E & O Committee White Paper: Recommendations for CUAHSI Education and Outreach Effort 2008-2013

A key component of the CUAHSI mission is to foster advancements in the hydrologic sciences, in the broadest sense of that term, by enhancing the visibility, appreciation, understanding, and utility of hydrologic science through programs of education, outreach, and technology transfer. As CUAHSI has evolved and matured as a research consortium, the need for a coordinated education and outreach effort has crystallized. The proposed program can be integral to ensuring the CUASHI accomplishments are recognized, acknowledged, sustained, transferred and celebrated widely. The proposed program is broad, covering outreach efforts to increase scientist communication, to improve teaching of hydrology and to improve the public appreciation of hydrology. The Committee membership is listed in Appendix A.

This report is the result of the discussions and deliberations of the CUAHSI E&O committee over the past six months on how best to initiate such a program. The committee's work was informed by earlier CUASHI education and outreach efforts and by the education and outreach work of other earth science facilities and research centers. Below we outline the vision, need and goals for a CUAHSI E&O program and our priorities and strategies for moving forward. The vision is presented as a list of recommendations that can be adopted as a whole or in part.

Vision and Need for CUAHSI E&O

The CUAHSI education and outreach effort will empower our community of scientists and educators to more effectively transfer advances in hydrologic science to students, policy makers and citizens such that all make scientifically informed and sound choices concerning water-related issues affecting society.

CUAHSI's E&O program will provide community members with support and opportunities to integrate their research with highly effective teaching and communication of hydrologic science to a broader audience. CUAHSI's motivation for action is influenced by the national agenda to increase American competitiveness in STEM disciplines, in particular the hydrologic sciences; the increased need for citizens to understand water issues, resources and management; and a desire to ensure the results of hydrologic research are applied in the most efficient and effective manner. The need for better understanding of water issues is undeniable. Worldwide, 6000 children under the age of five die every day because of unsafe water and sanitation; 1.1 billion people in developing countries have inadequate access to safe drinking water. Water-related diseases are the single largest cause of health-related death in the world. Water quality and availability is a growing concern in this country, not just in developing countries. Students need to be trained in hydrologic science and engineering to meet the challenge of the growing water quality and availability problems. Likewise, the public needs to have raised awareness of the seriousness of water quality and availability problems and the essential importance of hydrologic science in addressing them—this is the most compelling rationale for a public science education effort.

Goals

The committee identified elements of the program that are critical for long-term sustainability. The program must:

- Provide support, training or other scaffolding to enable members to conduct water science education and outreach locally, regionally and nationally without sacrificing their contributions to science research;
- Integrate the diverse sub-disciplines within the hydrologic community to strengthen the community and promote rich scientific and educational collaborations;
- Promote collaborations with other water science and related education efforts to reduce

duplication and increase impact;
- Address member's need for professional recognition of substantive participation in education and outreach activities for career advancement.

By addressing these elements, the committee believes that member participation, the quality of the activities, and overall impact will be greater.

The committee used these goals as guidelines for exploring a range of options for E&O activities and setting priorities.

Program Priorities

The need for water science education across all ages is great, as is the number of existing programs providing water science education. In this environment, CUAHSI can make a greater impact through careful selection of activities that build upon its unique strengths, that have high potential for engaging the members, and that meet identified needs. Based on this, we identified three areas for focusing our efforts:

- ***scientists communicating***—aimed at making scientists better communicators with the public, policy makers and classrooms;
- ***teaching hydrology in the 21st century***—aimed at improving hydrologic education at the university and graduate levels; and
- ***increasing public appreciation of hydrologic science***—aimed at engaging the public in learning about water through citizen science projects, informal education programs, etc.

In all three areas, a range of activities was proposed, each of which is designed to advance the mission, vision and goals of CUAHSI. The committee then refined the list of proposed activities that are best suited for launching a substantive but manageable E&O program over the next five years. Each area is discussed in detail below.

