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FECAL COLIFORMS AND *E. coli* LEVELS IN SURFACE WATERS FROM McCONNELL SPRINGS, 2011-2015

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Since the completion in 2009 of the McConnell Springs Stormwater Quality Wetland Pond by the Lexington-Fayette Urban County Government (LFUCG), the system has been monitored by the LFUCG Division of Water Quality to determine the effectiveness of pollutant reduction. While on site, additional surface water quality monitoring was performed on McConnell Springs itself. McConnell Springs is located in northwest Lexington, KY. The spring system consists of the Blue Hole, where water emerges from an underground channel and flows for approximately 38 m (125 ft.) then disappears underground; the Cave, an open fracture containing water; the Boils, where water emerges again as an artesian spring and flows for approximately 152 m (500 ft.); and the Final Sink, the point where water disappears underground again. The water reappears at Preston's Cave and flows into Wolf Run Creek, which empties into the Town Branch of Elkhorn Creek. Water quality monitoring included the Blue Hole, Cave, Boils, and Final Sink. A total of 28 sampling events were conducted by the LFUCG Division of Water Quality at McConnell Springs in 2011-2015. On-site measurements included: temperature, pH, dissolved oxygen (DO), conductivity, and total dissolved solids (TDS). Additional analysis included: alkalinity, hardness, carbonaceous biological oxygen demand (CBOD5), total suspended solids (TSS), total ammonia, nitrate, nitrite, total phosphorus, and orthophosphates. Bacterial enumeration of fecal coliforms, *E. coli*, and total coliforms were conducted using the IDEXX Colilert-18 and Quanti-Tray/2000 method.

Overall pH values at McConnell Springs remained consistent from 2011 to 2015. DO concentrations remained low, with the Blue Hole having the lowest DO and the Final Sink with the highest DO. Average DO concentrations were 4.49, 4.62, 3.90, 4.81, and 4.39 mg/L for 2011-2015, respectively. Conductivity was fairly constant, although an increase was observed in 2013. T DS, total alkalinity, total hardness, and total phosphorous remained constant during the monitoring period. TSS levels were fairly low throughout McConnell Springs. Average TSS concentrations in 2011-2015 for the Blue Hole, Cave, Boils, and Final Sink were 7, 17, 8, 12 mg/L, respectively. Overall ammonia levels were low in 2011-2013, but increases were observed during the February and June 2014 collections. Average nitrate concentrations were highest in 2011 (6.45 mg/L), but decreased in 2012-2015 (2.63, 2.51, 2.58, 2.27 mg/L). Average detectable nitrite concentrations ranged from 0.019 mg/L (2013 and 2015) to 0.030 mg/L (2011), but it was less detected in 2015. Orthophosphate concentrations slightly decreased over time.

Fecal coliforms and *E. coli* were detected in McConnell Springs during the monitoring period. In 2011, Dr. Gail Brion (UK-ERTL) reported contamination by fecal material in McConnell Springs. Dr. Brion proposed that the cold underground flow may retard fecal aging and the cold, dark conditions repressed indigenous bacterial growth while enhancing introduced coliforms, thus indicating that the source is not local and may be some distance from the collection site. Overall, microbial counts were most elevated in 2013. At the Blue Hole, fecal coliform geometric means for 2011 to 2015 were 719, 249, 742, 169, and 425 MPN/100 mL, respectively. Whereas, geometric means for *E. coli* at the Blue Hole were 290, 435, 620, 560, and 428 MPN/100 mL. Throughout the study period, bacterial enumerations tended to be elevated in June and October. Similar trends were observed in Dr. Brion's 2010 data. The highest bacterial counts were obtained October 18, 2013 at the Blue Hole, Boils, and Final Sink. Fecal coliform counts for all three locations were: 5371, 6086, and 6766 MPN/100 mL, respectively. While *E. coli* counts were 7328, 8361, and 6127 MPN/100 mL, respectively.

Most of the water quality results observed were consistent with levels found in artesian springs. Fecal contamination has been a historic problem at McConnell Springs. Of interest are the increases in fecal coliforms and *E. coli* counts in June and October and will be followed closely. Additional source tracking is required to reduce bacterial counts and pinpoint the cause of the seasonal fluctuations. LFUCG will continue to monitor water quality regularly. In particular, close monitoring of ammonia, nitrates, total phosphorous and bacterial counts which can have detrimental impacts to McConnell Springs and the receiving waters of Wolf Run Creek and Elkhorn Creek.

BURIED SOILS AS AN IMPORTANT CONTROL ON C STORAGE ALONG HUMAN-IMPACTED FLOODPLAINS IN KENTUCKY, USA

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One aim of floodplain restoration is to improve human-impacted wetlands, which affects carbon storage and water quality. However, few studies have assessed the long-term (>10 y) benefits of such restoration work. This study examines soil organic carbon (SOC) with depth in alluvial profiles that vary by restoration age and hillslope and upland profiles in western KY, USA. Five sites were examined. Three of the sites are floodplain soil profiles located in a (1) recently-restored (<1 year), (2) post-restored (>10 years), and (3) unrestored (0 years) setting. Two additional soil profiles along a foot slope and upland summit were examined that experienced reforestation following late nineteenth and early twentieth century deforestation and farming. The SOC was estimated from soil organic matter (SOM) measurements using loss-on-ignition (LOI) on oven-dried soil samples. Bulk density was also measured to calculate SOC stocks, reported here in kg C m^{-2}. The recently-restored site contains the highest SOC stock (22.39 kg C m^{-2}) and is situated on a clay-rich wetland adjacent to a former backchannel slough. The post-restored and unrestored sites have low SOC stock in the surface soil (3.35 and 5.58 kg C m^{-2}, respectively), yet higher SOC stocks at depth in buried soils (11.97 and 8.12 kg C m^{-2}, respectively). A similar pattern was noted at the footslope site, where the SOC stock in the surface soil (9.07 kg C m^{-2}) was lower than that of the buried soil (12.82 kg C m^{-2}). An average SOC stock was calculated for each buried and surface soil and a grand mean was then calculated for each group (buried soils, n=3; surface soils, n=5). The average SOC stock for buried soils (10.64±3.94 kg C m^{-2}) is similar to that of surface soils (10.97±2.35 kg C m^{-2}). The similarity between SOC stocks suggest that the presence of buried soils is an important control on carbon storage along human-impacted and restored floodplains and footslopes in western KY. The occurrence and extent of buried soils should be considered in restoration and carbon storage studies. Future research will include taking more samples at different locations to verify the similarity between SOC stocks of buried and surface alluvial soils and comparing different C analysis methods to account for structural water using the LOI method.

