SAVANNAH RIVER ECOLOGY LABORATORY

ANNUAL TECHNICAL PROGRESS REPORT OF ECOLOGICAL RESEARCH FOR FY2010

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Carl W. Bergmann and Kenneth W. McLeod,
Co-Directors

Prepared by
Savannah River Ecology Laboratory
P. O. Drawer E
Aiken, SC 29802

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SAVANNAH RIVER ECOLOGY LABORATORY
FY2010 OVERVIEW

The Savannah River Ecology Laboratory (SREL) is a research unit of The University of Georgia (UGA) that has been conducting ecological research on the Savannah River Site (SRS) near Aiken, South Carolina for almost 60 years. The overall mission of the Laboratory is to acquire and communicate knowledge of ecological processes and principles. SREL conducts fundamental and applied ecological research, as well as education and outreach programs, under a Cooperative Agreement with the U.S. Department of Energy (DOE).

The Laboratory's research mission during the 2010 fiscal year was fulfilled with the publication of 38 journal articles and book chapters by faculty, technical staff, students, and visiting scientists. Two books were also authored by SREL faculty and staff members. Additional journal articles and books have been submitted or are in press. Significantly, SREL outreach activities reached over 36,000 people of all ages. Other noteworthy events took place as faculty members, staff, and graduate students received awards. These are described in the section 'Special Accomplishments of SREL Personnel'.

The vision, structure, and operations of SREL continued to evolve since the changes in funding structure instituted in FY07. Funding from EM-HQ is based on two individual projects and SRS-based funding reflects the specific needs of EM. The funding mechanism currently in place necessitated a conversion to programs that are entrepreneurial and interdisciplinary, and to funding strategies that are competitive, responsive to sponsors' requirements, and based on a diverse and sustainable foundation. This recognition required restructuring of research and supporting infrastructure.

Although these changes were very challenging, a reduced, but robust SREL presence continued to operate on the SRS in FY10. Currently, SREL's total employment is approximately 60 faculty, technicians, students, and support staff. This number of employees and level of funding is lean but ensures continued progress toward stated objectives and does not compromise safety and security. New partnerships and collaborations with the Athens campus and other agencies are being explored and developed in order to maximize the use of SREL assets. Graduate student programs have continued with funding provided by external grants, UGA, or the student's host university.

SREL faculty have responded to the revised structure and have sought financial support from multiple external funding agencies, DOE-EM, DOE-NNSA (National Nuclear Security Administration), and SRNS-ACP (Savannah River Nuclear Solutions-Area Closure Projects), and UGA has provided temporary infrastructure support to SREL through this transitional period. Funding, made available as a result of the ARRA-DOE program, has facilitated SREL program development. The Cooperative Agreement with DOE allows SREL/UGA access to the SRS through 30 November 2011. Continued funding for SREL has been strongly supported by the local community for its role in research, environmental monitoring, and education/outreach programs for local schools and the general public.

Many challenges remain for SREL including reorganizing research programs to address DOE and SRS-specific concerns, maintaining current research staff, and attracting new personnel. SREL researchers are also vigorously pursuing additional funding sources to leverage existing

research funds, while continuing to focus the laboratory's research efforts on projects of interest to the SRS.

Researchers at SREL had funding from 26 external grants during FY10. Sources of grant awards range from private foundations such as the National Fish and Wildlife Foundation to federal agencies such as the U.S. Department of Interior, the National Science Foundation, and the Department of Defense.

SREL faculty hold positions in varied departments at the University of Georgia. In addition, several SREL faculty members (and emeritus faculty) have adjunct status at other colleges and universities. Faculty, staff, and students also are active in providing outreach and service to the scientific community. Representatives from SREL hold editorial or committee positions in national groups and organizations and also serve on several UGA academic and administrative committees. SREL faculty members continue to make scientific presentations and contribute posters to scientific meetings, and to present seminars at colleges and universities.

Participants in the SREL Education Program during FY10 included 12 undergraduate students and 14 graduate students from numerous colleges and universities in the United States. In the past year, two graduate students (JD Willson and Elizabeth Burgess) earned Doctor of Philosophy Degrees.

The SREL Outreach Program communicates scientific awareness to area schools and the general public, an audience which differs from science professionals. During the past year, SREL presented 270 talks, 20 tours, and 21 exhibits, reaching a total of over 36,000 people. Topics for these presentations included ecological studies of reptiles and amphibians, southeastern plants and habitats, long-term research, safety, biodiversity, local wetlands and watersheds, conservation, and careers in ecology and research. In the past year, the SRS has initiated a public tour program (two tours per month of 30-40 citizens) in which SREL participates by providing presentations on the history and research of the lab as well as a "show and tell" session featuring research animals native to the SRS. In addition, outreach personnel have initiated and promoted a monthly tour for SRS employees.

The SREL Conference Center has continued to be a valuable asset to SREL and other groups on the SRS. SREL used the facility to host numerous meetings and environmental education programs for students, teachers, and other groups this past year. The facility is also used by DOE and the USDA Forest Service when it is available.

In FY2010, Dr. R. Cary Tuckfield joined the SREL faculty. Dr. Tuckfield is a statistical biologist and was previously employed by the Savannah River National Laboratory.

During FY10, the SREL faculty and staff were still adjusting to reduced funding and faculty and staff realignment. Many research programs were impacted, and in some instances may result in reduced reporting in this document, for example if the Principal Investigator is no longer employed by SREL.

SPECIAL ACCOMPLISHMENTS OF SREL PERSONNEL IN FY2010

In FY2010, several SREL faculty members were honored by their scientific peers.

At a May award ceremony in Washington, DC, **Dr. Rebecca R. Sharitz**, was honored with the 2010 National Wetlands Award in Science Research, given by the Environmental Law Institute. Annually these awards honor six citizens from across the country for their exceptional and innovative contributions to wetlands conservation. ELI partnered with six federal agencies (the U.S. Environmental Protection Agency, NOAA Fisheries, the U.S. Fish and Wildlife Service, the Natural Resources Conservation Service, the Federal Highway Administration, the USDA Forest Service, and the George and Miriam Martin Foundation) to showcase the remarkable contributions the winners have made to a healthy and productive environment." **Dr. Sharitz** is a senior research ecologist at SREL and a leading expert on the ecology of southeastern floodplain forests and Carolina bays.

Dr. J. Whitfield Gibbons was elected as a Fellow of the Association for the Advancement of Science (AAAS), an honor bestowed upon members by their peers. Fellows are recognized for meritorious efforts to advance science or its applications. In addition, **Dr. Gibbons** was selected as the 2009 C.W. WATSON AWARD recipient from the Southern Division of the American Fisheries Society, the Southeastern Section of the Wildlife Society, and the Southeastern Association of Fish and Wildlife Agencies, in recognition of his contributions to the conservation of natural resources.

Several of our SREL publications and research projects generated considerable scientific and public interest.

A publication by **Dr. Stacey L. Lance** (SREL # 3118) reporting mate fidelity in the American Alligator (**Lance, S.L**., **Tuberville, T.D**., **Dueck, L.**, Holz-Schietinger, C., Trosclair, III P.L., Elsey, R.M., and Glenn, T.C. [2009] Multi-year multiple paternity and mate fidelity in the American alligator, *Alligator mississippiensis.* Molecular Ecology 18:4508-4520. doi: 10.1111/j.1365-294X.2009.04373.x) generated press interactions/interviews/web releases from media, including BBC Wildlife magazine, National Geographic News, ABCNews.com, Science Daily, and msnbc.

Studies examining aspects of invasive Burmese Pythons were conducted at SREL and in South Florida by **J. D. Willson** (a SREL Ph.D student), **Dr. Mike Dorcas** (a Davidson University faculty member and a former SREL Post Doctoral associate) and **Dr. J. W. Gibbons**. These studies were of considerable interest to scientists and the public and included cold tolerance, physiology, and behavior; estimating python density and impacts in Florida; and evaluating scenarios for python introduction and spread.

Another publication, SREL #3130 (**Buhlmann, K.A**., T.S.B. Akre, J.B. Iverson, **D. Karapatakis**, R.A. Mittermeier, A. Georges, A.G.J. Rhodin, P. P. van Dijk, and **J. W. Gibbons**. 2009. A global analysis of tortoise and freshwater turtle distributions with identification of priority conservation areas. Chelonian Conservation and Biology 8(2): 116-149.represents the culmination of a project started in 1999. This publication reports the

conservation status of the approximately 317 recognized species of turtles and tortoises in the world.

Dr. I. L. Brisbin, Jr. and **Tom Condon**, one of his graduate students, have been featured in a recent National Geographic prime-time television special in the "Geographic Explorer" series. The show is titled "How Man tamed the Wild", and features Condon's thesis research dealing with the conservation biology, genetics and behavior of wild red jungle fowl and the free-ranging feral bantam chickens of Fitzgerald, Georgia.

SREL faculty published several books in FY2010.

FROGS: THE ANIMAL ANSWER GUIDE. In Press. (Mike Dorcas and **Whit Gibbons**). Johns Hopkins University Press.

SALAMANDERS OF THE SOUTHEAST. 2010. (Joe Mitchell and **Whit Gibbons**). UGA Press.

WILD PIGS: BIOLOGY, DAMAGE, CONTROL TECHNIQUES, AND MANAGEMENT. 2009. (J. J. Mayer and **I. L. Brisbin, Jr.** (eds.)) Savannah River National Laboratory (SRNL–RP-2009-00869).

SREL faculty and students also served on numerous editorial boards of scientific journals, including:

Kurt A. Buhlmann –
Chelonian Conservation and Biology
Northwest PARC Habitat Management Guidelines
Habitat Management Guidelines for Amphibians and Reptiles of the Midwestern United States
PARC Inventory and Monitoring Techniques Manual
Conservation Biology of Tortoises and Freshwater Turtles

J Vaun McArthur –
Applied and Environmental Microbiology
ISRN Ecology (International Scholarly Research Network)

Kenneth W. McLeod –
Castanea (2008-2010)

John Seaman –
Journal of Environmental Quality (2007-2010)

John D. Willson
Herpetological Review – Natural History Notes

SREL faculty and students were also societal officers and provided service to other scientific societies, including:

Dr. John C. Seaman - Elected Chairman of the Soil Chemistry Division of the Soil Science Society of America (SSSA), an international professional society with 6,000+ members. Responsibilities of the chairman include representing the division on the society's governing board, updating the division's website, and organizing the division's program for the SSSA's annual meeting scheduled for November 1-4, 2010, in Long Beach, CA. **Dr. Seaman** also

served on the Technical Planning Committee for the 2009 Georgia Water Resources Conference and Symposium planning committee for 2010 Annual ASA Meetings.

Kurt A. Buhlmann – Member of the Proposal Review Panel for the Linnaeus Fund; Executive Board Member for the Turtle Conservation Fund (TCF); Steering Committee Member – Turtle Survival Alliance; Member – National Steering Committee of Partners in Amphibian and Reptile Conservation.

Rebecca R. Sharitz – Member of the Executive Board of Audubon South Carolina and the Executive Committee of UGA Plant Biology Department

Tracey D. Tuberville – Member of the Florida Fish & Wildlife Conservation Commission; Co-Founder and Co-Chair of the Southeast Partners in Amphibian and Reptile Conservation Reintroduction Working Group; South Carolina State Representative to the Gopher Tortoise Council; Instructor at the Envirovet Training Program, St. Catherines Island / White Oak Plantation; Biological expert for the Indigo Snake Captive Propagation and Repatriation Meeting; Biological expert on gopher tortoise population biology and reintroduction technologies for the South Carolina Department of Natural Resources, including contributor to state conservation plan for gopher tortoises (currently under review by agency); Served as biological expert on population viability and reintroduction of Blanding's turtles for the U.S. Fish and Wildlife Service, Great Meadows National Wildlife Refuge complex.

John D. Willson - Website Administrator for Partners in Amphibian and Reptile Conservation

SREL faculty and staff also provide numerous services to the Savannah River Site and the overall CSRA public.

Dean Fletcher is producing numerous GIS layers and maps that will be widely used by researcher and managers working on SRS streams. GIS layers and maps are delineating perennial, intermittent and ephemeral streams, flow impediments including both active and abandoned dams, levees and crossings, rip rap, and check dams. Areas of severe erosion, incision, or sedimentation are being recorded. Stream reaches, modified by ditching or channelization, are being mapped. Runoff patterns from industrial areas and outfall routes are being drawn on GIS layers based on field data.

Rebecca Sharitz and **Kurt Buhlmann** serve on the Craig's Pond Advisory Committee to define an active management plan for this Carolina bay, including discussions about fire management and gopher frog habitat use.

David Scott, Sean Poppy and others continue to provide Public Outreach Activities, such as Earth Day talks, exhibits, watershed tours and special activities at Hidden Bay in Aiken including talks, education/service projects, and coordinated public workdays for invasive species removal.

Finally, in November 2009, SREL hosted a National Environmental Research Park Workshop, which included representatives from the seven DOE NERPs, including Fermilab, Hanford, Idaho, Los Alamos, Nevada, Oak Ridge, and Savannah River. The workshop was stimulated by the recent legislation in Congress (H.R. 2729) which has sparked resurgent interest in the

research value of NERPs. The bill would recognize the DOE NERP sites, and provide funding for the next five years to conduct research related to the environmental aspects associated with DOE missions on each site. One important outcome of such legislation would be the opportunity to create a nationwide network of NERP sites with collaborative research programs and mutual consideration of environmental issues faced by the sites. Such a network could provide an unprecedented opportunity for research aimed at addressing regional, local, and global issues pertinent to current and future energy missions.

With the prospect of creating such a network, the Savannah River Ecology Laboratory hosted a NERP workshop to bring together participants from each NERP site for a two-day discussion of creating a NERP network. A majority of the workshop was devoted to discussing research being conducted at each NERP site along three major themes: climate change, stewardship on DOE sites, and the coexistence of energy production and stewardship. An overarching theme of the Workshop was also that one mission of the National Environmental Research Parks is the education of students and the general public about site activities.

OVERVIEW OF RESEARCH THEMES

Through a Cooperative Agreement between the Department of Energy and the University of Georgia Research Foundation, SREL provides an independent evaluation of the ecological effects of SRS operations through a program of ecological research, education, and public outreach. This program involves basic and applied environmental research, with emphasis upon expanding the understanding of ecological processes and principles, and upon evaluating the impacts of industrial and land use activities on the environment.

This is accomplished through a broad-based program of field and laboratory research conducted on the SRS and published in the peer-reviewed scientific literature; by providing education and research training for undergraduate and graduate students from colleges and universities throughout the United States and abroad; and by engaging in community outreach activities and service to professional organizations.

The FY10 SREL research plan can be divided into three critical research areas:

(1) *environmental characterization*,
(2) *ecological risks and effects, and*
(3) *remediation and restoration*.

Research at SREL addresses knowledge gaps in these areas by taking advantage of unique expertise in the environmental sciences and ecology, the unparalleled field research opportunities at the SRS, and the long-term data sets, research tools, and capabilities that SREL has developed over the last half-century.

ENVIRONMENTAL CHARACTERIZATION

Characterization is a necessary first step in determining environmental and health risks and in devising appropriate remediation and restoration strategies. Environmental information is also needed to make informed decisions about long-term stewardship and land management, and it is also a critical component of NEPA (National Environmental Policy Act) reports, Records of Decision (ROD), and other regulatory documents. Environmental characterization is more than simply measuring contaminant concentrations in biota or other media, or reporting the presence of organisms at various locations. It includes developing an understanding of the processes that control distributions of contaminants, chemical forms, and their bioavailability. Characterization is also necessary to construct models of how natural and engineered systems function, both in the presence and absence of environmental contamination.

Environmental Professional Training

Ken McLeod

SREL, in conjunction with SRNS-ACP personnel, has organized and taught a series of short courses for ACP professionals on the SRS. Major course objectives were to broaden the knowledge base of individuals who may not have formal training in a specific area, and to provide refresher training to individuals who already have some background. The series focused on technical topics appropriate for environmental professionals working on the SRS. SREL faculty and SRS professionals served as instructors for most of the courses, with outside faculty assisting as needed. A list of tentative topics, instructors, and dates, was selected in conjunction with ACP.

During FY2010, this training series began with the initial class taught by Dr. Walt Kubilius (SRNS-ACP) on *Lab Analyses-Target Compound List/Target Analyte List (TCL/TAL) Overview.* The 2nd class, *Metals Contamination at Steed Pond and Tim's Branch,* was taught by Drs. John Seaman (SREL) and Karen Gaines (Eastern Illinois University). The 3rd class, *Bioavailability and Toxicity of Metals*, was taught by Dr. Gary Mills (SREL). Student evaluations of the classes were positive regarding both the content and instructors. Student participants are issued Continuing Education Units (CEUs) through the University of Georgia based on the length of the sessions. Generally sessions have 15-25 participants. Classes are held in the Distance Learning Building at SREL, except where special facilities are needed. Classes continue into FY2011.

Developing an Automated Remote Stream Monitoring Network within the Tims Branch/Steed Pond System

John Seaman, Julian Singer, Shea Buettner[1], and Aaron Thompson[2]
[1]UGA Graduate Student, [2]UGA Assistant Professor, Crop and Soil Science Department

Conventional approaches to stream monitoring for contaminants generally consist of discharge estimates based on stream depth calibrated with manual stream profile data, and water samples collected at arbitrary intervals for chemical analysis. However, previous studies conducted by SREL in the early 1990s demonstrated that erosion and sediment transport was a significant vector for contaminant migration within the Tims Branch/Steed Pond (TBSP) system, while

routine monitoring efforts observed little contaminant movement associated with base flow. Stream sampling to account for such discrepancies, however, can be logistically and financially prohibitive. Monitoring efforts are further complicated by the characteristic lag between precipitation, maximum stream discharge, and particulate mobilization that depend on the precipitation rate, stream location, watershed moisture status and other complex, interrelated factors which hinder the development of a standardized monitoring protocol that is applicable to all stream sites, even those within the same watershed. Therefore, a responsive monitoring system designed to collect discrete stream-water samples when triggered by any number of user-defined environmental parameters reflects a significant improvement over conventional methods.

