

Richard F. Carbonaro, Ph.D, P.E.

Principal Environmental Engineer

EDUCATION:

Ph.D. Environmental Engineering, Johns Hopkins University, 2004

M.E. Environmental Engineering, Manhattan College, 1999

B.S. Environmental Engineering, Manhattan College, 1997

PROFESSIONAL HISTORY:

Consulting Engineering

Mutch Associates, LLC
Principal Environmental Engineer
2009 to present

HydroQual, Inc.
Environmental Engineer
2006 – 2009

Academia

Manhattan College
Chemical Engineering
Professor
2019 – present
Associate Professor
2010 – 2019
Assistant Professor
2004 – 2010

PROFESSIONAL AFFILIATIONS:

American Chemical Society:
Environmental Chemistry Division

Society of Environmental Toxicology
and Chemistry

EXPERIENCE SUMMARY:

Dr. Richard F. Carbonaro has worked as an environmental engineer for nearly twenty years, specializing in the fate and transport of contaminants in soil, groundwater and sediments. He consults on a range of topics related to hazardous site characterization and remediation including in-situ remediation of chlorinated solvents and inorganics, contaminant partitioning, fate and transport, groundwater geochemistry, and environmental forensics.

Dr. Carbonaro has a Ph.D. from the Department of Geography and Environmental Engineering at Johns Hopkins University, where he studied the sources, sinks, and speciation of chromium in heterogeneous media. He has developed numerical models for modeling chromium fate and transport in groundwater during in-situ remediation, and has worked on numerous chromium contaminated sites (see specific project experience below). He has published several peer-reviewed papers on transformations of chromium and other trace metals in aquatic systems and has been a presenter or co-author on over 60 presentations at technical conferences.

Dr. Carbonaro is also a faculty member within the Chemical Engineering Department of Manhattan College. As part of his work at Manhattan College, Dr. Carbonaro has managed several federally-funded research projects related to transport modeling of organic chemicals and metals in surface waters and sediments, and partitioning of metals onto natural organic matter. He has taught courses at the undergraduate and graduate levels in water chemistry, water treatment, fate and transport modeling of environmental contaminants, and environmental statistics.

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REGISTRATIONS:

Professional Engineer, New York (2013)

40-Hour Training: Hazardous Waste
Operations and Emergency Response
Standard (29 CFR 1910.120(e))

APPOINTMENTS & HONORS:

Invited Paper: Journal of Environmental
Monitoring (Emerging Investigators
Issue), 2012.

Best Paper Award, University Forum,
NYWEA 84th Annual Meeting and
Exhibition, 2012

Gordon Research Conferences,
Environmental Sciences: Water. Invited
Talk, 2008

Outstanding Teacher Award
(Environmental Engineering),
Manhattan College, 2006, 2007, 2010,
2012, 2013

U.S. Environmental Protection Agency,
Science to Achieve Results (STAR)
Fellowship, 2000

Tau Beta Pi - National Engineering
Honor Society

SELECTED PROJECT EXPERIENCE:

Reactive Transport Modeling

***Development of a “Unit World” Lake Model for Modeling
Metals Fate and Transport***

This work involved development of numerical algorithms and software package for the TICKET-UWM platform for modeling metals fate and transport in the environment. The publicly available model (www.unitworldmodel.net) is being used to support metals classifications under REACH in the European Union. The model includes a robust chemical description of metal partitioning to dissolved and particulate organic carbon in the water column and sediment.

***Evaluation of Remedial Alternatives for a Hexavalent
Chromium Plume Using Custom Reactive Transport Modeling***

Custom reactive transport FORTRAN code was developed for modeling chromium transformations within RT3D (Reactive Multispecies Transport in 3-Dimensional Groundwater Systems). The model was used to perform simulations to evaluate the effectiveness of various alternatives for in-situ additions of chemical reductants including calcium polysulfide. In addition, the RT3D model was used to model the results of bench-scale column testing of reductant addition and to evaluate the performance of in situ chemical reduction of hexavalent chromium “push-pull” and permeable reactive barrier technologies.

***Reactive Transport Modeling of Degradation of Chlorinated
Solvents using Catalyzed Hydrogen Peroxide (CHP)***

Custom reactive transport FORTRAN code was developed for modeling the interaction of CHP with a PCE/TCE dissolved plume. Modeling was performed using RT3D (Reactive Multispecies Transport in 3-Dimensional Groundwater Systems). The model was used to perform simulations to evaluate the effectiveness of treatment and clean-up times for the site.

Sediment Remediation and Assessment of Contamination

***Assessment and Allocation of Sediment Contamination from a
PRP located on Berry’s Creek (NJ) Superfund Site***

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An assessment of metals and VOC contamination was performed for a PRP involved in the Berry's Creek Superfund site. Historical loadings of metals from the PRP discharge were compared to total metals present in surficial sediments at Berry's Creek. This information was used to assess the appropriateness of the PRP's cost allocation for the remedial investigation of the site.

Geochemical Analysis of Sediment from the Gowanus Canal (NY) Superfund Site for use in Source Identification

A review of sediment geochemical data was performed for the Gowanus Canal Superfund Site. The purpose of the review was to determine the suitability of sediment geochemical data for use in source identification of PAHs and other COCs at the site. The review revealed that the geochemical and statistical data analysis techniques performed by the opposition's consultant were not appropriate and fundamentally flawed. The client used this information to argue that the opposition's claims based on the use of this data were without scientific merit.

Remediation of Contaminated Soil and Groundwater

Remediation of Hexavalent Chromium in Soils in Jersey City, NJ

Treatability studies were designed for soils collected from this site using a variation of the ASTM dynamic column leaching test protocols. Soils were leached for up to 3 months using clean groundwater from the site. Column effluents were monitored for hexavalent chromium and other key water quality parameters to determine time-scales for flushing. Additional leach testing was performed using groundwater dosed with a chemical reductant to determine its effectiveness for in-situ remediation. This information was vital for the selection and design of remedial alternatives for the site.

Groundwater Sparging with CO₂ of a Plume of Caustic Brine to Achieve Reduction in pH in Brunswick, GA

This site was characterized with a subsurface plume of high pH and high total dissolved solids from historical operations of a mercury cell facility. The resulting plume contained high pH (~12), high total dissolved solids and dissolved metals such as mercury, arsenic and chromium. As part of this work, a "proof of concept" test was performed to evaluate the effectiveness of sparging the plume with carbon dioxide to lower pH and metals concentrations. The test was successful, resulting in implementation of this technology for the entire 8 acre site.

