

**Virginia Water Resources Research Center  
Annual Technical Report  
FY 2016**

# Introduction

The Virginia Water Resources Research Center (VWRRC) was established at Virginia Tech in 1965 as a federally authorized program. In 1982, the Virginia General Assembly authorized the VWRRC as a state agency under the Code of Virginia (§23-135.7:8). In 2005, the VWRRC became an administrative unit in the College of Natural Resources and Environment at Virginia Tech.

## *Mission*

The VWRRC provides research and educational opportunities to future water scientists; promotes research on practical solutions to water resources problems; and facilitates timely transfer of water resources information to policy- and decision-makers and the general public.

## *Mission Elements*

### *Research*

- Assisting university researchers in securing research support funds from public and private sources to address water resources issues.
- Assisting university researchers in initiating and executing water resources research.
- Conducting research on water resources issues appropriate for expertise of personnel affiliated with the VWRRC.

### *Education*

Advancing educational opportunities for students in water resources fields by

- Helping university researchers provide undergraduate and graduate research experiences in water resources.
- Coordinating an undergraduate minor and graduate certificate in water resources at Virginia Tech.
- Coordinating a multidisciplinary undergraduate B.S. degree program in *Water: Resources, Policy, and Management* at Virginia Tech.
- Connecting students in water resources fields with internship opportunities.

### *Outreach*

- Maintaining and frequently updating the VWRRC website and social media outlets to provide access to information on water resources science, engineering, and policy.
- Publishing *Virginia Water Central*, a newsletter featuring articles on water-related policy and law, summaries of water conditions in Virginia, and news briefs about water issues.
- Producing *Virginia Water Radio*, a weekly radio show and podcast featuring unique perspectives on water sounds and news, and information involving Virginia's waters.
- Securing academic advisors to work in an advisory capacity with public and private sectors as requested.
- Initiating and participating in development and execution of seminars, conferences, and symposia on Virginia, regional, and national water issues.
- Developing and maintaining stormwater, water monitoring, and water education websites for state agencies and associations.

## *Program Administration*

Administrative oversight of the VWRRC is provided by the Dean of the College of Natural Resources and Environment. A Statewide Advisory Board appointed by the Governor advises the VWRRC director on state water research and information priorities. Because of its multiple legislative authorities and administrative responsibilities, the VWRRC has a number of reporting requirements. In addition to the annual reporting requirements to the USGS and the National Institutes for Water Resources (NIWR), it presents an annual report to the Virginia Tech administration and the College of Natural Resources and Environment. Five-year reports and reviews are presented to the USGS and the State Council on Higher Education for Virginia (SCHEV).

### *National Affiliations*

The VWRRC is affiliated with NIWR and the Universities Council on Water Resources (UCOWR).

### *Programs of the VWRRC*

#### *Introduction*

Programs are structured to meet strategic goals of the VWRRC and are consistent with the VWRRC mission as authorized by the U.S. Congress through the Water Resources Research Act of 1984 (Public Law 98-242), and Code of Virginia (§23-135.7:8). Programs in research and education are available to students and faculty at all Virginia colleges and universities. Outreach and collaborative programs include information transfer to policy/decision makers and citizens, and collaborative partnerships with state and federal agencies and other water-interest groups.

#### *A. Research Programs*

1. The VWRRC's statewide competitive grants program for students provides research funds to find practical solutions to water problems in Virginia and the region. The grant period begins June 1 and ends May 31 of the following year. Proposals are evaluated with emphasis on intellectual merit, innovation, likelihood of success, broader impacts on Virginians, and alignment with state or regional water resources needs and challenges. A priority listing of water research needs for this competitive grants program is updated annually in consultation with the VWRRC Statewide Advisory Board. These grants are designed to support research efforts with a high potential for expanded funding from additional sources.
2. The VWRRC applies for external grants and conducts in-house research.
3. The VWRRC facilitates research team building and interdisciplinary, multi-institute collaborative research.
4. The VWRRC facilitates research opportunities to other university faculty and external contractors through a partnership with federal agencies that provides targeted funding from the USGS.