Scientists Communicating

The opportunities and demand for scientists to communicate effectively and educate broad audiences are great and include:

- **Contributing to scientific or policy based decision-making**—For this, scientists might undertake formal and informal training to participate in Congressional visits, provide testimony, or fill other expert roles.
- **Increasing public understanding of science** —Scientists might receive training in new and more effective ways of communicating science concepts and discoveries in museum programs, public presentations, on researcher's websites, etc.
- **In classrooms**—Scientists could receive help with learning to tell the story of their research or career in K-12 classrooms and to more effectively teach future scientists and educators in undergraduate and graduate programs of higher education.

Presently, the training and resources easily accessible to support scientists in these roles are limited. While each of these activities is recommended for CUAHSI E&O in the long-term, the committee identified the following steps to get started.

- Provide training and tools to aid scientists in communicating with the public and media;
- Coordinate these activities with other organization's E& O efforts; and
- Develop a media bank of high quality films and images for communicating about water, as well as best practices and case studies of successful education and outreach.

The committee felt strongly that CUAHSI should leverage as much as possible existing programs offered by professional societies and other scientific groups.

Provide training and tools for communicating with the public and local media

Several organizations (e.g. Union of Concerned Scientists) have developed training programs for scientists to improve their communication with policy makers, the public and media. CUAHSI should do a review of existing resources and then determine the optimum strategy for providing these resources to the hydrologic community. The content might be delivered in multiple *formats (electronic white paper, cyberseminar, etc.) to reach the broadest audience and increase use*. Beyond informing and supporting members, CUAHSI should collaborate with other organizations and networks emphasizing public education and outreach to encourage coordinated efforts.

Design, organize, and host a media bank of films, images, and best practices on communicating water science

The committee felt it was important to document information on readily available high quality video and imagery that could be used in informal education of the public and in classrooms Information could be stored in a searchable database and, to ensure the high quality of each resource, a peer review process could be implemented. Ideally, an interactive website would allow community members to post information on potential additions to the database as well as comments about the usefulness and quality of resources that have already been vetted through the peer review. Success of this effort is dependent upon CUAHSI staff developing the database and review process, regularly polling the community and conducting their own searches for resources, and engaging members in reviewing and posting comments on use of the materials.

The website and database also will provide CUAHSI members with current information on best practices, strategies, and issues of common interest in communicating with the public. Along with the media components, this repository of examples of E&O best practices and supporting resources will improve the ability of CUAHSI and its members fulfill Criterion 2 for NSF awards, thereby increasing the impact of their research. Individuals in the community will be able to customize the resources and best practice ideas and implement them locally, while benefiting from the collective knowledge gained from previous efforts.

Teaching Hydrology in the 21st Century

Hydrology education at the university level is provided in a wide range of science and engineering departments and at both the undergraduate and graduate levels. Approaches to advancing hydrology education should recognize and support the interdisciplinary nature of the topic to achieve improvements for a broad range of students (Nash et al., 1990; Wagener et al., 2007). A recent survey of over 600 water professionals suggests that better education in watershed hydrology and hydrological modeling is an important and widely recognized need (Bourget, 2006). The committee suggests two main projects in support of two different aspects of hydrology education. Both of the new projects and all future CUAHSI projects of a similar nature should share the following characteristics to ensure their compatibility and widespread use:

- All material is accessible through the WWW.
- All material is modular in structure so that educators can select components as they see fit.
- Material can be combined into something similar to an e-book.

Case Studies in Hydrology Education

Much of the research proposed by the CUAHSI community involves interdisciplinary investigations of watersheds or watershed processes. These same investigations can provide rich context and content for instructional case studies at the graduate and undergraduate level. Building case studies around the

WATERS test beds, for example, is an ideal means of integrating research and education. Teaching hydrology through case studies is common and several CUAHSI members have a new project getting underway to develop new case studies. Project MOCHA (*Modular Curriculum for Hydrologic Advancement*; http://www.mocha.psu.edu/; Wagener, McGlynn, Gooseff, Marshall, McGuire) could provide the model and organizing structure for a broader curriculum effort among the CUAHSI members. This recently funded education project evolved out of discussions of the *Research and Education Advancement through Cooperative Hydrology* (REACH) group (see http://watershed.montana.edu/hydrology/REACH.html).

