3B. COMPLETE FILE OF THE CANDIDATE

Raymond M. Hozalski

B-1 BIOGRAPHICAL DATA

Date of Birth: June 10, 1968
Citizenship: United States of America

B-1.1 Education

1996 Ph.D., Environmental Engineering, Johns Hopkins University
1992 M.S., Environmental Engineering, Johns Hopkins University
1990 B.Ch.E., Chemical Engineering, Villanova University

B-1.2 Principal Fields of Interest

I am interested in the application of biological processes for the treatment of water, wastewater, and hazardous waste. One of my main areas of specialization within biological processes is biofilms, which are microbial communities immobilized on solid surfaces. My biofilms research program aims to enhance understanding of the structure and function of biofilms in engineered and natural systems, to develop and improve biofilm-based water treatment processes, and to develop strategies for controlling biofilm growth on surfaces in systems where biofilm accumulation has negative consequences (*e.g.*, pipelines, medical implant devices). In addition, I am interested in studying the sources, composition and reactivity of aquatic natural organic matter (NOM) with emphasis on the impacts of NOM on drinking water quality and treatment. A major focus of my research group concerns biological and chemical processes in water distribution systems and their effects on drinking water quality. Specific areas of emphasis in distribution systems include biofilm control, the fate of halogenated disinfection by-products (*e.g.*, haloacetic acids), and corrosion control. Finally, I am working with collaborators in Civil Engineering, Electrical and Computer Engineering, and Computer Science and Engineering to develop wireless *in situ* water quality monitoring networks for use in urban water quality assessment and management and in the development of autonomously reconfigurable water treatment facilities.

B-1.3 Current Research

My research group is currently conducting research in three areas:

(1) Water Distribution Systems

a) **Biodegradation of Haloacetic Acids in Distribution Systems.** Haloacetic acids (HAAs) are halogenated disinfection byproducts formed when chlorine is added to water. HAAs are potentially hazardous to human health and their levels in drinking water are currently regulated by the USEPA. The main goal of this research is to improve our understanding of HAA biodegradation and HAA-degrading bacteria in order to facilitate the development of models for predicting HAA fate in distribution systems, to better assess temporal and spatial variability in HAA exposure and to facilitate the development of HAA control strategies. This research involves a detailed investigation of the kinetics of HAA biodegradation, the organisms responsible for HAA biodegradation, and the diversity of dehalogenase genes involved. We are developing a novel and highly sensitive method for detecting HAA-degrading bacteria in environmental samples using molecular techniques. In addition, we are collecting water and biofilm samples from a wide range of distribution systems to evaluate the prevalence of HAA-degrading bacteria. Kinetic models will be developed from the data generated in the HAA biodegradation experiments. The results of this work will improve our understanding of HAA fate in distribution systems and aid in the development of new treatment approaches for removing HAAs from water supplies.

b) **Investigation of the Mode of Action of Stannous Chloride as an Inhibitor of Lead Corrosion.** Many water utilities, especially those in larger and older U.S. cities, are struggling to meet the 15 μg/L lead action level (AL) of the 1991 Lead and Copper Rule. Orthophosphate, sometimes in combination with polyphosphate, is the most commonly used corrosion control chemical and has proven to be effective for lead corrosion problems. Unfortunately, phosphate is an important nutrient and its addition to drinking water can stimulate the growth of microorganisms in some distribution systems and increase P loads to wastewater treatment facilities. Stannous chloride ($SnCl_2$) is a relatively new corrosion inhibitor in that it has only recently been approved for use in potable water distribution systems in some states. Unfortunately, little is known about the mechanism and effectiveness of $SnCl_2$ for lead corrosion control in water distribution systems and to our knowledge, there is no information available in the peer-reviewed literature. The main goal of this research is to elucidate the mechanism or mechanisms by which $SnCl_2$ decreases the corrosion of lead and the corresponding release of Pb into the water supply. One hypothesis is that the $SnCl_2$ inhibits or inactivates bacteria that contribute to microbially influenced corrosion. The research involves a combination of batch experiments, analysis of pipe samples collected from full-scale distribution systems, and continuous-flow column experiments. This research will improve our understanding of $SnCl_2$ as a corrosion inhibitor and provide guidance for water utilities struggling to meet the lead AL that also are concerned about the possible detrimental effects of phosphate on microbiological water quality.

(2) Microbial Fuel Cells for Wastewater Treatment

The recent discovery of the ability of bacteria to transfer electrons outside of their cytoplasm and onto solid surfaces such as electrodes has made it possible to use bacteria to produce electricity directly from waste organic material. In these “microbial fuel cells” (MFCs) bacteria act as self-assembling, self-regenerating biocatalysts able to oxidize diverse fuels and transfer electrons to an electrode. Unfortunately, our understanding of the fundamental aspects of MFCs, such as the mechanism(s) of electron transfer out of the cell to solid surfaces and of the interactions between electricity-producing cells and other bacteria in a mixed community, are very limited. Thus, our ability to improve the power output and efficiency of MFCs is severely inhibited, with current efforts largely relying on the trial-and-error approach. Through mathematical modeling and well-controlled experiments, our team is attempting to elucidate the fundamental molecular, microbiological, and mass transfer parameters that control electricity production in MFCs. Our *specific aim* is to define the microbiological and engineering parameters that limit electricity production by these bacteria, and address these issues to increase power output and efficiency.

(3) Urban Water Quality Assessment and Management

a) Wireless Technologies and Embedded Networked Sensing: Application to Integrated Urban Water Quality Management

The water quality of streams draining watersheds has been degraded by increasing urbanization. The general symptoms of this degradation include more frequent large flow events, reduction in channel complexity, reduced retention of natural organic matter, and elevated concentrations of nutrients and organic chemicals. The sustainable restoration and management of stream water quality require quantification of hydrological, chemical, biological, and geomorphological processes across a range of temporal and spatial scales. We propose to transform traditional and very limited (in terms of spatial and temporal resolution) field measurements through the integration of multi-scale, spatially-dense, high frequency, real-time, and event-driven observations by a wireless network with embedded networked sensing. This will allow quantification of processes across temporal and spatial scales and the characterization of non-linear events. The overall aim of our research is to establish a wireless network with embedded sensing capable of monitoring fundamental water quality parameters. The ability of these fundamental water quality parameters to be used for predicting the presence of emerging chemical contaminants in urban streams will also be determined. It is hypothesized that the water quality in streams draining similar impervious urban areas is controlled by the mean and variance of effective stormwater residence time. Water quality in streams will be observable as a dynamic response to land use gradients and hydrological transients rather than as an equilibrium described by average properties. This approach will enable process-based scaling and forecasting of water quality in streams from the in-stream processes to the watershed level.

b) Development of a Stormwater Best Management Practice (BMP) Assessment Protocol

The 1987 Amendments to the Clean Water Act required implementation of a two-phase program to regulate discharges of stormwater. Phase I focused on large construction sites, industrial facilities, and major metropolitan municipal separate storm sewer systems (MS4s). Phase II expands these regulations to include smaller construction sites, industrial activities in small municipalities, and smaller municipalities. In response to these regulations, municipalities and private firms will spend millions of dollars installing and evaluating stormwater treatment systems or "best management practices" (BMPs) over the next five years. This research project will assist municipalities and other entities (i.e. state agencies, consulting firms, etc.) by developing a stormwater BMP assessment protocol, which incorporates not only monitoring but also testing of stormwater BMPs. Testing is a potentially time- and cost-saving concept that involves investigation of BMP performance without the need to wait for natural storm events to occur. This research involves laboratory experiments, field experiments, and modeling to develop and evaluate BMP testing procedures for inclusion in a BMP assessment guidance document.

B-1.4 Employment Experience

7/03 –	**Associate Professor**, Department of Civil Engineering, *University of Minnesota*, Minneapolis, Minnesota
8/97 –7/03	**Assistant Professor**, Department of Civil Engineering, *University of Minnesota*, Minneapolis, Minnesota
9/96 – 6/97	**Post-Doctoral Researcher**, Department of Geography and Environmental Engineering, *The Johns Hopkins University*, Baltimore, Maryland
5/96 – 8/96	**Instructor**, Part-Time Program in Engineering and Applied Science, *The Johns Hopkins University*, Baltimore, Maryland
9/90 – 5/96	**Graduate Research Assistant**, Department of Geography and Environmental Engineering, *The Johns Hopkins University*, Baltimore, Maryland

B-1.5 Awards and Honors

1. Norwegian Marshall Fund Award from Norge-Amerika Foreningen (The Norway-America Association) (NOK 20,000 provided in partial support of 2 month sabbatical stay in Norway), Awarded May 2004.

2. Department Development Award, Civil Engineering, University of Minnesota, Awarded December 2000.

B-1.6 Scholarships and Fellowships

Abel Wolman Doctoral Fellowship sponsored by the American Water Works Association, Awarded June 1993.

B-1.7 Membership in Professional Societies

American Chemical Society (ACS)
American Water Works Association (AWWA)
Association of Environmental Engineering and Science Professors (AEESP)
International Humic Substances Society (IHSS)

B-1.8 Professional Registration

Registered Professional Engineer in the State of Minnesota.

B-2 TEACHING CONTRIBUTIONS

I teach civil (primarily environmental) engineering courses at both the undergraduate and graduate levels. The courses that I have offered under the semester system (starting in Fall 1999) include two undergraduate required courses (4xxx level), an undergraduate/graduate elective course (4xxx level), and two graduate courses (8xxx level). In all of my courses, I strive to provide a firm foundation in theoretical concepts, with demonstration of the application of those concepts through real world example problems. I also require the students to read articles from the peer-reviewed engineering and science literature, even in undergraduate classes. This is done to familiarize the students with an important resource for understanding and solving problems. Finally, I attempt to provide an intellectually stimulating and interactive classroom environment by combining traditional lecture material with a liberal use of visual aids, group problem solving, and discussions.