NOTES

BURIED SOILS ARE AN IMPORTANT CHEMICAL INTERFACE CONTROLLING MINERAL WEATHERING AND SOLUTE GRADIENTS ALONG RIVER CORRIDORS

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Soils along river corridors are important water filters that regulate nutrient flux as water travels downstream. Buried soils are common features along these corridors; yet, very few studies have addressed soil water dynamics in these buried alluvial soils and their role in influencing nutrient cycling in bottomland ecosystems. This project explores the bottomland soil nutrient dynamics for one alluvial terrace soil that hosts a *Quercus stellata* (post-oak) flatwood community using both solid-state and pore-water chemistry and physical characterization.

The Clarks River terrace soil profile is mapped as a poorly drained Alfisol with shrink-swell features and a buried soil at 1 m below the surface. Simulated K_{sat} values for the buried soil in the profile are much lower than the surface soil and are similar to those found in unweathered clays or shale. Mass balance geochemistry of the leachable soil fraction shows loss of K, Mg, and Na and enrichment of total Fe in both the surface and buried soils. These elemental trends are more common in well-drained soils. Pore-water Chloride, a proxy for water movement in soil, is in excess of 0.01 mol L^{-1} in the buried soil suggesting that this is a potential zone of slow moving pore water with longer residence times. Mean pore-water silica concentrations increase with depth from 20 mol L^{-1} in the modern surface to almost 70 mol L^{-1} in the buried soil; whereas, mean silica flux is higher in the surface soil (6,485 mol ha^{-1} y^{-1}) and very low in the buried soil (13 mol ha^{-1} y^{-1}).

The soil and pore-water chemistry trends for this one Clarks River alluvial terrace soil are reminiscent of upland soils weathering residuum. Although we have no model that explains how the buried soil chemistry influences the surface water dynamics, we hypothesize that this clay-rich buried soil may affect flatwood development by acting as an important chemical interface, like indurated parent material, and influencing the near-surface chemistry through nutrient uptake in the rooting zone.

NOTES

GEOSPATIAL EVALUATION OF SEWER GAS TO INDOOR AIR PATHWAYS RELEVANT FOR VAPOR INTRUSION

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Aging sewer lines are a major challenge for modern cities. Cracked, broken, or otherwise deteriorated sewer lines can be penetrated by water from outside the sewer. The unintentional entering of groundwater or runoff (e.g. inflow and infiltration (I&I)) into sewer systems is well-known to be a management challenge due to both the increased volume of water being transported by the sewer, as well as the larger volume of water that requires treatment. A less known, but important, challenge associated with aging sewer lines is when contaminated water and vapors enter the deteriorated sewer lines near hazardous waste sites. In this situation, the sewer system can serve as a preferential pathway transporting contaminated water and vapors long distances.

Deteriorated sewer lines are not only a concern outside of homes, but also within homes because plumbing fixtures are often poorly maintained. In most buildings, plumbing traps prevent sewer vapors from directly venting to the indoor air. Therefore, in buildings where plumbing is appropriately installed and maintained, sewer gas infiltration is less likely. However, if traps and/or drains become dry, or if joints and fittings are not properly working, sewer gas vapors have been shown to enter indoor spaces at concentrations that pose health risks.

This research project investigates the sewer gas to indoor air pathway relevant for vapor intrusion scenarios by evaluating available GIS maps of sewer lines and geospatial information about hazardous waste sites within Kentucky, particularly Fayette County. Maps delineating areas where contaminated groundwater (and vapors) from hazardous waste sites may be entering aging sewer lines have been generated. These maps inform about which areas are most susceptible for sewer systems to act as a preferential pathway transporting hazardous waste contaminants long distances from the original hazardous waste site. This sewer gas to indoor air pathway may produce increased exposure risks due to the transport of hazardous waste chemical vapors into indoor air environments.

NOTES

INVESTIGATION OF THE UPPER MISSISSIPPI EMBAYMENT AQUIFER SYSTEM HYDROSTRATIGRAPHY USING INTEGRATED GEOPHYSICAL METHODS: JACKSON PURCHASE, KENTUCKY

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Increased groundwater withdrawals associated with agricultural irrigation in the Jackson Purchase has prompted questions related to groundwater availability and sustainability. A key factor in evaluating these questions is knowing the extent and thickness of the local hydrostratigraphic system, or more specifically the upper part of the Mississippi embayment aquifer system.

The upper Mississippi embayment aquifer system is Eocene and includes the upper Claiborne aquifer, middle Claiborne confining unit, and the middle Claiborne aquifer. The upper Claiborne aquifer consists of sand, silt, and clay while the middle Claiborne confining unit is predominantly clay and silt. The middle Claiborne aquifer is primarily composed of sand, minor amounts of clay, and some lignite.

Fifty natural gamma-ray and resistivity well logs have been used to construct cross-sections of the upper Claiborne aquifer and middle Claiborne confining unit in the southwestern part of the Jackson Purchase. The cross-sections have enabled us to improve the resolution of the extent and thickness of the upper Claiborne aquifer and middle Claiborne confining unit. The thicknesses of the upper Claiborne aquifer and middle Claiborne confining unit range between 11-58, and 5-33 meters, respectively. The logs are not deep enough to determine the full extent of the middle Claiborne aquifer, however.

