

Strategic Directions in *Water Quality and Quantity*

Executive Summary

Penn State's College of Agricultural Sciences (CAS) is dedicated to leadership and excellence in research, education and outreach in the area of water quality and quantity. Below we provide key recommendations by the *Water Quality and Quantity Team (WQQT)*, with ranked priorities indicated. Criteria for determining priority include: 1) centrality to college goals and integrated college mission of teaching, research and extension; 2) potential to achieve excellence and secure external funding; 2) current capacity and resources needed to offer the program; and 4) alignment with university goals.

Current critical challenges related to water quality and quantity call for interdisciplinary, integrated educational, research and outreach activities to achieve innovative and durable solutions. Associated with each of the recommendations below, the CAS should actively foster the creation of materials that market and promote interdisciplinary, multifunctional work that addresses water quality and quantity issues. The following prioritized initiatives are recommended:

Immediate Goals

- **Priority #1 recommendation:** *Educational Initiatives.* Changes to resident and graduate educational programs to emphasize water quality and quantity were judged by WQQT as the highest priority for implementation since these initiatives are key to CAS and University goals, and can be implemented immediately with the need for only minimal additional resources given strong current capacity within CAS to offer such programs. In the area of undergraduate education, the WQQT supports: The development of a water science option within the existing college-wide Environmental Resource Management major, administered by the Environment & Natural Resources Institute (ENRI); and the development of a natural resources engineering option within the existing Biological Engineering major, administered by the Department of Agricultural & Biological Engineering. Further, we recommend the creation of a land & water management minor to be administered through ENRI. In the area of graduate education, the WQQT supports the examination of the structure of the Watershed Stewardship option, currently offered as a Graduate Option in Watershed Stewardship, to determine if it should be broadened into a master's level graduate degree program within CAS (and beyond). WQQT also encourages the creation of a cross-campus dual-title graduate program in the area of water resources.
- **Priority 2 recommendation:** *Expand the Functions of the Center for Watershed Stewardship Initiative.* This initiative expands the activities of the CWS from education to include research and outreach, and to broaden CAS participation. This initiative meets the four criteria and is requires few new resources. This initiative has the potential to serve as a focus for building collaborative relationships across the college, and expand collaborative relationships between CAS, other colleges, and external stakeholders.
- **Priority 3 recommendation:** *Legacy and Emerging Contaminants of Water Initiative.* This initiative will advance on-going legacy issues (e.g., nutrients and water resources), and addresses emerging water quality contaminants (e.g., pharmaceuticals). This area is a current strength within CAS, and represents an area for further investment. It conforms to three of four criteria listed above: potential

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for external funding; centrality to integrated college mission of teaching, research and extension; and alignment with university goals. CAS is especially well-positioned with current staffing to address legacy issues. Additional resources, including increased extension and research faculty staffing, will be needed to address emerging issues. The WQQT sees this as a critical area for future growth.

Long-Term Goals

- **Priority 4 recommendation:** *Watershed Science and Management Initiative*. This initiative calls on CAS to provide leadership in research, education, and extension focused on the science and management of water resources. This initiative builds on current strengths in watershed hydrology, biogeochemistry, and management throughout CAS, from both fundamental and applied science points of view. The goal is to provide a scientific basis from which to assess, protect, conserve, restore, and manage water resources, in terms of both water quantity and quality. Considering the watershed system, this initiative emphasizes linkages between air, land, and water, and emphasizes an understanding of social, economic, physical, chemical, and biological processes affecting watersheds. This initiative has the potential to achieve excellence and external funding; emphasizes interdisciplinary collaboration within CAS, the University and beyond; is central to integrated college mission of teaching, research and extension; and is aligned with university goals. Additional costs associated with this initiative include increased extension and research faculty.
- **Priority 5 recommendation:** *Climate and Water Initiative*. This initiative seeks to advance CAS leadership in the area of climate variability and change. CAS already is a leading resource to state water planning, through the synthesis and research of the ENRI climate group assembled by Jim Shortle. To expand on this effort, this initiative would address links between climate, water, and energy resources; provide locally relevant climate information to decision makers and communities in Pennsylvania; and advance understanding of capabilities to manage climate risks and build resilience in key sectors.

Staffing Needs

Toward achieving the above initiatives and toward CAS capacity to address water quality and quantity issues of importance in Pennsylvania, the WQQT recommends creation of the following positions:

- Four additional, full-time Extension Educators with responsibility for water resources programming (one within each extension region)
- University Park Faculty (with Extension appointments) in the areas of:
 - Risk Communications
 - Water Resources Engineering
 - Watershed Modeling
 - Watershed Processes and Management
 - Water and Energy

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Water is the best of all things.
PINDAR (C. 522-C. 438 B.C.), Olympian Odes

1. Introduction

An abundant, high quality water resource is essential to sustain life. Pennsylvania's waters span 83,000 miles of streams and rivers, more than 4,000 lakes, reservoirs, and ponds, 120 miles of coastal waters and countless acres of wetlands and floodplains, and complex, natural systems of underground aquifers. These waters sustain the Commonwealth's range of needs – from drinking water, forests, and wildlife, to the diverse agricultural, industrial, and service economy. Population growth, land use changes, and environmental changes are intensifying stresses on water resources throughout the Commonwealth and beyond. Pennsylvania has benefited from abundant and reliable supplies of freshwater, yet is one of 39 states in the nation that expect some level of water shortage within the next decade (GAO 2003). Water availability is a function of both water quantity and quality, affected by factors such as development, climatic variability, and pollution. Increasing and competing demands for water require decision-making about water management and allocation to support multiple and competing uses, including off-stream uses (domestic, industrial, agricultural, energy) and in-stream uses (recreation, hydroelectric power production, sustain water quality and aquatic ecosystems). Periodic droughts and floods are both an environmental and economic threat. Stormwater runoff is one of the leading causes of water quality impairment in Pennsylvania, and proper management is recognized as a critical priority as watersheds become increasingly urbanized.

Given the broad-scale importance of issues of water quality and quantity, coupled with our institutional capacity, Penn State's College of Agricultural Sciences (CAS) has identified *water quality and quantity* as a priority theme for focus and further investments, aiming to build upon existing strengths as well as stimulate new areas of opportunity across resident education, research, and extension (CAS 2008-2013 Strategic Plan). To fulfill these aims, the CAS must be fully engaged in research, education, and outreach to enable society to address a range of historic problems, as well as emerging and current complex challenges.

Below we review CAS activities and opportunities in the areas of education, research, and outreach. The WQQT details a ranked set of priorities, with regard to implementation of new activities in the short and long term. Criteria for determining priority of the WQQT recommendations include: 1) potential for external funding; 2) centrality to college goals and integrated mission of teaching, research and extension; 3) potential to achieve excellence and to secure external funding; 4) capacity and resources needed to offer the program; and 5) alignment with university goals.

2. Educational Programs and Initiatives

- **Undergraduate majors and minors with water-related content.** Currently, there are no academic majors within CAS that have “water” in the title, but all of the CAS undergraduate majors include coursework that highlights the relationships of water to natural resources and the environment, including:

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- Animal Sciences
 - Veterinary and Biomedical Sciences
 - Food Science
 - Immunology and Infectious Disease
 - Toxicology
 - Agribusiness Management
 - Community, Environment, and Development
 - Agricultural and Extension Education
 - Agricultural Science
 - Agricultural Systems Management
 - Biological Engineering
 - Environmental Resource Management
 - Forest Science
 - Wildlife and Fisheries Science
 - Wood Products
 - Agroecology
 - Horticulture
 - Landscape Contracting
 - Turfgrass Science
- **Undergraduate majors & minors with water emphasis.** The CAS has several undergraduate programs that focus or specialize in water resource issues.
 - The interdepartmental *Environmental Resource Management major* has graduated 94 students between 2005-2008 (63 of 94 students) with 67% of students obtaining the campus-wide *minor in Watershed and Water Resources*. The interdisciplinary minor is administered by the Department of Geography.
 - The School of Forest Resources' *Forest Science major/Watershed Management option* has graduated 14 students between 2000 and 2008.
 - The School of Forest Resources' *Wildlife and Fisheries Science major/Fisheries option*, and the *Wildlife & Fisheries minor* have many students who focus studies on aquatic ecosystems.
 - The Department of Agricultural & Biological Engineering's' *Biological Engineering major/Agricultural Engineering option* has a significant number of students that focus on soil and water engineering courses and graduate to employment in water resources fields.
 - **Graduate programs with water emphasis.** Many of the Academic Units within CAS and Inter-College/interdisciplinary programs recruit graduate students whose research focuses on water quantity or quality. A wide variety of water-related courses to support these programs are included in Appendix 1. Programs that frequently host students focusing on water-related topics include:
 - Department of Agricultural and Biological Engineering (MS, PhD)
 - Department of Agricultural Economics and Rural Sociology (MS, PhD)
 - Department of Crop & Soil Sciences (MS, PhD)
 - School of Forest Resources, Forest Resources (MS, MFR, PhD)
 - School of Forest Resources, Wildlife & Fisheries Science Program (MS, PhD)
 - Intercollege Program in Ecology (MS, PhD)

