

EREF NEWS



Developing environmental solutions for the future

VOLUME 14

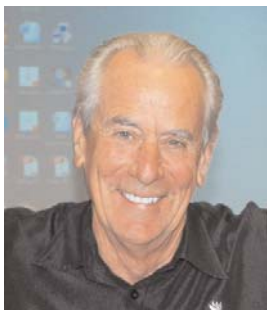
2010 EDITION

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From the President **MICHAEL J. CAGNEY**

Dear friends,

On the occasion of my retirement from EREF, I recall a line from the play Annie when one of the actors said, "How lucky I am to have something that makes saying goodbye so hard."

I want all of you to know that I consider the last fifteen years as president of EREF to encompass the finest moments of my career; not just because I value the work I have done, but mostly because of whom I did it with. Thanks for the memories to all

of my friends in the waste industry! Some of you have become close friends and I will relish the future times we will spend together; many others I look forward to serendipitous encounters wherever that may be.

For all of you who wonder what I might do in my retirement, I will take Mark Twain's advice: "Twenty years from now I will be more disappointed by the things I didn't do than by the ones I did do. So I will throw off the bowlines. Sail away from the safe harbor. Catch the trade winds in my sails. Explore. Dream. Discover."

Kindest regards,
Michael J. Cagney
EREF President (ret.)

16TH ANNUAL EQUIPMENT AUCTION RAISES OVER \$950,000!

The solid waste industry is even smarter! Thanks to generous donors and bidders, more than \$950,000 was raised at the 2010 EREF Equipment Auction at WasteExpo in Atlanta – enabling EREF to continue to develop environmental solutions for the industry and greater society. Participants enjoyed food, drinks and fellowship during the auction reception sponsored by Perkins Manufacturing. Auctioneer Gary Seybold of Ritchie Brothers Auctioneers took the stage and kept the audience members on their feet as he "going once, going twice, SOLD-it-to-you" 32 lots of trucks, compactors, balers, trips and specialty event tickets to benefit EREF. The frenzy paused only to allow EREF Board member Ron McCracken to take the microphone and ask the audience to open their wallets for the EREF Scholarship program. Generous donors raised their paddles and the scholarship fund is \$6000 richer.

The EREF Equipment Auction is held annually at WasteExpo and represents the foundation's largest fundraising event of the year. For 16 years competitors have come together



continued on page 2

Carolyn Hodges Stewart



Environmental Research And Education Foundation
Developing environmental solutions for the future

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er in a spirit of generosity to benefit the only foundation in the U.S. specifically devoted to furthering solid waste management practices through science. Major companies, independent operations and individuals alike depart with new equipment and specialty items. Donated items include everything from leather jack-

ets to front loader refuse trucks to golf outings with major waste company CEOs. Items are donated by WASTEC and NSWMA members. Donations are now being accepted for the 2011 Auction at WasteExpo in Dallas. Please contact EREF's Director of Development Kristy Pickkurel at kpickkurel@erefdn.org or 919.861.6876 ext. 103 to get involved.

A Special Thank You to the Auction Donors

Ameri-Kan
Autocar, LLC
Big Truck Rental
Richard Burke, Veolia Environmental Services, NA
Currotto Can, Inc.
Debbie Busby, Penton Media
Donovan Enterprises
Environmental Solutions Group
Bayne Thinline
Heil Environmental
Marathon Equipment
Global Sensor Systems

Intec Video Systems, Inc.
Labrie Environmental Group
Mack Trucks, Inc.
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Mickey Flood, IESI
James O'Connor, Republic Services, Inc.
Orion Safety Apparel
OTTO Environmental Systems North America, Inc.
Perkins Manufacturing
PTR Baler and Compactor Company
Rehrig Pacific Company
Scott & Ven Poole
David Steiner, Waste Management, Inc.
Stellar Industries, Inc.
tarpARMOR

Kevin Walbridge, Republic Services, Inc.
Wastequip Companies
Galbreath
Pioneer
Toter

And the Auction Sponsors

E-Z Pack Trucks (booklet)
Perkins Manufacturing (Reception)
Ritchie Bros. Auctioneers (professional auction services)
Penton Media (booth space)
RDK Truck Sales (booklet design)



Ed Furnari



Auctioneer Gary Seybold

Congratulations to the Raffle Winner!

Congratulations to Bill Lamothe, winner of the 2010 raffle. Bill's ticket was drawn from the approximately 260 sold during the course of WasteExpo. He was both thrilled and surprised at his name being called, and is now the proud owner of a 1971 Chevrolet Nova.



Raffle winner
Bill Lamothe



Kevin Walbridge, Bob MacArthur, Rita Ugianskis



Leone Young, Ron McCracken, James Cowhey



Valerie Burrelle, Miranda Schield, Denisse Ike, George Farr

EREF Staff Provides Stewardship Reports to Key Stakeholders

In an effort to improve awareness and expand the educational mission of the EREF, staff members visited the Environmental Solutions Group in Chattanooga, TN and Republic Services, Inc. in Phoenix, AZ to provide stewardship reports to their executive teams. Staff provided an overview of environmental trends affecting the solid waste industry,

information on EREF's history and mission, an introduction to EREF's research program and a peek into where EREF is headed in the future. As part of their stewardship report, Bryan Staley, the EREF's incoming President, also met with Republic's incoming CEO, Don Slager, and Executive Vice President of Operations Kevin Walbridge, to thank them for their historical commitment to the foundation and to update them on future initiatives planned within the next few years to support solid waste research and education.

