DEPARTMENT OF
CIVIL & ENVIRONMENTAL
ENGINEERING

GRADUATE STUDY

IN

ENVIRONMENTAL ENGINEERING

2007-2008 Academic Year

COLLEGE OF ENGINEERING
UNIVERSITY OF MASSACHUSETTS at AMHERST

PREFACE

Since 1960 over 450 sanitary and environmental engineers have graduated with M.S. and Ph.D. degrees from the Environmental Engineering Program at the University of Massachusetts at Amherst. Many of these graduates are employed in industry, consulting firms, government agencies, research institutions, and universities.

The highest priority of our Program is the education of our students. As of September 2007, the Program consists of eight core faculty members, and 30 to 40 students pursuing advanced degrees in environmental engineering. Most of our students are supported through research assistantships, fellowships, and teaching assistantships. Our Program enjoys an excellent national reputation.

This booklet describes opportunities for graduate study in the Environmental Engineering Program at the University of Massachusetts. Please use the FAQ page that follows or the Table of Contents below to find your way through this booklet. Additional information can be found on our web site:

www.ecs.umass.edu/cee/eve

or by contacting:

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Frequently Asked Questions

Who will I work with…

You will work closely with your fellow students, your class instructors and your advisor. Course work includes many opportunities for team projects. Each student is matched with a faculty member who serves as advisor and supervises the out-of-class research activities of the student. Our Program strives to provide the facilities, resources and events that foster a vibrant learning environment among students and faculty. See page 3 for a description of our faculty members and page 9 for a description of our research activities and facilities.

What are the degree requirements…

Our Program offers the MS and PhD degrees. The MS degree is earned by following one of several requirement paths. The path you select will depend on your undergraduate degree and on your interests. See page 6 for details on the available degree paths and the degree requirements.

What courses will I take…

The courses you take will include some that are required of all students and electives that you will choose in consultation with your advisor. With eight faculty in the Program we are able to offer a number of electives each semester. In addition, other Departments in the University offer courses often taken by our students. Course sizes are generally less than 10 students. All students are required to do either a Dissertation, Research Thesis or an Engineering Report depending on their degree path. See Appendix A for a complete list of courses offered by the Program.

How will I support myself …

Nearly all of our students receive financial aid. This aid is sufficient to cover living costs in Amherst. For most, this aid comes in the form of a research assistantship which is provided by the advisor. In return for this aid the student is expected to participate in a research project under the supervision of the advisor. See page 14 for more details on financial aid.

What is it like to live in Amherst …

Amherst is a lively college town. The University of Massachusetts has an enrollment of approximately 23,000 students, including 6,000 graduate students. The University joins with its academic neighbors - Amherst, Hampshire, Mount Holyoke and Smith Colleges - in maintaining the rich tradition of education and cultural activity associated with the Pioneer Valley. Situated in one of the most picturesque sections of the state, the Valley offers a wide array of musical, art, theatre and other cultural resources. Boston, New York City, Cape Cod and numerous other recreational opportunities are located within several hours driving distance.

FACULTY

The Graduate Faculty in the Environmental Engineering Program, their educational background, research interests, and the year of appointment at the University of Massachusetts are given here. More information about our faculty can be found online at http://www.ecs.umass.edu/eve/faculty.html .

Core Faculty

David P. Ahlfeld, Professor (1998)

B.S.	Humbolt State University	Environmental Engineering	1983
M.S.	Princeton University	Civil Engineering	1985
Ph.D.	Princeton University	Civil Eng. & Operations Research	1987

Water resources engineering, mathematical modeling and numerical methods, groundwater flow and contaminant transport, design of groundwater remediation systems.

Sarina J. Ergas, Associate Professor (1994)

B.S.	Humbolt State University	Environmental Engineering	1988
M.S.	University of California at Davis	Civil Engineering	1990
Ph.D.	University of California at Davis	Civil and Environmental Eng.	1993

Biological water and wastewater treatment, membrane bioreactors, biological nutrient removal, bio-remediation of contaminated soil and groundwater, biofiltration for control of air toxics and air pollution

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David W. Ostendorf, Professor (1980)

B.S.E.	University of Michigan	Civil Engineering	1972
M.S.	Massachusetts Institute of Technology	Civil Engineering	1978
Sc.D.	Massachusetts Institute of Technology	Civil Engineering	1980

Surface and groundwater hydrology, environmental fluid mechanics, hazardous waste disposal.

David A. Reckhow, Professor (1985)

B.S.	Tufts University	Civil Engineering	1977
M.S.	Stanford University	Civil Engineering	1978
Ph.D.	University of North Carolina	Environmental Engineering	1984

Water treatment processes, physical-chemical treatment, chemistry of natural waters, organic contaminants in drinking water.

Chul Park, Assistant Professor (2007)

B.S.	Yeungnam University	Environmental Engineering	2000
M.S.	Virginia Tech	Civil and Environmental Engineering	2002
Ph.D.	Virginia Tech	Civil and Environmental Engineering	2007

Biological wastewater treatment processes; metaproteomics and metagenomics; membrane technologies

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Paula L. Sturdevant Rees, Assistant Professor (1999)

B.S.	University of Iowa	Civil Engineering	1992
M.A.	Princeton University	Civil Eng. & Operations Research	1994
Ph.D.	Princeton University	Civil Eng. & Operations Research	1997

Water resources engineering, hydrology, urban hydrology, basin-scale water quality and sediment transport.

Erik J. Rosenfeldt, Assistant Professor (2007)

B.S.	Washington University	Chemical Engineering	1999
M.s.	Duke University	Civil and Environmental Engineering	2003
Ph.D.	Duke University	Civil and Environmental Engineering	2007

Physical/chemical treatment processes, UV and advanced oxidation technologies for water treatment

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John E. Tobiason, Professor (1987)

B.S.	University of New Hampshire	Civil Engineering	1976
M.S.	University of North Carolina	Environmental Engineering	1979
Ph.D.	Johns Hopkins University	Environmental Engineering	1987

Transport and transformation of pollutants in natural and engineered systems, particle deposition in porous media, water treatment processes.