B-2.1 Courses Taught and Enrollments

Quarter System (Fall 1997 – Spring 1999)
CE 5501[*] – Analysis and Design of Wastewater Systems
CE 5540[#] – Remediation Technologies
CE 8502[**] – Biological and Chemical Processes for Wastewater Treatment
CE 8097[**] – Biofilms

Semester System (Fall 1999 – present)
CE 4102[*] – Capstone Design (team taught, students mostly work with external mentors)
CE 4502[*] – Water and Wastewater Treatment
CE 4562[#] – Environmental Remediation Technologies
CE 8505[**] – Biological Processes
CE 8553[**] – Biofilms

[*] Required undergraduate course
[#] Elective course (undergraduate and graduate)
[**] Graduate course

Quarter System

	Course Enrollments			
Term	**CE 5501**	**CE 5540**	**CE 8502**	**CE 8097**
W 1998			11	
S 1998		15		
F 1998				11
W 1999	86			
S 1999		19		

Semester System

	Course Enrollments				
Term	**CE4102**	**CE 4502**	**CE 4562**	**CE 8505**	**CE 8553**
F 1999		75			
S 2000			25	11	
F 2000		50			
S 2001			17		4
F 2001		43			
S 2002			20		
F 2002		35			
S 2003			12		
F 2003		42			
S 2004	53		15		
F 2004	Sabbatical				
S 2005	Sabbatical				
F 2005		64			
S 2006	None				
F 2006		61			
S 2006	None				

B-2.2 Development of New Courses

CE4502 Water and Wastewater Treatment
As part of the transition from the quarter system to semesters, a decision was made to combine two separate quarter long courses, Analysis and Design of Water Supply Systems and Analysis and Design of Wastewater Systems, into one semester long course. As the first faculty member to teach the new course, I was responsible for putting together an outline, developing and revising lecture material, and selecting a textbook (*Water Supply and Pollution Control* by Viessman and Hammer). The theory and design of water and wastewater treatment systems are emphasized in the course, with extensive problem solving both in the classroom and in homework assignments. The course has been well received by the students (see Course Evaluations below). The course is continually being revised and updated by Prof. Timothy LaPara (who also teaches the course) and me to address current “hot” topics such as Total Maximum Daily Load, water system security, and UV disinfection for water treatment.

CE8097/8553 Biofilms
This specialty course concerns one of my main areas of research interest, biofilms. The purpose of this course is to discuss how biofilms form, the reactors and techniques used to study them, the processes involved in their growth and maintenance, beneficial applications, and detrimental effects. A focus of the course is the mathematical modeling of various biofilm processes (*e.g.*, substrate uptake and growth). This course was developed by blending lecture notes and materials from a similar course offered at Johns Hopkins University (taught by Prof. Ed Bouwer), material obtained from a recent book (*Biofilms II: Process Analysis and Applications* edited by James D. Bryers), and journal articles. In addition to formal lectures, the course features in-class

discussions of journal articles and demonstrations of biofilm models and modeling software. Each student in the class is required to write a paper and deliver an oral presentation to the class on a specific topic of interest within the field of biofilms.

B-2.3 Course Revision

CE4562 Remediation Technologies

This course was called "Analysis of Groundwater-Soil Pollution Abatement Technology" when I began to teach it. There was no textbook, and the focus was primarily on biological degradation mechanisms and kinetics. I decided to adopt a book (originally *Remediation Engineering* by Suthersan, currently *Hazardous Waste Management* by LaGrega et al.) for the course to provide some structure and a reference for the students. In addition, I significantly revised the course outline to cover a range of topics including physical-chemical removal processes (*e.g.*, soil-vapor extraction, air sparging) in addition to bioremediation. New or emerging technologies such as phytoremediation also are discussed. Again, my approach in teaching the material is to provide the relevant theory on the technologies, then discuss the applications. I have included a substantial course project in which groups of approximately five students are given a feasibility study from an actual site and asked to recommend a remediation approach and perform a preliminary design and cost analysis. A significant component of the project is the evaluation of a variety of remediation strategies for potential use at the site by performing both technical feasibility and economic analyses. The project is submitted as a report and also presented to the class. The course is typically taken by a wide range of students including, undergraduate Civil Engineering students, Chemical Engineering students, Geology students, and graduate students. Thus, it is a challenge to provide sufficient background material (*e.g.*, chemical properties, contaminant transport) to satisfy the less advanced students without boring more advanced students. The course has been well received to date so it appears that the balance between background material and new concepts is reasonable.

CE8502/CE8505 Biological and Chemical Processes for Wastewater Treatment/Biological Processes

This is an advanced graduate course concerned with pollutant degradation processes involving bacteria. The course covers a range of topics including: microbial kinetics, modeling of suspended growth and biofilm treatment systems, fundamentals of nutrient removal, and recent developments (*e.g.*, use of molecular techniques for microbial identification and process analysis). The course is based primarily on peer-reviewed literature, using a mixture of older seminal journal articles (*e.g.*, Lawrence and McCarty, 1970, *Journal of the Sanitary Engineering Division*, Proceedings of the ASCE) and more recent "cutting-edge" articles (*e.g.*, Bott and Love, 2000, *Water Research*). There is a significant amount of in-class discussion of the papers, often led by one of the students. This course is taught by Paige Novak and me (in alternating years) and we have worked together on its development and continue to collaborate on revising and updating the course material.

B-2.4 Course Evaluations

The following table presents results for questions 1 and 2 of the standard University course evaluation form.

Question 1: "How would you rate the instructor's overall teaching ability?"

Question 2: "How would you rate the instructor's knowledge of the subject matter?"

The ratings shown are for the University scale of 1 to 7, with 1 being "very poor" and 7 being "exceptional".

Table of Results from Student Course Evaluations

Course	**n**[1]	**Question 1**			**Question 2**		
		Mean	Std. dev.	Median	Mean	Std. dev.	Median
CE8502 - W '97	11	5.5	1.1	5.8	5.7	1.1	5.9
CE5540 - S '98	13	6.3	0.7	6.5	6.6	0.5	6.6
CE8097 - F '98	11	6.4	0.5	6.4	6.7	0.5	6.8
CE5501 - W '99	68	5.9	0.9	6.0	6.2	0.8	6.3
CE5540 - S '99	18	6.6	0.5	6.7	6.6	0.5	6.7
CE4502 - F '99	59	5.9	0.9	6.0	6.6	0.6	6.7
CE4562 - S '00	23	6.4	0.6	6.3	6.4	0.6	6.3
CE8505 - S '00	11	6.2	0.6	6.0	5.9	0.5	6.0
CE4502 - F '00	22[2]	5.9	0.9	6.0	6.6	0.6	6.7
CE4562 - S '01	17	6.1	0.7	6.1	6.1	0.8	6.2
CE8553 - S '01	4	6.5	0.6	6.5	6.8	0.5	7.0
CE4502 - F '01	40	6.2	0.8	6.3	6.4	0.7	6.6
CE4562 - S '02	16	6.3	0.8	6.3	6.6	0.5	6.6
CE4502 - F '02	28	6.0	0.8	6.0	6.7	0.5	6.8
CE4562 - S '03	11	6.5	0.7	6.7	6.6	0.5	6.7
CE4502 - F '03	32	6.0	1.0	6.1	6.6	0.5	6.7
CE4562 - S '04	13	6.2	0.6	6.2	6.5	0.6	6.6
CE4102[3] **-** S '04	50	4.8	0.9	4.5	5.0	1.1	4.8
CE4502 - F '05	50	5.9	0.9	6.0	6.5	0.7	6.7
CE4502 - F '06	41	5.9	1.2	6.1	6.2	1.2	6.4

[1] n = number of surveys
[2] Low number of returned surveys due to mix-up in survey form distribution (~half of the students did not receive the university evaluation form, they only received the departmental teaching award survey form).
[3] Course was "team taught" with Joe Labuz, involved only a few lectures, with the majority of student instruction provided by project mentors from the local (external) engineering community.

Comparison of Question 1 Mean Scores for Hozalski and Department of Civil Engineering

Course	**Department (F99 – S02)**	**Hozalski (F99 – S02)**
Required	5.6	6.0
4xxx	5.6	6.3
8xxx	5.9	6.4

B-2.5 Graduate Student Supervision

Completed Ph.D. Degrees

1. Eric Poppele – *The Cohesive Strength of Biofilms*. Defended December 2006.

2. Chanlan Chun (co-adviser W. Arnold) –*The Degradation of Disinfection Byproducts by Synthetic Fe Minerals and Sorbed* Fe^{2+}. Defended May 2006.

3. Xin (Cissy) Ma (co-adviser P. Novak) - *Delivery of* H_2 *via Hollow Fiber Membranes: Transformation of Chlorinated Ethenes and Effects on the Bacterial Communities*. Defended August 2004.

4. Li Zhang (co-adviser W. Arnold) – *Reactions of Haloacetic Acids with Zero-Valent Iron: Pathways, Kinetics, and Modeling*. Defended April 2004. Winner of "Best Student Paper Award" at the 23rd Midwest Environmental Chemistry Workshop, Oct. 2000. Also awarded a University of Minnesota Doctoral Dissertation Fellowship for 2002-03.

5. Xiaojun Dai – *Removal of Cryptosporidium parvum Oocysts in Granular Media Filters*. Defended September 2003.

Completed M.S. Plan A Degrees

1. Matt Wilson (co-advisers J. Gulliver and O. Mohseni) – *Performance Assessment of Underground Stormwater Treatment Devices.* Defended June 2007.

2. Roger Scharf (co-adviser M. Semmens) – *Evaluation of Geosmin Removal Mechanisms*. Defended June 2007.

3. Robert "Bo" Johnston (co-adviser M. Semmens) – *Bench and Pilot-Scale Evaluation of Geosmin Removal Technologies*. Defended December 2005.

4. Hui Li – *Use of Capillary Electrophoresis to Characterize Natural Organic Matter (NOM)*. Defended December 2004.

5. Agarwal, Navin - *Zone of Influence of an In Situ Hollow-Fiber Membrane Gas Delivery System Operated In Passive and Pumped Modes: Experimental and Model Studies*. Defended April 2003.

6. Elizabeth Esbri– *Lead Corrosion Control Study for St. Paul Regional Water Services*. Defended October 2002.

7. Bethany McRae – *Biodegradation of Haloacetic Acids: Kinetics and Characterization of Enrichment Cultures*. Defended September 2002.

8. H. David Muenzner (co-advisers P. Novak and M. Semmens) – *Support of Reductive Dechlorination of PCE by a Mixed Methanogenic Culture Using Hollow-Fiber Membranes*. Defended November 2001.

9. Denice Nelson (co-adviser P. Novak) – *A Membrane Batch Study to Determine the Effects of Nitrate and Sulfate on Biological Reductive Dechlorination*. Defended July 2001. Consulting Engineer, Arcadis, Minneapolis, Minn.

10. Trisha Coyle (co-adviser M. Semmens) – *An Assessment of the Costs and Benefits of Ozonation for the St. Paul Water Utility*. Defended Dec. 2000.

11. Miao Zhang – *An Evaluation of Biostability and Microbiological Quality in a Full-Scale Water Distribution System*. Defended Dec. 2000.

Completed M.S. Plan B Degrees

1. Michael Kohn – *Are Biologically Aerated Filter (BAF) Systems an Effective Alternative to More Traditional Systems for the Treatment of Municipal Wastewater?* Defended October 2004.

