Prof. Jeffrey Bielicki, Assistant Professor with a joint appointment in the Department of Civil, Environmental and Geodetic Engineering and in the John Glenn College of Public Affairs at the Ohio State University completed an Ohio Water Resources Center funded project via a joint Office of Energy and Environment at OSU and Ohio WRC subaward. This project, "**Developing Integrated Assessments of Water and Energy in Ohio"** was conducted with Yaoping Wang, a Ph.D. student, and seeks to improve understanding of how electricity demand, and the demand for water by thermoelectric power plants that supply electricity, depend on weather in the short and long term. This integrated assessment of energy and water interactions in Ohio's electricity system will enable stakeholders from multiple agencies at different levels to coordinate energy and water policy and planning.

The relationships between electricity and meteorological variables in two transmission zones in the eastern US (Figure 1) was investigated using "segmented" regression. The effects of temperature, past days' temperatures, relative humidity, and wind speed were quantified and compared in terms of their relative importance. Past temperatures were found to be important predictors of electricity load, the effect of relative humidity was found to be smaller than temperature, and wind speed was potentially negligible. Past studies noted that the effect of humidity was only significant in hot, humid regions like Louisiana, but the two transmission zones in this study are in the northern part of the United States. Furthermore, the results of this empirical study indicate existence of "comfort zones" (about 5 ºC wide but varying somewhat diurnally), where the slope of electricity response was either zero (the AEP zone) or small but non-zero (the PS zone) (Figure 2). Therefore, the base temperatures of heating- and cooling-degrees should not be assumed to be identical. That the electricity response to temperature increase in the comfort zone can be non-zero also suggests that the use of heating- and cooling-degrees might not be adequate for electricity demand projection under all situations.

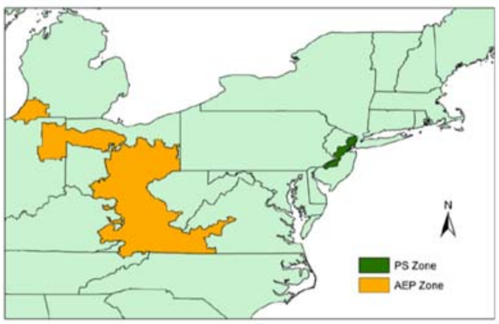

Figure 1 The transmission zones used in this study. Map adapted from the information on the PJM website (PJM, 2016). PS - Public Service Electric and Gas Company. AEP - American Electric Power Co., Inc.

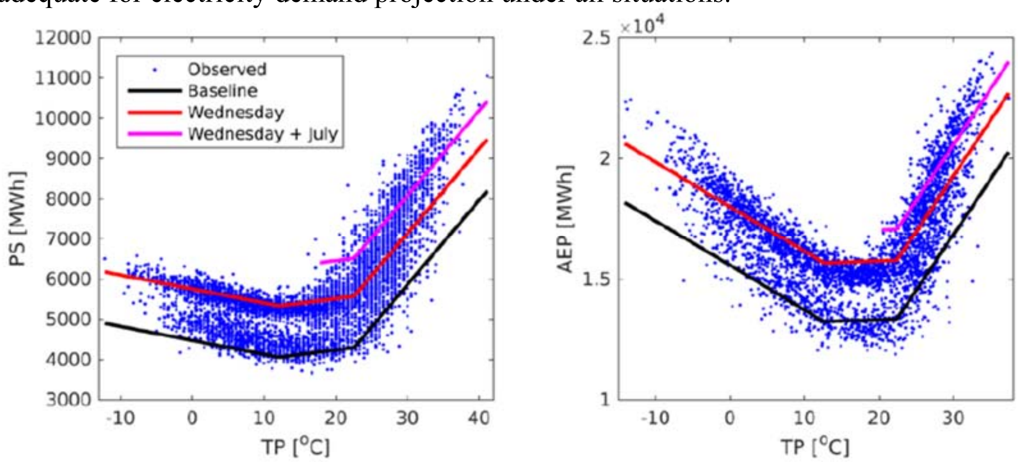

Figure 2 Observed relationship between temperature and electricity load at hour 14, and the fitted piecewise linear relationship for the baseline (i.e. December Sunday), Wednesday (December), and July Wednesday. The July relationship is only shown for July temperatures.

