

ROHIT B. WARRIER, Ph.D., P.G.

Site investigation and remediation
Groundwater modeling
Hydrogeology and Geochemical tracers
Geotechnical Investigations

EDUCATION

Ph.D., Hydrogeology, University of Michigan, Ann Arbor, Michigan, 2012
M.S.E, Environmental Engineering, University of Michigan, Ann Arbor, Michigan,
2008
Bachelor of Technology, Civil Engineering, National Institute of Technology,
Kurukshetra, India, 2007

REGISTRATIONS AND CERTIFICATIONS

Professional Geologist in North Carolina, 2018
Duke Powersafe Training, 2017
DOT Hazardous Materials Shipping for Environmental Professionals, 2016
Shipping with Dry Ice, 2016
Norfolk Southern/CSX Railroad Worker Safety Training, 2016, 2015
OSHA Hazardous Waste Site Worker (40-Hour Certification), 2014
First Aid & CPR, 2014
Bloodborne Pathogen Awareness, 2008
Comprehensive Laboratory Safety Training, 2008
Hazard Communication Standard for Laboratory Personnel, 2008

CAREER SUMMARY

Dr. Warrier is a geologist with diverse technical, field and management expertise. His unique educational background has enabled him to successfully perform various groundwater modeling, environmental site investigation and remediation, geotechnical field investigations, and construction quality control/oversight. Dr. Warrier's technical interests include modeling and understanding the fate and transport of contaminants, developing natural geochemical tracers, geochemical characterization and data management and visualizations. He has co-authored six papers in international peer-reviewed journals, and presented at six international conferences.

Site Investigation and Remediation

Characterizing Creosote DNAPL at a superfund site, Fayetteville, North Carolina. Successfully performed field sample collection efforts to identify the spatial and vertical extent and mobility of DNAPL at a former wood preserving facility superfund site. Primary goals of field efforts were to constrain the efficacy of a screening tool (TarGOST) and perform an In-Situ Stabilization Pilot (ISS) study. Specific responsibilities included visual logging of soil recovered by sonic drilling, including identifying areas of DNAPL impact; identifying target zones of high TarGOST readings and; collecting samples for ISS, SVOCs, SPLP and residual saturation from areas of impact. Non-technical skills gained from this project include project and personnel management including drillers and other field staff, successful right-of-way application with NCDOT and effective communication with a large project team. The successful field event has yielded a robust data set that will be statistically analyzed to help better characterize the spatial and vertical extent of DNAPL, constrain TarGOST values at the site and develop a viable remedial approach.

Characterizing CVOCs at a superfund site, Charlotte, North Carolina. Successfully performed field sample collection and analytical efforts to identify the contaminant migration pathway at a former leather cleaning facility superfund site. Primary goals of this effort were to track contaminant migration pathway through vertical groundwater profiling, soil and groundwater sampling and slug testing. Specific responsibilities included detailed visual logging of soil and rock recovered from the residual, saprolite, transition and fractured bedrock zones; recording drill, purge and recovery rates; performing CVOC colorimetric analyses in the field to determine areas of highest impact and installing monitoring well screens in these zones; collecting soil and groundwater samples by vertical profiling at every 5 feet to fractured bedrock and; pneumatic and physical slug testing of seven wells across the Site including on-site analysis of data using AQTESOLV. Non-technical skills gained from this project include personnel management and effective communication with a large project team including drillers, field staff, on-site regulators from NCDEQ and EPA. The successful field event yielded a robust data set that has helped better characterize the complex hydrogeology and provided an improved understanding of contaminant migration at this Site helping conceptualize a viable remedial approach.

UNC Co-Generation Facility, Chapel Hill, NC. Performed field activities and statistical analysis to delineate the horizontal and vertical extent of CCB impacts in soil and groundwater at an industrial coal-fired power plant, where Geosyntec has been assessing coal combustion byproducts (CCBs) that were encountered in the sub-surface. Specific field tasks performed at this site include soil logging, visual identification of

CCB impacted soil, collection of soil samples for metals and SVOCs and low-flow groundwater sampling. Additionally, a set of background samples collected at the site were statistically analyzed to determine natural background concentrations for metals using EPA's ProUCL software. The statistical analysis identified naturally elevated levels of select metals and helped narrow down the list of major constituents of concern. Geosyntec is currently in the investigation stage of assessing the CCB-impacted soil.

G&K Services, Graham, NC. Performed various field activities to assist with the groundwater and soil gas investigation at the former dry cleaning facility both within the source area as well as off-site in residential neighborhoods. Specific tasks performed at the site include groundwater and soil sampling, sonic and hollow-stem drilling oversight, monitoring well installation oversight, soil gas sampling, soil vapor extraction (SVE) well installation and pilot study, Low Uptake Waterloo Membrane Sampler deployment, saturated zone permeability testing and, groundwater profiling. Results from these field activities have helped better characterize areas of impact both on and off site as well as provide additional information on possible transport mechanisms for the contaminant of concern.