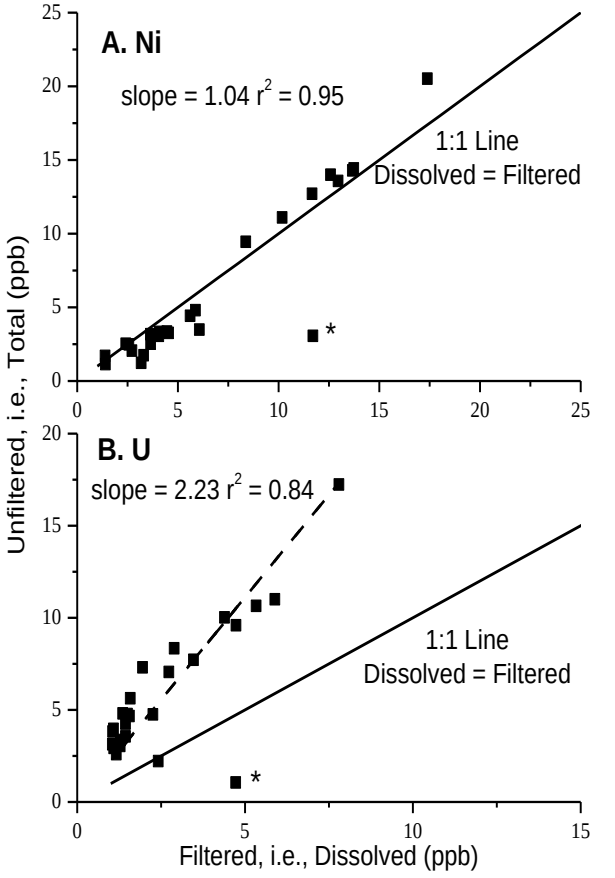
To address such limitations, SREL is developing an automated stream monitoring system that responds to transient flow conditions in a manner designed to evaluate the impact of episodic precipitation events on the export of contaminants within TBSP. Furthermore, the proposed system makes use of SREL's Federal Communications Commission dedicated transmission frequency to remotely monitor and control system performance, providing real-time data acquisition capability. In FY2010, an updated version of the online data reporting system was installed on the SREL network.

A prototype monitoring system has been assembled consisting of the following: YSI water quality probe including turbidimeter, data logger, flow meter, depth gauge, ISCO sampler, batteries, solar panels, antenna, and transmitter/receiver. We are currently awaiting the results of an SRS Radcon survey to redefine the soil contamination area adjacent to Steed Pond. Assuming the radiation levels are consistent with previous surveys, the area encompassing the proposed stream monitoring site will be open to greater access that would simplify installation and routine maintenance of the prototype monitoring system. Following the Radcon survey, both manual and instrumental sampling will intensify.

Throughout FY 2010, SREL collected a preliminary set of Tims Branch stream samples to estimate current contaminant export rates during base flow. Concentrations of uranium (U) and nickel (Ni), the primary contaminants of concern (COC) in the TBSP system, were generally low, with Ni ranging from ≈ 1 to 20 μg L^{-1}, and U ranging from ≈ 1 to 17 μg L^{-1} (see Fig. 1 below). Even at base flow, a plot of unfiltered vs. filtered (0.2 μm pore size) metal concentrations indicates that a fraction of transported U (i.e., slope > 1 and poor r^2) was associated with a colloidal phase subject to filtration, while virtually all of the Ni (slope ≈ 1) passed through the filter, i.e., soluble. These trends are even stronger when the apparent outlier is removed from the data set prior to linear regression. Meanwhile, Dr. A Thompson and Shea Buettner continue to focus on the development of dynamic light scattering (DLS) combined with field flow fractionation (FFF) techniques to characterize mobilized colloidal materials collected from Tims Branch during storm events. Until greater access to the monitoring site has been approved, clays extracted from SRS soils are serving as experimental surrogates for TBSP colloids in refining instrumental analysis protocols.

In a related effort, Drs. John Seaman (SREL) and Karen Gaines (Eastern Illinois University) taught a one-day short course entitled "Metals Contamination at Steed Pond and Tim's Branch" on September 7th, 2010, which was open to site personnel for CEU credits. Nineteen people were in attendance.

Fig. 1. Total and dissolved Ni (A) and U (B) concentrations in Tims Branch stream samples collected in 2010. Starred (*) samples were excluded from the regression analysis



Contaminant Bioaccumulation and Trophic Relationships in Beaver Dam Creek Biota from the D-Area Coal Combustion Waste Plume

Angell Lindell, Dean Fletcher, and J Vaun McArthur

Coal combustion waste (CCW) has been produced by coal fired power plants on the Savannah River Site (SRS) since the early 1950's. Contaminant bioaccumulation and adverse effects of CCW on aquatic organisms has been documented in and near CCW basins adjacent to Beaver Dam Creek (BDC). Even though BDC represents the conduit connecting the contaminant sources to the Savannah River, it remains an understudied stream on the SRS. The goal of this study is to understand how and to what extent aquatic organisms in BDC are at risk from the contaminated system. Stable isotope analyses will be employed to assess the trophic organization of this stream. Concurrent trace element analyses will assess contaminant bioaccumulation. Trophic positions will not only be compared between species, but within

species that undergo ontogenetic diet or habitat shifts. Two sites in BDC are being compared to assess spatial variation in trophic organization and contaminant accumulations in aquatic organisms within the stream. Sites that differ in hydrologic regimes were selected using field reconnaissance combined with GIS layers, aerial photos, and LiDAR imagery.

The selection of aquatic organisms from a variety of ecological habits and trophic levels will allow a greater understanding of the risk of contaminant accumulation in aquatic organisms found in BDC. Fish, macroinvertebrates, mollusks, crayfish, and sediment were sampled in 2010. The ecological habits of 46 species of fish collected to date include surface, midwater, and lower water column dwelling species. Trophic levels range from small prey (e.g. cyprinids) through large predators (e.g. bowfin and gars) and diet groups include generalized invertivores, invertivore/molluscivores, invertivore/piscivores, and piscivores. Sample processing in 2010 emphasized upper level predators (longnose gar, bowfin, and largemouth bass) and four species of catfishes (channel catfish, flat bullhead, snail bullhead, and white catfish). Length frequencies were examined to ensure samples were well stratified across the available size ranges for each sex. The gonadosomatic and hepatosomatic indexes were calculated. Gut contents and extra samples/taxa were archived.

Macroinvertebrates, mollusks, shrimp, and crayfish are a critical lower link in food chains to fish and other vertebrates. Consequently these organisms may represent a vector of trophic transfer of contaminants into the BDC food web. Samples collected in 2010 encompass the functional feeding groups: predators, scrapers, shredders, filterers, gatherers, and collectors. Ecological habits (mode of locomotion, attachment, concealment) of sampled invertebrates include burrowers, sprawlers, clingers, climbers, swimmers, and surface swimmers. Sample processing in 2010 focused on eight genera of dragonfly nymphs, shrimp, mayflies, gyrinid beetles, and the Asian clam (*Corbicula*). Sediment was extensively sampled in both sites for potential contaminant analyses. These samples provide a critical record of the state of the system when the biota was sampled. Sample preparation and analyses will continue in FY11. Supplemental sampling for some prey species will also be conducted. A comprehensive community-wide analysis can provide critical insight on trophic organization and exposure pathways among aquatic organisms in Beaver Dam Creek and provide a model system for other CCW contaminated sites. This analysis will also provide valuable baseline data establishing the state of BDC during D Area power plant operation for post-operational comparison.

Stream System Field Condition Survey

Dean Fletcher, Garrett Stillings, and Christopher Barton[1]
[1] Department of Forestry, University of Kentucky

Today a broad array of disturbances ranging from pre-Savannah River Site (SRS) land use to contemporary industrial activities shapes the local landscape. Pre-SRS land use subjected streams to extensive disturbances including cattle grazing, timber harvest, channelization, and intensive agriculture. Lasting effects are evidenced by deep erosion gullies along stream valleys and incised or rerouted stream channels. Riparian corridors were fragmented by numerous dams and levees; remnants of many remain. Construction of the original SRS infrastructure in only five years (1951-1956) was a monumental task that consequently impacted many SRS streams. Agricultural land that occupied the Site prior to SRS has regenerated to forests, but present day stormwater runoff and effluent releases from SRS industrial areas continue to alter some streams. Geomorphic impairments from channelization have also been

problematic, and stream flow impediments are both a historical and present concern. Both active and abandoned structures may fragment streams, alter hydrology, and provide nick points for beaver impoundment. Characterizing SRS streams will allow us to assess effects of legacy and recent disturbances as well as identify potential contaminant sources including waste sites, outfalls, and contaminated aquifers in relation to surface flow paths and seep zones.

A collaborative effort among SRNS-ACP, University of Kentucky, USDA Forest Service, Savannah River National Laboratory, and Savannah River Ecology Laboratory has been undertaken to establish a baseline of wetland impacts to SRS headwater streams and support SRS natural resource stewardship through a three phase program. The present work addresses Phases I and II. Phase I includes a broad scale survey of potential stream disturbances and hydrological characterization. This effort requires examining aerial photos (1938-2010), LiDAR imagery, existing GIS data, maps (1943 to current), and literature as well as a field survey taken by walking entire stream drainages to identify disturbances such as flow impediments, erosion, or channelization. A digital elevation model displaying 1 m gradients created from the 2009 LiDAR imagery (by K. Weymouth, EGIS) is aiding basin characterizations. Documented flow impediments include active and abandoned dams, road and railroad crossings, and utilities cuts. Severe erosion, incision, and sedimentation from historical and present land use, outfalls, roads, railroads, utilities cuts, and abandoned borrow pits are being recorded. Pathways of outfalls and runoff from industrial areas reaching perennial or intermittent streams are being mapped. Disturbances are being placed into a temporal context to establish whether of pre-SRS or SRS origins. Perennial and intermittent streams are being field delineated and detailed maps created using LiDAR imagery. Basin characteristics are being measured for each tributary basin. Disturbed stream reaches suitable for restoration or enhancement are being located. We are summarizing our data in GIS layers, text descriptions, and detailed tables.

Phase II, initiated in 2010, further assesses impacts of disturbance and defines physical and biological endpoints for restoring the structure and stream processes of select streams. Stream hydrology, geomorphology, and habitat availability at the reach, segment and basin level are being assessed. In 2010 the entire Meyers Branch drainage comprised of the main stem and 16 perennial tributaries was walked as were six perennial tributary basins of Tinker Creek. Processing of field data additionally continued on the 13 perennial tributaries of Mill Creek. To date in these three drainages over 95 km of perennial stream which includes over 100 perennial links are being processed. Over 40 active and more than 75 abandoned structures were identified as potential flow impediments. Efforts will begin to focus on tributaries of Upper Three Runs and Pen Branch in 2011. The proposed Phase III project will prescribe, implement and monitor enhancement and restoration efforts.

Seasonal Remote and Field Reconnaissance of the Lower Three Runs Creek Corridor

Charlie Davis and Ken McLeod

The Lower Three Runs Creek Corridor (LRTCC) is an isolated and remote area of the Savannah River Site's (SRS) known to have radioactive contamination. Loosely patrolled, the area is large (~ 4300 ac/1740 ha), long and narrow (~13 miles/20.9 km), and is bordered by private ownership (38 miles/61 km of unfenced boundary). In addition, it has multiple public access points such as roads, rails, utility ROWs, and river frontage. These conditions make the

LTRCC area largely uncontrollable and therefore attractive to illegal trespass and poaching activities. Favored game such as deer, duck, turkey, hog, and alligator range widely throughout the LTRCC, prompting environmental regulators to have concerns that consumption of contaminated game and fish illegally harvested from the LTRC may pose a potential human health risk.

To more fully address the potential for a human health risk due to trespass, poaching, and consumption of game animals from the LTRCC, SREL performed an efficient, real time, and thorough reconnaissance by accompanying WSI in flyovers followed up by field verification and ground truth of observed evidence. These complimentary methods will better determine to what degree the LTRCC is seasonally receiving unauthorized use, while seeking real time evidence of trespassing and poaching that may be occurring in the LTRCC.

The project consisted of two tasks: seasonal remote reconnaissance and ground truth verification of this aerial based reconnaissance. With WSI agreeing to use their helicopter to fly the LTRCC as part of their required air time at no cost to SREL, SREL flew the four stream reaches of LTRCC during the leaf-off season to visually locate, thermally detect, and GPS indicators of trespass and poaching. Leaf-off time better enables locating ATV tracks, ladder hunt stands, food plots and shelled corn piles, motor boats, and parked vehicles at trespasser access points. SREL flew the LTRCC several times monthly from mid-October to the end of January, and then again from mid-March to the first of May. Flight time increased during the peak breeding season for deer and turkey.

Based on recorded observations from seasonal helicopter over flights, SREL verified on the next day any trespasser/poacher locations with GPS, photographs, and descriptions. With SRS remote imagery shapefiles, SREL will generate GIS maps with detailed contours elevations of the LTRCC enabling locations of likely/preferred trespasser access points. Used in combination with available registered historical photography and other GIS layers, this data will aid SRS in reconstructing the original SRP boundary for the LTRCC. This will provide visual verification of the SRS boundary when field navigating to trespass/poaching locations and for acquiring GPS locations for trespasser/poaching access points.

The field reconnaissance found numerous activities well into the SRS property, including ladder stands, raccoon bait bucket, access roads with trash and shotgun shells at its terminus, active looting on the SRS and within 10 meters of paleo-archeological dig site. Along the boundary, additional evidence included more ladder stands, remnant corn piles, and evidence of an abandoned dam, likely for waterfowl hunting and fishing. Some boundary signs were noticeably missing and/or were facing the wrong direction.

Assessing the Ecological Health of the D-Area Ash Plume Wetland

Brian Metts, David Scott, Tracey Tuberville, and William Hopkins[1]
[1] Virginia Tech

Coal-fired facilities have been in operation on the SRS since the early 1950s. All coal combustion waste (CCW) contains a complex mixture of metals, as well as naturally occurring radionuclides, that become concentrated in the fly ash during the combustion process. Public concerns about exposure to metals and naturally occurring radionuclides are understandable, but in reality little is known concerning the biological effects of chronic exposure to mixed waste (metals/metalloids/low level radiation). Determining the long-term ecological risks from chronic

exposure to contaminant mixtures is among the major challenges facing the environmental sciences.

At the D-Area power generating facility adjacent to the Savannah River, CCW was sluiced into fly ash settling basins <200 m from a floodplain forest and associated wetlands. In the early 1970s, CCW from one of the primary ash basins (hereafter referred to as “Ash Basin,” or AB) was released onto the bottomlands, resulting in a CCW plume that extends over 40 ha of floodplain at depths up to 2.7 m, including a natural wetland (hereafter referred to as “Ash Plume Wetland,” or APW). The D-Area coal plant is still in operation and the AB continues to receive fresh sluiced CCW. The APW has not received CCW discharge for >35 years and the impacted area (including the wetland) has become revegetated and a thin organic soil layer has developed. SREL has conducted research in the D-Area system for >20 years, including investigations to: characterize the severity and spatial extent of the spill, monitor water and soil chemistry parameters, determine body burdens of contaminants in a wide variety of taxonomic groups, and conduct experimental manipulations to determine the biological effects of contaminants on aquatic organisms.

Most SREL research has focused on the active D-Area settling basins where contaminant levels are highest rather than on the floodplain where natural attenuation has occurred. Research in the AB has demonstrated that amphibians and other wildlife inhabiting the basins and discharge streams can accumulate elevated concentrations of trace elements [e.g., arsenic (As), selenium (Se)] that cause adverse effects on survival, growth and development, energy acquisition and allocation, behavior or performance, and recruitment. Metal levels in the CCW associated with the APW are generally lower than levels in recent ash. Active CCW basins may be ecological sinks, but the ecological status of floodplain spill sites is unknown. For example, the contaminated D-Area floodplain site 35 years post-release appears to have an amphibian community diversity (19 documented species) and composition comparable to a nearby uncontaminated reference site, and the surrounding recovering forest exhibits species richness and basal area typical for a forest of its age.

The floodplain habitat in D-Area is critical to many amphibian species which rely on both aquatic and terrestrial habitats to complete their complex life cycles. Amphibians have been the subjects of numerous ecotoxicology studies, which have demonstrated adverse effects of CCW on amphibians. Exposure to trace metals found in CCW may decrease survivorship of larvae, increase time to metamorphosis, decrease size at metamorphosis, and alter offspring viability. Due to their biphasic lifecycle, many amphibians are susceptible to contaminants in both the aquatic and terrestrial life-stages. In addition, amphibians represent a large portion of the ecosystem biomass. One study at our reference site found that >362,000 individuals (1400 kg) of 15 species survived through metamorphosis and emigrated from the wetland in a single season. Consequently, if environmental contaminants negatively affect amphibian populations, then the whole ecosystem can be impacted.

Aquatic and drift fence sampling were combined at the APW and a reference site (REF; Ellenton Bay, EB) with artificial mesocosm studies to 1) determine the species utilizing the APW, 2) determine if southern toads maternally transfer contaminants from females to offspring, and 3) assess the biological effects of exposure to CCW on pond-breeding amphibians.

To assess the effects of exposure to CCW on reproduction, 44 toads were collected from the three sites (REF = 15, APW = 15, AB = 14) and allowed to breed in plastic containers with fresh

water. We measured clutch size, hatching success, frequency of malformations, and overall viability of each clutch. To determine maternal transfer, concentrations of arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, strontium, vanadium, and zinc were measured in females and their eggs.

Experimental mesocosms (1,500-L polyethylene cattle tanks) were used to examine the effects of CCW on the survival and growth of larval southern toads [*Anaxyrus (Bufo) terrestris*]. The mesocosms were established using 93 L of sediment from the AB, APW, or river sand [low organic content; the REF treatment], 1.5 kg of dry leaf litter per tank, and filled with well water. Mesocosms were assigned a treatment based on sediment type (AB, APW, REF) and female origin (AB, APW, REF), with each treatment replicated four times, yielding a 3x3 completely randomized design (n=36). Larval toads were reared to metamorphosis and measured and weighed. Performance of metamorphs was assessed in speed trials. Survival to metamorphosis was calculated in each mesocosm, and statistical comparisons among treatments were conducted for the dependent variables.

We captured 10 species of amphibians entering the reference site (EB) to breed, and seven species entering the APW during the same time period. We observed seven species of newly metamorphosed juveniles emigrating from EB. In contrast we documented only three species that produced metamorphs at the APW.

Female toads accumulated As, Cu, Ni, Se, Sr, and V in the contaminated sites, and transferred Cu, Ni, Se, and Sr to their eggs. Although, female toads were similar in size among sites, clutch size of AB females was 19% lower than REF females and 28% lower than APW females. Hatching success of larvae from AB and APW females was reduced 17% and 28%, respectively, compared with REF animals. The frequency of developmental abnormalities was similar among sites. However, when hatching success and malformations were considered together as a viability index, the percentage of viable offspring was reduced 21% and 31% in AB and APW females, respectively, compared with REF. Furthermore, overall reproductive success was reduced 39% in AB females and 28% in APW females compared with REF. In the mesocosms, survival to metamorphosis was significantly reduced by exposure to contaminated sediments, but was dependent on maternal origin (Fig. 1). Survival to metamorphosis was highest for REF larvae reared on REF sediments and lowest for AB larvae reared on AB sediments.

When reared on REF or AB sediments, survival to metamorphosis was significantly reduced in larvae with mothers originating from the AB and APW compared to REF females. However, when reared on APW sediments, survival to metamorphosis was significantly higher in larvae with mothers originating from the APW and AB compared with REF females (Fig. 1). Furthermore, survival to metamorphosis was significantly reduced in larvae from REF females reared on APW or AB sediments compared with REF sediments (Fig. 1). Larval period duration in AB sediments was 28% longer than larvae reared in REF sediments. In fact, larvae reared n AB sediments had the longest larval periods regardless of female origin.