Researcher Profile: Prof. Jeffrey Bielicki holds a joint appointment in the Department of Civil, Environmental, and Geodetic Engineering and in the John Glenn College of Public Affairs. He researches issues in which energy and environmental systems and policy interact. He focuses on understanding opportunities, causes, and consequences of energy development and technology deployment in order to understand how energy systems have evolved and how this evolution can be directed in ways that will improve environmental, economic, and social conditions.

Dr. Dominic Boccelli, Associate Professor in the Department of Biomedical, Chemical and Environmental Engineering at the University of Cincinnati completed an Ohio Water Resources Center funded project via Ohio Water Development Authority subaward. This project titled "**Spatial Demand Estimation: Moving Towards Real-Time Distribution System Network Modeling"** aims to develop a composite demand-hydraulic model – one that couples a demand model with a network hydraulic solver. This model will enable real-time water demand estimation and forecasting, that water utilities could use to assist with, for example, pump scheduling.

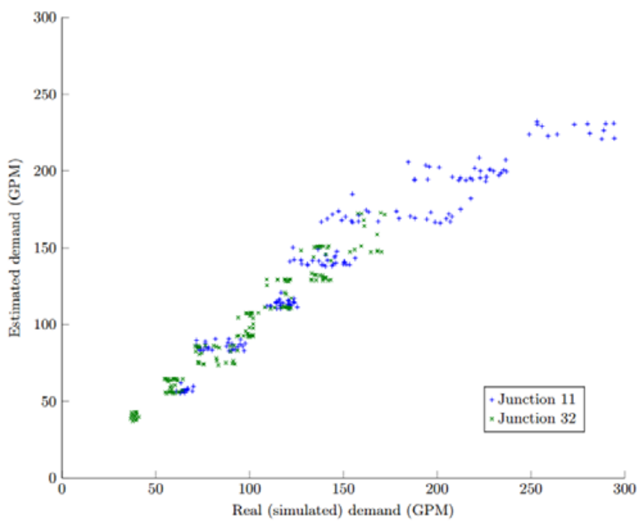

Figure 1 Scatter plot of the estimated (Y axis) versus the "real" (X axis) demands for best and worst performing consumer nodes for one-week time span. Junction 11 – blue plus signs, Junction 31 – green crosses.

The central hypothesis was that the observed hydraulic data commonly collected via utility SCADA systems can be used to estimate the expected values and uncertainty from a composite demand-hydraulic model that characterizes the temporal and spatial patterns of consumptive demands. The development of the composite demand-hydraulic model was shown capable of estimating the demands and parameters of a time series model using limited hydraulic information (Figure 1). From the figure, the estimated demands generally matched the real demands, but the estimates for the high-demand hours are not as accurate as those for low-demand hours. Noticeably, the high demands at Junction 11 (greater than 200 GPM) are mostly underestimated. Furthermore, the proposed clustering algorithm was shown capable of grouping nodes based on similarities in water quality (Figure 2). This ability to group nodes will provide opportunities to reduce the scale of network demand estimation problems. the clustering approach presented allows the grouping of nodes with similar water quality characteristics that can also help to reduce the problem scale of other applications such as locating sensors for contaminant warning systems or identifying regulatory sampling locations.

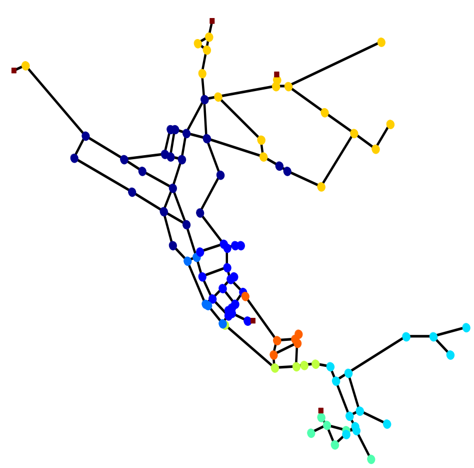

Figure 2. Results of the clustering algorithms applied to a small test case network. The consumer nodes (circles) have been clustered into eight groups of nodes with similar hydraulic impacts.