In an effort to more cost-effectively map these units, surface electrical resistivity was acquired and compared with a downhole geophysical log at a well-constrained site to test its limit for resolving these hydrostratigraphic units. The Wenner, Dipole-dipole, and Schulmberger electrical resistivity arrays were considered. The Schlumberger array gave the optimal electrical resolution, and had good correlation with the hydrostratigraphic picks of a g amma-ray log collected from an irrigation well (Thorpe well) located approximately 305 meters north of the electrical resistivity line (Fig. 1). The Schlumberger profile suggests that the top of the upper Claiborne aquifer is located about 14 meters below ground surface. The middle Claiborne confining unit is located about 73 meters below ground surface. The electrical resistivity survey is not deep enough to estimate the top of the middle Claiborne aquifer (increased electrode spacing or additional electrodes would be required). The Thorpe well gamma log indicates that the top of the upper Claiborne aquifer if 7 meters below ground surface and that the top of the middle Claiborne confining unit is 70 meters below ground surface. The correlation is very reasonable for first-order hydrostratigraphic mapping.

Reinterpretation of a P-wave seismic reflection profile collected by Woolery and Almayahi (2014) at the well-constrained Central United States Seismic Observatory borehole site located in the study area indicates the stratigraphic interfaces comprising the hydrostratigraphic system fall within the one-quarter wavelength vertical resolution limits of the data. A relatively modest elastic impedance contrast yields moderate-to-good image quality. Improving vertical seismic resolution and image quality for the hydrostratigraphic system will be tested with additional seismic reflection soundings using an S-wave energy source.

Aquifer and confining unit surfaces and thicknesses within the Mississippi embayment aquifer system, in Kentucky, need to be better defined in order to more accurately evaluate groundwater availability and aquifer interaction. This will require integrated invasive and non-invasive techniques to provide the needed resolution in a cost-effective manner.

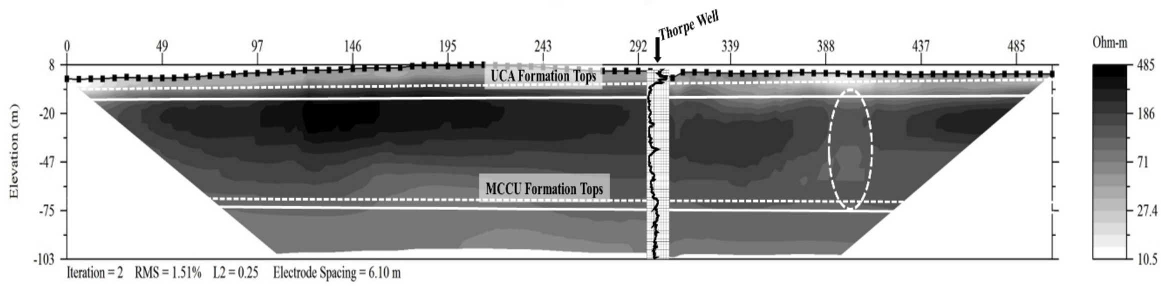

Figure 1. Schlumberger resistivity profile correlated to the Thorpe well gamma log (located 298 meters north of the electrical resistivity line). The darker colors suggest more resistive material (sand) while lighter colors suggest lower resistivity material (clay). The Thorpe well gamma log indicates the top of the upper Claiborne aquifer (UCA) is at 7 meters below ground surface (top white dashed line). The electrical resistivity suggests an average formation top at approximately 14 meters below ground surface (top white line). The Thorpe well gamma log shows the top of the middle Claiborne confining unit (MCCU) at 70 meters below ground surface (bottom white dashed line) while the average electrical resistivity top is at approximately 73 meters below ground surface (bottom white line).The gamma log and electrical resistivity correlation is reasonable for first-order mapping. The smoothing effects of the resistivity inversion curtail the resolution of more exact picks. The anomalous low resistivity zone (ellipse) below electrode 64 can be interpreted geologically as a highly fractured zone or an inversion artifact associated with the highly conductive material at the ground surface.

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EVALUATING PEDESTRIAN COMPACTION VARIATION UNDER DIFFERENT GROUND USE SYSTEMS IN CALLOWAY COUNTY, KENTUCKY

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Over time, playing fields are monitored by general overall appearance. However, pedestrian compaction is not evenly distributed throughout the entire surface. The objectives of this investigation were to determine the spatial variation of soil compaction in a 50 m square area with 425 measurements using a penetrometer (1st study) and to compare soil compaction, soil water content and soil organic matter of 5 different grassed areas in Calloway county (2nd study).

The first study was conducted in The University Quad of Murray State University at the soil depth of 15 cm. The highest soil compaction observed was 300 psi and the lowest was 50 psi with an average of 202 psi. The coefficient of variation for the measured values was 36%.

The second study investigated 5 different land use systems including the Soccer Field, Intramural Field, University Quad, Prairie, and the Pullen Farm Recreation Area at a depth of 15 cm. The highest soil compaction and soil water content were found in the University Quad and the Pullen Farm Recreation Area, with the lowest values found in the Soccer Field and Intramural Fields. In addition, there were correlations between soil compaction and other soil properties including soil bulk density, soil water content and soil organic matter.

NOTES

LAND COVER PIXEL SHIFT IN THE KENTUCKY RIVER BASIN AND ITS EFFECTS ON SPATIAL STATISTICS

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Watershed health indicators can benefit from basic land cover data such as those provided by the 2011 National Land Cover Database (MRLC, 2016). Such spatio-temporal variables are: land cover class, percent imperviousness and percent tree canopy closure and their change rates and trends. The 2011 National Land Cover Database contains the most recent and official land cover data layer for Kentucky (MRLC, 2016). The coordinate reference system utilized is the USGS's own -- Contiguous USA -- Albers Equal Area Conic – NAD 1983 (*USGS-Albers*) with specified parameters (USGS, 2013). On the other hand, the official coordinate reference system for the Commonwealth is State Plane Coordinate System Single Zone -- Lambert Conformal Conic – NAD 1983 (*SPCS-KY-1Zone*) with specified parameters (Bunch, 2004; DGI-a, 2016; KRS-a, 1992; KRS-b, 2012; KAR, 2016; Georepository, 2016).