CUAHSI could take an active role in facilitating the development and distribution of case studies for all levels of university education in two ways. CUAHSI could provide a web-based portal to host and disseminate case studies developed by members of the hydrological community, and it could promote pedagogical guidelines for design and development of such case studies. The portal would ensure greater dissemination of these types of resources and the guidelines would improve overall quality and reuse of components and entire case studies. Moving beyond MOCHA, CUAHSI staff could work with other community members to submit similar proposals to funding agencies (e.g. NSF's CCLI program) based on the lessons learned from MOCHA. If case studies were to be developed around current CUASHI research, creation of a database derived from CUAHSI observation testbeds could facilitate development and classroom implementation of the case studies. Finally, CUAHSI could coordinate widespread testing and evaluation of the case studies to ensure they work in a variety of teaching environments and students. Each case study would incorporate tools for instructors to assess his/her students' learning. Guides for teaching would be included with each case study, as well as tools to assess the usability (e.g. D'Avanzo et al, 2006). Examples of the use of case studies in education can be found in groundwater hydrology (Bair and Lahm, 2006), and in ecology (see http://tiee.ecoed.net/index.html).

Laboratory Manual for Hydrology

Multiple universities have field camps to teach hydrologic measurement techniques. However, site-specific field camps, which might be open to students from anywhere, are inherently limiting because of logistics (travel costs, scheduling, etc.,) and because (arguably) the specific lessons learned may not transfer to other regions, climates etc. Our vision is to develop a set of laboratory and field exercises that could be executed anywhere, perhaps customized by an instructor for a particular location, and that would teach concepts fundamental to most hydrology classes. These exercises would not necessarily focus on advanced, cutting-edge techniques – though those would not be excluded. Rather, the exercises might be simple, low-cost activities that would be excellent demonstrations of the concepts that are important in hydrology. The audience for this manual is envisioned to be assistant professors and professors developing a hydrology field or laboratory course.

Most current hydrologic laboratory manuals are discipline specific (e.g. groundwater or surface water or water quality), the purpose of this manual is to assemble a set of laboratory and field exercises that cover the discipline of hydrology. As an example of a discipline-specific manual, see the "Hydrogeology Laboratory Manual" by Lee, Fetter, and McCray. It is a set of 21 laboratory exercises that all have to do with hydrogeology analyses, and all of the exercises are done in a classroom. Data and analysis techniques or directions on where to get them are provided and no fieldwork is necessary). For the proposed manual, each exercise will be pedagogically designed for instructor assessment of his/her students. Teaching guides also will be included.

A model of how this laboratory manual could be developed is the *Environmental Engineering Processes Laboratory Manual* (Association of Environmental Engineer and Science Professors http://www.aeesp.org/). For that manual, an editorial board consisting of an editor and four associate editors solicited and reviewed laboratory exercises from the environmental engineering and science community. This manual would complement the CUAHSI Hydrologic Measurement Facility effort being led by John Durant to develop a *Handbook of Hydrologic Measurements*. The vadose zone toolkits by Selker provide an example of lab kits that could complement the lab manual (see http://bioe.orst.edu/Faculty/selker/Vzp/Vadose%20Teaching%20Kits.htm).

Increasing Public Appreciation of Hydrologic Science

CUAHSI's strengths are in formal education of future hydrologists and advancing understanding of water resources in the world. Yet, outreach to the public is critical as each individual on this planet can directly affect water quality and availability locally and globally. To more effectively engage the public and enhance their understanding of water research, the committee recommends two types of projects: communicating science through short videos and engaging citizens in long-term research projects whose outcome is of interest to both the public and CUAHSI community. Both efforts complement the activities proposed to help scientists communicate and to teach hydrology in the 21st century.