2. Peter Kero – *Feasibility Study for Removal of Particles from Potable Water*. Defended April 2003.

3. O. Craig Anderson – *The Transport and Fate of Soluble Organic Contaminants in the Subsurface Environment*. Defended December 1999.

4. Chris Bryan – *Oil Separation and Wastewater Treatment Plant Capability Evaluation*. Defended June 1999.

Completed M.C.E. Degrees

1. Gregory Johnson – *Comparison of Reverse Osmosis and Ion Exchange for Arsenic Removal at a Small Water Treatment Facility*. Defended May 2002. Project Manager, Short Elliot Hendrickson Inc., Minnetonka, Minn.

Current Ph.D. Students

1. Carrie Bressler (co-adviser W. Arnold) – *The Role of Fe(0) and its Corrosion Products in the Degradation of Disinfection Byproducts*. Expected graduation December 2007. Awarded an EPA STAR Fellowship in 2004.

2. David Wunder – *Removal of Antibiotics in Slow Rate Biofiltration Processes*. Expected graduation May 2009.

3. Bethany (McRae) Brinkman – *Effects of Land Use on the Concentration, Composition, and Treatability of Natural Organic Matter in Surface Water.* Expected graduation August 2009.

4. Alina Grigorescu – *Characterization of a Novel Haloacetic Acid-Degrading Bacterium.* Expected graduation December 2009.

5. Gregory LeFevre (Co-adviser P. Novak) - *The Role of Rhizosphere Bacteria in Stormwater Treatment*. Expected graduation 2012. (NSF Fellowship recipient, NSF IGERT Fellow, University of Minnesota Graduate School Fellowship recipient)

Current M.S. Plan A Students

1. Brooke Asleson (co-adviser John Nieber) – *Assessment of the Stormwater Infiltration Capacity of Rain Gardens.* Expected graduation May 2007.

2. Rebecca Nestingen (co-adviser John Gulliver) – *Assessment of the Pollutant Removal Performance of Rain Gardens.* Expected graduation December 2007.

3. Ying Tan – *Investigation of the Mode of Action of Stannous Chloride as an Inhibitor of Lead Corrosion*. Expected Graduation August 2008.

Current M.S. Plan B Students

(none)

B-2.6 Postdoctoral Researcher Supervision

1. Tsutomu Shimotori (January 2006 – present; co-supervised by T.M. LaPara and D.R. Bond) – Research focus: *Microbial Fuel Cells for Wastewater Treatment: Modeling and Experimental Studies*.

2. Ping Zhang (January 2006 – present; co-supervised by T.M. LaPara) – Research focus: *Biodegradation of Haloacetic Acids in Water Distribution Systems*.

3. Sungchul Kim (September 2006 – present; co-supervised by M. Hondzo, P. Novak, and W. A. Arnold) – Research focus: *Wireless Technologies and Embedded Networked Sensing: Application to Integrated Urban Water Quality Management*.

4. Xiaojun Dai (October 2006 – present) – Research focus: *Investigation of the Mode of Action of Stannous Chloride as an Inhibitor of Lead Corrosion*.

5. Lee Jeong-Yub (February 2005 – August 2006; co-supervised by W.A. Arnold) – Research focus: *Effects of Dissolved Oxygen and Chlorine on the Rate of Reduction of Halogenated Disinfection By-products by Iron and Iron Corrosion Products*.

6. Lee Clapp (January 1999 – August 2002; co-supervised by P.J. Novak and M.J. Semmens) – Research focus: *Modeling Perchloroethene Degradation in Anaerobic Aquifers*. Lee also worked extensively with graduate students on related experimental studies. Lee is currently an Assistant Professor at Texas A&M University-Kingsville.

B-2.7 Undergraduate Student Supervision

1. Zachary Edmonson (June 2002 – Dec. 2002) – *Degradation of Bromate by Zero-valent Iron*. Co-advised by W.A. Arnold. Funded by a University of Minnesota UROP* grant.

2. Kathleen Thompson (Jan. 2002 - May 2002) – *Effects of Corrosion Inhibitor and pH on Lead Release into Treated Drinking Water*. Funded by a University of Minnesota UROP grant.

3. Michael Grotenhuis (Sept. 1998 – April 1999) – *Use of Capillary Electrophoresis to Evaluate the Electrophoretic Mobility of Bacteria* (Former student at Minnetonka High School in Minnesota, research performed under Mentor Connection program). Presently an undergraduate student at Cornell University.

*Undergraduate Research Opportunities Program

B-2.8 Student Organizations

1999- Chief Advisor to Tau Beta Pi (Engineering Honor Society), University of Minnesota Chapter.

1998-1999 Advisor to Tau Beta Pi (Engineering Honor Society), University of Minnesota Chapter.

B-3 RESEARCH CONTRIBUTIONS

B-3.1 Summary of Research Activities

My primary research activities concern biological processes for the treatment of water, wastewater, and hazardous waste. I am especially interested in biological processes involving bacteria immobilized on surfaces in what are termed biofilms. I have performed both experimental and computational investigations of biofilm systems beginning with my graduate work at The Johns Hopkins University. My initial research concerned biologically-active filters for use in drinking water treatment to remove natural organic matter and ozonation by-products. Since becoming a faculty member at the University of Minnesota, I have continued to work in the area of drinking water biofilms, including investigations of pathogen removal in biologically active filters, biodegradation of disinfection byproducts, and bacterial regrowth in water distribution systems. I also have expanded my range of interests in biofilms/biological processes to include bioremediation of synthetic organic chemicals and microbial fuel cells for wastewater treatment. For example, I was a co-PI on a U.S. Department of Defense-funded project concerning bioremediation of groundwater contaminated with chlorinated solvents (*e.g.*, tetrachloroethene, trichloroethene). This project involved bench-scale, pilot-scale, and field-scale experiments as well as the development of a mathematical model to simulate the bioremediation process. In addition, a five-year working relationship with St. Paul Regional Water Services also has led me into new areas such as lead corrosion control in water distribution systems. Finally, I have begun to perform research in the area of surface water quality assessment and management in collaboration with colleagues from a wide variety of disciplines including civil engineering, electrical engineering, and computer science.

The philosophy of my research program is to address problems with both experimental and numerical approaches over a range of scales, from basic well-controlled batch experiments, to “first principles” mathematical modeling, to pilot-scale studies, and if possible, to field-scale/full-scale/demonstration systems. In this way, we can gain fundamental understanding of the problem, determine how to scale up the system, and eventually solve engineering problems for the benefit of society. The contributions of my research group to the environmental engineering field, as recorded in peer-reviewed publications, are described below.

Use of Biologically Active Filters to Remove Natural Organic Matter from Drinking Water Supplies. (PI: Edward Bouwer, Funding from the American Water Works Association Research Foundation). Natural organic matter (NOM) is ubiquitous in natural waters and it can impart color, taste, and odor to water. NOM generally is considered non-hazardous; nevertheless, NOM is problematic in water supplies for several reasons including: (1) it reacts with chemical oxidants such as chlorine to form potentially hazardous disinfection byproducts and (2) it can serve as a substrate to support the (re)growth of bacteria in water distribution systems. My Ph.D. research focused on the removal of NOM from water supplies by biodegradation and combined ozonation-biodegradation (ozonation can be used to enhance the biodegradability of recalcitrant NOM fractions). I was part of a team of two graduate students that performed batch studies to evaluate NOM biodegradation as a function of NOM composition and ozone dose (Goel et al., *Journal of the American Water Works Association*, 1995) and column studies to simulate biologically active filters (Hozalski et al., *Journal of the American Water Works Association*, 1995). In addition, I investigated the effects of periodic filter cleaning (i.e. backwashing) on biofilter performance both experimentally (Hozalski and Bouwer, *Journal of the American Water Works Association*, 1998) and numerically (Hozalski and Bouwer, *Water Research*, 2001a; Hozalski and Bouwer, *Water Research*, 2001b). The key contributions of this work were to demonstrate that: (1) the ratio of UV absorbance at 254 nm to total organic carbon (i.e. UV/TOC or specific UV absorbance) can serve as an indicator of NOM biodegradability; (2) biofilters are effective at removing the biodegradable fraction of NOM; and (3) periodic backwashing generally does not impair biofilter performance.

Removal of Pathogens in Biologically Active Filters. (Funding from the U.S. Geological Survey Water Resources Research Institutes Program). *Cryptosporidium parvum* is a pathogenic protozoan that is commonly found in drinking water supplies obtained from surface sources. *C. parvum* oocysts are relatively resistant to chemical disinfection, therefore, an effective means of removing these protozoa during water treatment is through particle removal processes including filtration. The main focus of this work concerned an evaluation of the effects of dissolved natural organic matter and biofilms on the removal of oocysts in filters and an evaluation of the suitability of non-hazardous particles (*e.g.*, latex microspheres) as surrogates for viable oocysts in filtration experiments. The accumulation of biofilm on the filter media can affect the media surface characteristics, bed porosity, and ultimately the particle capture efficiency. The main finding was that NOM and biofilms adversely impacted oocyst removal in filters (Dai and Hozalski, *Water Research*, 2002). The detrimental effects of NOM were attributed primarily to an increased negative surface charge on the oocysts. The detrimental effects of biofilm likely were due to changes in filter media surface characteristics (*e.g.*, charge and hydophobicity), a decrease in filter bed porosity resulting in short-circuiting, or both factors. We also demonstrated that 5 μm latex carboxylate microspheres serve as a suitable albeit slightly conservative surrogate for *C. parvum* oocyst in filtration experiments over a range of solution conditions (Dai and Hozalski, *Environmental Science and Technology*, 2003).

Development and Testing of Approaches for *In Situ* Groundwater Remediation. (Co-PIs: M.J. Semmens, R.M. Hozalski, and P.J. Novak, Funding from the U.S. Department of Defense SERDP program). The goal of this research was to develop an innovative passive barrier remediation technology that will reduce the costs, risks, and time required for cleanup of subsurface environments contaminated with chlorinated solvents. Specifically, we evaluated the behavior and performance of hollow-fiber membranes for delivering hydrogen to groundwater to stimulate the *in situ* biological reductive dechlorination of tetrachloroethene (PCE). The research involved batch experiments, pilot-scale continuous-flow experiments, field testing and mathematical modeling to evaluate the effectiveness of membranes for hydrogen delivery, the effects of biological and chemical fouling on hydrogen delivery, and PCE dechlorination performance. Significant contributions from this work include: (1) evaluation of gas transfer to groundwater under creeping flow conditions (Fang et al., *Water Research*, 2002; Fang et al., *Journal of Membrane Science*, in press; and Fang et al., *Water Research*, 2004); (2) assessment of the effects of biotic and abiotic fouling on membrane gas transfer (Roggy et al., *Environmental Engineering Science*, 2002); (3) evaluation of the effects of competing organisms/electron acceptors (*e.g.*, denitrification, sulfate reduction, and methanogenesis) on hydrogen consumption and PCE degradation (Muenzner et al., *Bioremediation Journal*, 2002; Nelson et al., *Bioremediation Journal*, 2002); (4) demonstration of PCE dechlorination stimulated by membrane-delivered H_2 in continuous-flow column studies (Ma et al., *Water Research*, 2003 and Ma et al., *Water Research*, 2006) and in the field (Edstrom et al., *Environmental Engineering Science*, 2005); (5) development of a numerical model to evaluate and optimize the membrane system operating conditions (Clapp et al., *Journal of Environmental Engineering*, 2004); and (6) assessment of the effects of hydrogen addition on microbial community composition (Ma et al., *Bioremediation Journal*, 2007).