Remediation of Arsenic in Gypsum and Fly-Ash Waste Beds at a Chemical-Processing Facility in Amhurstburg, Ontario, CA

Design of a monitoring program to assess speciation of arsenic in groundwater and solid waste material. This work involved the development of source code in VBA for modeling chemical diffusion through porous fractured rock matrices. The resulting matrix diffusion model was used to model arsenic diffusion through fractured rock at this site.

Bench Scale Leaching and Treatability Studies

Investigation and Design of a Permeable Reactive Barrier for Arsenic Fixation

This work was performed in support of a pre-design investigation with the objective of mitigating on-going releases of arsenic from a groundwater seep as part of an Interim Remedial Measure (IRM). Treatability testing conducted as part of this work was somewhat unique in that it was performed in the field. The main arsenic species were arsenite, arsenate, methylated As and thioarsenate complexes. The treatability testing consisted of two phases: 1) a field treatment evaluation of speciation and preliminary treatability characterization, and 2) an in-well treatability test using various permeable reactive media.

Column Leaching Study for Soil Collected from a Hexavalent Chromium Containing Site

The purpose of this study was to determine (i) the leaching characteristics of Cr(VI) from contaminated soil samples using kinetic leaching tests and (ii) elucidate possible Cr(VI) mineral and/or chemical mechanisms that may be responsible for Cr(VI) retention in the soil. The tests utilized a modification of the ASTM Test Method D 4874 (Standard Test Method for Leaching Solid Material in a Column Apparatus).

Batch Study Investigating Chromium Transformations During pH Adjustment of Raffinate Waste Stream

This study examine chromium speciation and redox transformations during adjustment of a raffinate waste stream (pH ~ 0) to near-neutral pH. Caustic soda and hydrated lime were used separately and in small increments to raise the pH. Redox and pH were monitored through the titration and chromium speciation was assessed prior to and after the titrations were complete. These results were used successfully to satisfy the regulatory agencies concern over hexavalent chromium formation during pH adjustment.

Batch Microcosm Study for Treatment of Hexavalent Chromium Contaminated Soil

The purpose of this study was to assess the effectiveness of a carbon substrate to promote reducing conditions in soil and lower hexavalent chromium concentrations. The bench scale batch testing needed to be performed in the absence of oxygen. Therefore, all work was performed in an anaerobic environment using a glove bag filled with nitrogen gas.

Environmental Forensics

Chemical Fingerprinting of Chemical Contaminants in Groundwater Originating from Landfill Leachate at the Pennsauken NJ MSW landfill.

This project utilized new methods for determining whether chemical contaminants present in groundwater originate from landfill, septic systems or other sources. These methods rely upon the measurement of bromide and iodide which are usually minor constituents in groundwater. Their abundance relative to major ions such as sodium and chloride can be diagnostic of different origins of groundwater.

Chemical Fingerprinting and Intermedia Transport Modeling, Industrial Plant, Illinois

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Conducted a forensics analysis of a plume containing vinyl chloride, 1,1-DCE, and other constituents using stable isotopes of H, O, and N; and major and minor ions to demonstrate that the plume could not have impacted residential wells in a nearby village. Use of air emission diffusion models to estimate volatilization losses of vinyl chloride from groundwater through the vadose zone.

ARTICLES IN PEER-REVIEWED JOURNALS

1. Murillo-Gelvez, J.; Di Toro, D.M.; Allen, H.E., Carbonaro, R.F.; Chiu, P.C. “Reductive Transformation of 3-Nitro-1,2,4-triazol-5-one (NTO) by Leonardite Humic Acid and Anthraquinone-2,6-disulfonate (AQDS)” *Environmental Science & Technology* 2021, 55(19), 12973–12983
2. Cárdenas-Hernández, P.; Anderson, K.; Murillo Gelvez, J.; Di Toro, D.M.; Allen, H.A.; Carbonaro, R.F.; Chiu, P. “Reduction of 3-nitro-1,2,4-triazol-5-one (NTO) by the hematite aqueous Fe(II) redox couple.” *Environmental Science & Technology* 2020, 54(19), 12191-12201.
3. Hickey, K.P.; Di Toro, D.M.; Allen, H.E., Carbonaro, R.F.; Chiu, P.C. “A Unified Linear Free Energy Relationship for Abiotic Reduction Rate of Nitroaromatics and Hydroquinones using Quantum Chemically Estimated Energies.” *Environmental Toxicology and Chemistry* 2020, 39(12), 2389-2395.
4. Di Toro, D.M.; Hickey, K.P.; Allen, H.E., Carbonaro, R.F.; Chiu, P.C. “Hydrogen Atom Transfer Reaction Free Energy as a Predictor of Abiotic Nitroaromatic Reduction Rate Constants: A Comprehensive Analysis.” *Environmental Toxicology and Chemistry* 2020, 39, 1678-1684.
5. Murillo-Gelvez, J; Hickey, K.P.; Di Toro, D.M.; Allen, H.E., Carbonaro, R.F.; Chiu, P.C. “Experimental validation of hydrogen atom transfer gibbs free energy as a predictor of nitroaromatic reduction rate constants.” *Environmental Science & Technology* 2019, 53(10):5816-5827.
6. Rader, K.J.; Carbonaro, R.F.; van Hullebusch, E.; Baken, S.; Delbeke, K. “The Fate of Copper Added to Surface Water: Field and Modeling Studies” *Environmental Toxicology and Chemistry* 2019 38(7): 1386-1399.
7. Huntsman, P.; Beaudoin, R.; Rader, K.J.; Carbonaro, R.F.; Burton, G. A.; Baken, S.; Garman, E.; Waeterschoot, H. “Method Development for Determining the Removal of Metals from the Water Column under Transformation/ Dissolution Conditions for Chronic Hazard Classification.” *Environmental Toxicology and Chemistry* 2019, 38(9): 2032-204.
8. Burton, G. A.; Hudson, M.; Huntsman, P.; Carbonaro, R.F.; Rader, K.J.; Waeterschoot, H.; Baken, S.; Garman, E. “Weight-Of-Evidence Approach For Assessing Removal Of Metals

From The Water Column For Chronic Environmental Hazard Classification.” *Environmental Toxicology and Chemistry* 2019, 38(9): 1839-1849.