Metamorph size (SVL and mass) was statistically similar among treatments; however, larvae exposed to AB sediments weighed nearly 30% less than those reared in APW and REF sediments. Growth rate of larvae raised in AB sediments was significantly reduced compared to larvae raised in REF and APW sediments. In fact, larvae raised in AB sediments grew on

average 0.4 mg/day less than those raised in REF sediments. Metamorph performance (sprint speed) was reduced significantly (34%) in metamorphs reared in AB sediments compared with APW. Although not statistically different, hopping speed of metamorphs reared in AB sediments also 26% lower than those reared in REF sediments.

Our study supports mounting evidence that CCW disposal systems pose significant risks as ecological traps by attracting wildlife from surrounding areas while simultaneously having detrimental effects on reproduction and recruitment, as well as sublethal effects that can influence fitness. Our results also suggest that impacts from CCW released to floodplain habitats may attenuate over time, as some of the biological effects examined in this study were intermediate in the APW treatment compared to AB and reference treatments. In addition, offspring from ash-exposed females reared in APW sediments outperform those from non-exposed females suggesting that with multigenerational exposure acclimation and/or adaptation to intermediate levels of metals can occur. Currently we are conducting similar a mesocosm study to assess effects of the APW sediments on southern leopard frogs, *Lithobates (Rana) sphenocephalus*.

Update of the Wildlife Literature Survey (WLS) GIS Database

Charlie Davis and Ken McLeod

For FY10, the SRNS-ACP Group continued to fund SREL to update, enhance, and maintain a literature and GIS (Global Information System) database on SRS vertebrates (and 1 mollusk) of which 77 receptor species are recognized for use in SRS risk assessments and for incorporation into the IOU (Integrative Operative Unit) GIS project. In each update, SREL collects and reviews publications, reports, theses, and dissertations and assembles records of all vertebrate (and 2 mollusk) species found in these documents. Specific site locations for the receptor species are then generated for inclusion into the WLS Excel and DBF database and ArcView GIS coverage.

SREL prepared and submitted only one update in FY10 - Version 20. Nine publications were located. Database spreadsheets were provided in ArcView.dbf and Excel.xls formats. No shapefiles were created for this Version. Metadata for the WLS shapefile was updated and publication abstracts were created in html formats. The Update Version 20 was burned to CDs and provided to ACP.

Work on this project was suspended during FY10 when the original PI resigned to take another position. The WLS and its GIS database continue to be funded for FY11 with another PI leading the project.

Improved Modeling of Inorganic Contaminant Transport in the Vadose Zone: A Defensible Basis for Monitored Natural Attenuation (MNA) and Enhanced Attenuation (EA)

John Seaman, Julian Singer and Hyun-shik Chang
SRNL Collaborators: Miles Denham and Dan Kaplan
LBNL Collaborators: J. Wan and N. Spycher

Consistent with the DOE-EM mandate, the current project seeks to improve our understanding of the fate and transport of contaminants (e.g., U and Cr) under physicochemical conditions that are both spatially and temporally variable at the field scale, focusing mainly on the EM-32 Applied Field Research Site (EM-AFRS). The current project evaluates the utility of applying surface complexation modeling (SCM) in the prediction of contaminant fate and transport in the vadose zone (i.e., unsaturated zone). SCM has received considerable attention in recent years because of the potential to predict contaminant fate under transient chemical conditions that typically confound empirically-based modeling techniques.

Extensive characterization of the reactive solid-phase is required to improve the mechanistic validity of SCM. Thirty-eight samples representing both the vadose zone and the water table aquifer at the AFRS were extensively characterized as an indication of 'reactive surface area' available for contaminant sorption, including qualitative/quantitative clay mineralogy. An additional 5 pre-fractionated clay samples submitted by LBNL were also characterized. In 2009, SREL submitted the draft report entitled "Clay Mineralogy of Sediment Cores collected from the EM-32 Applied Field Research Site" detailing the results of characterization efforts. A revised version of the report was submitted in 2010.

Based on the initial mineralogical characterization efforts, three bulk materials were chosen for subsequent batch and column experiments to represent typical soil and vadose materials from the AFRS. These materials were subjected to additional physical characterization efforts to determine their water holding capacity and hydraulic conductivity as a function of water content, i.e., $K(\theta)$, using a modified centrifuge system known as the Unsaturated Flow Apparatus (UFA Ventures, Inc.). The same UFA system will be used to complete the steady-state contaminant leaching experiments at various degrees of saturation.

To some degree, laboratory progress was hampered by analytical constraints as SREL transitioned to a new inductively coupled plasma-mass spectrometer (ICP-MS), purchased with funds provided by the UGA-Office for the Vice President of Research (OVPR). Therefore, modeling efforts focused on an existing Cr(VI) data set derived from an extensive set of column experiments using soil materials typical of the SRS (Seaman et al., 1999). The data set includes treatments designed to evaluate Cr(VI) partitioning in the presence of competitive anionic species (SO_4^{2-}, Cl^-, weak organic acids, etc.), and altered redox conditions where the subsequent precipitation of Cr(III) is largely controlled by pH and the presence of other sparingly soluble metals, i.e., Fe(III), and Al^{3+}. Although the mobile form of uranium in the subsurface environment is the cationic U(VI) uranyl species (i.e., UO_4^{2+}), competition for sorption sites and sensitivity to redox conditions make Cr an appropriate test surrogate for modeling efforts. Consistent with the laboratory results, initial modeling efforts demonstrated the importance of pH and competition for sorption sites in controlling Cr fate and transport.

In 2010, Dr. Hyun-Shik Chang (PhD, University of Washington) joined the SREL research staff after completing a Post Doctoral term at PNNL. While at PNNL, Dr. Chang developed a geochemical transport model based on the CrunchFlow code (Dr. C. Steefel, LBNL) to predict contaminant partitioning at the Hanford site. His research efforts also included a series of saturated and unsaturated column experiments evaluating reactive mineral transformations resulting from exposure to caustic tank-waste solutions (Chang et al., 2011; Um et al., 2011).

Chang, H., Um, W., Rod, K., Serne, R.J., Thompson, A., Perdrial, N., Steefel, C.I., and Chorover, J. Strontium and cesium release mechanisms during unsaturated flow through waste-weathered Hanford sediments. Environ. Sci. Technol. 2011, under review.

Seaman, J.C., Bertsch, P.M., and Schwallie, L.. 1999. In situ Cr(VI) reduction within coarse-textured, oxide-coated soil and aquifer systems using Fe(II) containing solutions. Environ. Sci. Technol. 33:938-944.

Um, W., Chang, H,; Icenhower, J.P., Serne, R.J., Qafoku, N.P., Westsik, J.H., Buck, E.C., Smith, S.C., Lukens, W.W. Immobilization and Limited Reoxidation of Technetium-99 by Fe(II)-Goethite. Environ. Sci. Technol. 2010, under review.

Support of the SRS Trophic Transfer Modeling Effort

Larry Bryan

Significant effort has been expended by Savannah River National Laboratory (SRNL) and the Area Closure Project (ACP) group to develop a model to assess ecological risk on DOE's Savannah River Site (SRS), including one contaminant exposure model to determine potential doses to endpoint receptor species (e.g. river otter and belted kingfisher). The model evaluates risk within geographic areas according to their location in integrator operable units (IOUs). To date, this modeling effort has been hindered by a lack of data from some areas and erroneous data for some areas. Our task was to develop a database of appropriate data from historical and ongoing SREL studies, assist SRNL in integrating these data into the model, and identify data gaps to be resolved to more effectively assess risk within components of the various IOUs. A second phase of this project includes collections and analyses to close these data gaps, resulting in a more efficient model.

SREL has identified databases containing appropriate data from Tims Branch, Fourmile Branch, Lower Three Runs, lower Steel Creek, and sites within the Savannah River Swamp System (SRSS) and is working to convert these databases into a format compatible to the SRNL model. The databases for Tims Branch, Fourmile Branch, Steel Creek, and Lower Three Runs containing concentrations of multiple analytes in multiple species of biota have been provided to ACP/SRNL, or are being formatted for delivery (SRSS only).

Data gaps identified by ACP/SRNL include upper Steel Creek, Pen Branch (upper, middle & lower sections), Indian Grave Branch, Castor Creek, lower Meyers Branch, SRS Pond 2, and SRS Pond A. As of mid-September 2010, aquatic biota (fish and crayfish) have been collected from all of these locations (40-80 individuals per site) and are being prepped for chemical analyses, which should occur in the fall of 2010.

ECOLOGICAL RISKS AND EFFECTS

Estimated risks and effects determine the need for remediation and restoration efforts, while perceived risks and effects determine the public's acceptance and support of DOE policies and actions. Estimating ecological risks and effects on the basis of sound science helps to ensure that good decisions are made by reducing uncertainties associated with complex environmental processes. A 1999 report from the National Academy of Sciences stated that *"Ecological risks are better characterized at the Savannah River Site than at any other DOE installation, due in part to the designation of the site as a National Environmental Research Park and the presence of the Savannah River Ecology Laboratory."*

A Comprehensive Risk Assessment Model for the Tims Branch/Steed Pond System on the Department of Energy's Savannah River Site

Larry Bryan, Karen Gaines[1], and Jim Novak[1]
[1]Eastern Illinois University

Various contaminants have been released into the Tims Branch/Steed Pond System on the DOE's Savannah River Site since the mid-1960s, including nickel, uranium, lead, chromium, copper, and other potential toxicants. These contaminants pose potential ecological and human health risk if they become incorporated in biological systems and get passed through the food chain. Our goal is to (1) examine historical contaminant data from this system's biota and (2) gather additional contaminant data needed to develop a comprehensive risk assessment model for the Tims Branch/Steed Pond system, determining the intrinsic ecological and human health risks to end point receptor species. The result of our examination of site-specific historical databases was that more information was needed pertaining to contaminant uptake within the lower trophic levels of this system.

To address this data gap, a graduate student was assigned to the project to examine contaminant uptake in amphibian larvae (tadpoles), biofilms, and aquatic insect larvae, specifically dragonfly larvae (Odonates). These samples were collected during the period of April through September, 2010, in a series of beaver impoundments (n=6) on the Tims Branch gradient starting above the M-Area input (as a "control") and extending down gradient to the Old Pond 25 site, immediately upstream of the confluence of Tims Branch and Upper Three Runs Creek. These samples will be analyzed for contaminants and stable isotopes (to document trophic position) in the fall/winter of 2010/2011. Fish and crayfish had been previously collected and analyzed from many of these same ponds in 2006-2007. Completion of the risk assessment model will occur after analyses of the current samples in 2011.

Reptiles as Long-Lived Receptors for Ecological Risk Assessment on the SRS

Tracey Tuberville and David Scott

Future management and remediation efforts within different Integrator Operable Units (IOUs) on the SRS may depend in part on predicted risks to wildlife species from contaminant exposure models. Contaminants that persist in the environment may jeopardize the reproductive fitness of long-lived organisms only after prolonged exposure. Contaminant exposure models have been

developed for river otters and belted kingfishers to examine the potential effects of metal contaminants on wildlife associated with aquatic systems on the SRS. However, models for these relatively short-lived species (otters, 8-9 yrs; kingfisher, 15 yrs) may not be representative of the exposure risks for species at similar trophic levels but with much longer life spans.

American alligators and several turtles species occur in aquatic systems of the SRS, have diets composed largely of vertebrate and/or invertebrates, and have estimated longevities of up to 40-70 years. As a result, alligators and turtles may be more appropriate ecological receptors for assessing risks associated with long-term contaminant exposure. A review of the literature to compile parameters necessary to construct the risk assessment models for these long-lived species will aid in predicting exposure risks to long-lived organisms and in identifying SRS IOUs where exposure risks are greatest.

Due to their longevity, turtles and alligators may serve as reservoirs of contaminants, and because of their mobility and (at least in some species) use of rivers and streams as movement and dispersal corridors, aquatic turtles and alligators can potentially transport contaminants offsite. For example, radioactively contaminated turtles have been captured on private lands adjacent to the SRS. Both taxonomic groups are likely to be consumed by humans in surrounding communities. Indeed, alligators are now legally hunted and consumed in both South Carolina and Georgia. Therefore, body burdens of metals and radiological contaminants in wildlife are of concern not only for the wildlife but for the humans that may consume them.

The SRS IOUs differ in their contaminant types, levels, and spatial scales, and each IOU will need to be considered individually. For example, nickel and uranium are the primary contaminants of interest in the Tims Branch/Steed Pond area of the Upper Three Runs Creek IOU, radioisotopes (especially cesium-137) are of concern in impoundments in the Lower Three Runs Creek IOU, metals such as arsenic and selenium are elevated in the Beaver Dam Creek IOU, and elevated mercury is a problem across several IOUs where environmental conditions (e.g., low pH, high dissolved organic carbon, fluctuating water levels) favor mercury methylation. By virtue of their long life spans, physiology, and trophic status as top predators, some reptile species may accumulate significant body burdens of a variety of contaminants. An assessment of tissue burdens in long-lived reptiles in SRS IOUs that have elevated levels of contaminants of potential concern would provide important validation for exposure risks models and could potentially provide opportunity to monitor long-term changes in body burdens of individuals previously sampled.

Throughout the 1970s and 1980s the turtle community in PAR Pond, Pond B, and other reservoirs in the watershed was studied intensively, including estimates of numbers, demographic parameters, and body burdens of ^{137}Cs. By selectively re-sampling particular areas and determining the current population and contaminant status we will be able to provide data needed for IOU risk assessment models. Cesium-137 kinetics in turtles has been well-studied by SREL researchers and the gamma emission of ^{137}Cs allows the estimation of body burdens without destructive sampling. Recapture of some of the 245 Pond B yellow-bellied slider turtles (*Trachemys scripta*) monitored by SREL researchers from 1986-1990, and estimates of ^{137}Cs total body burdens (TBB) will provide important insights for the risk assessment models. In addition to turtles we will also capture alligators and estimate ^{137}Cs TBB for animals in this system. Body burdens of ^{137}Cs have also been previously investigated in alligators from the Pond B and Par Pond reservoirs, providing important historical data for American alligator populations occurring at those sites and will also provide opportunity for monitoring changes in TBB for animals recaptured during our surveys.

Field sampling began in April 2010 and we sampled turtles—primarily yellow-bellied sliders (*Trachemys scripta*)—and alligators (*Alligator mississippiensis)* from a series of aquatic sampling sites that differed in their contaminant types, levels and spatial scales, including references sites not known to be contaminated. Alligators were captured using Murphy traps and by hand; turtles were captured using baited aquatic hoop net traps. Traps were set at each location for 4 days/3 nights and night time sampling for alligators was conducted once each week. We permanently and uniquely marked all animals, took standard morphometric measurements, and measured gamma radiation. We used a Canberra multi-channel analyzer and Genie 2000 spectroscopy system with a 10.16 x 15.24 cm NaI crystal to determine ^{137}Cs total body burden in subsamples of turtles and young alligators from each location. Large alligators (>40 cm) were counted with an Eberline ESP 2 Gamma Counter. The region of interest for ^{137}Cs was 596-728 keV. Count times were generally 30 minutes. The counting data were corrected for background radiation, and these data will be used to determine tissue concentrations of radioisotopes (after adjusting for the physical decay of the ^{137}Cs phantoms and animal geometry effects on counting efficiency). In addition, we collected whole blood, nail, and scute (alligators only) samples for analysis for a suite of metals.

We captured 220 turtles and 162 alligators from metals-contaminated, radiologically contaminated, and uncontaminated reference sites across the SRS. To date, 44 blood samples from yellow-bellied sliders and 44 scute samples from American alligators have been analyzed for metals. Our preliminary data suggest that ^{137}Cs is elevated in yellow-bellied sliders (Figure 1) and alligators (Figure 2) from Pond B and Par Pond, with the highest levels documented at Pond B. In addition, we also documented elevated gamma counts in turtles from a site not previously known to us to be contaminated – the Upper A01 Wetland. Our preliminary identification of the spectrum is a thorium isotope present at above-background levels due to SRS operations. The primary finding in regards to metals analysis were the extremely high body burdens of selenium in yellow-bellied sliders (presented as means and 95% confidence intervals; Figure 3) and alligators (Figure 4) from the D-Area ash basin. Analysis of the remaining samples collected to date, in addition to sampling planned for the 2011 field season, will provide a more comprehensive survey of the TBB of metals and radiological contaminants in turtles and alligators across the SRS. We will also compare our results to historical data on TBB in both turtles and alligators on the SRS, particularly in regards to individuals captured in both study periods, to evaluate accumulation and elimination of contaminants in these long-lived vertebrates over their lifetime. Finally, in future studies, we hope to examine other biological endpoints, including reproductive success, hatchling fitness, and molecular and cellular level damage.

Figure 1. Cesium levels in *Trachemys scripta* from various locations on the SRS.

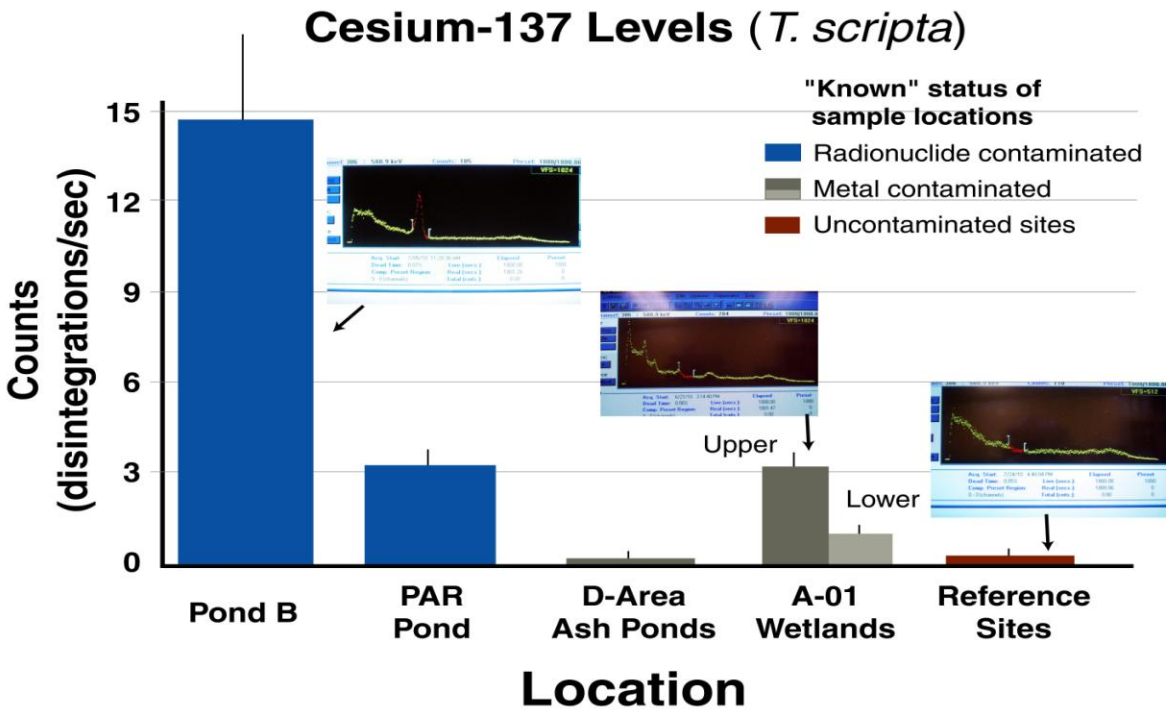


Figure 2. Cesium levels in *Alligator mississippiensis* from various locations on the SRS.