Emeritus Professors

James K. Edzwald

- **Retired from UMass June 2006**
- **Continuing as Editor, The Americas, Journal of Water Supply: Research and Technology – AQUA (IWA); Visiting Professor, Clarkson University**

Michael S. Switzenbaum

- **Retired from UMass, August 2003**
- **Currently Professor and Executive Associate Dean, College of Engineering, Marquette Univeristy, Milwaukee, Wisconsin**

Supporting Faculty

There are numerous faculty within the Civil and Environmental Engineering Department and in other departments of the University such as Chemistry, Geosciences, Environmental Science, Microbiology, Resource Economics, Polymer Science & Engineering and Public Health who work with our program. Some of these faculty are listed below:

Paul K. Barten, Associate Professor of Natural Resources Conservation

Ph.D.	University of Minnesota	Forestry	1988

Watershed structure and function.

Don J. DeGroot, Associate Professor of Civil and Environmental Engineering

Ph.D.	Massachusetts Inst. of Technology	Civil Engineering	1989

Environmental geotechnology, soil behavior.

Steven D. Goodwin, Prof. of Microbiology, Dean College of Natural Resources and the Environment

Ph.D.	University of Wisconsin	Microbiology	1986

Environmental microbiology.

Derek Lovely, Professor of Microbiology

Ph.D.	Michigan State University	Microbiology	1982

Environmental microbiology

Alan J. Lutenegger, Professor of Civil and Environmental Engineering

Ph.D.	Iowa State University	Geotechnical Engineering	1979

Environmental geotechnology, field analysis of soil behavior.

Klaus R.L. Nusslien, Associate Professor of Microbiology

Ph.D	Michigan State University	Microbiology	1998

Genetic diversity and population dynamics of microorganisms

Richard F. Yuretich, Professor of Geosciences

Ph.D.	Princeton	Geosciences	1976

Lake sediments, clay minerals, environmental geochemistry

GRADUATE DEGREE REQUIREMENTS

The objectives of the Environmental Engineering Program are to educate environmental engineers capable of addressing both current and future environmental problems, **e**ngage students in the generation and dissemination of knowledge and promote a sense of professionalism and leadership among our students. These objectives are achieved through a course of study carefully prepared by the student and his/her advisor. Advanced understanding of environmental problems is obtained from a core of fundamental courses that relate theory to design practice. Additional elective courses and the research experience prepare the student for a variety of career options including work with consulting engineering firms, environmental government agencies, industries, and water or wastewater utilities or authorities.

Three degrees are offered: the Master of Science in Environmental Engineering, the Master of Science in Civil Engineering, and the Doctor of Philosophy (PhD). The MS in Environmental Engineering degree is accredited at the advanced level by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (EAC/ABET). There are two options for the MS in Environmental Engineering degree: a research option and a professional practice option. The specific degree requirements and the appropriate degree depends on your undergraduate background. A general description of each of the degree programs follows.

MS Degrees

Four paths are available for obtaining the M.S. degree through the Environmental Engineering Program. The four paths are:

A. Research Option
B. Professional Practice Option
C. Research Option (science major)
D. Civil Engineering Option

Paths A, B, and C lead to an MS degree that is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET). Students pursuing path A must have a bachelor's degree in an engineering field from an ABET accredited program. This path generally requires 3 to 4 semesters of study. Students pursuing path B must have a bachelor's degree in an engineering field from an ABET accredited program. The Professional Practice Option is designed to be completed in 9 to 12 months and includes a prescribed program of study including an engineering report. Students pursuing path C enter the Program without an ABET accredited degree. Students pursuing this path typically have undergraduate degrees in Physics, Chemistry, Biology or other science disciplines. These students must make up coursework at the basic level of undergraduate engineering. Depending on the background of the student this path typically requires 6 to 7 semesters to complete. Path D is available to students who possess an undergraduate engineering degree that is not accredited by ABET.

In addition to the general Graduate School requirements for the M.S. Degree, a minimum of 31 graduate credits must be earned by all degree candidates. An overview of requirements for the M.S. in Environmental Engineering are described below. Full details are available in the "Environmental Engineering Program Information, Procedures and Advising Manual."

A. Students with Engineering Baccalaureate-Research Option

The research option is designed for graduate students interested in pursuing a career in engineering practice, an applied research career or a subsequent PhD degree. Students under this option have research financial support in the form of a research assistantship, teaching assistantship, or fellowship. This option requires independent research in the form of a thesis and generally requires 3 to 4 semesters to complete.

*** <u>Core Courses</u>**
The core courses are intended to provide students with a basic knowledge of environmental engineering processes and design. These required courses are:

Designation	Title	Credits
CEE 671	Environmental Biological Processes	4
CEE 672	Physical and Chemical Treatment Processes	4
CEE 770	Environmental Engineering Design	4
CEE 691/692	Seminar	1

*** <u>Master's Project</u>**
The student is required to write a research report and present an oral defense before a Master’s Committee on a topic determined in consultation with the advisor. The content of the report normally derives from the research conducted by the student as part of their research assistant duties. A minimum of 6 credits, taken as CEE 689, must be earned under the Master’s Project.

*** <u>Electives</u>**
In addition to the Core Courses and Master’s Project, the student completes a minimum of twelve credits of electives taken in areas relevant to the student's professional objectives. All electives must be courses taken at the graduate level (500 level or higher). Students may take electives in other departments at the University; however, no more than 9 graduate credits taken outside the Civil and Environmental Engineering Department can be counted toward the 31 credit requirement. Graduate courses are listed in Appendix A.

*** <u>Transfer Credits</u>**
No more than six graduate credits can be transferred from courses taken before the student enters the Environmental Engineering Program.

B. Students with Engineering Baccalaureate-Professional Practice Option

The professional practice option is designed for students interested in careers in practice: consulting engineering firms, environmental government agencies, industries, water or wastewater utilities or authorities. This option requires an independent practical project dealing with an environmental engineering problem. No financial aid is available for this degree, but this degree option is designed to be completed in 12 months. This option is only open to students with ABET accredited undergraduate engineering degrees.