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- Intercollege Program in Environmental Pollution & Control (MS, MEPC)
- Graduate Program in Agricultural, Environmental, & Regional Economics (MS, M.Agr., PhD)
- Graduate Option in Watershed Stewardship (operated jointly by the School of Forest Resources and the Department of Landscape Architecture through the Center for Watershed Stewardship, certificate)
- **Courses in water quality and quantity.** Highlighting the cross-cutting theme of water throughout the CAS academic programs, there are a wide variety of water resource-related courses offered at both the undergraduate and graduate levels. A list of current water-related courses offered in the College is attached to the end of this document (**Appendix 1**). There are many other courses offered that do not have a specific water focus by title, but nonetheless address water-related issues as a significant part of the course content.
- **Opportunities and new initiatives in undergraduate education.** Recognizing the College's strength in water-related undergraduate curricula and courses, the Environment and Natural Resources Institute recently initiated the development of a *water science option* within the *Environmental Resource Management* major. Similarly, the Department of Agricultural & Biological Engineering is developing a *Natural Resource Engineering Option* within their existing *Biological Engineering undergraduate major*. Several potential new courses to enhance the College's current course offerings in water resources, including courses in hydrologic measurements and monitoring, water quality modeling, water management and policy, and limnological methods have been identified for development, some of which would be cross-listed (e.g., within the ERM program as well as the home department). The WQQT recommends the development of these new water-related options and coursework, aimed at enhancing existing undergraduate majors.

Further, the development a College-wide minor that takes advantage of the wide breadth of land and water resource-related courses the college offers has also been the subject of discussion at various College planning meetings (see contributors to this report, below). Many students in CAS who are interested in water are well served by the *environmental inquiry* minor (administered by PSIEE) and the *watersheds & water resources* minor (administered by Geography). To complement these choices, the WQQT recommends the creation of a new *land & water management* minor emphasizing the land grant mission of CAS, to be administered by ENRI. The minor program would include course work regarding: 1) relationships between land, water and agriculture; e.g., the role of land and water in sustaining agriculture and food systems; 2) methods of protecting water quantity and quality; e.g., through land and water planning, management, and restoration; 3) improving communities throughout Pennsylvania and beyond, emphasizing integrated watershed management, participatory approaches, and outreach; and 4) formal training about the network of land grant institutions, and the role of these programs in meeting challenges of land and water management across the nation. Courses for the minor would be drawn from many CAS units (e.g., Agricultural & Biological Engineering, Agricultural Economics & Rural Sociology, Agricultural & Extension Education, Crop & Soil Sciences, Forest Resources), as well as outside of CAS (e.g., Landscape Architecture, Geography). The existing watershed & water resources minor emphasizes *processes* (chemical, physical, biological) that control the transport and chemistry of waters, which is quite different in

scope than the envisioned new minor which would emphasize *management*, though they are both directly related to water resources.

- **Opportunities and new initiatives in graduate education.** Given the cross-cutting nature of water resources issues, there is significant opportunity for collaboration across the campus and beyond to offer state of the art, interdisciplinary water educational initiatives. In addition to expertise within CAS, there is strong expertise and interest in water quantity and quality in many other Colleges on the campus, such as the College of Earth & Mineral Sciences, the College of Engineering, and the College of Arts & Architecture.

Along those lines, a recent task force assembled by PSIEE/OSVPR is in the final stages of completing a report, which includes a recommendation to form an interdisciplinary, campus-wide graduate program in water science. This would be a dual-title program, where a student already enrolled within an existing graduate program (e.g., from an individual CAS unit) would apply to the dual-title program and take substantial, interdisciplinary course work in the areas of water resources drawing from opportunities for water-related course work from across the campus. The student's diploma (masters and/or doctorate) would carry the name of both the major within the home academic unit and the dual-title water program. WQQT recommends the creation of a cross-campus dual-title graduate program in the area of water resources. CAS should encourage both the development of the program and involvement of CAS faculty and graduate students.

The Center for Watershed Stewardship (CWS) also emphasizes educational initiatives between CAS and other partners on campus. The CWS is an inter-college Center that is administered by two of Penn State's Professional Schools: the School of Forest Resources and the School of Landscape Architecture (online at water.psu.edu/cws). The mission of the CWS is focused on education, training students as watershed stewards, and providing a graduate option to many existing majors within multiple Colleges. The WQQT recommends the examination of the structure of this graduate degree option to determine if it should be broadened into a water-related graduate degree program to be offered in CAS (and possibly in CAA as well, given the partnership between the School of Forest Resources and the School of Landscape Architecture in administering the current graduate option). WQQT makes further recommendations about expanding the functions of CWS in the research section below.

- **Priority #1 recommendation: Educational Initiatives.** Changes to resident and graduate educational programs to emphasize water quality and quantity were judged by WQQT as the highest priority for implementation since these initiatives are key to CAS and University goals, and can be implemented immediately with the need for only minimal additional resources given strong current capacity within CAS to offer such programs. In the area of *undergraduate education*, the WQQT supports: The development of a water science option within the existing college-wide Environmental Resource Management major, administered by the Environment & Natural Resources Institute (ENRI); and the development of a natural resources engineering option within the existing Biological Engineering major, administered by the Department of Agricultural & Biological Engineering. Further, we recommend the creation of a land & water management minor to be administered through ENRI. In the area of *graduate education*, the WQQT supports the examination of the structure of the Watershed Stewardship option, currently offered as a Graduate Option in Watershed Stewardship, to determine if it should be broadened into a master's level graduate degree program within CAS (and beyond). WQQT also encourages the creation of a cross-campus dual-title graduate program in the area of water resources.

3. Water Programs and Activities

Key CAS Extension and Outreach Activities. CAS offers several excellent water extension programs and activities, as detailed in each of the individual unit plans. Some cross-cutting key activities are listed below. Descriptions of these programs can be found in **Appendix 2.**

- Cooperative Extension Program Teams
- Penn State Cooperative Extension Water Resources web portal, <http://water.cas.psu.edu>
- Penn State Cooperative Extension Gas Well Drilling web portal, <http://naturalgas.extension.psu.edu>
- Master Well Owner Network, <http://mwon.cas.psu.edu/Default.html>
- Conewago Creek Discovery Watershed Project
- Agriculture in Balance Visioning. 2-day statewide working conference in 2008

Other Key Water-Related Programs. CAS hosts or participates in several interdisciplinary programs and activities, some of which are listed below. Descriptions of these programs can be found in **Appendix 3.**

- Center for Watershed Stewardship (CWS), <http://water.psu.edu/cws/index.htm>
- Penn State Institutes of Energy & the Environment (PSIEE), <http://www.environment.psu.edu/>
- Environment and Natural Resources Institute (ENRI) <http://enri.cas.psu.edu>
- Agriculture and Environment Science Center <http://aec.cas.psu.edu>
- The Pennsylvania Water Resources Research Institute (PA-WRRI), <http://www.pawatercenter.psu.edu/>
- Penn State Agricultural Law Research and Education Center <http://www.dsl.psu.edu/centers/aglaw.cfm>
- The Pennsylvania Atmospheric Deposition Research Program, <http://www.reeis.usda.gov/web/crisprojectpages/198685.html>
- Critical Zone Watershed Observatory, <http://www.czen.org/content/susquehanna-shale-hills-critical-zone-observatory>
- Penn State Cooperative Wetlands Center, <http://wetlands.psu.edu/home.asp>

