Scientific, Technical, Research, Engineering, and Modeling Support (STREAMS)
Task Order 44

EVALUATING THE TECHNICAL FEASIBILITY OF INTEGRATING WETLANDS INTO A WATER QUALITY TRADING PROGRAM FOR THE GREAT SALT LAKE:

AN ALTERNATIVE FUTURES APPROACH

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INTRODUCTION

The Cadmus Group, Inc. (Cadmus) and its team members, **Dr. Heidi Hoven**, the Founder and Director of the Institute for Watershed Sciences (IWSciences), **Dr. Barry Evans**, the Director of the Geographic Information Systems (GIS) Support Center, a research unit of the Penn State Institutes of the Environment (PSIE), **Dr. Don Hayes**, Civil Engineering Professor at the University of Louisiana, and recent professor at the University of Utah, and **Mr. Steve Jensen** (wetlands restoration consultant with local expertise, and Program Manager for the Water Resources Planning and Restoration Program in the Salt Lake County Division of Engineering) are pleased to submit this proposal to the U.S. Environmental Protection Agency (EPA) to conduct an alternative futures analysis that evaluates the consequences of development/wetland protection and alteration scenarios for the Farmington Bay area of the Great Salt Lake (GSL). Increasing pressures on wetland and wildlife resources of GSL are becoming a reality as Salt Lake City develops the Master Pan for its Northwest Quadrant. The alternative futures analysis will help the Farmington Bay community make informed decisions about future land use and water quality management.

This analysis will complement research efforts examining the potential integration of a water quality trading program in the Farmington Bay area. The primary purpose of water quality trading programs is to achieve water quality goals more efficiently. Trading comes in many forms. In the case of wetlands, trading can take the form of wetlands mitigation banking, where wetlands credits are produced and used as offsets for dischargers facing higher pollution control costs. As detailed below, Cadmus staff have extensive knowledge of and experience with water quality trading programs, and have been national leaders in this area.

The Cadmus team has extensive experience (much of it local) in wetland restoration engineering approaches and application of constructed and restored wetlands for nutrient removal and water quality improvement. The Cadmus team also has extensive experience developing and applying geographical information system (GIS) models to support water resource and water quality assessment needs. Finally, the Cadmus team has extensive knowledge of estuarine and wetlands ecology. Team member Dr. Hoven has focused much of her attention on GSL and its wetlands during the last nine years. She was the lead scientist for the ecological characterization of Farmington Bay and GSL wetlands and directed wetland restoration monitoring programs within the Farmington Bay and Toelle region. Currently, she is collaborating with Dr. Theron Miller of the Utah Department of Environmental Quality's (DEQ) Division of Water Quality on several wetland condition assessment projects related to GSL watersheds. In Dr. Miller's words, "Heidi Hoven and I know more about the [Farmington] Bay and its wetlands than anybody."

TECHNICAL EVALUATION CRITERION 1 – TECHNICAL APPROACH

In this section, we present our technical approach to each of the 10 tasks, as well as summaries of our relevant past research experiences using models and analysis procedures for watershed planning, including tradeoffs between development and non-point source pollution management. We demonstrate our knowledge and capability to integrate wetlands into a water quality trading program using an alternative futures modeling approach. We summarize our experience and capabilities in wetland restoration, ecology of GSL wetland types, and application of constructed/restored wetlands for nutrient removal and water quality improvement. So as not to interrupt the flow of our technical approach, however, we have not included full details on our past performance in this section. Instead, we have included this additional detail in a third subsection of Technical Evaluation Criterion 2 – Corporate Experience. This third subsection is entitled *Technical Support (GIS Analysis, Watershed Modeling, & Data Assessment),* and begins on page 7 of this proposal. We hope that this organization facilitates EPA's review of this proposal, and welcome you to reference page 7, if you prefer, as you read through this section.

Task 1. Quality Assurance Project Plan (QAPP)

Cadmus will prepare a QAPP to set forth a standard ensuring that all project goals are met. The QAPP will be developed using a number of EPA guidance documents, including those for: 1) the Data Quality Objectives Process (QA/G-4); 2) QAPPs for Secondary Research Data; and 3) EPA Quality Manual for Environmental Programs and Requirements for QAPPs (QA/R-5). The QAPP will describe, in detail, the steps to be followed to achieve the objectives of the project and measures required to maintain quality assurance given that the majority of the data will be secondary data (i.e., collected or developed for a different project). Cadmus has prepared numerous QAPPs under many EPA Work Assignments and Task Orders, including numerous QAPPs for projects involving the collection of secondary data, as this task order does, and numerous QAPPs for the application of water quality models. Dr. Julie Blue, the Task Order Leader, helped to initiate QAPPs to ensure the quality and appropriate use of secondary data in support of EPA's Standards and Risk Management Division in the Office of Water, and has developed numerous QAPPs for the Drinking Water Protection Division and ORD's National Risk Management Research Laboratory. The QAPP for this task order will incorporate the expertise of technical personnel and the Task Order Leader. It will be discussed with EPA prior to finalization. After QAPP approval, we will begin task 2. We will submit the QAPP to EPA for review within 30 days of the award of the task order.

Task 2. Assemble and Coordinate Design Team and Finalize Project Planning

Given the importance of the outcomes and implications of this project, it is essential that the project design for the alternative futures analysis take into account detailed input from local experts and stakeholders through the development of a Project Design Team. Cadmus will identify the Design Team's potential members; team members will provide guidance on the planning assumptions used to

develop the wetland templates and alterative futures scenarios. Cadmus will consult with EPA on the type of expertise and experience sought after for team members. Cadmus staff and consultants are available to participate in the design team, including: Dr. Julie Blue (Cadmus), Ms. Laura Blake (Cadmus), Dr. Don Hayes (University of Louisiana), Dr. Heidi Hoven (Institute for Watershed Sciences), and Mr. Steve Jensen (Consultant and Salt Lake County Division of Engineering). Cadmus has also identified (and confirmed that they are interested in participating in the Design Team, if asked) the following additional potential team members: Dr. Theron Miller, (Utah DEQ, Division of Water Quality), Ms. Ella Sorensen (National Audubon Society), Ms. Anne Neville (wetlands ecologist with Kennecott Utah Copper Corporation), and Dr. Richard Toth (Utah State University). While we realize it may be desirable to keep the initial team small, we want to start with a broad net of knowledgeable potential participants. Additional proposed team members may include Rich Hansen of the Utah Division of Wildlife Resources, Bridget Olson of the Bear River Migratory Bird Refuge, and Dr. John Cavitt of Weber State Univ.

The list of recommended and accepted team members, (including contact information), the revised project plan, and the revised project schedule will be submitted to EPA for review within 60 days of the award of this task order. Once the team is finalized, Cadmus will meet with EPA and the Design Team to review the goals and objectives of the project, discuss technical approach and individual tasks, refine the project plan (if necessary), and discuss and revise the proposed project schedule.

Task 3. Site Inventory and Literature Review

There are several basic wetland types that develop under varying hydrologic conditions around GSL. Many types of hydrologic conditions occur within the Farmington Bay area. Most waterbodies draining to Farmington Bay have been developed for agricultural, urban, or waterfowl management uses and are conveyed through a series of canals, levees/dykes, and drainage ditches. Wetlands that develop in association with these drainages vary in salinity and range from wet meadow (freshwater emergents) to salt meadow (saltgrass dominant) seasonally wet areas to seasonally flooded emergent marsh areas with some woody shrubs. Impounded areas are typically fringed by emergent marsh communities and have submergent aquatic vegetation that is sometimes out-competed (shaded) by epiphytic algae, phytoplankton, cyanobacteria, and duckweed. Outflows of the impounded areas develop channels for a short distance and then sheet-flow towards Farmington Bay. Wetlands that develop in the sheet-flow areas also exhibit a gradient that increases in salinity with distance from the source-water. Plant communities along this salinity gradient respond with their respective tolerance to saline water and soil. At sites with higher nutrient inputs (effluent discharge from treatment facilities), cattail and Phragmites dominate an emergent community. Preliminary data analyses from the Farmington Bay wetland assessment study suggest that as nitrogen attenuates and salinity increases, an alkaline bulrush – dominated community develops. At the terminus of the sheet-flow, salt tolerant species are prevalent with populations of pickleweed becoming established during drought (low Lake-level) years.

Farmington Bay is surrounded by highly productive wetlands that serve as nesting grounds and habitat for forage and staging for migratory shorebirds and waterbirds, as well as provide other wetland-associated functions such as nutrient and pollutant cycling, flood attenuation, and aesthetic and recreational resources. Wetland restoration in the area has successfully used existing topography and historic Jordan River features to manage for shorebird and waterbird habitat, however, there has been little effort in the immediate area to construct wetlands for nutrient removal even though the potential for such treatment exists (e.g., at water treatment discharges). Sewer treatment facilities either have in place (North Salt Lake) or plan to construct (Central Davis Sewer District) treatment wetlands for nutrient removal and research purposes; however, a larger scale implementation of treatment wetlands for improving water quality of waters leading to Farmington Bay has yet to be planned.

The Cadmus Team has the knowledge and experience to conduct an efficient, thorough, and detailed literature review of material related to wetland functions in the Farmington Bay area. Cadmus staff have conducted hundreds of literature reviews and prepared numerous studies for EPA on a variety of related topics. We will conduct research at libraries and on the Internet to obtain the broadest coverage of relevant published materials, and the local consultants on our team will participate extensively in this task, given their broad knowledge of recently published material on the Farmington Bay wetlands. In addition, Cadmus staff maintain subscriptions to a wide variety of relevant journal publications. Many are university-affiliated with access to first rate library resources including those of MIT, Harvard, Clark Univ. and the Johns Hopkins University. Dr. Blue, the task order lead, has successfully managed numerous EPA projects involving comprehensive literature reviews and report preparation. The literature review will serve as the basis for a summary on wetland nutrient functional relationships and ecological services provided by wetlands. Specifically, the review will focus on 1) wetland assimilative capacity relative to nutrient processing and exposure, 2) the outcome and performance of wetland restoration projects by wetland type, 3) ecological services provided by the wetlands in addition to nutrient processing, and 4) the effects of lake level fluctuation on ecological services.

In addition to published journal articles, relevant unpublished documents obtained from credible sources will also be included in the literature review. Cadmus' QA Lead Reviewer will conduct periodic reviews during the research to ensure that the QAPP is being followed. Cadmus will search relevant databases and the internet and develop a summary of the literature search results in an appendix format. Cadmus will submit the appendix to EPA prior to completing the literature review. The results of the literature review will be summarized in a report. Cadmus will also develop a "wetlands research matrix" to accompany the report. Cadmus will consult with EPA on the desired format of the matrix; however, Cadmus recommends creating the matrix in a Microsoft Excel workbook. The matrix will outline and organize the various wetland nutrient functional relationships and ecological services according to wetland type.

The summary and the matrix will provide the basis for the quantitative spatial modeling activities to be conducted during the project. The summary and the matrix will be submitted to EPA within 150 days of the award of the task order.

Task 4. GIS map and Database Development for Spatial Modeling for Farmington Bay Area

Cadmus will work with County, State, Federal, and other creditable sources to obtain GIS and other data necessary to produce various project maps, develop the wetlands templates, and model the alterative futures scenarios. GIS data sets will be sought out on a statewide and county basis; example datasets that Cadmus has already accessed include:

Data	Source	Links
Land Use (2004)	IRDIAC	http://earth.gis.usu.edu/landcover.html
Animal Density	NASS	http://www.nass.usda.gov/census/census02/censusfaqs.htm
SSURGO Soils	NRCS	http://www.ncgc.nrcs.usda.gov/products/datasets/ssurgo/
Salt Lake Wetlands	Salt Lake City	http://www.surveyor.slco.org/html/gis_data.html
Septic Systems	USCB	http://factfinder.census.gov/metadoc/stf3appc.pdf
Streams	USGS	http://nhd.usgs.gov/data.html
Watershed Boundary	USGS	http://ut.water.usgs.gov/gis/hub.html
Macro invertebrate	USU	http://water.usu.edu/mapviewers/common/viewer.php
Water Quality Sampling	USU	http://water.usu.edu/mapviewers/common/viewer.php
USGS Flow Stations	USU	http://water.usu.edu/mapviewers/common/viewer.php
Weather Stations	UTAH AGRC	http://agrc.utah.gov/agrc_sgid/sgidlib/shpindex.htm
Elevation - DEM	UTAH AGRC	http://agrc.utah.gov/agrc_sgid/dem.html
Physiographic Province	UTAH AGRC	http://agrc.utah.gov/agrc_sgid/dem.html
Roads	UTAH AGRC	http://agrc.utah.gov/agrc_sgid/sgidlib/shpindex.htm
Unpaved Roads	UTAH AGRC	http://water.usu.edu/mapviewers/common/viewer.php
Point Sources	UTAH AGRC	http://agrc.utah.gov/agrc_sgid/sgidlib/shpindex.htm
Orthographic Imagery	UTAH AGRC	http://agrc.utah.gov/agrc_sgid/sgidlib/shpindex.htm
Surficial Geology	UTAH AGRC	http://agrc.utah.gov/agrc_sgid/sgidlib/shpindex.htm
Sewer Systems	UTAH AGRC	http://agrc.utah.gov/agrc_sgid/sgidlib/shpindex.htm
Wetlands	UTAH AGRC	http://agrc.utah.gov/agrc_sgid/sgidlib/shpindex.htm
County (and zip codes)	UTAH AGRC	http://agrc.utah.gov/agrc_sgid/sgidlib/shpindex.htm

Cadmus will also utilize wetland GIS data from both the Toelle and Shorelands SAMPs. These data are already in GIS format as cover classification from IKONOS satellite imagery. These and other GIS data will be formatted to meet the specific needs for the modeling strategies defined by this project. Other pertinent data will be gathered to supplement and, in some cases, to amend to existing GIS data. Examples include water quality and wetland condition data from Utah DEQ's Farmington Bay wetlands assessment study lead by Dr. Theron. These and other data (e.g., stream flow, water quality, historical weather, tax parcel information, wetland categorization, etc.) will be used to evaluate the location and quality of wetland areas, as well as to identify existing hydric soils (i.e., for potential restoration or preservation sites). All GIS maps and databases will be submitted to EPA via a Cadmus FTP site for review within 180 days of the award of the task order.