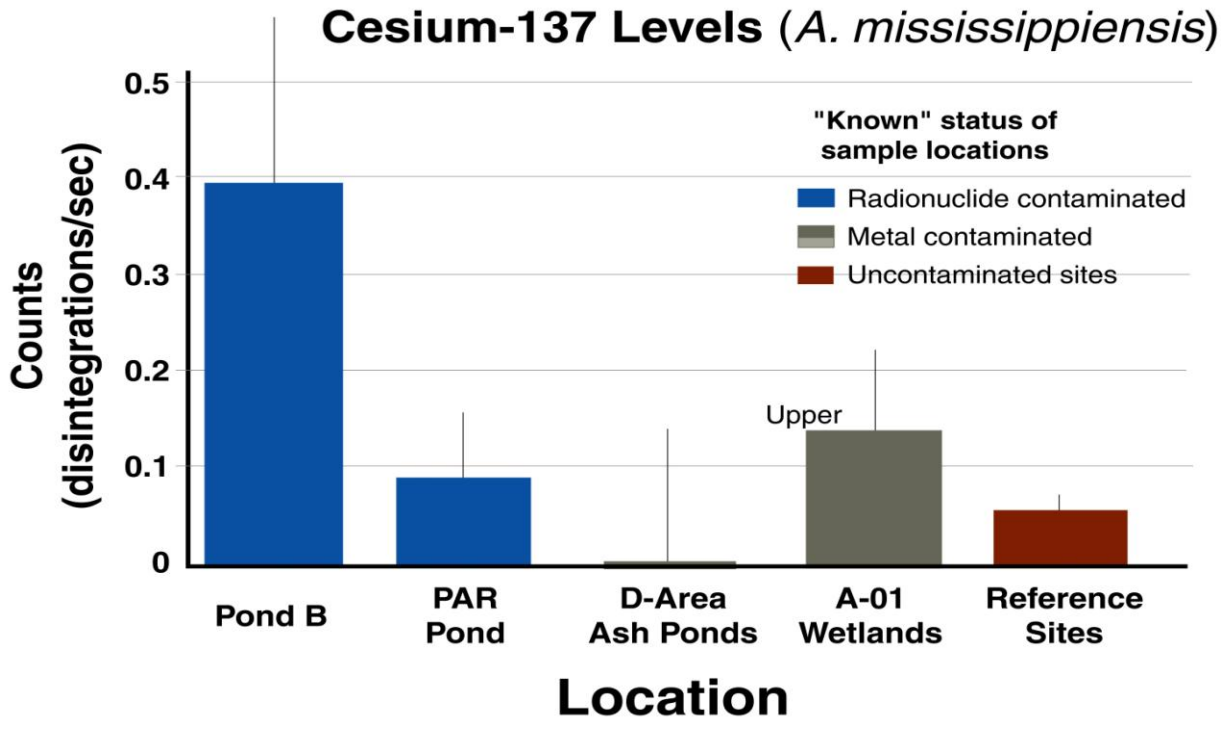


Figure 3. Selenium levels in *Trachemys scripta* from various locations on the SRS.

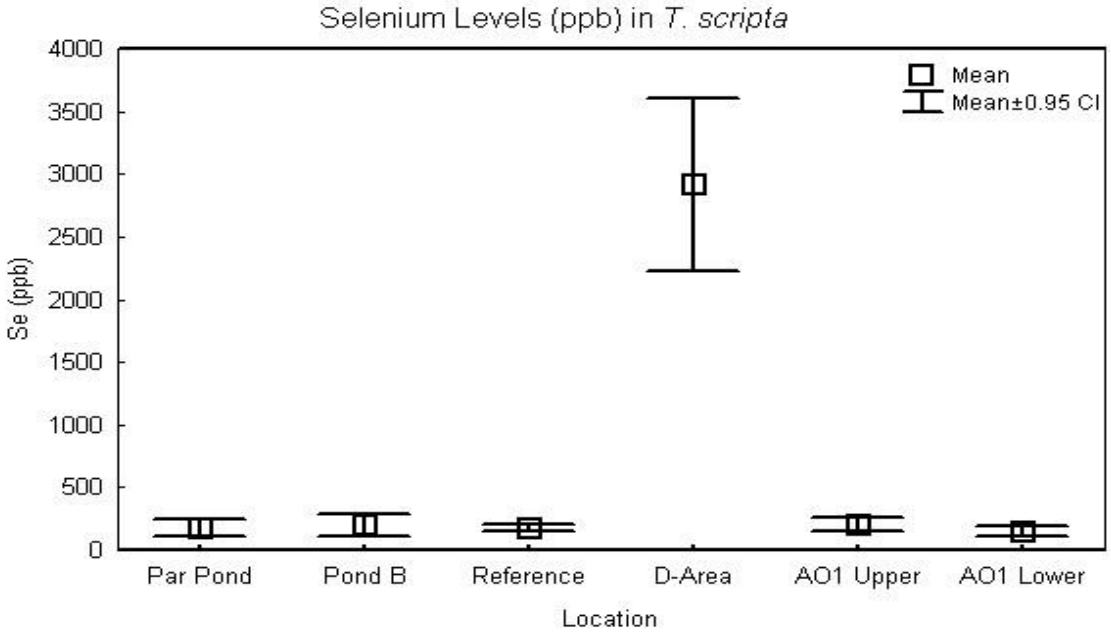
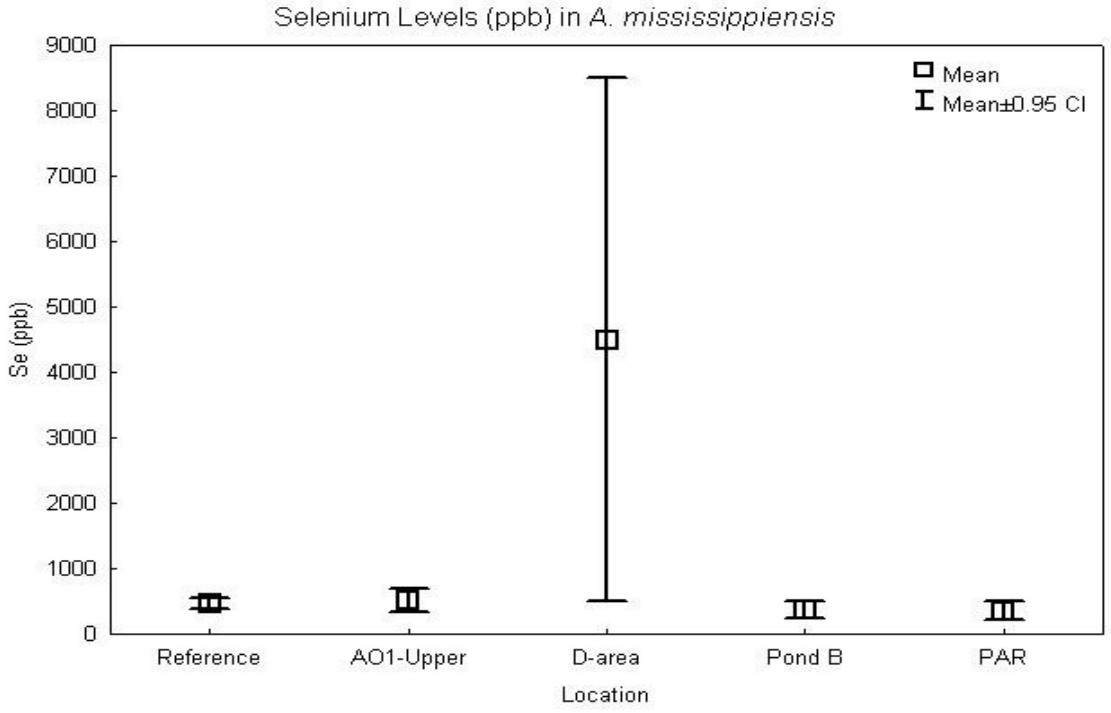


Figure 4. Selenium levels in *Alligator mississippiensis* from various locations on the SRS.



Impact of Proposed MOX Facility Effluent Discharge to Upper Three Runs Creek Watershed

Gary Mills, Michele Harmon[1], Elizabeth Burgess, and Ken McLeod
[1]University of South Carolina–Aiken

The Upper Three Runs Creek Stream Management Policy divides the stream into three regions: Region I is above the confluence of Upper Three Runs Creek (UTR) and Tinker Creek, Region II is between this confluence and the confluence of Tims Branch and UTR, and Region III is downstream of Tims Branch to the Savannah River. Regulatory compliance with the management plan requires a sound scientific evaluation of the impact of the chemicals on the aquatic ecosystems within the UTR watershed. The goals of this study are to (1) determine the current water quality characteristics and copper concentrations of UTR and compare these values to a historical comprehensive database; (2) model the chemical speciation of Cu within the expected range of Cu concentrations and measured water quality parameters to predict Cu bioavailability; (3) directly test aquatic toxicity using a standardized bioassay; and (4) develop a site-specific biotic ligand model (BLM) and water effects ratios (WER)s for UTR by linking dose-response data for Cu toxicity and geochemical Cu speciation data. Three sites, representing the three management regions have been sampled on a weekly basis for the past year. The site locations include: CCW30, northern sampling point located at bridge on Road 8-1; AEL, midpoint located at Aquatic Ecology Lab station off Road C; and UTR 3, a southern sampling point located at the bridge on Highway 125.

Temperature, pH, dissolved oxygen, and redox potential were measured in the field using potable probes. Samples for general water quality parameters were collected, and after returning to the lab were analyzed for fluoride, chloride, bromide, nitrite, nitrate, phosphate, sulfate, and alkalinity. Samples for Cu and Zn metal analysis collected for 44 sampling weeks in the study region were analyzed by inductively coupled plasma mass spectrometry (ICP-MS). The bioavailability of dissolved Cu and Zn were calculated using the EPA Biotic Ligand Model (BLM). All field and laboratory work has been completed and a final report is in preparation and will be submitted in February 2011.

Environmental Protection of DOE Lands: Studies in Long-Term Stewardship

J Vaun McArthur, Cary Tuckfield, Rebecca Sharitz, and John Morse[1]
[1]Clemson University

This project covers two main areas: (1) implementing a watershed approach to assess effects of ongoing and future industrial activities to effectively prepare for future missions, and (2) determining the effects of DOE operations on biodiversity.

I. Implementing a watershed approach –
To implement a long-term approach to stewardship of the Savannah River Site (SRS), effects of site management practices must be understood in the context of other regional changes, such as long-term droughts and increased water usage in communities surrounding the SRS. Because of funding constraints, we have chosen to begin our studies on the Upper Three Runs Creek (UTRC) watershed, which encompasses areas both on and off the SRS. We have

acquired aerial imagery of the UTRC watershed and have begun GIS evaluation of land-use changes over the last 40 years. In addition, we have assembled a database of historic water quality parameters from locations along UTRC and initiated additional sampling to evaluate changes in water quality that may be associated with off-site and on-site activities. We have made water collections at 12 study sites located on the UTRC watershed including sites both on and off of the SRS. We have completed 6 months of water quality (metals, cations, anions, etc.) sampling at 12 locations along Upper Three Runs Creek. Nine of these locations were on-site with the farthest downstream location (Box Landing) near the confluence with the Savannah River. Three locations were off-site and upstream in the watershed from the site boundary. The suite of analytes measured per water sample included Al, Ca, Fe, Mg, Mn, K, Na, As, Cd, Cr, Cu, Pb, Ni, and Zn. The intent is to compare these results with those obtained from the 1986 Comprehensive Cooling Water study (Newman 1986). Preliminary results are presently in statistical review.

II. Determining the effects of DOE operations on biodiversity –
We have completed collections of samples from our previously determined sampling locations based on the historical sites used by Dr. Morse during his studies in the early 1970s. These sites include UTRC near the site boundary. This site had the highest reported aquatic insect richness of any stream in North America. Any impacts from site operations will be minimal at this location. The other sites include locations on Tinker Creek, Mill Creek and further downstream on UTRC. We sampled every two weeks through November and then again in early March. Dates chosen for collection corresponded to the dates of the 1970 sampling plan. This will allow us to determine whether or not there has been a shift in biodiversity over the past thirty years. Our initial efforts were to identify species of Ephemeroptera (mayflies), Trichoptera (caddisflies) and Plecoptera (stoneflies). These three orders of insects are among the most environmentally sensitive species and are excellent indicators of stream health. In subsequent years of funding as many of the other aquatic insects as possible that were captured in the traps will be similarly identified. Identifications of caddisflies have been completed. Interestingly, for the caddisflies there has been no decrease in diversity over the last thirty years and indeed there are new records for the State of South Carolina.

Baseline Studies of Water and Soil Quality, Aquatic Macroinvertebrate Communities, and Vegetation in an Area Adjacent to the MOX Fuel Fabrication Facility

J Vaun McArthur, Rebecca Sharitz, John Seaman and Dean Fletcher

Construction of Plutonium Disposition Program (PDP) facilities on the SRS, including the Mixed Oxide (MOX) facility, may have unforeseen environmental consequences. According to an Environmental Impact Statement prepared for the MOX Fuel Fabrication Facility construction, no sedimentation or contamination was expected in the creeks that drain the industrial site. However, in June 2006 at least one storm event washed sand from the construction site down through an adjacent wetland slope onto the floodplain of a small stream (TRIB-1) which is a tributary of Upper Three Runs Creek (UTR) and into the stream itself. Sand deposits on the floodplain ranged up to two feet in depth. Sedimentation resulted in significant mortality of trees and other vegetation on the slope and floodplain, and was expected to affect water quality and macroinvertebrate biodiversity in the stream. Potential future effects, as the sediment load migrates downstream, are unknown and complicated by pre-existing disturbances not associated with construction activities.

In order to assess the effects of the 2006 sedimentation event, we examined water chemistry and stream macroinvertebrate biota, and the continuing effects on wetland vegetation. During this year we completed surveys of vegetation and macroinvertebrates and initiated studies on ecosystem processes such as decomposition. Our preliminary results suggest that construction of the PDP facilities may have effects on ecosystems and ecological processes that were unforeseen by the EIS. Our results also indicate the TRIB-I adjacent to the MOX site has a long history of disturbance and had been significantly altered prior to construction activities. Given that the MOX facility is the first of three major PDP construction projects to be built in this drainage, and given the environmental sensitivity of this area, we propose that broader pre-constructional / post-constructional and preoperational baseline surveys of soils, vegetation, and stream chemistry, hydrology, geomorphology, and biota in areas adjacent to the MOX site would be a good environmental stewardship action for DOE/NNSA to support. These studies should focus on the underlying causes of the observed perturbations.

I. Survey of Streams, Springs and Wetland Seeps adjacent to the PDF Construction Site – Field surveys, remote sensing analyses, and literature surveys were analyzed to establish the pre-operating condition of the area adjacent to the PDP facilities. This effort was made in conjunction with the ongoing SRS Stream Condition Survey/Stream Mitigation Bank Project being conducted by C. Barton, University of Kentucky, D. Fletcher, SREL, and J. Blake USDA Forest Service.
II. Preliminary Evaluation of Water and Soil Quality in Seepage Areas Along UTR and TRIB-I – Two stream gauging stations established in 2009 in the vicinity of the MOX facility, one within TRIB-I and the second within a nearby reference stream (u-10) continued to estimate water discharge and sediment loading during base flow and episodic storm events.
III. Evaluation of the Aquatic Invertebrate Community in UTR and TRIB-I – We continued and completed our survey of macroinvertebrates at our four sampling locations: two on UTR and one each in TRIB-I below the MOX facility and the reference stream. From these samples, it is clear that the stream adjacent to the MOX facility has been greatly altered in terms of numbers, richness and diversity of species. These sampling efforts have established that there are differences in the biological quality of TRIB-I compared to the reference stream and to UTR. We measured biomass of the EPT (Ephemeroptera, Plecoptera and Trichoptera) and obtained more fine-tuned taxonomic resolution. In addition, we have completed a first year examination of decomposition processes. The processing or decomposition of terrestrially derived organic matter provides most of the energy base for all streams on the SRS. We performed leaf decomposition studies this past fall to contrast predicted differences in the rates between the reference stream and TRIB-I. Preliminary results indicated that decomposition has also been affected in the stream next to the MOX facility.
IV. Evaluation of the Vegetation in Areas Along UTR and TRIB-I Adjacent to the MOX Site - In August 2006, two months after the sedimentation event, dead trees in the seepage slope adjacent to the MOX construction site were recorded by species and stem diameter (E.A. Nelson, pers.com.). We sampled the vegetation 10 m x 10 m plots in the main impact area (7 plots), in the adjacent floodplain of the nearby stream (TRIB-I, 4 plots), and in two reference sites (8 plots) during the spring and summer of 2009 and the summer of 2010. In each plot, all trees and saplings greater than 1.4 m in height were identified to species and measured for girth (diameter at breast height, DBH). Within each plot, we also established two 2 m x 2

m subplots at random locations (one on each side of the plot) for sampling herb (<30cm tall) and shrub (30 – 140 cm tall) layer vegetation.

In the main impact area, there was heavy tree mortality, especially of tulip poplar which was the canopy dominant prior to the sedimentation event, and American holly, the former subcanopy dominant. In addition, almost all of the redbay trees, the most abundant understory species, died. In the floodplain, some tulip poplar trees have also died as the sediment has moved downstream and buried their roots, and sweetbay is the canopy dominant in this area. Tree basal area in the main impact area was reduced to 31% in 2009, increasing slightly in 2010. Basal area in the floodplain was 70 – 85% of that prior to the sedimentation event. Tree basal area in the reference sites is 50 – 75% greater than in the impacted and floodplain sites. Sapling composition in the impact area shows that canopy species, including tulip poplar, are regenerating. Thus, the forest may gradually recover much of its original composition, and this recovery should be documented. Saplings of sweetbay dominate in the floodplain. Higher light conditions have promoted different herbaceous vegetation in the impacted and floodplain areas than in the reference sites, although it is expected that many of these species will lessen in importance as woody vegetation recovers.

REMEDIATION AND RESTORATION

The knowledge and expertise based at SREL are ideally suited to address the remediation and restoration of large land areas contaminated with relatively low levels of metals, organics, and radionuclides. SREL conducts multidisciplinary research designed to assist in the development, evaluation and stakeholder acceptance of remediation and restoration efforts that protect human and ecosystem health. Fundamental to the success of various bioremediation, natural attenuation, and *in situ* remediation applications is an understanding of the underlying scientific principles on which they are based.