4. Student, Stakeholder and Market Needs and Expectations

- **Assessment of Water Resources Extension and Staffing Needs.** A survey of statewide stakeholders was conducted by the Water Resources Extension Group in Fall 2008. Details of this survey can be found in **Appendix 4.** Based on the results of this survey, the following areas of focus for programs were identified as a focus for the next five years:
 - Safe Drinking Water
 - Water Conservation
 - Pond and Lake Management
 - Watershed Education
 - Water Infrastructure

- **Survey of the Pennsylvania Water Resources Research Institute.** This stakeholder survey was conducted among resource professionals across the state, including federal & state agencies, county conservation districts, non-profit organizations, local watershed groups, and private professions such as environmental law, regional planning, & environmental engineering. These stakeholders were asked to detail what they felt were the most pressing water-related issues facing the Pennsylvania, which Penn State and other Universities should be addressing via research, training, and outreach. The responses fell into one of four broad categories, with the most frequently cited category first, and spanning a broad range:
 - *Land Use & Development.* Development of rural, urban, and agricultural lands and the impacts of land use change on Pennsylvania's land and water resources was a common theme. Issues included groundwater recharge, storm water treatment and control, and inefficient zoning and land use planning approaches.
 - *Future Demands and Finite Limits on Pennsylvania's water resources* was a major concern. Unknown limits on groundwater resources, lack of coordinated statewide water use, unchecked water withdrawals and unregulated private well construction were mentioned as important issues.
 - *Effects & Control of Diffuse Pollutants* was an important theme. Non-point source pollution in air and water and the myriad unknowns associated with such diffuse pollutants is a concern voiced across the board by resource professionals. Pollutants of particular interest include nutrients in agricultural runoff (especially in Chesapeake Bay and related problems), herbicides and lawn chemicals, mercury and heavy metals, acid mine drainage, and radon. Also of interest is the incidence of hormones, pharmaceuticals, and antibiotics in wastewater treatment plant effluent.
 - *Health of Aquatic Ecosystems.* Several broad topics emerged in this category including invasive aquatic species and control methods, the potential impacts of climate change on stream habitat and restoration efforts, and invasive species in riparian buffer zones. Of chief concern were the unknown long-term impacts of surface and groundwater withdrawals and fluctuating dam discharges on wetlands, stream baseflow levels and flow regimes, and aquatic habitat.

5. Opportunities for Collaboration

Current research agendas throughout the fields of environmental sciences demand interdisciplinary studies to confront contemporary water resources issues. Water is an integral part of the "Grand Challenges in the Environmental Sciences" as articulated by a recent and influential report of the National Academy of Sciences – including the need to understand hydrological forecasting, climate variability and change, biological diversity and ecosystem functioning, biogeochemical cycles, and land use dynamics. The report highlights that collaboration of scholars from various fields will be required in order to advance water resources problems that cut across traditional disciplines (NRC 2001). Accordingly, the CAS should provide incentives and rewards to interdisciplinary, multifunctional teams (and to individuals who participate in such teams) that confront critical water issues. Another recent report of the National Academy of Sciences entitled "*Facilitating Interdisciplinary Research*" highlights the challenges that these research directions pose for academics with regard to meeting promotion and tenure criteria (NRC 2004). By their very nature, complex problems require team-based

investigation and collaboration that link information and methodologies from multiple disciplines. Evaluating and appropriately rewarding the contributions of an individual for the significance, creativity, and productivity of an interdisciplinary team may be difficult by traditional measures. For example, publications and other outputs from the team may be multi-authored, order of authorship may be decided by non-traditional criteria, and location of publication may not occur in traditional, disciplinary outlets. Approaches to address these concerns and to reward contributions to multi- and interdisciplinary activities that advance understanding of and solutions to complex issues need to be developed.

Interdisciplinary activities will involve Units throughout the CAS and will foster broad collaboration across the campus and beyond. Advancing solutions to complex water issues is at the heart of the CAS Land-grant mission, and will involve partnerships with a diversity of academics and stakeholders. From the science and technology perspective, one major role of CAS activities is to provide a scientific basis and new options for restoring, conserving, managing, and protecting water resources. Similarly, public awareness, education, policies, economics, incentives, and community values will also impact effective water planning and management as CAS aims to balance environmental, social, and economic needs. A major strength of CAS is its ability to seek solutions to complex problems that require interdisciplinary approaches and the collaboration of researchers, educators, and stakeholders. PSU and CAS bring considerable resources in the form of facilities and extensive forest and agricultural property holdings that can be used for research, teaching, and outreach. Specific to the water focus, PSU is host to internationally-recognized long term watershed process studies – having among the longest available monitoring records of precipitation chemistry and stream water quality, coupled with measurements of precipitation and streamflow volumes.

There are numerous funding opportunities to support research, training, and outreach oriented activities in water quality and quantity. There are sources of funding in all areas, ranging from local to global in scope, and ranging from applied to basic in nature. Encouraging opportunities for networking among CAS faculty, between CAS faculty and other colleges and stakeholders, and providing incentives for writing collaborative proposals may facilitate development of collaborative projects and opportunities for garnering support through granting agencies and other sources. For example, both PSIEE and ENRI have been facilitated the development of new collaborative proposals and teams.

6. Emerging Needs

- A fundamental conclusion of the WQQT is that the report of the 2008 CAS Sustainable Environments Team (SET) remains valid, salient, and cogent as a guide to excellence and leadership in water research, education, and extension, where some needs were previously identified. Some general goals of the implementation phase in the next five years include:
 - Maintain core competencies and further develop world-class expertise in key areas of water quality and quantity;
 - Grow and adopt new areas that are of intellectual importance;
 - Promote interdisciplinary work, advancing such concepts as integrated water resources management, and relationships of water to sustainable development;
 - Modify and expand educational programs to attract students in water resources;
 - Attract extramural support;
 - Provide service, outreach, and public education on key issues of water quantity & quality,

- Raise the profile and awareness of CAS water-related activities.

7. Key Initiatives in Water Quantity & Quality

We encourage the creation and support of key initiatives or centers addressing pressing water resources issues, aimed at strengthening unique areas and addressing emerging needs within CAS. These initiatives would engage CAS' scientific talent and resources; integrate research, teaching, and extension activities; and promote collaboration and interaction with stakeholders, agencies, and other units on campus. This approach is relevant to the land grant mission and will position CAS to leverage extramural resources. Supporting the recommended initiatives will strengthen intellectual capacity and provide recognition for CAS in these key areas.

In association with each of the initiatives described below, the CAS should actively foster the creation of materials that market and promote interdisciplinary, multifunctional work that addresses water issues. Incentives could be in the form of small grants for multifunctional teams to come together to combine data and results with the goal of synthesizing and creating advanced information materials on key water issues. In addition to proposals and papers, products could include fact sheets, white papers, and presentation materials that distill complex information into key points for the public and for policy makers, and for use by CAS and other media outlets.

WQQT offers recommendations for three initiatives that build on current strengths and that could be initiated in the short-term, and two initiatives for development over a longer time horizon.