Development of a Method for Analysis of Haloacetic Acids in Water and Investigation of the Fate of these Compounds in Aquatic Environments. (Funding from the American Water Works Association Research Foundation). The standard methods for analysis of haloacetic acid (HAA) concentrations in drinking water are difficult and time consuming, often involving use of hazardous chemicals or conditions that present serious safety concerns. With funding from the American Water Works Association Research Foundation, we developed a novel method for analysis of HAAs in drinking water that is safe and relatively simple to perform. The basis for the proposed method involves the use of a capillary electrophoresis (CE) ion analyzer for separation and detection of the individual HAAs. Significant effort was devoted to improving method sensitivity so the method would be suitable for analysis of HAAs at the μg/L concentrations encountered in drinking water. Therefore, we developed a solid phase extraction procedure for HAA preconcentration. A manuscript on this work was published in the *Journal of the American Water Works Association* (Zhang et al., 2007). With a new method available, we began exploring the fate (i.e. reactivity) of HAAs in aquatic systems. Both biotic and abiotic degradation reactions are being investigated. We were the first group to demonstrate that HAAs are readily degraded by zero-valent iron (Hozalski et al., *Environmental Science and Technology*, 2001). This finding is significant in that it may help to explain some of the observed HAA losses in cast and ductile iron distribution systems and also may lead to development of a treatment system to remove HAAs from water and wastewater.

Biodegradation of Haloacetic Acids. (Co-PIs: R.M. Hozalski, T.M. LaPara, A. Camper, S. Parsons, and Y. Xie, Funding from the American Water Works Association Research Foundation). Initial results from batch HAA biodegradation experiments were significant in that we demonstrated that HAAs can be biodegraded and serve as sole carbon and energy source at the low concentrations found in drinking water. Furthermore, bromoacetic acid is rapidly degraded under aerobic conditions by a chloroacetic acid-degrading enrichment culture, suggesting that the dehalogenase enzyme is relatively non-specific. We also determined the kinetics of HAA biodegradation over a range of concentrations including typical values for surface waters and treated drinking water. In addition, the bacteria in the HAA-degrading enrichment cultures were identified using molecular techniques (PCR-DGGE-DNA sequencing), and organisms capable of growth on trichloroacetic acid and chloroacetic acid under aerobic conditions were isolated. These results were summarized in a journal article (McRae et al., *Chemosphere*, 2004).

The aforementioned results, obtained using enrichment cultures derived from wastewater activated sludge, lead to financial support from the American Water Works Association Research Foundation to continue our research on HAA biodegradation using drinking water bacteria. Significant findings to date from this ongoing research are: (1) enrichments and isolates from the oligotrophic drinking water environment demonstrated slower HAA degradation kinetics than wastewater organisms, (2) cultures or isolates that can degrade chloroacetic acid consistently are able to degrade bromoacetic acid and iodoacetic acid, and (3) a HAA-degrading methylobacterium was isolated from a water distribution system. The methylobacterium is especially intriguing for several reasons. First, it can grown on HAAs, while methylobacteria are known to grow on C1 compounds such as methanol. Furthermore, the organism does not contain either of the two known classes of haloacid dehalogenase genes, suggesting that it may contain a novel dehalogenase. As a result of this project, we have assembled a rich and diverse collection of HAA-degrading isolates from a variety of environments including pipe wall biofilms, tap water, wastewater, and GAC filters. The results of this work should significantly improve understanding of HAA biodegradation, including kinetics, the organisms involved, and haloacid dehalogenase genes.

Abiotic Degradation of Disinfection Byproducts (Co-PIs: R.M Hozalski and W.A. Arnold, Funding from the National Science Foundation and the American Water Works Association Research Foundation). Disinfection by-products (DBPs) formed upon addition of chlorine to water consist of a wide variety of compound classes including trihalomethanes (THMs), haloacetic acids (HAAs), halonitromethanes (HNMs) and others. Many DBPs are known or suspected carcinogens and therefore, the Disinfectants and Disinfection By-Products Rule was promulgated to limit exposure to these compounds via drinking water. In the negotiated Stage 2 DBP Rule, the spatial variability of DBP levels in the distribution system must be considered as new sample sites will need to be utilized that have maximum THM and maximum HAA occurrence. Unfortunately, little is known about the fate of DBPs in distribution systems. Because cast and ductile iron pipe are prevalent in distribution systems, this research was performed to evaluate the abiotic degradation of DBPs by iron metal (Fe^0) and iron corrosion products. Batch experiments were conducted in glass serum bottles to investigate the kinetics and pathways of the degradation of HAAs, HNMs, and other DBP compound classes by Fe^0, synthetic Fe minerals (*e.g.*, green rust, magnetite), and iron corrosion products obtained from full-scale distribution systems. This research has important implications for understanding and predicting the fate of DBPs in water distribution systems and may be useful for designing new water treatment systems for DBP removal from water supplies. Numerous publications have resulted from this work: Chun et al., *Environmental Science and Technology*, 2005, 2007; Lee et al., *Chemosphere*, 2007; Pearson et al., *Environmental Toxicology and Chemistry*, 2005; and Zhang et al., *Environmental Science and Technology*, 2004.

Cohesive Strength and Detachment of Bacterial Biofilms. (Co-PIs: R.M. Hozalski and P.S. Stewart, Funding from the National Science Foundation). The goal of this fundamental research project is to develop effective strategies for controlling and removing microbial biofilms based on an improved understanding of the mechanisms of cohesion of the biofilm extracellular matrix. Biofilms are dense agglomerations of bacterial or fungal cells that attach to wetted surfaces. These cells are held together by a mixture of highly hydrated biopolymers that the cells themselves secrete. Biofilms are responsible for troublesome fouling in water distribution systems and industrial equipment and for persistent infections in medicine and dentistry. Unfortunately, the use of antimicrobial agents to remove biofilms is frustrated by the reduced susceptibility of microorganisms in biofilms. Mechanical removal is effective, but requires physical access to the biofilm and can be labor intensive or involve equipment downtime. This research represents a paradigm shift in approach to controlling unwanted biofilms from “kill” and “scrape” to weakening the biofilm structure and promoting detachment. A significant accomplishment involved the development of a micromechanical method (adapted from a technique used on abiotic alum flocs developed by Yeung and Pelton, 1996) to quantify the cohesive strength of microbial aggregates (i.e. flocs and detached biofilm fragments). A manuscript on the method has been published (Poppele and Hozalski, *Journal of Microbiological Methods*, 2003). A new testing platform was developed for application of the method to intact biofilms and both methods were applied to investigate the effects of fluid shear on cohesive strength. Additional papers on this work are in preparation. A recent unsolicited grant from the National Science Foundation (beginning September 2007) will allow us to continue this work in collaboration with Phil Stewart from the Center for Biofilm Engineering at Montana State University.

Microbial Fuel Cells for Wastewater Treatment. (Co-PIs: D.R. Bond, R.M. Hozalski, and T.M. LaPara; Funding from the Institute on Renewable Energy and Environment of the University of Minnesota). Through mathematical modeling and well-controlled experiments, our team is attempting to elucidate the fundamental molecular, microbiological, and mass transfer parameters that control electricity production in MFCs. Our *specific aim* is to define the microbiological and engineering parameters that limit electricity production by these bacteria, and address these issues to increase power output and efficiency. Significant findings of our ongoing research to date include the following: (1) development of a comprehensive mathematic model of MFCs based on the fundamental processes of mass transfer, biodegradation, and electron transfer; (2) determination of the role of applied external resistance in MFC performance; and (3) extensive characterization of the electron transfer behavior of different strains of bacteria (*e.g.*, *Geobacter metallireducens*, *Shewanella putrafacens*) using fundamental electrochemical techniques such as cyclic voltammetry, differential pulse voltammetry, and electrochemical impedance spectroscopy. One manuscript on the modeling work has been submitted to a peer-reviewed journal (Shimotori et al., *Environmental Science & Technology*, in review) and several more papers on our research are in preparation.

Wireless Technologies and Embedded Networked Sensing: Application to Integrated Urban Water Quality Management. (Co-PIs: M. Hondzo, W.A. Arnold, R.M. Hozalski, P.J. Novak, and N. Jindal; Funding from the National Science Foundation and U.S. Geological Survey’s NIWR program). The overall aim of this ongoing research project is to establish and evaluate a water quality monitoring network test bed capable of real-time monitoring of fundamental water quality parameters such as turbidity, dissolved oxygen, pH, and nutrients (nitrate and phosphate). Our system is also capable of automatically triggered grab sampling for subsequent analysis of non-sensed chemical and biological contaminants. Finally, we are investigating novel approaches for quantifying stream velocities and fluid residence times using particle image velocimetry and radio frequency identification device technology, respectively. The monitoring network is being used to investigate the performance of selected stormwater best management practices (*e.g.*, ponds and wetlands) and the ability of the fundamental sensed water quality parameters to be used for predicting the concentrations of non-sensed chemical and biological contaminants in urban streams. The test bed was installed in summer of 2007 and the research is ongoing.

Development of a Stormwater Best Management Practice (BMP) Assessment Protocol. (Co-PIs: J.S. Gulliver and J. Anderson; Funding from Minnesota Pollution Control Agency, Metropolitan Council of the Twin Cities, and the Local Road Research Board). This research involves laboratory experiments, field experiments, and modeling to develop and evaluate BMP testing procedures for inclusion in a BMP assessment guidance document. Significant findings from the work to date include: (1) development, calibration, and evaluation of a new device for measuring the permeability of surface soils in rain gardens and other infiltration BMPs; (2) field evaluation of infiltration testing methods for rain gardens; and (3) development and evaluation of a testing protocol for underground hydrodynamic separators. The work on hydrodynamic separators is described in a journal article (Wilson et al., *Journal of Hydraulic Engineering*, in review). Three other manuscripts are in preparation.