#### *B. Educational Programs*

1. The VWRRC provides research opportunities to undergraduate students and assistantships to graduate students who participate in sponsored research. Also, numerous graduate and undergraduate students are supported through the VWRRC's competitive grants program in Virginia Tech academic departments, and at Virginia's other colleges and universities.
2. In 1999, the VWRRC established the William R. Walker Graduate Research Fellowship to honor the many contributions of Dr. William R. Walker, the VWRRC's first director. The annual monetary award is intended for individuals preparing for a professional career in water resources and is provided to at least one new graduate student at Virginia Tech each year. Details of the program can be found on the VWRRC website: <http://www.vwrrc.vt.edu/walker-award/>

3. The VWRRC coordinates the interdisciplinary Watershed Management Undergraduate Minor and a Watershed Management Graduate Certificate Program in collaboration with five colleges and ten departments at Virginia Tech. The VWRRC also developed and coordinates an interdisciplinary undergraduate degree program called *Water: Resources, Policy, and Management (WRPM)* in collaboration with the Department of Forest Resources and Environmental Conservation at Virginia Tech and nine other departments across five colleges (<http://waterdegree.frec.vt.edu/>). The VWRRC also coordinates Sustainable Water Scholarships and Sustainable Water Research Fellowships as part of the WRPM degree program.
4. The VWRRC has an internship program that provides an opportunity for an undergraduate student to assist with projects and sponsored research associated with the VWRRC.
5. The VWRRC supports and advises the Virginia Tech Chapter of the *American Water Resources Association*.

### C. Outreach and Collaborative Programs

1. The VWRRC provides administrative support for the Virginia Water Monitoring Council.
2. The VWRRC publishes research reports, symposia proceedings, and citizen education booklets. It provides funding for the publication of outreach efforts.
3. The VWRRC publishes a newsletter, *Virginia Water Central*, several times each year. It features scientific and educational articles, legislative information, and water news of interest. The newsletter is available to the public at <http://www.vwrcc.vt.edu/water-central-news/> and electronic copies are provided via email to more than 600 people.
4. The VWRRC sponsors or co-sponsors symposia, workshops, and seminars addressing contemporary water resources issues.
5. The VWRRC facilitates peer reviews for state programs when requested.
6. The VWRRC website (<http://www.vwrcc.vt.edu/>) serves as a repository of the Center's publications, houses an academic expert database, provides updated news and information relevant to water resources, and manages website links for collaborative partners, including the Virginia Water Monitoring Council, the Virginia Department of Environmental Quality Division of Public Education and Outreach, and the Virginia Department of Environmental Quality Stormwater BMP Clearinghouse. A news feed from the website allows users to subscribe to VWRRC updates via email.
7. The VWRRC has Twitter and Facebook sites and a Water News Grouper blog (<http://vawatercentralnewsgrouper.wordpress.com/>) to facilitate information exchange related to water resources and related news at the VWRRC.

# Research Program Introduction

## *Research Program*

The research program of the Virginia Water Resources Research Center (VWRRC) is supported through

- its annual appropriation from the Commonwealth of Virginia,
- external funding through grants and contracts, and
- a portion of overhead generated by external funding.

The VWRRC's 104b funds are not allocated to support research, but are used to support its outreach and information dissemination programs and to provide administrative support.

Through its annual appropriation from the Commonwealth of Virginia, the VWRRC funded three new research projects through allocation of \$5,000 seed grants to graduate students at Virginia Tech in the Department of Forest Resources and Environmental Conservation, at the University of Virginia in the Department of Chemical Engineering, and at Old Dominion University in the Department of Ocean, Earth, and Atmospheric Sciences.

External funding during the reporting period totaled \$505,987, supported 14 new and ongoing projects, 10 graduate students, nine undergraduate students, and one post-doctoral research associate.

