DEPARTMENT OF
CIVIL & ENVIRONMENTAL
ENGINEERING

GRADUATE STUDY

IN

ENVIRONMENTAL AND WATER RESOURCES ENGINEERING

2014-2015 Academic Year

COLLEGE OF ENGINEERING
UNIVERSITY OF MASSACHUSETTS at AMHERST

PREFACE

Since 1964 over 550 sanitary and environmental engineers have graduated with M.S. and Ph.D. degrees from the Environmental and Water Resources 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 2014, the Program consists of ten core faculty members, and about 45 students pursuing advanced degrees in environmental and water resources engineering. Most of our students are supported through research assistantships, fellowships, and teaching assistantships. Our Program enjoys an excellent national reputation.

This document describes opportunities for graduate study in the Environmental and Water Resources Engineering (EWRE) 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 document.; additional information can be found on our web site: cee.umass.edu/cee/graduate/ewre or by contacting: David Reckhow, Environmental and Water Resources Engineering Program Director, email: reckhow@ecs.umass.edu

TABLE OF CONTENTS

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 nine teaching 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 …

The vast majority of our students receive some form of financial aid. This aid is usually 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 24,000 students, including 5,000 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 time.

FACULTY

The Graduate Faculty in the Environmental and Water Resources 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://cee.umass.edu/faculty-by-area .

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.

Casey Brown, Associate Professor (2008)

B.S.	University of Notre Dame	Civil Engineering	1993
M.S.	University of Massachusetts	Environmental Engineering	1994
Ph.D.	Harvard University	Environmental Engineering Science	2004

Water resources engineering; climate informed flood risk estimation and proactive management; water allocation for multi-use reservoirs; hydroclimate information for climate risk management.

Caitlyn Butler, Assistant Professor (2011)

B.S.	Smith College	Engineering Science	2004
Ph.D.	University of Notre Dame	Civil Engineering	2010

Biofilm processes for water and wastewater treatment, bioelectrochemical systems for removal of organic and oxidized contaminants, microbial community structure and function of electrode-associated biofilms.

Boris Lau, Assistant Professor (2014)

B.S.	McGill University	Engineering Science & Bio	2000
M.S.	University of Wisconsin	Environmental Engineering	2002
Ph.D.	University of Wisconsin	Environmental Engineering	2005

Fate and Transport of nanoparticles in natural and engineered aquatic systems. Stability and mobility of colloids, role of surfaces in particle removal Mechanisms and kinetics of particle aggregation and deposition Adsorption capacity and affinity as a function of size-structure-reactivity interrelationships

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.

Richard N. Palmer, Professor and Department Head (2008)

B.S.E.	Lamar University	Civil Engineering	1972
M.S.	Stanford University	Civil Engineering	1973
Ph.D.	Johns Hopkins University	Civil Engineering	1979

Impacts of Climate Change on Water Resources, Water Resources Planning, Drought Management, Flood Management, Expert Systems, Risk Analysis, Optimization and Simulation Modeling of Engineering Systems

Chul Park, Associate 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

Mi-Hyun Park, Assistant Professor (2008)

B.E.	Inha University	Environmental Engineering	1996
M.S.	Imperial College	Civil and Environmental Engineering	1998
M.E.	KAIST	Civil Engineering	1999
M.S.	Imperial College	Computer Science	2001
Ph.D.	UCLA	Civil and Environmental Engineering	2004

Environmental remote sensing; surface water quality modeling using satellite imagery and GIS; urban watershed management and sustainability; Environmental informatics; Distributed sensor networks in water infrastructures; Decision support systems for surface water resource management using Bayesian networks

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.

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 June 2006)

Currently Technical Editor, 6th edition, Water Quality and Treatment (2010), AWWA.

Michael S. Switzenbaum (retired August 2003)

Currently Professor and Executive Associate Dean, College of Engineering, Marquette University, 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:

Kathleen Arcaro, Professor of Veterinary and Animal Science

Ph.D. Rutgers University Animal Behavior 1987

Watershed structure and function.

Paul K. Barten, Professor of Environmental Conservation

Ph.D. University of Minnesota Forestry 1988

Watershed structure and function.