- **Priority #2 recommendation: Expand the functions of the Center for Watershed Stewardship.** This initiative meets all of our criteria and requires limited new resources. This initiative has the potential to serve as a focus for building collaborative relationships across the college, and expand collaborative relationships between CAS, other colleges, and external stakeholders. The CWS is an inter-college Program and is administered by two of Penn State's Professional Schools: the School of Forest Resources and the School of Landscape Architecture (online at water.psu.edu/cws). The mission of the CWS is focused on education, providing a graduate option that trains students as watershed stewards (as described in the existing educational programs section of this report). There is great potential for further development of this Center, and we recommend broadening the Center's mission to further emphasize science in addition to stewardship, and broadening the overall scope of research, outreach, and training activities via the participation of more affiliates. The current program is unique in that it emphasizes the important link between academic knowledge and local communities, where students work with citizens who are interested in protection of water resources (e.g., with a local watershed group). The interdisciplinary watershed stewardship projects that CWS students conduct involve watershed planning, assessment, and restoration. There are numerous funding opportunities to support interdisciplinary research in these areas to advance a wide variety of water resources problems. For example, many current watershed grants requests call for interdisciplinary work in the area of integrated water resources management, emphasizing the link to humans and the need for participatory approaches (as are the hallmark of CWS). Faculty, extension associates, students, and post-doctoral scientists from many CAS units would be potential participants in broadened research, teaching, and outreach activities of the Center, including

involvement of Cooperative Extension. Overall, the Center has accomplished much in its first decade, training many students and providing visibility for CAS and Penn State in terms of successful outreach activities. It is important for CAS to provide resources to further support CWS, enabling strong leadership and growth of the program, and providing opportunities for tuition to encourage students from many CAS programs to participate

- **Priority #3 recommendation: Legacy and Emerging Contaminants of Water Initiative.**

This initiative builds on current strengths and recommends increased investments by CAS. This initiative will advance research, teaching and extension that address on-going legacy issues (e.g., nutrients, sediments, bacteria) and water resources, and addresses issues related to emerging water quality contaminants (e.g., pharmaceuticals, personal care products, mercury). This initiative conforms to three of four criteria listed above: potential for external funding; centrality to integrated college mission of teaching, research and extension; and alignment with university goals. CAS is especially well-positioned with current staffing to address legacy issues. Additional resources, including increased extension and research faculty staffing, will be needed to address emerging issues. The WQQT sees this as a critical area for future growth.

Nutrients and Water Resources focus (further investing in a current CAS initiative).

Nonpoint pollution from nutrients (nitrogen and phosphorous) represents the largest on-going pollution problem facing the United States. Nutrient pollution links an array of environmental problems, including eutrophication of lakes, rivers, estuaries; harmful algal blooms, hypoxic dead zones, acidification of soils and waters, degradation of vegetation, and loss of biodiversity. More than two-thirds of the nation's bays and estuaries are degraded by nutrient pollution. This is an area where CAS currently excels and has significant and diverse expertise, ranging from the process science of nutrient transport and transformation in the environment, to applied management techniques advanced via extension efforts, to policy and economic scenarios that may help to solve nutrient pollution problems. An expanded effort would address the relationships between human activities associated with food and energy production and changes to the major global cycles of nitrogen and phosphorus, and their consequences for human health and ecosystems. Research would advance understanding of sources and effects of nutrient pollution, integrated management solutions, ranging from whole farm management to market-based strategies. This initiative would emphasize all landscapes – highlighting the role of sources, fate, and transport of nutrients in terrestrial ecosystems (agricultural, urban, and forest) and aquatic ecosystems. A key goal of this initiative is research and outreach for the discovery and implementation of innovative solutions, including discovering ways to acquire and organize resources of various types in ways that lead to the behavioral changes that are needed, and implementing legal, institutional, and organizational innovations. Another goal would be to synthesize existing research from many points of view; for example, identifying and understanding the root causes of problems and associated uncertainties, to deliberately work to inform policy, and to quantify how scenarios (e.g., market-based efforts) would affect the nutrient problem. Partnerships are already in place with numerous stakeholders (e.g., Chesapeake Bay Foundation, US Environmental Protection Agency, **Appendices 5 and 6**). The current capacity for CAS to expand on this focus is very high, with significant expertise among faculty and staff in most of the departments within CAS. Potential leadership for this effort

might include Kristen Saacke Blunk, Cooperative Extension; Jason Kaye and Doug Beegle; Crop and Soil Sciences; Hunter Carrick, School of Forest Resources.

Water Quality Contaminants focus. “Research is documenting with increasing frequency that many chemical and microbial constituents that have not historically been considered as contaminants are widespread in water systems. These “emerging contaminants” are commonly derived from municipal, agricultural, and industrial wastewater sources and pathways. These newly recognized contaminants represent a shift in traditional thinking as many are produced industrially yet are dispersed to the environment from domestic, commercial, and industrial uses”. (USGS – Emerging Contaminants in the Environment, <http://toxics.usgs.gov/regional/emc/>). Along these lines, this focal area would seek to advance the profile of CAS in areas of water contamination and its relationships to public health, including “old” yet pervasive issues such as enrichment of waters with agricultural chemicals and their degradation products, to “emerging” contaminants such as mercury, personal care products, and pharmaceuticals. Participants from all CAS units could be brought together to collaborate on this new initiative. The focus would be on harmful chemical contaminants (e.g., industrial and agricultural chemicals, pharmaceuticals) and microbial contaminants (e.g., waterborne bacteria and parasites). Goals include advancing methods to quantify trace levels of these contaminants in aquatic systems, to quantify their occurrence in waters of Pennsylvania, to characterize the sources and the paths of pollution, to identify potential effects on human health and ecosystems, and to provide useful outreach materials to educate stakeholders and the public about the concerns, risks, and solutions. The current capacity within CAS to emphasize the emerging contaminants is low, with only a few faculty working on such issues at present, and a limited analytical capability on campus to quantify emerging and other contaminants. The WQQT encourages CAS to consider this as a priority area for *capacity building* within CAS, in terms of both faculty hires and support for analytical capability to quantify contaminants in soil and water samples. (e.g., a new faculty member to join the toxicology program with expertise in environmental rather than microbiological methods and applications). Potential leadership for this activity might include Jack Watson, Crop & Soil Sciences; Sandeep Parbhu from the Dept. of Veterinary and Biomedical Sciences; Jim Clark, McKean Co. Extension.

- **Priority #4 recommendation: Watershed Science and Management Initiative.** This initiative calls on CAS to provide leadership in research, education, and extension focused on the science and management of water resources. This initiative builds on current strengths in watershed hydrology, biogeochemistry, and management throughout CAS, from both fundamental and applied science points of view. The goal is to provide a scientific basis from which to assess, protect, conserve, restore, and manage water resources, in terms of both water quantity and quality. Considering the watershed system, this initiative emphasizes linkages between air, land, and water, and emphasizes an understanding of social, physical, chemical, and biological processes affecting watersheds. This initiative has the potential to achieve excellence and external funding; emphasizes interdisciplinary collaboration within CAS, the University and beyond; is central to integrated college mission of teaching, research and extension; and is aligned with university goals. Additional costs associated with this initiative include increased extension and research faculty.

Watershed management focus. As water becomes scarcer due to increased water use, diminished water resources, or increases in water impairments, management will continue to escalate in its importance. As variability in water availability increases, both water conservation and management of excess water will play a prominent role. Here, we aim for CAS to become the authoritative resource in Pennsylvania on water management – including all measures that reduce water loss, waste or use, and management of excess water, and considering ways to manage landscapes resources in order to protect, conserve, and restore water resources. Water management measures encompass land management, behavior changes, devices, technologies, improved design/process, and products. CAS faculty and extension agents are already involved in this area. This initiative will involve CAS personnel in the areas of integrated water management, water use efficiency, watershed management, water restoration and reclamation, engineering, hydrology, pedology, rural sociology, policy, and economics. Research has a key role to play in advancing concepts of water resources management and conservation with questions about how best to obtain or capture “new” sources of water, how to recycle and reuse waste water, how to best manage landscapes to protect water quality & quantity, how to model water resources at multiple space and time scales, innovative methods for stormwater management, and measurement and monitoring of water fluxes at a regional scale. Potential leadership for this effort could include Bryan Swistock, School of Forest Resources; Rob Berghage, Dept. of Horticulture; Jim Hamlett, Agricultural and Biological Engineering. Partners on campus could include water engineers in Office of Physical Plant.

