South Carolina Water Resources Research Institute

Annual Technical Report

FY 2000

Introduction

S.C. Water Resources Center

The past fiscal year (1999-2000) has been a busy and productive one for SCWRC. The lists below show projects finished within 1999, those currently taking place and two projects with proposals submitted that we feel have a very good chance of being funded. The completion of the urban growth prediction model for the Charleston area has dominated our attention this past year. The project has garnered over 20,000 hits on our web site and the director has personally presented the project at five different conferences and several smaller meetings. Center staff and several others at STI are working on potential funding schemes to apply this growth model to other parts of South Carolina. With the addition of impaired stream data, runoff models, habitat loss models and storm risk models, a more holistic view of the impacts of growth on South Carolina will be possible.

Projects recently finished:

"Assessment of the Effect of Bioturbation on Advective Contaminant Exchange at the Sediment-Stream Interface" Funding Agency: USGS/NIWR PI: P.A. Work, P. Moore, J.A. McEnery Clemson University

"An Urban Growth Scenario for the Charleston Area of the South Carolina Coast" Funding Agency: S.C. Sea Grant Consortium Partners: SC Coastal Conservation League, SC Sea Grant

Projects currently underway:

"Assessment of Conditions and Public Attitudes Concerning Marine Sanitation of the Lakes Encompassed by the Savannah River Watershed Region: Policy Projections for the Future" Funding Agency: USGS/SC Water Resources Center PI: Dr. Kenneth Backman and Dr. Sheila Backman Clemson University

"Reestablishment of an Estuarine Marsh and Waterway after Causeway Removal" Funding Agency: USGS/SC Water Resources Center PI: Dr. Carla Curran and Dr. Randall Cross University of South Carolina at Beaufort

"Monitoring Coastal Wetland Change and Modeling Ecosystem Health in South Carolina Using Advances in Remote Sensing Digital Image Processing" Funding Agency: NASA/EPSCOR Program Partners: University of South Carolina, College of Charleston

"Spatial Relationships of Polluted Streams, Animal Agriculture and Human Populations in South Carolina Watersheds" Funding Agency: CU Cooperative Extension Service Partners: CU Dept. of Ag and Applied Economics, CU Dept of Sociology

"GIS Analysis for the Savannah River Basin Watershed Project" Funding Agency: US Environmental Protection Agency Cooperating with many watershed stakeholders

"South Carolina Prime Lands Initiative Land-Use Change Detections" Funding Agency: CU Cooperative Extension Service Partners: Multidisciplinary effort at Clemson University

Potential funding:

"Development of a GIS-based Database Management and Spatial Modeling Program to Characterize Sources and Effects of Natural Parameters and Anthropogenic Impact to Coastal Ecosystems" Funding Agency: S.C. Sea Grant LU-CES Program $178,000 part of a $400,000 initiative Partners: University of South Carolina, NOAA NOS Southeast Fisheries Center

"Biocomplexity-Incubation Activity: Consequences of Urban Encroachment on Natural Ecosystems" Funding Agency: National Science Foundation - $25,000 part of a $80,000 initiative Partners: University of South Carolina, SUNY-Albany

Research Program

Basic Information

Title:	Assessment of Conditions and Public Attitudes Concerning Marine Sanitation of the Lakes Encompassed by the Savannah River Watershed Region: Policy Projections for the Future
Project Number:	B-10
Start Date:	3/1/1999
End Date:	2/28/2000
Research Category:	Social Sciences
Focus Category:	Water Quality, Management and Planning, Recreation
Descriptors:	Marine sanitation, waste disposal, water qauality management, lakes, boating, planning, watershed management rerecreation
Lead Institute:	South Carolina Water Resources Research Institute
Principal Investigators:	Kenneth F. Backman, Kenneth F. Backman, Sheila J. Backman

Publication

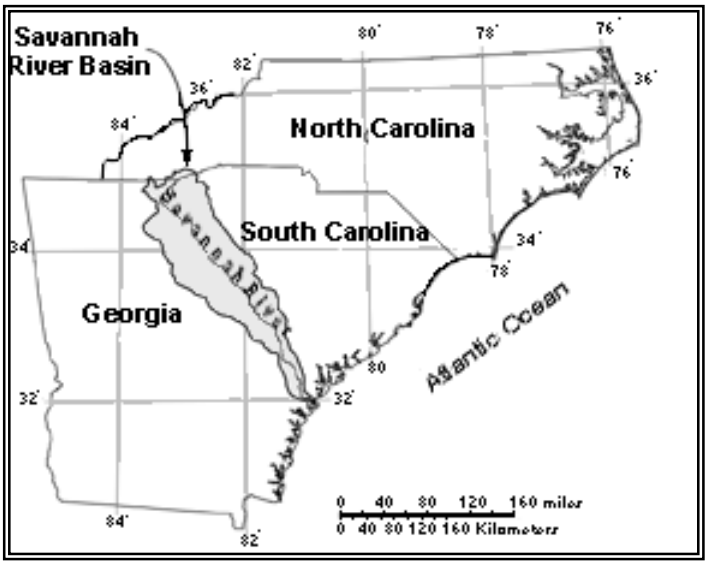
Assessment of Conditions and Public Attitudes

Concerning Marine Sanitation of the Lakes

Encompassed by the Savannah River Watershed Region

A Report for the

South Carolina Water Resources Center



by

Dr. Kenneth F. Backman
and
Dr. Sheila J. Backman

Clemson University
Clemson, SC 29634-0735

Executive Summary

Concerns are being expressed about the current practice of dumping treated and untreated waste into the lakes of South Carolina. This concern becomes even more evident with the state undergoing a three-year drought and lake water levels dropping to record levels. The current study attempted to add to the information base regarding water quality conditions in the five lakes included in the Savannah River Watershed region. A three component study of respondents to a mail survey, on-site survey, and marina operator survey was conducted for the region.

The finding of the study shows that the older mail survey respondents perceived the water quality in the region to be lower than did younger on-site boaters. Marine operators reported the highest positive perceptions of water quality. All respondents rated the quality of the water in Lake Hartwell as the lowest and in need of immediate attention. The water quality in the four remaining lakes was good. The findings of the study suggest that water quality testing should be undertaken on a regular basis.

Table of Contents

List of Tables

Page

Assessment of Conditions and Public Attitudes Concerning Marine Sanitation of the Lakes Encompassed by the Savannah River Watershed Region: Policy Projects for the Future

Focus Categories:
1. Water quality -- WQN
2. Management and Planning -- M&P
3. Recreation -- REC

Key Words: Marine Sanitation, waste disposal, water quality management, lakes, boating, planning, watershed management recreation.