SOLD OUT EREF FALL CLASSIC GOLF TOURNAMENT RAISES OVER \$250,000!

Republic Services, Inc. and Veolia Environmental Services hosted a fantastic event in October, raising more than \$250,000 for the EREF. The EREF Fall Classic Golf Tournament was held at the J.W. Marriott Desert Ridge Resort and Spa in Phoenix, Arizona. The tournament sold out with 36 foursomes. Players and sponsors mingled at an evening reception prior to the tournament. After a rainy night in the desert(!), golfers were greeted by a beautiful rainbow that introduced a weather-perfect day. Many thanks to all participants and sponsors for contributing to the success of this event, and for helping to further EREF's goal of improving solid waste management practices through the application of science.



It's a beautiful day for golf!



First Place Team: Louis Moorehead, George Moorehead, Don Moorehead, David Bennett



Kevin Walbridge of Republic Services, Inc. with Closest to the Pin Winner Jeff Jenkins



Second Place Team: Kevin Thompson, Junior Thompson, John LaManna, Kevin Walbridge



Lonnie Poole, Rita Ugianskis, Jim O'Connor



Kevin Walbridge with Longest Drive Winner John McShane



Kevin Walbridge with Putting Contest Winner Ray Burke

From the Chairman PAUL R. MITCHENER



The year 2010 has been one of great transition and exciting events.

Retirement of Lonnie Poole

After 18 years, in December 2009 Lonnie C. Poole, Jr. tendered his resignation from the Board of the EREF. On June 3, 2010 the foundation and friends had the chance to honor his leadership and service at a retirement golf tournament and banquet held at

The Lonnie Poole Golf Course and the State Club, both part of North Carolina State University's Centennial Campus. The event was jointly and generously sponsored by PTR Baler and Compactor Company, Otto Environmental Systems North America, Inc., Joyce Engineering, Inc., E-Z Pack Manufacturing, LLC, Penton Media Exhibitions, Evergreen Environmental Energy, Inc., Republic Services, Inc. and Environmental Solutions Group.



Paul Mitchener thanks Lonnie for his service to EREF

Lonnie joined the EREF Board of Directors as Chairman when the organization was founded in 1992. He has been instrumental in identifying the best candidates for board membership, solidifying EREF's position for the future. In the words of my good friend Michael Cagney, "Lonnie is proof that one man can make a difference. We are grateful for his steady hand on the tiller – anchors aweigh Lonnie!" In a fitting conclusion to his tenure on the Board, Lonnie's oldest son Ven Poole, the current Chief Executive Officer of Waste Industries, Inc., has recently joined the EREF Board. In recognition of Lonnie's contributions to EREF, he and Waste Industries have established and endowed an EREF scholarship for post-graduate education to be entitled "The Lonnie C. Poole, Jr. Scholarship."

Board Meeting—Dinner with Waste Management

In September the EREF Board of Directors convened in Houston, Texas for its second meeting of the year. First order of business was a Strategic Planning Meeting, during which the Board members discussed the direction of the foundation for the next 3–5 years and came up with some ideas to improve awareness of the EREF as well as to provide additional resources and education for the industry. Board members were then treated to dinner and presentations from David Steiner, Chief Executive Officer of Waste Management and Carl Rush, Vice President of Organic Growth for Waste Management.



David Steiner speaks to the EREF Board of Directors

Retirement of Michael Cagney

As most of you know, EREF President and Chief Executive Officer Michael Cagney is retiring at the end of 2010. Michael has been with the foundation for more than 14 years and through his unwavering enthusiasm and his fundraising talent, he has made the EREF what it is today.

In particular, Michael established the EREF Equipment Auction and Golf Tournament as "must-attend" industry events. Under his leadership, the EREF Board of Directors also created five scholarship funds, and in doing so helped pay the way for more than 30 scholars to reach their goals and contribute to the future of our industry at the same time.

One of those past scholars is Bryan Staley, Ph.D., P.E., whom Michael brought to the EREF as Vice President of Environmental Research in 2008. Since that date, Bryan has streamlined the process of approving research funding for the foundation, which has helped increase the amount of research we are doing today. It is a fitting tribute to Michael that Bryan will be taking over as EREF's President and Chief Executive Officer upon his retirement at the end of this year.



Bryan Staley and Michael Cagney

Michael plans to spend more time in the future with his two young grandsons Carter and Gavin (and of course his dog Molly), play more golf and enjoy spending time with friends on his boat "Talkin' Trash."

Michael – you are a true friend to this industry that you so enjoy. We thank you for your invaluable service and, having stood alongside you on the Board for nearly a decade, I know that I, the rest of the Board, the EREF staff and the industry will miss you a great deal.

Farewell From Your Chairman

As I write this letter, the EREF staff and Board members are preparing for the December meeting in London on 9th December. 2011 promises to be an exciting year for the foundation. This will be my last Board meeting as Chairman of the EREF and I am excited and honored to welcome the Board members and staff to the "old" country for this occasion.

The incoming Chairman of the EREF Board of Directors is Henry Saint-Bris of Suez Environnement. Henry has been with the waste industry for many years, including several years living and working in the U.S. With his interest in sustainability, Henry will bring a new perspective to the leadership of the foundation and I look forward to supporting him in his duties.