Watershed science focus. This initiative builds on current strengths in watershed hydrology, biogeochemistry, and processes in CAS. Water is the primary driving force behind the movement of pollutants throughout all ecosystems. Knowledge of local hydrology is needed to understand movement of pollutants through an area and impact on sensitive ecosystems. The goal is to promote further understanding of basic hydrologic processes in headwater streams and in larger catchments, and to learn how to “scale up” to understand the complex problems associated with much larger watersheds and the importance of cumulative watershed interactions. Headwater streams are one of the most sensitive, compact ecosystems in which we can monitor the flux of energy, moisture and pollutants. They are integrators of all environmental parameters that impact surface streams and the organisms that inhabit them, which are extremely sensitive to change. Routine monitoring of a series of such streams across the State would increase our understanding about how we influence our environment and how effective proposed and active control strategies are in protecting our environment and human health. CAS has a long tradition of excellence in watershed science, the CAS watersheds at Stone Valley have among the oldest records anywhere, and our watershed properties are thus internationally known. Potential leadership for this effort include Henry Lin, Crop and Soil Sciences; Elizabeth Boyer, School of Forest Resources; John Schmidt (USDA ARS).

- **Priority #5 recommendation: Climate and Water Initiative.** This initiative seeks to advance CAS leadership in the area of climate variability and change. CAS already is a leading resource to state water planning, through the synthesis and research of the ENRI climate group assembled by Jim Shortle. To expand on this effort, this initiative would address links between climate, water, and energy resources; provide locally relevant climate

information to decision makers and communities in Pennsylvania; and advance understanding of capabilities to manage climate risks and build resilience in key sectors. A potential lead for this effort is Jim Shortle, ENRI. Partners could include faculty associated with the PSIEE, the College of Earth and Mineral Sciences, Earth System Science Center.

- **Priority Overall Staffing Needs Recommendations.** To help meet the needs of water quality and quantity issues, the WQQT recommends creation of the following positions:

County-Based Extension Educators. Four additional full-time water resources educators are needed which could be geographically situated within each of the four Extension regions of the state. HIGH PRIORITY should be given to positions that could be established in the southeast and northwest areas of the state, which are currently underserved.

University Park Faculty. From the perspective of both current Extension water programs and future program areas of anticipated need, the following topic areas are suggested for future faculty hires with Extension appointments.

- Risk Communications - the ability to communicate risk and comparative risk are inherent to the environmental condition changes that are underway. This is most likely a social scientist specializing in areas including environmental sociology or psychology, adoption and implementation behaviors, environmental and risk communication from an interdisciplinary standpoint, and public health and the environment.
- Water Resources Engineer – critical infrastructure needs in both wastewater and water in the near future. Additional infrastructure needs for innovative storm water management and wastewater treatment of gas drilling waste fluids.
- Watershed Management/Process Scientist – Emphasizing hydrological processes controlling movement of water and solutes in the landscape, and watershed management strategies. Has skills linking water quantity and quality; for example, quantifying fate and transport of solutes (e.g., nutrients, emerging contaminants), quantifying TMDL's, or quantifying cumulative watershed effects.
- Water and Energy – new sources of both renewable and non-renewable energy will become a critical issue in the next ten years. Non-traditional sources such as wind, solar and hydrogen along with more traditional sources (cellulose, Marcellus gas, ethanol, etc.) all have implications for both the use and degradation of water resources. A scientist with an understanding of the water issues surrounding energy development will be critical.

8. Relationships of Water Initiatives to other Initiatives

CAS Initiatives

- *Energy.* Described as the “water-energy nexus,” water and energy resources are inextricably and directly linked. Energy production requires huge volumes of water, while water treatment and distribution is equally reliant upon energy. Production of electrical power results in one of the largest uses of water in the nation, and is by far the largest use of water in Pennsylvania -- in 2000, thermoelectric-power withdrawals accounted for 75% of total water use in the state. The exploration of new geological strata to provide new stocks of

fossil fuels is constrained by the need for water resources. One example of importance to CAS is the extensive development of natural gas wells that is underway in the Marcellus Shale belt of Pennsylvania and the eastern USA. The new horizontal drilling methods used to tap the shale require millions of gallons of water per well, and there are serious concerns over the availability of water to support gas well development, and the effects of this water use on surface and ground water supply and quality. Further, the hydraulic fracturing of shale requires use of a fluid that contains many synthetic chemicals, and there are concerns over the water treatment facilities necessary to process the tainted water that results from the gas well drilling and production processes. Increasing reliance on alternative, bio-based fuel sources from cropping systems is also of keen interest to CAS and is tightly linked to water, where productivity of biomass crops potentially requires significant water resources and irrigation. Further, there are important indirect relationships between energy production and water quality. For example, combustion of fossil fuels to produce energy emits airborne chemicals, which in turn are returned to the landscape via dry fallout and precipitation (atmospheric deposition). Owing to its location downwind of many fossil-fuel burning power plants and municipal incinerators, Pennsylvania has received among the highest levels of atmospheric deposition in the nation for many decades. Since population growth drives demand for both water and energy resources, both will be stressed in new ways in the future.

- *Food, Diet and Health.* The availability of potable fresh water is essential to health and human well being. The USEPA sets standards for approximately 90 contaminants in drinking water to protect human health, and ample challenges remain in understanding the sources, fate, and transport of contaminants in drinking water supplies. Water-related diseases are a major cause of morbidity and mortality worldwide, and pathogens, toxics, and emerging contaminants present important challenges to both the water and public health sectors. Water is also essential to food production. Both nationally and globally, irrigation to support agricultural production is the largest source of total freshwater use. Further, runoff enriched with fertilizers and manure associated with food production is the primary source of nutrient pollution of the nations' waters. Nutrient pollution, in turn, is a key issue of concern in Pennsylvania watersheds, and is deemed the nation's most pressing water quality problem.
- *Pest Prediction and Response.* Pest prediction and response is linked to water quantity and quality. Knowledge of the distribution of water on the landscape and soil moisture is a key part of understanding and managing pest habitat. For example, pools of standing or stagnant water are breeding sites for mosquitoes that are capable of transporting infectious diseases (e.g., Malaria or West Nile Virus), and thus water management is a key component of managing their spread. Water is also a key to the transport of pathogens in the atmosphere. For example, the spread of Asian soybean rust disease commonly occurs by the movement of fungal spores which can be transported over short- or long- ranges through the atmosphere. Deposition of the spores occurs primarily through precipitation, and the spread of ASR has been monitored with samples of precipitation chemistry through monitoring networks across Pennsylvania and the nation. Further, water is of key importance in the transport of chemical pesticides, herbicides, and insecticides used for pest control in conventional agricultural systems. Pesticides are transported readily in water vapor, in subsurface flow paths through the landscape, and along river networks. Pesticides and their degradation products contribute

to the pollution of surface and ground waters and can persist for many years depending on the nature of the chemical compounds, and are an important water quality concern.

- Entrepreneurship. There are many opportunities for partnering with small business industry, on innovations to conserve, protect, understand, and restore water resources.

Department Initiatives

- Center of Excellence in Sustainable Landscapes. We support the inclusion of a water focus in the development of this initiative, or center, as proposed by the Department of Crop & Soil Sciences. Their Unit plan calls for developing this Center, to facilitate additional resources and impact. They envision two thrusts as follows: 1) *Advancing Green Landscapes*: Provide a common framework for promoting productive and sustainable land use practices for the purpose of maintaining vital landscapes for community health and well being. Water issues would fall under: sustainable agricultural systems, nutrient and waste management, soil quality, urban environmental issues, green landscape/turf industry, and responses to a changing climate. 2) *Integrating Landscape Knowledge*: Digital tools and technologies are rapidly developing that allow better quantification and interpretation of the landscape across scales. There is a critical need to integrate our understanding from molecular characterization of soil and plant processes to regional applications in the landscape. Emerging areas with great promise for addressing water issues include the modeling of coupled soil hydrologic and biochemical processes, the expansion of geospatial and remote sensing technologies. Potential leads for this topic could include faculty from a number of CAS departments.

