 2009 Dr. Masud made a week-long visit to Pakistan, during which he gave a seminar at GIKI that was attended by GIKI faculty and students as well as faculty from Peshawar University and the University of Engineering and Technology Taxila. He also met with two master's degree students and one Ph.D. candidate and evaluated their progress. In June 2009 he made another visit to continue mentoring the students. Dr. Abid made a return visit to UIUC from July 17 through August 30, 2009, to continue work on ongoing projects, and in December Dr. Khokhar met with Masroor Hussain at the Frontiers of Information Technology Conference in Abbotabad. Later that month, a GIKI team supervised by Dr. Abid and including Mr. Muftooh-ur-Rehman, a graduate student participating in the project, took part in the 3rd All-Pakistan Digital Innovation Competition and Exhibition. Their project on Water Flow Simulation through the Tarbela Dam Reservoir and Spillways won second prize among projects submitted by 65 teams from throughout Pakistan.

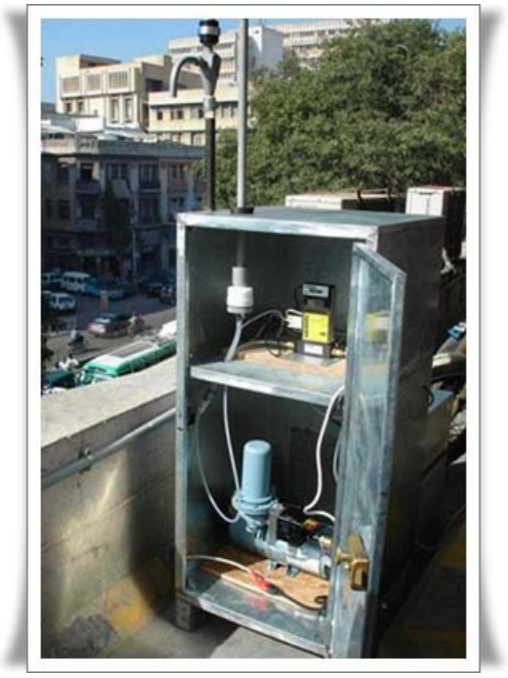
During the four years of its existence, this project has spurred increased awareness among academics and industry practitioners of the importance of computational mechanics in engineering design and analysis. More than 200 professionals have been trained through workshops and seminars, including graduate students and practitioners from different industrial and academic organizations. Thanks to the high performance computing infrastructure now available at GIKI, and some off-the-shelf available professional software, high-end solutions to problems of importance to industry are now possible in Pakistan, solutions that would not have been possible otherwise. National University (NU-FAST) faculty members trained at GIKI workshops offered under this project have started teaching parallel computing courses and carrying out small projects on parallel computing and distributed networking. GIKI has been requested to allow NU students and faculty to utilize GIKI's computational infrastructure for research, and other Pakistani academic institutions are also showing interest in utilizing the high-end computing infrastructure developed at GIKI. As of the project's end date in January 2010, 18 joint papers had been produced and 20 conference presentations had been made as a result of the project. Lists of these joint outputs as well as further details on the curriculum and infrastructure

development aspects of the project are included in the final report submitted by the principal investigators.

Comprehensive Summaries of Activities on S&T Projects Funded in Phase 2 (2006 Cycle) and Active in this Reporting Period

The following projects were selected for funding in the 2006 application cycle and began their activities in early 2007. One one-year project from this cycle was already completed in 2008 and is therefore not included. Several others have already received no-cost extensions, as noted below.

Association of Particulate Matter with Daily Morbidity in Urban Populations (2007-2009) (Extended through January 31, 2011)
David O. Carpenter, University at Albany
Gregory Pappas (through 2008) and Zafar Fatmi (2009 to present), Aga Khan University, Karachi
Pakistani Funding (HEC): $148,739
U.S. Funding: $126,295



Air sampling equipment in operation in the Tibet Center district of Karachi.

In recent years, interest in the health effects of air pollution in Asia has intensified due to increasing knowledge of the health effects of air pollution and to the alarmingly high levels of air pollution in Asia's major cities. The rapid and continuing increase in the population, vehicular traffic, and industrial development combined with meteorological conditions, inadequate transport infrastructure, lax environmental legislation and enforcement, weak institutions, and lack of sufficient skilled research and policy personnel have resulted in poorly planed urbanization and severe air pollution problems in Pakistan with serious health impacts.

This study is investigating the effect of short-term exposure of fine particulate matter ($PM_{2.5}$) in ambient air on hospital admissions and emergency room (ER) visits for respiratory and cardiovascular diseases among adults and young children in Karachi. $PM_{2.5}$ mass samples are being collected over 24-hour periods at multiple sites in the city, and daily records of hospitalizations and ER visits for respiratory and cardiovascular diseases at six hospitals serving the areas will be examined to estimate associations with air pollution on ER visits or hospitalizations while controlling for long-term trends, seasonality, and weather. This first-of-its-kind study aims to provide Pakistani scientists and decision makers with scientific evidence on the magnitude of health effects related to air pollution in urban centers of Pakistan over the next few years.

During the first year of the project (2007), the investigators were delayed by the slow process of obtaining the necessary institutional review board approvals from the various Pakistani and U.S. entities involved. As of late October 2007, however, the problem was nearly resolved, and Dr. Carpenter and Dr. Khwaja visited AKU to confer with their partners on next steps. Thanks to other funding, Pakistani collaborator Dr. Aftab Turabi visited Albany for nine months in 2007 and helped to move the approval processes along after returning to Pakistan. In 2008, Dr. Khwaja made two visits to Pakistan to provide training, and with funding from HEC two Pakistani trainees visited Albany (Dr. Manzoor Khattak and Dr. Azhar Siddique, January-April, 2008).

During the fall of 2008, the research team completed sampling for particulates at two sites in Karachi, one in a primarily industrial part of the city (Korangi), and the other in a residential area with major automobile and truck traffic (Tibet Center). Hospitalization data was collected during the same period at Jinnah Postgraduate Medical Center (JPMC), National Institute of Cardiovascular Diseases (NICVD), and AKU. The particulate samples were brought back to United States for analysis with the hospital data to follow.

The primary goal for 2009 was to complete particulate sampling at the present two sites over four periods of six weeks each in fall, winter, spring, and summer. Despite problems with electric power supply irregularities and vandalism of the sampling equipment, this effort was completed successfully. In 2010 the team will move the sampling equipment to two new sites within the city for sampling over the next year of the project. They will also continue collecting hospitalization data at the three hospitals listed. Training activities in 2009 included a one-day session at AKU on April 7, which provided the 24 participants with comprehensive understanding of the technical details of the project, primarily explaining basic concepts and theories of air pollution, ambient air sampling techniques, and the challenges encountered in data collection and analysis. The training included practical demonstrations of techniques for air sampling and measurement of specific pollutants, as well as relevant safety and quality control procedures. The trainees included two PhD students from the Chemistry Department of Karachi University, a research fellow doing a residency in Community Medicine at AKU Hospital, three MS students in Environmental and Occupational Health, four doctors from tertiary hospitals of Karachi, a biomedical engineer and eleven other staff members involved in this project.

Drs. Carpenter and Khwaja hope to make at least one visit, but much of the further training on the project will be done by the Pakistani fellows who were already trained in Albany. As of January 2010, three Pakistani PhD students enrolled in the Chemistry Department of Karachi University have been trained to perform the air monitoring and are being train to analyze the air data. In addition, graduate students and physicians from the collaborating hospitals involved in the project have been trained on how to collect and collate the information from hospital records and the outpatient department, and three postgraduate fellowship students in the Department of Community Medicine of Karachi University are gaining hands-on experience in project management, air monitoring, and data management. In Albany, Pakistani MPH student Zafar Aminov is also being trained in data analysis, and he will soon begin work toward his PhD, with data collected under this project forming the basis for his future dissertation. A visa request is being processed to bring another Pakistani student (Shaikh Mohiuddin) to Albany for a one-year visit supported by this grant, where he will be trained on particulate analysis techniques.

Secure Pakistan Wheat Production through Controlling Rusts (2007-2009)
Xianming Chen, Washington State University
Muhammad Ashraf, National University of Sciences and Technology, Islamabad
Pakistani Funding (HEC): $241,884
U.S. Funding: $100,001

Wheat is an essential food resource and grown all across Pakistan. With ever-increasing yield targets to meet national production goals, incorporation of stripe rust resistance into Pakistan's leading cultivars is currently a high priority. Monoculture of the Inqilab 91 variety has caused stripe rust to become widespread, and cultivar susceptibility is posing serious problems. The need for new genes to counter the threat is crucial, and this project is aimed at identifying genes offering protection against rust virulences and transferring them into commercial cultivars using efficient molecular tools. Wheat rusts are a major threat to production in the United States as well, so successful accomplishment of the objectives of this project would benefit wheat producers in both countries.

This project aims to adapt the system, approaches, and technologies established in the U.S. partner's laboratory in studying epidemiology of wheat stripe and stem and leaf rusts, identifying wheat germplasm resistance to these diseases, and developing molecular markers for efficient breeding of resistant wheat cultivars to control these diseases and thus secure wheat production in Pakistan. Another goal of this project is to support Dr. Ashraf's efforts to establish a genotyping lab at his university along the lines of a laboratory recently created in the U.S. Department of Agriculture—Agricultural Research Service unit at Washington State University, which will give Pakistani researchers new opportunities to use modern molecular techniques. Through the project, the partners involved are exchanging wheat germplasm with rust resistance and other valuable traits, an exchange that should also be beneficial for wheat breeding programs in the United States. In addition to the primary partner institutions, the project also involves researchers from the National Wheat Research Station of Ayub Agriculture Research Institute in Faisalabad and uses the research fields of the Wheat Research Institute, Pir Sabak; the Regional Agriculture Institute at Bahawalpur; and the Sakrand Wheat Research Station, Sindh.

Since the project's inception in the spring of 2007, researchers on both sides have been busy analyzing the germplasm samples that had been collected and conducting field trials on more than 40 wheat lines to determine their susceptibility to leaf, stripe, and stem rusts. New crosses are also being cultivated and studied. On the Pakistani side, a research associate and PhD and MS students have been engaged to work on the project. PhD student Sobia Tabassum of Quaid-e-Azam University (QAU, where Dr. Ashraf was based prior to his 2009 move to NUST) visited Dr. Chen's lab from February to September 2008. She tested more than 100 Pakistani wheat cultivars and genotypes under controlled greenhouse conditions with stripe rust pathotypes from the United States and Pakistan and in fields under natural infection. She also worked on identifying molecular markers for determining the genetic diversity of the Pakistani wheat cultivars and developing markers associated with resistance genes in the wheat germplasm. Dr. Tabassum received her PhD in December 2009.

In 2009 Dr. Ashraf conducted additional field trials and collection trips on the Pakistani side. Although he moved to NUST during this year, he maintains access to the plant genotyping laboratory he established at QAU in the first year of the project. That facility is now operational and fully equipped to support DNA extraction, as well as genotyping based on short sequence repeats and randomly amplified polymorphic DNA, and it provided an excellent infrastructure

for the five QAU students who completed their M.Phil. research related to this project in 2009. Meanwhile, Dr. Chen continued his experimental work on molecular markers and on field and greenhouse testing of wheat varieties for rust resistance. PhD student Hadi Bux arrived at WSU in early November 2009 to receive training and take part in the research effort, with the cost of his six-month visit being paid fully by the Pakistani side. Dr. Chen is also working to arrange the visit of another Pakistani researcher on the project, postdoctoral associate Dr. Samad Mumtaz.

Thanks to a no-cost extension, these researchers will have time to complete additional field trials in both Pakistan and the United States to test the resistance of selected lines to stripe rust. Further molecular mapping work is also planned on both sides. One joint publication on the project is in press (2010) in *Science in China Series C—Life Sciences* with another joint article recently submitted to the same journal.

Capacity Building in Research Ethics and for Research on Ethics (2007-2008) (Extended through November 30, 2009 – Completed)
Adnan A. Hyder, The Johns Hopkins University
Aasim Ahmad and Arshi Farooqi, Aga Khan University, Karachi
Pakistani Funding (HEC): $232,732
U.S. Funding: $150,000

The goal of this project was (1) to improve the ethical conduct of human subject research in light of indigenous sociocultural values in Pakistan and (2) to develop skills and capacity to conduct research on ethics in Pakistan. The development of capacity in Pakistan in research ethics involves the rationale that not only is international collaborative research involving developing counties increasing exponentially, but there is also a concerted effort to increase the number of researchers in these countries. To achieve this objective, this project involved six research ethics certificate courses to be presented over two years, resulting in the training and certification of some 120 researchers from all over Pakistan. The certificate courses offered had two components comprising modules in basic bioethics and research ethics. The former was a foundational module with a focus on three broad areas: bioethics history and issues to date; Western thought; and Islam and its philosophic tradition. The research ethics module covered essential principles for human subject research, examining different ethical issues raised by clinical trials, epidemiological studies, and public health research, especially in the context of developing countries and international collaborative research. The long-term goal of this project is for the individuals trained to become resource persons in their respective institutions not only for ethical review of research, but also for eventual establishment of similar training programs. In late 2007, Dr. Ahmad received a grant from the U.S. National Institutes of Health to support complementary activities in the area of research ethics education and training, including the development of a master's program in this field. These funds from NIH helped to leverage the resources available to his existing joint project with JHU.

In May 2007 Dr. Aasim Ahmad visited JHU for planning meetings with his counterparts, including Dr. Adnan Hyder (U.S. director), Dr. Hilary Bok (U.S. co-director), and Ms. Lynne Harris (U.S. coordinator). When the first research ethics workshop was announced in mid-July 2007, it attracted 150 applicants in only one week, attesting to the great interest in the topic in Pakistan. Thirty students were selected to participate in the workshop, which was held in Karachi August 4-8, 2007, with Drs. Hyder and Bok and Ms. Harris serving as key presenters. In October 2007 Dr. Ahmad again visited the United States and met with the JHU team to plan upcoming

activities, including the selection and placement of Pakistani research ethics fellows at JHU and the organization of a longer course in research ethics at AKU April 3-30, 2008, which trained 33 students selected from among 526 applicants. Another 27 students (out of 640 applicants) were trained in a research ethics certificate course held at AKU July 22-August 20, 2008, and a two-day research ethics workshop designed specifically for 14 institutional review board members was held in Karachi August 20-21, 2008. Dr. Bok traveled to AKU to help teach both the April and July-August certificate courses, and Dr. Hyder participated in the April course and co-directed the August two-day workshop.

In addition, three researchers from AKU were hosted at JHU for extended training and development of independent research projects, for which they have requested separate funding through AKU channels to carry out back home in Pakistan. Dr. Uzma Shoaib Shamsi spent July 16-August 22, 2008, in Baltimore, Dr. Muhammad Yousuf and Mr. Syed Shamim Raza visited November 9-December 14, 2008.

A no-cost extension was granted on this project through November 30, 2009. Funding delays and security issues on the Pakistani side set back the schedule for the final research ethics certificate course and final ethics workshop by a few months, but they were carried out September 28-October 10, 2009, and October 14, 2009, respectively. The Pakistani and U.S. project directors have submitted a detailed final report documenting their activities now that the project is complete. Of particular note was the extremely strong interest that the ethics courses and workshops attracted, drawing around 2,000 applicants for 152 available slots. The participants gave the training activities very positive evaluations, and given the fact that they represented most of the country's major public- and private-sector healthcare institutions, there is a strong likelihood that their involvement in the project will have a broad impact nationwide as research ethics standards and mechanisms are instituted and further developed.