<u>Researcher Profile:</u> Dr. Dominic Boccelli's primary research interests are in the areas of Water Resources, Water Quality, and Environmental Systems Analysis. His research activities are expected to focus on developing decision support tools based on fundamental principles of environmental engineering and science to assist engineers, managers, and policy makers in making technology, design, and regulatory decisions. More explicitly, these tools will incorporate various mathematical modeling and optimization techniques to attain the desired objectives.

Dr. John Hoornbeek, Director of the Center of Public Policy and Health (CPPH) and Associate Professor at Kent State University (KSU-CPPH), worked with staff and students at the KSU-CPPH to complete an Ohio Water Resources Center funded project via 104(b) USGS sub-award. This project titled "**Policy Tools for Reducing Harmful Algal Blooms"** is seeking to inform the policy conversation around addressing the nutrient enrichment issue in Lake Erie by conducting research that focuses on better understanding the policy tools currently being used to reduce nutrient runoff into the lake and what is being done elsewhere to address nutrient issues in major water bodies.

Figure 1 John Hoornbeek and Dr. Joseph Ortiz discussing the project

We found that federal government agencies and the State of Ohio are making *substantial* efforts to reduce nutrient flows in the Ohio Lake Erie basin. They are requiring many hundreds of federal and/or state permittees to assess and/or develop nutrient treatment and management capacities. They are spending many millions of dollars on nutrient reduction efforts. They are also collecting and disseminating information on nutrient enrichment, HABs, and ways in which these problems can be addressed. And finally, both federal and state governing entities are organizing multiple efforts to address and/or manage flows of nutrients to the Lake Erie water basin.

However, based on information compiled and analyzed during the course of this project, we offer lessons and ideas for consideration by Ohio policymakers and natural resource practitioners. First, while the State of Ohio and federal government agencies are carrying out many activities to reduce nutrient flows, they appear fragmented. They do not appear to be *implemented* in a way that adheres to a single coordinated and focused nutrient reduction strategy targeted to reduce nutrient flows in the Ohio Lake Erie basin. By contrast, at least several other water basin programs around the United States (US) appear to be focusing their nutrient reduction efforts in strategic and coordinated fashion, and these efforts also appear to be characterized by clearly articulated goals and publicly available tracking and accountability systems to measure progress. We found no similar tracking and accountability system in place for Ohio's Lake Erie basin, and suggest that policymakers consider tasking a single organization to develop and implement such a system to track and report on progress in implementing nutrient reduction efforts (perhaps in coordination with other Lake Erie basin jurisdictions). Finally, our review of other basin-wide nutrient reduction programs -- including the Chesapeake Bay Program, the Long Island Sound Study program, and the Tampa Bay Estuary Program – identified additional policy tools targeting nutrient reductions that can be considered for use in Ohio's Lake Erie basin. These include (but are not limited to): 1) more comprehensive nutrient management programs for animal feeding operations; 2) effluent trading programs applicable to nutrients; 3) efforts to work with the agricultural community to enable enhanced reporting on agricultural Best Management Practice (BMP) implementation for geographically specified watersheds, and; 4) additional revenue-raising programs to support state level nutrient reduction efforts.

<u>Researcher Profile:</u> Dr. John Hoornbeek studies environmental and public health policy, and his research spans issues of local and state concern to issues with national and international implications. He has served as a policy practitioner at the federal, state, and local levels of government in the US. His public service work has included appointments with the Milwaukee County Department of Health and Human Services, the Wisconsin State Legislature, the U.S. Environmental Protection Agency, the U.S. Congress, and the National Environmental Services Center at West Virginia University. Dr. Hoornbeek earned his Doctoral Degree from the University of Pittsburgh, his Master's Degree from the University of Wisconsin – Madison, and his Bachelor's Degree from Beloit College.