- **Core Courses**. In addition to the core courses listed for the Research Option, students in the Professional Practice Option are required to take CEE 680 (Aquatic Chemistry) in the Fall semester.

- **Electives**. There are 12 credits of electives. Students must choose one course from each of Groups A, and B, as shown below.

  Group A (Modeling and Transport): CEE 577, CEE 660, CEE 661, CEE 690K, CEE 774
  Group B (Water Resources, Air Quality, Solid and Hazardous Wastes): CEE 525, CEE 560, CEE 561, CEE 575, CEE 579, CEE 662, CEE 776

- **Engineering Report**. (CEE 679, 3 credits) Students are required to prepare an Engineering Report concentrating on a topic relevant to the professional practice of Environmental Engineering and selected in conjunction with the student's academic advisor. The written report is generally prepared in the summer following the spring semester.

  Course scheduling is shown below:

Fall		Spring		Summer	
CEE 672	4 cr	CEE 671	4 cr	CEE 679	3 cr
CEE 680	4 cr	CEE 770	4 cr	(Engr Report)	
Electives	6 cr	CEE 692	1 cr		
	14 cr	Electives	6 cr		
			15 cr		

C. Students with Non-Engineering Baccalaureate

Occasionally students with non-engineering degrees are admitted to the Program. Students must have a B.S. in science (such as Physics, Chemistry, Biology, or Environmental Science) to be admitted. Foreign students must have a BS in Engineering to be eligible for admission.

The M.S. requirements are the same as those for path A (research option), but in addition, the student must take (or have taken) coursework required for basic level engineering including: Mathematics (at least 16 credits beyond trigonometry), Basic Sciences (at least 16 credits including both general chemistry and physics), Engineering Sciences (at least 32 credits), Engineering Design (at least 16 credits including a Capstone Design Course), and Humanities and Social Sciences (at least 16 credits). Credit is given where appropriate for the student's previous course work.

D. Students With Engineering Baccalaureate (Non-ABET accredited)

Students with a BS in Engineering from an institution without ABET accreditation may pursue the Master of Science in Civil Engineering degree. The requirements are the same as those for path A.

The Ph.D. Degree

The Program has a PhD research program which offers students the chance to do original research. Such high level research may contribute to a new view of an aspect of environmental engineering, or a solution to an existing problem. It also provides students with the opportunity to obtain the credentials in the environmental engineering profession needed to practice engineering at the highest level. Graduates of the PhD program are employed in a variety of areas including faculty positions at, Colorado State University, Union College, University of Pennsylvania, Case Western Reserve, University of Florida, University of New Hampshire, the State University of New York at Buffalo, and Worcester Polytechnic Institute.

Individual Ph.D. programs are specially designed to reflect the interests and needs of each Ph.D. candidate. Before being admitted to the Ph.D. program the student normally must hold an M.S. degree in environmental engineering. In addition to the doctoral degree requirements of Civil and Environmental Engineering and the Graduate School concerning admission, residency, dissertation, and examinations, the Environmental Engineering Program requires mastery of knowledge in the major area and at least 18 credits of approved coursework beyond those used to meet the degree requirements for the M.S. degree in Environmental Engineering (or equivalent degree). Typically, six of these credits are devoted to a research skill, such as statistics, numerical methods, or engineering mathematics.

RESEARCH ACTIVITIES

Students are deeply involved in research and work closely with faculty. The Environmental Engineering Program has an active research program with annual research expenditures of over $2,000,000. Environmental Engineering maintains an extensive and modern laboratory system. Over 13,000 square feet of new laboratory space is available for research in the modern and well-equipped Program laboratories. These analytical and computational resources support the Program's research effort, directed along experimental and theoretical lines towards diverse problems in water and wastewater treatment, environmental chemistry and microbiology, groundwater and hazardous wastes, water resources, and air pollution control. Various categories of research are described below, however, there are no distinct lines between research areas. Faculty will often be involved in projects in more than one area. Current and recent research projects undertaken by the Program are listed on the following pages for each of the research areas. Selected publications of the faculty are also included in Appendix B. Extensive information about the facilities, projects and faculty of the Environmental Engineering Research Group can be found online at http://www.ecs.umass.edu/eve/ .

- **Drinking Water Treatment**. Unit processes and operations for drinking water production are a dynamic research area in the program. The Program is especially well known for its strengths in the area of physical, chemical and biological treatment technologies for the purification of drinking water. Faculty in the Environmental Engineering Program study the control of carcinogenic organic byproducts of drinking water disinfection; factors which affect the formation of these byproducts; the use of ozone for the purification of drinking water; removal of particulate contaminants by granular media filtration and dissolved air flotation; removal of pathogens such as *Cryptosporidium* and *Giardia*; chemistry of coagulation; coagulation of natural organic matter in water; biologically-active filtration for drinking water purification**;** control of algae in water supplies; optimal design of dissolved air flotation; removal of manganese; and biological denitrification. An emerging research area is treatment processes for application in the developing world.nn

- **Wastewater Treatment**. The Program has been an innovator in wastewater treatment technology since its inception. The types of wastewaters studied have included municipal, industrial, and those classified as hazardous wastes. This work has involved elements of process performance, design, operation and monitoring. Other areas of research include use of membrane bioreactors for treatment of municipal and industrial wastewater, control of chlorinated organic compound precursors, biological nutrient removal, color removal in textile wastewaters, treatment of volatile emissions from municipal wastewater treatment plants with biofilters, the stability of residual biosolids, aerobic and anaerobic digestion of sludges, and the use of advanced oxidation processes such as UV and ozone in the control of trace contamainants in wastewater reuse applications.