Current GIS data layers provisioning protocols provide access to land cover data via services with coordinate reference system *SPCS-KY-1Zone* (DGI-b, 2016). It is well known that the process of reprojecting the data from their native coordinate system may result in changes in area, shape, orientation, etc. In the case of raster datasets, such as the land cover map, equivalent spatial resolution is maintained by converting pixels from metric units to English units (i.e. 30 meters to 98.425 feet). Spatial resolution controls the scale at which the map should be utilized (Nagi, 2010).

The 6, 8, 10 and 12-digit Hydrologic Unit boundaries corresponding to the Kentucky River Basin were used as the study area (DGI-c, 2016). The process of reprojecting the basin boundary polygon represented changes in surface area tabulations for each land cover class. Increases and decreases in the number of pixels assigned to each land cover class were observed and quantified for all 230 sub-watersheds, adding to a total diminution of pixels. Center of pixel points were also used to sample the land cover classes in HUC HUC051002050404 (Drakes Creek watershed) in both the original, *USGS-Albers* and the *SPCS-KY-1Zone* coordinate systems, and to quantify land cover class migration.

Thus far, a state-wide class accuracy analysis for land cover related data layers from different epochs are not available for Kentucky. As a result of geoprocessing of the original data, distortions in the spatial distribution of specific land cover types in some watersheds may be a potential additional contribution to the cartographic error budget of land cover maps for the Commonwealth.

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EFFECTS OF VARIOUS LAND USES IN STEWART COUNTY, TENNESSEE ON SELECTED SOIL PROPERTIES

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Different land uses have various effects on physical and chemical properties of the soil. The goal of this study is to examine the impact of six land uses located in Stewart County, TN on selected soil properties (soil water content, bulk density, soil organic matter, and soil acidity levels). The land uses examined include a tobacco field, hardwood forest, corn/soybean rotation, garden, lawn, and a pasture. The garden and tobacco field were plowed using conventional tillage methods for 15 years. The corn/soybean field has been a no-till system for the past 6 years. The forest, pasture and lawn are not plowed. Disturbed soil samples from topsoil (0-4" deep) were collected from each field to determine pH and organic matter content. Undisturbed soil samples of two depths (0-7" and 7-14") were collected from each field for soil water content, and bulk density. The results show that the tobacco field had the highest bulk density (1.10 g/cm^3), while the garden had the lowest bulk density (0.66 g/cm^3). The lawn had the highest soil water content (18.9%), while the corn/soybean field had the lowest soil water content (12.6%). The forest had the highest soil organic matter content (10.7 %) while the tobacco field had the lowest (3.2 %). The garden's soil had the highest pH (5.8), while the tobacco field had the lowest pH (5.0). However, all fields were considered in the acid range. The findings of this study provides implications that can help farmers to make decisions regarding soil management for better growing media.

NOTES

DIFFERENCES IN SOIL CHARACTERISTICS AMOUNG NATURAL AND AGRICULTURAL ECOSYSTEMS IN WESTERN KENTUCKY

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Different ecosystems greatly impact soil properties. Soil physical properties are considered sensitive indicators of perturbation due to soil management practices and land covers. Four ecosystems were investigated including forest and grassland as the natural ecosystems while the agricultural systems were conventional tillage and no-till systems. The forest and grassland ecosystems are located in the Kentucky Dam Village State Resort Park in Gillbertsville, KY. The agricultural systems are located in in Calloway County, KY. The forest has been undisturbed for at least the last forty years. Part of the grassland, which surrounds the local airport that has been around since 1990, is mowed twice a year with tractor and a pull behind rotary mower. The no-till ecosystem has been in a corn and soybean rotation with an occasional wheat crop for the last ten to twelve years. The conventional tilled system is in a rotation of one year of tobacco and then corn or soybeans for the next two years and then tobacco is planted again. Soil bulk density, soil organic matter content, soil water holding capacity, macroporosity and soil water at field capacity were determined from the depth of 0 to 6 cm and 6 to 12 cm. The results show that the values of these soil properties varied depending on the ecosystem and the soil depth. On average, the highest to lowest bulk density ranking is 1) Grassland 2) No-till 3) Conventional tillage 4) Forest. Soil water holding capacity ranking from highest to lowest is 1) Forest, 2) Grassland, 3) Conventional Tillage, 4) No-till. Macroporosity ranking from highest to lowest is 1) Grassland, 2) Forest, 3) No-till, and 4) Conventional tillage. Soil water content at field capacity ranking from highest to lowest is 1) Grassland, 2) Forest, 3) Conventional tillage, and 4) No-till. Results from this study increase our understanding of the effects of natural and agricultural soil management on s oil properties.

NOTES

INCORPORATING HUMAN IMPACTS AND NATURAL PROCESSES TO ASSESS SINKHOLE RISK

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Current sinkhole hazard maps in Kentucky are based solely on geology, but the USGS estimates that over 80% of sinkhole collapses are anthropogenic in origin. There is a need for a reliable sinkhole risk map for use by land use planners, government agencies, and other stakeholders. We develop a new map of sinkhole hazard probabilities utilizing the random forests method and high precision sinkhole data from the Floyds Fork Watershed in North Central Kentucky. In applying the random forests method, we evaluate land use, geology, hydrogeology, land cover, topography, and soils to predict sinkhole risks. This work will identify the most common risk factors based on anthropogenic and natural impacts on a karst environment. Ultimately, we intend to create more accurate sinkhole risk maps in other karst environments by applying the random forests classifier we generated to other areas.