9. Carbonaro, R.F.; Farley, K.J.; Delbeke, K.; Baken, S.; Arbildua, J.; Rodriguez, P.; Rader, K.J. “Modeling the Fate of Metal Concentrates in Surface Water.” *Environmental Toxicology and Chemistry* 2019, 38(6): 1256-1272.
10. Wilson, J.M., Farley, K.J. and **Carbonaro, R.F.** “Kinetics of Fe^{II}-polyaminocarboxylate oxidation by molecular oxygen.” *Geochimica et Cosmochimica Acta* 2018, 225, 116-127.
11. Santos, M.A., **Carbonaro, R.F.**; Sharp, R.R. “Control strategies for the mitigation and removal of attached manganese biofilms.” *Journal of Environmental Engineering* 2017, 144 (1).
12. Whitehead, C.F.; **Carbonaro, R.F.**; Stone, A.T. “Adsorption of Benzoic Acid and Related Carboxylic Acids onto FeOOH(goethite): The Low Ionic Strength Regime.” *Aquatic Geochemistry* 2015, 21(2), 99-121.
13. **Carbonaro, R.F.**, Stone, A.T. “Oxidation of Cr^{III} Aminocarboxylate Complexes by Hydrous Manganese Oxide: Products and Time Course Behavior.” *Environmental Chemistry* 2015, 12(1), 33-51.
14. **Carbonaro, R.F.**; Mutch, R.D.; Changa-Moon, D.C.; Gupta, P.K.; Morris, J.J.; Nambiar, A.; Cordone, L.; O’Loughlin, J.M. “In Situ CO₂ Sparging Part 1: Neutralization of a Caustic Brine Plume and Reduction of Mercury Levels.” *Journal of Hazardous, Toxic, and Radioactive Waste* 2015, 19 (1), C4014005.
15. Mutch, R.D.; **Carbonaro, R.F.**; Changa-Moon, D.C.; Gupta, P.K.; Morris, J.J.; Nambiar, A.; Cordone, L.; O’Loughlin, J.M. “In Situ CO₂ Sparging Part 2: Groundwater Mounding and Impacts on Aquifer Properties.” *Journal of Hazardous, Toxic, and Radioactive Waste* 2015, 9 (1), C4014006.
16. Atalay, Y.B.; Di Toro, D.M.; **Carbonaro, R.F.** “Estimation of Stability Constants for Metal-Ligand Complexes Containing Neutral Nitrogen Donor Atoms with Applications to Natural Organic Matter.” *Geochimica et Cosmochimica Acta* 2013, 122, 464–477.
17. Lindsay, D.R.; Farley, K.J.; **Carbonaro, R.F.** “Oxidation of Cr^{III} to Cr^{VI} During Chlorination of Drinking Water.” *Journal of Environmental Monitoring* 2012, 14, 1789-1797.
18. Wilson, J.M.; **Carbonaro, R.F.** “Capillary Electrophoresis Study of Iron(II) and Iron(III) Polyaminocarboxylate Complex Speciation.” *Environmental Chemistry* 2011, 8(3), 295-303.
19. **Carbonaro, R.F.**; Atalay, Y.B.; Di Toro, D.M. “Linear Free Energy Relationships for Metal-Ligand complexation: Bidentate Binding to Negatively-Charged Oxygen Donor Atoms.” *Geochimica et Cosmochimica Acta* 2011, 75 (9), 2499-2511.
20. Farley, K. J.; **Carbonaro, R.F.**; Fanelli, C.J.; Costanzo, R.; Rader, K.J.; Di Toro, D.M. “TICKET-UWM: A Coupled Kinetic, Equilibrium and Transport Screening Model for Metals in Lakes.” *Environmental Toxicology and Chemistry* 2011, 30 (6), 1278-1287.

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21. Atalay, Y.; **Carbonaro, R.F.**; Di Toro, D.M. "Distribution of Proton Dissociation Constants for Model Humic and Fulvic Acid Molecules." *Environmental Science & Technology* 2009, 43 (10), 3626-3631.
22. Mendola, M.; Paul, T.; Strathmann, T.J.; **Carbonaro, R.F.** "Investigation of the Aquation Kinetics of the 1:2 Complex between Cr(III) and Nitrilotriacetic Acid." *Polyhedron* 2009, 28 (2), 269-278.
23. **Carbonaro, R.F.**; Gray, B.N.; Whitehead, C.F.; Stone, A.T. "Interaction of Carboxylate-Containing Chelating Agents with Amorphous Chromium Hydroxide: Adsorption and Dissolution." *Geochimica et Cosmochimica Acta* 2008, 72 (13), 3241-3257.
24. Naka, D.; Kim, D.; **Carbonaro, R.F.**; Strathmann, T.J. "Abiotic Reduction of Nitroaromatic Contaminants by Iron(II) Complexes with Organothiol Ligands." *Environmental Toxicology and Chemistry* 2008, 27 (6), 1257-1266.
25. **Carbonaro, R.F.**; Di Toro, D.M. "Linear Free Energy Relationships for Metal-Ligand Complexation: Monodentate Binding to Negatively-Charged Oxygen Donor Atoms." *Geochimica et Cosmochimica Acta* 2007, 71 (16), 3958-3968
26. Rader, K.J.; Bisceglia, K.J.; **Carbonaro, R.F.**; Farley, K.J.; Mahony, J.D.; Di Toro, D.M. Iron(II)-catalyzed oxidation of Arsenic(III) in a sediment column. *Environmental Science & Technology* 2005, 39, 9217-9222.
27. **Carbonaro, R. F.**; Mahony, J. D., Walter, A.D., Halper, E. B., Di Toro, D. M. Experimental and Modeling Investigation of Metal Release from Metal-Spiked Sediments. *Environmental Toxicology and Chemistry* 2005, 24(12), 3007-3019.
28. **Carbonaro, R. F.**; Stone, A. T. Capillary Electrophoresis Analysis of Chromium(III) and Cobalt(III) (Amino)carboxylate Speciation. *Analytical Chemistry* 2005, 77, 155-164.

GRANT FUNDING

Enhanced Evaporative Flux to Remediate Brine-Contaminated Soil. Imhoff, P., Carbonaro, R.F., Allen, H.A., Di Toro, D.M. ExxonMobil. (2018-2020).

Measuring and Predicting the Natural and Enhanced Rate and Capacity of Abiotic Reduction of Munition Constituents. SERDP ER-2617. Chiu, P.C., Carbonaro, R.F., Allen, H.A., Di Toro, D.M. (2016-2020).