Cadmus staff have extensive experience in the application of GIS and spatial analytical methods. Dr. Sham is an authority on the implementation of GIS for water quality management. **Dr. Sham** was the lead GIS analyst supporting the Indiana Department of Environmental Management in gathering, organizing, compiling, and developing data using GIS to update Indiana's Unified Watershed Assessment (see http://www.informatik.uni-trier.de/~ley/db/journals/gis/gis9.html#ShamBM95). Dr. Sham co-authored the book chapter, *GIS and Environmental Modeling: Progress and Research Issues* in Analyzing Septic Nitrogen Loading to Receiving Waters: Waquoit Bay, Massachusetts. In addition, Dr. Sham has published numerous papers the use of GIS for environmental protection. **Dr. Evans** currently serves as the Director of the GIS Support Center, a research unit affiliated with PSIE. Over the last 10 years, Dr. Evans has provided EPA and states with expert advice and technical assistance in areas related to GIS, remote sensing, and environmental analysis. **Mr. Mulcahy** has applied his GIS expertise in numerous projects. His skills include GIS analysis and mapping; geostatistical analysis; spatial data analysis; and data collection, interpretation, and management. He was also instrumental in developing the GIS-based watershed assessment model (AVGWLF) for the Northeast.

Task 5. Project Development On-site Workshop

Within 210 days of the award of the task order, Cadmus will organize and lead a Project Development Workshop (in Salt Lake City). At the workshop, Cadmus will obtain input and guidance from the project collaborators on the final project approach. Specifically, the following items will be reviewed, discussed, and finalized during the workshop:

1) **Major wetland types for the templates.** Appropriate wetland areas for preservation or restoration will be defined by reviewing and discussing the ecological functions and services provided by various wetlands (e.g., nutrient and sediment retention; shoreline stabilization, etc.). Cadmus will work with the project collaborators to select the optimum types of wetlands for mitigating water quality impacts (e.g., based on their ability to assimilate nutrients) for use in the modeling analyses.

2) **Farmington Bay scenarios for the futures analysis.** Cadmus will work with the project collaborators to design three to five wetland protection/restoration futures analysis scenarios for the Farmington Bay area. The scenarios will represent reasonable combinations of the wetlands templates (see item 1 above) and water quality management practices (e.g., BMPs, land use management, sewage treatment plant upgrades, etc.) that can be applied in the Farmington Bay area.

3) **Analysis and modeling approaches.** One or more models will be used to evaluate the impact of different combinations of wetland templates and future scenarios on water quality in the Farmington Bay area. There are numerous modeling approaches available for evaluating the consequences of different scenarios on water quality. Cadmus will identify several options, and solicit ideas from the collaborators on other modeling options. Task 6 provides examples of modeling options already identified.

Cadmus staff have extensive experience leading project advisory committees. With his training in hydrology, GIS, fluvial geomorphology (M.A.), and planning (B.A.), Dr. Chi Ho Sham is able to effectively integrate research from experts in various disciplines and put the research findings in an integrated framework for comprehensive evaluations and implementations. Dr. Sham recently facilitated a series of workshops to develop a watershed management strategy to safeguard the source water of Groton, Connecticut. Ms. Blake also has significant experience leading project committees and facilitation technical workshops. From 2001 to 2006, Ms. Laura Blake served as the Chair for the Northeast Regional Total Maximum Daily Load (TMDL) Workgroup, which is comprised of the TMDL program coordinators from EPA Regions 1 and 2 and the New England and New York States. Between 2001 and 2006, Ms. Blake also served as chair for several State-EPA technical advisory committees, including the Connecticut River and Long Island Sound Nitrogen Loading Assessment Project.

Task 6. Template and GIS-based Spatial Model Development for Three Farmington Bay Scenarios

A series of parcel scale level (i.e., less than 200 acres) GIS templates will be created for a range of different potential wetland treatment and restoration options. The results of the literature review will aid in the selection of options with the greatest potential to offset the effects of significant land use changes (e.g., increased urban development) on Farmington Bay water quality. In addition to creating several wetland templates, three to five futures analysis scenarios will also be developed. The scenarios will focus on various factors that may contribute to or mitigate water quality impacts. For example, scenarios may look at water quality changes resulting from urban development, implementation of BMPs, and increased or decreased loading from wastewater treatment facilities. Each of the Farmington Bay area scenarios will be analyzed using one or more GIS-based models in combination with each of the wetland templates. Cadmus has already performed a preliminary review of modeling options and identified four example options that cost-effective and user-friendly; the modeling options include:

ArcView Generalized Loading Function (AVGWLF): AVGWLF is a GIS-based watershed runoff model used to evaluate the impacts of different landscape features (e.g., land use) on water quality. AVGWLF can be used to estimate nutrient loading in the Farmington Bay area, including loads resulting specifically from wetlands. Using the different wetland templates, AVGWLF's wetlands retention tool can be used to estimate the potential retention of sediments and nutrients by wetlands as a result of increased or decreased wetlands coverage in the Farmington Bay area. AVGWLF can also evaluate the impact of other land use changes (e.g., increased urban development) on water quality in the Farmington Bay area. Dr. Evans is the principal developer of the AVGWLF modeling system; further, Ms. Blake and Mr. Mulcahy have applied the model for various watershed management projects and are currently using it to analyze nutrient loading in northeastern watersheds.

Pollutant Removal Estimates for Wetlands (PREWet): PREWet is screening-level model that estimates the amount of water quality improvement provided by wetlands. PREWet calculates nutrient removal efficiencies based on a number of processes, such as microbial metabolism, adsorption, volatilization, denitrification, and settling, as well as ambient conditions, such as water temperature. Using information and data gathered during the literature review on wetland nutrient detention time and removal mechanisms, PREWet could be used to compute the nutrient removal efficiencies for the Farmington Bay area wetlands. Estimated nutrient loading to the wetlands could be obtained from AVGWLF (or another model or measured data in the field) and input into PREWet (as inflow concentrations). PREWet could then estimate nutrients outflow concentrations for the different combinations of Farmington Bay area wetland templates and futures scenarios.

Pollution Reduction Impact Comparison Tool (PRedICT): PRedICT allows for the evaluation of watershed management scenarios in which the effect of BMPs and other nutrient management options (e.g., wastewater treatment facility upgrades) can be evaluated for a given landscape condition (e.g., current or potential future land use). PRedICT would be particularly useful for estimating the nutrient load to Farmington Bay associated with each of the different futures land use scenarios identified at the Project Development Workshop. Dr. Evans is the principal developer of PRedICT, which is used by EPA and states for BMP planning.

Impervious Surface Analysis Tool (ISAT): The National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center and the Univ. of Connecticut (UCONN) Nonpoint Education for Municipal Officials Program developed the GIS-based ISAT, which is a model, used to calculate the percentage of impervious surface area of user-selected geographic areas (e.g., watersheds, municipalities, subdivisions). Using the alternative futures scenarios, ISAT could be used to evaluate water quality impacts associated

with scenarios involving increased or decreased impervious surfaces in the Farmington Bay area. Cadmus staff are very familiar with ISAT and have a close working relationship with UCONN, the model's developers.

Even though Cadmus has begun to identify potential modeling options, this is not an exhaustive list of options; additional options can be identified following award of the task order and upon further discussion with EPA and other project partners. The goal for the modeling analysis is to evaluate the potential impacts of different wetland restoration options in combination with land use changes and nutrient management activities (e.g., BMPs) on water quality in the Farmington Bay area. Evaluating the consequences of the wetland templates and futures scenarios on wetland habitat in the Farmington Bay area will rely heavily on the research undertaken for the literature review. Once critical habitat components and functions are identified for the various wetland types in the Farmington Bay area, nutrient and sediment thresholds can be developed for each category. Such information can then be used to run spatially-explicit wetland restoration and development scenarios using a combination of AVGWLF, PRedICT, PREWet, ISAT, or other models. The results of the analyses would identify where and when water quality thresholds will be exceeded in the basin, which will provide insight on the scope of the nutrient enrichment problem for the Farmington Bay area wetlands and how it might be mitigated through various restoration projects and possibly a trading program. The wetlands templates and the GIS-based models that will be used for evaluating the Farmington Bay scenarios will be completed and submitted to EPA within 300 days of the award of the task order. As discussed in Task 7, the Cadmus Team has extensive modeling experience that will facilitate the efficient and highest quality completion of the project's modeling analyses.

Task 7. Model Evaluation of Three Farmington Bay Scenarios

Cadmus will perform the model runs for the different combinations of wetland templates and futures scenarios identified at the workshop using one or more models. The wetlands templates and the GIS-based models used for evaluating the Farmington Bay scenarios will be completed and submitted to EPA within 300 days of the award of the task order. The results of the modeling analysis will be summarized in a feasibility report (see Tasks 8 and 10). The report will contain a significant number of maps and graphical summaries that illustrate the likely outcomes for the suite of alternative future scenarios.

The Cadmus team has practical hands-on experience with the development and application of GIS-based models with varying levels of complexity. While working at Boston Univ., **Dr. Sham** was the Principal Investigator of a five-year (1990 to 1994), $2 million, Land Margin Ecosystem Research (LMER) project funded by the National Science Foundation, NOAA, and EPA. **Dr. Sham** used three-dimensional groundwater flow GIS models to estimate the loading rate of nutrients from various land uses to a coastal ecosystem at Waquoit Bay, Massachusetts. His findings have been used by local agencies to develop strategies to protect groundwater and estuarine water quality. In 1995 and 1996, Dr. Sham supported EPA's Office of Science and Technology in the development of the Waquoit Bay Nitrogen Loading Model, a dynamic model for evaluating the delivery of nutrients over time from the watershed to the estuaries. Since 1996, Dr. Sham has continued to participate in the Waquoit Bay Watershed Ecological Risk Assessment Project as a consultant and as a volunteer. **Dr. Evans** currently serves as the Director of the GIS Support Center, a research unit affiliated with PSIE. He is the principal developer of the AVGWLF, PRedICT, and numerous other GIS-based watershed and BMP modeling systems. Over the last 10 years, Dr. Evans has provided EPA and states with expert advice and technical assistance in areas related to GIS, remote sensing, and environmental analysis.

Mr. Mulcahy has significant expertise and knowledge of watershed modeling, especially using GIS techniques. While working with the New England Interstate Watershed Pollution Control Commission (NEIWPCC), Mr. Mulcahy offered technical oversight and guidance to state water quality managers for a host of model and GIS applications. Mr. Mulcahy was one of the technical leads, along with Dr. Evans, on the development of the Northeast AVGWLF Model. Mr. Mulcahy also assisted in the development of GIS data used in New York State's draft Lake Lonely TMDL, created and formatted GIS data for a model evaluation of nutrient loading in two New Hampshire ponds (Rust pond and Perkins pond), and evaluated, formatted, and analyzed data used to calibrate the QUAL2K Model for the Sugar River in New Hampshire. From 2001 to 2006, **Ms. Blake** participated in the development of the GIS-based SPAtially Referenced Regressions on Watersheds (SPARROW) watershed model for New England to support nutrient loading analysis for coastal and inland watersheds. Following development of the model, Ms. Blake used the model to estimate nitrogen loading to Long Island Sound from each of the basin's four states (Connecticut, Massachusetts, New Hampshire, and Vermont). The results of the analysis are currently being used to support the development of a nitrogen reduction plan for the basin. In March 2005, **Ms. Blake** was invited to talk about the role of models in water quality management at a congressional briefing, titled *Moving from Monitoring to Prediction: The Quality of the Nation's Streams.*

Task 8. Draft Feasibility Report

Cadmus will prepare a feasibility report that discusses the goals and objectives of the project, outlines the analyses that were performed, and summarizes the results of the modeling analyses. In addition to narrative, the report will include a substantial number of maps, tables, and charts that illustrate the results of the project. Finally, the report will also discuss the feasibility of integrating wetlands restoration/protection into a water quality trading program in the Farmington Bay area. Options such as wetlands mitigation banking will be discussed. Cadmus will discuss the potential for wetlands credits to be used as offsets for dischargers facing higher

pollution control costs and the likelihood of a wetlands trading program to achieving water quality improvements in the Farmington Bay. The draft feasibility report will be submitted to EPA for review and comment within 420 days of the award of the task order.