- **Soil and Groundwater Contamination**. Faculty in the Program conduct research to characterize subsurface pollution and to understand the nature of bioremediation in contaminated soils, providing expertise in groundwater modeling, biological processes in the subsurface, and transport of particles and colloids in the subsurface. Faculty members have extensive field drilling and sampling experience, capabilities for innovative chemical and biological analysis in the laboratory, and have worked at numerous contaminated groundwater sites. Principal areas of study include the fate and transport of light nonaqueous phase liquids (LNAPLs) and associated soil gas, transport of solutes in heterogeneous media, soil vapor extraction and air sparging of volatile organic compounds, vapor-phase bioremediation, and field sampling techniques for assessing contaminated soils and groundwater. Related work has involved the impacts of road salt on ground and surface water. These studies have involved petroleum hydrocarbons, volatile halogenated solvents and simple organic acids.

- **Environmental Chemistry and Pollutant Analysis**. Members of the faculty have made important contributions to the field of environmental chemistry, especially in the areas of oxidation and complexation reactions in homogeneous aqueous systems, chemical analysis of organic oxidation byproducts in water, and measurement of VOC emissions from hazardous waste sites and POTWs. Fundamental research such as this is often conducted in parallel with applied studies. For example, a study supported by the USEPA showed that ozone would react with natural organic matter altering its complexation capacity for calcium and aluminum. This work was conducted in parallel with alum coagulation studies of colored surface waters, demonstrating the practical implications of the fundamental work.

- **Environmental Microbiology**. Work in environmental microbiology has focused on the microbial ecology of wastewater treatment systems, bioremediation of contaminated groundwater, control of drinking water pathogens such as viruses, *Cryptosporidium*, and *Giardia*, autotrophic biological reduction of nitrate and perchlorate, biological Fe(III) reduction for remediation of acid mine drainage sites and the study of soil microcosms containing petroleum hydrocarbons. Work has also been done on chemical transformations in biologically-active filters for drinking water treatment, and on improved bioassays for determining assimilable organic carbon (AOC) and biodegradable organic carbon.

- **Water Resources Engineering, Planning and Management.** Program faculty have conducted research on a variety of aspects relating to the quantity and quality of water. Research in the area of hydrologic studies has concentrated on natural processes and how knowledge of those processes can be incorporated into sound management policy that will foster improved environmental quality, reduce flood hazards, and address long-term hydrologic sustainability issues. Applications have included methods for design of groundwater remediation systems, and risk based strategies for prioritizing groundwater cleanups. Another research focus is on the impact of land use on surface water quality and the magnitude of flood events. Water quality modeling studies undertaken by faculty members have had important implications to water resources management. These include the fate and transport of active chlorine from disinfected wastewater discharges, the use of calcium magnesium acetate (CMA) as an environmentally beneficial road salt alternative, and land use management for reservoir water quality control. Ongoing projects include analysis of flow and contaminant transport at stream/aquifer boundaries, strategies for designing and monitoring stormwater flows, impacts of urbanization on flood frequency and severity, and identification of pathogenic contamination source-areas.

- **Numerical Modeling of Water Resource Systems**. Faculty in the program have been involved in development and use of a wide variety of mathematical models for water related problems. Numerical models for groundwater flow and solute transport have been constructed and used to support analysis at major groundwater contamination sites. Research into the efficacy of air sparging for groundwater remediation has been enhanced by the use of complex numerical models. Models have been used to study the growth of biofilms for application to both natural and engineered systems. Numerical models have been constructed of the response of coastal streams and flood plains to tidal forcing. Models of reservoir hydrodynamics and water quality have been applied to coliform and natural organic matter modeling for large drinking water reservoirs. Groundwater simulation models have been combined with optimization techniques to produce powerful tools for use by practitioners in the management of groundwater systems. A product of this research is a software package which is now distributed to the practitioner community through a web site (http://www.ecs.umass.edu/modofc/).

- **Environmental Geotechnology**. Faculty in the Environmental Engineering Program have worked closely with those in the Geotechnical Engineering Program in the Department on a number of research efforts. Research has included both laboratory and field studies of groundwater contaminant transport and reaction in the natural environment. Topics have included leaky underground storage tanks and appropriate assessment protocol, analysis of spilled aviation fuel plumes, and the impact of alternative highway deicers.

- **Air Pollution**. Program Faculty research in this area has focused on both laboratory and field studies of biofiltration and membrane systems for the control of volatile organic compound (VOC), NOx and odorous air emissions. Work has also been done on characterization and measurement of emissions from hazardous waste remediation sites and wastewater treatment plants.

Examples of Recently Funded Projects	**Funding Agency**
• Establishing Guidelines for the use of Ozone-GAC for Control of Endocrine Disruptors and Related Compounds in Water	MA Dept. of Environmental Protection
• Groundwater-Surface Water Interface Models	U.S. EPA w/ subcontract through UConn
• Salt Remediation Program	Massachusetts Highway Department
• Enhancements to Models for Groundwater Management	U.S. Geological Survey
• Chloramination Feasability Planning Study	CDM/Hazen & Sawyer, NYC Dept. of Environmental Protection
• Membrane Bioreactor Technology for Water Reuse in the Chemical Industry	National Environmental Technology Institute
• Watershed Management and Drinking Water Supply Research Instrumentation	National Science Foundation
• Water Quality in Massachusetts Reservoirs: Modeling, Watersheds, Source Water Protection	MA Dept. of Conservation and Recreation
• Highway Deicing Agent Impacts on Soil and Groundwater Quality	Massachusetts Highway Department
• Autotrophic Biological Denitrification with Hydrogen or Sulfur for Complete Removal of Nitrogen from Septic System Wastewater	NOAA/Cooperative Institute for Control and Estuarine Environmental Technology (CICEET)
• Blackstone River Assessment of Water Quality, Ecological Health, and Ecological Risk through Data Collection and Modeling	Upper Blackstone Water Pollution Abatement District
• Anaerobic Membrane Bioreactors for Treatment and Reclamation of Domestic Wastewater	National Science Foundation
• UMass Assistance to Risk Based Prioritization of Disinfection Byproducts	Awwa Research Foundation
• Optimizing the Generation and Capacity of Adsorptive Sites on Oxide Surfaces for Manganese Control	Awwa Research Foundation
• Biogeochemistry of Fe(III) and Sulfate Reduction in Extreme Acidic Environments	National Science Foundation
• Event-based Transport of Cryptosporidium , Giardia & Source-Specific Indicator Organisms from Agricultural and Residential Areas	Awwa Research Foundation
• Characterization of TOX Produced During Disinfection Processes	Awwa Research Foundation
• Distribution System Water Quality Modeling and Strategies for Control of Natural Organic Matter and Disinfection By Products	Aquarion Water Company of Connecticut
• An Investigation into Biosolids Sampling and Handling Methods for USEPA-Approved Microbial Detection Techniques	Water Environment Research Foundation