# Development of Dynamic Gridding Tools for the USGS MODFLOW? USG Computer Program for Simulating Groundwater Flow"

## Basic Information

<b>Title:</b>	Development of Dynamic Gridding Tools for the USGS MODFLOW? USG Computer Program for Simulating Groundwater Flow"
<b>Project Number:</b>	2014VA176S
<b>USGS Grant Number:</b>	
<b>Sponsoring Agency:</b>	USGS
<b>Start Date:</b>	9/22/2015
<b>End Date:</b>	9/21/2016
<b>Funding Source:</b>	104S
<b>Congressional District:</b>	VA-008
<b>Research Category:</b>	Ground-water Flow and Transport
<b>Focus Categories:</b>	None, None, None
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	JyhMing Lien

## Publication

1. Lien, Jyh-Ming, Guilin Liu, Christian Langevin, 2015. GRIDGEN Version 1.0: A computer program for generating unstructured finite-volume grids, DOI:10.3133/ofr20141109, 26 pages.

## Development of Methods for Simulating Flow and Transport in Aquifers with Complex Geometrics

A PhD student of the Department of Computer Science at George Mason University (GMU), Guilin Liu, is hired as a Graduate Research Assistant (GRA) to work on this project during the period March 1, 2015 through May 15, 2016 under the guidance of the PI Jyh-Ming Lien. During this period, Mr. Liu, Dr. Lien at GMU and Dr. Langevin at the U.S. Geological Survey (USGS) have joint effort to support the public community for use, maintain and further development of gridding tools for the USGS MODFLOW-USG computer program. A complete manual titled “*A computer program for generating unstructured finite-volume grids*” has also been written by the team members. The project webpage, where the software tool and manual are maintained can be found here <https://water.usgs.gov/ogw/gridgen>.

The team developed software tools to model and create unstructured grids for representing three-dimensional subsurface hydrogeology. These tools can perform GIS intersections of two-dimensional features, such as points, lines, and polygons with these grids. These tools allow users to create advanced hydrogeologic structures in both 2D and 3D and allow users to define the behavior of the top/bottom values of a grid. The GRA also tasked with computer programming tasks using the C++ programming language and the development of data structures and algorithms in software tools designed specifically for the MODFLOW-USG computer program currently under development by the USGS. In addition, efforts by Mr. Liu, Dr. Lien and Dr. Langevin have also been made to develop a computer software tool for porting MODFLOW-USG computer program to C++ language.

## Information Transfer Program Introduction

The VWRRC supports timely dissemination of science-based information to policy- and decision-making entities and to citizens. The VWRRC used its USGS 104b funds to support expert personnel with responsibilities related to the VWRRC's outreach and collaborative programs. USGS 104b funds were not used to support the VWRRC's research program. During the reporting period, the USGS 104b funds supported:

1. Preparation and electronic publication of the newsletter *Virginia Water Central*.
2. Partial administrative support for the *Virginia Water Monitoring Council*.
3. Partial support for production and management of the VWRRC webpage, VWRRC Facebook, VWRRC Twitter, and *Virginia Water Radio*.
4. Preparation and electronic publication of the *Virginia Water Central Water News Grouper* containing annotated links to articles and references relevant to Virginia's water resources. The *Water News Grouper* is accessed via the VWRRC webpage (<http://vawatercentralnewsgrouper.wordpress.com>).