As one of EPA's 10 most important contractors, Cadmus has decades of experience providing the highest quality reports in formats specified by EPA. Cadmus maintains editorial staff to ensure that all written products are of the highest quality. **Dr. Blue**, although a hydrologist, holds a masters degree in English, and will, as the task order lead, review all project deliverables for quality and consistency, as well as for technical issues.

Task 9. Participation in Project Outreach Workshop

Cadmus will organize and lead a Project Outreach Workshop to present and discuss the results of the modeling analyses, as well as to present options for communicating the results of the futures analysis to the Farmington Bay area stakeholders. At the meeting, Cadmus will provide an overview of the models used to conduct the analyses and present the results of the modeling analyses. The workshop will provide Project Collaborators with a chance to ask questions about and provide feedback on the modeling analyses, as well as the draft feasibility report. Cadmus will draw examples from past experiences on how best to present the results of the technical analysis to stakeholders who might not be familiar with watershed modeling or futures analysis studies. Cadmus will discuss effective outreach options, such as stakeholder meetings and outreach material. In preparation for the workshop, Cadmus may produce a number of maps, charts, and tables to illustrate the results of the modeling analysis. The Project Outreach Workshop for the Collaborators will be held within 450 days of the award of the task order.

Dr. Hoven has personally worked with diverse stakeholder groups within the study area for a number of Farmington Bay wetland and urban growth projects. Dr. Hoven has met with most, if not all, local landowners interested in area issues, as well as with real estate developers in the area. She has a well-deserved reputation with Utah DEQ as being particularly skilled at public outreach in the area, and few others have the experience with Farmington Bay wetlands technical issues and the trust of stakeholders to be as successful as she will be on this task. Cadmus staff are primed to support this workshop, and have significant experience and a record of success with public outreach projects. We regularly prepare documents for communicating scientific and technical issues to stakeholders, as well as the general public. We provide community outreach support to EPA research and rulemaking programs. Dr. Julie Blue, the task order lead for this project, provides technical advisory services and outreach for community groups, including groups in Nebraska, Texas, Rhode Island, and Maryland, concerned about environmental issues and public health related to Superfund sites.

Task 10. Final Feasibility Report

Cadmus will revise the draft feasibility report based on the discussion and outcomes of the Project Outreach Workshop. Cadmus will also address written comments from EPA in the revision. The revised final feasibility report will be submitted to EPA within 600 days of the award of the task order. As discussed under Task 8, EPA can expect the highest quality reports from Cadmus. We value timeliness and can meet quick turn-around deadlines, as evidenced by the many excellent references and recommendations we can provide from satisfied EPA project managers.

TECHNICAL EVALUATION CRITERION 2 – CORPORATE EXPERIENCE

Workshop Organization

Cadmus staff have facilitated numerous multiple-stakeholder meetings and workshops for EPA, addressing a range of issues relating to water quality assessment, planning, and management. Our support generally includes preparing advance materials, preparing agendas, disseminating meeting materials and information, taking notes during the meeting, and quickly preparing and distributing concise, accurate, and easy-to-read meeting summaries. The Design Team for this task order must be composed of creative, energized experts who understand the issues facing all stakeholders interested in the Farmington Bay wetlands and nearby development. Cadmus stands ready to support the EPA TOM in identifying these experts. In fact, one of Cadmus' greatest strengths is our ability to recruit experts that can best serve our clients' needs.

Members of our team have organized and facilitated many workshops, chaired many conferences, and served on dozens of Steering Committees. Cadmus' Dr. Chi Ho Sham was the chair of the planning committee for American Water Works Association's (AWWA) 2005 Source Water Protection Symposium. Cadmus has developed many peer review panels for EPA and professional organizations such as AWWA and the Ground Water Protection Council. From 2005 to 2006, Cadmus prepared and facilitated workshops on the development of source water protection strategies for New Hampshire, Maine, Connecticut, and Hawaii. Currently, we are working with the City of Groton (CT), organizations along the Saco River (ME and NH), and Hawaii Department of Health in formulating strategies to effectively protection their sources of drinking water. Cadmus also provided coordination support for supported the Steering Committees for the 2003 National Source Water Protection Conference and the 2003 National Gap Forum. Often, we are asked to facilitate calls or meetings, especially among groups dealing with contentious issues. We provided coordination and facilitation support for several subgroups of the National Drinking Water Advisory Council (NDWAC). Cadmus facilitated these conferences, and the members were so pleased with Cadmus' work that they wrote a letter to the Administrator expression their appreciation.

Cadmus Team Member Dr. Hoven has worked with diverse stakeholder groups within the study area for a number of projects related to wetland resources and urban growth. Dr. Hoven facilitated Steering Committee and Planning Advisory Team meetings for the Salt Lake County SAMP that engaged public and private wetland and waterfowl managers, local environmental organizations, state and Federal agency wetland and wildlife specialists, habitat conservation policymakers and local planners, and state and private land owners to review the approach and provide oversight for developing the Shorelands SAMP. She also led and facilitated the development of a wildlife functional assessment with a technical advisory group consisting of university, state, Federal, and non-profit wetland and wildlife specialists. Recently, Dr. Hoven facilitated the Vegetation and Wildlife Technical Subcommittee meetings for developing the Legacy Nature Preserve Habitat Management Plan. Key issues from these projects are central to developing alternative futures scenarios in the Farmington Bay area and many of the same stakeholders will likely participate in the project.

Report Preparation

As one of EPA's 10 most important contractors, Cadmus has decades of experience providing the highest quality reports in formats specified by EPA. Cadmus provides reports in hard copy, via e-mail or Web-based file transfer sites, on CDs, or on Web sites. Cadmus maintains editorial staff to ensure that all written products are of the highest quality. All of the Cadmus Team is experienced in working within government programs with tight controls on formatting issues. For example, Dr. Chi Ho Sham analyzed data collected for the National Survey of Pesticides in Drinking Water Wells and was responsible for writing many reports and applying GIS technology in the project. Working closely with EPA staff, Dr. Sham developed a Class V Underground Injection Control State Implementation Guide and PowerPoint slides for 10 training sessions. Dr. Julie Blue manages and contributes to the development of numerous EPA technical documents and regulatory guidance manuals for water quality issues, including a State-of-the-Art Report on the Effectiveness of Natural and Constructed Wetlands in Mitigating the Water Quality Degradation. Ms. Blake and Mr. Mulcahy also provide EPA and the states with technical report writing support through the development of regulatory TMDL reports.

Dr. Hoven is the lead author on a wetland and wildlife functional assessment for the Shorelands SAMP and a habitat management plan for the Legacy Nature Preserve, as well as many annual monitoring reports for local wetland restoration projects. She co-authored a South Davis Constructed Wetland Feasibility Study for South Davis Sewer District, Utah; a Box Elder County comprehensive wetlands management plan; Box Elder County, Utah; in addition to other regional large-scale habitat restoration plans (Lower Colorado River Multi-Species Conservation Plan, Arizona, Nevada, and California; Conservation Management Plan for the lower Truckee River, Northeastern Nevada; and Pabco Road Riparian Restoration Project; Clark County, Nevada).

Technical Support (GIS Analysis, Watershed Modeling, & Data Assessment)

State-of-the-Art Report on the Effectiveness of Natural and Constructed Wetlands in Mitigating the Water Quality Degradation. (PI: Dr. Julie Blue, Sponsor: EPA NRMRL: 2006-present). Cadmus is finalizing an outline, following a QAPP we prepared, conducting an extensive literature review, and writing draft and final reports on the issue. Reviews of modeling studies are included. We are focusing on documenting long-term performance of wetlands for mitigating water quality degradation.

Nitrogen Loading Study for Four Estuaries on Cape Cod, Massachusetts (PI: Dr. Chi Ho Sham, Sponsor: MA DEP, 2001-current). Cadmus is supporting the assessment of nitrogen loading to selected estuaries on Cape Cod. The project will evaluate land use in the estimation of nitrogen loading, estuarine flushing dynamics, and critical load for the preservation of ecosystems.

Nitrogen Loading Modeling Land Margin Ecosystem Research (PI: Dr. Chi Ho Sham, Sponsors: NSF, NOAA, EPA, 1990-1994). Dr. Sham used three-dimensional ground water flow models, GIS, field data, and biogeochemical data to determine the loading rate of nutrients from various land use to ground water and a coastal ecosystem at Waquoit Bay, Massachusetts. His findings were a basis for ground water protection strategies in the Waquoit Bay watershed.

Ecological Risk Assessment of Nutrient Impacts on Estuarine Ecosystem at Waquoit Bay, Massachusetts (PI: Dr. Chi Ho Sham, Sponsor: EPA OST, 1995-1996). Cadmus participated in the Waquoit Bay Ecological Risk Assessment Project, assessing the impacts of nutrients on the estuarine ecosystem, and developing a dynamic model that evaluates the delivery of nutrients over time from the watershed to the estuaries.

Developing a Wildlife Functional Assessment Tool as a Supplement to a Slope Depressional Wetland Functional Assessment Method Used in the Salt Lake County Shorelands SAMP (PI: Dr. Heidi Hoven). Salt Lake County, Utah includes some of the most important migratory shorebird habitat adjacent to GSL. Currently, the County and Salt Lake City are in the process of updating their master plans for this habitat. Dr. Hoven assisted with the development of a SAMP for this area to help City and County planners and the Army Corps of Engineers minimize negative influences of development that are encroaching or may encroach on the area. One of the first steps of the SAMP was to map wetlands and determine their relative level of functioning.

Farmington Bay Wetlands Condition Metrics Phase I; Salt Lake, Davis and Box Elder Counties, Utah (PI: Dr. Heidi Hoven, Sponsor: Utah DEQ, 2006-2007). The study involves identifying metrics of wetland condition that correlate with water

quality to be used to develop standards by which beneficial use can be quantitatively described. Work includes review of statistical analyses of data from DEQ's Farmington Bay Wetlands Condition Metrics Study, identification of data gaps, and develop recommendations for refining metrics.

Reference Wetland Network Phase I; Salt Lake, Tooele, Utah, Davis and Box Elder Counties, Utah (PI: Dr. Heidi Hoven, Sponsor: Utah DEQ, 2006-2007). Review existing assessment data from various sources, identify data gaps and develop how data will be processed to form a reference wetland network (with oversight from EPA). Convene Utah Wetlands Assessment Group (UWAG) to review process and provide input.

Rapid Assessment Method (RAM) Development for wetlands of Great Salt Lake Phase I; Salt Lake, Tooele, Utah, Davis and Box Elder Counties, Utah (PI: Dr. Heidi Hoven, Sponsor: Utah DEQ, 2007). Convene UWAG to draft a RAM model and test it against existing RAM model results. Use of reference wetland data to calibrate the GSL wetlands RAM planned.

Evaluation of Selenium Fate and Transport in Farmington Bay Wetlands (PI: Dr. Don Hayes, Sponsor: Utah DEQ, 2005-2007). A proposed new discharge to GSL requires the development of a Selenium standard for GSL. As part of an effort to assess current Selenium loading to GSL, this study is collecting an extensive water quality data set from the beginning of a wetland complex along the shores of Farmington Bay to its discharge into GSL. The flow and water quality data are being used to identify and quantify the natural physical, chemical, and biological processes that affect Selenium fate and transport in GSL wetlands.

Development and Calibration of Flow and Water Quality Models for the Jordan River (PI: Dr. Don Hayes, Sponsor: Utah DEQ, 2006). Utah DEQ is in the process of developing TMDLs for the lower portion of the Jordan River. Initial analyses and data collection showed significant problems with dissolved oxygen, dissolved solids, and bacteria as the result of upstream activities. Dr. Hayes helped to develop and calibrate flow and water quality models (HEC-RAS and QUAL2K, respectively) for the Jordan River from Utah Lake to GSL. Both models are currently in use by the Division of Water Quality for TMDL analyses on the Jordan River.

Groundwater Assessment Along the Proposed Legacy Parkway Alignment (PI: Dr. Don Hayes, Sponsor Utah Department of Transportation, 2003-2005). Legacy Parkway is a new highway proposed for the northwest corner of the Salt Lake Valley that would connect I-215 to I-15 through a bypass between the existing I-15 corridor and GSL. After the initial design, the Utah Dept. of Transportation became concerned that the surcharge load associated with the roadway embankment would restrict groundwater flow across the highly productive wetland ecosystems that exist along the shores of GSL. As a result of these analyses, the embankment was reduced in size to minimize its influence on the complex groundwater flows in the area.

Lake Kinneret, Israel AVGWLF Model (PI: Dr. Barry Evans, Sponsor: National Water Commission of Israel, 2004-current). Dr Evans is currently working with the National Water Commission of Israel to use AVGWLF to assess water quality problems in Lake Kinneret (also known as the Sea of Galilee) located in the northern part of the country. Interim papers and articles related to this project are available upon request.

Mexico AVGWLF Model (PI: Dr. Barry Evans, Sponsor: Mexican Institute of Water Technology (IMTA), 1999-current). Dr. Evans is working with IMTA in their efforts to apply AVGWLF to diffuse pollution/water quality projects in Mexico, including development of a Spanish-language version of AVGWLF and software training to IMTA technical staff.