Applied Research with St. Paul Regional Water Services (SPRWS). Four applied research projects have been performed in conjunction with staff at SPRWS and funded by that water utility.

(i) The first project investigated the effects of assimilable organic carbon (AOC), temperature, and chlorine on the **biostability and microbiological quality of the water in the SPRWS distribution system**. A significant finding from the research was that a distribution system containing water with a relatively high AOC concentration (~200 μg/L) could remain biologically stable by maintaining a moderate chloramine residual (≥ 2 mg/L) throughout the system. That work was published in *Journal AWWA* (Zhang et al., 2002).

(ii) The second project involved an investigation of the **ozone** dosage needed to meet the expected CT requirements for *Cryptosporidium parvum* inactivation and to eliminate taste and odor problems. The project also investigated the effects of ozone on NOM characteristics and removal by subsequent treatment processes. We found that ozone applied at moderate doses (i.e. those deemed suitable for *C. parvum* inactivation and destruction of geosmin) did not significantly effect the removal of NOM by carbon adsorption, MIEX^{TM} resin, or lime softening.

(iii) The main goal of the third project (completed in August 2002) was to develop a **lead corrosion control** strategy for the SPRWS distribution system. Specifically, we investigated the ability of several corrosion control chemicals to ensure compliance with the lead action level (AL) of 15 μg/L without adversely affecting microbiological water quality. Both batch experiments and pilot-scale pipe loop systems were used to test the effects of four corrosion inhibitors (orthophosphate, polyphosphate, ortho-/poly- blend, and stannous chloride) on lead corrosion. To our knowledge, this work was the first to comprehensively compare phosphate-based corrosion inhibitors with stannous chloride. The research showed that orthophosphate maintained the lowest Pb levels and stannous chloride was also beneficial, but slightly less effective. Similar to other studies reported in the literature, formulations containing polyphosphate were ineffective. This is not surprising given that polyphosphate is an effective metal binding ligand. All treatment involving phosphate addition, however, resulted in increased biological activity as measured by heterotrophic plate counts (HPC), which was consistent with full-scale observations. Interestingly, addition of stannous chloride resulted in significantly lower HPC levels than the untreated control. Unfortunately, none of the treatments investigated was able to maintain Pb levels consistently below the AL for water samples collected after 8 hours of stagnation time in the lead pipes. Nevertheless, all treatments and even the untreated control pipe loop exhibited sub-AL Pb concentrations for flowing water (stagnation time = 0). A paper was published in *Journal AWWA* (Hozalski et al. 2005). Furthermore, research funding was obtained from the American Water Works Association Research Foundation to investigate the mechanism(s) by which stannous chloride reduces lead corrosion rate.

(iv) The St. Paul Regional Water Services (SPRWS) has a problem with taste and odor complaints every summer. The taste and odor complaints were linked to the presence of geosmin in the water, which is produced by algae growing in the chain of lakes supplying the treatment plant. The goal of this research was to **evaluate treatment options for removing geosmin** from the water. Pilot-scale experiments were performed to evaluate geosmin removal by three parallel treatment trains: anthracite-sand filter (control), GAC filter-adsorber, and ozone followed by a GAC filter-adsorber. Batch experiments were also performed to investigate geosmin sorption behavior, geosmin biodegradation, and geosmin degradation by ozone. The main findings of this work include: (1) GAC is an effective treatment option even with a relatively high background total organic carbon concentration, (2) ozone significantly improves geosmin removal and extends GAC bed life, (3) biodegradation can be a significant loss mechanism for geosmin in rapid filters, and (4) recommendations on how to perform GAC studies to get accurate predictions of full-scale performance. Two journal articles on this work are in preparation.

B-3.2 Publications

B-3.2.1 Books Authored or Edited

(none)

B-3.2.2 Chapters in Books

1. **Hozalski, R.M.**, and Bouwer, E.J. (1999). Biofiltration for Removal of Natural Organic Matter. In *Formation and Control of Disinfection By-Products in Drinking Water*, P. Singer (ed.). AWWA, Denver, Colo.

B-3.2.3 Papers in Refereed Journals

The asterisk symbol (*) indicates a UMn faculty member or external colleague. All others are students or post-doctoral researchers except for Bouwer (Ph.D. adviser) and Goel (classmate). (†) *denotes the corresponding author.*

Published or in press

1. Ma, X., *Novak, P.J., Ferguson, J., *Sadowsky, M., *LaPara, T.M., *Semmens, M.J., and †**Hozalski, R.M.** (2007). The Impact of H_2 Addition on Dechlorinating Communities in Soil Columns. *Bioremediation Journal*, 11:2:45-55.

2. Chun, C., **Hozalski, R.M.**, and *†Arnold, W.A. (2007). Degradation of Disinfection Byproducts by Carbonate Green Rust. *Environmental Science and Technology,* 41:5:1615-1621.

3. Zhang, L., *Capel, P.D., and †**Hozalski, R.M.** (2007). Development of a Solid Phase Extraction-Capillary Electrophoresis Method for the Analysis of Haloacetic Acids in Drinking Water. *Journal AWWA*, 99:3:83-94.

4. Lee, J., †**Hozalski, R.M.**, and *†Arnold, W.A. (2007). Effects of Dissolved Oxygen and Iron Aging on the Reduction of Trichloronitromethane, Trichloracetonitrile, and Trichloropropanone. *Chemosphere*, 66:2127-2135.

5. †Velasquez, R., **Hozalski, R.M.**, and *Marasteanu, M. (2006). Investigation of the Effectiveness and Mechanisms of Enzyme Products for Subgrade Stabilization. *International Journal of Pavement Engineering*, 7:3:213-220.

6. Ma, X., *Novak, P.J., *Semmens, M.J., Clapp, L.W., and †**Hozalski, R.M.** (2006). Comparison of Pulsed versus Continuous Addition of H_2 via Membranes for Stimulating PCE Biodegradation in Soil Columns. *Water Research*, 40:1155-1166.

7. Chun, C., †**Hozalski, R.M.**, and *†Arnold, W.A. (2005). Degradation of Disinfection Byproducts by Synthetic Goethite and Magnetite. *Environmental Science and Technology*, 39:21:8525-8532.

8. Pearson, C.R., **Hozalski, R.M.**, and *†Arnold, W.A. (2005). Degradation of Chloropicrin in the Presence of Fe(0). *Environmental Toxicology and Chemistry*, 24:12:48-53.

9. Agarwal, N., *Semmens, M.J., *Novak, P.J., and †**Hozalski, R.M.** (2005). Zone of Influence of a Gas Permeable Membrane System for Delivery of Gases to Groundwater. *Water Resources Research*, 41:W05017.

10. Edstrom, J.A., *Semmens, M.J., **Hozalski, R.M.**, Clapp, L.W. and *†Novak, P.J. (2005). Stimulation of Dechlorination by Membrane-Delivered Hydrogen: Small Field Demonstration. *Environmental Engineering Science*, 22:3:281-293.

11. †**Hozalski, R.M.**, Esbri-Amador, E., and *Chen, C.F. (2005). Comparison of Stannous Chloride and Phosphate for Lead Corrosion Control. *Journal AWWA*, 97:3:89-103.

12. Zhang, L., *†Arnold, W.A., and †**Hozalski, R.M.** (2004). Kinetics of Haloacetic Acid Reactions with Fe(0). *Environmental Science and Technology*, 38:24:6881-6889.

13. †Clapp, L.W., *Semmens, M.J., *Novak, P.J., and **Hozalski, R.M.** (2004). Model for In Situ Perchloroethene Dechlorination via Membrane-Delivered Hydrogen. *Journal of Environmental Engineering*, 130:11:1367-1381.

14. Fang, Y., Clapp, L.W., **Hozalski, R.M.**, Novak, P.J., and *†Semmens, M.J. (2004). Membrane Gas Transfer Under Conditions of Creeping Flow: Modeling Gas Composition Effects. *Water Research*, 38:2489-2498.

15. McRae, B.M., *LaPara, T.M., and †**Hozalski, R.M**. (2004). Biodegradation of Haloacetic Acids by Bacterial Enrichment Cultures. *Chemosphere*, 55:915-925.

16. Fang, Y., *Novak, P.J., **Hozalski, R.M.**, *Cussler, E.L., and *†Semmens, M.J. (2004). Condensation in Gas Permeable Membranes. *Journal of Membrane Science*, 231:47-55.

17. Poppele, E.H. and †**Hozalski, R.M.** (2003). Micro-Cantilever Method for Measuring the Tensile Strength of Biofilms and Microbial Flocs. *Journal of Microbiological Methods*, 55:607-615.

18. Ma, X., Clapp, L.W., *Novak, P.J., *Semmens, M.J., and †**Hozalski, R.M.** (2003). Evaluation of Polyethylene Hollow-Fiber Membranes for Hydrogen Delivery to Support Reductive Dechlorination in a Soil Column. *Water Research*, 37:2905-2918.

19. Dai, X. and †**Hozalski, R.M.** (2003). Evaluation of Microspheres as Surrogates for *Cryptosporidium parvum* Oocysts in Filtration Experiments. *Environmental Science and Technology*, 37:5:1037-1042.

20. Roggy, D.K., *Novak, P.J., **Hozalski, R.M.**, Clapp, L.W., and *†Semmens, M.J. (2002). Membrane Gas Transfer for Groundwater Remediation: Chemical and Biological Fouling. *Environmental Engineering Science*, 19:6:563-574.

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22. Nelson, D.L., **Hozalski, R.M.**, Clapp, L.W., *Semmens, M.J., and *†Novak, P.J. (2002) Investigation of the Effects of Nitrate and Sulfate on Biological Reductive Dechlorination. *Bioremediation Journal*, 6:3:225-236.

23. †Dai, X. and **Hozalski, R.M.** (2002). Effect of NOM and Biofilm on the Removal of *Cryptosporidium parvum* Oocysts in Rapid Filters. *Water Research*, 36:3523-3532.

24. Fang, Y., †**Hozalski, R.M.**, Clapp, L.W., *Novak, P.J. and *Semmens, M.J. (2002). Passive Dissolution of Hydrogen Gas into Groundwater using Hollow-Fiber Membranes. *Water Research*, 36:3533-3542.

25. Zhang, M., *Semmens, M.J., *Schuler, D. and †**Hozalski, R.M.** (2002). Evaluation of Biostability and Microbiological Quality in a Chloraminated Distribution System. *Journal AWWA*, 94:9:112-122.

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27. †**Hozalski, R.M.**, and Bouwer, E.J. (2001). Non-Steady State Simulation of BOM Removal in Drinking Water Biofilters: Model Development. *Water Research*, 35:1:198-210.