Communicating through Short Videos

The concept behind this effort is to create short videos that communicate basic hydrologic principals, highlight relevant new discoveries, raise awareness and action to address critical water issues, or reveal processes or concepts not easily observed in nature. Committee members expressed a personal need for videos that helped them in their teaching, as many have struggled to find quality clips that address key concepts that are difficult for undergraduates to grasp. While the undergraduate audience is not the primary target audience for this effort, the lack of resources for undergraduates is a strong indicator that the resources also are lacking for the public. Importantly, committee members expressed a desire to support this type of CUAHSI-led effort by contributing their time and knowledge to identifying a list of topics in need of effective video for teaching and developing the content of such videos.

Topics for the videos will likely cross multiple sub-disciplines in water research bringing together scientists across the water research community and better unifying the CUAHSI members in how they communicate their science. In a similar way, these videos could trigger collaborations with other science and education efforts across the geoscience community, as the videos could be used in curriculum for K-16 and informal education programs for citizens of all ages that are funded by NSF and other agencies.

CUAHSI has already launched an effort in this area, having created three such videos in 2006 with the help of scientists who shared their science and videographers, scriptwriters and editors who produced the final product. We believe this model will be successful because it uses the scientists in roles that are easy for them to fulfill, and places the burden of organization and finding specialized experts in education and videography on CUAHSI staff.

Aside from the community need and interest in these videos, the committee believes that they will have utility in many settings from museum kiosks, to news stations, to public lectures, to education or training programs for volunteers and employees in water education or environmental programs, manufacturing, agriculture and other industries. CUAHSI has already been contacted by a soft-drink bottling company about using the existing three videos in an education program worldwide for bottling plant employees. Dissemination for video is increasingly easy with venues like Google Images, YouTube and other sites reaching the public, as well as traditional science outlets such as the USGS, water departments across the country, and other organizations involved in water management or research. Additionally, the media bank recommended by the committee will provide an excellent dissemination point for the resources.

Engaging Citizens and Scientists in Solving Problems Related to Watersheds

Our committee strongly endorsed CUAHSI developing a new or collaborating on an existing citizen science program that has applicability across the country. A major criterion for choosing the science project is that it must provide to both the citizens and the scientists clear opportunities for data gathering, analysis, and synthesis for the purpose of understanding a relevant and important question. Often, citizen science programs either lack an opportunity for data analysis and problem solving for the citizen or the problem being investigated or data gathered are of little value to the scientists. Two potential citizen science programs with a water focus should be investigated for their applicability

towards CUAHSI's goals and member interests, although citizen science programs in other disciplines should also be explored as models. CoCoRaHS, the Community Collective Rain, Hail and Snow Network, is active in nineteen states with plans to expand to six new states each year. It has educational resources for use in classrooms, volunteer coordinators in every state, and its data is shared with the National Weather Service. RainLog is relatively new program focused primarily on weather monitoring in Arizona and is a project sponsored by SAHRA and the state of Arizona. GLOBE (http://www.globe.gov) has partners in nearly every state and teachers and students have been involved for more than 10 years taking precipitation observations as well as water quality observations. GLOBE engages mainly students and teachers however is applicable across all age groups. CUAHSI should explore how one or all of these programs might be customized to meet both a research and education need of the community. Collaboration with an existing program could improve the existing program while providing CUASHI a straightforward entry into this type of educational activity. Assessment of the success of such activities will need to include two-way communication between the scientists and the citizens collecting data. Examples of assessment information to be gathered are how many volunteers join and leave, quality of data, and how the data are used.

It may be possible to develop a common infrastructure for supporting citizen science projects of different types customized to regions of the country or to interests of subgroups within CUAHSI. However, to ensure sustainability, the program must meet the needs of both the scientists and the citizens. The committee briefly explored some potential research questions of value to watershed science such as having citizens look for source regions of non-point pollution using MODIS cloud sensor and snow observations collocated with watershed turbidity data. More such questions will likely arise as the CUAHSI members begin to implement the science plan and see ways that local, citizen scientists could enhance an investigation.

A citizen science project offers opportunities for customization at a local or regional level by CUAHSI members, has potential for collaboration with other geoscience education efforts, and to engage citizens of all ages and walks of life. Due to the complexity of the infrastructure often needed to support a citizen science project, this effort is best supported by a shared infrastructure at the national level.