Sarina J. Ergas, Professor of Civil and Environmental Engineering, Univ. of South Florida

Ph.D. University of California at Davis Civil and Environmental Eng. 1993

Adjunct Professor, UMass, Amherst, CEE Dept. 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

Don J. DeGroot, 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 Sciences

Ph.D. University of Wisconsin Microbiology 1986

Environmental microbiology.

Derek Lovely, Professor of Microbiology

Ph.D. Michigan State University Microbiology 1982

Environmental microbiology

Klaus R.L. Nusslein, Professor of Microbiology

Ph.D.	Michigan State University	Microbiology	1998

Genetic diversity and population dynamics of microorganisms

Erik J. Rosenfeldt, PhD, PE, Hazen & Sawyer Engineers

Ph.D.	Duke University	Environmental Engineering	2007

Adjunct Professor, UMass Amherst, CEE Dept. Advanced oxidation processes

Bret Towler, Adjunct Professor of Civil and Environmental Engineering

Ph.D.	Montana State Univ.	Engineering	2004

Fish passage, fish ladders, hydraulic engineering, surface water hydrology

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 and Water Resources Engineering Program are to educate engineers capable of addressing both current and future environmental and water resource problems, engage 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). There are two options for the MS degrees: a research option and a coursework option. The specific degree requirements and the appropriate degree depend on your undergraduate background and if the degree is research-based or not. A general description of each of the degree programs follows.

MS Degrees

Two main paths and two degree options are available for obtaining the M.S. degree through the Environmental and Water Resources Engineering Program. The two paths are:

A. Research Option
B. Coursework Option

The two degree options are:

1. MS in Environmental Engineering
2. MS in Civil Engineering

The research option is usually followed by students receiving financial support in the form of a research or teaching assistantship (RA, TA). The coursework option is designed to be completed in 9 to 12 months; students pursuing this option cannot be recepients of a full RA. Students who have been admitted into the Program without an engineering baccalaureate must make up prerequisite coursework at the basic level of undergraduate engineering in order to be eligible for the M.S. degree; no graduate credit is granted for this basic level work.

The M.S. in Environmental Engineering option (abbreviated MS EVE) is intended for students who have taken at least one of the graduate process engineering courses (CEE 671 or 672). This degree has, until 2010, been our ABET accredited degree, reserved for Environmental Engineering students with Baccalaureate degrees from US institutions. Since our decision not to seek ABET accreditation for our graduate degree, the MS EVE has been made available to all MS candidates, regardless of their undergraduate degree. However, it retains an association with our historical process engineering roots, and therefore requires CEE 671 or 672. The M.S. in Civil Engineering is offered to all students who meet the MS requirements, including those who choose not to take any of the advanced process engineering courses. In addition, there is the specialization in Fish Passage Engineering. If a student takes the required courses for this (i.e., CEE 560, 561 or 577, 597F, 597P and 2 credits of related work), a Letter of Specialization is awarded in addition to the M.S. diploma.

An overview of requirements for the 31 credit hour M.S. degrees in Environmental or Civil Engineering is described below. Full details are available in the "Environmental and Water Resources Engineering Program Information, Procedures and Advising Manual." In addition, the general UMass Graduate School requirements for the M.S. Degree must be met.

Coursework for the MS degree is very flexible based on the student's interests; as there are only two required courses (five credits). Students may study EWRE in general, or focus in areas such as water and wastewater treatment processes, water resource systems, or fish passage engineering and ecohydrology. At the start of the first semester, students work with their advisor to plan their program of study for the ensuing two to four semesters; revisions are made based on changing student interests and course availability.

A. 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. MS students receiving financial support in the form of a research assistantship, teaching assistantship, or fellowship take the Research Option. 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 670	Transport Processes in EWRE	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 assistantship duties. Six credits, taken as CEE 689, must be earned under the Master's Project and are applied to the 31 total credit requirement of the MS degree.

*** <u>Electives</u>**
In addition to the Core Courses and Master's Project, the student completes a minimum of twenty 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 at another institution.