Northeast AVGWLF Model (PIs: Dr. Barry Evans, Ms. Laura Blake, & Mr. Tom Mulcahy, Sponsor: New England Interstate Water Pollution Control Commission, 2004-current). Dr. Evans and team adapted AVGWLF for use in the Northeast. The project has involved calibration and testing on 22 watersheds in the region and adjustments to various data parameterization and model simulation algorithms to provide for better estimates of nutrient and sediment loads.

Development of NY Phosphorus, Dissolved Oxygen, and Silt/Sediment TMDLs for Small and Medium Sized Lakes (PI: Ms. Laura Blake, Sponsor: EPA, 2006-current). Cadmus is currently working on a project for EPA to develop TMDLs for nutrient impaired lakes in New York State using a linked GIS-based watershed runoff and in-lake water quality model.

Integrated Watershed Approach Demonstration Project for the Green Bay AOC/Lower Fox River Watershed (Ms. Laura Blake, Sponsor: EPA, 2006-current). Cadmus is currently working on a demonstration project for EPA to compare multiple alternative pollutant reduction scenario options that could be used to address nutrient impairments in Lower Green Bay and the Lower Fox River (LFR) Watershed. The project is investigating the most cost-effective combination of implementation approaches for restoring the Green Bay AOC and the LFR Watershed using an integrated watershed approach.

Development of Landscape and Water Quality Model for the Hangman Creek Watershed, Washington and Idaho (Ms. Laura Blake, Sponsor: EPA, 2006-current). Cadmus is currently working on a project for EPA to calibrate the GIS-based water quality WARMF model for the Hangman Creek Watershed, to develop a TMDL for total suspended solids and total phosphorus.

TECHNICAL EVALUATION CRITERION 3 – PERSONNEL

Cadmus offers EPA a superior project team for this task order in that they include local experts with the strongest background in Farmington Bay wetlands (e.g., **Dr. Heidi Hoven**, a wetlands ecologist, has worked closely with proposed Design Team member, Dr. Theron Miller, on Farmington Bay wetlands projects) and scientists and engineers with expertise in wetland restoration, GIS-based modeling (including the principal developer of the GIS-based AVGWLF and PRedICT modeling systems), water quality trading systems, and working with diverse stakeholders. They have extensive experience managing and reporting research (as most have spent the greatest part of their careers supporting EPA or other government entities), as well as in organizing workshops (including high-level technical input) for diverse stakeholders. Additional detail on these individuals is provided in the attached resumes.

Dr. Julie Blue is a Senior Scientist at Cadmus and will serve as the Task Order Lead for this project. Dr. Blue will be responsible for monitoring technical progress and costs incurred, overseeing consultants' contributions, and discussing the project status with key staff on each of the tasks on a regular basis. She will lead the QAPP preparation, provide a final review of all major deliverables, and will maintain close communication with EPA. Dr. Blue has more than 14 years of experience in environmental research and monitoring. She is currently task order lead for an EPA ORD project writing a State-of-the-Art Report on the Effectiveness of Natural and Constructed Wetlands in Mitigating the Water Quality Degradation. She has managed numerous projects on stormwater management for EPA. She leads Cadmus' efforts on the STREAMS contract, and manages a River Rouge E. coli monitoring project. Formerly full-time college faculty, Dr. Blue has taught on the effectiveness of wetlands in mitigating water quality degradation. Her expertise includes data analysis, mathematical modeling, and contaminant fate and transport. With an M.S. in English and a doctorate in Hydrology, Dr. Blue has written extensively for numerous EPA documents, including an EPA source water microbial report focusing on non-point source pollution. She has conducted research on the costs and benefits of BMPs to control both point and nonpoint source pollution. She has managed numerous EPA projects involving extensive literature reviews and report preparation and founded and directs Cadmus' Technical Assistance program, whereby Cadmus provides technical advisory services and outreach to community-based organizations concerned about environmental issues.

Dr. Chi Ho Sham is a Senior Scientist and Vice President at Cadmus. Dr. Sham received his doctoral degree (with a focus on hydrology and GIS) from the State Univ. of New York at Buffalo. Dr. Sham joined Boston Univ. in 1982 and was a member of the faculty at the Center for Energy and Environmental Studies and the Department of Geography, where he taught graduate and undergraduate courses in hydrology, water resources, landscape analysis, environmental principles and policy, GIS, and computer modeling. During his 10 years at Boston Univ., Dr. Sham conducted numerous extramurally funded research projects including Waquoit Bay Land Margin Ecosystem Research, GIS implementation and natural resource management at the Cape Cod National Seashore, Urban Forest Assessment, GIS land use mapping for water quality assessment, and distributed GIS processing over a wide-area network. Dr. Sham joined Cadmus in 1991 and began providing technical support to various EPA offices, including the Office of Wetlands, Oceans, and Watersheds (OWOW), Office of Research and Development (ORD), and numerous others. Over the past decade, Dr. Sham has provided technical support to federal, state, and local clients with drinking water protection, wastewater analysis, watershed planning, groundwater modeling, GIS applications or water quality management and wetlands advance identification, public involvement, pollution prevention, source water assessment, TMDL development, and stormwater planning and management.

Dr. Heidi Hoven brings a wealth of local and regional expertise in addressing wetland and watershed issues. She has extensive experience in estuarine and wetlands ecology, and is experienced in wetland restoration and conservation planning. Many of Dr. Hoven's projects focus on GSL at its wetlands. She was the lead wetland scientist for the ecological characterization of Farmington Bay and GSL wetlands, developed a wildlife functional assessment model for the Salt Lake County Shorelands SAMP, conducted a monitoring program as a baseline study and assisted in planning for the restoration of Jordan River floodplain on the Legacy Nature Preserve in Davis County, Utah, led a large-scale monitoring program for the successful mitigation of 2500 acres of wetlands of the Inland Sea Shorebird Reserve of Salt Lake County, and helped develop a Comprehensive Wetlands Management Plan for the GSL subwatershed in Box Elder County, Utah. Currently, Dr. Hoven is collaborating with Dr. Theron Miller of the State of Utah Division of Water Quality on a number of wetland condition assessment projects related to GSL watersheds. Additionally, she is a Visiting Research Professor at Weber Sate Univ. of Ogden, Utah, where she offers quest lectures on wetland science and her current research. Dr. Hoven has applied experience in watershed management issues and planning sustainable use of resources within watersheds.

Dr. Barry Evans is the Director of the GIS Support Center, a research unit affiliated with the Penn State Institutes of the Environment (PSIE). He has over 25 years of experience in the environmental sector. One of his primary ongoing activities involves the development of specialized GIS and other software applications to support water resource/water quality assessment needs. Dr. Evans is the principal developer of the GIS-based AVGWLF and PRedICT modeling systems that are currently being used by EPA, numerous states, and other entities to support TMDL development and other watershed assessment and water quality analyses. In addition to his EPA and state-related work, Dr. Evans has worked on projects sponsored by the National Science Foundation, and has provided technical expertise to such diverse groups as the Ontario Ministry of Environment; the Mexican Institute of Water Technology; the State of Nuevo Leon, Mexico; the Swedish Meteorological and Hydrological Institute, and the National Water Commission of Israel. Dr. Evans has a B.S. in Natural Resources (Ohio State), a Master's degree in Environmental Pollution Control (Penn State), and a Ph.D. in Soil Science (Penn State).

Ms. Laura Blake is a Scientist and Project Manager at Cadmus. Ms. Blake received her Master degree in Environmental Management (with a focus on water resources) from Duke Univ.'s School of the Environment and her B.A. in Geology and Environmental Science. Ms. Blake has extensive experience supporting EPA and states on the application of watershed assessment models. Ms. Blake served as the TMDL Technical Program Manager for the New England Interstate Water Pollution Control Commission (NEIWPCC), where she developed water quality models to support watershed protection at the state and local levels, including the AVGWLF Model for NPS pollutant load measurement and tracking and the SPARROW Model for nutrient loading assessments. As the Northeast TMDL Workgroup Chair, Ms. Blake facilitated the exchange of ideas, methods, and progress with regard to restoring polluted water bodies among the States and with EPA. From 2001-06, Ms. Blake coordinated and facilitated specialty workshops on regional water quality issues, including bacteria-impaired waterbodies and waterbodies impaired due to urban stormwater runoff. Ms. Blake was a member of the New England Biological Assessment of Wetlands Workgroup (NEBAWWG), where she worked to identify wetland assessment techniques and evaluate the performance of wetland restoration projects.

Mr. Thomas Mulcahy is a GIS and Modeling Research Analyst at Cadmus. Mr. Mulcahy has significant expertise and knowledge of the AVGWLF Model and was one of the technical leads (while working for NEIWPCC), along with Dr. Evans, on the development of a large, regional AVGWLF Model. Mr. Mulcahy worked with state and federal agencies to identify relevant data sources to compile, manipulate, re-project, and create multiple GIS data layers for use in AVGWLF. Mr. Mulcahy was the lead in developing and formatting all the required data for calibration and validation of AVGWLF for 27 watersheds in New England and New York. While at NEIWPCC, Mr. Mulcahy offered technical oversight and guidance to state water quality managers for a host of other model and GIS applications. Mr. Mulcahy assisted in the development of GIS data used in the Lake Lonely TMDL, created and formatted GIS data for an AVGWLF evaluation of nutrient loading in two New Hampshire ponds, and helped to evaluate and analyze data used to calibrate the QUAL2K Model for the Sugar River in New Hampshire, in preparation for a TMDL.

Dr. Karen Sklenar, a Senior Scientist with Cadmus, will lend her expertise in pollutant trading, wetlands, and working with stakeholders, to the literature review and project planning, a review of sections of the final project report, and participation in the project outreach workshop. Her Ph.D. work in Environmental Engineering Science from the Univ. of California, Berkeley, was focused on applied limnology. She has worked on ***pathogen removal in wetlands*** in New York's Catskill watershed, ***selenium distribution and reduction in constructed wetlands at the Kesterson Wildlife Refuge*** in California's San Joaquin Valley, and the ***role of wetlands in the distribution of heavy metals*** in the San Francisco Bay. She is currently working with ***stakeholders*** in the Octoraro watershed, an interstate basin with high nitrate levels that drains into the Chesapeake Bay, where the local task force is establishing a ***nutrient trading marketplace*** for point and nonpoint source polluters. Dr. Sklenar is particularly interested in finding ways for groups with common water quality interests to work more effectively together. She leads an AwwaRF study to improve water utility participation in the TMDL process. She has coordinated an annual conference for water utility managers to learn more about reservoir management and watershed protection. She has served on numerous watershed committees, and has a strong understanding of water chemistry and environmental microbiology.

Mr. G. Tracy Mehan, III, a Principal with Cadmus, will serve as an expert in pollutant trading and contribute to the literature search, project planning, and final report. He has extensive experience working with stakeholders. Mr. Mehan was EPA's Assistant Administrator for Water from 2001-03 In that capacity he directed the Clean Water and Safe Drinking Water Acts programs including permitting, infrastructure finance, wetlands regulation, standards and watershed management. As Assistant Administrator, Mr. Mehan ***developed new policies and guidance on watershed-based permitting and water quality trading***. Mr. Mehan has published articles, made numerous presentations on the principles and role of water quality trading and was instrumental in ***organizing the first National Water Quality Trading Conference***. He is a graduate of Saint Louis Univ. and its School of Law.

Dr. Don Hayes will serve as a consultant on Farmington Bay wetland restoration issues for this task order and will be available to participate in the Design Team. He was recently a faculty member of the Department of Civil and Environmental Engineering at the Univ. of Utah and is currently the Co-Director of the Institute for Coastal Ecology and Engineering and the UNOCAL/BORSF Professor of Civil Engineering at the Univ. of Louisiana, Lafayette. He holds a Ph.D. in Environmental Engineering and Water Resources Planning and Management. Prior to his academic career, Dr. Hayes worked for 10 years with the US Army Corps of Engineers at the Engineer Research & Development Center. He has published over 100 journal papers, research reports, and book chapters and is widely recognized for his research on wetland restoration and contaminated sediment remediation. He has co-chaired a number of national conferences, including two focused on wetland restoration.

Mr. Steve Jensen will lend his extensive local wetlands experience to this task order as a consultant on wetland restoration issues and on the task order's GIS-based modeling tasks, and will be available to participate in the Design Team. Mr. Jensen is the Program Manager for the Water Resources Planning and Restoration Program in the Salt Lake County Division of Engineering. His wetland planning experience includes completion of three EPA-funded regional wetland advance identification projects, which mapped and prioritized the areas (for conservation/acquisition) using functional values (Adamus) covering 13,000 acres. His graduate degree in environmental planning, strongly influenced by McHarg (the father of GIS analysis), provided a strong background for his work in watershed-based mapping & analysis. He is a certified wetland delineator and has thirty five years of experience focused on water quality, stormwater, and water resource planning & restoration.

JULIE BLUE, Ph.D.