Strategy for Implementation

During the last five years, CUAHSI has redefined its mission significantly. As initially conceived, CUAHSI was to be distributed centers (Hydrologic Observatories, HO) that would have their own place-based education and outreach programs. As the implementation of those centers slowed down, and the central office of CUAHSI evolved to become a place that supports the design of HO. For this role, the central office needs to develop a multi-pronged education and outreach plan. To shepherd these efforts, the E&O strongly recommends CUAHSI hire an E&O Director. This person should be actively involved in workshops that focus the CUAHSI scientific activities, as well as forging ties with other federal agencies to leverage resources. An example job description is appended to this report (Appendix B). Estimates of the resource needs for implementing these recommendations are given in Appendix C.

Examples of Successful Outreach Efforts

Numerous examples exist of successful education and outreach programs. A model that provides a road map is the COSEE (Centers for Ocean Sciences Educational Excellent (http://www.cosee.net). Currently there are nine COSEE centers and a central coordinating office. Not a single agency can support an outreach program of that magnitude; their network has become diversified, leveraging resources from a range of agencies and programs (NSF, Sea Grant, NOAA, ONR and CORE). The COSEE centers provide a host of services to the oceanographic community, aligned with its goals of fostering partnerships between scientists and educators and improving scientific literacy.

A COSEE activity that has garnered attention is the development of the ocean literacy standards, which, according to their website "are guiding many local, state and national efforts to develop science

standards, instructional materials, assessments, teacher professional development programs, museum and aquarium exhibits, free choice learning opportunities, and state and federal ocean policy." Developing hydrologic literacy standards is already a CUAHSI priority.

Establishing a Digital Library

To maintain resource links and quality control of the material, we propose that CUAHSI develop and maintain control of its own digital library system to organize and disseminate its education and outreach material. We are well aware of the existing online science libraries such as the NSDL (National Science Digital Library) and MERLOT (Multimedia Educational Resource for Teaching and Online Learning). Currently there are a number of earth science libraries in NSDL (e.g. ERESE, DLESE, SERC and BRIDGE), with several groups proposed to be become the GEO portal. In the development of the CUAHSI digital library, we will use standards-compliant metadata and appropriate protocols so other digital libraries can access the CUAHSI digital library. In the development of our digital library, we will carefully consider the NSDL, Suggested Tools such as the open source environment metadata repository system CWIS (Collection Workflow Integration System).

Assessment Activities

The CUAHSI E&O committee is aware that any activity we propose will have to be assessed for effectiveness. Assessment activities can be grouped under three general headings: quantitative indicators (e.g. demand for a product or number of hits on a website), qualitative indicators (e.g. personal anecdotes), and effectiveness assessments (comparing knowledge before and after an activity). We propose that CUAHSI use all three types of assessments, as appropriate to the scale and type of activity. For example, we are proposing workshops to improve science communications skills as well as determining subject matter for educational modules. These can be evaluated for knowledge and attitude change and satisfaction of participants as compared with their expectations and the stated goals of the workshop. Resources requested for assessment include setting aside funds to hire experts as needed (preferably from our member institutions) to develop appropriate assessment tools.

Obstacles to Success

To build a successful E&O program will take a significant commitment on the part of CUAHSI and the success of such an organizing effort is heavily dependent on potentially competing professional priorities. At the very least, CUAHSI members may need to self-examine how they and their respective institutions' value Education and Outreach as criteria for tenure and promotion or professional advancement. We suggest a forum on this topic be hosted by CUAHSI at AGU or other relevant society meetings. CUAHSI should develop tangible points of recognition for E&O, such as a Citation of Recognition.

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Appendices

Appendix A - Committee Membership

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Appendix B - E&O Director

For administrative support, we recommend that CUAHSI hire an:

> Outreach manager: PhD level earth system scientist (or M.S. degree at least 6 years experience) with assessment skills. His/her function would be to oversee, coordinate and assess outreach efforts, work with funding agencies to be sure CUAHSI meets its outreach obligations, work with CUAHSI member institutions to develop outreach opportunities, oversee web development and outreach support personnel. Must have proven track record of raising resources. This person would be located in DC and work closely with the CUAHSI Executive committee and the webmaster. (Salary range: full time equivalent should be in $40-$70K range depending on experience.)