Dr. David Singer, Assistant Professor in the Department of Geology at the Kent State University completed an Ohio Water Resources Center funded project titled "**Soil Development on Coal Mine Tailings: Impact of Trace Metal Sources and Mobility to Acid Mine Drainage**". His project aimed to evaluate how soil development on coal mine tailings may potentially promote or limit the mobility of trace metals that further contribute to degradation of water quality via acid mine drainage (AMD). His results will help guide AMD reclamation projects regarding how to address metal and acid leaching from soils developing on historic mine waste, which often covers a significant amount of area at reclamation sites.

Figure 1 Soil core samples being bagged and labeled by Laura Zemanek, MS Student at KSU. Photo by David Singer

Restoration at sites such as Huff Run in Ohio target discharge from surface and below ground mines, but typically do not target leaching from historic mine tailings. Soils from two locations within the Huff Run Watershed were examined – one impacted by AMD leaching from coal mine waste, and the other location at an undisturbed shale which is part of a highwall as a control site. Solid phase characterization of soils was performed on samples collected in 10 cm depth increments from the soil surface to 1.2 m depth (Figure 1) using bulk X-ray diffraction, sequential extraction procedure and ICP/OES for metals and loss on ignition for organic content. The analysis showed that metal solubility increased near the soil surface, but differed between sites and depths; Fe and Al were more mobile in the highwall; Mn was more mobile in mine tailings. Interestingly, sulfate was lower in the mine tailings pore water, which was not expected as it was hypothesized that greater AMD production would also result in increased sulfate concentrations. Results from the sequential extraction (Figure 2) suggest that a pool of Fe, Mn, and Al can continue to be mobilized during weathering and impact downgradient water. Finally, the mine tailings seem to be a potentially larger source of Mn to streams than previously understood.

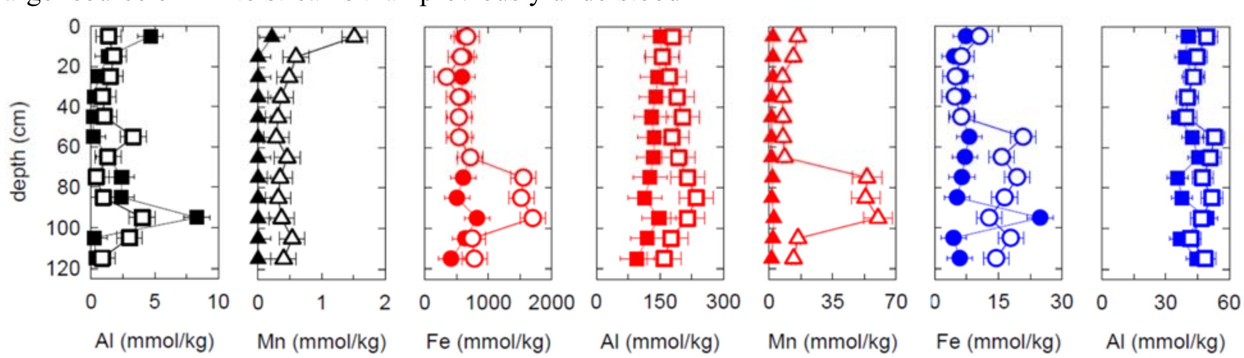

Figure 2 Sequential extraction data for Fe (circles), Al (squares), and Mn (triangles) from the highwall (closed symbols) and mine tailings (open symbols) soil cores. The three fractions are exchangeable (black), reducible (red), and oxidizable (blue).

<u>Researcher Profile:</u> Dr. David Singer an environmental mineralogist and geochemist, focusing on the fate and transport of metals and radionuclides in the environment. In particular, he is interested in the (bio)geochemical processes that occur at mineral surfaces which can limit or promote contaminant transport in a range of surface environments. His research has ranged from applied characterization studies of contaminated field sites to fundamental studies of the processes by which metals are sequestered at mineral surfaces. Recent work has aimed at determining the mechanisms by which heavy metals or radionuclides can interact with complex and porous mineral interfaces. Research opportunities and contact information are available at: https://sites.google.com/a/kent.edu/dsinger/

Dr. Gajan Sivandran, Assistant Professor in the Department of Civil, Environmental and Geodetic Engineering at the Ohio State University completed an Ohio Water Resources Center funded project via 104(b) USGS program. This project titled "**Spatial and Temporal Dynamics of Non-Point Source Pollution"** aimed to identify the hydrologic and land surface characteristics that influence the spatial and temporal dynamics of non-point source (NPS) pollutants (nitrogen and phosphorus, in particular). The project outcome will lead to identification of Critical Source Areas (CSAs) in a watershed, which offers an opportunity to prioritize and tailor conservation practices that will better protect water quality and reduce costs and transform a purely NPS problem into a quasi-point source problem.