Senior Hydrologist **The Cadmus Group, Inc.**

EDUCATION

Ph.D., Hydrology, University of Arizona
M.S., Earth Sciences/Hydrogeology, University of California
M.A., English, Indiana University
B.A., English and Mathematics, Swarthmore College

QUALIFICATIONS

- Prepares training materials and conducts short courses on the source water assessment process and source water protection.
- Former full-time college faculty (assistant professor). Courses taught include Hydrogeology, Surface Water Processes, Environmental Geology, Contaminant Transport.
- Managed and conducted projects addressing a range of topics including wetlands for mitigating water quality degradation, lake eutrophication, delineating source water protection areas, non-point source pollution, storm water, industrial wastewater disposal, hazardous waste remediation, watershed assessments, microbial pathogens, contaminated sediments, etc.
- Oversees and contributes to development of technical documents and regulatory guidance manuals for water quality issues.
- Lead author on EPA Safe Drinking Water Act Guidance Manuals, including the Riverbank Filtration Guidance for the Long-Term 2 Enhanced Surface Water Treatment Rule, and Hydrogeologic Sensitivity Assessment Guidance for the Ground Water Rule.

RELEVANT PROJECTS

2005-10 **Research Support for EPA's Office of Research and Development.** Deputy Contract Manager. Responds to RFPs and meets with EPA technical staff as manager of Cadmus's 5-year contract with EPA's National Risk Management Research Laboratory. Under this contract, Cadmus provides EPA with technical, laboratory, field, and modeling support related to a variety of research areas including watershed stressors, wetlands, biosolids and wastewater treatment, waste management, endocrine disrupting compounds, groundwater, sustainability, and emerging wastes.

2005-2006 State-of-the-Art Report on the Effectiveness of Natural and Constructed Wetlands in Mitigating the Water Quality Degradation. Project Manager / Senior Scientist. Finalizing an outline, preparing and following a QAPP, conducting an extensive literature review, and writing draft and final reports on the issue. Reviews of modeling studies are included. Focusing on documenting long-term performance of wetlands for mitigating water quality degradation.

2003-06 **Source Water Assessment Program Training**. Project Manager / Senior Scientist. Led the development of and conducted several training courses on Source Water Assessments for tribal environmental and drinking water staff in EPA Region 9.

2005-06 **Technical Advisory Services to Woonasquatucket River Watershed Council.** Program Director/Project Manager/ Senior Scientist. Lead a team of Cadmus scientists and engineers evaluating technical and regulatory documents on risk assessment and remedial activities associated with contaminated soil and sediment at the Centerdale Manor Superfund Site in Providence, RI. Prepare comments and written reports for the council and the public. Attend public meetings and give presentations.

2005-07 **Large Capacity Septic Systems, Stormwater Best Management Practices, and Stormwater Drainage Wells**. Project Manager / Senior Scientist. Contributed to report on the evaluation of large capacity septic systems on tribal lands. Evaluates stormwater best management practices (BMPs) recommended by NPDES Program and prepared report for EPA's Underground Injection Control (UIC) program. Identifies target audiences for outreach on proper use of stormwater drainage wells. Conducted research on potential impacts of such wells. EPA will use the report to evaluate regulatory efforts to prevent endangerment of underground sources of drinking water.

2004-07 **Class V Industrial Injection Well/Septic System Compliance Assistance and Outreach**. Project Manager / Senior Scientist. Supported EPA in developing compliance assistance documents for selected commercial and industrial sectors. Conducted literature review of case studies of groundwater contamination by industrial septic systems and other Class V wells, and evaluated constituents of wastewater from numerous industrial sectors.

2004-05 **Assessing the Economic Impact of Proposed General Permit Requirements for Stormwater Class V Injection Wells: EPA Workgroup Meeting Support.** Senior Scientist. Researched BMPs for stormwater management. Researched state general permit programs for EPA workgroup meeting and managed preparation of final workbook. Assessed the economic impact associated with the use of general permits on owners and operators of stormwater drainage wells and EPA Regions and Headquarters.

2002-06 **Long-Term 2 Enhanced Surface Water Treatment Rule – Microbial Toolbox – Riverbank Filtration Guidance.** Senior Scientist. Reviewed literature and researched key issues related to riverbank filtration, and wrote Bank Filtration chapter for guidance document. Supported EPA's response to comment process.

2004 **Study on the Impact of Waterborne Microbial Disease on Public Health.** Supported EPA in preparing a study of point source and non-point source pollution as it relates to public exposure to waterborne microbial disease. The study emphasized sources such as confined animal feedlot operations (CAFOs), wildlife, and other non-point sources.

SELECTED PUBLICATIONS AND PRESENTATIONS

Blue, Julie; Sham, Chi Ho; Jollie, Jeff. Stormwater Drainage Wells and their Threats to Underground Sources of Drinking Water. Proceedings of the New England Water Works Association Fall 2006 Water Resource Symposium, Oct. 2006.

Blue, Julie (Invited Speaker). Bank Filtration and the Long Term 2 Surface Water Treatment Rule. *Riverbank Filtration Design Workshop at the New England Water Treatment Technology Assistance Center*. University of New Hampshire, Oct. 2006. Workshop manual forthcoming (co-author).

M.L. Brusseau, N.T. Nelson, Z. Zhang, J.E. Blue, J. Rohrer, and T. Allen. Source-Zone Characterization of a Chlorinated-Solvent Contaminated Superfund Site in Tucson, AZ. *J. Contaminant Hydrology*. Recommended for publication, 2/06.

USEPA, Draft Microbial Toolbox Guidance Manual for the Proposed Long Term 2 Surface Water Treatment Rule. http://www.epa.gov/safewater/lt2/pdfs/guide_lt2_toolbox.pdf. June 2003.

Boving, Thomas; Blue, Julie, Long Term Contaminant Trends at the Picillo Farm Superfund Site in Rhode Island, Remediation. Wiley Interscience, Spring 2002.

J. Blue, J. Davis, D. Naftz, E. Feltcorn, G. Freethey, et al.. Field Demonstration of Permeable Reactive Barriers to Remove Dissolved Uranium from Groundwater, Fry Canyon, Utah. Spring, 1999. www.epa.gov/radiation/cleanup/docs/frycan_techdemo _interim_040201.pdf

HEIDI MORRILL HOVEN

Plant Biologist/Wetland Ecologist **The Institute for Watershed Sciences**

Education and Training

- Ph.D., major in Natural Resources, University of New Hampshire, 1998
- M.S., major in Botany, University of New Hampshire, 1992
- B.S., major in Natural Resources, University of Rhode Island, 1986

Areas of Expertise

Dr. Hoven is a plant biologist with extensive experience in estuarine and wetlands ecology as well as plant ecotoxicology. She has a strong understanding of ecological plant physiology of halophytic and riparian vegetation, and is experienced in wetland restoration and conservation planning. She has a broad range of academic and professional experience that provides her with a well-rounded perspective in approaching natural resources management problems. She has applied experience in watershed management issues and planning sustainable use of natural resources within watersheds.

Many of her more recent projects focus on Great Salt Lake at its wetlands. She was the lead wetland scientist for the ecological characterization of Farmington Bay and Great Salt Lake wetlands, developed a wildlife functional assessment model for the Salt Lake County Shorelands SAMP, conducted a monitoring program as a baseline study and assisted in planning for the restoration of Jordan River floodplain on the Legacy Nature Preserve in Davis County, Utah, lead a large-scale monitoring program for the successful mitigation of 2500 acres of wetlands of the Inland Sea Shorebird Reserve of Salt Lake County, and helped develop a Comprehensive Wetlands Management Plan for the Great Salt Lake subwatershed in Box Elder County, Utah. Currently, she is collaborating with Dr. Theron Miller of the State of Utah Division of Water Quality on a number of wetland condition assessment projects related to Great Salt Lake watersheds.

Dr. Hoven is the Founder and Director of the Institute for Watershed Sciences (founded in 2006). IWSciences is organized exclusively for scientific and educational purposes. We provide solutions through scientific research, technology development, and technical services for the benefit of government, industry, and the public. So that policy and operational decisions are informed by sound scientific process, IWSciences effectuates the public and private management and understanding of the resources of Great Salt Lake and its subwatersheds. Dr. Hoven brings a wealth of local and regional expertise in addressing wetland and watershed issues. Additionally, she is a Visiting Research Professor at Weber Sate University of Ogden, Utah, where she offers quest lectures on wetland science and her current research. Students are encouraged to participate as interns on local studies with The Institute for Watershed Sciences by assisting in field research and sample processing. Students learn to apply the scientific method and the elements of sample design.

Current Relevant IWSciences Projects

Farmington Bay Wetlands Condition Metrics Phase I; Salt Lake, Davis and Box Elder Counties, Utah (2006 -07): The study involves identifying metrics of wetland condition that

correlate with water quality to be used to develop standards by which beneficial use can be quantitatively described. Work includes review of statistical analyses of data from DEQ's Farmington Bay Wetlands Condition Metrics Study, identification of data gaps, and develop recommendations for refining metrics, *Client: State of Utah DEQ*.

Reference Wetland Network Phase I; Salt Lake, Tooele, Utah, Davis and Box Elder Counties, Utah (2006 -07): Review existing assessment data from various sources, identify data gaps and develop how data will be processed to form a reference wetland network (with oversight from EPA). Convene Utah Wetlands Assessment Group (UWAG) to review process and provide input. *Client: State of Utah DEQ*.

Rapid Assessment Method (RAM) Development for wetlands of Great Salt Lake Phase I; Salt Lake, Tooele, Utah, Davis and Box Elder Counties, Utah (2007). Convene UWAG to draft a RAM model and test it against existing RAM model results. Use of reference wetland data to calibrate the Great Salt Lake wetlands RAM will be carried out in future work. *Client: State of Utah DEQ*.

Relevant Professional Experience

- Founder and Director of the Institute for Watershed Sciences (2006 - present).
- Senior Scientist / Project Manager, SWCA Environmental Consultants; Salt Lake City, Utah (1999–2006).
- Field and Laboratory Research Assistant, Eelgrass Restoration Project for the New Hampshire Port Authority Port Expansion Project (1995–1997).
- Field Collections Coordinator, Estuarine Ecological Risk Assessment for Portsmouth Naval Shipyard (1991–1993).
- Research Assistant, Waquoit Bay Estuary Watershed Risk Assessment (1989).

List of Relevant Publications, Reports, and Presentations Available upon Request

CHI HO SHAM, PH.D.

Vice President/Senior Environmental Scientist **The Cadmus Group, Inc.**

EDUCATION/SPECIAL TRAINING

Ph.D., Geography, State University of New York at Buffalo, 1984
M.A., Geography, State University of New York at Buffalo, 1980
B.A., Geography (with Great Distinction), University of Regina, Canada, 1978

Geographic Information System Development and Implementation

Principal Investigator, Geographic Information System (GIS) and Ground Water Modeling for Land Margin Ecosystem Research. As a Principal Investigator of a five-year (1990 to 1994), $2 million, Land Margin Ecosystem Research (LMER) project funded by the National Science Foundation, National Oceanic and Atmospheric Administration, and EPA, Dr. Sham linked three-dimensional ground water flow models and a GIS, field data to determine the loading rate of nutrients from various land use to ground water and a coastal ecosystem at Waquoit Bay, Massachusetts.

Project Manager and Principal Scientist, Development and Implementation of GIS Technology for Aquifer Protection and Management. From 1991 to 1995, Dr. Sham directed the development and implementation of GIS for EPA Region 2 to provide analytic and decision support tools for aquifer protection and management activities at the local level. Dr. Sham was responsible for the development of system specifications, the integration of hardware and software, database development, and training of GIS users. Dr. Sham also conducted comprehensive reviews of the quality and usability of various GIS data layers (including data developed using Global Positional System and address matching).

Principal Investigator, Development and Implementation of GIS Technology for Natural and Cultural Resource Management and Planning. From 1987 to 1990, Dr. Sham directed the development of a GIS for the U.S. National Park Service to provide decision support in the areas of natural and cultural resources management and planning. Dr. Sham managed the integration of hardware and software components of the GIS, the development of the database and subsequent applications. The systems are currently used by the National Park Service to identify and manage natural and cultural resource problems.

Technical Support to Water Quality Assessment and Protection Programs

Program Manager/Senior Scientist, Development of TMDL and Water Quality Analyses. From 2002 to 2006, on behalf of EPA Office of Wetlands, Oceans, and Watersheds, Dr. Sham managed and coordinated a variety of TMDL and water quality studies under Contract 69-C-02-109 and they cover locations in Pennsylvania, Louisiana, District of Columbia, Minnesota, Montana, Michigan, and Arkansas. In addition, Dr. Sham participated in an comparative study that evaluates the water quality standards for various stream segments that have drinking water intakes.

Senior Scientist, Performing TMDL Reviews. In 2000, on behalf of EPA Region 3, Dr. Sham provided technical support in reviewing TMDLs submitted by Pennsylvania and Maryland on a range of pollutants that include nutrients, heavy metals, and acid mine drains. These reviews were completed under a very tight schedule and delivered to EPA Region 3 in a timely fashion.

Principal Investigator, Nitrogen Loading Modeling Land Margin Ecosystem Research. As PI of a five_year (1990 to 1994), $2 million, Land Margin Ecosystem Research (LMER) project funded by the National Science Foundation, National Oceanic and Atmospheric Administration, and EPA, Dr. Sham used three_dimensional ground water flow models, GIS, field data, and biogeochemical data to determine the loading rate of nutrients from various land use to ground water and a coastal ecosystem at Waquoit Bay, Massachusetts. His findings were a basis for ground water protection strategies in the Waquoit Bay watershed.