Abiotic attenuation, which involves chemical reactions between contaminants and a soil/sediment constituent, is an important sink for many contaminants in the environment. If engineered correctly, the process can also be an inexpensive, semi-passive approach to control plume migration in soil and

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groundwater. Under anoxic subsurface conditions, redox-labile chemicals are especially susceptible to reductive attenuation processes. Hence, sites where these contaminants are present have the greatest opportunities for successful application of enhanced abiotic attenuation. Many soil constituents have been identified that can either reduce or catalyze the reduction of these contaminants, including ferrous iron-containing minerals, ferrous iron complex, natural organic matter, and black carbon. However, the reactivity of both the reductants and contaminants can vary by many orders of magnitude, depending on the type and nature of the reactants and the geochemical conditions. The objective of this project is to develop a methodology for predicting (1) the abiotic reduction rates of munitions compounds in the solid matrix of any given geochemical state of a solid, and (2) the longevity and enhancement frequency necessary to control plume migration.

USEPA Targeted Watershed Implementation Grant, Saw Mill River. Subcontracted by the Saw Mill River Coalition. Carbonaro, R.F. (PI) (2008-2012).

This project involved a four-year water quality monitoring program to track spatial and seasonal changes in water quality along the Saw Mill River as it flows through Westchester County into the Hudson River. Water samples collected from the Saw Mill were analyzed for fecal coliform bacteria, total phosphorous, nitrate, total ammonia, pH, conductivity and turbidity. Data collected from this project was shared with local government agencies to track down sources of contamination to the river.

Predicting the Fate and Effects of Resuspended Metal Contaminated Sediments (2010-2013) SERDP Farley, K.J.; Carbonaro, R.F.

This project involved the development and application of computer modeling codes for describing metal fate and transport during re-suspension of contaminated sediments. The model developed for this project (TICKET) was windows-based executable that is capable of modeling metal speciation in a variety of scenarios including batch systems, flow through reactors, lakes, streams, and embayments. The model has been tested using datasets from the literature and from experiments currently being performed by co-investigators at the University of Michigan.

National Institute of Environmental and Health Sciences "Effect of Natural Organic Matter on Bioavailability and Mobilization of Metals." Farley, K.J., and Carbonaro, R.F. (co-PIs) (2009-2011).

This project examined the oxidation of inorganic and soluble organic-bound Cr(III) complexes and their oxidation by aqueous chlorine. The work was designed to directly address knowledge gaps related to reaction rates and stoichiometry resulting from disinfection of drinking water.

NYC DEP/Malcolm Pirnie. "Contamination Warning System Demonstration Project: University Partnership." Carbonaro, R.F. and Sharp, R.R. (co-PIs) (2010-2011).

The New York City Department of Environmental Protection (NYCDEP), with the assistance of Malcolm Pirnie, Inc. and CH2M Hill, partnered with Manhattan College (MC) as part of the Contamination Warning System Demonstration Pilot Project (CWSDP) University Partnership (UP). Specifically, the UP was tasked with the following: i) Side-by-side testing of eleven (11) Online Water Quality Instruments (OWQI) measuring pH, chlorine residual, turbidity, temperature, conductivity, total organic carbon (TOC) (chemically based, UV derived, or UV 254 surrogate), and

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polycyclic aromatic hydrocarbons (PAHs), and ii) Spike-testing analysis of the OWQIs to assess their response to various inorganic and organic chemicals. In addition this project involved development of a QAPP and several SOPs for the OWQIs.

New York City DEP, DEP-FPI “Manganese Deposit Characterization and Treatment Study,” Carbonaro, R.F. and Sharp, R.R. (co-PIs) (2008-2010).

The Catskill Aqueduct, part of the New York City drinking water distribution system, has shown evidence of manganese-based biofilm growth on its concrete walls. This study investigated i) formation of the attached biofilm by manganese oxidizing bacteria (MOBs) using rotating Annular Reactors (ARs), and ii) subsequent disinfection strategies for removal and mitigation of the biofilm growth. System changes resulting from the disinfection by Cl_2 and ClO_2 including pH, ORP, chlorine residual, and disinfection byproducts chlorite (ClO_2^-) and chlorate (ClO_3^-) were monitored. Outcomes from the study were applicable to treatment strategies for the control of biofilm deposits in the New York City water distribution system.

PRESENTATIONS AT PROFESSIONAL MEETINGS

1. Rader, K.J.; Fanelli, C.J.; Huntsman, P.; Burton, G.A.; Costello, D.; Baken, S.; Garman, E.R.; **Carbonaro, R.F.**; “Modeling Metal Rapid Removal Experiments for Hazard Classification.” Society of Toxicology and Environmental Chemistry, 39th Annual Meeting in North America. Sacramento, CA, November 4-8, 2018.
2. Huntsman, P.; Rader, K.J.; **Carbonaro, R.F.**; Burton, G.A.; Baken, S.; Garman, E.R. “Metal removal from the water column for chronic hazard classification: Method development for an extended transformation/dissolution protocol.” Society of Toxicology and Environmental Chemistry, 39th Annual Meeting in North America. Sacramento, CA, November 4-8, 2018.
3. Burton, G.A.; **Carbonaro, R.F.**; Rader, K.J.; Huntsman, P.; Baken, S.; Garman, E.R. “Metals removal from water for hazard classification.” Society of Toxicology and Environmental Chemistry, 39th Annual Meeting in North America. Sacramento, CA, November 4-8, 2018.
4. Burton, G.A.; Hudson, M.; Baken, S.; **Carbonaro, R.F.**; Garman, E.R. “Metal partitioning to oxic natural sediments and removal from water.” Society of Toxicology and Environmental Chemistry, 38th Annual Meeting in North America. Minneapolis, MN, November 12-16, 2017.
5. Fanelli, C.J.; **Carbonaro, R.F.**; Moore, J.; Casey, R.E.; Rader, K.J.; “Development and Application of a Copper Roof Runoff Assessment Tool.” Society of Toxicology and Environmental Chemistry, 38th Annual Meeting in North America. Minneapolis, MN, November 12-16, 2017.
6. Di Toro, D.M.; Allen, H.E.; **Carbonaro, R.F.**; Chiu, P.C. “Predicting the Rate of Abiotic Reduction of Munitions Constituents Using the Reaction Energy of A Hydrogen Atom Addition.” Society of Toxicology and Environmental Chemistry, 38th Annual Meeting in North America. Minneapolis, MN, November 12-16, 2017.
7. **Carbonaro, R.F.**; Mutch, R.D. “Reactive Transport Modeling: A New Paradigm in Design of In Situ Treatment Systems.” AEHS Foundation 32nd Annual International Conference on Soils, Sediments, Water and Energy. Amherst MA, October 17-20, 2016.
8. **Carbonaro, R.F.**; Mutch, R.D.; Rader, K.J.; Gupta, P.K.; Morris, J.J. “Effect of in-situ CO₂ sparging on chemistry of groundwater impacted by caustic brine discharges.” 252nd American Chemical Society National Meeting & Exposition, Philadelphia, PA August 21-25, 2016.
9. **Carbonaro, R.F.**; Di Toro, D.M. “Development of linear free energy relationships for estimating metal binding to sulfur functional groups present in natural organic matter.” Society of Toxicology and Environmental Chemistry, 36th Annual Meeting in North America. Salt Lake City, UT, November 1-5, 2015.
10. Farley, K.J.; Rader, K.J.; **Carbonaro, R.F.** “Release of Metals During Sediment Resuspension Events” Society of Toxicology and Environmental Chemistry, 36th Annual Meeting in North America. Salt Lake City, UT, November 1-5, 2015.