Appendix C - Resources Needed

To implement this plan, CUAHSI will depend on member involvement. To start activities, the committee proposes offering incentives for scientist involvement: workshop logistics and travel and some summer salary/grad student stipend for case study, etc. development (proposed outreach activities are listed below). These funds would be competitively awarded. Estimates for proposed activities are listed below.

In addition, the effectiveness of all activities should be assessed. To accomplish this, the committee recommends that CUAHSI hire assessment experts as needed to develop evaluation material and to evaluate performance of E&O efforts as needed. The cost for this is difficult to estimate; it could be as low as $5000 per year if we use resources at member institutions or significantly higher if we go to commercial assessment organizations.

Resource Plans for Specific Activities

Resource Plan for Scientists Communicating

These activities will require both administrative oversight and web support.

Activities 1 & 2: (PY1-5) – Media Bank and Development of “white paper”. Conduct a survey of CUAHSI members to find available resources. Have an editorial committee to determine suitability of content. Determine copyright issues. Develop interactive web-based portal for films as well as reviews.

PY1 – Conduct survey & assemble material. Establish an editorial committee. Organize a workshop to develop review criteria: determine best methods for access; assign attributes such as target age-group, language, and content. Develop web-based portal for reviewers and for reviewed material. Director 6 hours/week

PY2-3 – Add reviewed material to the website. Director 3 hours/week

Resource Plan for Teaching E&O Activities

Activity 1 (PY1-3) – Development of a web-based portal (including database) to facilitate the development and evaluation of case studies in hydrology. This effort includes the development of pedagogical guidelines regarding how to create case studies, some initial pilot case studies, as well as assessment material (both for in-class assessment by the students and for on-line assessment by the instructor). It is intended that this 3 year activity would culminate in a separate proposal effort, perhaps to the NSF CCLI (”Curriculum, Class and Laboratory Improvement) competition. In addition to these costs outlined below, support from CUAHSI web administrator is required.

PY1 Workshop to launch this effort for max. 12 participants ($20,000)

PY1-2 Graduate student support to launch effort (stipend + tuition /yr: $45,000)

PY1-2 Summer salary for main faculty leading effort (maybe 2 weeks /yr: $5,000/yr)

PY1-2 Summer salary for educational specialist supporting effort (2 weeks /yr:$4,000/yr)

PY3 Workshop to review what does/doesn't work, further advance this effort ($20,000)

Activity 2 (PY1-3) – Development of an online hydrology laboratory manual. Much of this work would be managed by CUAHSI web administrator, though material to be made available would be reviewed by editorial panel to check for completeness. The web-based framework developed under the first activity can be modified to house the lab manual activity – incl. database, on-line assessment etc.

PY1 Workshop to discuss details of design, list of laboratory topics, implementation, etc. ($20,000)

PY1 1 semester graduate student support to launch effort (stipend + tuition / yr: $22,500)

PY1-3 Summer salary for main faculty leading effort (2 weeks /yr: $5,000/yr)

Resource Plan for Public Awareness of Hydrology

These activities will require both administrative oversight by CUAHSI staff and web support.

Activity 1 Short videos.

PY2 Compile list of currently available videos (see Scientist communicating, activity 1); hold workshops to develop new video topics. Identify resources and hydrologic components at CUAHSI observatories for developing new educational videos; identify funding opportunities and submit proposals; identify dissemination avenues

PY3-5 Develop new educational videos on acquired funding

Activity 2 Engaging citizens.

PY-1 CUAHSI initiate review of existing hydrologic monitoring programs and programs in similar organizations (CLEANER, LTER, etc); identify roles for citizen scientists that complement scientific need. Make recommendation to CUAHSI membership on best options to proceed in developing a program.

PY-2 Provide review and recommendations to CUAHSI members and NSF Division of Education for next steps.

PY3-5: follow through on identified steps.