NOTES

VIRTUAL 3D MODEL FOR CONTAMINANT FLOW WITH GROUNDWATER DUE TO UNDERGROUND PIPE BURST FOR EDUCATION AND OUTREACH

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Several underground pipelines exist in northwest Indiana to transport oil to different destinations. Most of these pipelines are located in the Lake Michigan watershed running in the east – west direction. Several companies such as Enbridge own these pipelines. Due to aging and other factors, pipeline failures were reported. For example, in Michigan, the Kalamazoo River was contaminated due to one such pipe failure (http://www3.epa.gov/region5/enbridgespill/). Residents and environmentalists from northwest Indiana were concerned when Enbridge started a new pipeline project a year ago. This research is an attempt to develop education and outreach modules using a virtual 3D platform. This will facilitate visualization and help the public understand potential contamination movement in the ground when an underground pipeline fails in a specific location.

Model development

Developing such models is a data intensive process. From published USGS documents and well log details, soil type and variations with depth were documented. A regional ground water solute transport model was developed to a size of 1600 x 500 x 200 feet. Pipelines in this region are located in the Lake Michigan watershed where, in general, flow is towards the north. The modeling sequence followed is shown in Figure 1.

Based on t he soil type, properties such as porosity and hydraulic conductivity were determined from the literature. By implementing boundary conditions (constant head boundaries and recharge boundaries), the initial model grid was structured in the GW Vistas software. Groundwater flow was modeled with MODFLOW. Using MT3D software, a solute transport model was developed. A hypothetical pipe burst and the associated spill were simulated by assuming a 24 hour leakage. The volume of spill and basic properties were estimated to develop the initial concentration at the spill site. Daily simulation was conducted for 2 years and the results were captured for every 15 day time period. Using the GW Vistas platform, cell by cell concentrations were captured and taken to generate virtual 3D models.

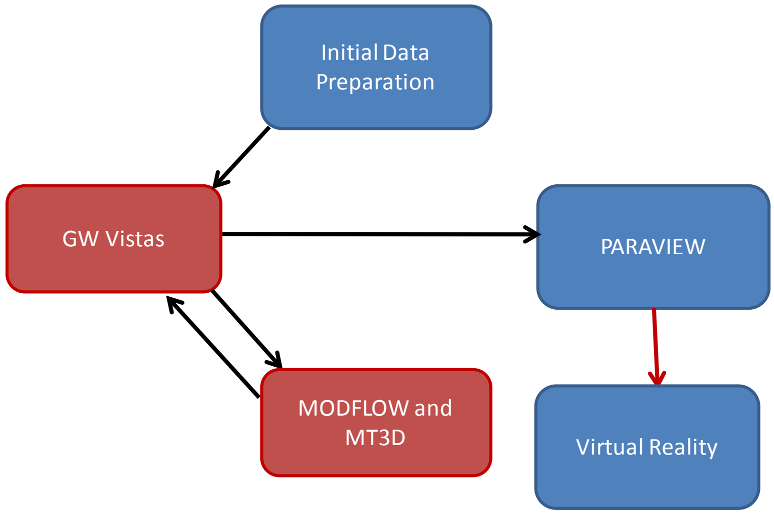

Figure 1. Modeling outline

These virtual 3D models can be used on a regular PC with 3D glasses or in an online platform using 3D glasses. A 2D version is also available. A user can take a scenario and study the contamination spread with respect to time to help understand the potential risks.

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NUTRIENT TMDL FOR DEEP RIVER WATERSHED USING KY NUTRIENT TOOL

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Non-point source nutrients emerging from a watershed produce spikes in concentrations during rainfall events. Best management practices are needed to control non-point source pollution. Point sources also contribute to nutrient loads, but they are better managed. For developing Nutrient TMDLs (Total Maximum Daily Loads), loads from different land uses, failing septic systems and other sources need to be calculated for identifying the required load reductions. An Excel based worksheet program called the KY Nutrient tool, was used to develop a nutrient TMDL for the Deep River system located in northwest Indiana. This tool was developed by a KWRRI research team.

The Deep River system drains towns (including Crown Point, Merrillville, Hobart and Gary) to Lake Michigan. Over half of this 180 square mile watershed is classified as agricultural/pasture/forest/wetland categories. A management plan is being developed and a nutrient TMDL is a part of this plan. Recently, the Kentucky Water Resources Research Institute (KWRRI) created an Excel based worksheet program called the KY Nutrient tool (White *et al.*, 2015). The model uses a daily time step for load calculation. Users can directly use field observed flow data or they can use the tool to simulate and calibrate flow data using rainfall and the SCS curve number runoff calculation (USDA 1973). Water quality is estimated using an event mean coefficient based approach. Hydrologic modeling is done using linear reservoir models and water quality transport is modeled using mass balance approaches. The model provides flexibility to include point source loads and non-point sources. Sanitary sewer overflows and septic systems are modeled as point sources, whereas the non-point source loads for different land use types can be accommodated using coefficients. The model provides flexibility to perform hydrology and water quality calibrations (White *et al.*, 2015).

The Deep River system was subdivided into 9 sub watersheds. Land use data for each sub watershed, observed United States Geological Survey (USGS) flow, rainfall data and soil data were needed. Initially, land use data and soil data were consolidated through geo-processing. Watershed delineation was done using ArcGIS and all of the reaches were derived with proper connectivities. Land use data were obtained from the NOAA (National Oceanographic Atmospheric Agency) Coastal Service Center. The area of different land use types for each sub-watershed was calculated and the area covered by different hydrologic soil groups for each sub-watershed was estimated using the NRCS soil database. The rainfall data were obtained from NOAA. Flow data were downloaded from the USGS website (2006-2013). The USGS observation station is located below Lake George at Griffith, IN. Flows for each sub-watershed were estimated using an area based proportioning method. Water quality observations were made by the Indiana

Department of Environmental Management (IDEM) during 2013 at 15 locations in this system. Nine stations from that study were used for water quality calibration. Model results and observed data were compared and after fine tuning of coefficients, calibrations were finalized (Figure 1).