B. Coursework Option:

The coursework option is designed to be completed in 9 to 12 months, and therefore it is not intended for those receiving an assistantship or research fellowship

- **Core Courses**. The core courses are the same as listed for the Research Option.

- **Electives**. There must be at least 26 credits of graduate electives (500 or higher level). At least 7 of these credits must be at the 600 level or higher to meet the UMass Graduate School MS degree requirement of at least 12 graduate credits at the 600 level or higher (the 5 credits of required courses are all at the 600 or higher level). 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 at another institution.

C. Students with Non-Engineering Baccalaureate

Some 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) or mathematics to be admitted. To be awarded an MS degree, students without a BS in engineering degree must make up prerequisite coursework at the undergraduate level; this coursework does not receive graduate credit. The coursework can be completed prior to entering, or in some cases, during, the student's UMass MS program. A summary of these prerequisites is shown below.

Required prerequisite courses/subjects for MS in Environmental Engineering degree program:
- Mathematics: Calculus I, II and III (multivariate) and Differential Equations
- Probability and Statistics
- Biology (one semester)
- Chemistry (usually two semesters)
- Physics (usually two semesters, calculus based level)
- Thermodynamics
- Engineering economics (as in a systems engineering course, or similar)
- Statics
- Fluid Mechanics
- Introductory EWRE course(s) (CEE 370 or equivalent)

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 and water resources engineering, or a solution to an existing problem. It also provides students with the opportunity to obtain the credentials in the environmental and water resources engineering profession needed to practice engineering at the highest level. Graduates of the PhD program are sought by a variety of employers, including those in industry, consulting and higher education. For example, graduates of our program currently hold 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, University of New Haven and Worcester Polytechnic Institute.

Individual PhD programs are specially designed to reflect the interests and needs of each PhD candidate. Before being admitted to the PhD program the student normally must hold a BS or an MS degree in environmental engineering or a similar field. In addition to the doctoral degree requirements of the Civil and Environmental Engineering Department and the UMass Graduate School concerning admission, residency, dissertation, and examinations, the EWRE 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; the remaining 12 are chosen to support the student's research and academic interests. For students entering the PhD program without an MS degree, or with an MS degree in an unrelated field, the minimum coursework requirement is normally 43 credits (25 + 18). In addition, students are required to earn at least 18 dissertation credits.

To earn the PhD degree students must complete the following milestones. The Preliminary Comprehensive Examination is administered after all or nearly all of the coursework for the PhD program has been completed (e.g., usually following 2 or 3 semesters of coursework for students already having a related MS degree). The exam includes written and oral components and must be successfully completed for the student to continue in the program. The student must then prepare and defend a Dissertation Prospectus before their dissertation committee. No sooner than 7 months after a successful prospectus defense, the student must make a final presentation and defense of their dissertation. In general, the overall duration for earning a PhD degree is typically four years beyond the MS degree.

RESEARCH ACTIVITIES

EWRE graduate students are deeply involved in research and work closely with faculty. The Environmental and Water Resources Engineering Program has an active research program with annual research expenditures of over $2,000,000. The EWRE Program maintains an extensive and modern laboratory of over 13,000 square feet. These analytical and computational resources support the Program's research efforts, directed along experimental and theoretical lines towards diverse problems in water and wastewater treatment, environmental chemistry and microbiology, groundwater and hazardous wastes, and water resources. 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. More information about the facilities, projects and faculty of the Environmental and Water Resources Engineering Research Group can be found online at http://cee.umass.edu/cee/graduate/ewre/ .

- **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.

- **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 contaminants 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. The group uses small scale and large-scale mathematical models, simulation tools, disciplined planning approaches, and mediation techniques to explore complex issues in the field of water resources. These issues include the relationship between water, climate and economic development and the management of climate risk in infrastructure systems. During the past decade the group has had the opportunity to work on water resource problems and conflicts in nearly every region in the United States, from Florida to Washington and California to Massachusetts. They have also applied their research internationally in Korea, Jordan, Mexico, and in portions of Africa, including the Nile River. Other 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.