To my fellow Directors, I would like to thank you for all your help and support during my tenure.

NEW EREF BOARD MEMBERS

The EREF Board of Directors is pleased to announce the election of three new Board members:



Ven Poole, Chief Executive Officer of Waste Industries
Ven Poole joined Waste Industries in Raleigh, North Carolina in 1990 and currently serves as Chief Executive Officer. Prior to his assuming the CEO duties in 2008, he worked at Waste Industries as Vice President, Corporate Development, Director of Support Services and Risk Management Director. He holds a B.S. in Aerospace Engineering from North Carolina State University. Mr. Poole has more than 20 years experience in the solid waste industry.

Claude Boivin, President of The Labrie Environmental Group

Claude Boivin is President of Labrie Environmental Group in Quebec, Canada. Claude joined Labrie, then a heavy-vehicle distributorship in 1965; subsequently acquiring the company in 1971. During his tenure with Labrie, Claude has shifted its focus to the development and production of a fleet of world class refuse trucks.



Pat Carroll, President and Chief Executive Officer of the Environmental Solutions Group



Pat Carroll is President and CEO of Dover's Environmental Solutions Group of companies including Heil Environmental, Marathon Equipment Company and Bayne Machine Works. Prior to ESG he was the President of DE-STA-CO (also a Dover Company) where he was instrumental in positioning the company for future growth. Prior to his role at DE-STA-CO, Pat was with Terex Corporation for five years, four years as President of the Telelect Utilities business and one year in business development at the corporate office. He also spent twelve years with Ingersoll-Rand in their construction, utilities and mining business. Pat holds a Bachelor of Science degree in Engineering Science from Montana Tech and an MBA from the University of Texas in Austin.

2010 Board of Directors

Chairman

Paul R. Mitchener
Macquarie Infrastructure Management (USA), Inc.

President & Chief Executive Officer

Michael J. Cagney
Environmental Research and Education Foundation

Vice Chairman

Henry Saint Bris
SUEZ Environnement DRIS2D

Secretary/Treasurer

Richard Burke
Veolia Environmental Services

Claude Boivin <i>Labrie Environmental Group</i>	Robert J. Riethmiller, Jr. <i>PTR Baler and Compactor</i>
Pat Carroll <i>Environmental Solutions Group</i>	Robert P. Stearns, P.E., DEE <i>SCS Engineers</i>
Jim Dowland <i>Waste Management, Inc.</i>	Thomas H. Van Weelden
Michael Hosfeld <i>McNeilus Companies</i>	Kevin Walbridge <i>Republic Services, Inc.</i>
Leonard E. Joyce, Jr., P.E. <i>Joyce Engineering, Inc.</i>	Director Emeritus
Ronald J. McCracken <i>RJM Associates</i>	Robert C. Duncan* <i>Duncan Holding Company</i>
Ven Poole <i>Waste Industries, Inc.</i>	Ted Flood <i>International Baler Corp.</i> <i>(Retired)</i>
Debra R. Reinhart, Ph.D., P.E. <i>University of Central Florida</i>	Lonnie C. Poole, Jr. <i>Waste Industries, Inc.</i> <i>(Retired)</i>

* = Deceased

Honorariums & Memorials

In memory of John McLoughlin

—Lonnie & Carol Poole

In appreciation of Gerry Haven's mentoring and guidance, and in celebration of her career and in support of the RPS/SCS Fellowship Program.

—Robert and April Dick

Express your thanks and appreciation with an EREF Honorarium

In search of a special way to honor a loved one, friend or colleague? Looking for a simple, complementary means for recog-

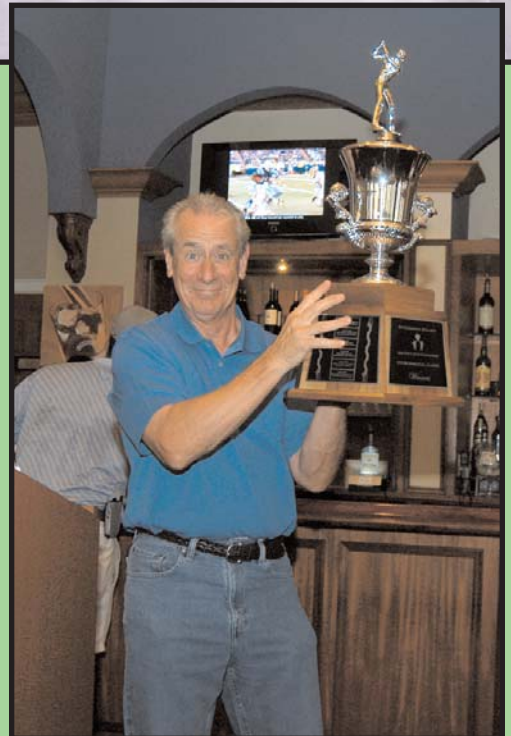
nizing employee dedication and accomplishment? Consider an honorarium or memorial in EREF's newsletter. Honorariums most often expressed represent the birth or adoption of a child, an anniversary or wedding, a personal milestone, retirement or receipt of a distinguished award. Written recognition is powerfully touching and rewarding.