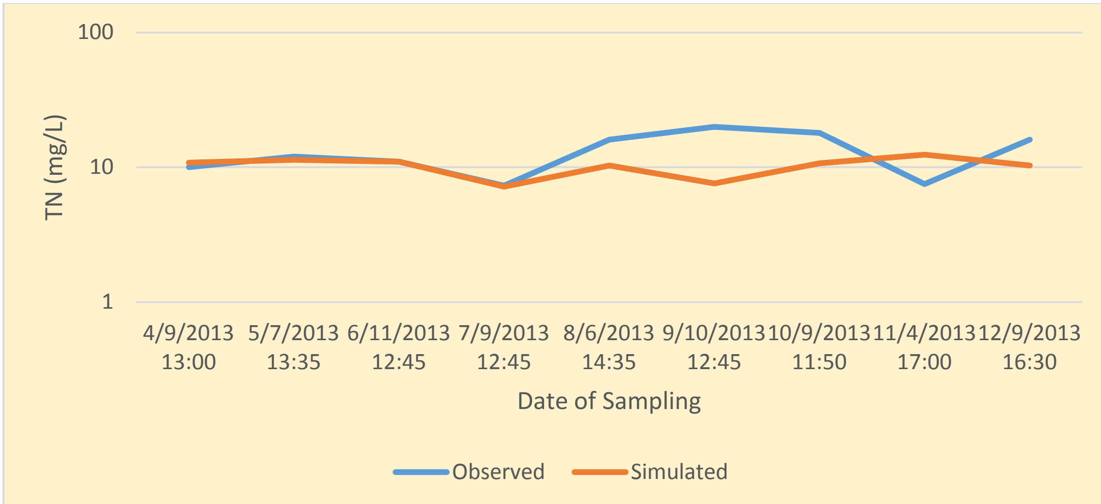

Figure 1. Observed and Simulated TN concentration at Sub watershed 1 (40400010501), Station LMG-05-0018

After satisfactory calibration, TMDL reductions were performed. Load reductions for different sources estimated for each sub-watershed varied from 1% to 90% for the various different land use categories.

Acknowledgement: Support for this study was provided by IDEM.

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DESIGNING POLYPHENOLIC NANOCOMPOSITE MATERIALS FOR THE CAPTURE AND SENSING OF POLYCHLORINATED BIPHENYLS IN CONTAMINATED WATER SOURCES

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Polyphenolic based nanocomposite materials have been developed using several distinct methods to capture and sense organic pollutants from water sources. The polyphenolic moieties were incorporated to create high affinity binding sites for organic pollutants within the nanocomposites and serve as a sensing platform. Multiple strategies have been employed to create these polyphenolic based nanocomposite materials. The first method utilized a surface initiated polymerization of poly(ethylene glycol)-based and polyphenolic-based crosslinkers on the surface of iron oxide magnetic nanoparticles to create a core-shell nanocomposite. The second method consisted of a single step direct functionalization process for the synthesis of polyphenol coated iron oxide magnetic nanoparticles. The third method utilized a bulk polymerization method to create macroscale films that were composed of iron oxide nanoparticles incorporated into a polyphenolic-based polymer matrix, and then, these films were processed into microparticles. All three methods produce nanocomposite materials that can specifically bind chlorinated organics, can rapidly separate bound organics from contaminated water sources using magnetic decantation, and can use thermal destabilization of the polymer matrix for contaminant release and material regeneration. The polyphenol functionalities used to bind organic pollutants, such as polychlorinated biphenyls (PCBs), were quercetin, curcumin, quercetin multiacrylate (QMA), and curcumin multiacrylate (CMA), the latter two which are acrylated forms of the nutrient polyphenols. In some systems, N-isopropylacrylamide (NIPAAm) was incorporated to create temperature responsive materials for reversible binding. All particles were characterized using transmission electron microscopy (TEM), dynamic light scattering (DLS), Fourier transform infrared spectroscopy (FTIR), and thermal gravimetric analysis (TGA). Pollutant binding studies were performed using PCB 126 as a model system for chlorinated organic pollutants to determine binding affinity and capacity, and this was quantified using gas chromatography coupled to an electron capture detector (GC-ECD).

NOTES

EMERGING TRENDS IN KENTUCKY LAKE WATER QUALITY:
25 YEARS AND OVER 500 CRUISES

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Kentucky Lake water quality has been monitored at sixteen sites on the lake and six sites on small tributaries by the Hancock Biological Station (HBS, Murray State University) since 1988 (Fig 1). Several long-term trends in some water quality parameters have emerged. For example, as sulfur dioxide emissions from fossil fuel plants have decreased over the past three decades for several reasons, sulfate ($SO_4^{=}$) concentrations also have decreased and pH has increased in precipitation falling on the lake and subwatersheds. $SO_4^{=}$ concentrations in Kentucky Lake surface water also have decreased while surface water alkalinity has increased in both main channel and tributaries suggesting that atmospheric inputs are no longer an important source of sulfates to the lake. Nitrate (NO_3^{-}) nitrogen concentrations have increased over time while phosphate ($PO_4^{\equiv}$) concentrations have remained the same over the 25-year record.

Most interesting, however, is that mid-channel water temperature has increased by 1°C since 1988, consistent with increasing temperatures reported for other lakes over the same time period. Additionally, the frequencies of water temperatures above 30°C during summer months (June, July, and Aug) has increased over the past decade. Water temperatures of two streams (Panther and Ledbetter creeks, Fig. 1) discharging into Kentucky Lake also have increased over the same time period. While Kentucky Lake, a mid-latitude lake, has not experienced temperature increases as dramatic as boreal (e.g., Lake Superior) or arctic lakes, it is not immune to the effects of climate change.