The Development, Optimization, and Application of a High-Performing Engineered Fertilizer (2007-2009 – Extended through April 30, 2011)

Syed H. Imam, Gregory Glenn, and Mark Jackson, USDA Agricultural Research Service, Western Regional Research Center
Farooq-e-Azam, Nuclear Institute of Food and Agriculture, Peshawar
Pakistani Funding (MoST): $100,000
U.S. Funding: $116,250

This multidisciplinary project aims to combine fundamental knowledge of plant growth and development with polymer science and engineering to create a novel, high-impact fertilizer of superior functionality with an inherent sustained delivery mechanism. In view of the substantial losses of fertilizer nitrogen in the environment, the specific goal of the project is to engineer a high-performance plant fertilizer (HPF) by encapsulating fertilizer nitrogen in a biopolymer matrix so it can be released over time as the matrix breaks down. Besides the fertilizer nitrogen, encapsulation matrices will also contain essential nutrients, growth stimulants, and biocontrol agents, as well as natural microbes that fix nitrogen and synthesize humic and growth promoting compounds for optimal performance. Sustained release of the active materials will be achieved via manipulation of biodegradation properties of the matrix polymer. When exposed to soil, microbes, humidity, and sunlight, the matrix polymers will degrade at a controlled rate, loosening the matrix and gradually releasing encapsulated agents over a long period. As opposed to multiple applications of a convention fertilizer, a single application of the

HPF should be sufficient until the crop is harvested, not only saving time, energy, water, and overall cost, but also benefitting the environment. The long-term goal of this study is to conduct extensive field trials to assess the impact of the HPF formulation and evaluate its commercial viability.

By late September 2007 the project participants reported that they had completed almost all of their Year 1 objectives, including selection and characterization of matrix polymers, acquisition and characterization of microbes, evaluation of bacteria for plant growth promotion, identification of optimal matrices, and preparation and evaluation of humates. Experimental evaluation on the biodegradation of the encapsulation matrix continued at USDA in 2008 along with work on development of microsclerotia for incorporation in the matrix as a bioinsecticide. In April 2008 Dr. Iman made a self-funded visit to Pakistan to monitor research progress and transfer the technology for making the fertilizer matrix. While at NIFA, he delivered a lecture on emerging trends in agriculture and met with three research groups at NIFA to discuss research and development in material science and bioproducts. He also took the opportunity to visit the Pakistan Fertilizer Institute and the University of Agriculture Faisalabad, two organizations that are cooperating on the project.

Dr. Imam (left) and Dr. Azam at work in the lab at NIFA in March 2009.

In March 2009, Dr. Imam again visited NIFA. As a U.S. government employee he has so far been unable to obtain the necessary country clearance for official travel; therefore, motivated by his strong commitment to the project, he has taken personal leave and paid for his own travel to Pakistan out of his own personal funds in both 2008 and 2009. During this most recent visit, he presented a week-long training course on development of slow-release microbial fertilizer formulations to the institute's Soil Science Group. He also met with his counterpart Dr. Azam to monitor progress on the project objectives, assist with planning for the large-scale production of fertilizer for greenhouse and field studies, and discuss next steps in the research process. In addition, Dr. Imam presented a seminar to the entire NIFA research staff on bioproducts from renewable resources.

Dr. Farooq-e-Azam and a colleague had hoped to visit California in 2009 to learn the processing and production of encapsulation matrices, although these plans were thwarted by long funding delays on the Pakistani side. Meanwhile, work proceeded on developing new formulations for polymer matrices for microbial encapsulation and on identifying additional microbes for inclusion in the fertilizer being develop. Efforts were also under way to devise the most efficient and cost-effective methods for producing the fertilizer. Initial field trials of two engineered fertilizer formulations were conducted with several different vegetable crops, and the initial results have been very encouraging, with the engineered fertilizers producing plants with considerably better growth than conventional synthetic nitrogen fertilizer.

A joint patent on "Development of starch-gypsum based encapsulation matrix: novel chemistry and unique microstructure" (USDA-ARS Log # 221567) has been filed, with Dr. Azam, Dr. Imam, and Dr. Gregory Glenn as co-inventors, and once the patent is registered a paper on the work will be submitted to the *Journal of Controlled Release*. As of early 2010, however, the patent has been delayed pending results from additional field trials, which have been postponed due to funding problems on the Pakistani side. As soon as those funds are released by MoST, Dr. Azam and Dr. Imam are eager to proceed with the trials and scale up pilot production of the engineered fertilizer in cooperation with the National Fertilizer Institute in Faisalabad. They have been in contact with two Pakistani fertilizer companies interested in acquiring the new technology once the patent is issued so that they can begin producing the new varieties for sale. An Italian manufacturer has also expressed interest in signing a cooperative agreement to further develop the microbial formulation. Because it remains unclear when or if MoST will be able to meet its commitments, Dr. Imam is currently exploring with his lab whether they would be willing to transfer some of his own grant funds to NIFA so that the vital field trials may proceed without further delay.

As an unexpected side benefit of this project, while working on the project-related experiments, scientists in NIFA discovered that under composting conditions, cellulosic biomass (consisting mostly of leaves, twigs and other agricultural discard) generated heat due to exothermic bioprocesses, raising the temperature of the compost quite significantly. By maintaining the moisture level and with added insulation, heat generated inside the compost was able to maintain the temperature of water in a metal (conductive) container up to 75° C (167° F) for a period of several weeks. This discovery could have an enormous impact on the lives of poor rural residents without access to electricity. At NIFA, Dr. Azam has assembled several functional units called "BioGeysers" of variable sizes (5 - 300 Liter capacities) for local testing, and he characterizes the results as astonishing. Upon perfection, this technology would be able to provide lukewarm to warm water to rural populations, particularly during the winter months, at little or no cost. No grant funds or resources were utilized for this work, as it is not directly related to the objectives outlined in the original project, but Dr. Azam has assigned a separate team of additional scientists and technicians on this project. A publication is expected to follow from this work as well.

Building Molecular Biology Capacity for Preventing Tick-Transmitted Diseases in Pakistan (2007-2009 – Extension requested through February 28, 2011)

Thomas N. Mather, University of Rhode Island
Abdullah G. Arijo, Sindh Agricultural University, Tando Jam
Pakistani Funding (HEC): $225,451
U.S. Funding: $290,000

In Pakistan more than 75 percent of the rural population practices livestock husbandry, and a majority of them depend on livestock for their subsistence. Crimean-Congo Hemorrhagic Fever virus and other significant tick-transmitted pathogens of humans and animals are endemic to certain regions of Pakistan and have the potential to cause significant human morbidity and mortality and impact Pakistan's agricultural economy and the livelihood of its rural citizens. This project proposes to establish a molecular entomology laboratory at Sindh Agricultural University (SAU) to build Pakistani capabilities to study and prevent tick-transmitted diseases in Pakistan. The project is also focused on developing high-throughput transcriptomic, functional genomic, and proteomic systems and strategies aimed at identifying tick salivary proteins that can produce strong delayed-type hypersensitivity responses, antibody responses, or a combination of both, that correlate with protection from tick-borne disease (TBD). This novel approach could accelerate anti-tick and TBD vaccine development by informing the vaccine candidate selection process. Moreover, functional genomic screens involving inhibitory RNA are expected to identify novel pharmaco-therapeutic targets for disrupting tick feeding and pathogen transmission.

Dr. Mather and his colleagues at URI are continuing their studies on vaccine and small molecular targets to disrupt feeding of black-legged ticks (Ixodes scapularis) and transmission of the agents causing Lyme disease, anaplasmosis, and babesiosis. Dr. Arijo and his fellow researchers at SAU are working to (1) develop TBD surveillance and assessment capabilities to identify and prioritize vector tick species in Sindh Province; (2) establish a capacity at SAU to conduct TBD diagnostics using rapid polymerase chain reaction (PCR) and reverse transcription PCR assays without requiring specialized biocontainment facilities; and (3) focus vaccine and pharmaceutical discovery research on important Pakistani tick species identified by the activities described in aims 1 and 2.

Dr. Arijo working in the lab during his visit to URI.

In addition to these efforts on both sides, the project originally included ambitious plans for a series of hands-on workshops at SAU to train Pakistani faculty, researchers, and students in the cutting-edge techniques needed to build and advance an appropriate molecular biology capacity that can be applied to various programs for preventing tick-transmitted diseases in Pakistan. Unfortunately, due to the security situation in Pakistan and particularly in rural south Sindh, plans for these workshops have been postponed, although Dr. Mather and his U.S. colleagues have been able to deliver some of the training by videoconferencing, and in November 2009 one of Dr. Mather's colleagues from URI presented some training in person at SAU.

In 2007 the Pakistani partners at SAU began rehabilitating a molecular entomology lab and animal space following suggested guidelines from URI scientists, who also provided input concerning proposed purchases of equipment and molecular kits and reagents. Renovations were completed by June 2008, and in the last quarter of that year the university received several critical pieces of equipment, including PCR thermal cyclers, a gel documentation system, a nanodrop spectrophotometer, and an incubator. SAU has hired and begun training a senior scientist, lab technician, computer operator, and four postgraduate students on the project, and efforts to collect ticks from livestock in various regions of Pakistan are ongoing. In addition, Dr. Arijo visited the URI molecular entomology lab in October 2007. He spent approximately one month receiving intensive training on experimental procedures and working with URI scientists to further develop training curricula and workshop plans. With outside support, third-year medical student Umar Rashid also visited URI for six weeks in June-August 2008 for training on technical procedures, tick sampling and rearing, lab safety, and research ethics.

In additional to the laboratory research and field work under way in both institutions, in March 2008 Dr. Arijo held a mini-symposium to provide background and justification for developing this new Pakistani research capacity targeting molecular detection of veterinary parasites and anti-tick vaccination for detecting and preventing tick-borne diseases. Later in the year and he and colleagues conducted a pilot survey of stakeholders (farmers, veterinarians, etc.) to determine their perceptions of the tick problem and raise awareness of the importance of this issue for both animal and human health. A more extensive nationwide survey will be carried out later this year.

In 2009 considerable progress was made on establishing a pathogen-free tick (*Hyalomma anatolicum*) colony at SAU; this step is critical for developing well-characterized and bio-secure salivary gland material for transcriptomic sequencing and analysis. Through tele-video conferencing, the partners in this project continue to identify specific needs for customized molecular reagents and protocols with built-in biological safeguards. URI participants developed PCR primers specific for the most likely pathogens to be encountered in Pakistani *Hyalomma* ticks, as well as standardized protocols for bio-safe sample preparation, DNA extraction, and molecular pathogen detection. Additionally, URI developed appropriate animal research protocols for tick rearing at SAU and provided SAU with appropriate supplies to carry out tick colony development. These efforts were greatly facilitated by two exchange visits during the reporting period: SAU scientist Dr. Bachal Bhutto spent seven weeks at URI in November-December 2009 focusing on tick surveillance, tick rearing, tick colony development, molecular pathogen detection, and genes to vaccines techniques. In November 2009 URI scientist Dr. Aftab Ahmed conducted proteomics training and hands-on workshops at SAU and UOK. Important inter-cultural and scientific interchange was ongoing through the period via live tele-video conference lab meetings, e-seminars, e-mail, and taped lectures. The group even piloted a joint undergraduate student exchange project between SAU and URI, as students at both institutions collaborated on zoonotic disease perception survey development and data analysis. Progress made during this reporting period will be critical for meeting the project milestone of obtaining transcriptomic information on Pakistani tick salivary glands from a characterized, pathogen-free source colony. Once available, these data will be used in a URI genes-to-vaccines strategy to identify anti-tick vaccine candidates for evaluation in Pakistan at SAU and UOK as well as at URI. A no-cost extension for an additional year has been requested and will be processed as soon as a complete 2009 progress report is received from both sides.

Establishment of Virtual Trainer Lab for Improving Minimally Invasive Surgery Skills of Post-Graduate Trainees and Faculty of the Surgery Department of Rawalpindi Medical College and Allied Hospitals
and
Multitasking of Telemedicine/E-health Training Center (2007-2008)
(Extended on the U.S. side through December 31, 2010)
Ronald Merrell, Virginia Commonwealth University
Asif Zafar Malik, Holy Family Hospital, Rawalpindi
Pakistani Funding (MoST): $270,000
U.S. Funding: $213,000

This project includes two separate but related components aimed at building Pakistani capacity in the healthcare sphere. The first involves laparoscopic or minimally invasive surgery, which has become very popular in the last 15 years. Because many operations that were once performed "open" are now done almost exclusively laparoscopically, skills training in this area is becoming necessary for many surgical subspecialties. The current goal of simulator training is to help trainees acquire the skills needed to perform complex, minimally invasive surgical procedures prior to practicing them on living patients. Unfortunately, minimally invasive surgery training facilities were previously unavailable in most of the teaching hospitals of Pakistan. During this project, a virtual training laboratory has been established at Surgical Unit II, Holy Family Hospital (HFH), in collaboration with the Medical Informatics and Technology Applications Consortium at Virginia Commonwealth University (VCU). The lab, which will include box trainers, virtual reality simulators, and full procedural simulators, will be used to train surgical residents. The operating rooms and training lab will be linked together and also to minimally invasive training centers in the United States.

The second project component focuses on expanding an existing joint telemedicine training program at HFH. Pakistan is one of the most densely populated countries in the world, but the doctor-to-patient ratio is only 1 to 1,555, and there is just one specialist available for every 15,000 citizens. Moreover, the majority of the population resides in rural areas, while medical facilities are concentrated in the urban areas. One solution to bridge this rural-urban disparity is to build new hospitals in rural areas and send specialists to those areas, but this is difficult for a variety of reasons. The other feasible solution is using telemedicine to address the limited availability of specialists at remote sites. The implementation of telemedicine requires health professionals trained in this field, which was previously unknown in Pakistan. In 2003, the partners involved in this project received a grant under the Pakistan-U.S. Science and Technology Cooperation Program in its previous form to provide telemedicine training to medical personnel in Rawalpindi and Islamabad. During that six-month project, 45 doctors and nurses from various institutions were trained, and they are now pursuing telemedicine projects in their own institutions. During the current project, medical personnel from throughout Pakistan are being trained at the telemedicine/E-health training center established at HFH. In addition, this facility is being utilized to provide telemedicine training and tele-rehabilitation services to paraplegic victims of the October 2005 earthquake.

Although both sides experienced significant delays in setting up their grant accounts and agreements at their respective institutions, in May 2007 the VCU team met with Dr. Zafar in Nashville at the American Telemedicine Association (ATA) annual meeting and agreed upon the final revision of the training curriculum and budget. At this meeting, Dr. Zafar and his colleague

Dr. Faisal Murad made three presentations on earthquake relief with telemedicine, telemedicine for follow-up of earthquake patients, and telemedicine for pre- and post-operative follow-up of elective surgical patients. The partners all agreed on revision of a formal report on the scientific lessons learned from their first project for publication in the ATA journal Telemedicine and e-Health. After the conference, Dr. Murad spent a week at VCU to examine a variety of telemedicine products and systems in anticipation of setting the equipment list for the project. In addition to working with equipment for training and courses of instruction, he visited with vendor representatives and established the necessary links for purchase orders from Pakistan to the United States.