Examples of Recent Funded Projects	**Funding Agency**
Establishing Guidelines for the use of Ozone-GAC for Control of Endocrine Disruptors and Related Compounds in Water	Water Research Foundation/MA Dept. of Environmental Protection/AECOM
Groundwater-Surface Water Interface Models	U.S. EPA w/ subcontract through UConn
Salt Remediation Program	Massachusetts Department of Transportation
Enhancements to Models for Groundwater Management	U.S. Geological Survey
Chloramination Feasibility Planning Study	CDM/Hazen & Sawyer, NYC Dept. of Environmental Protection
A Novel Method for Biological Perchlorate Reduction Using Elemental Sulfur as an Electron Donor	National Science Foundation
Evaluating Reservoir Operations and the Impacts of Climate Change in the Connecticut River Basin	The Nature Conservancy
Water Quality in Massachusetts Reservoirs: Modeling, Watersheds, Source Water Protection	MA Dept. of Conservation and Recreation
Phenotypic characteristics of activated sludge generated under different feeding conditions and implications for wastewater treatment performance and sludge treatment	UMass Faculty Research Grant/Healy Endowment Grant
Regenerating Spent Zeolites used to Remove Endocrine Disrupting Compounds from Drinking Water with UV and UV/H_2O_2 Processes	UMass Faculty Research Grant/Healy Endowment Grant
Fate of Non-regulated DBPs in Distribution Systems	Water Research Foundation
Robust Water Management for Ecohydrologic Sustainability under Climate Uncertainty	National Science Foundation CAREER Award (C. Brown)
Adaptive Management Planning for the International Upper Great Lakes Study	US Army Corps of Engineers
UMass Assistance to Risk Based Prioritization of Disinfection Byproducts	Water Research Foundation
Chemical Treatment of Ion-Exchange Regenerant	MWH Americas Inc./Solano County Water Authority
Natural attenuation of Ethylene Dibromide at MMR	US Air Force Center for Engineering and the Environment
Role of DON in Fouling of Low Pressure Membranes	Water Research Foundation
EDC/PPCP Benchmarking and Monitoring for Drinking Water Utilities	Water Research Foundation
Control of Manganese, Natural Organic Matter and Disinfection By-Products for Mystic, CT	Aquarion Water Company of Connecticut
Assessment of Hydroclimatic Variability Effects on Economic Growth in Sub-Saharan Africa	World Bank
Investigation of advanced adsorbent for arsenic and phosphorous removal	Dankook University
Assessing Climate Risk to Water and Food Security in the Indus River Basin.	The World Bank
Transforming Our Cities: High Performance Green Infrastructure.	Water Environment Research Foundation
Collaborative Development of Climate Information for the Connecticut River Basin using Shared Vision Forecasting.	NOAA
RISA: Climate Consortium for the Urban Northeast	NOAA
Investigation of advanced adsorbent for arsenic and phosphorous removal	Dankook University, Korea Association of Industry, Academy, and Research
Assessing the effects of conventional and advanced nitrogen removal wastewater treatment on receiving water eutrophication	Springfield Water and Sewer Commission
Pilot-scale operation of algae photobioreactor and anaerobic digester at Frevar, Fedrikstad, Norway	Aquateam
A New sludge and nutrient reduction method for wastewater treatment	CVIP Technology Development Award, University of Massachusetts Amherst

FACILITIES

Environmental Engineering Laboratories occupy approximately 13,000 square feet of recently (2004) constructed laboratory space. A very useful and detailed description of our facilities is available online at http://cee.umass.edu/cee/graduate/ewre/research-facilities . 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, mass spectrometry 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 into the CEE Department and the EWRE Program 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. The Environmental and Water Resources 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) within the last 5 years.
- Foreign students must take the Test of English as a Foreign Language (TOEFL) or the IELTS.

The application process is entirely online at the UMass Graduate School web site at: http://www.umass.edu/gradschool/prospective_student_online_application.htm . Applicants should select the Civil Engineering area and the Environmental and Water Resources Engineering sub-area, under either the MS or PhD degree option. Students without an MS degree who are interested in a PhD degree may elect to apply directly for the PhD, or they may select the MS degree option and indicate their desire to pursue a PhD in their personal statement. While not required, the MS degree path is excellent preparation for the preliminary comprehensive PhD examinations and can be fast-tracked.