9. Contributors to this Report

This report is a product of the meetings and correspondence of the College of Agricultural Sciences' *Water quality and quantity strategic planning team (WQQT)*: Administrative sponsor: Dennis Calvin. Mary Barbercheck, co-chair, Beth Boyer, co-chair, Bill Achor-external stakeholder, Matt Ehrhart-external stakeholder & PSAC, Doug Beegle, Virginia Ishler, Dana Rizzo, Kristen Saacke Blunk, Rob Shannon, Bryan Swistock. Staff Assistant: Elizabeth Matthiesen

The report incorporates ideas and writings taken from related recent meetings, with overlapping membership to our committee:

- *CAS-sustainable environments team strategic planning meetings* (Spring 2008; Leads -- Jim Shortle & Mary Barbercheck; with Craig Altemose, Doug Beegle, Beth Boyer, Matt Ehrhart-external stakeholder, Virginia Ishler, Paul Patterson, Dana Rizzo, Kristen Saacke Blunk, Rob Shannon).
- *ENRI strategic planning meetings* (Spring 2009; Lead - Jim Shortle; with Beth Boyer, Dave Eissenstat, Jason Kaye, Ross Pifer, Edwin Rajotte, Greg Roth, Dana Rizzo, Kristen Saacke Blunk, Rob Shannon, David Sylvia).
- *ENRI ERM-water option meetings* (Spring 2008; Leads - Rob Shannon & Beth Boyer; with Jamison Colburn, Hunter Carrick, Paola Ferreri, James Hamlett, Al Jarrett, Henry Lin, Bryan Swistock).

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- *SFR-water planning meetings* of Spring 2009 (Lead - Beth Boyer, with Dave DeWalle, Paola Ferreri, Matt Marshall, Matt Miller, Lysle Sherwin, Bryan Swistock).
- *CAS individual Unit Plans* of Spring/Summer 2009

10. Appendices.

Appendix 1: Current Courses Related to Water

[A S M 327](#) Soil and Water Resource Management (3) Soil and water management systems and practices including hydrology, surface drainage, open channels, and erosion, subsurface drainage, impoundments and irrigation. Prerequisite: [PHYS 250](#)

[B E 307](#) Principles of Soil and Water Engineering (2) Utilization and engineering of soil-water resources; including rainfall- runoff, soil-water movement, erosion/sediment transport and flow processes. Prerequisite: [C E 360](#) or [M E 320](#)

[B E 467](#) Design of Stormwater and Erosion Control Facilities (3) Design of best management practices for stormwater management, erosion and sediment control as applied to the agriculture-urban interface. Prerequisite: [B E 307](#) or [C E 361](#)

[ENT 425](#) Freshwater Entomology (3) Collection and identification of insects and other arthropods in freshwater ecosystems; field study of habitats.

[E R M 435](#) (W F S 435) Limnology (3) Biogeochemistry and natural history of freshwater ecosystems. Prerequisite: [BIOL 110](#), [BIOL 220W](#), [CHEM 110](#)

[E R M 447](#) Stream Restoration (3) Stream restoration including fluvial geomorphology, stream classification, impairment, sediment transport, stable stream design, and watershed assessment. Prerequisite: [A S M 327](#) or [A B E 307](#) or [C E 361](#)

[E R M 450](#) (W F S 450) Wetland Conservation (3) Wetland types, classification, functions and values; hydrology, soils, and plants; introduction to wetland identification and delineation; wetland regulations. Prerequisite: [E R M 300](#) or [W F S 209](#)

[FOR 470](#) Watershed Management (3) Introduces a basic understanding of fundamental hydrological processes, and how management of natural resources can be adapted to protect the quality and quantity of water resources. Prerequisite: 3 credits in Soils

[FOR 471](#) Watershed Management Laboratory (1) Introduction to hydrologic and climatic measurements and computations useful in watershed management. Prerequisite: [FOR 470](#)

[SOILS 405](#) (GEOSC 405) Hydropedology (3) Soil and water interactions across scales, integrated studies of landscape-soil-water relationships, fundamental processes of water flow and chemical transport. Prerequisite: [SOILS 101](#)

[W F S 310](#) Wildlife and Fisheries Measurements (3) Introduction to field and laboratory approaches for collecting, analyzing, and communicating data regarding wildlife and fish populations and their habitats. Prerequisite: [W F S 209](#), [STAT 240](#)

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[W F S 410](#) General Fishery Science (3) Introduction to the study, management, and uses of fish populations; methods of investigation, culture, and harvest of fishes.

Prerequisite: [BIOL 210](#) or [W F S 209](#)

[W F S 422](#) Ecology of Fishes (3) Role of fishes in aquatic communities and general ecosystems. Environmental factors influencing fish as individuals, populations, and communities. Prerequisite: [BIOL 220W](#) or [W F S 209](#)

[W F S 452](#) Ichthyology (2) Study of the structure, taxonomy, systematics, and natural history of freshwater and marine fishes.

Prerequisite: [BIOL 110](#), [BIOL 240W](#)

[W F S 453](#) Ichthyology Laboratory (2) Identification of fishes, major fish families, use of keys. Prerequisite: [BIOL 110](#), [BIOL 240W](#). Prerequisite or concurrent: [W F S 452](#)

[W F S 463W](#) Fishery Management (3) Management of sport and commercial fisheries, including biological, political, social, and economic factors; regulations and other management techniques. Prerequisite: [W F S 209](#), [W F S 300](#), [W F S 301](#), [W F S 310](#)

Appendix 2: Key CAS extension and outreach activities related to water

- Cooperative Extension Natural Work Groups are designed to address key issues of importance in Pennsylvania, including a strong cross-cutting emphasis on water quality and quantity. Extension provides a comprehensive set of state programs based on a foundation of new research and technology. Currently, the Water Resources Extension Group is comprised of Water Resources Extension Specialists and extension educators affiliated with CAS in Pennsylvania. In addition to these, there are faculty and educators from the animal, agronomic, renewable and natural resources, and economic and community development areas who have affiliated with the Water Resources Extension Group to increase cross-pollination with programs that interface with water quality and quantity issues.
- Penn State Cooperative Extension Water Resources web portal provides comprehensive web-based resources to the public, including fact sheets, videos, publications, and technical guidance about water quality and quantity (online at: <http://water.cas.psu.edu/>). Water resources faculty and staff in the College of Agricultural Sciences provide support for extension programs related to drinking water, water conservation, pond management, on-lot septic, non-point-source pollution, water policy, and watershed education.
- Penn State Cooperative Extension Gas Well Drilling web portal provides comprehensive educational and research materials about Marcellus shale, natural gas, and how it may affect the Commonwealth (online at: <http://naturalgas.extension.psu.edu/>). The Marcellus Shale Education & Training Center (MSETC), a partnership of Penn State Cooperative Extension and Penn College of Technology, was established to provide the regional area and the natural gas industry with a central resource for workforce development and community education needs as related to the Marcellus. Publications include impacts on water quality, such as "Gas Well Drilling and Your Private Water Supply."
- Discovery Watershed. The newly funded Conewago Creek Initiative (including many partners/stakeholders, awarded support in late 2009 from the National Fish and Wildlife

Foundation) is a targeted watershed approach that will establish "discovery" farms and landscapes. These sites will showcase BMPs in farm-, forest-, or developed areas that are new, innovative, or improved practices. The discovery sites would be established for transfer of information to other producers or land managers within and outside of the watershed. The importance of having demonstration or "discovery" farms established within the local landscape is a critical component in the transfer of the technology in a farmer-to-farmer, resident-to-resident, municipality-to-municipality approach.

- Achieving Balance Visioning. Penn State Agriculture & Environment Center, Environment and Natural Resources Institute, Penn State Cooperative Extension and the Penn State College of Agricultural Sciences convened stakeholders from across the Commonwealth to develop a vision for "agriculture in balance." Among other concepts, the activity emphasized the pervasive water quality problems stemming from agriculture. The vision stated that agriculture in balance would be profitable, productive, progressive, and proactive, preserving its rich heritage of community involvement and environmental stewardship to build a better Pennsylvania. Representatives from across all of Pennsylvania's agriculture and environment sectors were represented – from regional-, state-, and federal agencies, academia, farm and environmental NGOs, ag-business, municipal associations, and legislators. The development of the vision provided a starting point for convening a 2-day statewide working conference in 2008, attended by nearly 200 people who collectively identified the barriers and opportunities for pursuing this vision for ensuring the health and prosperity of Pennsylvania's agriculture and environment.
- Master Well Owner Network. PSU Cooperative Extension within CAS initially received approximately \$160,000 from the USDA, CSREES National Integrated Water Quality program to initiate an outreach and assistance program for owners of private water systems in Pennsylvania. The project created a Master Well Owner Network as a partnership among Penn State Cooperative Extension, Pennsylvania Department of Environmental Protection, Pennsylvania Ground Water Association, Pennsylvania Rural Water Association, U.S. EPA Region 3, and various volunteers. Structurally, the MWON network includes a central state coordinator with regional assistance from Cooperative Extension educators all supporting a network of over 400 trained volunteers. The goal of this project is to provide education and assistance to the three million rural residents of the state utilizing individual water supplies (wells, springs and cisterns serving an individual home). The original project occurred from September 2004 through September 2006. Since then, the MWON network has received various sources of federal, state, industry and private funding to continue in Pennsylvania and expand to five other states. To date, the Pennsylvania MWON project alone has received over \$600,000 in funding from various sources. Each year, the MWON program provides assistance to 3,000 to 7,000 private water supply owners. This assistance includes information on proper location, construction, testing and treatment of private drinking water supplies. Surveys of clients have indicated that more than 80% take actions to improve their water supply following their interaction with MWON network staff or volunteers.