FACILITIES

Environmental Engineering Laboratories occupy approximately 13,000 square feet of newly (2004) constructed laboratory space. A very useful and detailed description of our facilities is available online at http://www.ecs.umass.edu/eve/facilities.html . The facilities include:

Instructional laboratories for aquatic chemistry, environmental microbiology, and environmental engineering process design.

Specialized research laboratories, bench scale apparatus for studying water and wastewater treatment processes, and biological reactors for studying aerobic and anaerobic treatment processes, and general microbiological and chemical equipment. Groundwater research laboratory capabilities include transport test stands for column degradation studies and soil microcosm analysis. Water resources computational laboratory capabilities include high speed computers, graphical display capabilities and a software library suitable for the modeling, design and management of water resource systems.

Analytical and Process Equipment available in the research laboratories include the following categories of instruments: General Laboratory Equipment, Process Equipment, Equipment For Sample Preparation, Electrochemistry, Spectroscopy, Chromatography, and numerous other instruments, including field instrumentation such as portable gas chromatographs.

Computing facilities are available for a wide variety of computational and spatial analysis environmental applications.

ADMISSION REQUIREMENTS

To be considered for admission by the Graduate School, the applicant must have a bachelor's degree in engineering or science areas from a college or university of recognized standing. Foreign students must have a bachelors degree in engineering. The Environmental Engineering Program does not assess an applicant's qualifications until all application materials are submitted. Additional requirements include the following:

- Official transcripts of all previous college work (undergraduate and graduate).
- At least two letters of recommendation submitted from former professors or persons in the field of the applicant's academic major.
- A Graduate Record Examination (Verbal, Quantitative, Analytical)
- Foreign students must take the Test of English as a Foreign Language (TOEFL).

Applications for admission may be obtained by writing to:

Graduate School
Goodell Building
Box 33290
University of Massachusetts
Amherst, MA 01003-3290

Or via the web at site http://www.umass.edu/gradschool/prospects.html.

If applying for the Professional Practice Option please note this on the application form as: Environmental Engineering – Prof. Practice Option.

All applicants are considered for financial aid by the Environmental Engineering Program, except for those specifically applying to the one year MS Professional Practice Option. No additional forms are required.

FINANCIAL AID

Financial aid is offered through research and teaching assistantships and fellowships. The exact number of these awards is subject to change depending upon renewal of grants, available Departmental support, and other factors. Assistantships provide a stipend plus a tuition waiver. The amount of the stipend depends on the type of research or teaching assistantship, the funding source, the degree being pursued and the student's experience and background. The tuition waiver exempts students from paying tuition and a portion of health fees, in effect, increasing the total value of an assistantship. The value of the tuition waiver (for 12 credits) depends on whether tuition is being considered at the in-state rate ($1320 per semester) or out-of-state rate ($4968 per semester). Students receiving a Research or Teaching Assistantship can not pursue the Professional Practice Option. The expected ranges of annual stipend levels, fees, and overall awards for incoming graduate students in Fall 2005 are shown below, based on out-of-state tuition rates:

Degree Sought	Typical Annual Stipend Range	Tuition Waived	Fees Waived[1]	Effective Annual Award
M.S.	$19,500 - $20,500	$9937	$7000	$35,937 - $37,437
Ph.D.	$21,000 - $25,000	$9937	$7000	$37,437 - $41,937

[1]Fees totaling approximately $1500 can not be waived and must be paid by the student.

We are especially pleased to receive applications from those students that traditionally have been under-represented in the field of Civil and Environmental Engineering, namely minorities and women. To help increase representation from under-represented groups, the Department pursues fellowships for minorities and women.

Factors of race, color, sex, age, religion, national origin, or handicap are not considered in the admission or treatment of students or in employment, in accordance with Federal and State laws and regulations.

APPENDIX A: COURSE DESCRIPTIONS

ENVIRONMENTAL ENGINEERING

CE-ENGIN 525 ENVIRONMENTAL GEOTECHNOLOGY (3 credits). Geotechnical Engineering related to environmental issues. Topics include: site investigation techniques for environmental drilling; site instrumentation procedures; groundwater sampling methods; methods of evaluating *in situ* and laboratory hydraulic conductivity for use in design; design of containment facilities; and current methods for addressing subsurface environmental problems. Written engineering reports.

CE-ENGIN 560 HYDROLOGY (3 credits). A quantitative account of elements of the hydrologic cycle, including precipitation, evapotranspiration, snowmelt, infiltration, and surface runoff. Basic laws from such various disciplines as physics, chemistry, meteorology, astronomy, fluid mechanics, and thermodynamics, combined into simple mathematical descriptions used in the hydrologic design process.

CE-ENGIN 561 OPEN-CHANNEL FLOW (3 credits). A rigorous mathematical study of flow in open channels, including uniform, gradually varied, rapidly varied, tidal, and flood flows. Analytical and numerical solutions to the governing conservation equations will be developed with the aid of the computer, and stable channel design addressed.

CE-ENGIN 572 ENVIRONMENTAL ENGINEERING ANALYSIS (3 credits). With lab. Basic concepts of physical and chemical parameters used to measure water quality in natural aquatic systems and in treatment plants. Laboratory covers important water analysis methods including gravimetric, volumetric, colorimetric, and alkalinity-acidity titration.