Successful applicants must demonstrate a strong academic record through their GRE scores, undergraduate or graduate GPA, letters of recommendation and personal statement. There are no firm minimum criteria for standardized testing scores, however, our typical accepted applicant pool has mean verbal GRE scores of 560 (157 new scale) and quantitative GRE scores of 770 (162 new scale). For those who's native language is not English, we note mean TOEFL scores of about 95 (80 is the minimum accepted by the UMass Graduate School). The typical mean GPA for accepted applicants is about 3.4, although this is highly dependent on the Institution and program.

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FINANCIAL AID

All applicants are considered for financial aid by the Environmental and Water Resources Engineering Program, except for those specifically applying to the one year Coursework Option MS. No additional forms are required. 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 Coursework Option. As an example, the ranges of annual stipend levels, fees, and overall awards for incoming graduate students in Fall 2012 are shown below, based on out-of-state tuition rates. Current rates a bit higher through cost of living increases.

Degree Sought	Typical Annual Stipend Range	Tuition Waived	Fees Waived[1]	Effective Annual Award
M.S.	$21,133 - $24,000	$9937	$18,315	$49,384 - $52,252
Ph.D.	$22,000 - $26,000	$9937	$18,315	$50,252 - $54,252

[1]Fees totaling between $1000 and $2000 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

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 597G GIS for ENGINEERS (3 credits). Principles of geographic information systems (GIS) and spatial analysis for engineering application. Topics include data structures and manipulation, topology, and attribute information. Use of spatial data for mapping and spatial analysis to address real world problems.

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 670 TRANSPORT PROCESSES IN ENVIRONMENTAL AND WATER RESOURCES ENGINEERING (4 credits) Transport of fluids and constituents in environmental systems. Advection, diffusion, dispersion, zero and first-order reaction principles and kinetics and equilibrium partitioning processes. Mathematical models solved with analytical and numerical methods. Multi-scale application to surface and subsurface waters and the atmosphere.

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 684 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 689 MASTER'S PROJECT (6 credits). Research toward an MS thesis or report. The particular program is tailored to the student’s interest and the requirements of the research assistantship, if there is one. The student prepares a report or thesis and makes at least 2 public presentations (EWRE seminar and MS defense).

CE-ENGIN 690R REMOTE SENSING IN ENVIRONMENTAL ENGINEERING (3 credits) Introduction to the fast-growing field of remote sensing from space. The course covers physical concepts and other aspects of remote sensing including: characteristics of electromagnetic spectrum and remote sensing devices, digital processing methods for interpreting, manipulating and analyzing remotely-sensed image data, and application of satellite imagery to environmental monitoring.

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 697CC - CLIMATE CHANGE AND THE URBAN ENVIRONMENT (1 credit) This 1 credit seminar explores the impact of climate change on the urban environment. Topics range from models of regional and local governance in adaptation to climate change to economic climate policy options to renewable energy solutions. Five speakers from various academic disciplines, as well as private business, will present different visions of impacts and how they can be addressed. Course grades are based on class room participation and student facilitated discussions on issues addressed by the speakers as well as assigned readings

CE –ENGIN 697R - WATER RESOURCES PLANNING (3 credits) This course prepares graduate students for the challenges they will encounter in working in the field of water resources planning. Students are introduced to fundamental water resources concepts, review current issues driving water resources today, and develop a team project, to apply what they have learned in a semester long project. The project requires that the students create a planning report that forecasts water supply demands and availability for a mythical city (Fairweather) that has recently suffered water shortages and that is concerned about the future impacts of climate change.

CEE-ENGIN 697x ADVANCED TOPICS IN WATER QUALITY AND PROCESS ENGINEERING. (1 Credit). Graduate level course on reading and analyzing current literature in the field of water quality, water and wastewater treatment, and aquatic systems modeling

CEE-ENGIN 697z ORGANIC COMPOUNDS IN WATER AND WASTEWATER. (3 CreditS). Graduate level course on natural and anthropogenic organic compounds in water. Covers occurrence, origin, transformations, modeling and impacts on human and ecological health.