In the second year of the project, five two-week telemedicine training courses were held at HFH in March, April, and June 2008, serving a total of 55 trainees (33 of whom were female) from medical institutions around the country. Plans had initially called for Pakistani doctors to come to VCU for training as well, but after visa complications arose, Dr. Merrell decided to present the course in person instead. He traveled to Pakistan for two weeks in November 2008 to provide minimally invasive surgical training to 10 Pakistani physicians using the new equipment installed at HFH. The course included three modules, including laparoscopic training lectures and demonstrations, work on virtual simulators, and finally hands-on training on patients supervised by Drs. Merrell and Zafar. While in Pakistan, Dr. Merrell also had the opportunity to participate in grand rounds at HFH, visit one of the telemedicine clinics in Attock, and take part in Surgicon 2008, the annual meeting of the Pakistani national surgical society.

Dr. Merrell (center) and Dr. Malik (left) during a surgical training session at HFH in 2008.

In 2009 four more surgical training courses were held (one in March, two in June, and one in July), serving a total of 40 trainees. A short training course in tele-rehabilitation was organized for two trainees from the Abbas Institute of Medical Sciences in Muzaffarabad, and four doctors from HFH attended the ATA annual meeting in Las Vegas, during which they each presented papers on their recent research and training activities. Dr. Zafar has also been appointed to the editorial board of the the ATA journal Telemedicine and e-Health.

Due to the late start of activities as a result of various financial and administrative delays, a no-cost extension has been issued on the U.S. side through December 2010 to provide additional time to complete and consolidate work on this project. In particular, as of March 2010 HFH had still not received much of its promised grant funds from the Ministry of Science and Technology, which is preventing it from buying needed laparoscopic equipment that had been included in the approved project budget and conducting additional training workshops. Despite the budget delays, the partners have persevered in their work, and in March 2010 Dr. Merrell

made another week-long-visit to Pakistan during which he helped present a surgical training course for 10 participants and worked alongside the trainees in the operating room to demonstrate minimally-invasive techniques for cholecystectomy and appendectomy.

Development of Biosecure, Sustainable, and Cost-Effective Culture Technologies for Edible Shrimp (*Fenneropenaeus merguiensis*) in Pakistan, Establishment of Viral-Pathogen-Free Populations of *Farfantepenaeus duorarum*, and Refinements of Super-Intensive Production Practices for Table-*Litopenaeus vannamei* in the United States (2007-2009 – Extended through January 31, 2011)

Tzachi Samocha, Texas A&M University
Zarrien Ayub, University of Karachi
Pakistani Funding (HEC): $271,677
U.S. Funding: $116,003

Shrimp form the backbone of capture marine fisheries in Pakistan, with more than 50 percent of foreign exchange earnings resulting from shrimp export. Over the last decade, over-fishing has caused a tremendous stress on wild shrimp stocks, which is evident from the fact that despite the increase in the number of fishing trawlers, shrimp catches have declined considerably. This decline might be alleviated by the development of shrimp farming in the country while using sustainable and biosecure management practices. Pakistan does not have a previous history of farming shrimp, although it possesses considerable potential and resources for the development of such an industry, particularly along the Balochistan coast. Following the recommendations and guidelines available in the literature, and with the help of American partners, Pakistan can establish management practices for the successful production of edible shrimp under local environmental conditions, with an emphasis on biosecurity and sustainability.

The objectives of this project are to adopt and establish sustainable, biosecure, and cost-effective management practices for the production of edible shrimp suitable for the local environment and conditions in Pakistan to include (1) isolation of VPF broodstock population of *Fenneropenaeus merguiensis*; (2) building and operation of a closed-recirculating induced maturation system for *F. merguiensis*; (3) construction of a shrimp hatchery and development of a larval rearing protocol; (4) construction, operation, and development of protocols for intensive nursery and grow-out systems for shrimp under biosecure and limited discharge conditions; and (5) transfer of the technology to the end-users. The objectives for the portion of the project to be conducted in the United States are (1) development of VPF broodstock populations of *Farfantepenaeus duorarum*; (2) production of table-size shrimp in a super-intensive limited discharge and biosecure system; and (3) training and transfer of shrimp production technology to Pakistan.

The U.S. side, which received its grant funds earlier in 2007, has been pursuing its research on *Litopenaeus vannamei*, or the Pacific white shrimp. Results from the first year of the project showed that more than 9 kg/m^3 of table-size shrimp can be produced in 94 days from juvenile shrimp (1.25 g) with a good survival rate (>88%), good growth (1.2-1.3 g/wk), and low feed conversion ratio (1.2-1.4). The work with the Atlantic pink shrimp, *Farfantepenaeus duorarum*, showed that viable F1 VPE generation can be produced under a controlled environment. Meanwhile, Dr. Samocha also provided conceptual designs, equipment lists, and reviews of plans of the research facilities being built in Pakistan. Although the Pakistani side received its funds in August 2007, extensive efforts proceeded through the spring and summer of

that year to acquire land for the proposed research center at Damb, Sonmiani, Balochistan. The governor of Balochistan took a personal interest in the issue, and on July 12 he heard a presentation on the project. It was decided that a four-acre plot would be provided for the purpose free of charge at Sonmiani, where the hatchery of the National Institute of Oceanography (NIO) is located. The governor visited the site on September 4, 2007, and the land acquisition was finalized. At the governor's recommendation, an agreement has been signed between NIO and the Center of Excellence in Marine Biology at the University of Karachi instituting research cooperation between the two parties for the development of shrimp farming in Pakistan.

All conceptual designs of the systems to be built were finalized and in February 2008 a tender was opened requesting bids for the construction of the water purification and treatment systems, the induced maturation, larval rearing, algae production, Artemia hatching, nursery buildings and tanks, and the grow-out ponds. The basic infrastructure has been completed and various pieces of equipment and accessories were being finished and installed at the end of 2008. The reasons for the slight delay in completion of the work were shortages of raw materials such as sand and cement, the law and order situation at the site, and recent price hikes.

Two Pakistani research associates had been invited to come to Texas in February 2009 for training on operation of the facilities for induced maturation, larval rearing, algae production, water treatment, and grow-out under sustainable and biosecure management conditions. The costs of their visits were to be paid entirely by the Pakistani side using their grant funds. However, their visa applications were denied by the U.S. Consulate. Because the training is crucial for the project, Dr. Samocha agreed to cover part of the costs of their visits, and the visitors reapplied for their J-1 visas through the USAID visa process. This time, the visas were issued, and the visitors arrived in Texas on February 27, 2010, just in time to take part in operations associated with the annual maturation of shrimp larvae. Khalid Mahmood and Shakeel-ur-Rehman Rajput will be gaining new skills and experience in Dr. Samocha's lab through late August, now that their visit has been extended.

Shakeel-ur-Rehman Rajput (left) and Khalid Mahmood monitoring water flow into a reservoir at the Texas AgriLife Mariculture Research Lab (March 2010).

Identification and Cloning of Drought-Related Genes in Wheat (*T. aestivum*) (2007-2009)
Daniel Schachtman (until August 1, 2008) and Liming Xiong (after August 1, 2008), Donald Danforth Plant Science Center, St. Louis
Nasir Saeed, National Institute for Biotechnology and Genetic Engineering, Faisalabad
Pakistani Funding (MoST): $100,000
U.S. Funding: $109,963

Wheat is the staple food of millions of people around the world, and drought is the major limiting factor in its production. Pakistan is located in arid and semi-arid climate zones and is facing severe and growing shortages of irrigation water. The country's average wheat yield is 2.5 metric tons per hectare, which is quite low compared with other countries like China (4.27), Egypt (6.07) and Mexico (4.62), and Pakistan has been a net importer of wheat grain in the last decade. To feed its growing population, there is a great need to focus on developing drought tolerant crops that can grow with limited water.

This project involves the use of microarray technology to identify and clone key genes involved in adaptation of wheat to drought stress. Candidate genes are being cloned into expression vectors for transformation and development of drought tolerant wheat. Wheat crop productivity and yield stability are affected by a number of factors (biotic and abiotic). In the past, attempts have been made to introduce drought tolerance genes by conventional breeding. Wheat and other crop genomes are being sequenced by a number of research teams, and many different genes have been tested under a range of conditions to determine whether they may contribute to drought tolerance. In this study, four drought tolerance enhancing genes (HVA1, WXP1, DREB1A and AtNCED3) and a stress responsive constitutive promoter rd29A have been chosen. Over-expression of these genes may enhance drought tolerance and agronomic value of wheat. Few studies have addressed the topic of drought tolerance in wheat using molecular tools; although breeding efforts and germplasm screens have been undertaken. In addition to using the above approach, microarray technology offers new ways to find gene expression changes and manipulate them for developing drought tolerant crops. It is particularly useful to examine where and when specific genes associated with water deficit stress are expressed. Full length cDNAs of a few candidate genes that are regulated by drought are being cloned into plant expression vectors for transformation, and the over-expression of these genes is being tested for their ability to increase wheat production under drought conditions.

Although some delays were encountered in 2007 in getting the project under way, Dr. Schachtman assisted Dr. Saeed by cloning genes for transformation into local wheat varieties while Dr. Saeed worked on transforming wheat. In the first stage of the project, one Arabidopsis gene DREB1A under the control of a constitutive promoter (FMV) and a drought inducible promoter rd29 were cloned, and the U.S. side sent vectors to Pakistan containing AVP1 and AVP1D for transformation into wheat. Three more genes (HVA1, WXP1, and NCED3) were subsequently cloned, and each cDNA was cloned into plant transformation vectors containing a constitutive promoter and a drought inducible promoter. Dr. Schachtman sent all the clones to NIBGE by the end of November 2007 except rd29-HVA1. Those genes received before that date (rd29-DREB1A, rd29-WXP1, rd29-AtNCED3, FMV-DREB1A, FMV-WXP1, FMV-AtNCED3, FMV-HVA1, AVP1 and AVP1-D) were used in wheat transformations, which produced putative transgenic wheat plants of three wheat varieties (Sehar, Ufaq and Shafaq). These transgenic plants, which grew to maturity and produced seeds during the 2007-2008 wheat season, were

confirmed by BAR selection, BASTA herbicide spray, and PCR amplifications of specific genes. When AVP1-D plants (To) were exposed to 14 days of drought stress in pots, the transgenic plants survived while the control plants died.

The major focus of work in 2008 was to analyze the transcriptome of two wheat germplasms with contrasting drought resistance (one drought-resistant one and the other drought-sensitive). The purpose of this comparative transcriptome analysis was to identify candidate genes associated with drought resistance. For this strategy to work, it is important that the drought resistance of the cultivars be reliably determined. Ideally, the growth and development of the germplasms to be compared will be similar under normal growth conditions and their genetic backgrounds should be similar too. Dr. Saeed provided the seeds for four wheat germplasms that were previously compared under field conditions and were respectively referred as ether "drought resistant" or "drought susceptible." Data on the drought resistance of these germsplasms, which has not yet been reported in the literature, showed that their growth and development appear to differ under normal growth conditions. Concerned with the suitability of these germplasms for in-depth transcriptome analyses, the researchers decided to subject them to additional physiological studies, including measurement of water relations and stomatal conductance of these germplasms under progressive drought stress. Drought resistance of the plants will also be compared under well-controlled laboratory conditions. These studies will determine whether these germplasms have altered drought resistance and which pair is better for comparison of their transcriptomes.

In August 2008, Dr. Liming Xiong of the Danforth Center took charge of the project on the U.S. side after Dr. Schachtman left the center for a position in industry. Dr. Xiong began preparing the physiological and microarray analyses, and while conducting these experiments, he found that the seeds for two of the germplasms provided by his Pakistani partners were of very poor quality, perhaps due to long-term storage or quarantine treatments. The germination rate was very low, and the seedlings were not uniform in growth. This prevented the researchers from obtaining enough seedlings for any of the studies, although they planted four times the number of plants needed. In addition, these non-uniform seedlings also did not allow reliable comparison of their physiological response to drought stress. With this unexpected circumstance and the difficulty in obtaining more seeds from Pakistan, they had to grow the few germinated plants to maturity in order to get more seeds. This unexpected difficulty delayed the schedule for about five months. By December 2008, they planted the second round of plants, and in the spring of 2009 they began conducting the respective physiological studies and then the microarray experiments with these new plants.

More important than the technical difficulties encountered, the major problem impacting this project has been the non-payment of expected grant funds on the Pakistani side. Dr. Saeed was supposed to visit the Danforth Center in 2008 to participate in some of the above experiments. Although he eventually received his U.S. entry visa, unfortunately he was unable to obtain the required funds to make the trip because payments on his grant from MoST have been delayed for some two years. He still hopes to make the visit as soon as his grant funds arrive, and the partners on the project have requested a one-year no-cost extension on their grants, which will be made as soon as they submit their required progress report for 2009.

Assessment and Development of Renewable Ground Water Resources in the Quetta Valley, Pakistan (2007-2009 – Extended through January 31, 2011)

Mohamed Sultan, Western Michigan University, and Shuhab Khan, University of Houston
Abdul Salam Khan, University of Balochistan, Quetta

Pakistani Funding (HEC): $254,590
U.S. Funding: $199,986

Balochistan is the largest province in Pakistan, yet it has the lowest population density, largely due to the scarcity of its water resources. Furthermore, the indiscriminate and unplanned use of groundwater resources to meet water requirements in Balochistan in general and in the Quetta Valley in particular has led in recent years to unsustainable overexploitation of groundwater. This has progressively depleted groundwater levels in Quetta, which has had serious socioeconomic impacts due to the resulting migration of rural residents to urban areas. All of this points to the urgent need for assessing and developing the groundwater resources of the Quetta Valley. With funding previously provided by the United Nations Development Program and the Global Environmental Facility, researchers at one of the U.S. partner institutions on this project, Western Michigan University, have developed cost-effective methodologies for groundwater assessment and exploration in arid lands. These experiences and methodologies are being brought to bear in the current project.

The partners involved in this project are applying an integrated multidisciplinary approach for groundwater exploration in the Quetta Valley in which inferences from remote sensing data are integrated with observations extracted from other data sources, such as geochemistry, field geology, drilling, geophysics, and surface runoff and groundwater flow modeling to gain a better understanding of the hydrological setting and identify locations of potential productive wells. A five-fold exercise involving the following elements is being conducted to assess the groundwater potentials in the Quetta Valley:

- A field campaign to collect and analyze groundwater and surface water samples for geochemical, isotopic, and geochronologic analysis;
- A database incorporating all relevant data sets in a GIS environment to achieve a better understanding of the spatial relationships between these data sets;
- A Web-based GIS interface (ArcIMS) that can be applied along with geophysical methods to identify locations for potential productive wells targeting different types of shallow (<200m) reservoirs;
- Calibrated rainfall-runoff models and groundwater flow models to simulate runoff and recharge and to compute sustainable extraction; and
- Training for the Pakistani researchers both in Pakistan and the United States on various aspects of the adopted integrated applications and approaches and specifically in the applications of GIS, remote sensing, geochemistry, surface runoff modeling, groundwater flow modeling, and geophysics in groundwater exploration.

Dr. Shuhab Khan visited Pakistan in May 2007 to coordinate efforts with the Pakistani collaborators, conduct a preliminary field trip in the study area, and address logistical aspects of the project. During the trip, he and his colleagues identified and collected preliminary geologic and hydrogeologic data for the project, identified sites for water sampling, met with officials from several governmental agencies for potential collaboration (including the Geological Survey

of Pakistan, Water and Power Development Authority, Water and Sanitation Agency, Irrigation Department, and others), and interviewed and selected Pakistani students and technicians who will work on the project. Dr. Khan also conducted an informal training session at the Center of Excellence in Mineralogy (CEM) at the University of Balochistan, Quetta. The session, which covered the basics of water sampling, laboratory analysis and GIS and remote sensing methodologies, was attended by the Pakistani principal investigators and other faculty members from CEM and the Departments of Chemistry and Geology.