Project Manager/Senior Scientist, Ecological Risk Assessment of Nutrient Impacts on Estuarine Ecosystem at Waquoit Bay, Massachusetts. From 1995 to 1996, on behalf of EPA's Office of Science and Technology (OST), Dr. Sham participated in the Waquoit Bay Ecological Risk Assessment Project, assessing the impacts of nutrients on the estuarine ecosystem, and developing a dynamic model that evaluates the delivery of nutrients over time from the watershed to the estuaries.

Senior Scientist, Nitrogen Loading Study for Four Estuaries on Cape Cod, Massachusetts. Starting in early 2001, on behalf of Massachusetts Department of Environmental Protection, Dr. Sham begins supporting the assessment of nitrogen loading to selected estuaries on Cape Cod. The project will evaluate land use in the estimation of nitrogen loading, estuarine flushing dynamics, and critical load for the preservation of ecosystems.

Lead Analyst, Assessment of Nitrogen Reduction Strategies from Septic System. For EPA's OGWDW, Dr. Sham analyzed information and submitted a technical report on the feasibility of various nitrogen reduction strategies related to septic systems.

Lead Analyst, Nonpoint Source Pollution of Coastal Water Through Ground Water Discharge. For EPA's Office of Ground Water Protection, Dr. Sham provided technical assistance in the evaluation of BMPs on the pathways and extent of nonpoint source pollution of coastal water through ground water discharge.

Principal Investigator, Water Table Mapping and Ground Water Modeling. As a Principal Investigator of the Waquoit Bay Land Margin Ecosystem Research (WBLMER) Project, Dr. Sham utilized remote sensing technology (i.e., ground_penetrating radar), along with conventional water level measurements, to produce ground water table maps and data for ground water modeling.

Senior Scientist, Minnesota Watershed Cost_Benefit Model Scoping Study. In 1989, for the Minnesota Cost_Benefit Analysis Task Force (convened by the Minnesota Pollution Control Agency), Dr. Sham participated in the development of a scoping study on cost_benefit analysis and watershed_scale modeling. On the basis of various requirements presented by the Task Force, an integrative framework that links mathematical modeling, GIS, and cost_benefit analysis was formulated, along with a model design and development work plan.

Senior Scientist, Analysis of Nitrogen and Phosphorus Loadings in Major Pork Producing States. From 1989 to 1999, for the National Pork Producers Council, Dr. Sham reviewed and compiled literature and data on nitrogen and phosphorus loadings from a variety of sources that include publicly owned treatment works, private septic systems, animal feeding operations, and croplands. Using data from federal agencies (e.g., U.S. Geological Survey, U.S. Department of Agriculture, and U.S. EPA) and state governments (e.g., Minnesota Agricultural Statistics Service), Dr. Sham developed nutrient loading estimates for the top 17 pork producing states.

SELECTED PUBLICATIONS

Sham, C.H., Kirsch, B, and J.T. Harvey. 2006. Protecting Lake Maumelle: A Drinking Water Supply Source of Central Arkansas Water, Proceedings of the 2006 American Water Works Association Annual Conference and Exposition, San Antonio, Texas: American Water Works Association 15 pp.

Sham, C.H., 2003. Source Water Assessment and Protection of Crystal Lake, Wakefield, Massachusetts, Proceedings of the 2003 Source Water Protection Symposium: New Tools and Technologies, Albuquerque, New Mexico: American Water Works Association, 11 pp.

Brawley, J.W., G.N. Collins, J., Kremer, C.H. Sham, and I. Valiela. 2000. A Time_Dependent Model of Nitrogen Loading to Estuaries from Coastal Watersheds, *Journal of Environmental Quality* 29(5): 1448-1461.

Sham, C.H., 1999. Identification of Potential Contaminant Sources in Source Water Protection Areas Using Commercially Available "Low_Cost" Data on Business, Proceedings of the 1999 Ground Water Protection Council Annual Forum, Newport, Rhode Island: Ground Water Protection Council, pp. 101_110, 1999.

Valiela, I., G. Collins, J. Kremer, K. Lajtha, M. Geist, B. Seely, J. Brawley, and C.H. Sham. 1997. Nitrogen Loading from Coastal Watersheds to Receiving Estuaries: New Methods and Application. *Ecological Applications* 7(2): 358-380.

Sham, C.H., J.W. Brawley, and M.A. Moritz. 1996. Analyzing Septic Nitrogen Loading to Receiving Waters: Waquoit Bay, Mass. In *GIS and Environmental Modeling: Progress and Research Issues.* ed. M.F. Goodchild et al. Fort Collins: GIS World Books.

Sham, C.H. and J. Brawley, 1996. *Ecological Risk Assessment for Watersheds: Waquoit Bay Nitrogen Loading Model Development and Results.* Technical Report to the U.S. Environmental Protection Agency, Office of Science and Technology, Washington, D.C., 24 pp.

Sham, C.H., J.W. Brawley, and M.A. Moritz. 1995. Quantifying Septic Nitrogen Loadings to Receiving Waters: Waquoit Bay, Massachusetts. *International Journal of Geographic Information Systems* 9(4):463-473.

Sham, C.H., E. Ettlinger, D.E. Flockhart, and Y. Xiao. 1993. Expanding a Successful Application: A GIS Graphic User Interface for Water Resources Protection in New York State. In *Proceedings of the Thirteenth Annual ESRI User Conference*, Redland: Environmental Systems Research Institute.

Valiela, I., K. Foreman, M. LaMontagne, D. Hersh, J. Costa, P. Peckol, B. DeMoe-Anderson, C. D'Avanzo, M. Babione, C.H. Sham, J.W. Brawley, and K. Lajtha. 1992. Couplings of Watersheds and Coastal Waters: Sources and Consequences of Nutrient Enrichment in Waquoit Bay, Massachusetts. *Estuaries* 15:443-457.

BARRY EVANS

Director **GIS Support Center, Penn State Institute of the Environment**

EDUCATION

Ph.D., Soil Science, The Pennsylvania State University, 2002
M.E.P.C., Environmental Pollution Control, The Pennsylvania State University, 1978
B.S., Natural Resources, The Ohio State University, 1975
Pre-Engineering, Vincennes University, 1970-71

CAREER SUMMARY

2002-Present Senior Research Associate, Penn State Institutes of the Environment

Dr. Evans is Director of the GIS Support Center, a research unit affiliated with the Penn State Institutes of the Environment (PSIE). At PSIE, he is primarily responsible for obtaining and managing research projects funded by a variety of governmental and institutional sponsors. One of his primary ongoing activities at present involves managing a multi-year, multi-million dollar open-end contract to provide environmental /GIS support services to the Pennsylvania Department of Environmental Protection (PaDEP), as well as other state agencies. Of late, he has been primarily involved in developing specialized software applications to support water resource/water quality assessment needs. To date, Dr. Evans' group has developed numerous software applications (e.g., AVGWLF, AVStreams, PRedICT, AVNPSTool and SWAP-GIS) to support activities in the areas of watershed modeling, TMDL assessment, source water protection, and evaluation of pollution mitigation strategies (e.g., urban and agricultural BMPs, wastewater treatment upgrades, etc.) at the watershed level. In addition to his state-related work, Dr. Evans has worked on projects sponsored by the U.S. Environmental Protection Agency and National Science Foundation, and has provided technical expertise to such diverse groups as the Mexican Institute of Water Technology; the State of Nuevo Leon, Mexico; the Swedish Meterological and Hydrological Institute; and to local and provincial groups in Ontario, Canada.

1995-2002 Senior Research Assistant, Environmental Resources Research Institute, Penn State University

Primarily responsible for obtaining and managing GIS projects funded by a variety of governmental and institutional sponsors. Managed a multi-year, multi-million dollar contract to provide GIS services to the Pennsylvania Department of Environmental Protection and other state agencies.

1988-1995 President, Geo Decisions, Inc., State College, PA

Responsible for corporate management as well as obtaining and managing GIS and environmental projects undertaken by the company.

1984-1988 Research Assistant, Environmental Resources Research Institute, Penn State University

Managed and conducted a variety of environmental assessment and mapping projects conducted using GIS and remote sensing technology.

1981-1984 Manager of Environmental Mapping Section, Resource Technology Corporation, State College, PA

Managed and supervised contracted work related to environmental mapping, geomorphology, and landscape analysis.

1980-1981 Owner/Manager, Remote Sensing Consultants, State College, PA

Obtained and managed contracted work such as septic system surveys, development of a wetlands analysis manual, and various non-point pollution source inventories.

1978-1980 Consultant, Development Sciences, Inc., Sagamore, MA

Worked on engineering sanitary surveys, various EPA-sponsored projects, and environmental resource inventories.

1976-1978 Project Manager, Trident Engineering, Warrenton, VA

Worked as an on-site contractor at the U.S. EPA's Environmental Photographic Interpretation Center. Projects completed involved use of aerial photography for various environmental analyses and mapping activities such as hazardous waste inventories, septic system analyses, oil spill emergencies, and land use/cover mapping.

PROFESSIONAL MEMBERSHIPS

Soil and Water Conservation Society
American Water Resources Association
International Environmental Modelling and Software Society
International Water Association

RECENT CONSULTANCIES

The Cadmus Group, Inc.
Greenland International Consulting, Inc.
Skelly & Loy, Inc.
Clear Creeks Consulting, Inc.
Louis Berger International, Inc.
CH2M-Hill, Inc.
Amazon Center for Environmental Education and Research
Swedish Meteorological and Hydrological Institute
Mexican Institute of Water Technology
National Water Commission, State of Israel

OTHER

Member of Management Committee of the Diffuse Pollution Sub-Group of the International Water Association

LAURA BLAKE

Associate/Environmental Scientist **The Cadmus Group, Inc.**

Education

M.E.M., Water Resources, Duke University, Durham, NC 2001
B.A., Environmental Science & Geology, Alfred University, Alfred, NY, 1999

Technical Support to Water Quality Assessment and Protection Programs

Project Manager & Technical Lead, Development of NY Phosphorus, Dissolved Oxygen, and Silt/Sediment TMDLs for Small and Medium Sized Lakes. Ms. Blake is currently managing a project for EPA to develop TMDLs for nutrient impaired lakes in New York State using a linked watershed runoff and in-lake water quality model.

Project Manager, Bear Lake Nutrient Study. Ms. Blake is currently managing a project for EPA to assess internal and external nutrient sources to determine sources contributing nutrients to Bear Lake in order to identify controllable sources and BMPs to meet applicable water quality standards for the lake.

Project Manager, Integrated Watershed Approach Demonstration Project for the Green Bay AOC/Lower Fox River Watershed. Ms. Blake is currently working on a demonstration project for EPA to compare multiple alternative pollutant reduction scenario options that could be used to address nutrient impairments in Lower Green Bay and the Lower Fox River (LFR) Watershed. The project is investigating the most cost-effective combination of implementation approaches for restoring the Green Bay AOC and the LFR Watershed using an integrated watershed approach.

Principal Investigator, Drinking Water Source Protection through Effective Use of TMDL Process. Ms. Blake is a co-principal investigator for a new AwwaRF Project looking at methods to better integrate the TMDL program with the source water protection program.

Project Manager, Development of Landscape and Water Quality Model for the Hangman Creek Watershed, Washington and Idaho. Ms. Blake is currently managing a project for USEPA to calibrate the GIS-based water quality WARMF model for the Hangman Creek Watershed, as part of the effort to develop a TMDL for total suspended solids and total phosphorus.

Project Manager, Connecticut River Nitrogen Loading Analysis. From 2001 to 2006, Ms. Blake oversaw an effort to assess nitrogen loading in the Connecticut River Watershed and determine the relative contributions of nitrogen entering Long Island Sound from the portion of Connecticut River Watershed residing in states upstream of Connecticut (i.e., Massachusetts, New Hampshire, and Vermont) in order to develop and implement defensible and equitable nitrogen load allocations and reduction goals. In addition to providing technical oversight and direction for the project, Ms. Blake analyzed nitrogen loading data collected during the project, as well as conducted a model evaluation of nitrogen loading to the watershed using the New England SPARROW Model. Ms. Blake also served as the chair for the project's technical advisory committee and gave many presentations on the project to stakeholders throughout the basin.

Environmental Analyst, TMDL Report Reviews. From 2001 to 2006, Ms. Blake provided technical support to NEIWPCC in reviewing draft and final pollutant reduction plans (known as a TMDLs) developed by the New England and New York States, including: Stormwater Pollutant TMDL for the Headwaters of the Shawsheen River (MA); Charles River Nutrient and Bacteria TMDLs (MA); Kickemuit Reservoir Fecal Coliform and Total Phosphorus TMDL (RI); a d Sugar River Total Phosphorus TMDL (NH). Ms. Blake provided technical comments to the states, as well as synthesized reports and presented findings to NEIWPCC's Executive Committee.

Principal Investigator, Northeast AVGWLF Model. From 2005 to 2006, Ms. Blake co-managed a project to calibrate and validate the Northeast AVGWLF Model for the New England States and New York State in order to provide state agencies with a tool for developing NPS pollutant load reduction estimates, as well as TMDLs. In addition to providing technical oversight of the project, Ms. Blake also chaired the project's technical advisory committee.