CE-ENGIN 573 ENVIRONMENTAL ENGINEERING MICROBIOLOGY (3 credits). With lab. Microbiological and biochemical properties of microorganisms important in environmental engineering practice. General fundamentals of environmental microbiology and their application to drinking water treatment and distribution, water pollution control, and natural systems.

CE-ENGIN 575 ADVANCED SOLID AND HAZARDOUS WASTE MANAGEMENT (3 credits). Introduction to municipal solid waste management and hazardous waste management. The relationship between the properties of wastes, the techniques and hardware used for waste handling and processing and the ultimate disposal (containment) of waste and other residual materials will be emphasized. Remediation of contaminated areas is also covered. The design of systems for the management and disposal of solid and hazardous wastes subject to economic factors, safety, reliability and ethical and social implications will be examined.

CE-ENGIN 577 SURFACE WATER QUALITY MODELING (3 credits). Evaluation and control of water quality in streams, lakes, and estuaries. Mathematical analyses of patterns of water movement and their relationship to water quality. Wasteload allocation design.

CE-ENGIN 579 AIR QUALITY (3 credits). The sources, fate, transport, and control of the major categories of air pollutants. Topics include: sources and characteristics of air pollutants; atmospheric chemistry and physics; effects of air pollutants on human health and the environment; global climate change; atmospheric dispersion modeling; and design of systems for the control of gaseous and particulate air pollutants.

CE-ENGIN 660 SUBSURFACE HYDRAULICS (3 credits). The transport of water through the unsaturated and saturated zone using rigorous mathematical theory, analytical and numerical solutions. Topics include hydraulic properties of soils, infiltration, confined and unconfined aquifer flow, consolidations, and well hydraulics.

CE-ENGIN 661 SUBSURFACE POLLUTION (3 credits). Transport of contaminants through the unsaturated and saturated zone using rigorous mathematical theory, analytical and numerical solutions. Topics include the fate and transport of conservative and reactive contaminants in single or multiphase flow fields.

CE-ENGIN 662 WATER RESOURCE SYSTEMS ANALYSIS (3 credits). Methods for designing and managing water resource systems. Methods include optimization, uncertainty and reliability analysis, economic and pricing analysis, water demand and drought planning, facility siting analysis. Applications to surface water, groundwater, water distribution, flood control and water quality control systems.

CE-ENGIN 668 PROFESSIONAL ENGINEERING PRACTICE CONCEPTS (2 credits). Discussion of the concerns and challenges of a professional engineer including project management, writing and presentation skills, negotiations, finance, ethics, organizational structure, and risk and liability.

CE-ENGIN 671 ENVIRONMENTAL BIOLOGICAL PROCESSES (4 credits). Overview of the fundamentals of microbiology and examination of biological processes used in environmental engineering including water and wastewater treatment, bioremediation and biological air pollution control. Laboratory experiments illustrate concepts in environmental microbiology.

CE-ENGIN 672 PHYSICAL AND CHEMICAL TREATMENT PROCESSES (4 credits). Lecture and lab. Fundamentals of physical and chemical processes used in environmental engineering. Applications include processes used in the treatment of drinking waters, industrial waters and wastewaters, municipal wastewaters, and hazardous waste remediation.

CE-ENGIN 679 ENGINEERING PROJECT (1-5 credits).

CE-ENGIN 680 WATER CHEMISTRY (4 credits). Chemical equilibrium principles of acids-bases, dissolution-precipitation, oxidation-reduction, and complexation are applied to understanding the chemistry of surface waters, groundwaters, and water and wastewater treatment.

CE-ENGIN 689 MASTER'S PROJECT (6 credits).

CE-ENGIN 690K ENVIRONMENTAL REACTION KINETICS (3 credits). Examination of the rates and kinetics of a range of chemical and biological systems important to Environmental Engineering. Fundamentals of kinetic theory are briefly covered and mathematical simulation of kinetic systems and analysis of kinetic data are covered.

CE-ENGIN 691, 692 SEMINAR (1 credit). Presentations by visiting lecturers and graduate students of selected current literature and research.

CE-ENGIN 696 INDEPENDENT STUDY (Variable credit)

CE-ENGIN 770 ENVIRONMENTAL ENGINEERING DESIGN (4 credits). Selection, evaluation, and design of environmental engineering processes and systems.

CE-ENGIN 772 INSTRUMENTAL METHODS IN ENVIRONMENTAL ANALYSIS (3 credits). Principles and techniques of instrumental chemical analysis, including molecular and atomic spectrophotometry, gas chromatography, mass spectrometry and electro-analytical methods. Emphasis on solving analytical problems of trace pollutants in water and wastewater. Two lecture hours and one laboratory.

CE-ENGIN 774 PROCESSES AT THE PARTICLE WATER-INTERFACE (3 credits). An analysis of physical and chemical aspects of the behavior of particles in aquatic systems. Topics include surface chemistry, adsorption, nucleation, precipitation, dissolution, forces between interacting surfaces, and the hydrodynamics of particle transport and deposition.

CE-ENGIN 776 BIOREMEDIATION OF CONTAMINATED SOILS AND GROUND WATER (3 credits). Application of biological processes as they are currently used to remediate conventional, industrial, and hazardous wastes. Fundamentals of microbial physiology and metabolism as applied to the major groups of hazardous chemicals. Both theory and design of remediation technologies are presented.

CE-ENGIN 778 PATHOGEN AND INDICATOR ORGANISM MICROBIOLOGY, (3 credits). This course will cover topics related to drinking water indicator organism and pathogen microbiology. Will focus on major groups of pathogens, their sources, their epidemiology, testing, and their indicators. Appropriate management and treatment technologies for prevention of pathogen transmission will also be covered.

CE-ENGIN 899 DOCTORAL DISSERTATION

APPENDIX B: Selected Faculty Publications

Adams, R. **Ahlfeld, D.P.**, and A. Sengupta, (2007) "Investigating the Potential for Ongoing Pollution from an Abandoned Pyrite Mine", *Mine Water and the Environment* 26: 2-13.