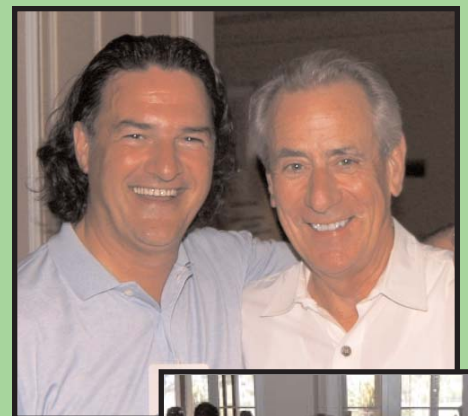
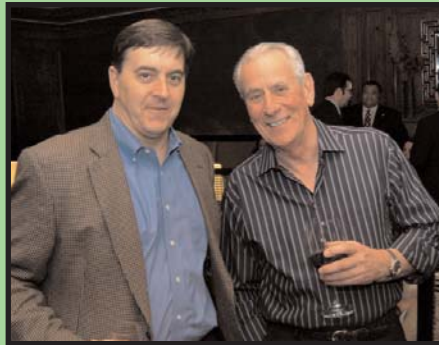
A contribution* is requested in exchange for printing each honorarium or memorial – the proceeds are used to fund research and education projects, but you may specify instead that your donation be applied to EREF's scholarship program. Please contact EREF at 919.861.6876 ext. 103 or kpickurel@erefndn.org for questions regarding your honorarium or for information about the foundation and its research and education initiatives.

*Donations are tax deductible to the extent allowed by law.

a photo tribute to...

Michael Cagney







Carrie Harns

**University of Wyoming
Stearns/SCS Scholar 2010**

Mechanistic Assessment of the Mobility of Titanium Dioxide and Cerium Oxide Nanoparticles through Municipal Solid Waste Landfill Clay Liners

Carrie originates from the small ranching community of Eden, WY. She received a Bachelor of Science Degree in Microbiology from the University of Wyoming in May 2010 and is now pursuing a Master's Degree in Environmental Engineering at the University of Wyoming. During her undergraduate career, Carrie had the opportunity to work on two different research projects. One project focused on understanding the role of cytochromes in the reduction of Fe(III) by microbial processes. The second project focused on electrically-induced reduction of TCE in groundwater. Her primary research interest is in the microbial processes that play a role in the degradation and transformation of wastes. The overall goal of her research project is to determine the ability of existing solid waste landfills to adequately serve as containment systems for nanotechnology associated waste products.

In her spare time, Carrie enjoys playing volleyball and basketball, reading and watching college basketball.



Paige Griffin

**Colorado State University
EREF Scholar 2010**

Anaerobic Digesters for Treatment of the Organic Fraction of MSW

Paige first became interested in research while pursuing an Environmental Science undergraduate degree at Lipscomb University in Nashville, TN. During this time, she was able to serve as an intern and researcher at a local State Natural Area and gain first-hand experience in the field. After graduating in May 2009, she enrolled at Colorado State University in the Environmental Engineering program to continue her studies. She is currently in the second year of her master's program. Her research interests include the study of anaerobic digestion and its process limitations. Paige is presently focusing on the rate-limiting step of hydrolysis in the anaerobic digestion process. A more efficient breakdown of substrates will greatly enhance the efficiency of the overall process. Her current project is monitoring the effects of temperature, salinity, and particle size on the hydrolysis rate of different substrates. This preliminary data will set the stage for future anaerobic digestion practices in which the microbial communities may be closely monitored for signs of impending instability in the reactor. In addition, this data will serve as a baseline for potential pilot-scale reactors to be implemented on the Colorado State University campus.

Paige grew up in Nashville, TN and enjoys any outdoor activity. In her spare time, she enjoys hiking, running, backpacking, rollerblading, traveling and reading.



Joo Young Park

**Yale University
EREF Scholar 2010**

Waste as Resources: Utilization of Coal Combustion By-products in the United States

Jooyoung is a Ph.D. candidate in the School of Forestry and Environmental Studies and the Center for Industrial Ecology at Yale University. Her research focuses at the intersection of waste and resource management, aiming to understand how industrial waste evolves into resources and how industries behave to utilize waste. To this end, she is interested in adopting interdisciplinary approaches from economics, strategic management and industrial ecology. Industrial ecology is an emerging area of study that inspires her to enlarge perspectives to address environmental issues from technical end-of-pipe orientation to holistic and complex systems approach. The aim of the proposed research is comprehensive understandings of CCB utilization in the U.S., both from the societal and individual firm's perspective, in order to draw general implications for waste and secondary resource management.

Before joining Yale, Jooyoung studied at Seoul National University in South Korea and earned both Bachelor's and Master's degrees in Civil, Urban and Geosystems Engineering.



Laura Knudsen

**Indiana University - Bloomington,
MPA & MSES
Riethmiller/PTR Scholar 2009**

Electronic Waste Issues and Solutions

Laura orchestrated another successful E-waste Collection Days program for Indiana University Bloomington (IU) and Indiana University South Bend, where approximately 600,000 pounds of e-waste were collected. Initiatives were undertaken to improve the event from the previous year, including comprehensive statistical analysis of the 2009 results, distribution of a 2010 e-waste community survey, increased participation from IU departments & regional campuses and increased education and public awareness of e-waste issues. The top 3 factors that spurred participants to take advantage of the event were: (1) helping the environment, (2) no charge to recycle, and (3) the drive-through convenience. For the 2010 event, the project team organized the first ever IU Bloomington E-waste Art Contest, which resulted in an

art display that was held in the lobby of the Herman B. Wells library for the month of April. Additionally, with regard to the e-waste collection event, high school students were utilized as volunteers so that broader community support for the event would grow. The project team once again utilized television, radio and newspaper in order to reach Bloomington citizens. Based on the experience of the project team, several ideas for improving e-waste initiatives on campus were generated during the project process. The fact that the 2010 event was extremely successful is a testament to the hard work and dedication of the project team. Fortunately, e-waste recycling has broad support at Indiana University and this



allows massive events like Electronic Waste Collection Days to take place. Continued formation of these campus relationships is crucial to dealing with electronic waste recycling in Bloomington and all the IU campuses and surrounding communities.