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11. Farley, K.J.; Rader, K.J.; **Carbonaro, R.F.** “Release of Metals from Contaminated Sediments: Translation from Laboratory- to Field-Scale Assessments.” Eighth International Conference On Remediation And Management Of Contaminated Sediments. New Orleans, LA, January 12-15, 2015.
12. **Carbonaro, R.F.**; Mutch, R.D.; Changa-Moon, D.C.; Nambiar, A.; Cordone, L.; O’Loughlin, J.M.; Gupta, P.K.; Morris, J.J. “In Situ CO₂ Sparging to Neutralize a Caustic-Brine Plume and Reduce Mercury Levels.” Ninth International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, CA, May 19-21, 2014.
13. DiPippo, G; **Carbonaro, R.F.** “The Leachate Treatment and Disposal Albatross;” New York State Solid Waste & Recycling Conference, Lake George, NY May 18-21, 2014
14. Mutch, R.D.; **Carbonaro, R.F.** “First Year Progress Report: In Situ CO₂ Sparging into a Caustic Brine Plume” 2014 NGWA Groundwater Summit, Denver CO, May 5 – 7, 2014.
15. **Carbonaro, R.F.**; Mutch, R.D.; Changa-Moon, D.C.; Nambiar, A.; Cordone, L.; O’Loughlin, J.M.; Gupta, P.K.; Morris, J.J. “In-Situ CO₂ Sparging to Neutralize a Caustic Brine Plume and Reduce Mercury Levels” Philadelphia, PA, January 27-29, 2014
16. Bubnyte, R.; Farley, K.J.; **Carbonaro, R.F.** “Modeling Metal Cycling and Bioavailability in Lake Coeur d’Alene Using the TICKET Unit World Model.” Society of Toxicology and Environmental Chemistry, 34th Annual Meeting in North America, Nashville, TN, November 17-21, 2013.
17. Farley, K.J.; Heegle, P.T.; Rader, K.J.; **Carbonaro, R.F.** “Modeling Metal Release and Bioavailability during Resuspension of Anoxic Sediments.” Society of Toxicology and Environmental Chemistry, 34th Annual Meeting in North America, Nashville, TN, November 17-21, 2013.
18. Bubnyte, R.; Villarosa, M.P.; **Carbonaro, R.F.**; Rader, K.J.; Farley, K.J. “Impacts of Propeller-Induced Disturbances and Other Sediment Resuspension Events on Metal Bioavailability.” Batelle, Seventh International Conference on Remediation of Contaminated Sediments, February 4-7, 2013.
19. Bubnyte, R.; **Carbonaro, R.F.**; Farley, K.J. “Modeling Metal Cycling and Bioavailability in Lake Coeur d’Alene.” New York Water Environment Association, 85th Annual Meeting, New York, NY, February 4-6, 2013.
20. **Carbonaro, R.F.**; Delbeke, K.; Rodriguez, P.; Rader, K.J. “Modeling the Transport, Effects and Fate of Metal Concentrates in a Lake Using the TICKET Unit World Model.” Society of Toxicology and Environmental Chemistry, 33rd Annual Meeting in North America, Long Beach, CA, November 11-15, 2012.
21. Bubnyte, R.; Villarosa, M.P.; **Carbonaro, R.F.**; Rader, K.J.; Farley, K.J. “Impacts of Sediment Resuspension on Metal Bioavailability and Toxicity Assessments.” Society of Toxicology and

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Environmental Chemistry, 33rd Annual Meeting in North America, Long Beach, CA, November 11-15, 2012.

22. Derderian, O.T.; Wolfson, A.H.; **Carbonaro, R.F.** "Degradation of Water Quality of the Saw Mill River Due to Urban Runoff." New York Water Environment Association, 84th Annual Meeting, New York, NY, February 6-8, 2012.
23. **Carbonaro, R.F.**; Atalay, Y.B.; Di Toro, D.M. "Linear Free Energy Relationships for Describing Metal Binding to Nitrogen Functional Groups" Society of Toxicology and Environmental Chemistry, 32nd Annual Meeting in North America, Boston, MA, November 13-17, 2011.
24. Atalay, Y.B.; **Carbonaro, R.F.**; Di Toro, D.M. "Comparison of Models for Metal Partitioning to Natural Organic Matter: Chemically-based Model and WHAM VI." Society of Toxicology and Environmental Chemistry, 32nd Annual Meeting in North America, Boston, MA, November 13-17, 2011.
25. Farley, K.J.; McMahon, P.M.; Rader, K.J.; **Carbonaro, R.F.** "Incorporation of WHAM VI Binding Reactions and Metal Sulfide Oxidation Kinetics into TICKET-UWM." Society of Toxicology and Environmental Chemistry, 32nd Annual Meeting in North America, Boston, MA, November 13-17, 2011.
26. Rader, K.J.; **Carbonaro, R.F.**; Farley, K.J. "Metal Classification Using a Unit World Model: Assessing Removal Rates from the Water Column and Remobilization from Sediment with Ticket-UWM." Society of Toxicology and Environmental Chemistry, 32nd Annual Meeting in North America, Boston, MA, November 13-17, 2011.
27. Mutch, R.D.; **Carbonaro, R.F.** "Optimizing the Performance of ISCR and ISCO Systems Through Three-Dimensional, Reactive, Transport Modeling." The 17th International Conference on Advanced Oxidation Technologies for Treatment of Water, Air and Soil (AOTs-17), November 7 – 10, San Diego CA.
28. Lindsay, D.R.; Farley, K.J.; **Carbonaro, R.F.** "The Oxidation of Cr(III) to Cr(VI) during Chlorination." Edwin C. Tift, Jr. Water Supply Symposium, Liverpool, NY. September 21 - 22, 2011.
29. Sesto, J.A.; Sharp, R.R.; **Carbonaro, R.F.** "Evaluation of Water Quality Monitors." Edwin C. Tift, Jr. Water Supply Symposium, Liverpool, NY. September 21 - 22, 2011.
30. **Carbonaro, R.F.**; Rader, K.J.; Mutch, R.D. "Field results and modeling of in situ chemical reduction of hexavalent chromium contamination." The 242nd ACS National Meeting, Division of Environmental Chemistry, Denver, CO, August 28-September 1, 2011.
31. Rader, K.J.; McMahon, P.M.; Fanelli, C.J.; **Carbonaro, R. F.**; Farley, K.J. "Predicting the Fate and Effects of Resuspended Metal Contaminated Sediments: Speciation Modeling." Battelle Sixth International Conference on Remediation of Contaminated Sediments, February 7-10, 2011, New Orleans, LA.