CE-ENGIN 770/771 ENVIRONMENTAL AND WATER RESOURCES ENGINEERING DESIGN (2 credits). Selection, evaluation, and design of environmental and water resources engineering 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 (variable) Research toward a PhD dissertation. The particular program is tailored to the student’s interest and the requirements of the research assistantship, if there is one. The student prepares research papers for publication, a dissertation and makes at least 2 public presentations (EWRE seminar and dissertation defense).

APPENDIX B: Selected Faculty Publications Since 2005

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 Baro-Montes, G. (2008), "Solving Unconfined Groundwater Flow Management Problems with Successive Linear Programming", *Journal of Water Resources Planning and Management*, Vol. 134, No. 5.

Ahlfeld, D.P. and Laverty, M.M. (2011) Analytical solutions for minimization of energy use for groundwater pumping. Water Resources Research 47.

Alemu, E.T., **Palmer, R.N**., Polebitski, A. and Meaker, B. (2011) Decision Support System for Optimizing Reservoir Operations Using Ensemble Streamflow Predictions. Journal of Water Resources Planning and Management-ASCE 137(1), 72-82.

Battin, J., Wiley, M.W., Ruckelshaus, M.H., **Palmer, R.N.**, Korb, E., Bartz, K.K., and Imaki, H., (2006) Projected impacts of future climate change on salmon habitat restoration actions in a Puget Sound river, Proceedings of the National Academy of Sciences, 104:6720-6725.

Block, P., and **Brown, C**. (2008). "Does climate matter? Evaluating the effects of climate change on future Ethiopian hydropower." *Proceedings of the Third Interagency Conference on Research in Watersheds*, Estes Park, CO.

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

Brown, C. (2010). "The End of Reliability." *ASCE Journal of Water Resources Planning and Management*, 136, No. 3, 2010 (May/June 2010).

Brown, C. and M. Carriquiry, (2007) "Managing hydroclimatic risk with option contracts and reservoir index insurance," *Water Resources Research*, 43 (11).

Brown, C. and U. Lall. (2006) "Water and Economic Development: The Role of Variability and a Framework for Resilience," *Natural Resources Forum* 30: 4, 306 – 317. doi:10.1111/j.1477-8947.2006.00118.x

Brown, C., Meeks, R., Hunu, K., and Yu, W. (2010). "Hydroclimatic risk to economic growth in Sub-Saharan Africa" *Climatic Change*, DOI: 10.1007/s10584-010-9956-9.

Brown, C. and P. Rogers. (2006) "Effect of Forecast-based Pricing on Irrigated Agriculture: A Simulation," *ASCE Journal of Water Resources Planning and Management* 122, 6, pp. 403-413.

Brown, C., Werick, W., Fay, D., and Leger, W. (2011) "A Decision Analytic Approach to Managing Climate Risks - Application to the Upper Great Lakes" Journal of the American Water Resources Association (*in press*).

Bull, R.J., **Reckhow, D.A**., (2008) "Use of chemical models and structure-activity relationships to identify novel disinfection by-products of potential toxicological concern," pp. 51-64 in Occurrence, Formation, Health Effects and Control of Disinfection Byproducts in Drinking Water, T. Karanfil, S.W. Krasner, P. Westerhoff and Y. Xie, editors, ACS Symposium Series 995, American Chemical Society.

Bull, R.J., **Reckhow, D.A**., Li, X.F., Humpage, A.R., Joll, C. and Hrudey, S.E. (2011) Potential carcinogenic hazards of non-regulated disinfection by-products: Haloquinones, halo-cyclopentene and cyclohexene derivatives, N-halamines, halonitriles, and heterocyclic amines. Toxicology 286(1-3), 1-19.