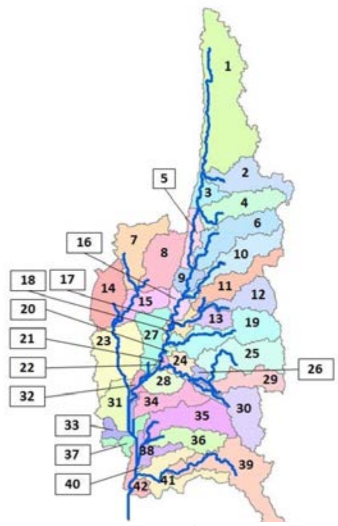

Figure 1 Subbasins of UBWC watershed used in our study

This study used the Upper Big Walnut Creek (UBWC) watershed in central Ohio as a case study. The watershed was divided into subbasins (Figure 1) in order to identify critical nutrient source area. Hydrological modeling was done using the latest release of SWAT model, SWAT2012, which includes a synthetic weather generator and improvements to simulation of nutrient cycling. Spatial modeling indicated that the top sixth of subbasins were responsible for contributing 52% of the total nitrogen and 55% total phosphorous. Modeling of variation of loadings over time revealed that three months, February, March, and October account for seven of the top ten contributing months. When examining the spatial-temporal interactions (subbasins and time), the top sextile represents 62% (Nitrogen) and 65% (Phosphorus) of the nutrient load, and an even higher percentage than both of these individually. Figure 2 indicates the interaction of both time and space. Vertical features on these plots indicate consistent spatial response at a given time. February, March, October, November and December all show stronger contributions across all subbasins. Horizontal features indicate a givens subbasins contribution to NPS pollution across time. Subbasins 20,21,22 and 32 all show high levels of contribution regardless of time. Based on our results, implementing best nutrient management practices that address both spatial and temporal issues could be a more efficient method of addressing nutrient pollution.

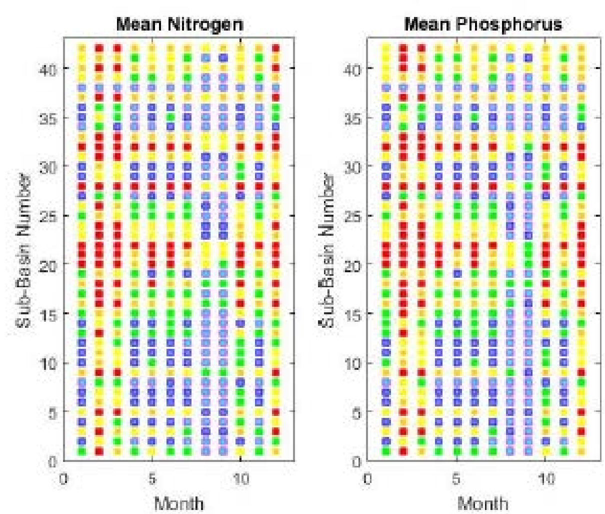

Figure 2 Monthly Mean Nitrogen and Phosphorus Load among 42 Subbasins and 12 Months in UBWC. Vertical features indication times of year of interest whereas horizontal features indicate areas within the catchment that consistently contribute to NPS. Red are top six contributors.

Researcher Profile: Dr. Gajan Sivandran is a watershed hydrologist/hydrodynamic modeler, fluid dynamics, focus on climate change, ecology, land management. His research focuses on semi-arid environments, where spatial and temporal variability in soil moisture is the primary control on the hydrologic cycle and ecological function, the dynamic feedbacks between hydrology and ecology.