Principal Investigator: Kenneth F. Backman, Ph.D. and Sheila J. Backman, Ph.D.
Clemson University
Department of parks, Recreation and Tourism Management
Clemson, SC 29634-0735
Telephone: 864-656-2204
Email: frank@clemson.edu

Congressional District: Third

Introduction

In 1992 the Congress of the United States of America passed the Clean Vessel Act (Wicks 1994). This act required each coastal state to conduct a survey of recreational boaters to determine the number and location of pump-out stations and waste reception facilities (dump stations). In 1998 in South Carolina the issue of recreational boaters dumping waste into its lakes became a public issue (*Anderson Independent*, February 14, 1998). Concerns were being expressed about the current practice of dumping treated waste into the lakes of South Carolina and ways to ensure that these lakes continue to be as clean and safe as they have always been historically.

The current project dealt with the determinant that sewage discharged by recreational vessels may be a substantial contributor to regional degradation of water quality in the lakes comprising the Savannah River Watershed Area (Lakes Jocassee, Keowee, Hartwell, Russell and Thurmond). Discharge of sewage from boats may degrade water quality by introducing microbial pathogens into the environment and locally increasing biological oxygen demand, particularly in poorly flushed water bodies. These conditions may negatively impact natural resources, contaminate potable water sources, and cause economic problems through such actions as requiring closure of recreational and tourism facilities.

The shoreline of the study area included hundreds of miles within the states of South Carolina and Georgia. The adjacent areas include a number of large population centers (Atlanta, GA; Greenville, SC; Charlotte, NC); the largest discrete unit is the Atlanta Metropolitan Region with a population of nearly one million people.

Recreational boating in the study area of South Carolina and Georgia is a growing activity due to the large nearby population, an increasing number of immigrant retiree

population, a popular sport fishery and a series of large and aesthetically attractive lakes. The burgeoning recreational boating industry includes a large and diverse recreational vessel that contains portable toilets or type III marine sanitation devices. The number of these boats using these lakes is not determined nor the number using concentration areas. Similarly, the number and location of pump-out stations and waste reception facilities are not known nor is their relationship to concentration areas of recreational boats.

Due to the recreational and tourism economic value of these lakes in South Carolina and Georgia, efforts must be made to ensure degradation of its water quality does not occur. As water quality of these lakes can be degraded by human waste discharged from recreational vessels, the potential for discharge from recreational boats and locations where discharge is most probably and most concentrated must be determined. This information is required to determine the need for additional pump-out stations and waste reception facilities.

Objectives

The primary objective of this project was to determine the factors influencing boaters' preceptors of water quality in the lakes comprising the Savannah River Watershed Region.

Methods

This project employed an on-site survey and mail survey of boaters in the study area. Personal interviews were conducted with study area marina operators. The data were coded, entered and verified in a SPSS database. Descriptive statistics were used to examine the data.

The Survey

The survey evaluated boaters and marina operators' existing attitudes and knowledge of existing laws, regulations related to discharge of waste from recreational boaters and benefits of such facilities. Data was also collected on demographic characteristics. The questionnaire also included questions on types of boats, uses of each study lake, demographics of boaters, views on the experience of recreational boating on the study lakes, water quality and sanitation, sanitary equipment and preferred alternatives to traditional marine sanitation devices for use by recreational boaters. The questionnaire was pretested with a group of boaters and marina personnel.

The data collection procedure for marina personnel was collected using the personal interview process.

The data collection method for the boaters used the Dillman Total Design (1978) mail survey technique where an advanced-notice letter is sent to all members of the selected sample. A second contact made about a week after the advance-notice letter, which included a personalized cover letter, questionnaire and stamped return envelope. Third, a postcard follow up was mailed to all members of the sample about a week after the questionnaire. Fourth, for all members of the sample who had not responded by the third or fourth week, a new personalized cover letter, questionnaire, and stamped return envelope was sent. Finally, a follow up was sent to those who still had not responded.

The sample for the boaters mail survey was obtained from a central database on boat registrations from the South Carolina Department of Natural Resources and the Georgia Department of Natural Resources. Data on registered boats was obtained for South Carolina and Georgia counties adjacent to the lakes in the study and from counties that are part of the

metropolitan areas close to the lakes in the study. A stratified sampling method was used in the selection of participants in the study using the following formula: boats 16 feet and under in length, boats 17 - 25 feet, boats 26 - 40 feet, and boats over 40 feet. These strata were derived from an EPA assessment that is described in the technical guidelines for the Clean Vessel Act (*Federal Register* Volume 58, No. 115, pages 33447-33457). In this the EPA suggested 20 percent of boats 16 - 26 feet have portable toilets, 50 percent of boats 26 - 40 feet have holding tanks, and 100 percent of boats 40+ feet have holding tanks.

The size of the boater's mail survey was selecting using Fleiss' (1973) Statistical Methods for Rates and Proportions which suggests that with a population size in both South Carolina and Georgia of approximately 50,000 in each, a sample of 400 from each state would more than ensure a sample size for 95 percent confidence level and a margin of error of plus or minus 2.5 percent.

Research Methods

Mail Survey

- The mail survey was conducted between the months of April and August 2000 using a modified Dillman Total Design method.
- The sample of potential mail survey respondents was generated using the list of registered boaters from the South Carolina and Georgia Department of Natural Resources.
- A stratified random sampling method was utilized to select the final list of potential respondents from both state files, based on boaters resident county being adjacent to the five lakes in the study region.
- 596 surveys were mailed to the sample of voters in both states. The usable number of returned questionnaires was 167, a response rate of 28 percent.

On Site Survey

- On site interviews were conducted at a random number of boat launch sites on each of the five lakes in the study region. This data collection was carried out between June and concluded in October 2000.
- Boat launch sites and days of the week and the times of day were varied in the data collection process to ensure total representation of the boater population.
- The on site survey was hampered by the low levels of water in the lakes (lowest lake levels in years and in the middle of a three year drought). Thus, 133 usable questionnaires were collected on site, with a 5 percent refusal rate.
- The questionnaire used in the on site survey was a condensed version of the mail instrument. This questionnaire took approximately 10 minutes to complete.

Marina Operators Survey

- A sampling of the small group of marina operators on the five lakes in the study area was conducted between August and October 2000.
- The sample was comprised of six marina operators from the study area. These marina operators were asked about their perceptions of water quality in the study area.

The marina operators were interviewed using a modified version of the mail questionnaire. The survey also contained questions, which asked marina operators to elaborate on their answers, to understand their responses.

Findings

This section presents the findings of the on-site and mail surveys, interviews with and marina operators. The first section presents the findings of questions that were asked on both surveys. Next, the additional results of the mail survey are presented. The final component of this section presents the results of the marina operator's interviews.

Demographic Characteristics of Boaters

Boaters responding to the on-site survey were typically 40 years of age reported a high school education, and an income of between $50,000 and $74,999 (Table 1). Although mail survey respondents were older, 52 years of age, they, like on-site boaters, had at least a high school education, and reported incomes between $50,000 and $74,999.