In addition, Drs. Shuhab Khan and Mohamed Sultan made two presentations related to their work in the Quetta Valley at the October 2007 annual meeting of the Geological Society of America. They also traveled to Pakistan in December 2007 to continue work on the project. While there, they conducted a two-day training session at the University of Balochistan on integrated research applications (remote sensing, GIS, geochemistry, geophysics) for identifying ground water reservoirs in arid areas. They also collected samples of surface and groundwater from various sites in the Quetta Valley and brought the samples back to the United States for geochemical and isotopic analysis. The U.S. researchers had planned to make another visit to Quetta in the spring of 2008, but this had to be postponed due to serious security problems in the Quetta area and in particular the assassination of the vice chancellor of the University of Balochistan in April 2008. However, the situation stabilized and they were able to travel to Quetta in August 2008 to present a week-long course entitled “Introduction to Geographic Information Systems and the Science and Application of Geochemical and Isotopic Methods in Groundwater Resources Evaluation.” A total of 15 students attended. During the visit they also had the chance to consult with Dr. Abdul Salam Khan and his colleagues in furtherance of their ongoing research.

Another member of the Quetta research team, Prof. Khalid Mahmood, visited the United States from December 11, 2008, through January 16, 2009. He spent two weeks each at the University of Houston and Western Michigan University, sharing and evaluating data with the U.S. partners and also receiving intensive hands-on training in rainfall-runoff modeling. As a result of this visit, Prof. Mahmood and Dr. Shuhab Khan produced a joint paper entitled "Trace element geochemistry of groundwater from Quetta Valley, western Pakistan" that will be published in the journal Environmental Earth Sciences. The team had planned for Pakistani project director Dr. Abdul Salam Khan to make the visit along with Dr. Mahmood, but unfortunately his visa application was delayed for months. Dr. Khan ultimately received his visa and visited both his U.S. partners at their universities from June 7 through July 15, 2009, with all costs for both visits to the United States being paid for by the Pakistani side. Three joint papers resulting from his visit are currently in preparation.

Dr. Sultan (at bottom) with Dr. Khalid and Mr. Ishaq of the University of Balochistan, gathering water samples from a kareze north of Quetta.

The data set gathered for this project by the Pakistani researchers represents a unique and valuable resource, as most of the information obtained from such sources as the Geological Survey of Pakistan, the Power and Irrigation Department, the Public Health Engineering Department, and the Geophysical Center Quetta, previously existed only in relatively inaccessible printed form. The data have now been digitized and manually entered into databases for analysis. The web-based GIS mentioned above has been created and posted for public access at (http://www.esrs.wmich.edu/website/Pakistan/viewer.htm). Upon completion, it will include comprehensive coverage in categories such as geophysics, geology, land use, precipitation, and remote sensing data sets. Meanwhile, the project has also made it possible for the University of Balochistan to establish a new water chemistry laboratory and GIS/remote sensing laboratory and to introduce new courses on advanced hydrogeology and water resources management. Under a no-cost extension during 2010, the U.S. and Pakistani partners on the project plan to continue work on their models and complete several joint papers on their results. Given the current high level of risk associated with travel to Balochistan, they expect to collaborate mainly through videoconferencing and e-mail.

Development of an ITS-Based Traffic Management Model for Metropolitan Areas of Pakistan with Karachi as a Pilot Study (2007-2009 – Extended through July 16, 2010)
Waheed Uddin, University of Mississippi
Mir Shabbar Ali, NED University of Engineering and Technology, Karachi
Pakistani Funding (HEC): $195,988
U.S. Funding: $94,000

Over the past decade, Pakistan has worked intensively to build and modernize motorways and national highways as part of the country's overall economic development efforts. However, traffic-related fatalities are alarmingly high, and about 41 percent of all crashes involve deaths, a figure that is significantly higher than in most other countries. Frequent congestion in most urban and metropolitan areas is adversely affecting travel time, business operating costs, and air quality, and increased air pollution is affecting public health. These problems require modern solutions emphasizing efficiency and safety as the main goals of traffic management. The primary objective of this project is to strengthen the capabilities of the Pakistani partner institution, NED University of Engineering and Technology in Karachi, for adapting modern geospatial technologies and scientific models of traffic flow and air quality. The implementation products should lead to increased transportation efficiency and safety, which can enhance economic prosperity, reduce public health costs, and benefit the people of Pakistan.

The partners conducting this project are adapting and implementing an Intelligent Transportation System (ITS) framework of traffic monitoring and evaluation technologies in which various traffic flow parameters and real-time traffic data are integrated to formulate an efficient Traffic Management System (TMS). Taking the densely populated metropolitan urban city of Karachi as a case study, they are compiling a geo-referenced road network database using geographical information systems (GIS) technology. A comprehensive cost-benefit analysis methodology is being implemented to assess traffic management strategies considering savings from reduced user and societal costs. The U.S. partner institution, the University of Mississippi, is assisting NED in adapting U.S. ITS experience, providing training in GIS/geospatial analysis and traffic simulation models, and developing self-reliance in these technologies. The project deliverable will be an efficient GIS-based TMS to be recommended for implementation to

Karachi City Traffic Officials (CDGK-EDO Transport), so the principal investigators are maintaining close contact with these authorities throughout the project. So far, there has been great interest in the outcome of the study of the part of local and regional government agencies, and a memo of understanding has been signed with the Karachi city government to share information from the traffic cameras installed by the project. Regional workshops are also being held to disseminate the methodologies and key results to other major Pakistani cities and universities. Further benefits should include a better trained professional workforce as well as modernization of curricula at both the undergraduate and graduate levels in Pakistan.

In the first exchange visit on this project, Dr. Waheed Uddin and his colleagues at NED presented a workshop at NED June 18-21, 2007, on GIS and imagery-based geospatial analysis for transportation planning. The workshop provided training to 43 participants, including professionals from CDGK, the National Highway Authority, the Pakistan Space and Upper Atmosphere Research Commission, the Jinnah Postgraduate Medical Centre's Traffic Safety Project, consulting engineers, professors, and graduate students. On July 30, 2007, a stakeholders' meeting was held in Karachi to involve officials and planners from local transportation agencies. Following the meeting, an executive summary highlighting key findings and recommendations was released. During his six-week visit, Dr. Uddin and his colleagues also sampled data for congestion assessment not only in Karachi, the focus of their study, but also in Lahore and Islamabad. While in the latter city, Dr. Uddin presented a lecture at the National Highway Authority and visited that agency's offices for consultations on remote sensing technologies for airborne terrain mapping to facilitate road construction in Pakistan's mountainous northern region. He delivered additional lectures to engineers at National Engineering Services (NESPAK) headquarters and to engineering students at NED.

Dr. Uddin and traffic police officials visit the congested streets of SITE town, Karachi, in July 2008.

In February 2008 Dr. Uddin welcomed a Pakistani graduate student, Mr. Afzal Ahmed, to begin work on his master's degree at the University of Mississippi. On Dr. Uddin's return visit to Pakistan in June-July 2008, in addition to working on the research aspects of the project and assisting in the training of NED graduate students, he and his partners presented a workshop on GIS-based decision support systems June 18 and a two-day course on geospatial analysis June 19-20, both at NED. On June 27 Dr. Uddin presented a lecture at the Pakistan Atomic Energy

Commission, and on June 28 he led a seminar on highway infrastructure design and management at the National Institute of Transportation, Risalpur. On July 2 he presented a seminar at NESPAK Lahore on enhancing traffic safety using remote sensing and GIS technologies, and on July 12 he and Dr. Ali led a full-day workshop in Karachi on air quality and the impact of global warming. On July 15-16 they conducted a workshop on traffic safety and intelligent transportation systems for Karachi traffic officials, researchers, students, and representatives of industry.

In the third year of the project, Dr. Ali made a two-week visit to the University of Mississippi May 31-June 15, 2009, with the costs funded by the Pakistani side of the grant. While in Oxford he worked with Dr. Uddin on various elements of their joint research, presented a lecture on the project to civil engineering faculty and students, and saw Mr. Afzal Ahmed successfully defend his master's thesis. After completing some revisions to his thesis, the latter received his degree and in late July 2009 returned home to Karachi, where he has now assumed a position as lecturer at NED University. In 2009 alone, participants in this joint project presented papers at six conferences.

Although much has been accomplished on this project, Dr. Uddin indicates that his colleague's efforts have reportedly been hampered due to some funding delays, which have forced them to push back planned travel and the purchase of data and equipment needed for their work. Therefore, their First International Conference on Sustainable Transportation and Traffic Management, which had been planned for December 2009, has now been postponed until July 1-3, 2010. A no-cost extension has been arranged on both sides.

Nanomedicine for Cancer Research (2007-2009 – Extended through January 31, 2011)
Kenneth Watkin, Brian Cunningham, and Irfan Ahmad, University of Illinois at Urbana-Champaign
Atiya Abbasi, University of Karachi
Pakistani Funding (HEC): $137,219
U.S. Funding: $250,000

More than 70 percent of the developing world's population still depends on complementary and alternative systems of medicine (CAM). Evidence-based CAM therapies have shown remarkable success in healing acute as well as chronic diseases. The Indo-Pakistani subcontinent is rich in such remedial sources, most of which remain untouched and unstudied. Pakistan is among the world's leading exporters of medicinal plants, but there is a need to build partnerships that help provide the infrastructure and training to apply and use recently develop new rapid screening techniques for evidence-based evaluation of various plant extracts.

Researchers at UIUC have employed a new label-free optical biosensor system for high-throughput evaluation of natural products. This new biosensor system is being used for rapid evaluation of the breast cancer apoptotic potential of plant extracts. Preliminary research has revealed several potential extracts that kill breast cancer cells. The potential cancer treatment extract candidates will progress to clinical evaluation. In order to achieve this vision, the partners involved in this project have devised a systematic plan by concentrating on cancer research and education and integrating these aspects with existing capabilities and infrastructure at the HEJ Research Institute of Chemistry at the University of Karachi. The application of this type of nanomedicine technology has enormous potential, not only for cancer treatment but also for the medicinal plant industry in Pakistan. Applications include high-throughput pharmaceutical

compound screening, molecular diagnostics, PCR, electrophoresis, label-free microarrays, proteomics, environmental detection, and whole cell assays.

In the initial phase of the project in the fall of 2007, microplate readers and reagents were purchased at both UIUC and HEJ. In addition, UIUC acquired a new flow cytometer that will be used by Pakistani faculty and graduate students during their planned visits to UIUC. On the U.S. side, two graduate students and a part-time post-doc have been hired on the project. The researchers have been using plant extracts to induce cancer cell apoptosis using the photonic crystal biosensors developed in the UIUC Micro and Nanotechnology Laboratory in collaboration with SRU Biosystems. These biosensors will be made available to researchers from Pakistan after training is conducted at UIUC. Dr. Atiya Abbasi and a student had been expected to visit UIUC during the summer of 2008, but due to visa and scheduling complications those visits have been postponed repeatedly.

Meanwhile, a course entitled Current Topics in Nanomedicine, conducted jointly by the University of Illinois and Washington University in St. Louis, was made available to University of Karachi students and faculty for the first time in the fall 2007 semester. Although Drs. Watkin and Ahmad had initially planned to present a summer course on nanomedicine in Karachi in 2008, they decided instead to make the course available online for a second year, not only to the University of Karachi but also to and other institutions the Pakistani collaborators designate. The course is possible thanks in part to leveraged support from an ongoing grant from the National Cancer Institute in support of UIUC's Cancer Nanotechnology Excellence Project (2005-2010). In August 2008 Dr. Ahmad also presented a poster at the IBC's 13th Annual Congress on Advanced Drug Discovery and Development of Innovative Therapeutics. He reports that the poster, which presented recent work on biosensing for cancer therapeutics that he has conducted jointly with Dr. Abbasi and colleagues from UIUC and Washington University, attracted interest from other conference participants who wish to collaborate on studies of potential uses of plant extracts for cancer treatment.

In January 2009 Dr. Ahmad visited Dr. Abbasi and her colleagues at the University of Karachi. During the visit he presented training seminars for faculty and students and met with Dr. Abbasi and the director of her institute to discuss future work on the project. Dr. Abbas has also provided her UIUC counterparts with several samples of plant extracts for further testing. The project team is currently aiming to organize a nanomedicine workshop in Karachi in 2010 in cooperation with Lahore University of Management Sciences and the Shaukat Khanum Memorial Cancer Hospital and Research Centre. The workshop had been planned for January 2010 but was cancelled due to the security situation and the reluctance of foreign participants to travel to Lahore.

This project appears to have made less progress than others in Phase 2. As noted above, the partners on this project have been extremely slow to make the necessary arrangements to obtain visas for proposed Pakistani visitors to the United States so they could receive training as planned, and Dr. Abbasi has been unwilling to accept the visa procedures. It is understandable that Dr. Watkin and his U.S. co-investigators have not been willing to travel, and the fact that they have made their nanomedicine course available on-line to Pakistani students is helpful. However, the reports submitted by the U.S. partners in 2007 and 2008 were somewhat thin, making it difficult to judge how much progress they are making on the specific objectives of this project. Although Dr. Ahmad traveled to Pakistan in January 2009, this did not seem to speed efforts to have Dr. Abbasi nominate trainees to be sent to UIUC. The U.S. PIs were advised in July 2009 that unless improvement was noted or documentation of progress provided,

particularly in terms of training visits from Pakistan to UIUC, the Academies would not recommend a no-cost extension beyond the existing end date of the project (January 31, 2010), and the U.S. partners would be required to return unspent funds. In mid-September they finally submitted information that Dr. Abbasi and a student would like to apply for visas to visit in the spring of 2010, and they were provided with the necessary forms and instructions by Academies staff. Because HEC advocated a year-long extension, it was granted. However, it subsequently took another seven months for Dr. Abbasi to provide the required paperwork for her own application, and at that time she reported that her student who was to have applied for a visa as well had been delayed in completing his PhD work and therefore he would apply at a later date.

Summary of Activities to Date on Earthquake-Related Research Projects Funded in 2006 Cycle

The following three projects were selected in a special focused competition in 2006 devoted to earthquake-related research. All have requested and received no-cost extensions through January 31, 2011.

Education and Learning after the Pakistan Earthquake: Can the Children Recover? (2007-2009 – Extended through January 31, 2011)
Tahir Andrabi, Pomona College
Ali Cheema, Lahore University of Management Sciences
Pakistani Funding (HEC): $240,000
U.S. Funding: $83,700

On October 8, 2005, a devastating earthquake hit Pakistan's Northern Provinces of NWFP and AJK and left the region in complete disarray. At the time this project began in early 2007, there was still little data available on the state of villages, households, and schools in the area. The researchers collaborating on this project are undertaking a series of surveys that will help to characterize the educational status of children by completing both a village mapping of educational facilities and a full module on the schooling environment at the level of the household. This represents an expansion of the originally funded project made possible thanks to a supplemental World Bank grant of $190,000 grant to Pomona College. The project is now comprised of four major parts: a household and facilities census, a household survey, a school and teacher survey, and child testing in four subject areas, and the effort covers 126 villages in the districts of Abbottabad, Muzaffarabad, Bagh, and Mansehra.