28. †**Hozalski, R.M.**, and Bouwer, E.J. (2001). Non-Steady State Simulation of BOM Removal in Drinking Water Biofilters: Applications and Full-scale Validation. *Water Research*, 35:1:211-223.

29. †**Hozalski, R.M.**, and Bouwer, E.J. (1998). Deposition and Retention of Bacteria in Backwashed Filters. *Journal AWWA*, 90:1:71-85.

30. †**Hozalski, R.M.**, Goel, S., and Bouwer, E.J. (1995). TOC Removal in Biological Filters. *Journal AWWA*, 87:12:40-54.

31. †Goel, S., **Hozalski, R.M.**, and Bouwer, E.J. (1995). Biodegradation of NOM: Effect of NOM Source and Ozone Dose. *Journal AWWA*, 87:1:90-105.

In review

32. Shimotori, T., Marsili, E., *Bond, D.R., *LaPara, T.M. and **Hozalski, R.M.** A Model of Microbial Fuel Cells in which Bacteria Use a Direct Electron Transfer Strategy. Submitted to *Environmental Science and Technology*.

33. Wilson, M.A., *Mohseni, O., *Gulliver, J.S., **Hozalski, R.M.** and *Stefan, H.G. Assessment of Hydrodynamic Separators for Stormwater Treatment. Submitted to *Journal of Hydraulic Engineering*.

B-3.2.4 Papers in Special Refereed Publications

1. **Hozalski, R.M.**, Bouwer, E.J., and Goel, S. (1999). Removal of NOM from Drinking Water Supplies by Ozone-Biofiltration. *Water Science and Technology*, 40:9:157-163.

2. **Hozalski, R.M.**, Goel, S., and Bouwer, E.J. (1992). Use of Biofiltration for the Removal of Natural Organic Matter to Achieve Biologically Stable Drinking Water. *Water Science and Technology*, 26:9-11:2011-2014.

B-3.2.5 Papers in Conference Proceedings

The presenter's name is underlined.

1. **Hozalski, R. M.**, Erickson, A., and Gulliver, J.S. (2007). A New Approach for Assessing the Performance of Stormwater Best Management Practices. *Proceedings of the ASCE/EWRI World Environmental and Water Resources Congress*. Tampa, FL.

2. **Hozalski, R. M.**, Zhang, P., T.M. LaPara, A.K. Camper and L.H. Leach. (2007). Enrichment, Isolation, and Characterization of Haloacetic Acid-Degrading Bacteria from Water Distribution Systems. *Proceedings of the ASCE/EWRI World Environmental and Water Resources Congress*. Tampa, FL.

3. **Hozalski, R. M.**, Arnold, W.A., Hondzo, M., Novak, P.J., Kim, S., and Jadzewski, J. (2007). Wireless Technologies and Embedded Networked Sensing: Application to Integrated Urban Water Quality Management. *Proceedings of the ASCE/EWRI World Environmental and Water Resources Congress*. Tampa, FL.

4. **Hozalski, R.M.**, Esbri-Amador, E. and Chen, C. (2003). A Pipe Loop Study to Test Phosphates and Stannous Chloride for Lead Corrosion Control. *Proceedings of the AWWA Water Quality Technology Conf.*, Philadelphia, PA.

5. Dai, X. and **Hozalski, R.M.** (2001). Effect of NOM and Biofilm on the Removal of Cryptosporidium parvum Oocysts in Bench-scale Granular Media Filters. *Proceedings of the AWWA Water Quality Technology Conf.*, Nashville, TN.

6. Zhang, L., Arnold, W.A., and **Hozalski, R.M.** (2001). Reactions of Haloacetic Acids with Zero Valent Iron. *Proceedings of the AWWA Water Quality Technology Conf.*, Nashville, TN.

7. Zhang, M., **Hozalski, R.M.**, Semmens, M.J. and Schuler, D. (2000). An Evaluation of Biostability and Microbiological Quality in a Full-Scale Distribution System. *Proceedings of the AWWA Water Quality Technology Conf.*, Salt Lake City, Utah.

8. Zhang, M., **Hozalski, R.M.**, Semmens, M.J. and Schuler, D. (2000). An Evaluation of Biostability and Microbiological Quality in a Full-Scale Distribution System. *Proceedings of the AWWA Annual Conf.*, Denver, Colo.

9. **Hozalski, R.M.** and Li, H. (1999). Development of an Innovative Method for Natural Organic Matter Characterization Using Capillary Electrophoresis. *Proceedings of the AWWA Water Quality Technology Conf.*, Tampa, Fla.

10. Coffey, B.M., Huck, P.M., Emelko, M.B., Bouwer, E.J., **Hozalski, R.M.**, and Smith, E.F. (1997). The Effect of BOM and Temperature on Biological Filtration: An Integrated Comparison at Two Treatment Plants. *Proceedings of the AWWA Water Quality Technology Conf.*, Denver, Colo.

11. **Hozalski, R.M.**, Goel, S., and Bouwer, E.J. (1993). Removal of Natural Organic Matter from Drinking Water by Biodegradation: Batch and Column Studies. *Proceedings of the AWWA Annual Conf.*, San Antonio, Texas.

12. Bouwer, E.J., **Hozalski, R.M.**, and Goel, S. (1992). Use of Biofiltration for the Removal of Natural Organic Matter to Achieve Biologically Stable Drinking Water. *Proceedings of the AWWARF Tech. Transfer Conf.*, Anaheim, Calif.

B-3.2.6 Technical Reports

1. Zhang, Li and **Hozalski, R.M.** (2004). *Development of a Novel Method for the Analysis of Haloacetic Acids in Drinking Water*. AWWARF and AWWA, Denver, Colo.

2. Bouwer, E.J.; Goel, S.; and **Hozalski, R.M.** (1995). *Removal of Natural Organic Matter in Biofilters*. AWWARF and AWWA, Denver, Colo.

B-3.3 Invited Lectures and Presentations

1. Invited lecture: "DBP fate in distribution systems". CIRSEE-AwwaRF Joint Workshop on Byproducts of Concern in Water Treatment, Paris, France, March 5-9, 2007.

2. Invited lecture: "Distribution Systems: DBPs, IDSE, and Hydraulics", Surface Water Treatment Workshop, Fargo, ND, April 25-27, 2006.

3. Invited lecture: "Fate of Disinfection By-Products in Drinking Water Distribution Systems", Nasjonalt Folkehelseinstituttet (Norwegian Institute of Public Health) in Oslo, Norway, October 1, 2004.

4. Invited lecture: "Abiotic Degradation of Disinfection By-Products", Cranfield University in Bedfordshire, England, September 17, 2004.

5. Invited lecture: "Fate of Disinfection By-Products in Drinking Water Distribution Systems", Norges Teknisk-Naturvitenskapelige Universitet (Norwegian University of Science and Technology) in Trondheim, Norway, September 15, 2004.

6. Invited lecture: "Abiotic Degradation of Disinfection By-Products", Texas A&M University-Kingsville, April 23, 2004.

7. Invited lecture: "Abiotic Degradation of Disinfection By-Products", Virginia Polytechnic Institute and State University (i.e. Virginia Tech), November 14, 2003.

8. Invited lecture: "Changes in Drinking Water Quality Occurring in Distribution Systems", Special Water Resources Workshop for the University of Minnesota College of Natural Resources 100th Anniversary Celebration, St. Paul, Minnesota, April 24, 2003.

9. Invited presentation: "In Situ Bioremediation of PCE using Membrane Supplied Hydrogen", Soil Science Society of America Annual Conference, Indianapolis, Indiana, November 10-14, 2002.

10. Invited poster presentation: "Development of a Safe and Rapid Method for Analysis of HAAs using Capillary Electrophoresis", AWWA Research Foundation poster session, AWWA Annual Conference, New Orleans, Louisiana. June 16-20, 2002.

11. Invited lecture: "Fate of Haloacetic Acids in Aquatic Systems". Department of Civil and Environmental Engineering, University of Maryland, College Park, Maryland. May 6, 2002.

12. Invited lecture: "Fate of Haloacetic Acids in Aquatic Systems". Department of Geography and Environmental Engineering, Johns Hopkins University, Baltimore, Maryland. December 7, 2001.

13. Invited presentation: "Evaluation of Biostability and Microbiological Quality in a Full-Scale Water Distribution System". Minnesota Section AWWA Annual Conference, Mankato, Minn. September 14, 2000.

14. Invited presentation: "Removal of Natural Organic Matter from Drinking Water by Ozone-Biofiltration". International Conference on Removal of Humic Substances from Water, Norwegian University of Science and Technology, Trondheim, Norway. June 24-26, 1999.

15. Invited presentation: "Application of Capillary Electrophoresis in HAA and NOM Analysis". Workshop on Innovative Technologies for Drinking Water Analysis, Water Quality Technology Conference, AWWA, San Diego, Calif. November 1, 1998.

B-3.4 Conference Presentations

When not listed under "Papers in Conference Proceedings". The presenter's name is underlined.

1. Zhang, P., **R.M. Hozalski**, T.M. LaPara, A.K. Camper and L.H. Leach. A novel *Methylobacterium* sp. capable of growth on dichloroacetic acid in drinking water. Poster presentation at the 107th General Meeting, American Society for Microbiology, Toronto, ON, Canada.

2. **Hozalski, R.M.** "Biotic and abiotic degradation of halogenated disinfection by-products in distribution systems". Oral presentation at the American Chemical Society National Meeting, Chicago, IL, March 25-29, 2007.

3. Shimotori, T., Marsili, E., Bond, D.R., Cussler, E.L., LaPara, T.M., and **Hozalski, R.M.** "Comprehensive Modeling of a Microbial Fuel Cell". Oral presentation at the AIChE Annual Conference, San Francisco, CA. November 12-17, 2006.

4. Scharf, R., **Hozalski, R.M.**, Johnston, R., and Semmens, M.J. "Bench-Scale and Pilot-Scale Experiments to Investigate Geosmin Removal Options". Oral presentation at the AWWA Water Quality Technology Conference, Denver, CO. November 5-9, 2006.

5. **Hozalski, R.M.**, Zhang, P., LaPara, T.M., Leach, L. and Camper, A. "Degradation of Disinfection By-Products in Distribution Systems". Oral presentation at the AWWA Water Quality Technology Conference, Denver, CO. November 5-9, 2006.

6. **Hozalski, R.M.**, Esbri-Amador, E., and Chen, C. "An Investigation of Stannous Chloride for Control of Lead Corrosion". Oral presentation at the AWWA Minnesota Section Annual Conference, Duluth, MN. September 20-22, 2006.