Table 1. Demographic Profile of Boaters

	On-Site	Mail
Age ($\overline{X}$)	40.9	52.2
Education Level %		
1 – 9	1.7	6.2
10 – 12	42.7	34.2
13 – 14	23.4	20.4
15 – 16	16.9	19.3
16+	15.3	19.9
Income		
Less than $30,000	5.4	19.1
$30,000 – $49,999	26.8	18.4
$50,000 – $74,999	40.2	25.0
$75,000 – $99,999	11.6	20.6
$100,000 and up	16.1	16.9

Table 1. Demographic Profile of Boaters

	On-Site	Mail
Age		
Less than 20	2.4	.6
20 – 29	16.5	2.5
30 – 39	29.4	14.9
40 – 49	28.6	20.5
50 – 59	17.5	31.7
60 – 69	5.6	19.9
70 and above	0	9.9

Profile of Vessel

The top three types of vessels reported by mail respondents were 1) runabout/speed boat (25.6%), 2) bass boat (25.0%), and 3) pontoon boat (18.6%) (Table 2). For the on-site respondents the top three vessel types were 1) runabout/speed boat (45.5%), 2) bass boat (31.9%), and 3) pontoon boat (8.9%). Both groups of respondents used similar vessels, but on-site respondents tended to use runabout/speed boats and bass boats more than mail respondents.

Table 2. Profile of Vessel

	On Site	Mail
Type of Vessel Owned (%)		
Jonboat	4.1	15.9
Runabout/speed boat	45.5	25.6
Cabin cruiser	.8	2.4
Pontoon boat	8.9	18.6
Sail boat	0	1.8
Bass boat	31.9	25.0
Houseboat	0	.6
Other	17.7	10.1

Table 2. Profile of Vessel

	On Site	Mail
Primary Activity (%)		
Fishing	49.6	56.8
Water skiing	13.4	4.9
Pleasure boating	34.6	34.0
Entertainment parties	.8	0
Other	1.6	4.3
Type of Head (%)		
None	81.5	81.5
Marine toilet with Coast Guard approved sanitation device	1.6	1.9
Port–a–potty	5.6	16.6
Use shore–side toilet facilities	8.9	0
Length of Vessel $\overline{X}$	18.6	18.3
Less than 16 feet	14.9	25.6
16 – 18	42.1	39.6
19 – 24	40.5	28.1
25 +	2.5	4.3
Number of Years Vessel Owned ($\overline{X}$) (%)	8.3	4.9
2 or less	45.0	19.0
3 – 5	27.8	27.7
6 – 10	20.0	25.7
11 – 14	3.2	8.0
15 +	4.0	8.5

The primary activity for which the vessels were used revealed a similar use pattern between the mail respondents and on-site respondents. Both primarily used their vessels for fishing, followed by pleasure boating, and thirdly for water skiing.

The length of the vessels used by the two groups of respondents was very similar with mail respondents having vessels ranging in length from less than 16 feet to over 25 feet in length, with the average length being 18.3 feet. For the on-site respondents, their vessels also ranged from less than 16 feet to over 25 feet, with their average only slightly longer at 18.6 feet.

As for number of years the vessel was owned by the respondent, there was some difference found. Although typical respondents in both groups owned their vessels for from less than two years, the average length of ownership varied. The average years of ownership varied from mail respondents who owned their vessel on average 4.9 years and on-site respondents who owned their vessel on average for 8.3 years or almost twice as long as the first group.

Finally, respondents were questioned as to the type of head (toilet) the vessel had, in both groups the majority of respondents' vessels had no head (81.5%) for both mail respondents and on-site respondents (Table 2). However, there was a difference between the two response groups on their use of port-a-potties. Only 16.6% of mail survey boaters and just 5.6% for the on-site respondents, used port-a-potties.

Perceptions of Water Quality by Mail Respondents

The results shown in Table 3 reveal the respondents' perceptions of the water quality in the five lakes included in the study area. Because these questions were only asked on the mail survey there are no comparable responses from the on-site interviews. When asked about their perception of the quality of the water for participation in various water-based activities respondents stated that their participation in swimming was limited (25.7%) due to a negative perception of the quality of the lake's water. The same was found for water skiing (14.2%) and fishing (16.1%) though not near the extent of concern as for swimming.

When asked about a specific lake's water quality mail respondents overwhelmingly expressed the feelings that Lake Hartwell needs the greatest improvement in water quality (79.2%) (Table 3). Respondents indicated that the other four lakes were perceived to need less

water quality improvement: Lake Thurmond at 28.9%, Lake Russell at 23.3%, Lake Keowee at 17.4% and Lake Jocassee at 11.6%.

However, when asked to rate the overall quality of the water of the five lakes in the watershed region, the mail respondents only rated the quality at 6.6 on a ten-point scale (Table 3). This slightly more than medium range evaluation of overall water quality is somewhat explained by the responses to the previous question on how many responded (yes) to the need for water quality improvement in each of the five lakes. The higher quality perceptions of the water quality in four of the lakes are masked by the perceived poor quality of the water in Lake Hartwell.

Next, respondents were asked which aspects of the water conditions needed improvement.

Table 3. Perceptions of Water Quality by Mail Respondents.

	Mean
Quality of Lake Water ($\overline{X}$)	6.6
Water Quality as a Constraint to	
Swimming	25.7
Water Skiing	14.2
Fishing	16.1
Need for improvement in lake water quality (% yes)	
Lake Jocassee	11.6
Lake Keowee	17.4
Lake Hartwell	79.2
Lake Russell	23.3
Lake Thurmond	28.9
Importance to Improve Water Quality for (% yes)	
Lake water levels	54.4
Clearness of water	49.7
Temperature of the water	15.9
Debris in the water	61.2

Table 3. Perceptions of Water Quality by Mail Respondents.

	Mean
Flow in the tailwater	23.7
Aquatic plants in water	35.5
Odor	50.4
Tailwater levels	18.2
Scum in water	58.9

The aspect which respondents felt needed most improvement was the amount of debris in the water. The amount of debris in the water was a concern for 61.2% of respondents (Table 3). Boaters then felt that scum in the water (58.9%), then lake water levels (54.4%), and odor (50.4%), were the most important aspects to improve the water quality.

Lake Water Quality Perceptions from Last Boating Trip

Presented in Table 4 are the responses from both mail survey respondents and on site respondents regarding observations from their last boating trip. In response to all questions regarding the water pollution they observed, the mail respondents rated lake pollution as quite bad at 3.07 versus the on-site respondents who rated lake pollution as fairly good at 7.58 (Table 4). These were both measured on a 10 point scale with 1 = extremely poor to 10 = extremely good.

When asked to identify the types of water pollution they had observed boaters indicated these items as the top five types of pollution: mail respondents - paper/plastic debris (76.5%), cans or bottles (76.5%), wood or lumber debris (46.9%), oily film on water (25.3%), and fishing debris (23.5%) (Table 4); on-site respondents - cans or bottles (62.3%), paper/plastic debris (49.6%), wood or lumber debris (45.1%), oily film on water (21.3%), and fishing debris (15.6%).

Although the order of the forms of pollution varied, both mail and on-site boaters indicated the same sources contributing to the problem.

Table 4. Lake Water Quality Perceptions on Their Last Boating Trip.