Dr. Andrabi visited Pakistan in June and August 2007 to being work on the project with his Pakistani partners. Their initial efforts focused on mapping the spatial distribution of the earthquake shock to draw a statistically representative sample of the affected communities, compiling a list of interventions, and partnering with major earthquake reconstruction organizations to create a list of interventions that needed to be documented in order to evaluate the recovery from the shock. Crucial linkages were established with NESPAK, a government firm that is the largest provider of engineering services in the earthquake area, and with the Earthquake Reconstruction and Rehabilitation Agency, the official Pakistani government body that coordinates all earthquake-related activity in the region. Questionnaires to be administered to school administrators, teachers, and children were developed, and research assistants and survey teams were hired and trained. Sampling field visits had been set to begin in November

2007, but the imposition of the state of emergency (and subsequent arrest and detention of Dr. Cheema and fellow LUMS faculty members), the December assassination of Benazir Bhutto, and the associated deterioration of security conditions in the region caused those plans to be put on hold for several months. However, by August 2008, the teams had conducted a baseline pilot survey, selected the village representatives, and calculated the sampling weights needed to make the inferences.

Dr. Andrabi made three visits to Pakistan in 2008 (April, August, and December) to continue work on the project. The first trip involved working in Lahore with his counterparts to finalize the details on the census questionnaires and plans for the pilot survey, which was carried out later in the summer. The second trip involved detailed talks with ERRA and the Ministry of Kashmir Affairs on their assessment of the current educational environment in the earthquake affected areas. The third trip involved final meetings with the government ministries in Islamabad and in NWFP to make arrangements for the upcoming census. During that December 2008 visit, Dr. Andrabi and Dr. Cheema also conducted a training workshop in survey procedures and data analysis for the 12 team leaders selected to manage the actual survey effort.

As noted above, security conditions have caused major complications and delays for this project. The bulk of the survey work was supposed to begin in the fall of 2008, but in the wake of the Marriott bombing and other security problems in the regions to be surveyed, the researchers concurred with the view of the NWFP government that it was too dangerous to send the survey teams into the field at that time. Because winter weather conditions in the region make some roads in the area impassable, the survey was postponed until April 2009, and Dr. Andrabi spent 2 weeks in Pakistan that month to help supervise the launch of the survey effort and participate in some interviews himself. The first round of the survey (the household and facilities census) was completed by the end of May, with data collected covering more than 28,000 households from 126 villages in the earthquake zone. Information was gathered on (1) household demographics; (2) injury, death, damage, and destruction; (3) details of compensation; (4) organizations providing assistance; (5) mental health status; and (6) education status. In addition, a village facilities survey was conducted to gather information on enrollment, staffing, damage, and reconstruction status at all schools in the selected villages. One important aspect of the survey was its inclusion of GPS coordinates on all households and facilities, which makes it possible to analyze the data by distance from the faultline as a measure of the shock impact from the earthquake.

The household survey was carried out from August through October 2009 and was conducted by the independent consulting firm RCons from Lahore, using a training module developed by the principal investigators. The firm trained more than 120 surveyors, primarily recent university graduates, who were hired from the affected districts. The training workshops were conducted in each of the districts as well. The cost of the survey and the training was covered by funds from the World Bank, which has allowed the research team to increase the scope and relevance of the original project tremendously.

The third phase of the project entailed a school survey, which covered more than 1,000 schools, and a student testing component in which more than 7,300 students in grades 4 and 5 were evaluated for their levels of achievement in English, Urdu, math, and civics. This phase of the project was successfully completed by the end of December 2009 with the help of funding provided on the Pakistani side of the grant by HEC. A no-cost extension has been made through January 2011 to allow for completion of this project, including a second round of student and school tracking in the fall of 2010. The researchers on this project are currently analyzing the

data generated and expect to produce a major policy paper as well as a series of academic papers this year. It would seem that their findings could be of great interest to the Pakistani government and international donor organizations involved in the education sector.

Development of a Framework for Probabilistic Seismic Hazard Maps for Pakistan (2007-2009 – Extended through January 31, 2011)

Scott Olson and Youssef Hashash, University of Illinois at Urbana-Champaign
Irshad Ahmad and Akhtar Naeem Khan, NWFP University of Engineering and Technology, Peshawar
Pakistani Funding (HEC): $130,000
U.S. Funding: $174,705

The October 2005 Kashmir earthquake demonstrated the extent of damage that an earthquake in Pakistan can cause. Given Pakistan's seismo-tectonic setting, this earthquake is not a one-time event, but part of a sequence of earthquakes that have happened in the past and will happen again in the future. More importantly, the earthquake highlighted the severe limitations of existing seismic hazard characterization in Pakistan. Several efforts by the Pakistan Meteorological Department and collaborations with the U.S. Geologic Survey as well as groups in Japan and Norway are under way to better define seismicity in Pakistan through various mapping, instrumentation, and data collection activities. These groups will use the collected data to generate region-specific attenuation relationships and ground motion estimates. However, an important gap remains in these efforts at the interface between seismology and earthquake engineering. That is, a need exists to develop appropriate factors to account for local soil response and topographic effects. These "site response" factors are a common component in design codes worldwide to translate ground motions developed by seismic hazard mapping efforts for use by design engineers. Perhaps more importantly, there is a need to train current and future Pakistani engineers to use the seismic hazard mapping tools and products that others are producing. This project focuses on building Pakistani capacity in the area of seismic hazard characterization for engineering applications and for developing loss scenarios and emergency response plans. The following project activities, combined with the efforts of the other groups mentioned above, should represent a significant step in improving the design and engineering of structures in Pakistan in order to reduce casualties and economic losses associated with future earthquakes:

- Course development and delivery: Develop and deliver course modules and short courses on the use of seismic hazard characterization for engineering applications.
- Input for seismic hazard analysis: Collect data from the literature to define available input to free and commercial seismic hazard analysis software such as OPENSHA and EZFRISK and perform preliminary seismic hazard analyses for northern Pakistan.
- Field Studies: Characterize one site in Pakistan to aid in defining local site and topographic effects in Pakistan.
- Local site and topographic effect factors: Perform studies to develop appropriate site and topographic effects factors using field data and the results of numerical modeling.

After the project began in early 2007, the U.S. and Pakistani partners worked closely to develop a semester-long course on Engineering Seismology and Seismic Hazard Analysis, which

was offered for the first time at NWFP UET in the fall 2007 semester. Many of the course lectures were delivered remotely by the U.S. partners on the project. In addition to developing the course curriculum and materials, the U.S. team also collected and reviewed relevant literature on seismicity in Pakistan and worked on adapting two seismic hazard analysis software packages for use with Pakistani data. Meanwhile, the Pakistani partners collected literature, maps, and other data and worked to identify potential sites for conducting field investigations and installing seismic instrumentation.

The researchers also devoted time to planning a workshop for practitioners in seismic hazard analysis, which was to have been presented in January 2008. It had to be postponed due to security conditions but was ultimately presented at HEC headquarters in Islamabad August 24-25, 2008. The workshop attracted 50 participants from universities, government agencies, and private engineering firms across Pakistan. Dr. Hashash participated in person while Dr. Olson delivered his lectures via video conferencing. Meanwhile, a site was selected at UET Mardan for installation of the field testing equipment. Once established, the site will be used as a field laboratory to teach students and practitioners about the importance of field work for seismic hazard analysis and earthquake engineering, as well as to obtain preliminary data on topographic effects.

Participants in the August 2008 seismic hazard workshop held at HEC headquarters.

In 2009, the graduate seismic hazard course was once again presented at NWFP UET, with students being assigned sites for deterministic and probabilistic analyses. Many of the specific research tasks in the project have been completed. Two papers are currently being prepared for submission to scientific journals and more are expected now that the probabilistic and deterministic seismic hazard studies have been completed for 11 major cities in Pakistan. However, the purchase and installation of the seismic instrumentation has been delayed repeatedly due to the complex requirements of NWFP UET's procurement system. A contract was issued to a Pakistani firm to carry out the necessary geophysical and geotechnical assessments of soil properties at the site, and that work began in October 2009. About 100 students have visited the site to learn more about the testing procedures, which have also been videotaped for use in future classes.

In view of these contracting delays as well as the security-related delays that pushed back the schedule for the second planned practitioners' workshop, the project has been granted a no-cost extension through January 31, 2011. During 2010 the researchers will work on procuring and installing the field instrumentation, developing a code-based procedure for performing seismic hazard analysis that will be applicable in all regions of Pakistan, studying the role of topographic effects in triggering landslides, and completing papers on their research findings for submission to technical journals.

Building Pakistan's Capacity for Instruction, Research, and Practice in Earthquake Engineering and Retrofit (2007-2009 – Extended through January 31, 2011)

Brian E. Tucker, GeoHazards International, Palo Alto
Sahibzada Rafeeqi, NED University of Engineering and Technology, Karachi
Pakistani Funding (HEC): $220,000
U.S. Funding: $241,595

This project aims to improve Pakistan's ability to reduce earthquake risk by building the capacity of its universities to teach and conduct research in earthquake engineering and transfer the knowledge needed to seismically retrofit essential structures to both new graduates and practitioners. The approach integrates formal instruction in theory with practice by using case studies of existing buildings typical of the local building stock. It recognizes that earthquake engineering exists in a broader societal context that balances safety with competing demands and values by employing multidisciplinary earthquake risk management decision-making processes. The project promotes sustainable academic interest in earthquake engineering research by encouraging cooperative research and professional relationships with American researchers through academic exchange, consultation on research topics that directly impact seismic safety in Pakistan, and creation of a Pakistan Earthquake Engineering Research Agenda. Throughout the project, participants will be applying the concepts learned through case studies of existing buildings, which will then, along with theory, form the basis for courses in seismic assessment and retrofit, comprising both practical training courses for practitioners and academic courses for students. American faculty members and practicing professionals are working with the Pakistani participants to develop, teach, evaluate, and revise these courses, which are being piloted in workshops for practicing professionals and as regular courses at NED University and other participating universities. After assessment and revision, courses for practitioners will be taught at six workshops with twenty participants each in Islamabad and five other cities to be determined. Several workshops will be held to build the capacity of additional faculty and students from participating institutions.

The project began when five U.S. participants (Dr. Gregory Deierlein of Stanford University, Mr. David Mar of Tipping-Mar+Associates, Dr. Khalid Mosalam of the University of California Berkeley, Dr. Janise Rodgers of GHI, and Mr. L. Thomas Tobin of GHI) traveled to Pakistan July 21-28, 2007, to meet with their counterparts and visit several sites in Karachi, Islamabad, and the earthquake-affected areas in Rawalakot, Bagh, Chakothi, and Muzaffarabad. The purpose of the visit was threefold: beginning to develop the case studies, improving the existing curriculum, and meeting with project partners throughout the country. The case study development began with defining characteristic building types and training a selected group of graduate students and junior faculty to screen buildings rapidly. Curriculum improvement efforts began with determining how the project can help build on existing capacity in earthquake

engineering in Pakistan's universities and benefit from the experiences of U.S. universities such as the University of California Berkeley and Stanford. During the visit, the U.S. research team met with Pakistani project partners in academia, private practice, and government. On July 21, 2007, the Pakistan Chapter of the American Concrete Institute organized and sponsored a seminar given by the U.S. research team members entitled "Performance-Based Earthquake Engineering and Applications to the Evaluation and Retrofit of Existing Buildings." The seminar was well-attended, attracting approximately 100 students, faculty, and practicing engineers.

The research team conducted similar activities when the participants from Pakistan visited the San Francisco Bay area in late October 2007 to interact with interested faculty and practicing engineers. Project leaders Prof. S. Rafeeqi and Prof. S. Lodi visited California for first-hand observation of seismic retrofit techniques, plus academic exchange with American researchers with the intent of encouraging future research collaboration and student exchange.

Participants tour a retrofit construction site with Holmes Culley Engineers during their October 2008 visit to California.

In 2008 progress on the project was slower than anticipated due to visa delays as well as funding delays on the Pakistani side. However, the case study teams made good progress on the initial group of six buildings, gathering information and drawings, developing computer models, and performing initial elastic analyses. In late October 2008, a 15-member team from Pakistan made a study visit to California. During the week-long visit, which was originally planned for July but rescheduled due to visa delays, the participants presented the results of their case study investigations to date, visited seismically retrofitted buildings, received instruction in nonlinear structural analysis, met with local practicing engineers and building officials, and toured laboratory facilities. The project team also met several times during the visit to complete the draft curriculum revisions and plan future project activities. The study visit was the only international travel during Year 2, however, as the American members of the project team were unable to travel due to the deteriorated security situation in Pakistan. Project participants continued meeting via videoconference, and investigated additional virtual collaboration tools to try to compensate for the lack of travel. Meanwhile, the project also had to deal with other challenges in 2008. NED University did not receive its Year 2 funds until well into the year,

which hindered the Pakistani partners' ability to work effectively. Despite these challenges, the NED project team made significant progress toward broadening the project's participant base throughout the country.

In 2009 plans for several U.S. participants to travel to Pakistan were again postponed due to security concerns, but regular e-mail, phone, and videoconferencing contacts continued. The number of building case studies was doubled, and by the end of the year 7 of 10 had been finished, with the rest to be completed in 2010. With regard to curriculum development, consensus recommendations have been drafted for national minimum standards for earthquake engineering education in Pakistan. The recommendations, which consist of the minimum basic earthquake engineering topics to be included in the civil engineering and architecture curricula, have been submitted to the National Curriculum Revision Committee (NCRC) at the Higher Education Commission (HEC) for adoption.

Taking into account what they had learned over the course of the project, the NED team presented two training workshops for practicing engineers in 2009. The first was held at NED August 12-13, 2009, to serve participants from southern Pakistan, and the second was held at the Hotel Green Retreat in Nathiagali for engineers from the north. Both workshops included both technical presentations and hands-on practice in evaluating actual buildings. Throughout the year, undergraduate and graduate students at NED also had the opportunity to become involved in work on the case studies being carried out for the project. As a measure of the interest of the Pakistani authorities in the results of the project, the Sindh Provincial Disaster Management Authority has asked the NED team to participate in capacity building exercises related to assessing the seismic vulnerabilities of schools and hospitals in the province. In addition, four Pakistani members of the project team are serving on a Pakistan Engineering Council committee that is designing the methodology for training stakeholders on application of the country's 2007 seismic code.

In 2010 the project participants are planning to hold one joint meeting in a third country to be determined, as well as two training workshops on seismic retrofit in Pakistan. They will also complete development of training materials, case study reports, and instructional modules. Due to the delays that have been encountered, a no-cost extension has been made through January 31, 2011.

Comprehensive Summaries of Activities on S&T Projects Funded in Phase 3 (2007 Cycle) (USAID-Supported Projects Only)

These projects were selected at the January 2008 joint review panel meeting and began their activities in the spring and summer of that year. This section includes summaries only for those projects being supported on the U.S. side with funds provided by USAID and not for those being supported with funds from the Department of State.