Allegion PLC, Rocky Mount, NC. The site is a former Schlage Lock facility that manufactured doorknobs, door locks and associated hardware. Primarily, the contaminants of concerns are Tetrachloroethylene (PCE) and daughter products in both soil and groundwater. Dr. Warrier successfully performed Geosyntec's field investigation of supplemental source zone soil assessment using Membrane Interface Probe (MIP) and Hydraulic Profiling Tool (HPT). He also supports the project by preparing annual reports of the performance of a groundwater pump and treatment system, developing work plans and proposals to assist with the remedial phase of the project.

Hydraulic Fracturing of Shales: Water Contamination Risks, Treatment Options, and Fate of Fracking Fluids, Michigan. Postdoctoral Research Scientist. Investigated the cross-formational migration of stray methane gas and other contaminants during hydraulic fracturing in northern Michigan using dissolved noble gas tracers. Responsible for collection and analysis of soil cores, gas and water samples from oil and gas production wells.

Application of anaerobic membrane biological reactor to treat low strength, low temperature municipal wastewater and generate biogas, Michigan. Research Assistant. Designed, maintained and operated a bench-scale anaerobic membrane biological reactor to treat low strength, low temperature municipal wastewater and generate biogas as part of an independent research study. Performed analyses of

principal bioreactor parameters, routine bioreactor checkups and maintenance, microscopy and microbial analyses resulting in a successful thesis study.

Design of effluent treatment systems, Siemens Water Technologies, Singapore. Engineering Intern. Designed effluent treatment systems for oil and gas process residuals, high purity water, drinking water and high strength brewery wastes as part of the water technologies engineering team. Successfully prepared and reviewed GA drawings, process and instrumentation diagrams, costing sheets along with construction design team.

Construction of an underground metro rail tunnel, Delhi Metro Rail Corporation, New Delhi, India. Engineering Intern. Oversaw tunneling, drilling and piling operations in the construction of underground metro rail tunnel under the site manager's supervision. Effectively communicated with contractors and regulatory agents and ensured 100% environmental compliance. Prepared site work plans, surveying and technical reports and completed construction on schedule.

Critical evaluation of an aging water supply system at a university, National Institute of Technology, Kurukshetra, Haryana, India. Undergraduate Researcher. Monitored and critically evaluated the water quality, pumping and distribution system at the National Institute of technology. Generated a report that identified pitfalls in the distribution system and engineered innovative solutions to sustain local water demand.

Groundwater Modeling

Fate and Transport Modeling for the design and support of interim source area treatment, Rocky Mount, NC. The primary objective of this modeling effort was to optimize the design and support of source area treatment by evaluating the reduction in soil tetrachloroethene (PCE) concentrations within target treatment areas of interest required so as to not impact a neighboring lake. Specific responsibilities included review of 25 years of historic lithologic and analytical data, generating a 3-D lithologic model in CTech's Earth Volumetric Studios (EVS), develop a six-layer, 9 square mile, steady-state groundwater model in Visual MODFLOW Flex and perform calibrations, sensitivity analyses, and fate and transport simulations for various scenarios. Challenges included assimilating a large volume of data, complex lithology and conceptual site model, calibrating heads with a large proportion of actively pumping recovery wells, working in a large team and short project duration. The project was successfully completed on time and results from the model were employed in establishing an optimized target soil concentration value post-remediation to a remediation vendor. This optimization of treatment design and remedial approach helped the client save time and money.

Modeling Groundwater Flow Path near a “funnel and gate” sheet pile and PRB wall, Panama City, FL. A groundwater flow model was constructed to understand the influence of installing a sheet pile barrier wall to “funnel and gate” arsenic impacted groundwater away from nearby residences and towards a permeable reactive barrier (PRB). The model was constructed, calibrated and run using MODPATH package to track particle path around and underneath the sheet pile wall. Results of the model were used to optimize the geometry and depth of the sheet pile to effectively divert arsenic-impacted groundwater from nearby residences towards the PRB.