# Information Transfer

## Basic Information

<b>Title:</b>	Information Transfer
<b>Project Number:</b>	2016VA189B
<b>Start Date:</b>	3/1/2016
<b>End Date:</b>	2/28/2017
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	9
<b>Research Category:</b>	Not Applicable
<b>Focus Categories:</b>	None, None, None
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Stephen H. Schoenholtz

## Publications

1. Brown, K.R., **K.J. McGuire**, W.C. Hession, and W.M. Aust, 2016. Can the Water Erosion Prediction Project (WEPP) model be used to evaluate BMP effectiveness from forest roads? *Journal of Forestry* 114(1):17-26, doi:10.5849/jof.14-101.
2. Chandler, H.C., **D.L. McLaughlin**, T.A. Gorman, **K.J. McGuire**, J.B. Feaga, and C.A. Haas. 2017. Drying rates of ephemeral wetlands: implications for breeding amphibians. *Wetlands*, doi:10.1007/s13157-017-0889-1.
3. Hensely, R.T., **D.L. McLaughlin**, M.J. Cohen, and P.H. Decker. 2017. Stream phosphorus dynamics of minimally impacted coastal plain watersheds. *Hydrological Processes*, doi:10.1002/hyp.11132.
4. **Juran L.**, J. Trivedi, and K. Kolivras, 2017. Considering the public in public health: popular resistance to the Smallpox Eradication Programme in India. *Indian Journal of Medical Ethics*, 2(2), 104-111.
5. Kelly, C.N., **K.J. McGuire**, C.F. Miniati, and J.M. Vose, 2016. Forest management changes streamflow response to increasing precipitation extremes. *Geophysical Research Letters*, 43(8), 3727-3736, doi:10.1002/2016GL068058.
6. Krenz III, R.J., **S.H. Schoenholtz**, and C.E. Zipper, 2016. Riparian subsidies and hierarchical effects of ecosystem structure on leaf breakdown in Appalachian coalfield constructed streams. *Ecological Engineering* 97:389-399.
7. Nijzink, R., C. Hutton, I. Pechlivanidis, R. Capell, B. Arheimer, J. Freer, D. Han, T. Wagener, **K.J. McGuire**, H. Savenije, and M. Hrachowitz, 2016. The evolution of root-zone moisture capacities after deforestation: a step towards hydrological predictions under change? *Hydrology and Earth System Science* 20:4775-4799, doi:10.5194/hess-20-4775-2016.
8. Van Meter, K.J., N.B. Basu, **D.L. McLaughlin**, and M. Steiff, 2016. The socio-ecohydrology of rainwater harvesting tanks in India: understanding water storage and release dynamics at tank and catchment scales. *Hydrology and Earth System Sciences* 20: 2629-2647, doi:10.519/hess-20-2629-2016.
9. **Vander Vorste, R.**, F. Mermillod-Blondin, F. Hervant, R. Mons, M. Forcellini, and T. Datry, 2016. Increased depth to the water table during river drying decreases the resilience of *Gammarus pulex* and alters ecosystem function. *Ecohydrology*, doi:10.1002/eco.1716.
10. **Vander Vorste, R.**, F. Mermillod-Blondin, F. Hervant, R. Mons, and T. Datry. 2016. *Gammarus pulex* (Crustacea: Amphipoda) avoids increasing water temperature and intraspecific competition through vertical migration into the hyporheic zone: a mesocosm experiment. *Aquatic Sciences*,

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doi:10.1007/s00027-016-0478-z.

11. **Vander Vorste, R.**, F. Malard, and T. Datry. 2016. Is drift the primary process promoting the resilience of river invertebrate communities? A manipulative field experiment in an alluvial, intermittent river. *Freshwater Biology* 61:1276–1292, doi:10.1111/fwb.12658.
12. **Vander Vorste, R.**, R. Corti, A. Sagouis, and T. Datry. 2016. Invertebrate communities in gravel-bed, braided rivers are highly resilient to flow intermittence. *Freshwater Science* 35:164–177, doi:10.1086/683274.
13. Leigh, C., N. Bonada, A. Boulton, B. Hugueny, S.T. Larned, **R. Vander Vorste**, and T. Datry. 2016. Invertebrate assemblage responses and the dual roles of resistance and resilience to drying in intermittent rivers. *Aquatic Sciences* 78:291–301, doi: 10.1007/s00027-015-0427-2.
14. **Peer-Reviewed Research Publication from VWWRC Seed Grant Program:** Bock, E.M., B. Coleman and Z.M. Easton. 2016. Effect of biochar on nitrate removal in a pilot-scale denitrifying bioreactor. *Journal of Environmental Quality* 45(3): 762-771, doi:10.2134/jeq2015.04.0179.
15. **Peer-Reviewed Research Publication from VWWRC Seed Grant Program:** Brown, K.R., **K.J. McGuire**, W.C. Hession and W.M. Aust. 2016. Can the Water Erosion Prediction Project (WEPP) model be used to evaluate BMP effectiveness from forest roads? *Journal of Forestry* 114(1):17-26, doi:10.5849/jof.14-101.