Appendix 3: Other key related CAS programs

- Penn State Institutes of Energy & the Environment (PSIEE), aims to expand Penn State's capacity to pursue the newest frontiers in energy and environmental research by encouraging cooperation across disciplines and engaging the participation of local, state, federal, and international stakeholders. The PSIEE is the central coordinating structure for energy and environmental research, education, and outreach at Penn State. It is a dynamic, tightly coupled, intercampus network of expertise and infrastructure organized under the Office of the Senior Vice President for Research. One of its core colleges includes CAS, and PSIEE's Assistant Director for Water is a CAS faculty member. PSIEE is a useful partner to CAS, helping with the hiring of new faculty, providing financial support of faculty developing large-scale research proposals; contributing to matching funds for individual proposals, proposal preparation services, communicating funding opportunities to faculty, and more. Currently, there are 7 CAS faculty members who were co-hired with support of both CAS and PSIEE, with additional hires in the area of energy currently in progress.
- Environment and Natural Resources Institute (ENRI) provides a portal to research, education, and outreach programs with CAS, and encourages interdisciplinary and collaborative research within and beyond the College. The overall mission of ENRI is to improve understanding and management of living systems, landscapes, and human-environment interactions with the objective of sustaining and enhancing ecosystem services and human-well being. ENRI is affiliated with PSIEE. ENRI supports many current initiatives that involve water quality and quantity, including the biomass energy center, the environmental markets and incentives initiative, the nutrient initiative, the sustainable agriculture working group, and the transitional zone ecosystem initiative.
- Agriculture and Environment Center (AEC): Initiated by the college's Environment and Natural Resources Institute and Cooperative Extension in 2008, the center is a focal point for cross-disciplinary research and outreach on air and water quality, soil conservation, invasive species, climate change and other environmental issues of consequence to agriculture. The primary thrust of the Center to date has been to increase Penn State visibility and engagement with local-, regional-, state-, and federal partners on conservation-related initiatives, largely focused on the reduction of nutrient emissions to air and water from agriculture. The "Achieving Balance" conference provided a diverse charge to the AEC to improve communications, address root causes of 'imbalance', increase integration of Penn State innovative practices, and to improve partnership efforts to remove agricultural impairments at the small watershed level with an eye towards scaling up to the larger watersheds.
- The Pennsylvania Water Resources Research Institute (PA-WRRI), founded in 1964, is authorized by Congress as one of the nation's 54 water resources research institutes comprising the National Institutes of Water Resources (NIWR). The Institutes are located at each state's land-grant University, and the PA-WRRI has been directed by CAS faculty members since its inception. In the spirit of the land grant mission, the institutes emphasize the role of University research, education, and outreach in advancing pressing complex problems in water quality and quantity. The national program is administered by the U.S. Department of the Interior through the U.S. Geological Survey, in a unique Federal-State-

University partnership. Within Penn State, the PA-WRRI is administered via PSIEE. A small federal grant provides annual base support for a program that allows for the identification of water resources research issues of priority in Pennsylvania, and distributes the funding to advance these issues via a small grants competition to researchers at Universities across the state. Via leveraging and partnerships, the institute matches every dollar of its base appropriation with at least two dollars from non-federal sources. PSIEE and the PA-WRRI operate a full water-quality service lab of interest to CAS, offering subsidized, inexpensive rates for various water quality analyses to all Penn State faculty and staff.

- Penn State Agricultural Law Research and Education Center is a collaboration between the University's Dickinson School of Law and the CAS. The Center is funded in part by the Pennsylvania Department of Agriculture. The Center is designed to provide the highest-quality educational programs, information, and materials to those involved or interested in the agricultural industry.
- The Pennsylvania Atmospheric Deposition Research Program. Because of the geographic location of Pennsylvania downwind of major sources of chemical emissions (including the precursors of acid rain), the early indication that precipitation in PA was more acidic than most, if not all, regions of North America; and the presence of numerous acid-sensitive ecosystems in PA; The Pennsylvania Department of Environmental Protection established a long-term atmospheric deposition monitoring network and associated research program in 1981 under a cooperative agreement with Penn State. CAS faculty members have directed this program since its inception, and the Program currently consists of a network of 17 monitoring sites across the Commonwealth where precipitation chemistry is measured weekly, and research addresses questions about the agricultural, industrial, automotive, and other sources contributing to the precipitation chemistry. These sites are part of the broader national-scale networks CSREES project NSRP-3, the National Atmospheric Deposition Program's National Trends Network and Mercury Deposition Network. The national program includes one site supported in part by CAS (located within Stone Valley, PA42 Leading Ridge). A goal of the Program is to provide publicly-available and quality-assured data and information in support of research on the exposure of managed and natural ecosystems and cultural resources to acidic compounds, nutrients, mercury, and base cations in atmospheric deposition.
- Critical Zone Watershed Observatory. The Shale Hills watershed within the Penn State Forest in Stone Valley was selected as one of only three prestigious experimental watershed sites by the National Science Foundation. Here, significant funding is being invested by NSF to establish an observatory that will significantly advance our understanding of the integration and coupling of Earth surface processes as mediated by the presence and flux of fresh water. Extensive monitoring and modeling is underway to advance understanding of the "critical zone" that supports life on earth, including air, water, soil, and bedrock. The watershed was initially established by the School of Forest Resources in the 1950's, and the record of long-term data to build from was one of the primary reasons that this site was chosen for further investment by NSF. The project currently involves numerous CAS faculty.

- Center for Watershed Stewardship (CWS), created in 1998, is an Intercollege Program administered by two of Penn State's Professional Schools: the School of Architecture & Landscape Architecture and the School of Forest Resources. The Center for Watershed Stewardship aims to create a network of highly-trained watershed professionals through an interdisciplinary and intensive graduate program. Students and mentors partner with communities and stakeholders in Pennsylvania, toward watershed assessment and planning, and effective long-term solutions for the protection of water resources.

Appendix 4: Assessments of Water Resources Extension Needs and Staffing Needs

- **Stakeholder Needs Assessment.**

As part of the Extension reframing process, the water resources extension work group compiled a Needs Assessment survey in the fall of 2008. The web based survey was completed by 402 stakeholders from 57 counties including: 245 homeowners, 59 water resources professionals, 34 farmers, 14 municipal government officials, and 44 others (state, federal government, etc.). 90% of respondents had at least some previous experience with Penn State Cooperative Extension while 10% had no previous experience. Stakeholders were asked what types of educational resources are needed for water resources outreach in Pennsylvania. The responses included:

- 77% favor written publications and fact sheets
- 66% favor web pages
- 42% like face-to-face programs
- 26% like videos (DVD, web video, etc.)
- 13% prefer webinars
- <10% each preferred podcasts and radio programs.

Those filling out the Needs Assessment were asked how important various water issues were to them and their family. For each water resource topic, respondents could give the following rankings: 1=Very important, 2= Somewhat important, 3=Somewhat unimportant, 4 = Not important at all. The water resources topics are listed below based on the average response received with low numbers (closer to 1.0) indicating topics of greatest concern and higher numbers (closer to 3) indicating topics of lesser concern.