Modeling Groundwater Flow in a Tidal Influenced Coastal Zone, Kodiak Island, Alaska. A hydraulic study was conducted at a contaminated site under investigation for migration of petroleum hydrocarbons in the subsurface in a 500-foot long plume, which is influenced by a nearby river and the ocean. Historic water level measurements show variation in groundwater flow directions at the Site, which can be attributed to tidal effects. This modeling effort was conducted to isolate major diurnal and semi-diurnal lunar and solar frequencies from water levels and calculate an average flow direction and gradient and estimate hydraulic conductivity using nearby tidal station data. A hydraulic model was built in Python that analyzed data collected every 1 minute for 88 hours (3.5 days) using pressure transducers (total of 6 million data points) installed in seventeen monitoring wells and three surface water stilling pipes. The modeling results were used to calculate site-wide flow directions and gradient. Hydraulic conductivity was estimated using tidal gauge data and measured water levels in groundwater and surface water, and spatial variation was mapped to identify preferential flow paths. Results from this model were used to clarify the groundwater flow regime at the Site and refine the existing conceptual site model.

Evaluating PCE impacts from groundwater to surface water, Hendersonville, NC. To support termination of an existing groundwater extraction system, a technical evaluation was conducted to study the impacts to a neighboring creek under non-pumping conditions. An existing groundwater numerical model was used in conjunction with EPA’s mass flux toolkit to calculate the PCE mass flux discharge under various non-pumping scenarios. This evaluation was submitted on behalf of the client to the North Carolina Department of Environmental Quality (NCDEQ) and EPA to request a temporary shutdown of existing recovery wells, reduce groundwater and surface water monitoring frequency and implement institutional controls to restrict the use of groundwater. The results of the modeling was well received by NCDEQ and EPA and the request to shutdown the groundwater extraction system was approved.

Investigating the underlying cause for well water decline in Monroe and Washtenaw counties, Michigan. Graduate Research Assistant. Investigated the underlying cause for well water decline in Monroe and Washtenaw counties, Michigan between 1991-2001 using numerical groundwater modeling (Visual MODFLOW 2.8.2). Formulated the conceptual model, calibrated the numerical model with historical well water data, performed sensitivity analyses and simulated model in transient mode resulting in a technical report.

Hydrogeology and Geochemistry

Tracing a past thermal event in a shallow aquifer in the Michigan Basin, University of Michigan. The regional effects of a past thermal event on a shallow aquifer system in the Michigan Basin was examined using a Rayleigh distillation model and dissolved noble gases as tracers. Particularly, the effects of reactivation of an ancient Mid-Continent Rift basin during the Late Devonian– Mississippian (370–323 Ma) period caused elevated temperatures (e.g., ~80–260°C) in the Michigan Basin, and vertical transport of dissolved gases. Using dissolved gas concentrations from shallow (~100 m) and deep aquifers (~3.5 kms), primary transport mechanisms (diffusion vs. solubility) of vertical gas transport to the shallow aquifer was modeled using a Rayleigh distillation model. This work has been published in the *Earth and Planetary Science Letters* journal.

Reconstructing the evolution of Lake Bonney, Antarctica using dissolved noble gases, University of Michigan. Postdoctoral research. The dynamics of a pro-glacial, perennially ice-covered lake, Lake Bonney, located in Taylor valley, Antarctica, was examined to constrained its chronology. Specifically, phase-partitioning and circulation of dissolved noble gas (He, Ne and Ar) concentrations and isotopic ratios were modeled to estimate water residence times. Water residence times were subsequently used to reconstruct the timing of hydrologic changes in Lake Bonney and thus, the evolution of past regional and global temperature changes and climate. This work was successfully published in *Applied Geochemistry* journal.

New applications of atmospheric noble gases in hydrogeology, atmospheric sciences, paleoclimate and tectonics, University of Michigan. Ph.D. Dissertation. Developed new applications of dissolved noble gases as tracers in groundwater systems. Pioneered the use of dissolved atmospheric noble gases as natural tracers of groundwater flow in fractured systems and applied this technique to identify the timing and location of groundwater recharge in the Galapagos Islands, Ecuador. Expanded the application of dissolved atmospheric noble gases as a paleoclimate indicator by reconstructing the past temperature and humidity changes in southern Michigan. Investigated the noble gas composition of rainwater for the first time and identified the relationship between noble

gas composition in precipitation and weather patterns. Also utilized atmospheric noble gases to provide insights into the thermal and tectonic history of the Michigan Basin.

Scouring and sediment transport underneath a sluice gate, National Institute of Technology, Kurukshetra, India. Undergraduate Research (Senior thesis). Investigated erosion and sediment patterns downstream of a weir following an impulsive discharge of impounded water for my senior thesis. Determined optimum conditions of flow, opening of sluice gate and tail water depth to regulate scouring and sediment transport.