## ***Outreach and Information Transfer Accomplishments***

### **Newsletter *Virginia Water Central***

Email distribution to approximately 600 recipients and announcement/availability on VWRRC Web site. Two issues of *Virginia Water Central* were published during the reporting period.

### **Notifications to *Virginia Water Monitoring Council***

The VWRRC provides administrative support to the *Virginia Water Monitoring Council (VWMC)*. The VWMC was formed to promote and facilitate coordination of water monitoring programs throughout the Commonwealth of Virginia. Membership in the VWMC is open to any person or organization with responsibility for or interest in water monitoring in Virginia. Weekly water-related announcements via list server are provided to 650 members (representing more than 250 different organizations) of the VWMC. Announcements include information about conferences, workshops, total maximum daily load (TMDL) public meetings in Virginia, job openings, newly published reports, information posted on Web sites, and other pertinent information.

1. Distributed 53 sets of general announcements (1,043 individual announcements) as e-mail messages to the VWMC membership; each message contained at least a dozen informational announcements, including: calls for papers, conference announcements, job openings, training opportunities, recently published reports, information posted on websites, total maximum daily load (TMDL) public meetings in Virginia, and other pertinent information.
2. Developed 10 sets of special announcements and distributed these as e-mail messages to the VWMC membership for a total of 101 unique announcements; these announcements pertained to VWMC-sponsored activities, information about beach-monitoring and water recreation as specified in grants from the Virginia Department of Health (VDH), job opportunities, stormwater management training opportunities and upcoming conferences.
3. Collaborated with VDH to develop special beach monitoring announcements for distribution to the VWMC membership and beyond.
4. Weekly announcements are posted on the VWMC's website, [www.VirginiaWMC.org](http://www.VirginiaWMC.org)

## **VWRRC Website**

([www.vwrrc.vt.edu](http://www.vwrrc.vt.edu))

The VWRRC website is updated at least weekly and supports a *Water News Grouper* blog page, which is updated several times each week. During the reporting cycle there were approximately 285 posts listed on the *Water News Grouper* blog page and approximately 9,804 page views (27/day). The VWRRC website also serves as the portal for two other websites that the VWRRC manages:

1. Virginia Water Monitoring Council (<http://www.vwmc.vwrrc.vt.edu/>)
2. Virginia Department of Environmental Quality Stormwater BMP Clearinghouse (<http://www.vwrrc.vt.edu/swc/>)

VWRRC is on **Twitter** at <http://twitter.com/VaWaterCenter> and

**Facebook** (<http://www.facebook.com/pages/Blacksburg-VA/Virginia-Water-Resources-Research-Center/186479556264?v=wall>)

## **Virginia Water Radio**

([www.virginiawaterradio.org](http://www.virginiawaterradio.org))

The VWRRC produces and hosts a weekly 5-minute radio show featuring summaries of recent water news, upcoming water events, and water-related sounds or music. The radio show also includes relevance to specific Virginia science and social studies standards of learning for Virginia public schools for each episode. *Virginia Water Radio* is broadcast on two campus stations: WECH at Emory & Henry College and WVRU at Radford University. During the past year 52 weekly episodes were produced and the Water Radio Web site had about 3,000 page views (about 9 per day).