	On Site	Mail
Forms of Water Pollution Observed (% yes)		
Paper/plastic debris	49.6	76.5
Oily film on water	21.3	25.3
Raw sewage	3.3	6.8
Cans or bottles	62.3	76.5
Wood or lumber debris	45.1	46.9
Fishing debris	15.6	23.5
No evidence	7.4	4.9
Rating of Lake Water Quality for last experience	*7.58	*3.07

* measured on a 10-point scale from 1 = extremely poor to 10 = extremely good.

Boater's Opinion of Water Quality of Individual Lakes

Respondents to the mail survey were asked to respond to a set of 18 statements on a five-point scale with 1 = strongly disagree with the statement to 5= strongly agree with the statement related to the water quality of the lake they boat on the most (Tables 5 through 9). The results will be reported for each of the five lakes in the study region starting with Lake Jocassee.

Overall the respondents felt the water quality in Lake Jocassee is just right (4.5). Also, they felt that the state should enforce pollution laws and fine people who pollute (5.0). But, respondents are undecided as to whether the water condition has improved over the last five years (3.3). Additionally, the respondents are undecided whether they are concerned about their family's health when in contact with lake water (3), but they suggest they would be willing to

pay more for better pump-out facilities (3.6). Finally, they report that water conditions did not stop them from participating in any activities on their last boat trip (2.3).

Table 5. Boaters' Opinions Toward Lake Jocassee

		Mean
a.	Water quality of the lake is just right	4.6
b.	It is important to find shore–side facilities instead of using the holding tank	4.0
c.	Regulation on sewage discharge by recreational boaters is too lax	3.6
d.	Water quality in the lake has improved over the last five years	3.3
e.	Most marina operators are conscientious about providing pump–out services	3.0
f.	If the water is polluted, it is primarily due to land–based sources	3.6
g.	The temperature of the water should be warmer for recreation	2.0
h.	It is not fair to make small boats comply with discharge laws	1.6
i.	I am concerned about my family's health when in contact with lakewater	3.0
j.	In general recreational boaters are now more conscientious about complying with discharge laws than they ever have been	2.6
k.	I obey discharge laws	4.3
l.	I would be willing to pay more for better pump–out facilities	3.6
m.	If the water quality were better I would enjoy the boating experience more	3.3
n.	Boaters don't affect water quality	1.0
o.	Poor water conditions are caused by people fishing and swimming	1.3
p.	The state should enforce pollution laws and fine people who pollute the lake	5.0
q.	The water looks cloudy sometimes	2.6
r.	Because of the water quality conditions, I did not participate in some activities that I would on my last boat trip	2.3

* Evaluated on a scale of 1 = strongly disagree to 5 = strongly agree

With respect to Lake Keowee respondents reported that they felt the "water quality of the lake is just right" rating is still fairly high (3.8) (Table 6) but not as high as Lake Jocassee (4.6). These respondents also felt they were undecided over whether water quality in Lake Keowee had improved over the last five years (3.1). These boaters were less in agreement about whether the state should enforce pollution laws and fine people (4.2) than those who use Lake Jocassee.

Lake Keowee boaters generally disagree that boaters don't affect the water quality (2.1) and they further disagree that water quality conditions would stop them from participating in certain activities on their last boat trip (2.0).

Table 6. Boaters' Opinions Toward Lake Keowee

		Mean
a.	Water quality of the lake is just right	3.8
b.	It is important to find shore–side facilities instead of using the holding tank	3.4
c.	Regulation on sewage discharge by recreational boaters is too lax	4.0
d.	Water quality in the lake has improved over the last five years	3.1
e.	Most marina operators are conscientious about providing pump–out services	3.0
f.	If the water is polluted, it is primarily due to land–based sources	3.0
g.	The temperature of the water should be warmer for recreation	2.0
h.	It is not fair to make small boats comply with discharge laws	2.3
i.	I am concerned about my family's health when in contact with lakewater	3.2
j.	In general recreational boaters are now more conscientious about complying with discharge laws than they ever have been	3.5
k.	I obey discharge laws	4.4
l.	I would be willing to pay more for better pump–out facilities	3.3
m.	If the water quality were better I would enjoy the boating experience more	3.3
n.	Boaters don't affect water quality	2.1
o.	Poor water conditions are caused by people fishing and swimming	1.7
p.	The state should enforce pollution laws and fine people who pollute the lake	4.2
q.	The water looks cloudy sometimes	3.1
r.	Because of the water quality conditions, I did not participate in some activities that I would on my last boat trip	2.0

* Evaluated on a scale of 1 = strongly disagree to 5 = strongly agree

Table 7 shows that Lake Hartwell is perceived to have the lowest water quality (2.8) of any of the lakes. They also indicated that the water quality in the lake has not improved over the last five years (2.6). These boaters also disagreed with the suggestion that small boats should not have to comply with discharge laws (2.3), but they agree that the state should enforce pollution

laws and fine polluters (4.5). When asked if water quality conditions stopped them from participating in any activities on their last boat trip, boaters tended to say it did not stop them (2.5).

Table 7. Boaters' Opinions Toward Lake Harwell

		Mean
a.	Water quality of the lake is just right	2.8
b.	It is important to find shore–side facilities instead of using the holding tank	3.8
c.	Regulation on sewage discharge by recreational boaters is too lax	3.7
d.	Water quality in the lake has improved over the last five years	2.6
e.	Most marina operators are conscientious about providing pump–out services	2.9
f.	If the water is polluted, it is primarily due to land–based sources	3.6
g.	The temperature of the water should be warmer for recreation	2.5
h.	It is not fair to make small boats comply with discharge laws	2.3
i.	I am concerned about my family's health when in contact with lakewater	3.6
j.	In general recreational boaters are now more conscientious about complying with discharge laws than they ever have been	3.0
k.	I obey discharge laws	4.3
l.	I would be willing to pay more for better pump–out facilities	3.3
m.	If the water quality were better I would enjoy the boating experience more	3.7
n.	Boaters don't affect water quality	1.9
o.	Poor water conditions are caused by people fishing and swimming	1.9
p.	The state should enforce pollution laws and fine people who pollute the lake	4.5
q.	The water looks cloudy sometimes	3.7
r.	Because of the water quality conditions, I did not participate in some activities that I would on my last boat trip	2.5

* Evaluated on a scale 1 = strongly disagree to 5 = strongly agree

For Lake Thurmond (Table 8) the respondents were somewhat undecided as to whether the water quality of the lake is just right (3.4). They also indicated that water quality in this lake had not improved over the last five years (2.9), but they tended to agree the state should enforce pollution laws and fine people who pollute the lake (3.9). Finally, these boaters also said that the

water quality conditions did not stop them from participating in activities on their last boat trip (2.0).