7. Arnold, W.A., Pearson, C.R., Lee, J. and **Hozalski, R.M**. **"**Disinfection By-Product Reactions with Iron Pipe Corrosion Products: Effects of Corrosion Mineralogy and Iron Content". Oral presentation at the ACS 231st National Meeting and Exposition, Atlanta, GA. March 26-30, 2006.

8. Chun, C. L., **Hozalski, R.M.** and Arnold, W.A. "Degradation of Disinfection Byproducts in the Presence of Synthetic Carbonate Green Rust". Oral presentation at the ACS 231st National Meeting and Exposition, Atlanta, GA. March 26-30, 2006.

9. **Hozalski, R.M.**, Pearson, C., Chun, C., Lee, J., and Arnold, W.A. "Degradation of Disinfection By-Products by Fe(0) and Iron Minerals". Oral presentation at the AWWA Minnesota Section Annual Conference, Duluth, MN. October 5-7, 2005.

10. **Hozalski, R.M.**, Pearson, C., Chun, C., and Arnold, W.A. "Degradation of Disinfection By-Products in the Presence of Fe(0) and Iron Corrosion Products". Oral presentation at the AWWA Annual Conference and Exposition, San Francisco, CA. June 12-16, 2005.

11. Pearson, C., Chun, C., Arnold, W.A., and **Hozalski, R.M.** "Abiotic Fate of Disinfection By-products in the Drinking Water Distribution System". Oral presentation at the AWWA Annual Conference and Exposition, San Francisco, CA. June 12-16, 2005.

12. Chun, C. L., Pearson, C., Arnold, W.A., and **Hozalski, R.M.** "Kinetics and Pathways of Degradation of Disinfection By-Products by Synthetic Iron Oxide Minerals". Oral Presentation at the 228th ACS National Meeting, Philadelphia, PA, August 22-26, 2004.

13. Pearson, C., Chun, C. L., **Hozalski, R.M.**, and Arnold, W.A. "Degradation Mechanisms of Disinfection By-Products in the Presence of Fe(0)". Oral Presentation at the 228th ACS National Meeting, Philadelphia, PA, August 22-26, 2004.

14. **Hozalski, R.M.**, Zhang, L, Pearson, C., Chun, C. L., and Arnold, W.A. "Abiotic Degradation of Disinfection By-Products". Poster presentation at the Gordon Research Conference (Environmental Sciences: Water), Plymouth, New Hampshire. June 28-July 2, 2004.

15. **Hozalski, R.M.**, Zhang, L, Bressler, C., and Arnold, W.A. "Abiotic Degradation of Disinfection By-Products: Implications for DBP Treatment and Fate in Distribution Systems". Oral presentation at the AWWA Minnesota Section Annual Conference, October 1-3, 2003.

16. **Hozalski, R.M.**, Ma, X., Clapp, L.W., Novak, P.J., and Semmens, M.J. "A Novel Membrane System for Stimulating the *In Situ* Bioremediation of PCE". Poster presentation at the International Conference on Membranes, Toulouse, France, July 7-12, 2002.

17. Novak, P.J., Edstrom, J.A., Clapp, L.W., **Hozalski, R.M.**, and Semmens, M.J. "Stimulation of Dechlorination by Membrane-Delivered Hydrogen: Small Field Demonstration". Poster presentation at the International Conference on Membranes, Toulouse, France, July 7-12, 2002.

18. Fang, Y., **Hozalski, R.M.**, Novak, P.J., Clapp, L.W., and Semmens, M.J. "Membrane Gas Transfer Under Conditions of Creeping Flow". Oral presentation at the International Conference on Membranes, Toulouse, France, July 7-12, 2002.

19. **Hozalski, R.M.**, Zhang, L., McRae, B., Arnold, W.A., and LaPara, T.M. "Biotic and Abiotic Degradation of Haloacetic Acids: Implications for Treatment and Fate", Poster presentation at the Gordon Research Conference (Environmental Sciences: Water), Plymouth, New Hampshire. June 23-28, 2002.

20. Novak, P.J., Edstrom, J.A., Clapp, L.W., **Hozalski, R.M.**, and Semmens, M.J. "Stimulation of Dechlorination by Membrane-Delivered Hydrogen: Small Field Demonstration". Platform (oral) presentation at the Third International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, Calif. May 20-23, 2002.

21. **Hozalski, R.M.**, Ma, X., Clapp, L.W., Novak, P.J., and Semmens, M.J. "A Novel Membrane System for Stimulating the Bioremediation of PCE". Poster presentation at the Third International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, Calif. May 20-23, 2002.

22. Clapp, L.W., **Hozalski, R.M.**, Novak, P.J., and Semmens, M.J. "Modeling Competition Between Dehalorespirers and Methanogens in a PCE-Contaminated Aquifer Pulsed with H_2 via Gas-Permeable Membranes". Poster presentation at the Partners in Environmental Technology Technical Symposium and Workshop, Arlington, Virginia, November, 2001.

23. Zhang, L., **Hozalski, R.M.**, and Arnold, W.A. "Reduction of Haloacetic Acids by Fe0: Implications for Treatment and Fate". Oral presentation at the 24th Midwest Environmental Chemistry Workshop, University of Minnesota, Minneapolis, Minn. October 5-7, 2001.

24. **Hozalski, R.M.**, Ma, X., Clapp, L.W., Novak, P.J., and Semmens, M.J. "A Novel Membrane System for Stimulating the Bioremediation of PCE". Poster presentation at the Sixth International Symposium on *In Situ* and On-Site Bioremediation, San Diego, Calif. June 4-7, 2001.

25. Novak, P.J., Muenzner, H.D., Nelson, D.K., Clapp, L.W., **Hozalski, R.M.**, and Semmens, M.J. "Dechlorination Supported by Membrane-Supplied Hydrogen: Effect of Hydrogen Partial Pressure". Platform (oral) presentation at the Sixth International Symposium on *In Situ* and On-Site Bioremediation, San Diego, Calif. June 4-7, 2001.

26. Fang, Y., Roggy, L.W., Clapp, L.W., **Hozalski, R.M.**, Novak, P.J., and Semmens, M.J. "Membrane Studies: Gas Transfer Behavior and Membrane Fouling". Poster presentation at the Partners in Environmental Technology Technical Symposium and Workshop, Arlington, Virginia, November, 2000.

27. Ma, X., Clapp, L.W., **Hozalski, R.M.**, Novak, P.J., and Semmens, M.J. "Column Study on Anaerobic Dechlorination using Membrane Delivering H_2 System". Poster presentation at the Partners in Environmental Technology Technical Symposium and Workshop, Arlington, Virginia, November, 2000.

28. **Hozalski, R.M.** and Zhang, L. "Development of a Novel HAA Analysis Method Using Capillary Electrophoresis". Workshop on Haloacetic Acid Analyses, Water Quality Technology Conference, AWWA, Salt Lake City, Utah, November 5, 2000.

29. Zhang, L. and **Hozalski, R.M.** "Development of a Safe and Rapid Method for Analysis of Haloacetic Acids in Drinking Water Using Capillary Electrophoresis". Oral presentation at the 23rd Midwest Environmental Chemistry Workshop, Western Michigan University, Kalamazoo, Mich., October 6-8, 2000. Li Zhang was awarded one of three "Best Student Paper" awards.

30. **Hozalski, R.M.**, Zhang, M., Schuler, D., and Semmens, M.J. "Evaluation of Biostability and Microbiological Quality in a Full-Scale Distribution System". Poster presentation at the Gordon Research Conference (Environmental Sciences: Water), Plymouth, New Hampshire. June 25-30, 2000.

31. Muenzner, H.D., Clapp, L.W., **Hozalski, R.M.**, Novak, P.J., and Semmens, M.J. "The Use of Hollow Fiber Membranes to Deliver Hydrogen to a Perchloroethene Dechlorinating Culture". Poster presentation at the Partners in Environmental Technology Technical Symposium and Workshop, Arlington, Virginia, November, 1999.

32. **Hozalski, R.M.** and Li, H. "Development of a Safe and Rapid Method for Analysis of Haloacetic Acids in Drinking Water Using Capillary Electrophoresis". Oral presentation at

the 22nd Midwest Environmental Chemistry Workshop, Michigan Technological University, Houghton, Mich., October 1-3, 1999.

33. **Hozalski, R.M.** "Ozonation and Biofiltration for Water Treatment". Oral presentation at the Minnesota Water '98 Conference in Minneapolis, Minn., May 5-6, 1998.

34. **Hozalski, R.M.**, Goel, S., and Bouwer, E.J. "Removal of Biodegradable Organic Matter in Drinking Water Biofilters: Experimental Studies and Model Development". Poster presentation at the Gordon Research Conference (Environmental Sciences: Water), New Hampton, New Hampshire, June 1996.

B-3.5 Sponsored Projects

Approximate percentage contribution/effort on grants with co-PIs is listed in parentheses. Co-PIs from University of Minnesota unless otherwise noted.

Current Research Projects

1. *Fate and Impact of Antibiotics in Slow Rate Biofiltration Processes*
   American Water Works Association Research Foundation
   Co-PIs: **R.M. Hozalski** (50%) and D.B. Wunder (Calvin College)
   $150,000.
   September 2007-September 2009.

2. *Collaborative Research: Cohesive Strength and Detachment of Bacterial Biofilms*
   National Science Foundation
   Co-PIs: **R.M. Hozalski** (60%) and P. Stewart (Montana State)
   $375,000.
   September 2007-September 2010.