<i>Water Resources Topic</i>	<i>Average Rank</i>
1. Safe drinking Water	1.29
2. Water supply conservation	1.50
3. Urbanization impacts on water	1.76
4. Nutrient and sediment pollution	1.77
5. Effects of Gas/Oil drilling on water resources	1.79
6. Water resources laws/regulations/policy	1.80
7. Emerging contaminants (pharmaceuticals, etc.)	1.81
8. Watershed restoration	1.82
9. Water infrastructure	1.87

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10. Agricultural pollution prevention	1.88
11. Wastewater (on-lot septic)	1.89
12. Youth water education	2.04
13. Mining impacts on water resources	2.06
14. Aquatic invasive species	2.15
15. Pond and lake management	2.42
16. Aquaculture	2.74

Based on these results, water resources extension team members identified the following areas of focus for programs over the next five years.

- *Safe Drinking Water* – based on our expertise and capacity in this program area along with its high ranking in the needs assessment.
- *Water conservation* – based on the high ranking in the needs assessment and current grants allowing for development of resources and programs.
- *Pond and lake management* – based on our expertise and capacity along with the uniqueness of our programs (no other agencies provide education in this area). Despite the relatively low needs ranking by stakeholders, it was felt that Extension provides a unique program to a targeted audience with a great need.
- *Watershed education* – based on our expertise and capacity along with the high ranking of numerous non-point issues (on-lot, nutrients, sediment, etc.).
- *Water infrastructure* – while infrastructure was only moderately ranked by stakeholders, team members felt that this is an area of future need related to Marcellus gas water and wastewater needs along with community drinking and wastewater infrastructure. Agency personnel also ranked this as a higher priority area.

- **Water Resources Staffing Needs Assessment.**

Various discussions with Extension educators and specialists have resulted in the following listing of both educator and faculty needs to address current and anticipated water priorities.

County-Based Extension Educators

Extension currently has no full-time Extension educators with a dedicated (100%) appointment focused on water resources. We have several educators with a large commitment to water resources programming including:

Central Region

James Clark – McKean County (multi-county) – covering northern part of region

West Region

Susan Boser – Beaver County (50% Extension, 50% Conservation District)

Dana Rizzo – Westmoreland County (50% Extension, 50% Conservation District)

Southeast Region

Thomas McCarty – Cumberland County (multi-county) – covering southcentral counties

Northeast Region

Peter Wulforth – Pike County (multi-county) – covering northern part of region

This staffing results in less than 1 FTE of Extension educators with a water resources background in most of the Extension regions. As a result, large portions of some regions are currently uncovered by water resources Extension programming.

Extension Staffing Needs Recommendation

County-Based Educators

- Four full-time water resources educators are needed which could be geographically situated within each of the four Extension regions of the state. HIGH PRIORITY should be given to positions that could be established in the southeast and northwest areas of the state which are currently underserved.

University Park Faculty – from the perspective of both current Extension water programs and future program areas of anticipated need, the following topic areas are suggested for future faculty hires with Extension appointments.

- Risk Communications - the ability to communicate risk and comparative risk are inherent to the environmental condition changes that are underway. This is most likely a social scientist who is specialized in areas including environmental sociology or psychology, adoption and implementation behaviors, environmental and risk communication from an interdisciplinary standpoint, and public health and the environment.
- Water Resources Engineer –critical infrastructure needs in both wastewater and water in the near future. Additional infrastructure needs for innovative storm water management and wastewater treatment of gas drilling waste fluids.
- Watershed Management/Process Scientist – an understanding of the fate and transport of emerging contaminants like EDC, pharmaceuticals, etc. in the context of a better understanding of the structure and function of watersheds. Adding to the understanding of all nonpoint source pollution problems and management
- Water and Energy – new sources of both renewable and non-renewable energy will become a critical issue in the next ten years. Non-traditional sources such as wind, solar and hydrogen along with more traditional sources (cellulose, Marcellus gas, ethanol, etc.) all have implications for both the use and degradation of water resources. A scientist with an understanding of the water issues surrounding energy development will be critical.

• **Appendix 5. Some Partners with Extension with interest in water quality and quantity**

Penn State Cooperative Extension is a partnership between the Federal, State and County governments and Penn State University. The partnerships do not stop there! Below is a sample of some key relationships in Pennsylvania. This list is not and is not meant to be all-inclusive. Many more partnerships exist.

Allegheny Kiski Health Foundation
American Farmland Trust
Aquatic Plant Management Society
Chesapeake Bay Foundation
Chesapeake Bay Program – PA
Environmental Defense Fund
Indiana University of Pennsylvania

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League of Women Voters and Pennsylvania Water Resources Education Network
Local hospitals
Northeast Aquatic Plant Management Society
Penn's Corner RC&D
Pennsylvania Association of RC&D Councils
Pennsylvania Association of Conservation Districts
Pennsylvania Boroughs Association
Pennsylvania Bureau of Forestry
Pennsylvania County Conservation Districts
Pennsylvania Department of Agriculture
Pennsylvania Department of Community and Economic Development
Pennsylvania Department of Conservation & Natural Resources
Pennsylvania Department of Environmental Protection
Pennsylvania Department of Health
Pennsylvania Environmental Council
Pennsylvania Farm Bureau
Pennsylvania Fish and Boat Commission
Pennsylvania Game Commission
Pennsylvania Groundwater Association
Pennsylvania Lake Management Society
Pennsylvania Land Trust Association
Pennsylvania Rural Water Association
Pennsylvania SeaGrant
Pennsylvania State Association of Township Supervisors
Pesticide Education Program
Pharmacies
Saint Vincent College, and other small colleges
The Center for Rural Pennsylvania
The Pennsylvania Forestry Association
Trout Unlimited
United States Environmental Protection Agency
United States Geological Survey
USDA CSREES (Cooperative State Research, Education, and Extension Service)
USDA-Natural Resources Conservation Service
USDA Farm Service Agency
USDA Rural Development
Various police departments (local and state)
Various school districts
Various townships and municipalities
Watershed associations
Well drillers
Westmoreland County Community College
Westmoreland Conservation District
Westmoreland Woodlands Improvement Association
Woodland Owners of the Southern Alleghenies

• **Appendix 6: Dairy and Animal Science Stakeholders**

American Association of Meat Processors
American Society of Animal Science
American Dairy Science Association
American Quarter Horse Association
American Youth Horse Council
Continental Dorset Club
Dairy Records Management System (DRMS)

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Eastern Meat Packers
Genex Cooperative
Federation of Animal Science Societies (FASS)
National Pork Board Swine Educators
Keystone International Livestock Exposition (KILE)
Mid-Atlantic Dairy Association
North American Deer Farmers Association
Penn Ag Industries
Penn State Agricultural Council
Penn State Stockmen's Club
Penn State Dairymen's Club
Pennsylvania Association of Conservation Districts
Pennsylvania Association of Meat Processors
Pennsylvania Angus Association
Pennsylvania Beef Council
Pennsylvania Cattlemen's Association
Pennsylvania Council of Cooperative Extension Associations
Pennsylvania Council on Therapeutic Horsemanship
Pennsylvania Deer Farmers Association
Pennsylvania Dairymen's Association
Pennsylvania Dairy Stakeholders
Pennsylvania Department of Agriculture
Pennsylvania Department of Agriculture Livestock Evaluation Center
Pennsylvania Dorset Breeders Association
Pennsylvania Equine Council
Pennsylvania Equine Council Foundation
Pennsylvania Environmental Council
Pennsylvania Farm Show
Pennsylvania Farriers Association
Pennsylvania 4H Horse Program Development Committee
Pennsylvania Hereford Association
Pennsylvania Holstein Association
Pennsylvania Horse Breeders Association
Pennsylvania Livestock Association
Pennsylvania Manure Haulers/Applicators Council
Pennsylvania Meat Goat Producers Association
Pennsylvania Milk Marketing Board
Pennsylvania Quarter Horse Association
Pennsylvania Pork Producers Council
Pennsylvania Sheep and Wool Growers
Pennsylvania Swine Council
Professional Dairy Managers of Pennsylvania (PDMP)
Quality Deer Management Association
Select Sire Power, Inc.