Alternative Vegetation Studies for Waste Cap Covers

John Seaman, Rebecca Sharitz, Linda Lee, and Julian Singer

The burial of waste material and the stabilization of the overlying soil is an important part of waste management at any operational facility. Maintaining a healthy vegetative cover is an important aspect in the long-term management of such systems. At the Department of Energy (DOE), with low-level radioactive waste often being a component of the buried material, maintaining a stable landfill cap has even greater urgency. Originally, the current project was designed to make use of the Bentonite Mat Demonstration site, a set of test covers constructed in 1993 to evaluate the effectiveness of geosynthetic materials as an alternative cover system configuration for the containment of radiological waste. However, the project scope was expanded to include developing specification standards for the installation and maintenance of ACP Closure Caps, including the development of an automated system for evaluating cap performance behavior (buried sensors, remote sensing, real-time systems), recommendations for optimizing the current management regime, and the potential use of native plant species that are well-suited to the SRS environment and require less maintenance (i.e., mowing, fertilization, etc.).

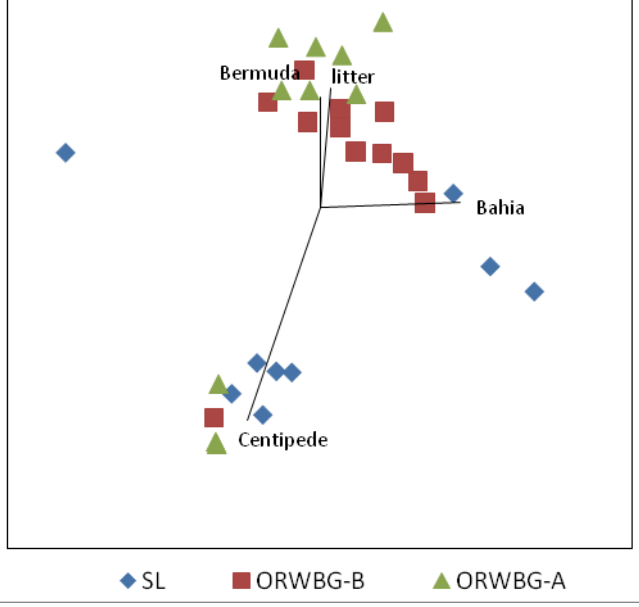
The waste caps at the Sanitary Landfill 740G (SL) south of Road C and the Old Radiological Waste Burial Ground (ORWBG) were chosen as SRS test sites because of their similar construction, and differences in age, with the SL installed in 1989 and the ORWBG completed in 2007. These field sites are being used to understand current soil and vegetation conditions on the caps, and how both soils and vegetation may change over time. These sites will also provide opportunities to pilot monitoring systems. Sampling transects were established in April 2010 on both waste caps, oriented in a manner to capture variations in slope resulting from cap installation, with exact locations documented using GIS. Soils and vegetation have been sampled at each location along these transects.

In June and July, SREL collected 9 intact soil cores at the SL (≤18” depth) and 22 soil cores at the ORWBG (4” to 18” depth), eventually yielding 92 discrete depth soil samples for analysis. Five additional soil cores were collected from areas that display extended periods of rainwater ponding within the Mixed Waste Management Facility burial ground. The intact soil cores were then transferred to SREL for visual and physicochemical characterization (i.e., particle size distribution, pH) to evaluate properties that impact infiltration and hydraulic conductivity, and aid in the design of a mesocosm test facility. The SL soil cores displayed the development of obvious soil horizons despite the limited time in place, i.e., 20 years.

Vegetation surveys were conducted at the SL and ORBG in May and October of 2010 along the sampling transect adjacent to soil sampling locations. Sampling entailed determining the

presence and area covered by all plant species within a 4 m^2 survey plot, and did not require removal of materials. Although planted grasses provided the greatest cover, 50 additional plant species were encountered in the plots on the ORWBG and 22 additional plant species in the plots on the SL. A non-metric multidimensional scaling (NMDS) ordination analysis of the May plot data (Figure 1) showed that the greatest compositional differences are driven by cover of centipede grass (typically more abundant on the SL) and Bahia and Bermuda grasses (more abundant on the ORWBG). Thus, primary differences in vegetation appear to reflect plantings rather than differences in soil characteristics or establishment of other native species through seed dispersal into the sites.

Figure 1. NMDS of Cap Vegetation, May 2010



As expected, seasonal changes on the caps mostly reflected the disappearance of cool-season species such as clovers.

The potential use of native plants as a low-maintenance cap cover, and their effects on soil water movement, will be examined primarily through a set of soil mesocosms. The mesocosms are small-scale models built to the same specifications as the materials overlying the cap: 18" of common fill, and 6" of topsoil. Sensors will be embedded in the soil, and will compare water movement under native vegetation and exotic turfgrassses. SREL has completed a prototype mesocosm. SREL has also selected a suite of native species, collected seeds from them, and completed germination tests to determine germination requirements for the seeds. A soil source for growing the plant materials has also been identified.

In FY 2011, SREL will install a series of soil pore-water sensors adjacent to the soil coring locations at the ORWBG for use in monitoring infiltration, as well as vertical and lateral water movement within the soil profile. Automated flow meters and depth gauges will be installed within the ORWBG drainage ditches, and runoff ponds to provide a gross estimate of cap infiltration. In combination with soil coring data, such information will be used in calibrating a two-dimensional (2D) model for estimating waste cap performance using the USDA's HYDRUS2D software code. The soil mesocosms designed in FY 2010 will be used to evaluate rainwater infiltration and runoff, and evapo-transpiration on moderate slopes under native and non-native vegetation. Results will indicate whether low-maintenance native vegetation provides comparable water management relative to higher-maintenance turfgrasses under meteorological conditions present on the SRS.

Continued Research at the Mixed Waste Management Phytoremediation Facility

Julian Singer and John Seaman

In support of remediation efforts at the Mixed Waste Management Facility (MWMF), SREL continued working in collaboration with the DOE, USDA Forest Service, and ACP (M. Kasraii) to assist with site management and provide the evapotranspiration efficiency estimates required for the Corrective Action Report (CAR). SREL representatives met with the MWMF management team on a regular basis to coordinate all activities, and maintain, update and report the results from the one dimensional (1D) tritium efficiency model originally developed by researchers from Cornell (Drs. K. Rebel and S. Riha). Efforts in FY 2010 focused on assisting with expansion of the irrigation area, including the installation of electronic flow meters for each of the twelve new plots and the collection of soil data for parameterization to update the Cornell Model to estimate water-use efficiency for the new irrigation plots. As in previous years, SREL also collected and analyzed two sets of bi-annual soil cores from the six instrumented plots. Twelve 3-meter cores (6 soil cores/report) were analyzed for soil physical properties and tritium concentrations in preparation for the 2009 end-of-year corrective action report (CAR) and a set mid-year 2010 efficiency calculations.

The 2009 end-of-year report for the CAR and the 2010 mid-year efficiency calculations also included the Cornell Model estimates of tritium use efficiencies and mass balance tritium use efficiencies based on soil data collected January 2010, and June 2010, respectively. Remediation efficiencies for the original irrigation area were calculated based on irrigation schedules, climate data, and soil core analysis from select plots within the facility since operation began in 2001. The lab results for the 2009 CAR report documenting the soil tritium data, evapotranspiration efficiency estimates, and updated results from the Cornell model were provided to ACP in February 2010. Average tritium use efficiencies for the six monitored plots within the original irrigation area were estimated to be 88% and 85% for tritium mass balance calculations and the Cornell model estimates, respectively. Increased rainfall in late November and December of 2009 influenced tritium concentrations sampled in the soil core samples and decreased irrigated water applications, but did not substantially affect yearly efficiencies when compared to efficiencies of previous years. Similar tritium-use efficiency rates were observed for the 2010 mid-year efficiency calculations.

SREL continued assisting the USFS in updating the irrigation system and automating various monitoring system components. In FY 2010 this included the routine maintenance of the weather station, pond-depth gauge, and automated data logging system that provides data to USFS personnel for the water deficit calculations used to determine irrigation rates. Fifteen soil cores, ranging from two to three meters in depth, were collected from expansion area plots, and characterized in terms of horizonization and soil texture. This information will be used in determining the depth placement of soil moisture sensors, and parameterizing the modified Cornell Model (i.e., rooting depths, soil horizon depths, water holding capacities/hydraulic conductivities) to reflect the new plots. SREL installed a series of electronic flow gauges within the main distribution lines serving the twelve new plots of the expansion area. A data logging station was established on site to control data collection, storage, and provide remote access to field measurements. The installation soil moisture sensors and vapor sampling equipment continues based on the core analysis results. Infiltrometer measurements within the expansion area, as an indicator of surface soil hydraulic conductivity, are also ongoing.

SREL researchers have initially completed the development of an alternate 1D model for describing tritium uptake by vegetation and downward movement through the soil profile based on the HYDRUS-1D code developed by researchers at the USDA. Initial efforts have focused on the effects of climate on phytoremediation efficiency as estimated using the two models. Preliminary comparisons with the Cornell Model evaluating various irrigation management strategies based on a 30-year site meteorological record were consistent. Continuing work will evaluate the importance of soil and vegetation variability on system efficiency. The results will be beneficial in adapting current irrigation management strategies to additional areas planned for the MWMF.

In-Situ Chemical Oxidation to Address Residual VOC Plumes on the Savannah River Site

John Seaman, Hyun-shik Chang, and Gary Mills

Groundwater plumes containing volatile organic contaminants (VOCs) such as trichloroethylene (TCE) and tetrachloroethylene (PCE) remain a major groundwater remediation challenge at Department of Energy (DOE) facilities, including the Savannah River Site (SRS). In an effort to address such challenges, the Savannah River Ecology Laboratory (SREL) working in collaboration with Savannah River Nuclear Solutions, LLC-Area Completion Projects (SRNS-ACP) and Redox Tech, Inc. conducted a field-scale technology demonstration to evaluate the utility of in situ chemical oxidation (ISCO) to address residual VOC contamination on the SRS. The chemical oxidant persulfate was chosen because of its limited hazard and extended persistence in the groundwater environment, an advantage in systems where effective contact between the oxidant and target compounds may be kinetically limited. Results from preliminary laboratory batch experiments indicated that base-activated persulfate was effective in destroying VOCs within two weeks both in the presence and absence of Fe-oxide rich SRS sediments.

An area down-gradient from the A-014 Outfall (a known VOC point source) and up-gradient from monitoring well SSM-19B, a well with measured TCE concentrations ranging from ≈ 10 to 40 mg L^{-1}, was chosen to serve as the M-Area Chemical Oxidation (MACO) test site. In July 2009, the four wells that constituted the MACO site, an injection well (MIP-1C) and three monitoring wells (MOP-1, MOP-2 and MOP-3) were installed. Due to the stratified nature of the VOC plume within the Lost Lake Aquifer Zone (LLAZ), and concerns that the concentrated persulfate injection solution would sink within the aquifer, the injection well screen for MIP-1C was placed at the top of the LLAZ, just below the Green Clay Confining Unit. Furthermore, two of the three observation wells (MOP-1 and MOP-2) were screened at two different sampling depths within the LLAZ.

In general, the VOC concentrations observed at the MACO site prior to persulfate injection were lower than initially anticipated based on data from SSM-19B, somewhat limiting the ability to discern persulfate-induced VOC destruction from dilution attributed to mixing with the injectate. Persulfate injection began December 10, 2009 (Day 0), and continued intermittently through December 21, 2009, with 10 oxidant batches totaling 4,800 gallons (18,168 L). After injection, the observation wells were sampled by SREL at least twice a week for the first four months, and then on a less frequent basis as groundwater data trends stabilized. The pH, electrical conductivity (EC) and oxidation reduction potential (ORP) were determined in the field, and samples were collected for persulfate, VOC, and metals analyses. The injection well MIP-1C was also sampled periodically to evaluate the persistence of persulfate.

High concentrations of persulfate persisted in injection well MIP-1C (i.e., 10 to 30 g L^{-1}) throughout the study, indicative of both a high degree of chemical stability and relatively low inherent groundwater migration rates. Quantifiable concentrations of persulfate were detected approximately two weeks after injection in both zones of well MOP-1 (1C and 1BU) located ≈ 15 ft (4.57 m) from the injection well. The concentration of persulfate observed in MOP-1 peaked at ≈ 150 mg L^{-1} around Day 40 and then slowly decreased over the course of monitoring. It is important to note that this concentration of persulfate is < 0.1 % of the initial injectate concentration (≈ 230 g $Na_2S_2O_8$ L^{-1}). Injectate breakthrough in observation well MOP-1 was also evident in the EC and Na^+ data, with ORP increasing initially and then becoming more variable with continued monitoring. Although somewhat variable at first, the TCE and PCE concentrations remained well below 0.5 and 0.05 mg L-1, respectively, through the end of December 2010. Furthermore, chloride (Cl^-) concentrations in MOP-1 were typically about twice the concentration observed in the MOP-2 well (4 vs. 2 mg L^{-1}), while sulfate (SO_4^{2-}) concentrations in MOP-1 were generally 10 time the values observed in MOP-2 and MOP-3BU. Despite limited persulfate breakthrough, the pH in MOP-1 remained essentially constant (pH ≈ 4.7) throughout the current study.

Persulfate was not detected in either zone of observation well MOP-2 (2BU and 2BL) located 25 ft. (7.62 m) down-gradient, or observation well MOP-3BU located 25 ft. up-gradient from injection well MIP-1C. Although quite variable at first, TCE concentrations in MOP-2BU and MOP-2BL have generally fluctuated between ≈ 7 to 24 mg L^{-1}, with PCE concentrations typically ≤ 1 mg L^{-1}. TCE concentrations in MOP-3BU were initially quite variable before leveling off around 15 to 20 mg L^{-1} for the first 100 days of testing, with even higher values ranging from 20 to 50 mg L^{-1}observed more recently.

In summary, low concentrations of persulfate breakthrough were observed in both screened zones of observation well MOP-1, in close proximity to injection well MIP-1C. TCE and PCE concentrations in observation well MOP-1 were much lower than observed in the other MACO wells throughout the duration of the study. Although some dilution is inherent in the in situ chemical treatment of aqueous phase contaminants, elevated concentrations of Cl^- and SO_4^{2-} observed in both zones of observation well MOP-1 are in part indicative of VOC destruction resulting from chemical oxidation. Subsequent laboratory experiments confirmed the somewhat limited mobility of persulfate in the SRS subsurface environment due to sorption in Fe-oxide rich materials, a factor that can in part account for low persulfate recoveries in the current study. However, some degree of reversible sorption combined with oxidant persistence can facilitate the remediation of aqueous-phase VOCs through the in situ formation of a chemically reactive treatment zone. Furthermore, batch results confirmed the continued effectiveness of persulfate in degrading VOCs in the absence of an activating agent at the relatively low persulfate concentrations (≤ 192 mg L^{-1}) observed in well MOP-1.

H-02 Constructed Wetland Biogeochemical Studies

Gary Mills, Elizabeth Burgess and Ken McLeod

The H-02 wetland was designed for treating effluents from multiple sources associated with the Tritium Facility at the DOE-Savannah River Site. Development of the wetlands has been monitored since 2007, including measurement of copper concentrations in surface water and sediments, as well as, characterization of the microbiological community associated with wetland biogeochemistry. During the last year, influent copper concentrations in surface water have ranged from 17.0-47.7 ppb (average 32.9 ppb) and effluent copper concentrations ranged

from below detection limits (~3 ppb) to 17.9 ppb. This corresponds with an average Cu removed of 75%. In addition to Cu removal, the wetland continues to ameliorate high pH and alkalinity values associated with the influent water. Dissolved organic carbon (DOC) is expected to play an important role in binding aqueous Cu and transporting it to the sediments. The Cu concentrations in the surface layer of the sediments have increased over the lifetime of the wetland and, along with DOC, demonstrate seasonal variation (i.e., higher concentrations in the summer months). C and N stable isotope ratio data suggest some additional changes in the wetland over time, which are being examined more closely with recently collected samples. By design, sulfate-reduction in the wetland should contribute to mineralization of Cu within the sediments over time. Black layers within sediment cores, suggesting sulfide formation, have been observed with increasing frequency. Reduced sulfur concentrations in the sediments ranged from below detection limits (<200 ppm) to 1480 ppm, however, the highest concentrations did not necessarily correspond to sediment depth or color. During the most recent core sampling event, sulfate reduction rates in the sediments were determined using radiotracer techniques. An active sulfur cycle in the wetland rhizosphere is suggested by sulfate-reduction rates from 12.1 to 18.5 µmol sulfate/dm^3•hr within the first three centimeters of sediment. These results are consistent with the detection of lipid biomarkers for sulfate-reducing bacteria in the surface sediments of previously collected core samples and are being confirmed by lipid analysis of the more recent samples. The highest sulfate reduction rate, 28.6 µmol sulfate/dm^3•hr, was measured between six and nine centimeters from the sediment surface. Along with sulfate-reduction rates, methane oxidation rates were also determined on a subset of the most recent core samples. The activity of methane oxidizing bacteria is a mechanism by which Cu may be incorporated into dissolved and particulate organic matter within the wetland and may be valuable for mitigating release of methane resulting from wetland construction. A methane oxidation rate of 472 nmol methane/ dm^3•hr was measured in the first three centimeters of the wetland sediments. The microbiological communities associated with the wetland sediments are also being characterized by analysis of environmental DNA. Thus far, the presence of Bacteria and Archaea at all depths examined has been confirmed by PCR of 16S rRNA genes. Subsequent sequencing of these genes should enable identification of the most abundant community members, as well as, how the communities have changed since the construction of the H02 wetland.

H-02 Constructed Wetland Studies: Amphibians and Plants

David Scott, Rebecca Sharitz, Tracey Tuberville, Gary Mills, Paul Stankus, Linda Lee, Matt Erickson, Wes Flynn, Brian Metts, and Stacey Lance

An artificial wetland complex (H-02) was constructed in H-Area on the Savannah River Site (SRS) in 2006-07 to treat process and storm water discharge from H-Area industrial facilities. The H-02 wetland complex is a series of surface flow constructed wetlands designed to reduce copper (Cu), zinc (Zn), and pH levels before H-Area effluent enters Upper Three Runs Creek tributaries. The ability of artificial wetlands and stormwater ponds to improve many aspects of water quality is well known. Trace metals such as Cu, lead (Pb), and Zn are removed by adsorption to organic matter and clay particles, and sulfate-reducing bacteria enable the precipitation of metal ions in the anaerobic soils.

Constructed wetlands that are engineered primarily for water quality improvement provide new habitat for local plant and animal species, but these artificial wetlands may also have negative consequences for biota. For aquatic-breeding animals such as amphibians, if high levels of trace metals limit recruitment then these wetlands could become population sinks. In addition,

there is potential for non-native invasive plant species to become established in artificial wetlands. The H-02 treatment complex consists of a retention pond, which receives the process water, and two constructed wetland cells. The two treatment cells were planted with giant bulrush, *Schoenoplectus californicus*, in 2007. Water in the retention pond has the highest levels of Cu, Zn, and pH, and after a residence time of several days water exiting the wetland cells has lower levels of these variables. The Savannah River Ecology Laboratory (SREL) initiated amphibian and vegetation surveys at the H-02 wetlands in May 2008. We are monitoring amphibian and plant species colonization and establishment in the wetlands, and evaluating the effects of elevated metal levels on amphibian success.