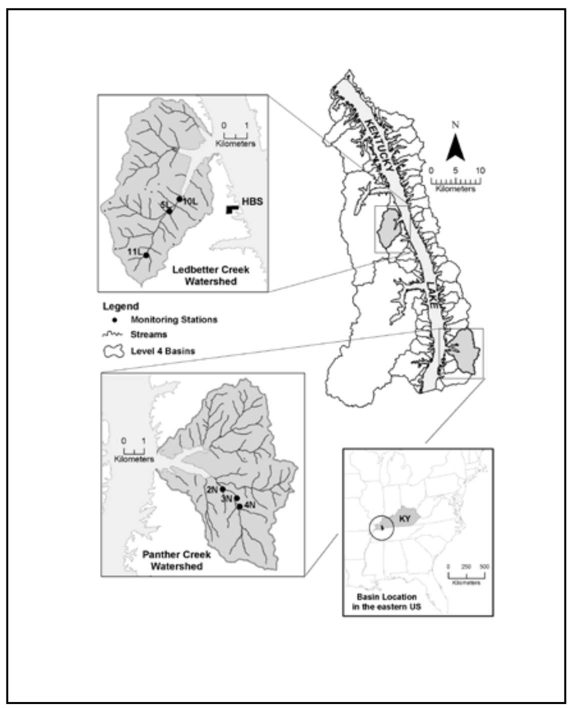

Fig. 1. Location of Kentucky Lake and tributaries, Ledbetter (west side and Panther Creeks

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DOES LIGHT PENETRATION AFFECT THE PELAGIC FISH COMMUNITY IN KENTUCKY LAKE?

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Kentucky Lake provides a valuable recreational and commercial fishery for the Western Kentucky region, and understanding the water quality of Kentucky Lake is essential to properly managing this ecosystem. The availability of light is a crucial water quality parameter, since light is necessary for photosynthetic organisms. Light is also essential for sight-feeding organisms, such as small fish. But, many things can degrade water quality and reduce the availability of light in the water. Reduced light penetration can have cascading, long-lasting effects on the rest of the aquatic ecosystem. Thus, studying the water quality of Kentucky Lake can lead to greater understanding of the fish community.

Although factors such as temperature are most often thought to control year class strength in young fish, few studies have looked at how water quality influences juvenile fish. Little is known how light penetration affects young fish, even though these fish are very reliant upon light for sight feeding. Sampling small, juvenile fish and coordinating those samples with other water quality sampling, such as turbidity and Secchi depth readings, might lead to a greater understanding of the dynamics of the Kentucky Lake ecosystem.

We propose to study the relationship between light penetration and small, pelagic, juvenile fish in Kentucky Lake. The Hancock Biological Station (HBS) of Murray State University collects bi-weekly water samples at several locations in Kentucky Lake. We wish to coordinate fish sampling with the HBS water quality sampling in order to look for effects of light penetration on these small fish. We will compare turbidity and Secchi depth samples to trawl samples of juvenile fish to determine how reduced light penetration affects these fish.

Trawl sampling for small, pelagic fish will be conducted at 2 of the HBS sampling locations. One site will be in a large embayment, and the other site will be in the main channel. The embayment site is more protected from the wind than the channel site, so a large difference in light penetration should exist between the 2 sites. A surface trawl will be used in order to obtain a thorough sample of the small, pelagic fish species. Sites will be sampled bi-weekly from March through August. All fish catch will be identified and measured (length and weight). The numbers, biomass, and species composition of the fish catch will be compared to the turbidity and Secchi depth readings obtained by HBS.

NOTES

LONG-TERM EFFECTS OF FORESTRY BEST MANAGEMENT PRACTICES ON HYDROLOGY AND WATER CHEMISTRY IN THREE APPALACHIAN HEADWATER CATCHMENTS

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Headwater streams are typically small in stature; however, they contribute 60 to 85% of the total stream length in a network, and drain 70 to 90% of the drainage basin area (Benda et al. 2005, MacDonald and Coe, 2007). Due to their small size, headwater streams are quite sensitive to anthropogenic disturbances such as timber harvesting, this can cause larger runoff volumes, higher peak flows, and decreased water quality. Although the significance of headwater stream systems on overall stream and river health has become more apparent in recent years, research on the consequences of timber harvesting in headwater stream systems is quite limited, especially on the long-term.

In 1982, a study was initiated in the Field Branch watershed in the University of Kentucky's Robinson Forest to evaluate forestry best management practice (BMP) effectiveness after intensive harvesting. The study utilized a paired watershed approach on three adjacent headwater catchments. One watershed was left as the control, one watershed had BMPs implemented (including a 50-ft undisturbed buffer along the stream), and one was clear-cut to the stream bank without BMPs (i.e. logger's choice). Most forestry BMPs are designed to decrease sediment transport resulting from soil erosion. Soil erosion and subsequent suspended sediment in surface waters is considered by many as one of the largest environmental concerns in the U.S. today. Erosion of organic and nutrient rich surface soil decreases forest productivity and has many adverse consequences once it reaches the stream. Some of these consequences include loss of stream habitat, altered stream hydrology and geometry, and nutrient/pH imbalances. Monitoring of the three streams has continued since the study began in February of 1982 and preliminary observations indicate that the hydrology of the two harvested watersheds still differ from the control watershed even after a 30-year period.

NOTES

PROGRESS TOWARD IMPROVED
STATEWIDE GROUNDWATER-LEVEL MONITORING

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Groundwater is an important natural resource used by the agricultural, industrial, and energy-extraction sectors throughout much of Kentucky, and by many municipalities and private citizens that rely on wells or springs as a source of potable water. As the state's population and economic activities continue to increase, data needed to evaluate groundwater availability and sustainability become more important. Long-term measurements of water-level fluctuations collected from a suitable network of observation (monitoring) wells provide fundamental information about changing groundwater conditions and help provide answers needed to assess how much groundwater is available at any point in time, whether stresses such as periodic droughts and increasing withdrawals are depleting Kentucky aquifers, and whether enough groundwater will be available to meet the commonwealth's future needs.