Ahlfeld, D.A., Barlow, P.M., and Mulligan, A.E. (2005), "GWM-A Ground-Water Management Process for the U.S. Geological Survey Modular Ground-Water Model (MODFLOW-2000),": U.S. Geological Survey Open-File Report 2005-1072, p. 124 (refereed).

Ahlfeld, D.P. and Mulligan, A.E. (2000), "Optimal Management of Flow in Groundwater Systems," *Academic Press*, San Diego, CA.

Ahlfeld, D.P., Joaquin, A., **Tobiason, J.E.** and Mas, D. (2003) "Case Study: Impact of Reservoir Stratification on Interflow Travel Time," *Journal of Hydraulic Engineering*, Vol. 129 (No. 12), pp. 966-975.

Barlow, P.M., **Ahlfeld, D.P**. and Dickerman, D.C. (2003) "Conjunctive-Management Models for Sustained Yield of Stream-Aquifer Systems," *Journal of Water Resources Planning and Management*, Vol. 129 (No. 1), pp. 35-48.

Bose P. and **Reckhow DA**. (2007) "The Effect of Ozonation on Natural Organic Matter Removal by Alum Coagulation". *Water Research*; 41: 1516-1524.

Edzwald, J.K., Tobiason, J.E., Udden, C., Kaminski, G.S., Dunn, H.J., Galant, P.B. and Kelley, M.B. (2003) "Impacts of the Recycle of Waste Filter Backwash Water on the Removal of *Cryptosporidium*," *Journal of Water Supply: Research and Technology – Aqua*, Vol. 52 (No. 4), pp. 243-258.

Ergas, S.J., Harrison, J., Bloom, J., Forloney, K., **Ahlfeld, D.P.,** Nüsslein, K., Yuretich, R.F. (2005) Chap. 7. Natural Attenuation of Acid Mine Drainage by Acidophilic and Acidotolerant Fe(III)- and Sulfate-Reducing Bacteria, in *Remediation of Hazardous Waste in the Subsurface: Bridging Flask and Field Studies*, C. Clark II and A. Lindner (eds.), American Chemical Society Symposium Series No. 940, American Chemical Society, Washington DC.

Ergas, S.J. and Rheinheimer, D.E. (2004) "Drinking Water Denitrification Using a Membrane Bioreactor," *Water Research*, Vol. 38(14-15), pp. 3225-3232.

Ergas, S.J., B.M. Therriault and **D.A. Reckhow** (2006) "Evaluation of Water Reuse Technologies for the Textile Industry", *ASCE Journal of Environmental Engineering*, 132:3:315-323.

Garvey, E. and **Tobiason, J.E.**, (2003) "Relationships Between Measures of Natural Organic Matter in Quabbin Watershed," *Journal American Water Works Association*, Vol. 95, No. 11, pp. 73-84, 2003.

Hua, G and **Reckhow, D.A**., "Determination of TOCl, TOBr, and TOI in Drinking Water by Pyrolysis and Off-line Ion Chromatography," *Anal. Bioanal. Chem*. 384:2:495-504 (2006).

Hua, G., **DA Reckhow**, and J. Kim (2006) "Effect of Bromide and Iodide Ions on the Formation and Speciation of Disinfection Byproducts During Chlorination," *Environmental Science and Technology*. 40: 3050-3056.

Hua, G. and **Reckhow D A**. (2007) "Comparison of disinfection byproduct formation from chlorine and alternative disinfectants." *Water Research*, 41:8:1667-1678.

Hua, G. and **Reckhow D. A**. Characterization of Disinfection Byproduct Precursors Based on Hydrophobicity and Molecular Size. *Environmental Science and Technology* 41:9:3309-3315 (2007).

Kennedy, M.G., **Ahlfeld, D.P.,** Schmidt, D.P and **Tobiason, J.E**., (2006) "Three Dimensional Modeling for Estimation of Hydraulic Retention Time in a Reservoir", *Journal of Environmental Engineering (ASCE)*, Vol. 132, No. 9, pp. 976-984.

Kim, J. and **Tobiason, J.E**., (2004) "Particles in Filter Effluent: The Roles of Deposition and Detachment", *Environmental Science & Technology*, Vol. 38, No. 22, pp. 6132-6138.

Leshem, E.N., Pines, D.S., **Ergas, S.J**. and **Reckhow, D.A.** (2006) "Electrochemical Oxidation and Ozonation for Textile Wastewater Reuse," *J. Environmental Engineering, ASCE*, 132(3):324-330.

Linden KG, **Rosenfeldt EJ**, Kullman SW, (2007) UV/H_2O_2 degradation of endocrine-disrupting chemicals in water evaluated via toxicity assays. *Water Science and Technology*, 55(12): 313-319.

Mas, D.M.L. and **D.P. Ahlfeld**, (2007) "Comparing artificial neural networks and regression models for predicting fecal coliform concentrations." *Hydrologic Sciences Journal*, Vol. 52, No. 4, pp. 713-731.

Mercer, K. and **Tobiason, J.E**., (2007) "Chemical Treatment for Management of Membrane Concentrate", in *Chemical Water and Wastewater Treatment IX*, H.H. Hahn, E. Hoffman and H. Ødegaard, editors. Proceedings of the 12th Gothenburg Symposium, 20-23 May, 2007, Ljubljana, Slovenia, IWA Publishing, London, pp. 307-315.

Min, K. and **S.J. Ergas** (2006) Volatilization and Biodegradation of VOCs in Membrane Bioreactors, *J. Water, Air and Soil Pollution*, 6:83-96.

Morgan-Sagastume, J.M., Noyola, A., Revah, S. and **Ergas, S.J.** (2002) "Changes in Physical Structure of a Compost Biofilter Treating H_2S," *J. Air & Waste Management Assoc.*, Vol. 53 (No. 8), pp. 1011-1021.

Nevin, K.P., Holmes, D.E., Woodard, T.L., Hinlein, E.S., **Ostendorf, D.W**., and Lovley, D.R. (2005), "*Geobacter bemidjiensis* sp. nov. and *Geobacter psychrophilus* sp. nov., Two Novel Fe(III) Reducing Subsurface Isolates," *International Journal of Systematic and Evolutionary Microbiology*, Vol. 55, pp. 1667-1674.