Copper concentrations in the H-02 system can vary spatially throughout the system, ranging as high as 31-37 ppb in the influent in summer months to 7 ppb in the effluent exiting the treatment wetlands. Levels in portions of the retention pond have reached 340-590 ppb. These concentrations may be of concern for normal amphibian development. The ecological research conducted by SREL at the site focuses primarily on four questions related to these treatment wetlands: 1) Over time, what amphibians, reptiles, and plants have become established in the wetlands? 2) Is there any evidence that elevated trace metal levels (e.g., Cu and Zn) in the wetlands affect amphibian reproductive and recruitment success? 3) How do the amphibian diversity and numbers compare to other, more natural, wetlands? 4) As the constructed wetlands age, how will the amphibian and plant communities respond?

This report summarizes our amphibian and vegetation sampling at the H-02 treatment wetlands from October 2009 to September 2010. We used permanent plots established for vegetation monitoring and aquatic trapping to characterize biota of the treatment wetlands. Adjacent drift fence arrays with pitfall traps (Figure 1) were used to estimate breeding amphibian numbers and juvenile production. In addition to monitoring amphibian and reptile use of the wetlands, we collected data on metal burdens of amphibians inhabiting the wetlands, and we are conducting field and laboratory tests on effects of Cu concentration on amphibian development in three species (the southern toad, *Bufo terrestris*, the eastern narrowmouth toad, *Gastrophryne carolinensis*, and the southern leopard frog, *Rana sphenocephala*). We are also monitoring vegetation colonization and succession patterns, with a special interest in how vegetation structure, species richness, proportional abundances, and invasive species numbers change over time.

Biotic samples were collected to determine Cu and Zn levels in amphibian tissue, and field and laboratory experiments were employed to assess metal effects. We are conducting laboratory and field experiments to test the effects these trace metals have on three common amphibian species. Experiments in FY-2009 documented that egg and early hatchling survival of *R. sphenocephala* was reduced at higher Cu concentrations (50, 100 and 150 ppb). In FY-2010 we conducted additional field and laboratory experiments on larval *R. sphenocephala*, as well as eggs and larvae of *B. terrestris* and *G. carolinensis*.

In general we have observed significant egg mortality at higher Cu concentrations for the three species tested to date (Table 1). Species appear to differ in their sensitivity to Cu treatments (Fig. 2), with *G carolinensis* most sensitive (highest egg mortality at low Cu levels*), B. terrestris* intermediate, and *R. sphenocephala* least sensitive. In addition, in several trials, eggs from different females varied in survivorship (across species; Table 1), and in one trial for *Bufo* the source location of the female (captured at the H-02 site or at a reference location) affected egg response. These results suggest that females may also differ in sensitivity to Cu, which provides the basis for adaptation or acclimation to elevated metal levels to occur over time.

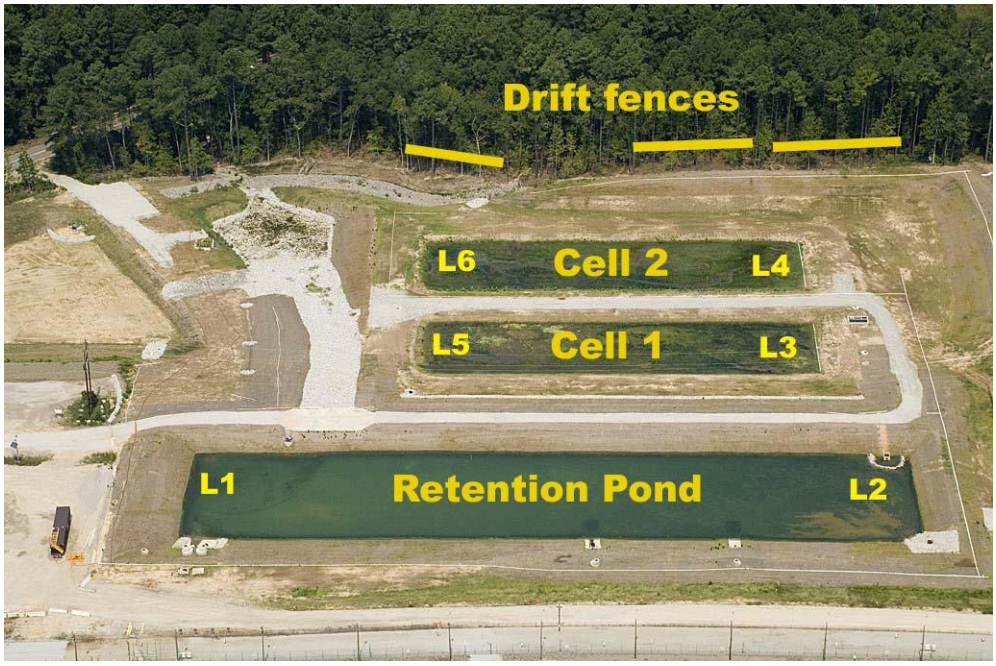


Figure 1. Drift fence/pitfall trap and egg/larval field experiment locations within the H-02 wetland system. Locations L1 & L2 (retention pond), L3 & L4 (influent end of wetland cells), and L5 & L6 (effluent end of wetland cells) represent a gradient of water chemistry along which the “bucket studies” have been conducted. Highest pH, Cu, and Zn levels occur in the retention pond, and progressively lessen throughout the treatment wetlands.

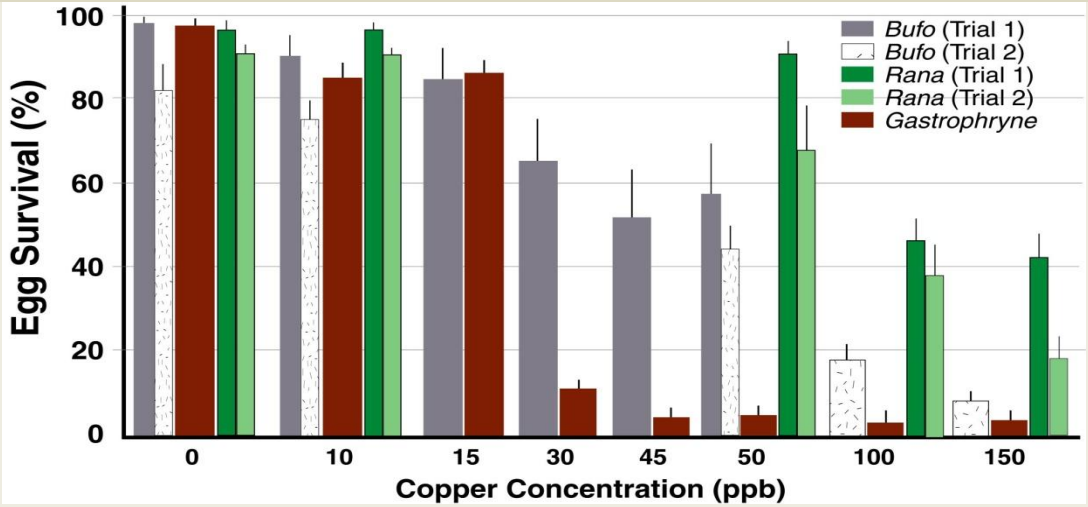


Figure 2. Combined egg survival for three amphibian species across a range (0-150 ppm) of copper concentrations. All trials were conducted with 30-50 eggs in 400-ml containers.

Table 1. Results of analysis of variance (ANOVA) for effects of copper on egg and larval survival for three amphibian species.

Species	Source (effect)	DF	F-value	P-value
Egg survival				
R. sphenocephala				
Trial 1	Cu	4	73.3	<0.0001
	Female	3	2.04	0.1162
Trial 2	Cu	4	41.8	<0.0001
	Female	2	17.7	<0.0001
B. terrestris				
Trial 1	Cu	4	82.3	<0.0001
	Location	1	107.7	<0.0001
	Female	6	4.9	<0.0002
Trial 2	Cu	5	7.7	<0.0001
	Female	3	15.1	<0.0001
G. carolinensis				
	Cu	7	335.8	<0.0001
	Female	3	0.9	0.435
Larval survival				
R. sphenocephala				
	Cu	3	3.0	0.09
	Female	3	9.7	0.0036
B. terrestris				
	Cu	5	30.7	<0.0001
	Female	3	3.1	0.0610

To date, we have analyzed the results of the larval experiments for *Rana* and *Bufo* (Table 1). *Bufo* larvae are more susceptible than *Rana* to increased Cu concentrations, although there also appears to be a trend for increased larval mortality even for *Rana* at higher Cu levels (100 ppm; Fig. 3A). Comparison of the total body burdens of Cu in laboratory trials versus field experiments indicates that the lab experiments appear to bracket the Cu concentrations in the H-02 system (Fig. 3B,C).

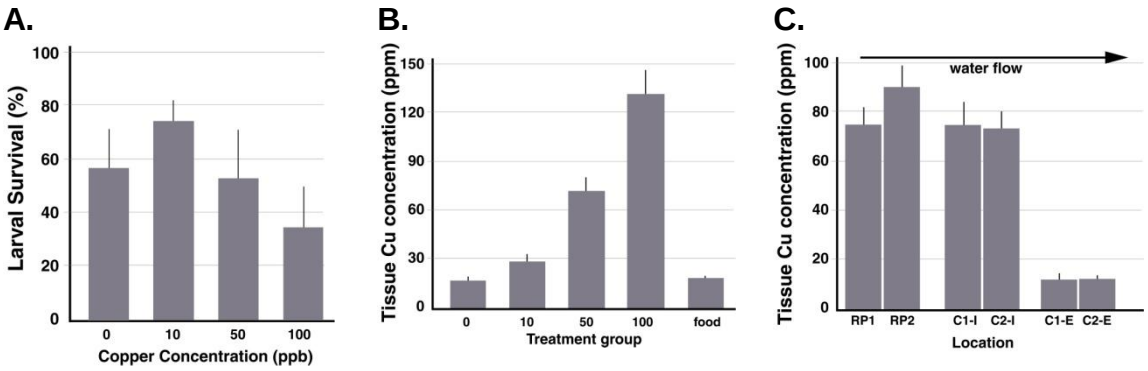


Figure 3. A. Larval survival of *R. sphenocephala* tadpoles reared at four Cu concentrations; B. Final body burdens of copper in metamorphs from the larval treatment groups; C. Final body burdens of copper in metamorphs from larvae reared across the water quality gradient in the H-02 wetland system (RP = retention pond locations, C-I = influent ends of wetland cells, C-E = effluent ends of wetland cells).

H-02 vegetation surveys — The dominant plant species were generally similar between the two cells of the H-02 wetland complex; most differences in species composition reflected differences in the less abundant species. The planted *Schoenplectus californicus* (giant bulrush) remains the dominant species although several floating aquatics, especially *Limnobium spongia* (spongeplant), *Lemna minor and Spirodela polyrrhiza* (the duckweeds), and *Azolla caroliniana* (mosquito fern) have increased in coverage (Fig. 4). Mosquito fern is of particular interest because it is a nitrogen-fixer. Coverage of this species has increased steadily from a small presence in 2008 to nearly 20% of total vegetation cover in 2010. Densities of the planted giant bulrush varied greatly among our sample plots in both wetland cells, but the variability declined in 2010, indicating a more even distribution of stems.

Though *Schoenoplectus californicus* was the only species actively planted in the wetlands, at least 23 additional species have been recorded. Most species found in the cells are typical native species of local wetlands; however, two of the plants previously found in the H-02 wetlands, *Alternanthera philoxeroides* (alligatorweed) and *Pistia stratiotes* (water lettuce), are on the South Carolina Department of Natural Resources Aquatic Nuisance Species list. In 2010, alligatorweed was found in only one sample plot in each of the wetland cells, with a cover value of less than 10%. This species has been reported in other wetland and aquatic sites on the SRS over the years.

The presence of these non-native species demonstrates one of the persistent problems associated with using non-local plant materials in wetland construction or restoration. In an examination of aquatic plant materials ordered from vendors in 17 states, it was reported that 93% of the orders contained a plant or animal species not specifically requested. In wetland construction or restoration efforts, there is often an initial period of invasion by undesirable species. Typically, if proper hydrologic conditions are imposed, such invasions are temporary, although selective removal may be necessary in the beginning. Vegetation will continue to be

monitored and compared from year to year; these data can also be compared with similar created wetland systems (e.g., the A-01 system) and natural wetlands on the SRS.

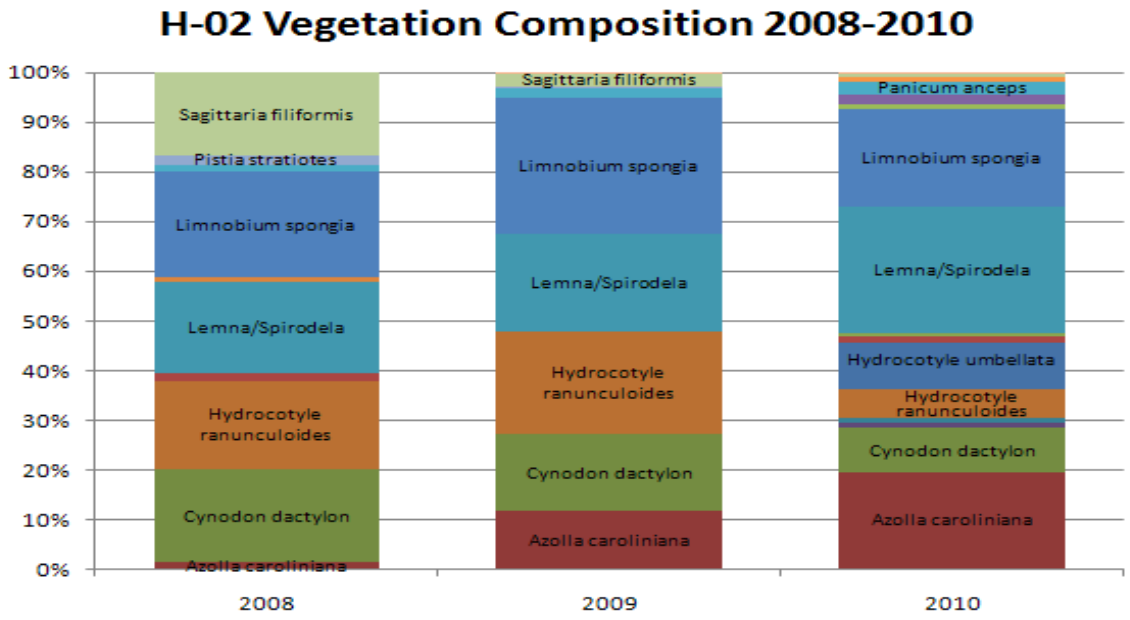


Fig. 4. Average percent cover of naturally established plant species in the H-02 constructed wetlands in 2008, 2009 and 2010, not including the planted *Schoenoplectus californicus.*

Continued studies – Our findings of significant differences in egg/larval survival among females and source locations of females in response to Cu concentrations suggests that future studies should include a genotoxiciology component. In addition to the potential effects of water chemistry on life history traits such as survival, there are concerns that contaminant-induced genetic changes may negatively impact both individuals (through increased mutation rates) and populations (through loss of genetic diversity). Among female differences suggest that there may be the potential for some species to adapt to elevated levels of metals. Adaptation to one stressor typically comes with negative trade-offs and may increase the risk that the H-02 wetlands become population sinks. We will develop species-specific microsatellite genetic markers for all three species as a tool to assess genetic effects; to date we have developed microsatellites via enrichment and 454 sequencing for *Rana*, and completed sequencing for *Bufo*. With these markers we can directly assess germline mutation rates and levels of population genetic variation. In addition we will be examining factors influencing gene expression. We have collected livers from 29 leopard frog metamorphs, extracted RNA, and created cDNA libraries, which will be used to compare transcriptomes among treatment groups using massively-parallel sequencing (Illumina platform). These data will allow us to directly compare the gene expression profiles of individuals, thereby comparing the activity of 1000's of genes at once. These profiles will indicate which sets of genes are up or down regulated in response to contaminant exposure that in turn provide insight into what biological pathways are impacted (such as oxidative stress, apoptosis, DNA repair, oncogene regulation).

Collectively, from all of the genetic assays we will be able to correlate contaminant levels with germline mutation rates and assess the impacts of contaminant exposure on the population genetics, as well as examine whether metal exposure affects gene expression. Together, these

genetic endpoints along with the life history endpoints will allow us to infer whether contaminant exposure causes genetic damage and whether this damage is likely to have long-term population-level consequences.

We also will continue studies on wetland plant community development and on focal amphibian species to better understand any water quality or contaminant thresholds that may negatively affect local populations. Because body burdens of trace elements acquired during the aquatic larval phase are retained through metamorphosis, these metals may be transferred from the wetland system (where they were acquired) into terrestrial food webs. This study will ultimately give us an understanding of how amphibians are an important pathway in trace element accumulation and elimination, and the extent to which they transfer metals from the H-02 wetlands to terrestrial food webs.

RESEARCH SUPPORT PROGRAMS

Several SREL programs provide critical support to the research, outreach, and education missions of the Laboratory. These support programs include:

Environmental Health and Safety Program
Quality Assurance Program
Research Data Archive Activities
SREL Undergraduate and Graduate Education Programs
Environmental Outreach Program
DOE Research Set-Aside Areas

Environmental Health and Safety (EH&S) Program

Donald Mosser, SREL EH&S Manager

The Savannah River Ecology Laboratory (SREL) continues to operate successfully under the work-smart safety and environmental standards that resulted from SREL's participation in U.S. Department of Energy's (DOE) Necessary and Sufficient process. These standards continue to address the hazards associated with SREL operations by permitting a focused effort on the health and safety issues most pertinent to SREL operations. SREL supports and promotes an integrated approach to SRS environmental health and safety issues as a signatory to the SRS Workplace Safety, Health and Security Policy and the SRS Environmental Management System Policy Statement.

SREL maintains a commitment of one, full-time position (SREL EH&S Manager) dedicated to the support of the SREL EH&S Program. In an effort to increase the efficiency and effectiveness of the SREL EH&S Program, an emphasis continues to be placed on safety and environmental training of SREL personnel. All new SREL personnel receive a two-hour SREL-specific orientation on the topic of SREL safety and environmental programs, policies, and procedures in addition to the SRS required General Employee Training (GET). New SREL personnel also receive job specific safety training provided for by their SREL supervisor. Approximately 28 (twenty-eight) new SREL personnel received this required training during FY2010. Additionally, SREL personnel received EH&S related training during FY2010 in the following functional areas as their job tasks required:

Radiological Training – Radiological Worker Training, Radioactive Sealed Source User Training, and Radiation Generating Device training

Remote worker training in accordance with SRS remote worker requirements

Hazardous Waste Management (RCRA) Training for workers responsible for handling or storage of hazardous wastes

Georgia Right-To-Know Law (GRTK- HAZCOM equivalent) chemical specific training for UGA/SREL employees who utilize hazardous chemicals in the work place

The SREL EH&S Manager functions as an interface with other SRS organizations in receiving and distributing applicable Lessons Learned information. By integrating with other SRS organizations to share Lessons Learned information, SREL takes advantage of the collective experience and improvements identified by other organizations for similar work processes and controls at SREL. SREL's internal computer network was used to provide targeted safety information to specific groups in the laboratory. The SREL EH&S Manager electronically distributed 26 (twenty-six) lessons learned notices in FY 2010 to targeted groups at SREL. Additionally, the SREL EH&S Manager electronically communicated in excess of 100 (one-hundred) SRS operational safety and environmental related announcements and notices to all SREL personnel.