3. *Vadnais Lake: Aeration Assessment and On-Line Water Quality Monitoring*
   St. Paul Regional Water Services
   Co-PIs: M. Hondzo, M.J. Semmens, and **R.M. Hozalski** (33%)
   $72,034.
   July 2007 – June 2008

4. *Wireless Technologies and Embedded Networked Sensing: Application to Integrated Urban Water Quality Management*
   National Science Foundation
   Co-PIs: M. Hondzo, W.A. Arnold, **R.M. Hozalski** (20%), P.J. Novak, and N. Jindal
   $250,424.
   September 2006 – August 2008

5. *Application of Wireless and Sensor Technologies for Urban Water Quality Management*
   NIWR/U.S. Geological Survey National Competitive Grant Program

Co-PIs: Miki Hondzo, William Arnold, Raymond Hozalski (25%), and Paige Novak
$149,176.
September 2006 – August 2008

6. *Biodegradation of HAAs in Distribution Systems*
American Water Works Association Research Foundation
Co-PIs: **R.M. Hozalski** (50%), T.M. LaPara, A. Camper (Montana State), S. Parsons (Cranfield, in UK), and Y. Xie (Penn State-Harrisburg)
$400,000.
January 2006 – June 2008

7. *Investigation of the Mode of Action of Stannous Chloride as an Inhibitor of Lead Corrosion*
American Water Works Association Research Foundation
Co-PIs: **R.M. Hozalski** (90%) and A. Camper (Montana State)
$150,000.
June 2006 – May 2008

8. *IGERT: Non-equilibrium Dynamics Across Space and Time: A Common Approach for Engineers, Earth Scientists, and Ecologists*
National Science Foundation
Co-PIs: C. Neuhauser, M. Hondzo, **R.M. Hozalski** (20%), S. Sugita, and C. Paola
$2,819,194.
August 2005 – July 2010

9. *An Integrated Approach for the Optimization of Microbial Fuel Cells*
Institute for Renewable Energy and the Environment (University of Minnesota)
Co-PIs: D. Bond, T.M. LaPara, and **R.M. Hozalski** (30%)
$477,000.
August 2005 – July 2008

<u>Previous Projects</u>

1. *Planning for a Full-Scale CLEANER: Options for Field Facilities and Cyberinfrastructure in America's Heartland*
National Science Foundation
Co-PIs: M. Hondzo, P.J. Novak, **R.M. Hozalski** (20%), S. Shekhar, and W.A. Arnold
$69,960.
August 2004 – July 2006

2. *Evaluation of Geosmin Removal Options*
St. Paul Regional Water Services
Co-PIs: **R.M. Hozalski** (50%) and M.J. Semmens
$59,000.
April 2003 – December 2004

3. *The Role of the Pipe Wall in the Abiotic Degradation of DBPs in Distribution Systems*

American Water Works Association Research Foundation
Co-PIs: **R.M. Hozalski** (50%) and W.A. Arnold
$149,997.
September 2003 – August 2005

4. *The Role of Fe(0) and its Corrosion Products in the Degradation of Disinfection By-Products*
National Science Foundation
Co-PIs: **R.M. Hozalski** (50%) and W.A. Arnold
$238,315.
September 2003 – August 2005

5. *Graduate Assistance in Areas of National Need Fellowship Program*
U.S. Department of Education
PI: **R.M. Hozalski**
$666,192.
August 2000 – August 2003

6. *An Innovative Passive Barrier System Using Membrane-Delivered Hydrogen Gas for the Bioremediation of Chlorinated Aliphatic Compounds*
U.S. Department of Defense
PI: M.J. Semmens, Co-PIs: **R.M. Hozalski** (33%) and P.J. Novak
$1,397, 005.
March 1999 – March 2003

7. *Development of a Safe and Rapid Method for Analysis of Haloacetic Acids in Drinking Water*
American Water Works Association Research Foundation
PI: **R.M. Hozalski**
$24,461. (Project Continuation Award)
April 2002 – December 2002

8. *Pilot Testing* (Open ended grant used to fund a variety of projects)
St. Paul Regional Water Services
PI/Co-PI (varies with specific project): M.J. Semmens and **R.M. Hozalski** (50%)
$253,000.
September 1996 – August 2002

9. *Natural Organic Matter: Soil and Water Quality, Water Treatment, and Plant Growth*
University of Minnesota (New Initiatives in Interdisciplinary Research and Postbaccalaureate Education)
PI: P.R. Bloom, Co-PIs: P.L. Brezonik, **R.M. Hozalski** (20%), K. McNeill, and E. Munson
$67,200.
July 2000 – June 2002

10. *Development of a Safe and Rapid Method for Analysis of Haloacetic Acids in Drinking Water*
Sponsor: American Water Works Association Research Foundation

PI: **R.M. Hozalski**
$108,685.
January 2000 – April 2002

11. *An Investigation of the Factors Affecting Removal of Cryptosporidium and Giardia from Drinking Water Supplies by Granular Media Filtration*
U.S. Geological Survey Water Resources Research Institutes Program
PI: **R.M. Hozalski**
$48,281.
March 1999 – March 2001

12. *Use of Capillary Electrophoresis to Characterize Natural Organic Matter (NOM) and to Develop Correlations Linking NOM Composition with Reactivity*
University of Minnesota (Grant-in-Aid of Research, Artistry and Scholarship)
PI: **R.M. Hozalski**
$15,908.
December 1998 – December 1999

13. *Effect of Biofilm on Removal of Cryptosporidium and Giardia in Drinking Water Filters*
University of Minnesota (Grant-in-Aid of Research, Artistry and Scholarship)
PI: **R.M. Hozalski**
$16,120.
December 1997 – December 1998

B-4 DISCIPLINE RELATED SERVICE ACTIVITIES

B-4.1 International, National, and Local Committees

2007-	Project Advisory Committee for American Water Works Association Research Foundation project 4128 “Towards the Development of Biosensors for Analysis of MIB and Geosmin: Phase II” (PI: Christopher Saint)
2006-	Member, NSF-sponsored WATer and Environmental Research Systems (WATERS) Network, Urban Environmental Field Facility Design Subgroup.
2003-	Member, Academic Achievement Award Committee, American Water Works Association (International level).
2002 – 2004	Project Advisory Committee for American Water Works Association Research Foundation project 2824 “Cometabolism of Trihalomethanes in Nitrifying Biofilters” (PI: Gerald Speitel)
1998-	Member, Research Committee, Minnesota Section of the American Water Works Association (Local level).
1999-2001	Member, Water Environment Federation (WEF) Literature Review Committee (International level).

B-4.2 Organization of Symposia, Sessions, Seminars, and Workshops

1. Member, Organizing Committee, NSF-sponsored Environmental Engineering Education Workshop, Arizona State University, Tempe, Arizona, Jan 8-10, 2007.

2. Member, Organizing Committee, *Frontiers in Assessment Methods for the Environment* Symposium, Sponsored by the National Science Foundation and the Association of Environmental Engineering and Science Professors, Minneapolis, Minnesota, August 10-13, 2003.

3. Member, Organizing Committee, *Midwest Environmental Chemistry Workshop*, University of Minnesota, Minneapolis, Minnesota, October 5-7, 2001

4. Co-organizer and Co-Chair of Workshop (with Yuefeng Xie), *Haloacetic Acid Analyses: Past*, *Present and Future*, Pre-conference workshop held at the AWWA Water Quality Technology Conference, Salt Lake City, Utah, November 5, 2000.

5. Member, Organizing Committee, *Natural Organic Matter in Soils and Water*, North Central Region Workshop, University of Minnesota, St. Paul, Minnesota, January 10-11, 2000.

6. Member, Organizing Committee, *Natural Organic Matter in Soils and Water*, An International Workshop and Symposium, St. Paul, Minnesota, October 23-24, 1998.

7. Organizer and Chair of Technical Session, *Advances in Treatment Technology I*, Technical Session held at the Minnesota Water '98: Protecting Minnesota's Water Supplies Conference, Minneapolis, Minnesota, May 5-6, 1998.

B-4.3 Editorial and Peer Review Duties

B-4.3.1 Editorial Duties

(none)

B-4.3.2 Peer-Review Duties

1997- Refereed Journals:

Advances in Environmental Research
Biotechnology and Bioengineering
Chemosphere
Environmental Science and Technology
Experiments in Fluids
Journal of the American Water Works Association
Journal of Environmental Quality
Journal of Environmental Management
Water Research
Water Environment Research

1997- Book Chapters

"Development of a Capillary Electrophoresis Method for Haloacetic Acids" in *Natural Organic Matter and Disinfection By-Products: Characterization and Control*
"Removal of Pathogenic Microbes by Granular High Rate Filtration" in *Encyclopedia of Environmental Microbiology*

B-5 OTHER SERVICE ACTIVITIES

B-5.1 University of Minnesota

2005- Member, Graduate School Engineering and Physical Sciences Policy and Review Council

2003-04 Member, Endowed Fellowship Committee

2001-02 Member, Water Resources Center External Advisory Committee

1998-2001 Member, Water Resources Science Program Graduate Studies Committee

1998-99 Panelist for a Preparing Future Faculty program course at the University of Minnesota entitled "Practicum for Instructors in Higher Education" (April 9, 1998; October 12, 1999).

B-5.2 Institute of Technology

1999-2004 Chief Advisor to Tau Beta Pi (Engineering Honor Society).

1998-1999 Advisor to Tau Beta Pi (Engineering Honor Society).

B-5.3 Department of Civil Engineering

2006 Faculty search committee, environmental engineering position

2005 Senior accountant search committee

2005- Civil Engineering Planning Council

2005- Director of Graduate Studies

1997-2001 Member, Graduate Studies Committee

1997-2001 Co-organizer (with J. Hajjar, D. Levinson) of "Beyond the Bachelor's Degree: An Informal Luncheon and Discussion", a session to discuss graduate school with Civil Engineering undergraduate students (November 18, 1997; November 18, 1998; October 21, 1999; May 3, 2001).

B-5.4 Other Outside Activities

March 2007	Member of AwwaRF DBP Issue Group. Purpose of group is to develop ideas for request for proposals to be issued by AwwaRF concerning disinfection byproducts.
Dec. 2006	Panelist for NSF Unsolicited Proposal Competition, Division of Chemical, Bioengineering, Environmental, and Transport Systems
Dec. 2005	Ad hoc reviewer (one proposal) for the Natural Sciences and Engineering Research Council of Canada (NSERC) Discovery Grant program
Aug. 2005	Ad hoc reviewer (one proposal) for the NSF CAREER Award program, Division of Earth Sciences, Hydrologic Sciences Program
July 2004	Review of book proposal for CRC Press (*Fundamentals of Biofilm Research* by Z. Lewandowski and H. Beyenal)
Dec. 2003	Ad hoc reviewer (one proposal) for the Wisconsin Water Resources Institute unsolicited proposal competition
June 2003	Ad hoc reviewer (one proposal) for the NSF Collaborative Research program, Bioengineering and Environmental Systems Division
2003	Technical (content) adviser for children's book entitled *Air: Outside, Inside, and All Around*, published by Picture Window Books, Minneapolis, MN
2003	Technical (content) adviser for children's book entitled *A Drop in the Ocean: The Story of Water*, published by Picture Window Books, Minneapolis, MN
Sept. 2002	Panelist for NSF SBIR/STTR Phase II Virtual Panel 7
April 2002	Panelist for NSF SBIR Panel
2002	Technical (content) adviser for children's book entitled *Water: Up, Down, and All-Around*, published by Picture Window Books, Minneapolis, MN
Dec. 2001	Panelist for NSF CAREER Award Panel (Biological and Environmental Systems Division)
May 2001	Ad hoc reviewer (one proposal) for the National Research Council's Collaboration in Basic Science and Engineering (COBASE) program