Table 8. Boaters' Opinions Toward Lake Thurmond

		Mean
a.	Water quality of the lake is just right	3.4
b.	It is important to find shore–side facilities instead of using the holding tank	3.4
c.	Regulation on sewage discharge by recreational boaters is too lax	3.5
d.	Water quality in the lake has improved over the last five years	2.9
e.	Most marina operators are conscientious about providing pump–out services	3.0
f.	If the water is polluted, it is primarily due to land–based sources	3.7
g.	The temperature of the water should be warmer for recreation	2.1
h.	It is not fair to make small boats comply with discharge laws	2.4
i.	I am concerned about my family's health when in contact with lakewater	3.1
j.	In general recreational boaters are now more conscientious about complying with discharge laws than they ever have been	3.2
k.	I obey discharge laws	4.3
l.	I would be willing to pay more for better pump–out facilities	2.9
m.	If the water quality were better I would enjoy the boating experience more	3.1
n.	Boaters don't affect water quality	2.3
o.	Poor water conditions are caused by people fishing and swimming	1.9
p.	The state should enforce pollution laws and fine people who pollute the lake	3.9
q.	The water looks cloudy sometimes	3.2
r.	Because of the water quality conditions, I did not participate in some activities that I would on my last boat trip	2.0

* Evaluated on a scale of 1 = strongly disagree to 5 = strongly agree.

Table 9 shows the results for Lake Russell boaters' opinions. These boaters tended to agree with the statement that water quality of the lake is just right (4.0). But, they were undecided about whether the water quality in the lake has improved over the last five years (3.0). They agreed with boaters on other lakes that the state should enforce pollution laws and fine

people who pollute the lake (4.6). Finally, they too did not stop participating in any activities on their last boat trip due to water quality conditions (2.1).

Table 9. Boaters' Opinions Toward Lake Russell

		Mean
a.	Water quality of the lake is just right	4.0
b.	It is important to find shore–side facilities instead of using the holding tank	3.9
c.	Regulation on sewage discharge by recreational boaters is too lax	3.5
d.	Water quality in the lake has improved over the last five years	3.0
e.	Most marina operators are conscientious about providing pump–out services	3.2
f.	If the water is polluted, it is primarily due to land–based sources	3.8
g.	The temperature of the water should be warmer for recreation	2.5
h.	It is not fair to make small boats comply with discharge laws	2.6
i.	I am concerned about my family's health when in contact with lakewater	4.0
j.	In general recreational boaters are now more conscientious about complying with discharge laws than they ever have been	3.0
k.	I obey discharge laws	4.1
l.	I would be willing to pay more for better pump–out facilities	3.1
m.	If the water quality were better I would enjoy the boating experience more	3.3
n.	Boaters don't affect water quality	2.2
o.	Poor water conditions are caused by people fishing and swimming	1.7
p.	The state should enforce pollution laws and fine people who pollute the lake	4.6
q.	The water looks cloudy sometimes	3.5
r.	Because of the water quality conditions, I did not participate in some activities that I would on my last boat trip	2.1

* Evaluated on a scale of 1 = strongly disagree to 5 = strongly agree

Respondent Use of Boat Ramps

In Table 10 results are quite evident that mail respondents reside much closer to the boat launch facility (3.11 miles) they prefer than those contacted on-site who are residing (31.78 miles) from their preferred boat launch facility. Mail respondents used a fewer number (2.85) of boat launch facilities than did boaters who completed the survey (4.93).

Table 10. Boat Launch Facility

	On-Site	Mail
Number of Miles of Closest Boat Launch (mean)	31.78	3.11
Number of Different Boat Launches Used (%)		
1	41.9	49.4
5 or more	31.5	39.8
Same	26.6	10.8
Number of Boat Launches Used in the Savannah Watershed Region Last Year	4.93	2.85

Management Preferences of Respondents

Table 11 presents the respondent's choices as to what they feel would be the most effective way to deal with disposal of boater's waste. Most respondents felt enforcement of existing regulations (53.1%) was best, then some type of educational program would work best (29.9%), followed by improvement of the waste disposal facilities (26.9%). Next, the respondents felt peer pressure (18.1) was the next best method to change current behavior, finally it was reported that development of better regulations (17.3%) would work best.

Table 11. Management Preferences of Mail Respondents

	Percent
Most Effective Measures for Disposal of Boater Waste	
Improvement of the waste disposal facilities	26.9
Education program	29.9
Development of regulations	17.3
Peer pressure	18.1
Enforcement of existing regulations	53.1

Marina Operators Survey Results

The investigators felt it was important to include a sample of the marina operators in this assessment of perceived water quality of the five lakes in the Savannah River Watershed region. So, the results of this sample are included in Table 12. These results must be used with caution as there were only 6 marinas sampled. But, the investigators believe their responses are representative of the small population of marina operators on these lakes.

The marinas in the sample were located on Lake Hartwell (4) and Lake Keowee (2) and on average, they had operated their marina for 14 years, but operations ranged from 3 to 24 years. These marinas were on average 3.2 miles from the closest boat launch facility. The boats that used the marinas were mostly runabouts, pontoon boats, houseboats, and sailboats.

Marina operators were asked about the percent of boats using their marina that have marine toilets. They indicated that from 21 percent to 9.5 percent of the boats had marine toilets. But three of the six marinas responded they did not have pump out facilities for sewage. Of those marinas with pump out stations, the number of times per month these pump out facilities were used varied from 10 to 15 times per month to 40 to 50 times per month. The other types of

toilet facilities available at the marina or within average boating distance were bathrooms (50%) and port-o-potties (50%).

The marina operators respond that on a ten-point scale, they rated the lake's water quality from 4 = fairly poor to 10 = extremely good, with an average rating of 7.5. The primary activity of boaters using their marina was pleasure boating (100%).

Then marina operators were asked if they had noticed any change in boating participation in the last five years. Although 100 percent responded that boater's participation had increased, they did not give any explanation for the increase, other than a good economy. Asked if they felt the lake water quality needed to be improved, 67 percent said yes it needs improvement.

When questioned further on types of water pollution they had personally observed, 100 percent saw paper or plastic debris, 100 percent saw wood or lumber debris, 100 percent saw an oily film on the water, 83 percent saw cans or bottles and 50 percent saw fishing debris. They were then asked what they believed would be the most effective means for ensuring that boater waste is disposed of properly. They ranked (1) enforcement of existing regulations, (2) an education program for boaters, (3) peer pressure, (4) development of regulations, and (5) improvement of the waste disposal facilities as the most effective means.

Marina operators were also asked if they had heard anything about pollution in any of the lakes in the last year and where they found the information. The majority (50%) indicated they obtained the information from newspapers, 17 percent from personal observation, 17 percent from a homeowners association, and 17 percent from the Department of Natural Resources.

Table 12. Characteristics of Marine Operators.

	Percent
Marina Location %	
Lake Hartwell	67
Lake Keowee	33
Mean number of years owned by operator	14
Primary boat type using marina %	
Runabout/cruiser	50
Pontoon	17
Houseboat	17
Sailboat	17
Mean distance (miles) to closest boat launch	3.2
Change in boater participation over last 5 years	
increased	100
stayed the same	0
decreased	0
Primary activity of lake users %	
Pleasure boating	100
Mean lake water quality rating (1=extremely poor, 10=extremely good)	7.5
Need to improve water quality of lake %	
Yes	67
No	33

Table 13. Marina Profile Related to Waste Disposal.