The SREL EH&S Manager also interfaces with other SRS Contractor Environmental Health and Safety Programs and Professionals through participation in site level management Committees (ISM Integration Council and the SRS Senior Environmental Managers Council).

SREL waste minimization and chemical disposal issues continue to be emphasized to increase efficiency and cost effectiveness. Waste minimization techniques such as source reduction and bench-top treatment continue to be incorporated into experimental protocols, reducing the burden associated with waste disposal procedures while supporting SREL's pollution prevention efforts. SREL generated very small amounts of hazardous wastes in FY2010. As part of SREL waste minimization efforts and to ensure that chemical hazards are addressed prior to purchasing chemicals, the SREL EH&S Manager reviewed and approved 74 (seventy-four) purchase requisitions that included chemicals purchased by SREL personnel.

The SREL EH&S Manager provided weekly reports of recordable personnel accidents or injuries to DOE-SR line management. SREL also provided monthly, SREL personnel work hour statistics to DOE-SR. SREL personnel reported 0 (zero) work related injuries/illnesses during FY2010.

SREL received no Notices of Violation in FY2010 as the result of external or internal reviews, inspections, or assessments. SREL conducted assessments in the areas of chemical and radiological air emissions, community right-to-know, and the Georgia Right-to-Know law in compliance with state and federal requirements. SREL also participated in the SRS's annual, comprehensive review and declaration process for Integrated Safety Management Systems (ISMS). As part of the annual ISMS declaration, SREL revised its Integrated Safety Management System Description Document, reviewed its FY2010 safety performance, and established its FY2011 safety performance goals.

Quality Assurance Program

SREL has attempted to maintain the U.S. Department of Energy (DOE)-approved Quality Assurance (QA) program. This QA Program is devoted to assuring the continued quality of research data, benefitting both the DOE and the research community. SREL's "Good Research Practices" highlight research concepts and context, research logistics, and the conduct of research and are available to all SREL personnel.

Research Data Archive Activities

Responsible management of research data plays an important role in preserving SREL's institutional memory. SREL has built a centralized repository of research data files and

associated “metadata” necessary to make these data fully accessible. Goals of SREL’s Research Data Archive activity are to avoid the inadvertent loss of data and to use advanced electronic computer/communication technology, including the use of computer networks and the Internet, to provide access to important data as efficiently as possible. A web-based SREL data archive system allows users to upload metadata information and actual data files directly from their office desktop computers. Anyone at SREL or on the SRS can search for data using this web-based system; however, decisions about releasing original data to third parties are retained by the principal investigators.

A computer security issue reduced our ability to interactively access this system. While the computer files still exist, they are not as conveniently linked and searchable as before and retrieval of these data would be quite time consuming. SREL has secured some additional funding late in FY10 from SRNS to begin to return these data archive files to their previous condition. It is anticipated that this effort will assist in Decontamination & Decommissioning (D&D) of facilities on the SRS and interacting with relevant state and federal regulators.

SREL Undergraduate and Graduate Education Program

Gary Mills

Objectives of the SREL Education Program are to (1) recruit and develop additional professionals to the environmental sciences and (2) enhance environmental awareness and research opportunities among undergraduate and graduate students with emphasis on conducting ecological research important to the DOE and Savannah River Site mission. We have made special efforts in the recruitment from under-represented minority groups and our faculty has worked with both students and faculty from Historically Black Colleges and Universities (HBCU) throughout the Southeast.

SREL has a long history of graduate and undergraduate education, training over 400 graduate and over 600 undergraduate researchers since 1967. Undergraduate students from more than 275 different colleges and universities have coauthored more than 170 peer reviewed research publications and more than 200 of these students have gone on to pursue careers in science. SREL offers students state-of-the-science laboratory facilities, a wide variety of natural and impacted habitats for field research, a diversity of faculty expertise, and more than fifty years of experience in ecological research. Since 1967, an average of six students per year has completed graduate studies at SREL, resulting in a total of more than 335 dissertations and theses. Since 1985, our graduate students have won over 200 awards from regional, national, and international competitions at numerous professional societies and foundations. During the past year, SREL graduate students continued to compete successfully for various national and regional awards. Some of these are listed in the section on Special Accomplishments. Undergraduate and graduate student participants in FY10 are listed in Tables 1 and 2, respectively. During FY10, two Ph.D. students completed their degree requirements (Table 3). In recent years, SREL has undergone significant changes in administrative infrastructure and transitioned to self-supporting funding model. Throughout this transition period, SREL has maintained its commitment to student research and education as an integral component of it mission. In fact, six of the current graduate students initiated their program of study in 2009.

In addition to the laboratory’s formal program in graduate and undergraduate education, SREL faculty and staff assist students and their faculty mentors at several universities and the Savannah River National Laboratory in various activities in less formal relationships. This

includes access to field sites, use of field equipment, temporary lab space, as well as analytical and GIS resources for their studies. Some of these activities are highlighted in Table 4.

Table 1. SREL Undergraduate Student Program Participants, FY 10

Student	Academic Institution	Faculty Advisor/Supervisor
Traci Jones	Tennessee Technological University	G. Mills
Cedric Shambly	South Carolina State University	G. Mills
Quinell Ross	South Carolina State University	G. Mills
Jaclyn Mills	Aiken Technical College	J. Seaman
Diana Nelson	Clemson University	S. Lance
Zach Ross	Abu Dhabi University	W. Gibbons
Bess Harris	Agnes Scott College	T. Tuberville/ I.L. Brisbin
Marshall Mills	Clemson University	W. Gibbons
Jennifer Wead	U. of Tennessee	W. Gibbons
Beryl Walker	Clemson University	D. Fletcher/ J V. McArthur
Chandler Tuckfield.	Clemson University	D. Fletcher/ J V. McArthur
Cynthia Villar	U. Federal de Sao Carlos, Brazil	L. Bryan/S. Lance

Table 2. SREL Graduate Student Program Participants, FY 10

Student	Degree	Institution	Faculty Advisor
Kimberly Andrews	Ph.D.	University of Georgia, Athens	J. W. Gibbons
Shea Beuttner	M.S	University of Georgia, Athens	J. C. Seaman
Elizabeth Burgess	Ph.D.	University of Georgia, Athens	G. Mills/J. Wiegel
Jaclin DuRant	M.S.	University of Georgia, Athens	R. R. Sharitz
Larchinee Turner	M.S.	University of Georgia, Athens	J. C. Seaman
Brian Metts	Ph.D.	University of Georgia, Athens	K. Buhlmann
Julian Singer	Ph.D.	University of Georgia, Athens	J. C. Seaman
John Wilson	Ph.D.	University of Georgia, Athens	J. W. Gibbons
Gabrielle Robinson	M.S.	University of Georgia, Athens	S. Hernandez/ G. Mills
Justin Henningsen	Ph.D.	U. of Massachusetts. Amhurst	T. Tuberville/S. Lance
Paul Edwards	M.S.	U. of Eastern Illinois	L. Bryan/ G. Mills
Cynthia Tant	Ph.D.	University of Georgia, Athens	J V. McArthur
Kimberly Andrews	Ph.D.	University of Georgia, Athens	J. W. Gibbons
Sean Sterrett	Ph.D	University of Georgia, Athens	T. Tuberville

Table 3. SREL Graduate Students Completing Degree Requirements in FY10

Elizabeth Burgess	Ph.D.	University of Georgia, Athens	G. Mills/J. Wiegel
John Willson	Ph.D.	University of Georgia, Athens	J. W. Gibbons

Table 4. Other Faculty and Staff Activities Supporting Student Research and Training Activities in FY10

Kurt Buhlmann:

Anthony Henehan, SUNY Cobbleskill—wood turtle nesting Great Swamp National Wildlife Refuge, NJ

Zachary Cava, University of Massachusetts—Blandings turtle radio telemetry, Assabet River NWR, Mass.

Robert Kennamer:

Collaborator on a NSF funded project with G. Hepp (Auburn U.) and W. Hopkins (Virginia Tech). Project requires facilities, equipment, and office space provided by the Savannah River Ecology Laboratory. Field studies are conducted at PAR Pond and L-Lake on the SRS. This project is providing research and educational opportunities for 2 graduate students, Johnathan Walls (Auburn Univ.) and Sarah DuRant (Virginia Tech). Walls, along with two Auburn field technicians are stationed at SREL for 6 months per year working on the project. Sarah DuRant makes visits to SRS/SREL from Virginia Tech to assist in field work.

Tracey Tuberville:

Committee member for Jess Gonyner (University of Georgia)

Co-advisor for (University of Georgia) summer project at St. Catherine's Island

Provided blood samples for Steve Kimble's graduate work at Purdue University.

SREL faculty advisor for several undergraduate and one graduate student (Kaetlyn Kerr) at Hofstra University for NSF-funded research on the SRS.

Environmental Outreach Program

J. Whitfield Gibbons

GOAL: Maintain SRS and public outreach programs to enhance the understanding of environmental issues affecting the SRS and to increase general ecological awareness.

The Savannah River Ecology Laboratory (SREL) Outreach Program uses information from SREL long-term research efforts to provide training and services to Savannah River Site employees and to educate the public locally, regionally, and nationally. The Outreach Program is designed to enhance SREL's overall mission of acquiring and communicating environmental knowledge and to highlight NNSA's and the U.S. Department of Energy's (DOE) focus on environmental issues on the SRS. We accomplish these goals via education initiatives focusing on 1) Environmental safety on the SRS, 2) On-site outreach to the general public, and 3) Off-site outreach activities at schools and community events. Issues as diverse as wildlife safety in the field, amphibian and reptile population declines, potential responses of organisms to contamination, distribution and abundance of sensitive species, wetland dynamics and remediation, water quality, and dispersal of organisms from radioactively or chemically contaminated sites all are important beyond SREL. Outreach initiatives during FY10 were accomplished through a variety of programs and materials funded predominately from NNSA MOX and SRNS.

During the past year SREL scheduled and completed the following:

1) 51 Public Tours; estimated number of attendees - 1260.

2) 10 Wildlife safety talks for SRS employees; estimated number of attendees - 429.

3) 3 LEED certification classes for NNSA MOX employees; estimated attendees - 75.

4) 208 Onsite and in the classroom education programs for elementary and secondary students; estimated number of attendees - 12,795.

5) 107 Presentations to college, civic, and professional groups; estimated attendees - 5,620.

6) 21 Exhibits at local and regional events; estimated number of attendees - 14,651.

7) 9 Workshops conducted; estimated number of attendees – 314. (Workshop participants were mostly adults. Subjects included Alligator Safety, NERP (National Environmental Research Park), Turtle Mark-Recapture and SCDNR (South Carolina Department of Natural Resources) Master Naturalist at Palmetto Bluff, Envirovet at St. Catherine's Island, Ga., and Academy for Lifelong Learning).

8) 21 Ecologist for a Day Programs (school field trips to SREL's Conference Center); estimated number of attendees - 1,034.

Total events: 427; Total estimated attendance: 36,103

Consistent with the goals of the MOX project, SREL provided information and presentations to schools and programs in addition to resource materials to demonstrate the ecological health of the SRS, and the importance of environmental stewardship and National Environmental Research Park (NERP) programs on the SRS. Accordingly, we taught Ecology of the SRS courses for MOX LEED certification requirements, conducted Lunch and Learn presentations, provided tours for site interns, and developed slideshows for the BAD lobby. Lastly, we produced literature on native SRS plants and animals specifically associated with the MOX site, and produced a NERP booklet.

We also provided on-site training and services to demonstrate the potential sources of injury from animals and plants found on the SRS and the CSRA that could occur to remote workers engaged in field activities or to employees and their families at home. We conducted workshops and training, attended site monthly safety meetings where we delivered live animal and PowerPoint presentations. We also developed and distributed safety materials (protocol badge cards, safety fact sheets, and website). While the primary focus of most of these programs has been on snakes and alligators, we are also able to provide information on plants, insects, spiders and mammals of concern.

We participated in SRS outreach to the general public via the SRNS Public Tours program with SREL providing a 45-60 minute presentation to two tours each month year-round (24 presentations). Our presentations provide a general introduction about the history and ongoing mission of SREL and the lab's involvement with research, teaching, and community service. We concluded these programs by fielding questions from participants on wildlife identification, safety, and other ecological matters.

Public Outreach programs include: *Ecotalk*, an opportunity for students to have nature brought into their classroom for a face-to-face lesson on a variety of live animals found in local habitats; *Ecologist for a Day* visits allow students to spend the day in the field gaining hands-on knowledge of the plants and animals of the unique Upper Three Runs Creek area at our conference center; civic group presentations; and ecological tours. All school programs incorporate science standards and curricula for particular school districts. In many of these programs participants get an opportunity to work with SREL staff as they catch, mark, and measure various species of reptiles, amphibians, fish, small mammals, and invertebrates. In addition, we offer an annual free program, *Touch an Animal Day*, to the CSRA community at the SREL Conference Center that allows the public of all ages to interact with live animal and plant species, to meet site researchers, and to learn more about SRS efforts. Lastly, the Outreach Program offers tours of SREL facilities, as well as exhibits and workshops for the general public.

The main SREL Outreach site receives numerous hits, as it has links to the popular *Ecologist for a Day* program, Outreach fact sheets and products, and the Ecoviews newspaper column. SREL also continues the website for *Kids Do Science* that provides all the necessary materials for 10 hands-on activities developed as part of the hands-on science program with the AHF (American Honda Foundation). This site is frequented by teachers from throughout the country who use the materials in their own classes.

SREL distributes thousands of copies of educational products and materials nationwide to schools, organizations, and the general public. Educational materials include two six-foot-long full-color posters describing the importance of wetlands, along with teachers' guides. The full-color brochure *Snakes of Georgia and South Carolina* (currently in its fifth printing) has proved to be an extremely successful educational product that reflects positively on DOE and the SRS. The book has been placed at no charge in every public library in Georgia and South Carolina and is also widely distributed at no cost to hospital emergency rooms, veterinary clinics, ambulance services, classrooms, scout leaders, and to other organizations such as the Boys and Girls Clubs in Aiken and Augusta. Articles referencing the book have appeared in numerous local newspapers and magazines including publications in Florida and Texas.

The Outreach Program also continued to distribute educational materials including fliers on *Carnivorous Plants and Their Habitats*; the national version of the Partners in Amphibian and Reptile Conservation (PARC) poster produced by SREL; the brochure *American Alligator* that discusses all safety, ecological, and conservation aspects of alligators; *An Amphibian's Eye View of Wetlands*; and *Is it a Water Moccasin?*; a children's comic book entitled *Stepping into Ecology: the Ecological Adventures of Mud E. Boot*; a sticker on *Chemistry – it's all about the nature of things*, and the *Metric System Rap* bookmark, as well as numerous fact sheets available through the website. These products are extremely popular with educators and their students, and thousands of copies have been distributed during the past year. Previously created full-color fact sheets and research "snapshots" on a wide variety of research topics were distributed as well. The SREL copies of *Carnivorous Plants and Their Habitats, American Alligator,* and the PARC poster are now depleted and reprinting will be necessary.

The Outreach Program continues to respond to inquiries from the press, directing reporters to the most appropriate researchers for their stories. In addition, SREL sends press releases to media contacts on a regular basis as well as submits research information to appropriate audiences. From 2009-2010 SREL researchers provided information to such diverse outlets as Reptiles Magazine, MSNBC, Science Daily, as well as local news outlets in the Southeast such as *the Aiken Standard*, *Atlanta Journal-Constitution*, *Athens Banner-Herald*, *Augusta Chronicle,*

Bluffton Today, Charlotte Observer, Edisto News, The Post and Courier, Tuscaloosa News, Jonesboro (AR) Sun, and *the State* newspapers. In addition, outlets from the Northeast such as the *Taunton (MA) Daily Gazette*, and *the Sun Chronicle (Attleboro, MA)* also reported information from SREL. Topics in the news included: animal behavior, animal release protocols, preserving data sets, conservation, and SREL researcher profiles.

DOE Research Set-Aside Areas

The SRS's Set-Aside Program began in the 1960s when the Atomic Energy Commission (AEC) established 10, relatively small *SREL Reserve Areas* to represent the various habitats on the SRP and to secure study sites for conducting long term ecological research. The Program was expanded in the 1980s to 30 *DOE Research Set-Aside Areas* to better protect sensitive species habitats, preserve the biological integrity of Upper Three Runs Creek, and to buffer SREL's long term research from encroaching forest management activities. These Areas are a significant component of the SRS landscape (7% of SRS totaling 14,560 acres/5,892 ha) and are found in 43 of the Site's 89 timber resource compartments. There are approximately 275 miles (443 km) of posted boundary line.

Set-Aside Areas are critical to the DOE's Environmental Stewardship mission: they provide for long term study sites as well as sanctuary and protection to much of the SRS's sensitive flora and fauna, including many archaeological sites. They also serve as benchmarks or baseline sites for conducting ecological risk assessments, contaminant transport studies, and site remediation and restoration work. They exist today in strong support of the SRS being a National Environmental Research Park.

SREL serves as the point of contact for the 30 Set-Asides and provides custodial oversight of the SRS Set-Aside Program. SREL chairs the DOE's Set-Aside Task Group which approves management prescriptions, evaluates proposed ecological research, and ensures protection from SRS land use activities. Since FY07, DOE funding support for this program has ceased. However, SREL continues the day-to-day administration of the program. Due to the recent resignation of the long-term SREL employee primarily responsible for this program SREL is in the process of developing an alternative strategy to oversee the Set-Asides.

Boundary maintenance and the development and implementation of stewardship management plans for the Set-Asides are not currently supported (i.e. funded) despite the need for such plans in order to maintain their ecological integrity and future research value. However, Site Use coordination and maintenance of research and GIS databases continues. Management treatments in the form of controlled fire or silvicultural thinnings are prescribed for timber stands/vegetation types in various Set-Aside Areas to create more natural plant communities that are suitable to the soil. It also reduces the potential for a damaging wildfire by reducing the fuel build up.

Research and Outreach in Set-Aside Areas

- Long-term research continued in Set-Aside Areas this FY using traditional study sites and reference sites for collections of uncontaminated plants, animals, soils, or water.
- SREL continued daily sampling of the Rainbow Bay Set-Aside, the longest continuous amphibian study in the world, while seasonal sampling at Ginger's Bay Set-Aside continued for the 26th continuous year. These and other long-term data coming from

studies in Set-Asides continue to be used to better understand survival patterns and population dynamics of southeastern herpetofauna. Studies continued on the effects of the chytrid fungus which has been reported on the SRS from several locales, which may yield an understanding of the factors that drive population size variation, especially with climate change predictions. Coupled with this, select amphibian species at a number of Carolina bay Set Asides continued to be sampled to help determine how genetically isolated populations are from one another. Combined with estimates of terrestrial distributions and movements of salamanders from the Ginger's Bay Set Aside, these site-wide genetic data will allow researchers to model connections among wetlands and the likelihood of recovery from local extinctions.