Response Modification Factors of Typical Pakistani Reinforced Concrete and Masonry Buildings for Pakistani Seismic Code Development (2008-2010)

Bassem Andrawes and Amr Elnashai, University of Illinois at Urbana-Champaign
Qaisar Ali, NWFP University of Engineering and Technology (UET), Peshawar
Pakistani Funding (HEC): $ 66,000
U.S. Funding: $ 100,750

The response modification factor (R) and displacement amplification factor (Cd) play a key role in safety and economy of buildings because they make it possible to reduce elastic seismic forces and amplify displacement to arrive at cost-effective and safe designs. However, these crucial design factors do not currently offer a uniform margin of safety and cost effectiveness for different seismic regions, given the diversity in structural systems, construction practices, and quality control. Improving the reliability and cost effectiveness of earthquake-resistant buildings in Pakistan requires accurately evaluating and calibrating these factors for typical Pakistani structures, not merely importing largely irrelevant and non-rigorous factors from other regions. This project includes comprehensive analytical simulations and a limited number of confirmatory tests to calibrate the R and Cd factors for typical reinforced concrete and masonry buildings in Pakistan. The primary objectives are as follows:

- Fully calibrate and verify earthquake design response factors (R and Cd) of reinforced concrete and masonry buildings for immediate use in the new Pakistani seismic code
- Transfer state-of-the-art methodology, technology, and software platforms to UET Peshawar for use in research and teaching
- Build top quality capacity in Pakistan in research, education, and training by holding a series of seminars in Pakistan and hosting Pakistani personnel at the University of Illinois at Urbana-Champaign (UIUC)

After the start of the project on the U.S. side in April 2008, Drs. Andrawes and Elnashai recruited a graduate research assistant (a master's degree student already enrolled at the university) to work on the project. Although the project suffered several months of funding delays on the Pakistani side, these researchers continued working to made progress toward their goals, and Dr. Ali also recruited a graduate student to work with him on the project. Communicating regularly by e-mail and phone, the U.S. and Pakistani partners initially focused on collecting data on design information and drawings for representative reinforced concrete and masonry buildings in Pakistan and on starting the preliminary analytical phase of the project. In addition, a series of preliminary analytical models of reinforced concrete frames was developed using the OpenSees finite element platform, a state-of-the-art inelastic analytical tool for static and dynamic analysis of steel, concrete, and composite structures.

In 2009 plans called for an exchange of visits between the two research teams. Dr. Andrawes had invited Dr. Ali and his graduate student to spend two weeks at UIUC during the summer of 2009 to observe the confirmatory experimental tests that will be conducted using the MUST-SIM hybrid simulation facility. All costs for the trip were to be paid for by the Pakistani side. However, the funding delays in Pakistan pushed back the work schedule on the project, so Dr. Ali and his team needed more time to catch up. During 2009 they provided the UIUC partners with design drawings for several reinforced concrete buildings under construction in Pakistan, which were used to develop advanced 2-D models incorporating the effect of infill masonry walls, a crucial feature of such buildings. These models were then used to predict the R factor for each building. The two teams also worked to establish the methodology for their survey of the Pakistani building stock, which should help to ensure that their models take into account typically encountered deficiencies such as those associated with the quality of the construction materials or of construction practices. After much consultation they agreed on the survey methodology, which involves collection of design information in the form of architectural and structural drawings and quantification of the disparity between the design specifications and

actual construction. This second component would be addressed through interviews with architects, engineers, and contractors, who would be asked a set of questions addressing compliance with various construction parameters. The survey was delayed somewhat by conditions in Pakistan but at last report was expected to be complete by the end of February 2010. In addition, the Pakistani team is also compiling a database on the properties of prototypical construction materials as well as ground motion data from various sites. Data acquisition has been slower than anticipated, but the Pakistani team is working with the relevant organizations to resolve the issue.

Dr. Andrawes and/or his graduate student, Mr. Adeel Zafar, were to visit UET Peshawar during the fall of 2009 to give several presentations related to the project. Those plans are on hold depending on the security situation in Peshawar, which became increasingly dangerous in 2009 and early 2010. Drs. Andrawes and Ali expect to have the chance to meet in Toronto during the 10th Canadian Conference on Earthquake Engineering in July 2010, after which Dr. Andrawes has invited Dr. Ali and his graduate student to visit UIUC for a week or two. In the meantime, they may continue to meet via videoconference as they focus on refining their numerical model and defining the building models based on the results of the building stock survey.

Implementation of SuperPave Binder and Asphalt Mix Specification to Improve Pavement Performance in Pakistan (2008-2010)

Gilbert Baladi and Syed Waqar Haider, Michigan State University
M. Waseem Mirza, University of Engineering and Technology, Lahore
Pakistani Funding (HEC): $411,000
U.S. Funding: $189,000

The Hot Mix Asphalt (HMA) industry in developing countries in general and in Pakistan in particular is facing a substantial challenge to meet transportation demands caused by ever increasing traffic volume and loads. High ambient temperatures and heavy truck loads further complicate the problem and accelerate premature pavement failure in Pakistan. This in turn taxes the limited resources of the road network and places an undue burden on the country's socioeconomic development. In order to meet the challenge, the HMA industry and the transportation authorities must enhance the design of HMA and improve the selection of materials used in highway construction. These tasks require a better understanding of the impact of design methodologies and material characteristics on long-term pavement performance. Although most of the primary road network in Pakistan is surfaced using HMA, the mixes have not been properly characterized to assess their long-term performance under heavy loads. This project entails evaluating the physical, engineering, and rheological properties of the various constituent materials of the HMA mixes (asphalt binder and coarse and fine aggregates) and analyzing the impacts of these properties on long-term pavement performance under prevailing traffic and environmental conditions in Pakistan. In summary, the goal of this study is to assist the Pakistani highway authorities and relevant industries and to train personnel in Pakistan to implement advanced testing techniques for the characterization of HMA mixes so as to optimize pavement performance in a cost-effective manner. As part of this effort, the U.S. partners will work with their counterparts at UET Lahore and representatives of government agencies and industry to develop and initiate an integrated pavement research program.

Although the U.S. side was able to begin its work in April 2008, the Pakistani side did not receive its grant until July, after which Dr. Mirza began the process of hiring a research associate and recruiting five graduate students to assist with the project. The teams reviewed existing literature and gathered information on existing Pakistani practices regarding asphalt characterization. Using HEC funds provided for this project, about $100,000 worth of laboratory equipment has been purchased and delivered to UET in 2009, and thanks to funds provided separately by UET and by other HEC grants, an additional $100,000 worth has already been installed.

Meanwhile, two members of the Pakistani research team (Dr. Mirza and Mr. Farhan Haider) visited the United States from October 19 to November 3, 2008. The main focus of their visit was a five-day training course at the National Center of Asphalt Technology in Auburn, Alabama. The course provided them with extensive hands-on training for conducting SuperPave tests on asphalt binders and asphalt mixtures. Next they visited Arizona State University's SuperPave laboratory to familiarize themselves with Simple Performance Equipment that is proposed for purchase in the second year budget of this project. While in Arizona they also visited Geotechnical Consulting and Testing Services, a company that develops servo-hydraulic systems for asphalt testing. Finally, they traveled to Michigan State University to meet with the U.S. research team to discuss and revise the research plan and finalize the study activities to be accomplished in the next year. They also had the opportunity to visit the asphalt laboratories of the Michigan Department of Transportation, the Spartan asphalt mixing plant in Lansing, and various paving construction sites, where they observed the field construction process and asphalt paving operations.

(From left) Dr. Waseem Mirza, Dr. Syed Waqar Haider, and Mr. Farhan Haider observe as a Michigan paving crew lays down asphalt with SuperPave binder.

After returning home to UET, Dr. Mirza and Mr. Haider shared what they had learned with other faculty members, students, and technical staff members. This technology transfer and the introduction of the new equipment purchased through this project have expanded the scopes of several courses at UET. Performance-based material evaluation and mix design procedures are

being incorporated in the course syllabi, and laboratory components of the courses will include material characterization using the SuperPave approach.

In 2009 these researchers worked to complete the literature review, collect samples of asphalt materials and actual pavement cores, and initiate binder and performance tests using the new laboratory equipment. Drs. Baladi and Haider had planned to visit Lahore in March 2009 in order to present a one-day course on SuperPave asphalt binder and mixture characterization, monitor and evaluate the laboratory tests and procedures, and meet with the chairperson and engineers from the National Highway Authorities (NHA) to discuss the possible implementation of SuperPave technology for highway construction in Pakistan. The visit was postponed until March 2010 and then postponed again due to the security situation, but meanwhile the U.S. partners on the project have provided training to five Pakistani graduate students and lab technicians via videoconferencing. The two sides remain in frequent contact in 2010 as they continue their planned tests, work on joint technical reports and papers, and mentor four Pakistani master's degree students as they complete their thesis projects. Once Drs. Baladi and Haider are able to travel to Lahore their visit will also include meetings and activities relevant to their now-completed grant under Phase 1 of the program. Contacts established during that project, including with the national and provincial highway authorities, refineries, and other Pakistani universities, will be particularly valuable in this new research collaboration.

Biotechnological Approaches to the Control of *Ascochyta* Blight of Chickpea (2008-2010)
Weidong Chen, Washington State University
S. Sarwar Alam, Nuclear Institute for Agriculture and Biology, Faisalabad
Pakistani Funding (MoST): $67,000
U.S. Funding: $127,219

Chickpea (*Cicer arietinum L.*) ranks first among legume crops in Pakistan and is an important source of dietary protein for many people in Pakistan. However, average yield rates for chickpea are quite low due to susceptibility to various stresses, both biotic (Ascochyta blight, Fusarium wilt, and insect pests) and abiotic (drought and cold). Among the stresses affecting chickpea productivity, Ascochyta blight caused by *Ascochyta rabiei* is one of the most important. This devastating disease is difficult to control, and chemical, cultural, and biocontrol treatments cannot effectively manage it. The overall research goal of this project is to advance control measures of Ascochyta blight of chickpea through understanding genetics of host resistance and pathogenic mechanisms of the pathogen. The project has four specific objectives: (1) to identify the resistant germplasm and study the genetics of resistance to Ascochyta blight of chickpea, (2) to map and tag the chromosomal regions involved using molecular markers for developing marker-assisted selection, (3) to determine relationship between phytotoxin production and virulence of the chickpea pathogen *Ascochyta rabiei*, and (4) to prove the roles of toxin production in causing the disease by generating non-pathogenic mutants via insertional mutagenesis and using complementation tests.

Dr. Sarwar Alam and Ms. Hina Ali inspecting blighted chickpea plants in the test plots at NIAB.

This cooperative research builds on the combined previous expertise of Dr. Alam and Dr. Chen, and the research tasks proposed by the Pakistani and U.S. scientists are truly complementary. The research in Pakistan will focus on host resistance genes, while the research in the United States will address mechanisms of pathogen activity. In summary, these researchers aim to gain a mechanistic understanding of the chickpea-*Ascochyta rabiei* pathosystem. Their results should not only facilitate management practices regarding this important disease in Pakistan and elsewhere, but should also advance basic understanding of host-pathogen interactions and improve the quality and capacity of education and research at NIAB.

Progress has already been made since the project began on the U.S. side in March 2008. The researchers have collected more than 100 isolates of the pathogen *Ascochyta rabiei* in several chickpea growing regions in the United States, and more than 50 of the isolates have been tested for virulence. Most of the isolates exhibited pathotype II phenotype showing severe pathogenicity on both cultivars tested. Dr. Alam and his team also attempted to collected isolates in Pakistan, but the disease was not epidemic in the 2008 growing season so no isolates were collected. Collection efforts continued in the next growing season. Mutant chickpea phenotypes were also produced through radiation so that they could be screened for reactions to pathogen infection, including infections by *Ascochyta rabiei*. In addition, more than 50 genotypes of chickpea germplasm were screened for resistance to *Ascochyta rabiei*, and three (PI 559361, PI 559363 and W6 22589) showed significantly higher levels of resistance to both pathotypes of *Ascochyta rabiei*. Several chickpea genotypes were also found to be highly resistant to pathotype I of the pathogen. Genetic crosses between susceptible and resistant chickpea genotypes were made, and the resulting plants are being cultivated in the greenhouse for further genetic testing.

Dr. Alam made a brief visit to the United States June 28-July 2, 2009, during which he participated in the Second International Ascochyta Workshop at WSU, with all costs of his visit paid for by the Pakistani side. At the workshop, he and Dr. Chen presented a total of four abstracts on work related to the project. Meanwhile, during the spring and summer 2009 growing season the research teams on both sides continued collecting isolates of *Ascochyta rabiei*, evaluating the isolates for pathogenicity and capacity for toxin production, investigating chickpea mutants and progenies of crosses for reaction to Ascochyta blight, and measuring toxin production in insertional mutants. Strains of *Ascochyta rabiei* and *Fusarium oxysporum* f.sp. *ciceris* were isolated from diseased chickpea plants in various regions of Pakistan and shipped under USDA-APHIS permits to WSU for molecular testing and phenotyping. Ms. Hina Ali, a

junior researcher involved in the project at NIAB, arrived at WSU for six months of training beginning December 4, 2009. Her stay in Pullman not only will be useful with regard to the project objectives but also will help her complete work required for her PhD dissertation. In addition to her research at WSU, she also had the opportunity to participate in the International Plant and Animal Genome Conference in San Diego, California, in January 2010. During the coming months, she will continue to be involved in planned activities on the project, including continued characterization of chickpea genotypes for resistance to Aschochyta blight and Fusarium wilt, identification of races of Fusarium isolates obtained from Pakistan, and characterization of isolates of *Ascochyta rabiei* for genetic diversity, pathogenic variation, and toxin production. It is hoped that delayed funds on the Pakistani side will be released so that the work can proceed to the full extent planned.

Upper Indus River-Flow Reconstructions Using Tree Rings: Implications for Agriculture and Hydroelectricity (2008-2010)

Edward R. Cook, Columbia University
Moinuddin Ahmed, Federal Urdu University of Arts, Sciences, and Technology, Karachi
Pakistani Funding (HEC): $140,000
U.S. Funding: $100,000

Pakistan is one of the world's most arid countries, with an average annual rainfall of less than 240 mm. The population and the economy are heavily dependent on an annual influx of water into the Indus river system, primarily from melting snow. Severe declines in the flow of the Indus River pose a great threat to Pakistan, particularly if they are especially severe and long-lasting (so-called "megadroughts"). Elsewhere there is strong archaeological evidence for the destabilizing influence of past droughts on advanced agricultural societies, something that should resonate today given the increasing vulnerability of modern water-based systems (both agricultural and hydroelectrical) to relatively short-term droughts. Understanding how past river-flow changes have developed and persisted is a timely scientific problem. However, a recent World Bank report on the topic clearly states that the science is in its infancy and that there is an inadequate knowledge base. The researchers involved in this project are working to address this point. Monitored river discharge records of the Indus River are simply too short (less than 40 years) to capture the range of past conditions, so surrogate or proxy-climate indicators must be used to provide the long-term record. Tree rings are the only suitable proxy that has been proven to be sensitive to changes in moisture supply, able to provide broad spatial coverage, has clearly-resolved annual resolution, can be exactly dated, and provide long enough records.

Fortunately, the northern area of Pakistan has forests containing a range of species that can provide long annual tree-ring chronologies thanks to the pioneering research undertaken by the Pakistani principal investigator, Dr. Ahmed. In this project, he and his U.S. partners aim to develop a network of tree-ring chronologies from the catchments of the upper Indus River and reconstruct river-flow for at least the last 150 years. Similar work has been successfully done in the United States, and two key people involved in that research (Dr. Cook and collaborating researcher Dr. Connie Woodhouse of the University of Arizona) are included in this project. The reconstructions will provide key information for the management of the river as well as provide a baseline from which to evaluate scenarios of future climatic change.

After receiving his grant funds in April 2008, Dr. Cook immediately made plans to send a consultant on the project, Dr. Jonathan Palmer of New Zealand, to Pakistan. His trip was to include field work in cooperation with the Pakistani partners, but the plans were somewhat complicated because they did not receive confirmation of their grant funding from HEC until after Dr. Palmer had already arrived for his visit (May 30 – June 20, 2008). Fortunately, however, on that visit and a second visit by Dr. Palmer October 27 – November 15, 2008, the researchers were able to collect core samples from conifer species at 14 sites in the Gilgit, Astore, and Skardu areas. In additional to assisting with field sampling, Dr. Palmer also helped his Pakistani colleagues install new equipment and provided intensive training on field sampling techniques, the use of specialized tree-ring measurement equipment, and the use of dedicated software tools for tree-ring analyses.