## **Coordination of Studies**

The VWRRC chaired the *Water Quality Academic Advisory Committee*, which serves an advisory role for the Virginia Department of Environmental Quality to establish and evaluate water quality criteria and standards for freshwater resources in the Commonwealth of Virginia. During the reporting period, the VWRRC coordinated 1) a study of development of a habitat protocol and condition index for Class VII blackwater swamps in the Chowan River Basin of Virginia ([http://www.vwrrc.vt.edu/wp-content/uploads/SR58-2016\\_Aquatic-Life-Use-Assessment-Protocols-for-Class-VII-Waters.pdf](http://www.vwrrc.vt.edu/wp-content/uploads/SR58-2016_Aquatic-Life-Use-Assessment-Protocols-for-Class-VII-Waters.pdf)); and 2) a screening approach to develop nutrient criteria for streams and

rivers in Virginia ([http://www.vwrrc.vt.edu/wp-content/uploads/SR59-2016\\_Screening-Approach-for-Nutrient-Criteria.pdf](http://www.vwrrc.vt.edu/wp-content/uploads/SR59-2016_Screening-Approach-for-Nutrient-Criteria.pdf)).

The VWRRC coordinated a study and convened an advisory panel for Virginia's state water planning and permitting program at the request of the Commonwealth's Joint Legislative Audit and Review Commission. The Commonwealth's sustainability model for groundwater in eastern Virginia and the sustainability model for surface waters throughout the state were evaluated and a resulting report was presented to the Virginia Legislature.

### **International Outreach Activities**

1. VWRRC Faculty serve as referees for numerous international journals.
2. Associate Director McGuire serves as Associate Editor of *Hydrological Processes* and *Journal of Environmental Quality*, which publish international research.
3. Associate Director McGuire is North American chair for the international Gordon Research Conference on Catchment Science.
4. Director Schoenholtz serves as sub-editor of *Current Forestry Reports*, an international journal.
5. Assistant Professor Juran donated water quality test equipment to nonprofit BEDROC to use for educational purposes in schools in Nagapattinam, India.
6. Assistant Professor Juran conducted five water quality and sanitation workshops in coastal fishing villages in Tamil Nadu and Puducherry, India.

# USGS Summer Intern Program

None.

<b>Student Support</b>					
<b>Category</b>	<b>Section 104 Base Grant</b>	<b>Section 104 NCGP Award</b>	<b>NIWR-USGS Internship</b>	<b>Supplemental Awards</b>	<b>Total</b>
<b>Undergraduate</b>	0	0	0	0	0
<b>Masters</b>	0	0	0	0	0
<b>Ph.D.</b>	0	0	0	0	0
<b>Post-Doc.</b>	0	0	0	0	0
<b>Total</b>	0	0	0	0	0

## Notable Awards and Achievements

The new interdisciplinary undergraduate degree in *Water: Resources, Policy, and Management* at Virginia Tech had first cohort of students enroll in August 2015 and currently has an enrollment of 47 students. The VWRRC coordinates curriculum and advising for this degree program. See <http://waterdegree.frec.vt.edu/> for more information.

VWRRC Director Stephen Schoenholtz served as President-Elect and President of NIWR during the reporting period.

The VWRRC supported three student interns, six undergraduate students, ten graduate students, and one post-doctoral research associate during the reporting period.

The VWRRC acquired \$505,987 in external funding, which supported 14 new and ongoing projects.

The VWRRC funded three new research projects through allocation of \$5,000 seed grants to graduate students at Virginia Tech in the Department of Forest Resources and Environmental Conservation, at the University of Virginia in the Department of Chemical Engineering, and at Old Dominion University in the Department of Ocean, Earth, and Atmospheric Sciences.

VWRRC faculty published 13 peer-reviewed papers.

The VWRRC coordinated research and reporting on sustainability of state water planning efforts to the Virginia Joint Legislative Audit and Review Commission.