Scholarships are awarded by EREF to recognize excellence in master's, doctoral or post-doctoral waste management research and education. Awards to doctoral students are given in memory of Francois Fiessinger, P.E., Ph.D., a graduate of Rutgers University, who was a founding director of the foundation; and by the Environmental Research and Education Foundation. Awards to master's students are given by Robert P. Stearns, P.E., DEE/SCS Engineers, former Chairman of EREF; and by Robert J. Riethmiller/PTR Baler and Compactor, current Chairman of the Scholarship Committee. More information can be found at www.erefndn.org/index.php/scholarships.



Kyle Bibby

Yale University
EREF Scholar 2009

Using Molecular Techniques to Determine the Fate of Pathogens (e.g. viruses) in Landfill Leachates and Source Material

Kyle just finished the second year of his Ph.D., recently passing his Area Exam and advancing to Ph.D. candidacy. His recent work has been focusing on bioinformatic methods of identifying human pathogenic viruses in environmental samples where the majority of viruses are bacteriophages. Soon, he plans to apply these methods to sequence viral DNA and identify the full diversity of viral pathogens in an environmental sample. Kyle received his BS in Civil Engineering from the University of Notre Dame in 2008, after which he began his Ph.D. studies at Yale University.

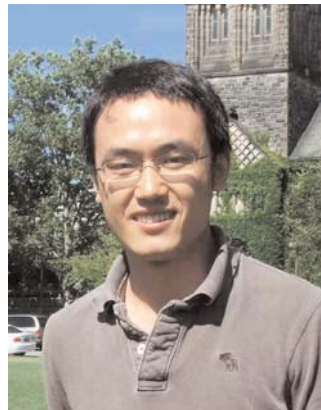


James W. Levis

North Carolina State University,
Ph.D.
Francois Fiessinger Scholar 2009

The Effects of Climate Change Legislation on Solid Waste Management Operations

In the past year Jim's paper "Assessment of the state of food waste treatment in the United States and Canada" was published in *Waste Management* – an international journal of integrated waste management, science and technology. His bibliography also includes the following papers: "Quantifying the Greenhouse Gas Emission Reductions Associated with Recycling Hot Mix Asphalt," "A Life-Cycle Inventory of Alternatives for the Management of Commercial Food Waste" and "A PDMS-Based Constant-Flowrate Micro Flow Regulator. Jim also presented a manuscript at the Global Waste Management Symposium in San Antonio, TX entitled "Cost Effective Solid Waste Management Decision Making in Consideration of Climate Change Policy."



Ming Xu, Ph.D.

Georgia Institute of Technology
Francois Fiessinger Scholar 2008

Quantifying Solid Waste Generated by Economic Activities

Since June 2009, Ming has been working in the Brook Byers Institute for Sustainable Systems at Georgia Tech. The support from the Francois Fiessinger Scholarship has been primarily utilized for continuing his research on the Physical Input Monetary Output (PIMO) model and its applications on a variety of issues in sustainability. The PIMO model investigates the complex relationship between environmental impacts (solid waste) and economic activities (consumption of products).

Ming participated in a cross-university initiative to prepare a grant proposal to the National Science Foundation (NSF) under the prestigious Engineering Research Center (ERC) program. His contribution to this proposal is the construction and application of PIMO model for

urban systems. Ming assisted in teaching a senior/graduate level course entitled "Sustainable Engineering" at Georgia Tech in Fall 2009. He taught the PIMO model and related topics. Ming has submitted three papers – two of which utilize the PIMO model and one directly for the PIMO model. One paper has been accepted by the scientific journal *Environmental Science & Technology*. Ming recently joined the University of Michigan-Ann Arbor as an assistant professor in the School of Natural Resources and Environment.



Ramin Yazdani

University of California at Davis, Ph.D.
EREF Scholar 2008

Factors Limiting Aerobic Degradation During Aerobic Bioreactor Landfilling

Ramin recently completed his doctorate degree and his dissertation was entitled "Quantifying Factors Limiting Aerobic Degradation During Aerobic Bioreactor Landfilling and Performance Evaluation of a Landfill-Based Anaerobic Composting Digester for Energy Recovery and Compost Production." Portions of this work have also been accepted for publication in the scientific journal, *Environmental Science and Technology*. Ramin's work has built upon the extensive research conducted at the Yolo County (California) landfill's bioreactor cell. This recent work used a tracer gas technique to evaluate gas flow through the landfill and showed that a large fraction of gas-filled pore spaces (as opposed to liquid filled spaces) were in immobile, inaccessible zones within the waste matrix, thus making it difficult to maintain aerobic conditions under relatively average moisture conditions of 33 – 36%.

This work suggests waste degradation rates are significantly affected by the rate of oxygen transfer to the immobile gas zones, which comprised 32 – 92% of the gas-filled pore space. Ramin's work also shows the utility of gas tracer testing to evaluate gas transfer, gas collection efficiency, and mass transfer rates within a landfill.