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32. Farley, K. J.; Fanelli, C.J.; **Carbonaro, R. F.** Assessing the Importance of Iron and Manganese Phases On Metal Cycling and Bioavailability Using TICKET-UWM.” Society of Toxicology and Environmental Chemistry, 31st Annual Meeting in North America, Portland, OR, November 7-11, 2010.
33. **Carbonaro, R. F.**; Lindsay, D.R.; Farley, K. J. “Effect of DOC on Cr(III) Mobilization and Oxidation in Aquatic Environments.” Society of Toxicology and Environmental Chemistry, 31st Annual Meeting in North America, Portland, OR, November 7-11, 2010.
34. **Carbonaro, R. F.**; Atalay, Y.B.; Di Toro, D.M. “Estimation of formation constants of metal complexes: Bidentate binding to oxygen and nitrogen donor atoms.” The 240th ACS National Meeting, Division of Geochemistry, Boston, MA, August 22-26, 2010.
35. Santos, M.A.; **Carbonaro, R. F.**; Sharp, R.R.; “Biological Manganese Deposition and Treatment Strategies for Biofilm Removal.” New York Water Environment Association, 82nd Annual Meeting, New York, NY, February 1-3, 2010.
36. Atalay, Y.B.; Rader, K. J.; **Carbonaro, R. F.**; Di Toro, D. M. “A Chemically Based Model for Metal Partitioning to Organic Matter.” Society of Toxicology and Environmental Chemistry, 30th Annual Meeting in North America, New Orleans, LA, November 19-23, 2009.
37. Rader, K. J.; **Carbonaro, R. F.**; Farley, K. J.; Di Toro, D. M. “Performance Assessment of Chemical Speciation Models.” Society of Toxicology and Environmental Chemistry, 30th Annual Meeting in North America, New Orleans, LA, November 19-23, 2009.
38. **Carbonaro, R. F.**; Rader, K. J.; Farley, K. J. “Are We Ready to Incorporate Manganese Oxides into Unit World Models for Metals?” Society of Toxicology and Environmental Chemistry, 30th Annual Meeting in North America, New Orleans, LA, November 19-23, 2009.
39. Di Toro, D.M. **Carbonaro, R.F.**; Farley, K. J.; “Sediment biotic ligand model predicts no toxicity variation due to hardness: Why?” The 238th ACS National Meeting, Division of Geochemistry, Washington, DC, August 16-20, 2009.
40. D’Agostino, D.J.; **Carbonaro, R.F.**; Farley, K.J.; Modeling metal cycling and bioavailability at contaminated sediment sites.” The 238th ACS National Meeting, Division of Geochemistry, Washington, DC, August 16-20, 2009.
41. McGuire, B.P.; Farley, K.J.; Di Toro, D.M.; **Carbonaro, R.F.** “Modeling metal sulfide oxidation kinetics.” The 238th ACS National Meeting, Division of Geochemistry, Washington, DC, August 16-20, 2009.
42. Wilson, J.M.; **Carbonaro, R.F.** “Analysis of iron(II) and iron(III) polyaminocarboxylate complex speciation using capillary electrophoresis.” The 238th ACS National Meeting, Division of Environmental Chemistry, Washington, DC, August 16-20, 2009.

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43. Miglino, A.N.; Fanelli, C.J.; Rader, K.J.; **Carbonaro, R.F.**; Farley, K.J. "Model Evaluations for Sediment Clean-Up Targets and TMDLs for Metals." Battelle Fifth International Conference on Remediation of Contaminated Sediments, Jacksonville, FL, February 2-5, 2009.
44. D'Agostino, D.J.; **Carbonaro, R.F.**; Farley, K. J.; "Fate of Metal Sulfides in Aquatic Systems." New York Water Environment Association, 81st Annual Meeting, New York, NY, February 1-4, 2009.
45. McGuire, B.P.; Farley, K.J.; Di Toro, D.M.; **Carbonaro, R.F.** "Kinetics and Modeling of Nickel Sulfide Oxidation." Society of Toxicology and Environmental Chemistry, 29th Annual Meeting in North America, Tampa, FL, November 16-20, 2008.
46. Farley, K.J.; Miglino, A.N.; **Carbonaro, R.F.**; Di Toro, D.M. "Validation of the 'Unit World' Model for Metals in Lakes." Society of Toxicology and Environmental Chemistry, 29th Annual Meeting in North America, Tampa, FL, November 16-20, 2008.
47. Rader, K.J.; **Carbonaro, R.F.**; Farley, K.J.; Di Toro, D.M. "A Probabilistic Unit World Model for Metal Fate and Toxicity in Rivers." Society of Toxicology and Environmental Chemistry, 29th Annual Meeting in North America, Tampa, FL, November 16-20, 2008.
48. Mutch, R.D.; **Carbonaro, R.F.**; "Groundwater Plume Forensics Using Minor Ions" The 24th Annual International Conference on Soils, Sediments and Water. University of Massachusetts, Amherst, MA. October 20-23, 2008.
49. Mutch, R.D.; **Carbonaro, R.F.**; Mahony, J.D. "Landfill plume forensics using minor ions and tritium." National Groundwater Association, 2008 Ground Water Summit, Memphis, TN, March 31-April 2, 2008.
50. Lumish, J.; Hanley, E.; **Carbonaro, R.F.** "Effect of urban runoff on seasonal and spatial trends in the water quality of the Saw Mill River." New York Water Environment Association, 80th Annual Meeting, New York, NY, February 3-6, 2008.
51. Mutch, R.D.; **Carbonaro, R.F.**; "A Study of Tritium in Municipal Solid Waste Leachate." The 23rd Annual International Conference on Soils, Sediments and Water. University of Massachusetts, Amherst, MA. October 15-18, 2007.
52. **Carbonaro, R.F.**; Di Toro, D.M. "Development of linear free energy relationships for estimating monodentate and bidentate binding to functional groups present in natural organic matter." Society of Toxicology and Environmental Chemistry, 28th Annual Meeting in North America, Milwaukee, WI, November 12-16, 2007.
53. Farley, K.J.; **Carbonaro, R.F.**; Rader, K.J.; Di Toro, D.M. Tier 1 "Unit World" Model for Metals in Lakes." Society of Toxicology and Environmental Chemistry, 28th Annual Meeting in North America, Milwaukee, WI, November 12-16, 2007.