Butler, C., Clauwaert, P., Green, S., Verstraete, W., Nerenberg, R., Bioelectrochemical Perchlorate Reduction in a Microbial Fuel Cell, Environmental Science and Technology, Vol. 44, No. 12, May 2010

Butler, C.. and Nerenberg, R., Microbial Fuel Cell Performance and Microbial Ecology as a function of Air-Cathode Materials, Applied Microbiology and Biotechnology, Vol. 86, No. 5, April 2010

Chon, D.H., Rome, M., Kim, H.S., and **Park, C**. (2011) Investigating the mechanism of sludge reduction in activated sludge with an anaerobic side-stream reactor. *Water Science and Technology*. 63 (1), 93-99.

Clauwaert, P., Desloover, J., **Shea, C.**, Nerenberg, R., Boon, N., Verstraete, W. Enhanced Nitrogen Removal in Bio-Electrochemical Systems by pH control, Biotechnology Letters Vol. 31, No 6, June 2009

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., 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.

Eum, H.I., Kim, Y.O. and **Palmer, R.N**. (2011) Optimal Drought Management Using Sampling Stochastic Dynamic Programming with a Hedging Rule. Journal of Water Resources Planning and Management-Asce 137(1), 113-122.

Ghile, Y., Schulze, R. and **Brown, C**. (2010). Evaluating the performance of ground-based and remotely sensed near real-time rainfall fields from a hydrologic perspective. *Hydrologic Sciences Journal*, 55(4), 497 – 511.

Ghile, Y., Schulze, R. and Brown, C. (2010) Evaluating the performance of ground-based and remotely sensed near real-time rainfall fields from a hydrological perspective. Hydrological Sciences Journal-Journal Des Sciences Hydrologiques 55(4), 497-511.

Gu, A., Nerenberg, R., Sturm, B.M., **Park, C**., and Goel, R. (2010) Molecular methods in biological systems. *Water Environment Research.* 82, 908-930.

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

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

Hua, G. and **Reckhow D. A**. (2008) Hydrophobicity and molecular size distribution of unknown TOX in drinking water *ASCE Journal of Environmental Engineering*, 134:3, 152-160.

Hua, G. and **Reckhow D. A**. (2008) DBP Formation during Chlorination and Chloramination: Effect of Reaction Time, pH, Dosage and Temperature, *Journal American Water Works Association*, Vol. 100, No. 8, pp. 82-95.

Hua, G., **Reckhow, D.A**., (2008) "Relationship between Brominated THMs, HAAs and Total Organic Bromine during Drinking Water Chlorination," pp. 108-123 in Occurrence, Formation, Health Effects and Control of Disinfection Byproducts in Drinking Water, T. Karanfil, S.W. Krasner, P. Westerhoff and Y. Xie, editors, ACS Symposium Series 995, American Chemical Society.

Hua, G.H. and **Reckhow, D.A**. (2012) Evaluation of Bromine Substitution Factors of DBPs during Chlorination and Chloramination. Water Research 46(13), 4208-4216.

Hua, G.H. and **Reckhow, D.A.** (2012) Effect of Alkaline pH on the Stability of Halogenated DBPs. Journal American Water Works Association 104(2), 49-50.

Hua, G.H. and **Reckhow, D.A.** (2013) Effect of pre-ozonation on the formation and speciation of DBPs. Water Research 47(13), 4322-4330.

Hua, G.H., Kim, J. and **Reckhow, D.A**. (2014) Disinfection byproduct formation from lignin precursors. Water Research 63, 285-295.

Islam, A.A., Goodwill, J.E., Bouchard, R., **Tobiason, J.E**. and Knocke, W.R. (2010) Characterization of filter media MnO(x(s)) surfaces and Mn removal capability. Journal American Water Works Association 102(9), 71-+.

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., **Park, C**., and Novak, J.T. (2011) Combination of coagulating agents, alum and cationic polymer, for sludge dewatering and odors. *Korean Society of Civil Engineers Journal of Civil Engineering*. 15 (4), In press.

Kim, Y.M., Lee, D.S., **Park, C**., Park, D., and Park, J.M. (2011) Effects of free cyanide on microbial communities and biological carbon and nitrogen removal performance in the industrial activated sludge process. *Water Research.* 45, 1267-1279

Kim, Y.M., Cho, H.U., Lee, D.S., **Park, C**., Park, D., and Park, J.M. (2011) Response of nitrifying bacterial communities to the increased thiocyanate concentration in pre-denitrification process. *Bioresouce Technology.* 102(2), 913-922.