- Studies continued to be conducted in the Steel Creek and Dry Bay Set-Asides where aquatic vertebrates and invertebrates were sampled to examine seasonal activity levels. Tissue samples were collected from greater sirens for use in population genetics and for the development of a sex-linked marker. Also in Dry Bay, a mark-recapture population analysis continued to be conducted on greater sirens and two-toed amphiumas using PIT tags. This study examined the distribution of species and individuals among microhabitats and depth levels in the bay and focused on the ability of these species to sense and respond to chemical cues from predators.
- Also, SREL researchers continue to use Ellenton Bay as a comparison site for the projects being conducted at the D-Area Ash Plume Wetland and the H-02 constructed wetland.
- The vegetation study in the Field 3-412 Set-Aside continued this FY. This study is part of a cross-latitude experimental network examining the effects of climate change on old field vegetation succession across the Eastern US. Data gathered from this study will aid researchers in assessing important controls on the rates of woody succession and in the development of predictive climate change models.
- DOE-HQ funded SREL to conduct a biodiversity study in the UTRC Set-Aside (Area No. 30) to determine the current status of its water quality and aquatic insect life and to assess the effects of SRS operations on these watershed resources.
- SREL and SRNL collaborated on a SERDP grant that uses Set-Aside streams to develop ecological reference models and an assessment framework for other southeastern coastal plain stream systems common to the DOD's military reservations.
- Archaeologists with the USC-Savannah River Archaeologist Research Program continued their investigations examining the occupational use of the Flamingo Bay sand rim.
- The USFS-SR in collaboration with UGA scientists installed a flow weir in the Rainbow Bay Set-Aside to evaluate the watershed effects of upstream timber harvests on riparian habitats and water quality.
- As part of the ACP's Stream Restoration Baseline Project, SREL worked with the USFS-SR and University of Kentucky to continue its stream characterization in the UTRC/Tinker Creek (Set-Aside Area No. 30) and Meyers Branch (Set-Aside Area No. 11) drainages for making recommendations to future DOE restoration and mitigation efforts.
- SREL's Outreach program continued to focus on the E. P Odum Wetland (UTRC) when conducting Ecologist-for-a-Day programs at the UGA Conference Center. The purpose of these outdoor classroom studies is to enhance environmental awareness about the UTRC watershed, to promote environmental stewardship, and to encourage students to consider careers in the sciences.

EXTERNALLY FUNDED GRANTS

PI	I. Lehr Brisbin
Project Title	UGA Foundation Canine Research
Funding Agency	UGA Foundation
Period	Open
Budget	$28,505

PI	Larry Bryan
Project Title	Producing a Summary Report of the Range-Wide Status of Wood Storks
Funding Agency	U.S. Department of the Interior-USFWS
Period	September 30, 2009 — May 15, 2010
Budget	$10,000

PI	Larry Bryan
Project Title	Wood Stork Foraging Habitat Assessment for Southwest Florida
Funding Agency	National Audubon Society
Period	June 1, 2007 — June 30, 2010
Budget	$7,200

PI	Kurt Buhlmann
Project Title	Development of Amphibian Monitoring Methodologies for the Gulf Coast Network (CESU) Phase 3
Funding Agency	CESU – Piedmont
Period	October 2008 – September 30, 2013
Budget	$29,253

PI	Kurt Buhlmann
Project Title	Flatwood Salamander survey, NAS Whiting Field and OLF Holley, Milton, FL
Funding Agency	Gulf South Research Corp
Period	September 23, 2009 – December 31, 2010
Budget	$15,000

PI	Kurt Buhlmann
Project Title	Bog Turtle and Wood Turtle Population and Habitat Enhancement at Great Swamp and Wallkill River National Wildlife Refuges
Funding Agency	USDI/Fish & Wildlife Service
Period	October 1, 2009 – September 30, 2010
Budget	$15,000

PI	Kurt Buhlmann
Project Title	A Partnership for Continued Research and Monitoring o the Gopher Tortoise Reintroduction Project at the Aiken Gopher Tortoise Heritage
Funding Agency	SC Dept of Natural Resources
Period	January 1, 2010 – June 30, 2010
Budget	$18,409

PI	Kurt Buhlmann
Project Title	Habitat use by the Carolina Gopher Frog at Craigs Pond (SC Heritage Preserve and Savannah River Site)
Funding Agency	SC Dept of Natural Resources
Period	February 20, 2010 – September 30, 2011
Budget	$15,000

PI	Kurt Buhlmann
Project Title	Development of Amphibian Monitoring Methodologies for the Gulf Coast Network (CESU) Phase 3
Funding Agency	CESU – Piedmont
Period	September 23, 2008 – September 30, 2013
Budget	$54,500

PI	Kurt Buhlmann
Project Title	A Habitat Assessment and Dip-Net Surveys for Flatwood Salamanders on NAS Pensacola, Nolf Bronson and NETPDTC Saufley Field
Funding Agency	CESU – Piedmont
Period	May 15, 2010 – September 30, 2011
Budget	$16,944

PI	Whit Gibbons
Project Title	Scientific Oversight and Web Site Enhancement for the North American Reporting Center for Amphibian Malformations (NARCAM) and National Biological Information Infrastructure (NBII)
Funding Agency	USDI – USGS
Period	August 23, 2010 – July 31, 2011

PI	Robert Kennamer
Project Title	Cost of Incubation: Linking Incubation-Induced Alterations in Phenotype to Changes in Fitness
Funding Agency	Virginia Polytechnic Institute
Period	September 1, 2006 – August 31, 2011
Budget	$83,832

PI	Robert Kennamer
Project Title	Ecological Study of Birds in the Vicinity of Augusta Regional Airport at Bush Field
Funding Agency	Augusta-Richmond County Consolidated Government
Period	October 1, 2009 – September 30, 2010
Budget	$98,573

PI	Stacey Lance
Project Title	Schistosomiasis Consortium for Operational Research and Evaluation (SCORE)
Funding Agency	B&M Gates Foundation
Period	December 1, 2008 – December 1, 2013
Budget	$16,048

PI	John Seaman
Project Title	Polarized Light Microscopy (PLM) and Chemical Analysis
Funding Agency	Savannah River Nuclear Solutions
Period	January 25, 2010 – September 30, 2010
Budget	$8,200

PI	John Seaman
Project Title	Molecular Mechanisms of Bacterial Attachments to FE(III) - Oxide Surfaces
Funding Agency	US Department of Energy
Period	September 15, 2005 — September 14, 2010
Budget	$684,403

PI	Tracey Tuberville
Project Title	Genetic Mating System of Translocated Gopher Tortoises
Funding Agency	Riverbanks Zoo
Period	June 1, 2008 — December 31, 2010
Budget	$4,804

PI	Tracey Tuberville
Project Title	Using Individual Behavior-Based Modeling to Predict Population Response and Long-Term Viability of “Species At Risk”
Funding Agency	US Department of Army
Period	August 26, 2008 — August 31, 2010
Budget	$76,749

PI	Tracey Tuberville
Project Title	Support of LoDif Facility at Par Pond
Funding Agency	Savannah River Nuclear Solutions
Period	July 1, 2009 – September 30, 2010
Budget	$48,000

PI	Tracey Tuberville
Project Title	Stream Ecological Reference Model Development
Funding Agency	Savannah River Nuclear Solutions
Period	September 14, 2009 – September 3, 2010
Budget	$69,000

PI	Tracey Tuberville
Project Title	Direct and Indirect Effects of Exurbanization on the Eastern Diamondback Rattlesnake
Funding Agency	Riverbanks Zoo
Period	January 1, 2001 – January 1, 2011
Budget	$9,200

PI	Tracey Tuberville
Project Title	Desert Tortoise Juvenile Survivorship at Mojave National Preserve
Funding Agency	USDI/NPS (CESU)
Period	March 15, 2010 – June 14, 2010
Budget	$11,750

PI	Tracey Tuberville
Project Title	A Survey of NAS Whiting Field & Associated Properties for Gopher Tortoises
Funding Agency	CESU – Piedmont
Period	May 15, 2010 – September 30, 2011
Budget	$21, 337

PI	Cary Tuckfield
Project Title	Statistical Analysis of Bird Density for the Carolina Bay Restoration Project
Funding Agency	USDA/US Forest Service
Period	May 17, 2010 – July 31, 2010
Budget	$9,600

PUBLICATIONS

Journal Articles Published In FY2010 (publication noted with an asterisk were previously published but never assigned an SREL publication number)

3117 Miles, L. G., S. L. Lance, S.R. Isberg, C. Moran, T.C. Glenn (2009). "Cross-species amplification of microsatellites in crocodilians: assessment and applications for the future." Conservation Genetics 2009(10): 935-954.

3118 Lance, S. L., T. D. Tuberville, L. Dueck, C Holz-Schietinger, PL Trosclair, III, R.M. Elsey, T.C. Glenn (2009). "Multiyear multiple paternity and mate fidelity in the American alligator, *Alligator mississippiensis*." Molecular Ecology 2009(18): 4508-4520.

3119 Weston-Glenn, J. L., D. J. Civitello, S.L. Lance (2009). "Multiple paternity and kinship in the gray fox (*Urocyon cinereoargenteus*)." Mammalian Biology 2009(74): 394-402.

3120 Lance, S. L., C. Hagen, T.C.Glenn, R.T. Brumfield, K.F. Stryjewski, G.R. Graves (2009). "Fifteen polymorphic microsatellite loci from Jamaican streamertail hummingbirds (*Trochilus*)." Conservation Genetics 2009(10): 1195-1198.

3121 Peters, M. B., J. R. Ovenden, D. Broderick, S.L.Lance, C.Hagen, T.C. Glenn (2009). "Fifteen microsatellite loci for the jungle perch, *Kuhlia rupestris*." Molecular Ecology Resources 9(6): 1467-1469.

3122 Semlitsch, R. D., B. D. Todd, S.M. Blomquist, A.J.K. Calhoun, J.W. Gibbons, J.P. Gibbs, G.J. Graeter, E.B. Harper, D.J. Hocking, M.L. Hunter, Jr., D.A. Patrick, T.A.G. Rittenhouse, B.B. Rothermel (2009). "Effects of Timber Harvest on Amphibian Population: Understanding Mechanisms from Forest Experiments." BioScience 59: 853-862.

3123 Kwit, C. and B. Collins (2008). "Native Grasses as a Management Alternative on Vegetated Closure Caps." Environmental Management 41: 929-936.

3124 Lance, S. L., C. Hagen, T.C. Glenn, N.A. Freidenfelds, T. Langkilde (2009). "Development and characterization of seventeen polymorphic microsatellite loci in the eastern fence lizard, *Sceloporus undulatus*." Conservation Genetics Resources 1: 233-236.

3125 Lance, S. L., K. L. Jones, C. Hagen, T.C. Glenn, J.M. Jones, J.P. Gibson (2009). "Development and characterization of nineteen polymorphic microsatellite loci from seaside alder, *Alnus maritima*." Conservation Genetics 10: 1907-1910.

3126 Miles, L. G., S. R. Isberg, T.C. Glenn, S.L. Lance, P. Dalzell, P.C. Thomson, C. Moran (2009). "A genetic linkage map for the saltwater crocodile (*Crocodylus porosus*)." BMC Genomics 10: 339-349.

3127 Lance, S. L., C. Hagen, T.C. Glenn, J.J. Apodaca, L.J. Rissler (2009). "Development and characterization of twelve polymorphic microsatellite loci in the threatened Red Hills salamander, *Phaeognathus hubrichti*." Conservation Genetics 10: 1919-1921.

3128 Hagen, C., S. G. Platt, C.J. Innis (2009). "*Leucocephalon yuwonoi* (McCord, Iverson, and Boeadi 1995) - Sulawesi Forest Turtle, Kura-Kura Sulawesi." Chelonian Research Monographs - Conservation Biology of Freshwater Turtles and Tortoises - A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group 5: 039.1 - 039.7.

3129 Burns, J. L., B. R. Ginn, D.J. Bates, S.N. Dublin, J.V. Taylor, R.P. Apkarian, S.A. Maro-Garcia, A.L. Neal, T.J. Dichristina (2010). "Outer Membrane-Associated Serine Protease Involved in Adhesion of *Shewanella oneidensis* to Fe(III) Oxides." Environmental Science and Technology 2010(44): 68-73.

3130 Buhlmann, K. A., T. S. B. Akre, J.B. Iverson, D. Karapatakis, R.A. Mittermeier, A. Georges, A.G.J. Rhodin, P.P vanDijk, J.W. Gibbons (2009). "A Global Analysis of Tortoise and Freshwater Turtle Distributions with Identification of Priority Conservation Areas." Chelonian Conservation and Biology 8(2): 116-149.

3131 Collins, B. and S. Fore (2009). "Potential role of pollinators in microhabitat structure within a large population of *Echinacea laevigata* (Asteraceae)." Journal of the Torrey Botanical Society 136(4): 445-456.

3132 Schalk, C. M. and T. M. Luhring (2010). "Vagility of Aquatic Salamanders: Implications for Wetland Connectivity." Journal of Herpetology 44(1): 104-109.

3133 Cea, M., J. C. Seaman, A. Jara, M. L. Mora and M. C. Diez (2010). "Kinetic and thermodynamic study of chlorophenol sorption in an allophanic soil." Chemosphere 78(2010): 86-91.

3134 Luhring, T. M. (2010). "Predation by a Green Heron (*Butorides virescens*) on a Greater Siren (*Siren lacertina*)." Bulletin Chicago Herp. Soc. 45(2): 2.

3135 Winne, C. T., J. D. Willson and J. W. Gibbons (2010). "Drought survival and reproduction impose contrasting selection pressures on maximum body size and sexual size dimorphism in a snake, *Seminatrix pygaea*." Oecologia 2010(162): 913-922.

3136 Miles, L. G., S. R. Isberg, P. C. Thomson, T. C. Glenn, S. L. Lance, P. Dalzell and C. Moran (2009). "QTL mapping for two commercial traits in farmed saltwater crocodiles (*Crocodylus porosus*)." Animal Genetics 41: 142-149.

3137 Luhring, T. M. and B. D. Todd (2010). "*Siren Intermedia* (Lesser Siren). Drought Survival." Herpetological Review 41(1): 60.

3138 Schalk, C. M., T. M. Luhring and B. A. Crawford (2010). "Summer microhabitat use of the Greater Siren (*Siren lacertina*) and Two-toed Amphiuma (*Amphiuma means*) in an isolated wetland." Amphibia-Reptilia 31(2010): 251-256.

3139 Weber, J. N., M. B. Peters, O. V. Tsyusko, C. R. Linnen, C. Hagen, N. A. Schable, T. D. Tuberville, A. M. McKee, S. L. Lance, K. L. Jones, H. S. Fisher, M. J. Dewey, H. E. Hoekstra and T. C. Glenn (2010). "Five hundred microsatellite loci for *Peromyscus*." Conservation Genetics 2010(11): 1243-1246.

3140 Green, A. D., K. A. Buhlmann, C. Hagen, C. Romanek and J. W. Gibbons (2010). "Mercury Contamination in Turtles and Implications for Human Health." Journal of Environmental Health 72(10): 14-22.

3141 Baker-Austin, C., J. V. McArthur, R. C. Tuckfield, M. Najarro, A. H. Lindell, J. Gooch and R. Stepanauskas (2008). "Antibiotic Resistance in the Shellfish Pathogen *Vibrio parahaemolyticus* isolated from the Coastal Water and Sediment of Georgia and South Carolina, USA." Journal of Food Protection 71(12): 2552-2558.

3142 Wright, M. S., C. Baker-Austin, A. H. Lindell, R. Stepanauskas, H. W. Stokes and J. V. McArthur (2008). "Influence of industrial contamination on mobile genetic elements: class 1 integron abundance and gene cassette structure in aquatic bacterial communities." The ISME Journal 2008(2): 417-428.

3143 Wright, M. S., G. L. Peltier, R. Stepanauskas and J. V. McArthur (2008). "Bacterial tolerances to metals and antibiotics in metal-contaminated and reference streams." FEMS Microbiol Ecol 2006(58): 293-302.

3144 Baker-Austin, C., J. V. McArthur, A. H. Lindell, M. S. Wright, R. C. Tuckfield, J. Gooch, L. Warner, J. Oliver and R. Stepanauskas (2009). "Multi-site Analysis Reveals Widespread Antibiotic Resistance in the Marine Pathogen *Vibrio vulnificus*." Microbial Ecology 2009(57): 151-159.

3145 Pinder III, J. E., T. G. Hinton and F. W. Whicker (2010). "Contrasting cesium dynamics in neighboring deep and shallow warm-water reservoirs." Journal of Environmental Radioactivity 101(2010): 659-669.

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3148* Kelsey-Wall, A., J. C. Seaman, C. H. Jagoe and C. E. Dallas (2006). "Biological Half-Life and Oxidative Stress Effects in Mice with Low-Level, Oral Exposure to Tritium." Journal of Toxicology and Environmental Health, Part A 69(2006): 201-213.

3149 Grosse, A. M., K. A. Buhlmann and C. Hagen (2010). "Nesting Behavior of the Red-necked Pond Turtle (*Mauremys* (*Chinemys*) *nigricans*) in Captivity." Turtle Survival Alliance 2010(August): 90-92.

3150 McCord, W. P., M. Joseph-Ouni, C. Hagen and T. Blanck (2010). "Three New Subspecies of *Trachemys venusta* (Testudines: Emydidae) from Honduras, Northern Yucatan (Mexico), and Pacific Coastal Panama " Reptilia(71): 39-49.

3151 Brisbin, J., I.L. and M. S. Sturek (2009). The Pigs of Ossabaw Island: A Case Study of the Application of Long-term Data in Management Plan Development. Wild Pigs: Biology, Damage, Control Techniques and Management - SRNL-RP-2009-00869. J. J. Mayer and J. Brisbin, I.L. Aiken, SC, Savannah River National Laboratory: 365-378.

3152 Carter, D. B., K. K. Henderson, J. Brisbin, I.L., C. Bagshaw and M. S. Sturek (2009). Prevalence of Antibodies to Selected Disease Agentsin an Insular Population of Feral Swine. Wild Pigs: Biology, Damage, Control Techniques and Management - SRNL-RP-2009-00869. J. J. Mayer and J. Brisbin, I.L. Aiken, SC, Savannah River National Laboratory: 379-386.

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3154 Pappas, M. J., J. D. Congdon, B. J. Brecke and J. D. Capps (2009). "Orientation and dispersal of hatchling Blanding's turtles (Emydoidea blandingii) from experimental nests." Canadian Journal of Zoology 87(2009): 755-766.

SREL ORGANIZATIONAL CHART – FY10

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Associate Director
John C. Seaman

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- Kurt A. Buhlmann
- Stacey L. Lance
- J Vaun McArthur
- Gary L. Mills
- John C. Seaman
- Rebecca R. Sharitz
- Tracey D. Tuberville
- R. Cary Tuckfield

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(As of 10/1/2010)