Tim Kramer

**Yale University, MS
Stearns/SCS Scholar 2008**

How Improved Waste Management Practices Can Tie into Carbon Markets and Create Emission Reductions

Over the course of the year Tim has worked on how the growing voluntary and regulated carbon markets can be used by waste management facilities and subsurface mineral rights owners to generate additional revenues. Currently, methane capturing and flaring at landfills is one of the most profitable sources of carbon credits on the voluntary market. With legislative proposals looking to put a price on carbon sequestration, improved waste management practices have a distinct advantage in the carbon markets since significant emission reductions can be made at a relatively low risk to investors. Through course work and research, Tim has assessed how this more regulated market can be developed in such a way that will actively encourage the continued participation of the waste management industry.

Yale's strong focus on a curriculum that balances policy understanding with scientific understanding resulted in Tim working with Professor Mark Bradford to

examine how soil carbon sequestration may be affected by land use change. This work will result in a published paper in late 2010/early 2011.

Tim also conducted research on how landfills, functioning as storage sites for carbon, can be accounted for in future cap and trade policies. Through this work, he investigated the possibility of using new waste management metrics to take into consideration previously unaccounted for carbon reductions found in the waste cycle from paper and wood products. The research found that while a carbon accounting system could be developed, issues such as how to adequately account for the long-term sequestration of the carbon over time may create a hindrance to their use. If accurate measurements of storage time could be made, these reductions could be a source of additional revenues for waste management companies.



Kurt F. Flor

**Baylor University, MBA
Riethmiller/PTR Scholar 2008**

Using Business to Spur Waste-to-Energy Technologies in Developing Countries

In the spring of 2010, Kurt worked with Whole Tree, Inc., a Baylor University-sponsored start-up on two projects regarding waste-based technology. The remnants of discarded coconuts grown in developing countries served as the platform of Whole Tree's technological innovations. In addition to creating technology from discarded coconuts that could be used in large-scale production projects, the company aims to create a new market for these discarded coconuts that will

help to reduce waste and provide an additional income stream to coconut farmers.

Kurt's first project was to create a working business plan regarding one of Whole Tree's patent-protected technologies dealing with a coconut-derived bio-composite; the company hopes to apply this technology to the construction, automotive, and/or consumer goods industries. Kurt's second project was to co-lead a team of engineering and MBA students in the Rice Business Plan Competition in Houston, Texas. After receiving an invitation to compete in the "Social Ventures" category of the prestigious contest, Kurt and the Whole Tree team set out to campaign for start-up funds from early-stage investors and venture capitalist firms around the country. The team won First Place in the Shark Tank Round.

In January 2009, Kurt formed a team of four first year MBA students in hopes of competing in the Wake Forest Business Plan Competition. The competition is one of the most well-known business plan competitions in the nation, distinguishing itself from many others by competing under the scenario of a two-minute elevator pitch, pitching the business plan in front of actual venture capitalists inside a moving elevator. Teams had to first submit an entry to the competition, either competing in the Regular Business Plan or Social Enterprise tracks. After submission of the Executive Summary of a business plan, the Wake Forest panel of judges, which included competition sponsors, venture capitalists, and business profession, invited teams to the semi-final round of competition.

Kurt led the Baylor team on a business plan writing campaign in which they had to complete a full business plan in the form of an Executive Summary as part of their entry to the Wake Forest Competition. The mission statement of his fictional corporation, Energess, was "To reduce landfill waste and improve the standard of living of slum residents in a developing country through the development of a waste-to-energy plant; this plant will utilize solid waste as a resource to produce electricity, employ working-age slum residents, and implement education programs that will benefit the children of those residents."

Field-Scale Assessment of Evapotranspirative Methane Oxidation (ETMO) Caps for Sustainable Management of MSW Landfills in Sub-Humid Climates

Grantee: Michigan State University

Federal regulations require final covers of municipal solid waste (MSW) landfills to contain a geosynthetic geomembrane layer, which is typically an expensive component of the landfill cap. To permit a more economical alternative cap, usually an earthen or evapotranspirative (ET) cap, the hydraulic performance of the alternative cap needs to meet or exceed that of the geosynthetic cap. To demonstrate this usually requires construction of a lysimeter, after with the lysimeter is and monitored and/or modeled for a few years to simulate performance of the alternative cap.

While a lysimeter is the most commonly used method to measure rainfall infiltration into the waste layer (percolation), it is not representative of an actual cap. This is because, unlike a landfill cap, the lysimeter has a bottom that is freely drained and is used for collecting the percolated liquid whereas, the bottom of an actual cap rests on the waste and is not

freely drained. Regulators typically permit an alternative cap when the observed or simulated annual percolation for it is low, only a few millimeters. Because the regulatory decision to permit an alternative cap can be influenced by the magnitude of percolation, one of the key objectives of the project was to quantify the differences in percolation measured from a lysimeter versus that of an actual cap. For this comparison, two field-scale test sections of 6-ft-thick earthen cap were constructed and instrumented at Woodland Meadows Landfill located in Detroit, Michigan. The test section and the instrumentation were designed such that hydraulic performance of the lysimeters versus the actual caps can be compared side by side.