	Percent
Boats with marine toilets %	35
Marina sewage pumpout facilities %	
Yes	50
No	50
Frequency of use of pumpout facilities per month	
marina 1	40-50
marina 2	20-25
marina 3	10-15
Toilet facilities available at marina %	
Bathrooms	50
Port-o-potties	50

Table 14. Marina Operators' Perceptions of Water Quality.

	Mean
Pollination information sources %	
Newspaper	50
Personal observation	17
Home owners association	17
Dept of Natural Resources	17
Types of water pollution observed %	
Paper or plastic debris	100
Wood or lumber debris	100
Oily film on water	100
Cans or bottles	83
Fishing debris	50
Other (noise, boat parts, Styrofoam)	50
Most effective means of boater waste (rank)	
Enforcement of existing regulations	1
Education program for boaters	2
Development regulations	4
Improvement of waste disposal facilities	5
Peer pressure	3

Table 14. Marina Operators' Perceptions of Water Quality.

	Mean
Mean perceptions of water quality	
Water quality is just right	3.0
Regulation of sewage discharge by recreational boaters is too lax	3.0
Water quality in the lakes has improved over the past 5 years	3.0
Water pollution is primarily due to land based sources	4.8
It is not fair to make small boaters comply with discharge laws	1.8
In general recreational boaters are conscientious	3.8
The state should enforce pollution laws and fine people	3.7
The marina has lost business because of water conditions	1.5

1=strongly disagree, 5=strongly agree

Graduate Student Involvement

In total three graduate students were involved in this project from the beginning to the end of the project. Their duties ranged from stuffing survey packets to mail, on-site interviewing, data entry, and data analysis. The three students were:

1. Chih-Liang Chao - a Ph.D. student in the Department of Parks, Recreation and Tourism Management.
2. Joseph T. Walker - a Ph.D. student in the Department of Parks, Recreation and Tourism Management.
3. Jason Davis - a Ph.D. student in the Department of Parks, Recreation and Tourism Management.

Presentations and Publications

Two presentations using data from this project were done at the 2001 Southeastern Recreation Research Conference, February 21 - 23, 2001, Asheville, North Carolina.

Davis, Jason, and Backman, Kenneth, F. "Boaters and Marina Operators' Perceptions of Water Quality in the Five Lake Savannah Watershed Region."

Walker, Joseph, and Backman, Kenneth F. "Exploring the Effect of Trip Distance on Boater's Perception of Water Quality."

One poster presentation and proceedings publication were done using data from this project for the College of Health, Education, and Human Development Faculty Research Forum, Clemson University, March 31, 2001.

Backman, Sheila, J., Backman, Kenneth. F. "Perceptions of Water Quality in the Five Lake Savannah Watershed Region," p.3.

Two poster presentations using data from this project for the Clemson University Graduate Student Research Award Competition.

Davis, Jason, Walker, Joseph, Backman, Kenneth F., and Chao, Chih-Liang. "Boaters and Marina Operators' Perception of Water Quality in the Five Lake Savannah Watershed Region."

Walker, Joseph, and Backman, Kenneth F. "Exploring the Effect of Trip Distance on Boater's Perception of Water Quality."

One poster presentation using the data from this project was selected by the graduate deans of Clemson University to be on display April 19, 2001 at the Annual Catfish and Guts Dinner for the state legislatures. This poster was only one of twelve posters chosen for this event.

Davis, Jason, Walker, Joseph, Backman, Kenneth F., and Chao, Chih-Liang. "Boaters and Marina Operators' Perceptions of Water Quality in the Five Lake Savannah Watershed Region."

Finally, a manuscript is currently being written from project data, which will be sent to a referred journal for publication.

Conclusions

The effectiveness of completing a boater study on lakes that have endured a three-year drought is somewhat tenuous, but necessary when the issue in question is perception of water quality. Because when would sewage and other pollutants cause more damage to the lakes' ecosystem, when the water levels are extremely low and there is less chance for the lake system to clear itself.

The study findings identify what appears to be two separate boater groups; those in the mail survey are older, had their boats longer, and perceive the water quality in the study's five-lake region to be lower than the boaters surveys at the lakes themselves. Why these two groups exist is beyond the scope of this study but suggests an interesting research project. When assessing water quality by three groups, the mail survey group, on-site survey group, and marina operators, there is a statistical difference between their mean ratings of water quality with the marina operators rating it the highest and the mail survey group rating it the lowest. Some of this difference may be explained by "selective memory" on the part of the mail survey respondents. When assessing the water quality by lake four of the lakes appear to be quite good with regard to their perceived water quality; but Lake Hartwell appears to have a problem. All survey respondent types rated Lake Hartwell's water quality low and in need of immediate attention. This consistency in opinion demands state and federal attention as Lake Hartwell is a Corp of Engineers controlled lake.

Overall, the results of this study suggest that water quality testing needs to be done on a regular basis and more enforcement of marine sanitation regulations needs better enforcement. Due to the economic generators these five lakes are for the counties adjacent to them any

negative image resulting from poorly perceived water quality could impact this region dramatically. Loss of boaters, lake residents, day visitors, tourists, and campers means the loss of jobs, tax dollars, reduced property taxes, and quality of life for the people residing in this area. Hopefully, this study's results can lead to changes in current policy such that these drastic impacts will be avoided.

APPENDICES

Appendix A

Mail Questionnaire

Appendix B

On-Site Questionnaire

Appendix C

Marina Operators' Questionnaire

Appendix D

Model Information Brochure for Boater Water Quality Education

Panel 1

Page 1 Did you know that?

Graphic 1	The water quality of Lake Hartwell (lakes could be identified individually) would improve thanks, in part to all boaters who pump out or do not dump their sewage into the lake?
Graphic 2	The disposal of sewage in lake waters can spread human diseases?
Graphic 3	Dumping sewage is in violation of the law, and those doing so are subject to heavy fines?
Graphic 4	Boating and marina activities can contribute to bacterial pollution similar to that caused by non-point sources such as on-shore septic systems?
Graphic 5	Marina operators will be glad to show you how to use the pump out equipment if you need assistance?
Graphic 6	The disposal of even small amounts of sewage into the water contaminates shellfish?

Panel 2

Do More for Your Environment by Leaving Less!

Our lakes give us rich enjoyment and, quality of life. Pleasure boating, sailing, fishing, swimming and water sports are just a few of the recreational benefits we enjoy in our waters. These rich resources must be protected from all waste from boats and pleasure craft.

You Make the Difference!

Each of us can do our part by not dumping or flushing raw or treated sewage from our boasts into the water. Even treated human waste can cause pollution problems because of heavy concentrations of chemicals used in the process. While the threat of pollution is greatest, in shallow waters around marinas, near the shoreline, and in small rivers, human waste is undesirable in all of our waters.

How Can You Help…..

You may think that one boater cannot make a difference, <u>BUT YOU CAN!</u> If you join the many boaters dedicated to not dumping, the results will be extraordinary! These are several simple ways you can help.