PROFESSIONAL EXPERIENCE

Geosyntec Consultants of NC, PC, Raleigh, North Carolina, Engineer, 2014 - present
University of Michigan, Postdoctoral Researcher, Ann Arbor, Michigan, 2013-2014
University of Michigan, Teaching Assistant, Ann Arbor, Michigan, 2009-2012
University of Michigan, Research Assistant, Ann Arbor, Michigan, 2008
Siemens Water Technologies, Singapore, 2008 (Summer Internship)
Delhi Metro Rail Corporation, New Delhi, India, 2005 (Summer Internship)

AWARDS AND RECOGNITIONS

Outstanding Student Paper Award, American Geophysical Union-2011
Scott Turner Research Award, University of Michigan-2010
Chevron Graduate Student Scholarship-2009
Research Fellowship, University of Michigan-2009

TEACHING EXPERIENCE

University of Michigan - 2009-2011. Hydrogeology
University of Michigan - 2010. Introduction To Physical Geography

REPRESENTATIVE PUBLICATIONS

Niu, Y., M. C. Castro, C. M. Hall, S. B. Gingerich, M. A. Scholl, and **R. B. Warrier** (2017), Noble gas signatures in the Island of Maui, Hawaii: Characterizing groundwater sources in fractured systems, *Water Resour. Res.*, 53, doi:10.1002/2016WR020172.

Warrier, R. B., M. Clara Castro, C. M. Hall, F. Kenig and P.T. Doran (2015). Reconstructing the evolution of Lake Bonney, Antarctica using dissolved noble gases. *Applied Geochemistry*, 58, pp. 46-61.

Warrier, R. B., M. Clara Castro, C. M. Hall, and K. C. Lohmann (2013a) Noble gas composition in rainwater and associated weather patterns, *Geophys. Res. Lett.*, 40, doi:10.1002/grl.50610

Warrier, R. B., M. C. Castro, and C. M. Hall (2013b) Large Atmospheric Noble Gas Excesses in a Shallow Aquifer in the Michigan Basin as Indicators of a Past Mantle Thermal Event, *Earth and Planetary Science Letters*, doi:10.1016/j.epsl.2013.06.001.

Castro, M. C., **Warrier, R. B.**, C. M. Hall and Lohmann, K. C. (2012) A Late Pleistocene - Mid-Holocene noble gas and stable isotope climate and sub glacial record in southern Michigan, *Geophys. Res. Letters*, 39, doi: 10.1029/2012GL053098.

Warrier, R. B., M. C. Castro, and C. M. Hall (2012) Recharge and source-water insights from the Galapagos Islands using noble gases and stable isotopes, *Water Resour. Res.*, 48, W03508, doi:10.1029/2011WR010954.

INVITED PRESENTATIONS

Warrier, R. B. (2015) Source-water assessment in the Galapagos Islands using naturally dissolved noble gases: A novel tool for assessment and remediation, Innovations in Assessment and Remediation presented at the Geosyntec Groundwater Action Group Conference in Chicago, 10-12 Sept. 2015.

Warrier, R. B., M. Clara Castro, C. M. Hall, F. Kenig and P. Doran (2013) Reconstructing the Paleo-Limnologic Evolution of Lake Bonney, Antarctica using Dissolved Noble Gases, Abstract H13I-1495 presented at 2013 Fall Meeting, AGU, San Francisco, Calif., 9-13 Dec.

Warrier, R. B., M. C. Castro and C. M. Hall (2012), Dissolved Noble Gases in Rainwater, Southern Michigan – Evidence for Lack of Rainwater Equilibration with the Atmosphere at Surface Conditions, Abstract 1463091 presented at 2012 Fall Meeting, AGU, San Francisco, Calif., 3-7 Dec.

Castro, M. C., Hall, C. M., **Warrier, R. B.** and Lohmann, K. C., Recent Advances In Our Understanding Of The Noble Gas Thermometer In Groundwater, Paper No. 124-1 presented at 2012 GSA Annual Meeting in Charlotte (4–7 November 2012).

Warrier, R. B., M. C. Castro, C. M. Hall and Lohmann, K. C. (2011), Mixing of deep basinal brines and glacial meltwater inferred from major ion chemistry, stable isotopes and noble gases in the Saginaw aquifer, Michigan, Abstract H33G-1394 presented at 2011 Fall Meeting, AGU, San Francisco, Calif., 5-9 Dec.

Warrier, R. B., M. C. Castro, C. M. Hall and N. D'Ozouville (2010), Tracing the Galapagos Volcanic Groundwater System Using Noble Gases and Stable Isotopes, Abstract V51D-07 presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec.

Warrier, R. B., M. C. Castro, C. M. Hall and N. D'Ozouville (2010) Galapagos Islands – Tracing a volcanic groundwater system using noble gases, *Geochimica et Cosmochimica Acta*, 74(11) S1, A1115. Goldschmidt, 2010, Knoxville TN.

AFFILIATIONS

Association of Environmental Geologists

American Geophysical Union

Geochemical Society

National Groundwater Association