After three years of meteorological, hydrological, and hydraulic monitoring of the test sections, as well as extensive unsaturated/saturated flow modeling using rigorous numerical models, the following preliminary findings have been obtained.

1) While the relative percolation amounts are influenced by the climate and hydraulic properties of the cap soils, typically percolation measured by lysimeter is greater than that from an equivalent actual earthen cap which is placed on the waste.

2) The difference in the percolation between the lysimeter and actual earthen cap is more for arid climates as compared to humid climates.

3) The difference in the percolation between the lysimeter and actual earthen cap is greater for thinner alternative caps.

4) The difference in the percolation between the lysimeter and actual earthen cap is greater when waste underlying the cap has a lower hydraulic conductivity.

5) Soil water storage of the instrumented test section can be used to directly correlate the magnitude of percolation. In other words, the greater the soil water storage, lower the percolation or vice versa.

Significance: These results indicate that these differences between lysimeters and actual alternative caps need to be considered when lysimeters are designed, monitored and modeled to permit alternative or ET caps. The design approach used in this project for constructing and instrumenting lysimeters will allow the collection of basic data needed to account for these differences.



Field-Scale lysimeters constructed at Woodland Meadows Landfill, Detroit, Michigan



Completed vegetated test sections

Moisture Consumption during Gas Production in Landfills: Implications to Permitting ET Caps

Grantee: Michigan State University

Federal regulations require the final cap of municipal solid waste (MSW) landfills to have a hydraulic conductivity that is equal to or lower than the bottom liner to ensure rainfall doesn't aggregate in the landfill, which would create a "bath tub" effect after it is closed. As a result, the MSW landfill regulations require the final cover to contain a relatively impermeable geomembrane layer, or an alternative earthen final cover that is hydraulically equivalent to the geomembrane. Because alternative landfill covers are usually much cheaper than covers containing the geomembrane layer, their implementation over geomembrane covers is attractive. While any landfill cap with a low permeability minimizes the extent to which rainfall runoff enters the waste, water within the waste is also removed during methane formation because water is consumed as part of the methane formation reaction. However, the amount of water consumed as part of methane formation within a typical MSW landfill has not been measured from field studies. Thus, the key objective of this research is to estimate how much liquid is consumed in a typical landfill during the gas production stage.

As part of this project, MSW samples were collected from an active landfill (Woodland Meadows, Detroit MI). These samples were collected from old (>13 years) and relatively new (<4 years) sections of the landfill at depths ranging from 20 to 100 feet. These samples were analyzed for water content, cellulose, hemicelluloses, lignin, and biological methane potential (BMP). Key results are shown in the following table.

Parameter	Old Waste (>13 yrs old)	New Waste (<4 yrs old)
Cellulose	10%	17%
Moisture Content	31%	20%
Organic Solids	34%	40%
BMP (mL CH ₄ /g)	19%	52%

The second phase of the project, which is scheduled to be completed by early 2011, will focus on spinning relatively large samples of the waste in a centrifuge to measure its moisture retention function. The retention function will be input to a numerical program to estimate

the water content of the waste from the infiltration of precipitation over the life of the landfill cell. The difference in the modeled water content versus the measured water content will be attributed to the moisture consumed by the waste during gas production.

Significance: The results from this project will provide practitioners with the relative magnitude of moisture removed within a landfill due to methane gas formation. It is anticipated the findings will be useful when computing the overall water balance of the landfill when permitting alternative final covers.

Estimates of Carbon Storage in Landfills from the Biogenic Carbon Content of Excavated Waste Samples

Grantee: NC State University

Landfills are estimated to receive 54% of municipal solid waste (MSW) in the U.S. While recycling and organics diversion programs serve to divert some waste from landfills, landfills are expected to remain a significant component of MSW management for the foreseeable future. Cellulose (C) and hemicellulose (H) are the major biodegradable constituents in MSW and comprise approximately 50% and 12% of residential refuse dry weight. Lignin, which constitutes about 15% of dry weight, is essentially recalcitrant under anaerobic conditions. When waste is buried in a landfill, a fraction of the biogenic carbon (i.e., that originating from living material such as food, yard and paper waste) is converted to carbon dioxide and methane by anaerobic microorganisms. Biogenic carbon that does not degrade is considered to be stored or permanently removed from the atmosphere. Recent analyses have shown carbon storage to be a significant factor in an overall landfill carbon balance.

The objectives of this study were to measure carbon storage factors (CSFs) associated with refuse excavated from landfills in varying states of decomposition, and to compare these estimates to estimates based on CSFs derived from laboratory studies. This is the first study to measure carbon storage on the basis of samples excavated from landfills as opposed to a laboratory system. To measure carbon storage in field samples, it is necessary to distinguish between

fossil carbon that comes from petroleum-derived products such as plastics and synthetic textiles, and biogenic carbon. The C associated with fossil C was stored prior to burial in a landfill so that only biogenic C contributes to carbon storage. Fossil and biogenic were differentiated on the basis of carbon dating measurements conducted at Woods Hole Oceanographic Institute.

CSFs were derived from samples of excavated waste by measurement of the total organic carbon, the fraction that is biogenic and the remaining methane potential of the samples. For samples that were close in composition to fresh waste, a CSF of 0.16 kg biogenic C stored kg dry MSW-1 was calculated. This is comparable to a value of 0.13 estimated independently on the basis of laboratory studies and waste composition studies. Applying a CSF of 0.16 kg biogenic C stored kg dry MSW-1 to waste tonnage in the U.S., carbon storage in landfills represents about 12% of the net CO₂ flux from carbon stock changes in land use, land-use change, and forestry.