From the mid-1950's until the late 1980's, groundwater-level data were collected cooperatively by the USGS and KGS across the state using a loosely defined network of abandoned or unused private water wells. The number of monitored wells in the network varied from more than 64 to fewer than 12, depending on available funding and other agency resources; however, over the years, continuing decreases in federal and State funding steadily eroded the number of observation wells until only one well in Graves County remained actively monitored in the early 1990's as part of the federally funded USGS National Climate Response Network. In 1998, KGS was mandated by KRS 151.625 to oversee the establishment of a long-term groundwater monitoring network for the purpose of "… characterizing the quality, quantity, and distribution of Kentucky's groundwater resources"; however, no funding was ever appropriated to enable carrying out this mission. As a consequence, groundwater-level data are lacking for much of the state, and records of water-level measurements collected from previously monitored wells are often 30 years or more out-of-date.

In 2015, KGS committed funding and resources to begin to address the critical lack of groundwater-level data and rebuild a statewide groundwater-observation network, with a goal of establishing at least 15 observation well sites to monitor naturally occurring changes in groundwater levels that are representative of groundwater conditions in major representative aquifers present throughout Kentucky. To minimize costs, existing wells, including some that have been previously monitored, are presently being inspected and tested by KGS hydrogeologists for inclusion in the network. All of the wells included in the observation network will be equipped with pressure transducers and data loggers recording groundwater levels at 15- to 30-minute increments. Approximately seven of the wells will also be equipped with a telemetry system that will automatically transmit recorded groundwater-level data to enable tracking and evaluation of daily changes in groundwater conditions. All groundwater data collected from the network's wells will eventually be posted to the KGS website and available for the public's use. To date, long-term observation well sites have been established in Calloway, Hickman, Henderson, Edmonson, and Fayette Counties. Additional wells are undergoing evaluation in Hardin County, and potential observation well sites are being sought in west-central, south-central, and eastern Kentucky.

Continuous monitoring of water-level measurements over a period of at least 5 years is needed to build the database (or period of record) needed to identify monthly, seasonal, and longer-term trends in groundwater-level fluctuations and to enable calculations of statistically valuable parameters such as mean (average), maximum, and minimum groundwater levels. KGS has committed the funds, equipment, and human resources needed to maintain the network through fiscal year 2017; however, longer-term maintenance of the network will require additional sources of funding and collaboration/support from additional partners.

DETECTION OF *Percopsis omiscomaycus* (TROUT-PERCH) USING eDNA in EASTERN KENTUCKY STREAMS

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Environmental DNA (eDNA) provides an effective, non-invasive method to detect the presence of rare organisms in aquatic systems, provided sufficient molecular tools are available. *Percopsis omiscomaycus* is a small fish with a limited, disjunct distribution in central and eastern Kentucky. We amplified and sequenced a 769 BP region of *Percopsis omiscomaycus* cytochrome b and used this sequence to design eDNA primers that selectively amplify *P. omiscomaycus* DNA from filtered water samples. One liter water samples were collected from 17 locations in northeastern Kentucky, filtered, and DNA was extracted in a manner consistent with established methods. Additionally, each location was intensively sampled for *P. omiscomaycus* by seining. Initial results indicate eDNA successfully detected *P. omiscomaycus* at sites where specimens were collected using seines in addition to at least one site in which suitable habitat was observed but no specimens were collected. These data add to the body of knowledge concerning *P. omiscomaycus* distribution and provide a useful tool for detecting cryptic populations for this and other species.

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SEASONAL FLUCTUATIONS IN SALAMANDER eDNA IN CENTRAL KENTUCKY STREAMS

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Environmental DNA (eDNA) provides an effective, non-invasive method to determine organism presence or absence in an efficient manner. The majority of salamanders native to central Kentucky have an aquatic phase to their life cycle. Some *Ambystomid* species persist as aquatic larvae for just a few months while other sympatric species spend more than one year in the juvenile aquatic phase. We developed species specific eDNA primers for streamside (*Ambystoma barbouri*), southern two-lined (*Eurycea cirrigera*), and cave (*Eurycea lucifuga*) salamanders that effectively amplify salamander DNA filtered from stream water. We collected 1 liter water samples biweekly from February to July 2015 in three small streams in Jessamine County to examine seasonal fluctuation in eDNA levels of different salamander species. Initial data reveal a complete absence of *A. barbouri* eDNA in early spring samples but high levels later in the spring corresponding with breeding and larval presence. These data add to the growing pool of knowledge concerning eDNA monitoring of species and should provide useful reference data for future monitoring or range delineation studies.

NOTES

ENGAGING STUDENTS IN COMMUNITY CLIMATE RESILIENCE AND EDUCATION

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The Center for Environmental Education has been integrating student learning with the implementation of the Triplett Creek Watershed-Based Plan. Triplett Creek is impaired by excess sedimentation, and streambank erosion is a significant contributor (Emrich, et. al., 2013). Further research conducted in the Triplett Creek Watershed on the causes of streambank erosion supports the implementation of Best Management Practices that reduce stormwater runoff in areas through the reduction of impervious surfaces within the watershed instead of focusing on habitat improvements along the streambanks (Haight, Phillips, Meade, 2015). Morehead State University has been conducting and promoting environmental protection and restoration activities for over 20 years and has recently engaged MSU preservice students in a service learning project to design the retrofit of an existing stormwater basin on campus. The identified stormwater basin was retrofitted into an outdoor classroom that focuses on watershed and climate change impacts. Through the service learning process the students designed features, activities, and educational signs for the classroom. A pre- and post-assessment of the project showed that students: 1) increased their ability to identify causes of flooding, waterway impairments, and climate change; 2) increased their willingness and confidence to teach climate change and watershed issues; and 3) were able to make more connections between climate change and community best management practices to improve community climate resilience. The number of students that believed climate change was happening also increased. This presentation will share the data and the resulting retrofit of the basin into an outdoor classroom.

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