Principal Investigator, Nutrient Pollutant Load and Source Estimation Model Results for Enhanced Nutrient Loading Analyses of New England Coastal Watersheds. From 2004 to 2006, Ms. Blake served as principal investigator of an effort to provide the New England scientific and management community with immediate access to pertinent watershed data for New England, including estimates for nutrient concentrations, loads, sources, and transport for each of the stream reaches in New

England. Ms. Blake oversaw the development of a graphical user interface and interactive website to disseminate the results of the New England SPARROW Model. Ms. Blake also provided training for coastal resource managers, decision makers, scientists, and educators in the use of SPARROW tools and data.

Project Manager, Development of the New England SPARROW Model. From 2001 to 2004, Ms. Blake oversaw an effort to calibrate and validate the SPARROW Model for New England in order to support TMDL and nutrient criteria development. Ms. Blake provided technical oversight for the project, participated in the review of beta versions of the model, and gave numerous presentations on ways to apply the model for water quality management purposes.

Project Manager, Development of a Regression Model to Assess the Susceptibility of Fish to Mercury Contamination in Water Bodies of New England. From 2001 through 2003, Ms. Blake oversaw a project to develop a regional regression model for determining the susceptibility of fish to mercury contamination and to identify characteristics of New England lakes and their associated watersheds that may lead to elevated Hg in fish. As Project Manager, Ms. Blake worked with the New England State programs to gather input data for use in calibrating the model. Ms. Blake also served in the project's technical advisory committee.

Advisory Committee Oversight & Meeting Facilitation

TMDL Workgroup Chair. From 2001 to 2006, Ms. Blake serves as the chair for the New England Regional TMDL Workgroup, which is comprised of the TMDL program coordinators and staff from EPA Region 1 and the New England and New York States. As workgroup coordinator, Ms. Blake facilitated the exchange of ideas, methods, and progress with regards to TMDLs among the States and with EPA.

Chair, Technical Advisory Committees. Between 2001 and 2006, Ms. Blake served as chair for a number of technical projects including the Connecticut River Nitrogen Loading Analysis and Northeast AVGLWF Model.

Workshop Facilitator & Coordinator. Between 2001 and 2006, Ms. Blake coordinated and facilitated a number of specialty workshops to focus on water quality issues of regional concern, including the Bacteria TMDL Workshop and the Stormwater TMDL Workshop. The workshops brought together EPA and state staff with the purpose of finding consensus on how best to address the problem topic of focus. Ms. Blake oversaw all aspects of the workshop planning, including agenda development and speaker selection. In addition to serving as the meeting facilitator, Ms. Blake also presented/spoke at the meetings. Ms. Blake also prepared summary reports for the meetings.

Publications

Crow, M., Blake, L., and Mehan, G.T., III, 2006. ERP Shows Promise as a Cost-Effective Stormwater Management Strategy, ECOStates. Fall 2006. pp 25-27.

Deacon, J.R., Smith, T.E., Johnston, C.M., Moore, R.B., Weidman, R.M., and Blake, L.J., 2006, Assessment of total nitrogen in the Upper Connecticut River Basin in New Hampshire, Vermont, and Massachusetts, December 2002–September 2005: U.S. Geological Survey Scientific Investigations Report 2006–5144, 89 p.

Employment History

2006 – Present	Associate The Cadmus Group, Inc., Watertown, MA
2001 – 2006	Environmental Analyst II New England Interstate Water Pollution Control Commission, Lowell, MA
2000 – 2001	Watershed Modeling Intern Duke Energy Corporation, Huntersville, NC
1999 – 2001	Research Associate Duke University Water and Soil Laboratory, Durham, NC
1998 – 1999	Water Quality Intern United States Geological, Tully, NY

THOMAS MULCAHY

Analyst **The Cadmus Group, Inc.**

QUALIFICATIONS

Mr. Mulcahy has considerable experience in the application and management of geographic information systems (GIS) technology for environmental protection and natural resource management. In addition, Mr. Mulcahy has significant experience utilizing hydrologic models for assessing water quality in forested and wetland eco-systems and for urban storm water assessments. Mr. Mulcahy has extensive field research experience in an assortment of diverse environmental settings.

Technical Support to Water Quality Programs

Project Analyst, **Development of NY Phosphorus, Dissolved Oxygen, and Silt/Sediment TMDLs for Small and Medium Sized Lakes.** Mr. Mulcahy is currently providing technical assistance for the development of TMDLs in New York State. For this effort, Mr. Mulcahy is creating and managing large sets of GIS data to be used in the AVGWLF watershed nutrient loading model. In addition, Mr. Mulcahy contributes language to supporting documentation and debriefs EPA on project progress and technical issues.

Project Analyst, **Contaminant Candidate List Reporting.** Mr. Mulcahy currently assists with the management and reporting of the Contaminant Candidate List. Mr. Mulcahy enters data, queries and reports specified information as needed from a large and complex database.

Technical Project Manager, New England and New York State/EPA TMDL NEIWPCC Workgroup. In 2006, Mr. Mulcahy offered technical oversight and guidance to state water quality managers for a host of model and GIS applications. Mr. Mulcahy worked with state, and federal agencies to identify relevant data sources to compile, manipulate, re-project, and create multiple GIS data layers for use in AVGWLF, a generalized watershed loading function model using Arc View for data input.

Research Assistant, Estimations of Whole-forest Carbon Exchange and Evapotranspiration Rates for Hemlock and Deciduous Forests in the Northeast. In 2004 and 2005, Mr. Mulcahy undertook various research projects with staff at Harvard University. The majority of this research was focused on the investigation of variables causative to whole-forest carbon sequestration and water exchange at Harvard Forest, a long-term ecological research site (LTER) in Petersham, MA. Mr. Mulcahy ran multiple regression analysis of data from two eddy covariance towers as part of a detailed comparison of water storage in different forest ecosystems. Mr. Mulcahy also measured soil respiration and prepared soil samples to measure nitrogen mineralization.

Research Technician, Deterioration of Pothole Prairie Ecosystems and the Observed Relationship to Population Decline of Lesser Scaup in the Upper Mississippi. In 2005, Mr. Mulcahy helped to facilitate a spatially large and temporally rapid sampling scheme to research the population decline of bluebill ducks *(lesser scaup)* for a joint Louisiana State University and USGS project. While coordinating the activities of interns and volunteers, he surveyed 200+ wetlands throughout IA, MN, and ND, coinciding with the vernal migration of bluebills in the Upper

Mississippi Watershed. This involved surveying emergent and submergent vegetation, assessing water quality, chlorophyll, turbidity, and habitat quality, sampling invertebrate and fish communities and utilizing GIS to evaluate various wetland categories.

Research Assistant, Avian Malaria Aspect of the Hawaiian Biocomplexity Project. In 2004, Mr. Mulcahy researched vector biology and avian disease occurrence in different altitudinal ecosystems on the Big Island of Hawaii with the University of Hawaii and USGS. He monitored and maintained gravid mosquito traps on the windward slope of Mauna Loa, mist-netted and banded native songbirds, and processed the resulting data.

EDUCATION/SPECIAL TRAINING

B.A., Environmental Science, Cum Laude, Johnson State College, Johnson, VT, 2004

DONALD F. HAYES, Ph.D., P.E., DEE

Associate Professor **Department of Civil & Environmental Engineering, University of Utah**

EDUCATION

Ph.D., Civil Engineering, Colorado State University, December 1990
Environmental Engineering and Water Resources Planning and Management
M.S., Civil Engineering, Mississippi State University, December 1986
B.S. (honors), Civil Engineering, Mississippi State University, Dec. 1981

PROJECTS

- *Selenium Speciation and Partitioning in Wetlands of the Great Salt Lake*, Utah Department of Environmental Quality, June 2005 – December 2006, $114,203.
- *Design and Evaluation of a Test Section to Minimize Legacy Highway Impacts on Lateral Groundwater Flow and Great Salt Lake Wetlands*, Utah Department of Transportation, $35,000, January 2001 – December 2003.
- *Design of a Wetland Systems for Migratory Bird Habitat and Water Quality Improvement in Association with Secondary for System Development*, City of Riverton, Utah, $220,000 (with Carollo Engineers and Western Wetland Systems), September 1999 - August 2000.
- *Wetlands Ecology and Ecology of the Wetlands/Transition Buffer Zones, Field and Laboratory Research*, unspecified amount, subcontractor to Louis Berger & Associates, East Orange, NJ, March 1997 - March 2002.
- *Wetland Creation Using Dredged Sediments in Tiger Pass, LA*, U.S. Army Research Office, $13,000, August – December 1996.
- *Sediment Retention Processes in Wetland Systems*, AASERT Program, Army Research Office, $140,000, July 1994 - June 1997.
- *Preparation and Assimilation of Materials for a Wetlands Engineering Design Manual*, USAE Waterways Experiment Station, $60,000, January 1994 - September 1996.
- *Improvement of Reservoir Water Quality by Constructing Barriers, Wetlands, and Sediment Traps*, Omaha District, US Army Corps of Engineers, $19,000, April 1994 - December 1994.
- *Review and Synopsis of Existing Literature and Ongoing Studies Involving Wetlands Engineering for Enhancement, Restoration, or Creation Activities*, USAE Waterways Experiment Station,$20,704, May - September 1992.

PUBLICATIONS & TECHNICAL REPORTS

Robins, J.P., Rock, J., Hayes, D.F., and Laquer, F.C., "Nitrate Removal From Synthetic Platte Valley, Nebraska Groundwater Using A Constructed Wetland Model," *Environmental Technology*, Volume 21, No. 6, June 2000.

America's Wetland Task Committee, *Restoring Coastal Louisiana: Enhancing the Role of Engineering and Science in the Restoration Program*, American Society of Civil Engineers, 2004, ISBN 0-7844-0736-3.

Hayes, D.F. (editor), *Designing Successful Stream and Wetland Restoration Projects,* American Society of Civil Engineers, Proceedings of the 2nd ASCE Wetlands Engineering and River Restoration Conference, August 2001 (CD-ROM).

Hayes, D.F., T.J. Olin, J.C. Fischenich, and M.R. Palermo, *Wetlands Engineering Handbook*, U.S. Army Corps of Engineers, June 2000, 812 pages (including appendices).

Hayes, D.F. (editor), *Engineering Techniques for Wetland and Riparian Engineering*, American Society of Civil Engineers, Proceedings of the 1998 Wetlands Engineering and River Restoration Conference, December 1998, 1150 pages (CD-ROM).

Hayes, D.F. (editor), *Presentation Summaries for the 1998 Wetlands Engineering and River Restoration Conference*, American Society of Civil Engineers, March 1998, 193 pages.

USDA Soil Conservation Service, *Wetland Restoration, Enhancement, or Creation*, USDA Soil Conservation Service, January 1992, 79 pages. (*co-author*)

Dearden, Mary and Hayes, Donald F., "Management Plan for BP Amoco SLC Wetland," final report to BP Amoco SLC Business Unit, May 2001.

Hayes, Donald F., "Wetlands Creation Using Dredged Material in Tiger Pass, Louisiana," Technical Report EL-98-xx, U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, MS, final report submitted August 1997.

Hayes, D. F. and D. Overbey, "Improvement of Reservoir Water Quality by Constructing Barriers, Wetlands, and Sediment Traps," Omaha District, US Army Corps of Engineers, December 1994.

Hayes, Donald F., Timothy R. Crockett, and Michael T. Arends, "Wetlands Engineering: Review of Literature Related to the Enhancement, Restoration, and Creation of Wetlands," Research Project Report, University of Nebraska-Lincoln, February 1993.

Maynord, S.T., Landin, M.C., McCormick, J.W., Davis, J.E., Evans, R.A. and Hayes, D.F., "Design of Habitat Restoration Using Dredging Material at Bodkin Island, Chesapeake Bay, Maryland," Wetlands Research Program Technical Report WRP-RE-3, U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, MS, June 1992.

CONFERENCE PROCEEDINGS

Hayes, D.F., "Engineering for Successful Wetland Restoration," *Proceedings of the 1998 From Swamps to Wetlands Conference*, October 1998.

Hayes, D.F., "A Handbook for Designing Wetland Restoration Projects," *Proceedings of the 1998 Wetland Engineering and River Restoration Conference*, March 1998.

Hayes, Donald F., "Using ADDAMS to Design Wetland Restoration Projects," *Proceedings of the Corps of Engineers Workshop on Wetlands Restoration and Establishment, Baltimore, MD*, July 1997.

Hayes, Donald F., "Wetlands Engineering, Design, and Construction: Current Practices and Research Needs," *US Army Corps of Engineers Wetlands Engineering Workshop Proceedings*, St. Louis, MO, July 6-8,1993.

Hayes, D.F., T.R., Crockett, and M.T. Arends, "Wetlands Engineering, Design, and Construction: State-of-the-Art and Research Needs," Proceedings of the 1993 ASCE Water Resources Planning and Management Division Annual Conference, *Water Management in the 90's: A Time for Innovation*, Seattle, WA, May 3-5,1993.

Hayes, D.F. and M.R. Palermo, "Engineering Aspects of Wetland Design," Proceedings of WATER FORUM '92, American Society of Civil Engineers, Baltimore, MD, August, 1992.

CONSULTING

- Western Wetlands, Inc., Heber City, UT, *Review of Hydraulic and Hydrologic Design of Duchesne River Mitigation Plans*, 1999.
- Baseline Hydrology, Park City, UT, *Constructed Wetland and Land Application Potential for Phosphorus Removal from a Summit County Wastewater Treatment Plant Discharge*, 1999.
- USAE Waterways Experiment Station, *Final Revisions to Wetland Engineering Handbook*, 1999.