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54. Farley, K.J.; **Carbonaro, R.F.**; Di Toro, D.M. "Development of a Unit World Hazard Ranking Model for Metals." Hudson-Delaware Regional SETAC Conference, Camden NJ, October 26, 2007.
55. Farley, K.J.; **Carbonaro, R.F.**; Di Toro, D.M. Application of the "Unit World" Model for Metals in Lakes." US EPA Metals Fate and Transport Modeling Workshop, Denver CO, February 13-15, 2007.
56. **Carbonaro, R.F.**, Di Toro, D.M. "Applications of linear free energy relationships for modeling metal binding to natural organic matter." US EPA Metals Fate and Transport Modeling Workshop, Denver CO, February 13-15, 2007.
57. Mutch, R.D.; Soukup, W.G.; **Carbonaro, R.F.**; Di Toro D. M. "Investigating the Impact of a Groundwater-Borne Plume of Hexavalent Chromium upon Estuarine Sediments and Water Quality." Battelle Fourth International Conference on Remediation of Contaminated Sediments. Savannah, Georgia; January 22-25, 2007.
58. Farley, K.J.; **Carbonaro, R.F.**; Di Toro, D.M. "Application of the "Unit World" Model for Metals in Lakes." Society of Toxicology and Environmental Chemistry, 27th Annual Meeting in North America, Montreal Canada, November 5-9, 2006.
59. **Carbonaro, R.F.**; Di Toro, D.M. "Applications of linear free energy relationships for modeling metal binding to natural organic matter. Society of Toxicology and Environmental Chemistry, 27th Annual Meeting in North America, Montreal Canada, November 5-9, 2006.
60. Esposito, C.; Joseph, J.; Kowalczyk, M.; O'Mara, C.; **Carbonaro, R.F.**; Mahony, J.D. "Remobilization of Sediment-Bound Toxic Heavy Metals." New York Water Environment Association, 78th Annual Meeting, New York, NY, February 6-8, 2006.
61. **Carbonaro, R.F.**; Di Toro, D.M. "Investigation of metal-ligand interactions of model ligands for modeling metal-organic carbon binding." Society of Toxicology and Environmental Chemistry, 26th Annual Meeting in North America, Baltimore MD, November 13-17, 2005.
62. Farley, K.J.; **Carbonaro, R.F.**; Di Toro, D.M. "Evaluation of critical metal loads using the Unit World Model for lakes." Society of Toxicology and Environmental Chemistry, 26th Annual Meeting in North America, Baltimore MD, November 13-17, 2005.
63. Farley, K.J., **Carbonaro, R.F.**, and Di Toro, D.M. "Development of a "Unit World" (Model) Simulation for Metals in Aquatic Environments," Invited Presentation, Metal Environmental Risk Assessment Guidance Document (MERAG) Science Consolidation Workshop, London UK, May 10-11, 2005.
64. O'Mara, C., Esposito, C., Grieco, L., **Carbonaro, R.F.**; Mahony, J.D. "Cobalt and Nickel Interactions with Iron Sulfide in Sediments." New York Water Environment Association, 77th Annual Meeting, New York, NY, February 6-9, 2005.

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65. Farley, K. J., Costanzo, R, **Carbonaro, R.F.**, Di Toro, D. M. "Development of a Unit World Model for Metals in Aquatic Environments." Annual Meeting of the Society of Toxicology and Environmental Chemistry, Portland OR, 2004.
66. Stone, A.T., **Carbonaro, R.F.**; Wang, Y., "Structure-Reactivity Relationships Governing the Fate of Metal Ions and Ligands in Soils." Biogeochemical Controls on the Mobility and Bioavailability of Metals in Soils and Groundwater" Workshop, Ascona, Switzerland. March, 2003.
67. Stone, A.T., Uchimiya, M., **Carbonaro, R.F.** "Extracellular Redox Biochemicals: Design Constraints", Keynote Lecture, "Biogenic Substances in the Environment" Symposium, Twelfth Goldschmidt Conference, Davos, Switzerland, August 2002.
68. Stone, A.T., **Carbonaro, R.F.**, Whitehead, C.F. "Using Capillary Electrophoresis to Distinguish Between Different Dissolved Metal Ion-Chelating Agent Complexes in Environmental Aqueous Media", Fourth Biennial International Conference on Monitoring and Measurement of the Environment", Toronto, Canada, May, 2002.
69. Morrissey, J.C., **Carbonaro, R.F.**, Mahony, J.D., Di Toro, D.M., "A study of the oxidation and acid extractability of sediment bound and pure metal sulfides." Annual Meeting of the Society of Toxicology and Environmental Chemistry, Philadelphia, PA, November 14-18, 1999.
70. **Carbonaro, R.F.**, Mahony, J.D., Di Toro, D.M. "The Calibration of a Sediment Metal Flux Model." Annual Meeting of the Society of Toxicology and Environmental Chemistry, Philadelphia, PA, November 14-18, 1999.
71. Di Toro, D.M., Mahony, J.D., **Carbonaro, R.F.**, DeMarco, T., Morrissey, J.C. Pablo, R.J., Page J.J., Shadi, T.S. "The Oxidation of Silver Sulfide and Other Heavy Metal Sulfides in Sediments." Argentum: Fifth International Conference on Transport, Fate and Effects of Silver in the Environment, Hamilton, Ontario, Canada, September 28-October 1, 1997.
72. Di Toro, D.M., Mahony, J.D, **Carbonaro, R.F.**, Love, J.H., Morrissey, J.C. "The Bioavailability of Silver in Sediments." Argentum: Fourth International Conference on Transport, Fate and Effects of Silver in the Environment, Madison, WC, August 25-28, 1996.