1. Serve as a role model to other boaters by always pumping out.

2. Show other boaters the location of the nearest pump out facility and bathrooms.

3. Demonstrate to other boaters the use of pump out facilities.

4. Encourage other boaters to always use pump out facilities.

5. Educate young boaters about proper sanitation procedures.

Doing Our Part!

The State of South Carolina, Department of Health and Environmental Control has designated Lake Hartwell as a NO DISCHARGE ZONE for marine toilets and is considering designation of Lake Keowee, Lake Thurmond, Lake Russell and Lake Jocassee as the same.
Most boaters already do their part in attempting to reduce pollutants, and over the next few years, you should see improvements to many marina pump out stations.

For your convenience, the names and telephone numbers of pump out bathroom facilities on the five lakes are listed below:

Lake Joccasse:

Devils Fork State Park	864 944-2639

Lake Keowee:

Keowee Sailing Club	864 882-9613
Lake Keowee Marina	864 882-2047

Lake Hartwell:

Big Water Marina	864 226-3339
Portman Marina Inc.	864 287-3211
Seneca Marina Inc.	864 653-8100

Lake Russell:

Calhoun Falls State Park	864 447-8267
Beaverdam Marina Resort	706 213-6462
Lake Richard B. Russell State Park	706 213-2045

Lake Thurmond:

Plum Branch Yacht Club	864 443-3000
Savannah Lakes Marina	864 391-3477
Soap Creek Lodge	706 359-3124
Rayaville Marine	706 595-5582
Little River Marina	706 541-1358
Tradewinds Marina	706 541-1380

Basic Information

Title:	Reestablishment of an Estuarine Marsh and Waterway after Causeway Removal
Project Number:	B-11
Start Date:	3/1/1999
End Date:	2/28/2001
Research Category:	Biological Sciences
Focus Category:	Water Quality, Hydrology, Ecology
Descriptors:	Marshes, Ecosystems, Estuaries, Fish Ecology, Water Quality Monitoring, Geochemistry, Sedimentation, Model Studies
Lead Institute:	South Carolina Water Resources Research Institute
Principal Investigators:	Jeffery Scott Allen

Publication

PROGRESS REPORT - 1999

Progress Report - Year 1 for M.C. Curran. Summary of nekton in Cowan Creek, St. Helena's Island.

The results of the nekton study indicate that there is variability in the abundance of fish in Cowan Creek during the summer of 1999. Peak abundance (1627 individuals) occurred near the end of the season (8/19/99); a total of 24 species were collected throughout the summer. The dominant species were, in order of numerical abundance, silversides, mummichogs, and anchovies. We collected over 1000 silversides on two occasions. We collected over 500 mummichogs on three occasions, and over 100 anchovies on one occasion. Based on our consistent collection of several species, including those mentioned above as well as mojarra, pipefish, and members of the drum family, we conclude that this area is an important habitat for juveniles of these species. Furthermore, results from 1998 also indicate that this small tidal creek is consistently important for these commercially important or forage fishes; we collected 2166 fishes on 8/12/98, and had over 200 specimens collected on nine different dates. Therefore, despite the limited flow of the creek, and the warm temperatures (reaching 39^{o}C), this creek provides valuable habitat for juvenile fishes that themselves are important commercial species or provide food for commercially important species. We anticipate continuing our survey of this area in 2000 to determine whether this trend of habitat use remains after bridge construction potentially increases creek flow.

We also determined the number of grass shrimp parasitized by an isopod crustacean. The percent parasitism ranged from 0.5-9.2% per sampling date. The mean rate of parasitism for the season was 4.5%. This is very similar to the overall value of 3.4% from the 1998 study. As grass shrimp are a staple food item for many of the juvenile fishes that utilize the estuary, it is important to determine if the parasitism rate changes in 2000 after the causeways are removed. This is because these parasites may reduce both shrimp growth and fecundity.

Progress Report - Year 1 for R.E. Cross. Summary of Work Conducted on Marsh Utilization by Nekton and Water Quality and Sediments 1999.

Funding from SCRWI for 1999 allowed the collection of baseline data prior to bridge construction and removal of the causeway. The following is a brief description of work conducted by R. Cross during from June through mid-August 1999.

The elevated walkway over the marsh was finished and the tidal elevation along the walkway was determined. Pit traps were installed into the marsh surface at four locations along the elevated walkway. The pit traps were used to sample larval and juvenile nekton that naturally utilize shallow pools of water on the intertidal marsh during low tide periods. Samples were also collected within 24 hrs of samples collected at the study site at a similar site (same tidal elevation) on Pritchards Island. It is hoped that the Pritchards Island site may be suitable as a control site in a BACI (Before-After-Control-Intervention) experimental design for differences in marsh utilization by nekton. Samples were highly variable in numbers of individuals but samples were numerically dominated by two species: mummichog (*Fundulus heteroclitus*) and grass shrimp (*Palaemonetes pugio*).

The following surface water quality parameters were determined weekly at mid-ebb and mid-flood tide stages at the study site creek: NH_3, PO_4, DO, turbidity, salinity, and temperature. Nutrient concentrations were determined spectrophotometrically. Dissolved oxygen concentrations were measured with a dissolved oxygen meter and turbidity measured with a nephelometer. Salinity was measured with a refractometer and temperature recorded with a temperature sensor. Duplicate water samples were collected at each sample time. There appears to be a consistent trend of greater NH_3, PO_4, and turbidity in mid-flood water.

Sediment particle size analyses were conducted for both creek bed and marsh areas at the study site in July. These analyses were performed using the ASTM particle size analysis for soils method D422 using a soil hydrometer to measure particle settling rates. A sediment trap was installed in the creek bed and a characterization of settled sediments was made. Organic content of creek bed and marsh sediments was also determined using the combustion method.

The benthic meiofauna community was also characterized using sediment core samples from the creek bed at the study site. The sediments were sieved to obtain the meiofauna and then stained and preserved. Preserved samples were examined under stereomicroscopes and enumerated into the following taxonomic categories and stages: nematodes, copepods, copepod nauplii, ostracods, oligochaetes, and polychaetes. Samples were numerically dominated by nematodes. Ostracods were second in importance, followed by copepods.

Related research was conducted on ray feeding pits which are numerous at the study site. Water retained within the feeding pits at low tide was analyzed for nutrient concentrations (NH_3 and $PO_{4)}$. Water in newly formed pits was compared to that in older pits and differences were found. In addition, short time scale nutrient dynamics were examined and changes in nutrients were evident over 15 min intervals.

Progress Report – Year 1 for E.J. Hayter

The specific objective being addressed by E. Hayter is the following: 1) studying the effects of the bridge/causeway changes on tidal- and wind-induced circulation through Cowan Creek and the resulting morphological changes in the creek and adjacent tidal marshes. The tasks performed in Year 1 to partially accomplish this objective are discussed below.