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Kulkarni, M., Green, S. K., **Shea, C.**, and Queeney, K. T., The role of etching in aqueous oxidation of hydrogen-terminated Si(100), Journal of Physical Chemistry C, Vol. 113, No. 23, June 2009

Kwon, H-H., **Brown, C**. , Xu, K., and Lall, U. (2009). "Seasonal and annual maximum streamflow forecasting using climate information: application to the Three Gorges dam in the Yangtze River basin." *Hydrologic Sciences Journal* 54(3) 582 - 595.

Kwon, H-H., **Brown, C**., and Lall, U. (2008). "Climate informed flood frequency analysis and prediction in Montana using hierarchical bayesian modeling." *Geophysical Research Letters*, 35, L05404, DOI:10.1029/2007GL032220.

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Liu, B.N. and **Reckhow, D.A**. (2013) DBP Formation in Hot and Cold Water Across a Simulated Distribution System: Effect of Incubation Time, Heating Time, pH, Chlorine Dose, and Incubation Temperature. Environmental Science & Technology 47(20), 11584-11591.

Liu, B.N., **Reckhow, D.A**. and Li, Y. (2014) A two-site chlorine decay model for the combined effects of pH, water distribution temperature and in-home heating profiles using differential evolution. Water Research 53, 47-57.

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.

McGuire, M.J., Karanfil, T., Krasner, S.W., **Reckhow, D.A**., Roberson, J.A., Summers, R.S., Westerhoff, P. and Xie, Y.F. (2014) Not your granddad's disinfection by-product problems and solutions. Journal American Water Works Association 106(8), 54-73.

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.

Mercer, K. and **Tobiason, J.E**., (2008) "Removal of Arsenic from High Ionic Strength Solutions: Effects of Ionic Strength, pH, and pre-formed versus in-situ formed HFO", *Environmental Science & Technology*, Vol. 42, No. 10, pp. 3797-3802.

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Nguyen, A.H., **Tobiason, J.E**. and Howe, K.J. (2011) Fouling indices for low pressure hollow fiber membrane performance assessment. Water Research 45(8), 2627-2637.

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.

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Ostendorf, D.W., **Palmer, R.N**. and Hinlein, E.S. (2009) Seasonally varying highway de-icing agent contamination in a groundwater plume from an infiltration basin. Hydrology Research 40(6), 520-532.

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Ostendorf, D.W., Xing, B., and Kallergis, N. (2009), "Cation Exchange in a Glacial Till Drumlin Subject to Highway Deicing Agent Contamination," Journal of Contaminant Hydrology, Vol. 106, pp. 118-130.

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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. and Novak, J.T. (2009) Characterization of lectins and bacterial adhesins in activated sludge flocs. *Water Environment Research*. 81, 755-764.

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Park, M-H. and Michael K. Stenstrom (2008) Bayesian Network Application for Urban Land Use Classification, *Journal of Environmental Management*, 86 (1) 181-192.

Park, M-H. and Michael K. Stenstrom (2008) Comparison of Pollutant Loading Estimation Using Different Landuses And Stormwater Characteristics In Ballona Creek Watershed, *Water Science and Technology*, 57(9), 1349-1354.

Park, M-H. and Michael K. Stenstrom (2006) Using Satellite Imagery for Stormwater Pollution Management with Bayesian Networks, *Water Research*, 40(18), 3429-3438.

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Park, M-H., Irwin H. (Mel) Suffet, and Michael K. Stenstrom (2007) Stormwater pollution management in Sweetwater reservoir drainage basins, *Journal of Environmental Engineering, ASCE*, 133(2), 203-210.

Park, M-H., Michael K. Stenstrom, and Stephanie Pincetl (2009) Water Quality Improvement Policies: Lessons Learned from the Implementation of Proposition O, Los Angeles, California, *Environmental Management*, 43, 514-522.

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