POSTER PRESENTATIONS AT PROFESSIONAL MEETINGS

1. Rader, K.J.; **Carbonaro, R.F.** "Monitoring Copper Concentrations in Freshwater Marinas" Society of Toxicology and Environmental Chemistry, 35th Annual Meeting in North America, Vancouver, BC Canada, November 9-13, 2014.
2. Stone, A.T.; Boland, N.E.; **Carbonaro, R.F.** "Chelating Agent Selection From A Kinetic Perspective: New Insights From Capillary Electrophoresis." 3rd Annual American Chemical Society Green Chemistry Institute Roundtable, 17th Annual Green Chemistry & Engineering Conference, North Bethesda, MD, June 19, 2013.

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3. Rader, K.J.; McMahon, P.M.; Fanelli, C.J.; **Carbonaro, R.F.**; Farley, K.J. "Predicting the Fate and Effects of Resuspended Metal Contaminated Sediments: Speciation Modeling." Sixth International Conference on Remediation of Contaminated Sediments. February 7-10, 2011.
4. Rader, K.J.; van Hullebusch, E.; **Carbonaro, R.F.**; Farley, K.J. "Assessment of Time-Variable Solutions in the Unit World Model for Metals in Lakes." Society of Toxicology and Environmental Chemistry, 31st Annual Meeting in North America, Portland, OR, November 7-11, 2010.
5. Farley, K.J.; **Carbonaro, R.F.**; Fanelli, C.J.; Rader, K.J.; Di Toro, D.M. "Unit World Hazard Ranking Model for Metals." NIEHS Workshop, Assessing Bioavailability as a Determinant of Pollutant Exposure, Tampa FL, February 19-21, 2008.
6. Wilson, J.M.; Farley, K.J.; **Carbonaro, R.F.** "Capillary Electrophoresis Investigation of FeII-polyaminocarboxylate Oxidation by Molecular Oxygen." Gordon Research Conferences, Environmental Sciences: Water, Holderness NH, June 23-27, 2008.
7. D'Agostino D.J.; **Carbonaro R.F.**; Farley K.J. "Metal Cycling and Bioavailability at Contaminated Sediment Sites." NIEHS Superfund Basic Research Program Annual Meeting, Asilomar Conference Grounds, Pacific Grove, CA, December 7-9, 2008.
8. Mendola, M. E.; **Carbonaro, R.F.** "Investigation of CrIII-NTA Speciation and Transformation Reactions Using Capillary Electrophoresis." 2005 Superfund Basic Research Meeting: Research Translation and Megasites, New York, NY, January 12-13, 2006.
9. Rader, K.J.; Bisceglia, K.J.; Farley, K.J.; Mahony, J.D.; **Carbonaro, R.F.**; Di Toro, D.M. "An experimental and modeling investigation of iron(II)-catalyzed arsenic(III) oxidation." Society of Toxicology and Environmental Chemistry, 26th Annual Meeting in North America, Baltimore MD, November 13-17, 2005.
10. **Carbonaro, R.F.**, Farley, K.J. "The Environmental Engineering Curriculum at Manhattan College (poster)." Enhancing Undergraduate Environmental Education in the Hudson Valley: Exposition & Connections, Marist College, Poughkeepsie NY, October 29 - 30, 2004.
11. **Carbonaro, R.F.**, Stone, A.T., Whitehead, C.F. "Monitoring Environmental Transformations of Chromium Using Capillary Electrophoresis". Gordon Research Conferences, Environmental Sciences: Water, Plymouth, NH, June 23-28, 2002.
12. **Carbonaro, R.F.**, Stone, A.T., Whitehead, C.F. "Capillary Electrophoresis Analysis of Ni(II), Cr(III), Fe(III) and Co(III) Aqueous Speciation: What Can and Cannot be Discerned?". The 12th Annual Frederick Conference on Capillary Electrophoresis, Frederick MD, October 15-17, 2001.

PROFESSIONAL ACTIVITIES

Editorial Board, Environmental Toxicology and Chemistry (2014-2019)

Richard F. Carbonaro, Ph.D., P.E.
Senior Environmental Engineer

Society of Toxicology and Chemistry, Annual Meeting in North America, Session Chair, Fate and Effects of Metals: Geochemical Perspective (2013 - present)

External Ph.D. Committee Member: Kevin Rader (University of Delaware); Yasemin Atalay (University of Delaware); Nathan Boland (Johns Hopkins)

Co-moderator, Breakout Session on “Exploring Case Studies and Project-Based Learning for the Classroom.” Enhancing Undergraduate Environmental Education in the Hudson Valley: Exposition & Connections, Marist College, Poughkeepsie NY, October 29 - 30, 2004.

Reviewer for the following peer-reviewed journals: Environmental Toxicology and Chemistry, International Journal of Chemical Kinetics, Environmental Science & Technology, Environmental Engineering and Science, Science of the Total Environment, Geochimica et Cosmochimica Acta

Student/University Committee, New York Water Environment Association (NYWEA (2006-pres.))

Internet Resources Committee, Association of Environmental Engineering and Science Professors (AEESP) (2006-2008)

Panel member, Ciba Foundation High School Science Awards (2005 – 2010)

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TEACHING EXPERIENCE

Manhattan College, Department of Chemical Engineering

CMHL 321: Chemical Reactor Design
CHML 342: Chemical Process Safety
CHMG 713: Advanced Chemical Reactor Design

Manhattan College, Department of Civil and Environmental Engineering - Undergraduate Courses

ENGS 115: Introduction to Engineering I
ENGS 116: Introduction to Engineering II
ENGS 204: Environmental Engineering Principles I
CEEN 308: Reliability Analysis in Civil and Environmental Engineering
ENVL 410: Hazardous Waste Design
ENVL 535: Surface Water Quality Laboratory

Manhattan College, Department of Civil and Environmental Engineering - Graduate Courses

ENVG 700: Mathematical Models I
ENVG 706: Aquatic and Sediment Chemistry
ENVG 712: Advanced Hydrogeology
ENVG 736: Advanced Unit Operations
ENVG 739: Chemical Processes in Environmental Engineering

University of Delaware, Department of Civil and Environmental Engineering - Graduate Courses

CIEG 667: Chemical Speciation Modeling of Metals in Environmental Systems

Columbia University, Department of Civil Engineering and Engineering Mechanics - Graduate Courses

CIEN E4257 Contaminant Transport in Subsurface Systems

Professional Short-Courses:

Northwest Environmental Training Center (NWETC). Groundwater Contamination and Remediation:
Principles and Practices (2014)

Water Quality for Municipal Engineers. Training for NYC Environmental Protection. (2011)

Water Quality Modeling. Summer Institute for Water Pollution Control. Manhattan College,
Riverdale, NY. (2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011)