Two of Dr. Ahmed's students work with local assistants to core a tree during Dr. Palmer's June 2008 visit to the Naltar Valley, near Gilgit.

Dr. Palmer made a third visit to Pakistan for additional field sampling and training from September 29 through October 26, 2009, during which he also presented a three-day training course at GC University, Lahore, on introduction to tree-ring studies and relevant applications. Dr. Ahmed also presented several other workshops or seminars during 2009 to disseminate information about the project to faculty and students at his own university and others. Meanwhile, the research teams also continued work in 2009 to analyze the tree-ring measurements and the measured river-flow data and begin preparing preliminary models of the tree-ring data. During his fall 2009 visit, Dr. Palmer provided additional training on the use of software tools and collection techniques. As of the end of 2009, the partners reported having collected samples from 6 different tree species at 18 sites, with some of the trees sampled being up to 700 years old. They are currently analyzing their findings to determine which species provide the best evidence of climate variations so that they can focus their work on those species in the summer of 2010. Additional sampling field trips are planned in the spring and summer, and a national conference is being organized in April 2010. Dr. Ahmed expects to present a paper at the International Conference on Dendrochronology in Finland in June 2010 and hopes to visit Columbia University in August. Efforts are also under way to obtain riverflow data from WAPDA so that this information may be incorporated into the models being developed.

Bioremediation of Chromium and Arsenic from Industrial Wastewater (2008-2010)

Michael J. McInerney and Lee Krumholz, University of Oklahoma
Shahida Hasnain and Muhammad Faisal, University of the Punjab, Lahore
Pakistani Funding (HEC): $268,000
U.S. Funding: $237,460

Continuous industrial usage of chromium (Cr) and arsenic (As) compounds by different industries has polluted the aquatic and terrestrial environment in Pakistan. Microbial processes offer a potential alternative for detoxification and removal of metals from a variety of industrial effluents via energy-dependent or independent mechanisms. Given the increasing awareness of the potential for detoxification, recovery, and reuse of Cr from spent tanning fluids and other effluents, there is a need to isolate chromium-tolerant bacteria and assess their Cr accumulation and Cr(VI) reduction potentials. In the same way, microbial arsenic transformation can also result in detoxification. The successful implementation of this project should not only contribute to Pakistan's scientific development but also improve understanding of metal transformation and ultimately lead to the development of new bioremediation strategies. The objectives of the project are as follows:

- To isolate and characterize chromium-reducing and arsenic oxidizing bacteria from contaminated Pakistani soils by a combination of culture-dependent and culture-independent methods
- To evaluate the chromium and arsenic detoxification potential of these strains (reduction of Cr(VI) to Cr(III), As(V) and oxidation of As(III) to As(V))
- To test whether the variation in geophysical parameters in soils and subsoils explains the spatial variation of microbial populations and whether this results in microsites with distinct microbial communities
- To train new Pakistani scientists in anaerobic microbiology, molecular ecology, and environmental genomics

During the first year of the project, which began on the U.S. side in April 2008, the Pakistani researchers collected contaminated and uncontaminated soil samples near tanneries from three sites in Din Garh (Kasur) and East Pakistan. They isolated eight bacteria resistant to Cr(VI) and eight bacteria resistant to Ar(III). Extensive phenotypic characterization of all 16 stains has been completed, and the U.S. partners are assisting their colleagues with genetic characterization of these strains. In 2009, 45 more strains highly resistant to arsenic were collected from additional sites in Shaikhupura and Silakot, and they have been characcterized for growth and metabolic properties. The Pakistani research team is also working to characterize the strains for their ability to reduce Cr(VI) and oxidize As(III), and the U.S. side has been providing training in the analytical methods needed to quantify the metals in various oxidation states. In order to test Pakistani soil samples in the United States, the U.S. researchers first had to secure the necessary import permits as well as space in a lab facility approved for work with foreign soils. With these hurdles overcome, they received the first batch of soil samples in November 2008 and began extracting and sequencing DNA from bacteria in the soil. Unfortunately, however, they found that the samples had deteriorated during shipment, so they decided instead to train the Pakistanis on how to extract DNA in their own lab in Lahore, as the DNA samples could easily be shipped without damage.

Although the Oklahoma researchers have been unable to provide training in Lahore in person due to the security situation, they produced a series of five video-based modules, which were provided to the Pakistani counterparts via YouTube in June 2009 to train them in various aspects of anaerobic microbiology lab procedures, including (1) construction of a gassing station, (2) media preparation, (3) transfer of cultures, (4) exchange and pressurization of the gas phase, and (5) preparation of microcosms. A two-part sixth video on extracting DNA from soils was

made available in February 2010. They have also provided the Pakistani researchers with written protocols and suggestions for DNA extraction from soils, and additional training on these procedures was provided to Dr. Shahida Hasnain when she visited OU in December 2009. Regular videoconferences are being held to facilitate training and ongoing research collaboration.

Now that Dr. Hasnain's lab has received several key pieces of new equipment in January 2010, they will be able to begin anaerobic microbiology work and apply the training provided by their OU colleagues. Pending receipt of the necessary visa, a graduate student from University of the Punjab will come to OU in 2010 for training in anaerobic microbiology and environmental genomics, and Dr. McInerney and his colleagues will continue training other Pakistani students in data analysis via distance learning. Dr. Hasnain and her students will also be intensively sampling another contaminated area and extracting DNA from the samples for subsequent analysis at OU.

Telephone-Based Speech Interfaces for Access to Information by Nonliterate Users (2008-2009 – Extended through October 1, 2010)

Roni Rosenfeld, Carnegie Mellon University (CMU)
Sarmad Hussain, National University of Computer and Emerging Sciences
Pakistani Funding (HEC): $ 60,000
U.S. Funding: $125,000

Information access is an essential, yet often-overlooked tool for socioeconomic development. While literate and affluent members of society have many ways to obtain information, there are alarmingly few options for the relatively impoverished nonliterate majority. Print media are unusable due to literacy issues, television and radio are mostly noninteractive, and face-to-face training is expensive. Although computers can provide an interactive learning experience, they are not viable for a variety of reasons. Cell phones provide a mechanism for human-computer communication for automated, self-service information access, as well as a host of other automated services. However, limited expertise in speech technology, the dearth of computer-based local language resources, and the lack of targeted research towards speech interfaces for nonliterate users have meant that such interfaces have not been developed, much less evaluated. Dr. Rosenfeld and Dr. Hussain have devised their project to take the first steps in this direction in Pakistan. In this project, they aim to design, develop, and evaluate an actual information access system for health information in Pakistan. Through this research project, they will investigate the use of speech interfaces in a field-deployed system and will also develop a speech recognition engine that could be easily adapted to other domains. The project should have the additional benefit of building the R&D capacity of Pakistani universities in the field of speech technology and enabling wider dissemination of this capacity through the development of coursework, which would pave the way for the creation of similar capacities in multiple Pakistani languages.

The project specifically is specifically focused on applying speech recognition technology to create a dialogue system for health information access. In the summer of 2008 they began by conducting a usability study testing a baseline prototype system for health information access in Dadu, Sindh. This was done in collaboration with Health and Nutrition Development Society (HANDS), a local nongovernmental organization that is headquartered in Karachi and has regional offices in various parts of Sindh. The aim of the study was to test the use of a

baseline spoken information access system by low literate community health workers, and to compare its use with traditional methods such as text-based brochures. They used Sindhi-language health brochures that HANDS had already created, and recorded a native Sindhi speaker reading the content aloud. They then designed a simple telephone-based system that would play back the "audiobook" on demand. Initial testing showed that while users preferred receiving information in spoken over written form, they could not easily absorb long passages of spoken material and needed the system to be more interactive. After modifications were made, further testing was using 23 community health workers in Umarkot as volunteer users. The initial testing has already highlighted interesting differences in how literate and nonliterate users process spoken information, and a paper on these findings has been submitted for publication.

The Pakistani side reportedly received its grant funds later in 2008, which slowed their research efforts. On the U.S. side, Dr. Rosenfeld faced a complication because the first graduate student assisting him on the project, who was of Pakistani origin, was preparing to complete his degree and leave the university. Another graduate student not of Pakistani origin was recruited, and the two students made a very successful visit to Pakistan on the project in August 2008, during which they participated in the testing described above. However, in the wake of the Marriott bombing in September, the second student's family no longer allowed him to travel to Pakistan. A third student was subsequently recruited but dropped out after the Mumbai attacks, so Dr. Rosenfeld was left to seek another student assistant. Another problem arose when the Pakistani partner, Dr. Hussain, was unable to obtain a U.S. visa in time to make a planned visit to Carnegie Mellon in December 2008. Instead, the research teams have consulted by conference calls to make up for the lack of in-person visits. In addition to completing work on the health information access system, ongoing consultations will focus on strengthening Pakistani capabilities in speech technology research and development and providing advice on the collection and curation of Urdu speech and language resources. In this regard, the Pakistani partners on the project held a week-long training session in early June 2009 for HANDS Staff involved in designing the health information access system. Two linguists and a technical staff member of the Pakistani team also attended a phonetics and phonology course at NUCES to build their capabilities to transcribe and tag the speech data being acquired.

Because of the continuing security problems, all collaboration in 2009 was carried out through conference calls and e-mail as both sides worked on various aspects of the projects including construction of an Urdu digit recognizer, design of a speech database, collection of additional data in recording sessions with a total of 60 Urdu speakers in Lahore, submission of data to the speech recognition engine, and testing of the engine's performance with both read and spontaneous speech. Dr. Rosenfeld and a Pakistani PhD candidate involved in the project, Jahanzeb Sherwani, had a joint paper accepted for the IEEE/ACM International Conference on Information and Communication Technologies and Development in Doha in April 2009, and they and two other colleagues had another joint paper appear in the December 2009 issue of *Information Technologies and International Development*. Plans are also under way to bring a Pakistani researcher on the project to CMU in 2010 for several months of intensive training. Research activities for the year will include completing recordings of additional Urdu speakers, transcribing the data collected, releasing the speech database, and preparing and testing data on the speech recognition engine. Work on cross-language pronunciation adaptation will also be completed and submitted for publication.

Capacity Building and Collaborative Research for Assessing Impact of Climate Change on Glaciers of the Karakoram Himalaya
(Karakoram-Ice Project) (2008-2010)

John F. Shroder, Jr., University of Nebraska at Omaha (UNO)
Ghazanfar Ali, Global Change Impact Studies Centre (GCISC), Islamabad
Pakistani Funding (MoST): $90,000
U.S. Funding: $230,000

While mountain glaciers worldwide are reported to be generally receding, impacts of climate change on global and regional ice-mass fluctuations are poorly understood because of complex feedback mechanisms and the shortage of good field or laboratory assessments. The Himalaya has been identified as a critical region for such study. Its glaciers are thought to be particularly sensitive to climate forcing due to high altitudes. The Karakoram Himalaya contain some of the longest and largest valley glaciers of the world outside high latitudes, and through their glacier melt, provide more than 60 percent of the Indus River flow. The study of these glaciers is thus crucial for ensuring water security in Pakistan. The current project is designed to bring about close collaboration between scientists from GCISC and UNO in order to (1) increase knowledge about the changes in volume of the overall cryospheric ice mass in the Western Himalaya because of ongoing climate change, and its attendant effects on the overall availability of downstream meltwater; (2) elucidate the potential problems associated with climate-change-caused breakout floods and landslide hazards associated with glacial valley-wall debuttressing or diminution of permafrost valley-wall binding strengths; and (3) build educational and research capacities and capabilities in the Pakistani government through education in both the United States and Pakistan.

This project was launched on the U.S. side in June 2008, after the US partner submitted a revised workplan and budget because he had received less than he had originally requested and unexpected delays in the procurement process also arose. However, Dr. Shroder had been in e-mail contact with Dr. Ali and other Pakistani colleagues on an informal basis since 2007 and had already provided them with some imaging data that they used to begin collecting glacier depth data. The counterparts exchanged information and realized that the existing imaging data contained some discrepancies, depending on the type of software used. This presented an argument for standardization of methodologies, which the project should help to resolve as the researchers strive for greater scientific validity of their glacier-change estimates.

Thanks to funding from the National Science Foundation and the Lounsberry Foundation, Dr. Shroder also had the chance to meet with Dr. Ali and other Pakistani colleagues from GCISC, the Pakistan Agricultural Research Council, the Water and Power Development Authority, and COMSATS University at a conference held at the Integrated Centre for Mountain Development in Kathmandu, Nepal, on March 31 to 3 April, 2008. Drs. Shroder and Ali discussed plans for their joint project and especially for proposed exchange visits, which they had hoped to begin already in the fall of 2008. However, their plans to send up to four Pakistanis to UNO for training could not be realized because MoST failed to provide the promised grant funds to GCISC (the funds have still not arrived as of April 2010). Meanwhile, Dr. Shroder began recruiting a postdoctoral associate to work on the project. He had also hoped to bring over a Pakistani PhD student, but because it would take him at least four years to complete his degree, it became clear that the duration of this grant and the funding it includes would not make such a long program feasible. Therefore, that student is applying directly to HEC for separate funding.

Dr. Shroder also planned a one-month field visit to the Shimshal Valley, Hunza, in the summer of 2009. This visit was to involve six other U.S. colleagues and as many Pakistani counterparts as possible, depending on their own funding situation. However, in the wake of the deteriorating security conditions that spring and ongoing financial and communications problems on the Pakistani side, the trip had to be postponed until the summer of 2010, with the field site possibly being shifted to another location in the Karakoram Himalaya just over the border in China.

By the end of 2009, communications between UNO and GCISC had unfortunately stalled, and another key Pakistani researcher whom Dr. Shroder had involved in the project to fill the gap left by GCISC left her government research position and emigrated with her family to Australia. Although contacts with GCISC have recently been revived in March 2010, the Pakistani PI reports that although he and his colleagues are eager to move forward and would be interested in participating in the summer 2010 expedition, he is unable to do any work on the project until he receives his funding from MoST. The U.S. PI had already spent substantial funds on carrying out the necessary background research in preparation for active collaboration that he had anticipated would begin, so at this point he has had to lay off staff as he awaits the arrival of funding on the Pakistani side.

Discovery of Genetic Variation that Enhances Improvement of Dairy Production and Health in Cattle and Buffalos (2008-2010)

Tad S. Sonstegard and Curt Van Tassel, USDA Agricultural Research Service
Masroor Ellahi Babar, University of Veterinary and Animal Sciences (UVAS), Lahore
Pakistani Funding (HEC): $351,000
U.S. Funding: $183,700

The hypothesis underlying this project is that genome-wide information on genetic variation will increase accuracy of predictions of genetic merit; will enhance heritability and reliability of these predictions through improved pedigree information; and will improve detection of most quantitative trait loci underlying a trait when analyzed using linkage disequilibrium mapping. Therefore, the central aim of this project is to develop genomic tools to aid characterization of the structure and function of both the bovine and water buffalo genomes, and then apply these tools using novel statistical methodology to accelerate genetic improvement for traits of economic importance in both species. These goals will be accomplished through completion of the following objectives, by which these researchers expect to deliver genomic tools and knowledge that will accelerate production while maintaining desirable traits for heat and disease tolerance, thus enhancing the way the Pakistani dairy industry practices selection for genetic improvement:

- Generation of a map of shared genetic variation between U.S. and Pakistani dairy breeds and water buffalo based on 50,000 SNP marker genotypes
- Partial genome sequencing of Sahiwal and Dhanni cattle and whole genome sequencing of Nili-Ravi buffalos to generate additional SNP resources for genotyping
- Development of SNP assays and statistical analyses for whole genome association and whole genome selection studies of Pakistani animals

Technicians at UVAS draw a blood sample from a buffalo.