Significance: The technique used to measure carbon storage in this study represents a second and independent measure of carbon storage that can be attributed to waste disposal in landfills. The carbon storage factors derived in this study were applied to carbon balances of landfills in arid and non-arid regions of the U.S., and to bioreactor landfills. While fugitive methane emissions still remain, a landfill can be carbon neutral with aggressive gas collection and conversion to energy.

Solid Waste Management in a Carbon Constrained Environment

Grantee: NC State University

The goal of the proposed research is to develop a life-cycle assessment (LCA) model capable of analyzing solid waste management (SWM) performance – at both the individual process and integrated system levels – taking into account implications of greenhouse gas (GHG) mitigation policies and competing SWM objectives (e.g., cost minimization, emissions reductions, and diversion targets). An integrated life-cycle model for analysis and decision support will be developed to estimate the costs, energy use, emissions, and environmental impacts associ-

ated with the processes (e.g., collection, separation, waste-to-energy, composting, anaerobic digestion, landfilling) that constitute the SWM system. The model will be used to meet the following objectives:

- 1) Quantify the changes in costs associated with various SWM processes due to different GHG mitigation policies, including anticipated energy price changes induced by these policies.
- 2) Evaluate the changes in integrated SWM strategies (i.e., waste flows and process choices) that most effectively respond to different GHG mitigation policies.
- 3) Quantify the effects of GHG mitigation policies and related energy price changes on other SWM-related environmental impacts (e.g., smog formation and acidification).

Work-to-date has focused on building individual process models (i.e., collection, composting, anaerobic digestion and waste-to-energy). Additionally, design of user interfaces to facilitate SWM life-cycle studies at the process and system level is ongoing. In addition, development of procedures to analyze and optimize the entire SWM system is ongoing. Various modeling approaches for implementing GHG pricing schemes and changes to the energy system are being developed and considered.

Significance: The results of this work will provide guidance as to how SWM operations can cost-effectively respond to proposed GHG pricing schemes and provide estimates of the likely environmental impacts. Additionally, tools will be developed and made available for decision-

makers in industry and government to better understand the systemic environmental and economic effects of different decisions.

Quantifying Capture Efficiency of Gas Collection Systems with Gas Tracers

Grantees: University of Delaware

There is a critical need for methods to quantify methane capture efficiency from landfill gas (LFG) collection systems. In addition to providing information that will improve calculations of landfill methane budgets, such measurements are essential for evaluating the utility of alternative gas collection systems and management practices. While measurements of surface methane emissions from landfills aid in determining methane capture efficiency, we propose a fundamentally new approach – quantifying the capture efficiency using controlled releases of inert tracer gases within refuse. Such tests are a straightforward means to quantify the efficiency of alternative gas collection well designs and management practices. In this work we aim to:

- 1) Demonstrate in situ gas tracer tests for quantifying the collection efficiency of a LFG well.
- 2) Compare gas tracer test results with in situ gas pressure measurements, to determine if the cheaper and easier gas pressure measurements can be used to define the zone of influence of a collection well where the LFG collection efficiency is high.
- 3) Compare gas tracer test results with predictions from a gas flow model to

evaluate the utility of such models for predicting gas flow patterns and residence time distributions in landfills.

Although the field portion of the study has only recently begun, much progress has been made. Testing and analysis of the field-portable device, a photoacoustic infrared spectroscope (PAS) for measuring tracer gases injected into landfills, has been completed. Field experiments taking place at the Yolo County Central Landfill (California), including the selection of tracer injection locations, depths, and methods to measure and collect the gas tracers from gas collection wells, have been designed and are being implemented. The gas flow model that will be used to assist in the interpretation of field test data has been developed.

Significance: Traditionally, collection efficiency has been computed as gas recovery divided by gas production, where recovery is measured directly from the sum of all gas collection wells, and production is the sum of recovery + oxidation in cover soils + surface emissions. While this traditional procedure works for evaluating the performance of an entire landfill, it is an expensive, indirect measurement that is performed infrequently due to cost limitations. This study evaluates a new way to quantify LFG capture efficiency involving in situ gas tracers. This technology can be used to quantify the benefits of alternative LFG collection systems, to track the efficiency of an existing collection system as a landfill cell moves from active to intermediate to final cover, or to evaluate various operational changes, such as modifications to the gas collection system to mitigate the effects on barometric changes on collection efficiency.

Research Council Adds Two New Members

This year the EREF added two new members to its Research Council, bringing the total number to 11 members. Both Catherine Collier, the Corporate Research and Development Portfolio Manager for Suez Environnement (Paris, France), and George Paturalski, Corporate Director of Risk Management for the Environmental Solutions Group (Chattanooga, TN) were inducted into the Council as part of an ongoing effort to add expertise that reflects the EREF's strategic mission to light a clear path for the development of sustainable waste management practices. Bryan Staley, EREF's Vice President of Environmental Research, noted, "To continue to be a leading institution that supports solid waste research, it is necessary to ensure the Council's expertise is well-rounded and represents the perspective that future waste management practices will essentially be a resource recovery activity as opposed to a disposal operation. We welcome Ms. Collier and Mr. Paturalski to the Council and appreciate the expertise they add. Thank you for your service to the EREF, the solid waste industry, and the public."