OTHER

- Chair, *Wetlands and River Restoration Committee*, Coastal, Oceans, Ports, and Rivers Institute (COPRI), 1999 – 2004.
- Conference Co-chair (with J. Craig Fischenich), *2nd* American Society of Civil Engineers, *Wetlands Engineering and River Restoration Specialty Conference*, August 2001, Reno, NV.
- Conference Co-Chair (with J. Craig Fischenich), 1998 American Society of Civil Engineers, *Wetlands Engineering and River Restoration Specialty Conference*, March 22-27, 1998, Denver, CO.
- Conference Chair, *From Swamps to Wetlands*, Center for Wetlands and Riparian Design, Salt Lake City, UT, October 1998 (250 registrants).

STEVEN F. JENSEN

Wetlands Restoration **Consultant**

EDUCATION: **Brigham Young University** B.A. Political Science 1971
University of Utah, Master of Public Administration 1981
Emphasis: Environmental Planning

EXPERIENCE:

1997-07	**Salt Lake County Engineering Program Manager, Water Resources Planning/Restoration**
1992-97	**Salt Lake County Commission,** Water Resources Planning Coordinator
1985-92	**City County Health Department**, Environmental Planning Coordinator
1982-85	**Salt Lake County Flood Control,** Water Quality Program Manager
1980-82	**Salt Lake County Department of Water Quality & Pollution Control, A**ssistant Director
1978-80	**208 Water Quality Project,** Director
1976-78	**208 Water Quality Project,** Project Planner
1972-76	**Salt Lake County Planning Commission**, Zoning & Canyon Master Planning

CERTIFICATIONS

- **U.S. Army Corps of Engineers,** Certified Wetland Delineator
- **U.S. Environmental Protection Agency,** Office of Wetland Certification in Jurisdictional Delineation of Wetland and Riparian Ecosystems in the American Southwest
- **American Society Agronomic Professionals,** Certified Professional Soil Erosion & Sediment Control Specialist

PROJECTS

- Emigration Creek TMDL/Microbial Source Tracking, 2006-2007
- Jordan River Restoration Project: Draper, Utah, 2005-2006
- Jordan River TMDL Water Quality Assessment, 2003-2004
- Little Cottonwood Creek 319 Abandoned Mine Project, 2003-2004
- Willow Heights HGM Wetland Assessment, 2003-2004
- Dry Creek Restoration Project, 2003-2004
- Emigration Creek Restoration Project: Level III, 2001-2002
- Emigration Creek Watershed Nonpoint Assessment, 2001-2002
- Alta Abandoned Mine Coalition & Runoff Assessment, 1998-2001
- Brighton Basin Wetland Assessment (7,500 acres), 1996-1998
- Jordan River Nonpoint & Wetland Management Plans, 1988-1995
- Rocky Mountain Headwaters Mine Waste Pilot Project, 1994-2001
- Jordan River Wetlands Acquisition (125 acres), 1994-1998

- Jordan River Wetland Advance Identification (2000 acres), 1994-1996
- Millcreek Canyon Restoration (Terraces area), 1992-1995
- Albion Basin Wetland Identification Project (2,000 acres), 1992-1994
- Jordan River Bank Restoration (7 Projects: 6 River Miles), 1992-2002
- Decker Lake Restoration (35 acres), 1992-1997

WETLAND CONSULTATIONS

- **Salt Lake City Water Reclamation,** Facility Wetland Park
- **Murray-Jordan River Parkway** Wetland Restoration/Enhancement, 5300 South
- **Bear Lake** Delineation for Utah State Parks
- **Summit County** Wetland Advance Identification Project (Peoa)
- **Riverbend Golf Course** Wetland Inventory & Mitigation Proposal for Salt Lake County Parks & Recreation
- **Prowswood Development** Compensatory Mitigation Project, Creekside Park
- **Brighton Basin** Wetland Delineation for B.W. McDonald (Brighton Loop)
- **Albion Basin** Advance Identification Study (Friends of Alta, EPA)
- **Utah Reclamation, Mitigation, Conservation Commission:** Colby Estate Delineation; Cromar Delineation; Huffman Delineation; Greenwood Estate Delineation.
- **Brighton Basin Advance Wetland Delineation Project** (EPA)
- **Patsy Marley Hill Development Proposal**, Town of Alta

PUBLICATIONS

- Nonpoint Source Management Plan for Abandoned Mines in Utah (2005)
- Jordan River TMDL Water Quality Assessment (2005)
- Level III Channel Stability Evaluation and Restoration Alternatives for Emigration Creek (2001)
- Emigration Watershed Non-point Pollution Assessment: Diurnal Bacterial Analyses (2001)
- Alta Fen Pilot Project Results & Analysis (1996-2001, 5 Interim & Technical)
- Brighton Basin Wetland Advance Identification Study (1998 Interim)
- Jordan River Nonpoint Source Management Plan for Hydrologic Modifications, 1995
- Decker Lake Phase II Restoration Project, 1995
- Ecological Characterization & Functional Evaluation of Subalpine and Lower Montane Wetlands in the Albion Basin Region of Utah, 1993
- Soil & Hydrology of Albion Basin Wetlands, 1993
- Wasatch Canyon Watershed Monitoring Network, 1988-91
- Jordan River Wetlands Advance Identification Study, 1986
- Recreation Use & Opportunities of the Salt Lake Valley Tributaries, 1982-84
- Shallow Aquifer Investigation in Salt Lake Valley, 1981-83
- Wetland Resources of Salt Lake County, 1981
- Multiple Soil Constraints in Urban Development Planning, 1981 (Master's Project)
- Slope Stabilization Demonstration Project, 1980
- Salt Lake County Erosion-Sediment Control Manual, 1981

G. TRACY MEHAN, III

Principal **The Cadmus Group, Inc.**

G. Tracy Mehan, III, is Principal with The Cadmus Group, Inc., an environmental consulting firm, with offices in Arlington, Virginia.

Mehan served as Assistant Administrator for Water at the U.S. Environmental Protection Agency from 2001-2003 pursuant to presidential nomination and senate confirmation. In that capacity he directed both the Clean Water and Safe Drinking Water Acts programs including permitting, infrastructure finance, wetlands regulation, standards and watershed management. During his tenure as Assistant Administrator, Mr. Mehan developed new policies and guidances on watershed-based permitting and water quality trading. He also promoted expanded ambient water quality monitoring and innovative approaches to meeting the challenge of the infrastructure financing gap. He served as Environmental Stewardship Counselor to the 2004 G-8 Summit Planning Organization (2004).

Mr. Mehan also served as director of the Michigan Office of the Great Lakes and a member of then Governor John Engler's Cabinet (1993-2001). He represented the State of Michigan in all matters relating to Great Lakes Water diversions under the Water Resources Development Act of 1986 and the Great Lakes Charter, and led the Michigan negotiating team during the mediation of disputes relating to exceedances of Supreme Court mandated limits on the Chicago Diversion of Lake Michigan water. He also was Michigan's representative on the Great Lakes Commission and the Water Quality Board of the International Joint Commission established under the Boundary Waters Treaty of 1909 between the U.S. and Canada. In addition, he chaired the Michigan Mercury Pollution Prevention Task Force which, among other things, negotiated a phase out of 9.8 metric tons of mercury used in auto switches, annually, by the Big Three auto companies.

Mr. Mehan also served, briefly, as Associate Deputy Administrator of EPA in 1992. He served as director of the Missouri Department of Natural Resources and member of the Cabinet of then Governor John Ashcroft from 1989 to 1992. In that capacity he managed the state's environmental, parks, historic preservation, geology and other programs. He represented the State of Missouri in all negotiations over the management of the Missouri River and the development of a proposed Master Manual as well as matters pertaining to water diversions including tribal reserved water rights potentially impacting main stem flows downstream. He negotiated the Times Beach cleanup settlement and implemented what was then the largest rails-to-trails conversion in the country, the 200 mile long KATY Trail.

Mehan is a graduate of Saint Louis University and its School of Law.

He is the recipient of the 2004 Environment Award from the Association of Metropolitan Sewerage Agencies (AMSA) and the 2003 Elizabeth Jester Fellows Environmental Partnership Award from the Association of State & Interstate Water Pollution Control Administrators (ASWIPCA).

Presently, Mehan is serving on the Committee on the Mississippi River and the Clean Water Act for the National Research Council of the National Academies.

Mehan is an Adjunct Professor in Environmental Law at George Mason University School of Law.

He is a member of the Water Environment Federation and the Environmental Law Institute.

KAREN SKLENAR

Senior Scientist **The Cadmus Group, Inc.**

EDUCATION

1995 Ph.D., University of California at Berkeley, Environmental Engineering Science (Applied Limnology)

1984 B.A., Yale University, New Haven, Connecticut

PROFESSIONAL EXPERIENCE

2002 – present
Senior Scientist, The Cadmus Group, Inc.

- Oversees development of technical documents and regulatory guidance manuals for issues related to water quality.
- Technical expert for water quality (nitrate) trading project in the Octoraro watershed (PA and MD, Chesapeake Bay tributary).
- Principal Investigator on American Water Works Association Research Foundation (AwwaRF) project trying to get water utilities more involved in the TMDL process.
- Senior reviewer for numerous projects, including project characterizing water quality standards for the 50 states.
- Prepares and presents training materials for new drinking water regulations.
- Assists U.S. EPA with sanitary surveys of public water systems on Indian lands, and provides sanitary survey training.
- Technical expert on projects that have addressed a range of topics including pathogens, arsenic and other metals, radionuclides, pesticides, and volatile organic chemicals.

2001 - 2002
Water Program Manager, Glens Falls District Office, New York State Department of Health

- Temporary assignment to re-organize water program for the NY State Department of Health's largest field office.
- Oversaw regulatory enforcement, plan reviews, and implementation of New York's drinking water program for approximately 1,000 public water systems.
- Oversaw water and wastewater enforcement for approximately 130 mobile home parks. Supervised five engineers and three seasonal public health inspectors.
- NYS Department of Health representative for permitting of new water supplies.

1994 – 2001
Research Scientist, Bureau of Public Water Supply Protection, New York State Department of Health

- Senior limnologist addressing water quality issues for the New York State Department of Health.
- Participated in decision-making regarding watershed activities in Lake George, Saratoga Lake, Skaneateles Lake and numerous other watersheds throughout New York State.
- Provided technical assistance on public health issues related to microbiological and chemical contamination of New York State's waters.
- Participated in studies investigating land application of treated waste, effectiveness of agricultural Best Management Practices at protecting water quality, and effectiveness of alternative fecal indicators in the natural aquatic environment.
- Represented New York State Department of Health during the development of water quality standards for New York City's reservoirs and source water protection standards for the City's Catskill and Delaware watersheds.
- Represented NY State on federal workgroups during the development of new drinking water regulations.
- Managed the implementation of new federal drinking water regulations at the state level.

1995 – present
Assistant Professor, Department of Environmental Health and Toxicology, School of Public Health, State University at Albany

- Faculty advisor to Ph.D., M.S. and M.P.H. students.
- Course director for "Water Quality and Public Health", a three-credit graduate course.

1992 – 1994
Water Quality Group Manager, F.X. Browne, Inc., Lansdale, Pennsylvania

- Managed four project managers and numerous projects for a consulting firm specializing in lake, reservoir, and watershed studies.

1990-1991
Consultant, Alex Horne and Associates, El Cerrito, California

- Evaluated water quality changes throughout the South Bay and California aqueducts.

1988 – 1990
Engineering Aide, East Bay Municipal Utility District, Oakland, California

- Developed a reservoir monitoring program for the water district's three largest water supplies.
- Evaluated monthly treatment costs and chemical use. Prepared annual water quality reports for five reservoirs.

1987 – 1988
Research Scientist, Lawrence Berkeley Laboratory, Berkeley, California

- Implemented and monitored selenium reduction methods using constructed wetlands at Kesterson Wildlife Refuge, Los Banos, California.

1984 – 1986
Legal Assistant, Morrison and Foerster, San Francisco, California

- Organized and summarized legal documents pertaining to the environmental impact of water diversion from Mono Lake, California for use in southern California.

PUBLICATIONS

K.S. Sklenar and A.J. Horne. 1999. Horizontal distribution of geosmin in a reservoir before and after copper treatment. *Wat. Sci. Tech.* Vol. 40, No. 6, pp. 229-237.

K.S. Sklenar and A.J. Horne. 1999. Effect of the cyanobacterial metabolite geosmin on growth of a green alga. *Wat. Sci. Tech.* Vol. 40, No. 6, pp. 225-228.

"Summary of New York City's Croton System's Historical Water Quality Data". 1996. New York State Department of Health Report.

"Summary of the Results of the 1995 New York State *Cryptosporidium* and *Giardia* Survey". 1995. New York State Department of Health Report submitted to U.S. EPA Region II.

"Results of the Lake George 1995 Hydrologic Study". 1996. New York State Department of Health Report.

Seligman, K., A. Enos, H.H. Lai. 1992. A comparison of 1988-1990 Flavor Profile Analysis results with water quality conditions in two northern California reservoirs. *Wat. Sci. Tech.*Vol. 25, No. 2, pp. 19-25.