Novak, J.T. and **Park, C**. (2004). Chemical conditioning of sludge. *Water Science and Technology*, 49, 73-80.

Novak, J.T., **Park, C.,** and Abu-Orf, M.M. (2004). "Conditioning and dewatering of digested waste activated sludges". *Journal of Residuals Science and Technology*, 1, 40-51.

Ostendorf, D.W., DeGroot, D.J., and Dunaj, P.J. (2007), "Water Hammer Dissipation in Pneumatic Slug Tests", *Water Resources Research*, Vol. 43, W02413, doi:10.1029/2005WR004817.

Ostendorf, D.W., Hinlein, E.S., **Ahlfeld, D.P.,** and DeJong, J.T. (2006), "Calibrated Models of Deicing Agent Solids, Pavement Texture, and Specific Conductivity of Highway Runoff," *Journal of Environmental Engineering*, Vol. 132, pp. 1562-1571

Ostendorf, D.W., Hinlein, E.S., Rotaru, C., and DeGroot, D.J. (2006), "Contamination of Groundwater by Outdoor Highway Deicing Agent Storage," *Journal of Hydrology*, Vol. 326, pp. 109-121.

Ostendorf, D.W., Rees, P.L.S., Kelley, S.P., and Lutenegger, A.J. (2004), "Steady, Annual, and Monthly Recharge Implied by Deep Unconfined Aquifer Flow," *Journal of Hydrology*, Vol. 290, pp. 259-274.

Ostendorf, D.W., Schoenberg, T.H., Hinlein, E.S., and Long, S.C. (2007), "Monod Kinetics for Aerobic Biodegradation of Petroleum Hydrocarbons in Unsaturated Soil Microcosms," *Environmental Science and Technology*, Vol. 41, pp. 2343-2349, doi:10.1021/es062313l.

Ostendorf, D.W., DeGroot, D.J., and Hinlein, E.S. (2007), "Unconfined Aquifer Response to Infiltration Basins and Shallow Pump Tests," *Journal of Hydrology*, Vol. 338, pp. 132-144.

Park, C. and Novak, J.T. (2007) Characterization of activated sludge exocellular polymers using several cation-associated extraction methods. *Water Research*. 41, 1679-1688.

Park, C., Muller, C.D., Abu-Orf, M.M., and Novak, J.T. (2006). The effect of wastewater cations on activated sludge characteristics: effects of aluminum and iron in floc. *Water Environment Research*, 78, 31-40.

Park, C., Abu-Orf, M.M., and Novak, J.T. (2006). The digestibility of waste activated sludges. *Water Environment Research*, 78, 59-68.

Persson, F., Långmark, J., Heinicke, G., Hedberg, T., **Tobiason, J.,** Stenström, T. and Hermansson, M., (2005) "Characterisation of the behavior of particles in biofilters for pre-treatment of drinking water", *Water Research*, Vol. 39, No. 16, pp. 3791-3800.

Pines, D.S., Min, K-N, **Reckhow, D.A.** and **Ergas, S.J.** (2004) "Investigation of Ozone Membrane Contactor," *Ozone Science & Engineering*, Vol. 27, pp. 209-217.

Pines, D.S., **Reckhow, D.A.** (2003) "Solid Phase Catalytic Ozonation Process for the Destruction of a Model Pollutant," *Ozone Science & Engineering,* Vol. 25 (No. 1), pp. 25-39.

Rosenfeldt EJ, Chen PJ, Kullman SW, Linden KG (2007) "Destruction of estrogenic activity in water using UV advanced oxidation." *Science of the Total Environment*, 377 (1): 105-113

Rosenfeldt EJ, Linden, KG (2007) "The $R_{OH,UV}$ concept to characterize and model UV/H_2O_2 process in natural waters." *Environmental Science and Technology*, 41 (7): 2548-2553

Rosenfeldt, EJ, Cononica S, Linden KG, von Gunten U. (2006) Comparison of ozone, low pressure UV + H_2O_2 and medium pressure UV + H_2O_2 for OH radical production in a batch system. *Water Research* 40 (20) 3695-3704

Rosenfeldt EJ, Linden KG (2005) "UV and UV/H_2O_2 treatment of Methylisoborneol (MIB) and Geosmin at environmental concentrations in water" *Journal of Water Supply Research and Technology* 54 (7) 423-434.

Rosenfeldt EJ, Linden KG (2004) Destruction of endocrine disrupting chemicals in water with direct UV and UV/H_2O_2 advanced oxidation *Environmental Science and Technology* 38 (20) 5476-5483.

Sengupta, S., **Ergas, S.J.**, Lopez-Luna, E., Wood, J., Sahu, A.K., Palaniswamy, K. (2006) Autotrophic biological denitrification for complete removal of nitrogen from septic system wastewater, *J. Water, Air, Soil Pollution*, 6(1-2):111-126.

Sturdevant Rees, P.L., Smith, J.A., Egorova, J. and Baeck, M.L., (2001) "Flood Hydrology of the Central Appalachians: Hurricane Fran," , *Water Resources Research*, 37(8), pp. 2143 – 2168.

Sturdevant Rees, P. L., S.C. Long, P.K. Barten, R. Baker, D. Bourdeau (2006) *Development of Event-Based Pathogen Monitoring Strategies for Watersheds.* Awwa Research Foundation, Denver, CO, 255 pp.

Tobiason, J.E., Edzwald, J.K., Gilani, V., Kaminski, G.S., Dunn, H.J. and Galant, P.B. (2003) "Effects of Waste Filter Backwash Recycle Operation on Clarification and Filtration," *Journal of Water Supply: Research and Technology – AQUA*, Vol. 52 (No. 4), pp.259-276.

Watts MJ, **Rosenfeldt EJ**, Linden KG (2007) Comparing OH radical formation by UV irradiation of H_2O_2 (AOP) and HOCl. Article accepted in *Journal of Water Supply Research and Technology*, May, 2007.