This project began on the U.S. side in April 2008, and by the end of the year the participants had already collected blood samples from various species of cattle and water buffalos and a first set of DNA samples had been shipped to Dr. Sonstegard's lab at USDA, and further shipments followed in 2009. Genotyping work is being carried out at USDA and the results are being provided to Dr. Babar at UVAS as well as to another U.S. collaborator on the project, Dr. Jerry Taylor at the University of Missouri. Further linkages have been established with researchers at the University of Maryland, the University of Iowa, and the Università della Tuscia in Italy to broaden the array of genomic data that will be included in the project. Dr. Sonstegard had planned to host Dr. Babar for a research visit at USDA in the summer of 2009 (being entirely funded by the Pakistani side of the grant). However, the necessary security clearances and issuance of visa documentation took much longer than expected and Dr. Babar had other schedule commitments in the meantime, but ultimately he arrived on December 15, 2009, for a two-month stay at the USDA lab.

By February 2010 this research team had completed a map showing shared genetic variation between U.S. and Pakistani dairy breeds. Some of the materials used for genotyping and sequencing in the process of creating the map belong to a new DNA repository at UVAS. This collection currently includes samples from more than 200 cattle and nearly 400 water buffalos and will be expanded in the future. The three researchers were among the co-authors on a paper entitled "Resolving the evolution of extant and extinct ruminants with high-throughput phylogenomics," which was published in *Proceedings of the National Academy of Sciences* in November 2009. Beyond its research aspects, this project has also facilitated the renovation of undergraduate and graduate student labs, the creation of a new genomics lab, and the upgrading of a bioinformatics lab at UVAS. This improved lab infrastructure has helped students in a new 4-year degree program in biotechnology and informatics created at UVAS in 2008.

In 2010 these researchers plan to complete sequencing of another Pakistani cattle breed (Cholistani) and will contribute to the ongoing International Water Buffalo genome project being led by Dr. John Williams of Parco Tecnologico Padano, Italy. Additional Pakistani students from UVAS may also be sent to USDA for training. Dr. Babar is also working to strengthen linkages

with the Livestock and Dairy Development Department of the Government of Punjab in order to bring the benefits of his research results to Pakistani dairy producers.

Development of DNA Database for Convicted Offenders in Pakistan (2008-2010)
Mohammad A. Tahir, Cuyahoga County Coroner's Office
Shaheen N. Khan, Centre for Applied Molecular Biology, Lahore
Pakistani Funding (MoST): $60,000
U.S. Funding: $90,000

By combining the resources of the two organizations involved—the Centre for Applied Molecular Biology (CAMB) and Cuyahoga County Coroner's Office—this project will provide Pakistani scientists with the most advanced forensic science technologies, allowing the country to take greater steps towards self-sufficiency in the fight against domestic and international criminal activity occurring on Pakistani soil. This project will not only bring the latest scientific knowledge to Pakistan, but it will also enable Pakistani scientists to impart this knowledge within the law enforcement and legal communities, so that the science can be used effectively from start to finish within the justice system. This system-wide approach in preventing and solving crimes has been successful in many parts of the world, so it should bring greater safety to Pakistani citizens and justice to those who would seek to use Pakistan to foment terrorist activity.

CAMB is the first dedicated laboratory engaged in forensic DNA testing services in Pakistan and collaborated with Dr. Tahir on a project funded in Phase 1 of the Pakistan-U.S. Science and Technology Cooperation Program. The current project builds on the previous one to focus specifically on a national DNA database, which is currently lacking in Pakistan. Therefore, the main goals of this project are to lay the groundwork for development of a DNA database for convicted offenders; train a group of scientists specifically for the development and usage of a DNA database; and promote the use of DNA technology by holding specifically designed symposia and seminars for the relevant stakeholders and training courses for criminal investigations officers in identification, collection, and preservation of biological evidence from the crime scene.

Plans had originally called for a group of four Pakistani trainees to come to Dr. Tahir's lab in 2008, but when they were unable to obtain visas in time, he decided to conduct the training in Pakistan instead. He participated in a training workshop at CAMB March 23 through April 12, 2008. The workshop trained 60 police and forensic technicians in evidence collection and preservation. He reports that as a result of the workshops conducted in the Phase 1 project as well as this one, the success rate in forensic cases has risen, and CAMB is now receiving 40 to 50 cases per month for processing, up from the previous level of about 15 per month. During this visit, Dr. Tahir also spent time conducting practical competency exams for six Pakistani forensic scientists. On a return visit August 29 through September 14, 2008, he worked with his CAMB counterparts to review their operating procedures in detail and make recommendations to facilitate the lab's upcoming application for ISO 17025 accreditation. During his visits, he also provided CAMB with a total of $13,000 worth of reagents and supplies purchased from his grant. [Note: Dr. Tahir has not yet submitted his 2009 progress report, but he and a U.S. colleague traveled to Lahore in late March 2010 to present a workshop and continue working with Pakistani colleagues on proficiency testing, quality assurance, and development of procedures for institution of a national DNA database.]

Development of a Materials Connection Center (2008-2010)
Rick Ubic, Boise State University
Yaseen Iqbal, University of Peshawar
Pakistani Funding (HEC): $188,000
U.S. Funding: $254,000

The need to use mineral and energy resources most efficiently leads to the development of new technologies that make manufacturing processes user-friendly and economical both financially as well as environmentally. Engineering and applications of materials range from the design and development of biocompatible soft bones (biotechnology) for organ implants on one extreme to state-of-the-art components and devices used in modern communication systems (optoelectronics, fiber optics) and structural materials for the construction industry on the other. Given the great diversity of materials, nearly every sector of life can be developed via intelligent planning and optimal utilization of mineral resources. Planning for the best use of such resources requires awareness of the available mineral resources in a particular region or country; identification of technical resources needed to purify or process minerals in accordance with consumers' needs; and a systematic search for feasible ways of converting available resources into affordable products for local and global markets. Achieving these goals requires a dedicated team of experts comprising academics, mineralogists, industrial experts, mine owners, and investors to share knowledge and expertise in order to address the issues hindering technological development. Proper planning to optimize the use of mineral resources can help promote sustainable development in the region both economically and socially by helping to employ and educate the people.

Dr. Iqbal collecting mineral samples in the Hazara region.

Therefore, this project is aimed at developing an infrastructure for (1) preparation of an up-to-date database of available mineral resources, with special emphasis on those that either have a large export potential and/or the most domestic relevance; (2) their systematic characterization using differential thermal analysis, X-ray diffraction, scanning electron microscopy, and transmission electron microscopy in labs both at the University of Peshawar (UOP) and Boise State University (BSU); (3) identification of the specific technical resources and processes required for their refinement and processing; and (4) design of individual research projects in the field of materials engineering to identify possible applications. This project is facilitating the establishment of a Materials Connection Center at UOP to serve as a platform for materials engineers, industrialists, investors, academics, and mineralogists to share their knowledge and expertise in seeking better ways of utilizing the mineral, human, and technical resources of the

region. Once critical mass has been achieved, the Center should become a self-sustaining entity that will liaise with industry on emerging materials engineering needs.

By the end of 2008, the Materials Connection Center had already been inaugurated at UOP, equipment tenders had been placed, and four research assistants had been hired, all of them being master's degree students on track to eventually obtain PhDs. They are currently gathering all available information on the mineralogy of the four zones of Pakistan's Northwest Frontier Province (NWFP) in order to develop the resource database mentioned above. In the spring of 2009 they and Dr. Iqbal began collecting samples in the field for analysis at both UOP and BSU. Drs. Ubic and Iqbal have also worked with the research assistants to design individual PhD projects for each of them that will promote their academic growth and training as well as help identify promising mineral resources for development.

Dr. Iqbal made a one-month visit to BSU beginning June 8, 2009, with all costs paid for by the Pakistani side of the grant. He and Dr. Ubic worked to analyze a collection of mineral samples that the former had brought from Pakistan and collaborated to plan the curriculum for a joint course to be offered in the fall 2009 semester. The original plans for this project had called for Dr. Ubic to deliver training workshops in person, but the security situation in Pakistan and particularly in Peshawar led him and Dr. Iqbal to explore possibilities for offering the training via distance learning. After all the technical and administrative issues were resolved, the semester-long course, entitled MSE 305 Bonding, Crystallography, and Crystal Defects, began on August 25, 2009, with the course meeting twice weekly until mid-December. Two-way videoconferencing allowed interaction between the students and Dr. Iqbal at University of Peshawar and Dr. Ubic back in Boise. Eighteen students took the course, which introduced them to the language, nomenclature, and tools of crystallography and demonstrated how structure determines properties in a variety of materials systems.

Synthesis and Characterization of Smart Polymer Microgels for Biomedical Applications (2008-2010)

Shuiqin Zhou, The City University of New York, College of Staten Island
Mohammad Siddiq, Quaid-i-Azam University, Islamabad
Pakistani Funding (HEC): $100,000
U.S. Funding: $178,645

Smart polymers undergo reversible and strong changes in conformation and properties upon a small change in environmental conditions, for example, temperature, pH, ionic strength, light, or glucose concentration. Due to this stimuli-responsive behavior, smart polymers offer great advantages in biomedical applications, such as for bioseparation, drug delivery, biosensors, and surfaces with switchable hydrophobic-hydrophilic properties. The proposed project aims to synthesize and characterize a series of novel multiple responsive polymer microgel particles for biomedical applications. Laser light scattering and electron microscope techniques will be employed to study the morphologies and volume phase transitions of the novel smart microgels under different external stimuli. With controllable permeability and rapid responses to pH, temperature, and glucose concentration change, the novel smart polymer microgels designed in this project can be developed as drug carriers for sustained release of protein and anticancer drug molecules.

Another major goal of this project is to establish a polymer materials research lab equipped with a laser light scattering instrument at Quaid-i-Azam University. Laser light

scattering is a non-invasive and absolute technique for characterizing macromolecules and a wide range of polymer and nanostructured particles in solution. In developed countries, it has been widely utilized for characterization of all kinds of biopolymers (for example, DNA, protein, polysaccharides, etc.), synthetic polymers, and nanostructured colloidal particles for both industrial applications and academic research. However, until now no laser light scattering lab for polymer materials research had been established in Pakistan. This project is adapting the synthetic and characterization approaches established in the U.S. partner's laboratory for studying polymer and colloidal materials.

After the project began, Dr. Zhou and Dr. Siddiq worked to identify an appropriate Pakistani graduate student to come to CUNY CSI for extended training. They selected Mr. Zahoor Hussain Farooqi, and he arrived in New York on January 31, 2009, for a 13.5-month visit. To begin his program he attended English classes full-time four days per week to help develop his language skills and provide him with a good orientation both to the university and to the city itself. On the days he was not in English class he began his hands-on training in Dr. Zhou's lab. After completing the 14-week language class, he began learning to synthesize and characterize smart polymeric microgel particles under the mentorship of Dr. Zhou and her research associate Dr. Weitai Wu, and he also gained expertise in utilizing laser light scattering instruments, photospectrometers, and electronic microscopes. Now that he has mastered these challenges, Mr. Farooqi is now able to synthesize routine pH-, temperature-, and glucose-sensitive polymer microgels independently, so he should be able to put his skills to use and pass them on to other students now that he has completed his visit and returned to QAU in early March 2010.

Mr. Zahoor Hussain Farooqi using the dynamic light scattering instrument in Dr. Zhou's lab at CUNY CSI.

Meanwhile, after receiving his grant funds Dr. Siddiq worked to purchase the laser light scattering equipment for his lab. While awaiting its delivery and installation, he made a 2-month visit to CUNY CSI beginning June 17, 2009, to receive training from Dr. Zhou on operation of the equipment, participate in joint research activities, and monitor his student Mr. Farooqi's progress. Soon after Dr. Siddiq arrived home in August, his new equipment was installed and calibrated by a technician sent to Islamabad by the manufacturer. With the experience and skills he gained during his visit to New York, he and two M.Phil. students in his lab are now using the new equipment to characterize microgels, and in 2010 he will establish a microgel synthesis lab

at QAU. Meanwhile, Dr. Zhou and Dr. Wu will continue their work to study permeability of smart microgel particles in response to external stimuli and loading and releasing behavior of novel microgels for model protein drugs. Dr. Zhou presented her work at the SPIE Photonics West Conference in San Francisco January 23-25, 2010, and published two joint papers in 2009 with another accepted for publication in 2010.

Problems Encountered

The most serious problem in 2009 was the continued inability of MoST to meet its grant commitments on existing projects. MoST's own figures, which were provided at the October 2009 Dubai meeting, indicated that the Ministry still owed more than $1 million in outstanding obligations for grants in Phases 1, 2, and 3:

	Committed	Paid	Still Owed
Phase 1	$ 308,530	$ 149,166	$ 159,364
Phase 2	$ 500,000	$ 110,799	$ 389,201
Phase 3	$ 500,000	$ 0	$ 500,000
TOTALS	$1,308,530	$ 259,965	$1,048,565

This debt on the part of MoST has had a serious impact on projects that had been promised support from the Ministry. In some cases, Pakistani PIs are able to continue working at a minimal level on the projects using their existing funds, but they have been unable to recruit the necessary graduate students, postdoctoral researchers, or staff. Purchasing vital equipment and arranging travel for training or research consultations remain impossible. The situation is also frustrating for the U.S. partners, who had made plans in expectation of moving forward on planned activities. Although the MoST Secretary and the S&T Member of the Planning Commission promised in October that funds had been allocated to bring the payments current, as of April 2010 this had not yet happened.

On the issue of visas, the USAID-sponsored J-1 process appears to work well for those visitors who go through it. Although the process is time-consuming and labor-intensive, we have had no visa denials for any applicants as yet because the vetting process is so thorough, which provides consular officers with assurances of the legitimacy of the visitors' motives for travel. However, in 2009 only three applicants under the program received visas through this process (two more were in process during 2009 and were issued in early 2010). Several others originally intended to apply, but when they learned of the long lead time and complex procedures involved, they decided against visiting. The greater share of visitors under the program are Pakistanis whose expenses are being paid entirely by the Pakistani side of the project, with no USAID funds being involved. They apply through the consulate by standard procedures on the basis of invitations issued by their U.S. host institutions. Although this process takes a bit less time, it has also led to some applicants being rejected for visas due to inadequate documentation. There is no simple solution, as the visa regulations are beyond anyone's control. In order to minimize the impact, program staff explain the USAID visa process carefully to hosts and visitors and provide help throughout the process.

Finally, security issues became an even more serious problem in 2009. Various incidents in major Pakistani cities from late 2008 through 2009 led many U.S. program participants to postpone their planned travel indefinitely. Some are continuing to travel, but even some

Pakistani-American participants have been reluctant to visit Pakistan until the situation stabilizes. Principal investigators on both sides are working together to revise work plans so as to carry out more training via videoconferencing or more frequent phone and e-mail contact, because bringing more Pakistani trainees to the United States instead is also problematic due to visa requirements.

Financial Reporting

Quarterly accruals data have been provided by the NAS program office to the Islamabad mission. Other required financial reports are submitted directly by the NAS Office of Contracts and Grants.