1. Measure the tides at both ends of Cowan Creek - The USGS has been operating a stage and conductance recorder in the Beaufort River across from the entrance to Cowan Creek as a component of a study to determine Total Daily Maximum Loads (TMDLs) in the river. Another stage and conductance recorder was installed by the USGS in August near the St. Helena Sound entrance to Cowan Creek. This second gage was paid for by the one-year seed-level project funded by the South Carolina Sea Grant Consortium. Funds from the proposed project will be used to pay for continued operation of both gages for an additional 12 months. These synoptic tide and conductance records are needed to serve as boundary conditions for the hydrodynamic and salt transport model being established for Cowan Creek.

2. Perform a survey of Cowan creek and tidal marsh – The elevations of at least 50 locations along the marsh in proximity to the Route 21 bridge were surveyed to determine the variation in the marsh surface elevation. In addition, the bathymetry of the creek was surveyed by the USGS at 11 selected cross-sections. One cross-section was at the bridge, five were south of the bridge, and the remaining five were north of the bridge. These studies were funded by Year 1 funds.

3. Construct a Digital Elevation Model (DEM) of Cowan Creek – The USGS was contracted to construct a DEM of Cowan Creek. The DEM was then imported into a pre-processor for the HSCTM-2D model and used to construct the finite element grid for Cowan Creek.

4. Model the circulation and sediment transport in Cowan Creek using the HSCTM-2D hydrodynamic and sediment transport model (Hayter et al. 1998). The purpose of this modeling effort is to predict the increase in hydraulic efficiency of the creek and the decrease in marsh surface area that we hypothesize will occur after bridge replacement. The input files, including the finite element grid developed for Cowan Creek, have been created, and initial runs of the hydrodynamic module in HSCTM-2D have been made to debug the input files. The measured tides and conductances at the two entrances of Cowan Creek, the measured wind field at the nearby U.S. Marine Corp Base on Parris Island, and the suspended sediment concentrations to be measured in Year 2 are being used as the boundary conditions. Current measurements to be made in Year 2 at several locations along the creek over a spring tidal cycle will be used to calibrate the hydrodynamic model. Similar measurements will be performed during a neap tidal cycle to partially validate the hydrodynamic model.

Information Transfer Program

The SCWRC uses its internet web site as a primary means for information transfer. The site is maintained by the Strom Thurmond Institute through a cooperative arrangement. The web site contains general information about the SCWRC, information about the competitive research program, research projects and relulting publications, news and announcements regarding SCWRC and links to other water-related sites.

Basic Information

Title:	Assessment of Conditions and Public Attitudes Concerning Marine Sanitation of the Lkes Encompased by the Savannah River Wateshed Region: Policy Projections for the Future
Start Date:	3/1/1999
End Date:	2/28/2000
Descriptors:	Marine Sanitation, waste disposal, water quality management, lakes, boating, palnning, watershed management recreation
Lead Institute:	South Carolina Water Resources Research Institute
Principal Investigators:	Kenneth F. Backman, Sheila J. Backman

Publication

Assessment of Conditions and Public Attitudes Concerning Marine Sanitation of the Lakes Encompassed by the Savannah River Watershed Region: Policy Projections for the Future

Focus Categories: 1. Water Quality—WQN
2. Management and Planning—M&P
3. Recreation—REC

Key Words: Marine sanitation, waste disposal, water quality management, lakes, boating, planning, watershed management recreation.

Starting Date: September 1, 1999
Ending Date: August 31, 2000

Federal Funds Requests: $22,600
Non-Federal (Matching) Funds: $42,838

Principal Investigator: Kenneth F. Backman, Ph.D. and Sheila J. Backman, Ph.D.
Clemson University
Department of Parks, Recreation and Tourism Management
Clemson, SC 29634-1005
Telephone: (864) 656-2204
email: ken@strom.clemson.edu

Congressional District: Third

INFORMATION TRANSFER PLAN

The study will provide information on the location and relative use and types of existing pumpout stations and waste reception facilities. In addition, potential locations of new or upgraded facilities will be provided. It will identify an approach to educate and inform recreational boat users and operators of marinas and other sites where boats congregate, of the environmental value and use of waste facilities. Also, an information brochure will be prepared for distribution on the environmental value, location and use of these types of waste facilities. Because no simple, easy-to-read or easily dispersed literature exists to provide information to recreational boaters on the value of these types of facilities, the brochure will be designed such that it can be distributed to the boating public, or others interested in this issue, and will be placed at readily accessible points such as marinas, tourist information centers, Corp of Engineer offices, or state health departments. In addition, the brochure will be placed on the world wide web at the Strom Thurmond Institute site. Links to relevant sites will be developed.

An additional audience for the information provided by this study are the committees involved in the Savannah River Basin Watershed Project (SRBWP). This project was initiated by the US Environmental Protection Agency Region 4 Office. The stated vision of the SRBWP is "to management comprehensively the Savannah River basin to conserve, restore, enhance, and protect its ecosystems, especially aquatic ecosystems, in a way that allows the balancing of multiple uses" (SRBWP report, 1995). The lakes included in this study are all part of this ecosystem, and currently, the data that this project would provide would assist in filling a number of information gaps in the ongoing management effort of this watershed area.

Basic Information

Title:	Reestablishment of an Estuarine Marsh and Waterway after Causeway Removal
Start Date:	3/1/1999
End Date:	2/28/2001
Descriptors:	Marshes, Ecosystems, Estuaries, Fish Ecology, Water Quality Monitoring, Geochemistry, Sedimentation, Model Studies
Lead Institute:	South Carolina Water Resources Research Institute
Principal Investigators:	Jeffery Scott Allen

Publication

A Proposal to the

South Carolina Water Resources Center

Clemson University

Reestablishment of an Estuarine Marsh and Waterway after Causeway Removal

By

Mary Carla Curran and Randall E. Cross
Division of Math and Science
University of South Carolina at Beaufort
801 Carteret Street
Beaufort, SC 29902

and

Earl J. Hayter
Civil Engineering Department
Clemson University
310 Lowry Hall
Clemson, SC 29634-0911

January 4, 1999

Mary Carla Curran, Assistant Professor
Principal Investigator

Chris Plyler, Dean USC Beaufort

RESEARCH PROPOSAL

1. TITLE: Reestablishment of an Estuarine Marsh and Waterway after Causeway Removal

2. FOCUS CATEGORIES: WL, WQL, HYDROL

3. KEYWORDS: Marshes, Ecosystems, Estuaries, Fish Ecology, Water Quality Monitoring, Geochemistry, Sedimentation, Model Studies

4. DURATION: From August 1, 1999 to July 31, 2001

5. FEDERAL FUNDS:

   Direct: $36,778 Indirect: $0 Total: $36,778

6. NON-FEDERAL FUNDS PLEDGED:

   Direct: $36,760 Indirect: $22,414 Total: $59,174

7. PRINCIPAL INVESTIGATORS:

Mary Carla Curran
Dept. of Marine Science
Univ. of South Carolina
at Beaufort
801 Carteret Street
Beaufort, SC 29902
843-521-4160
ccurran@sc.edu

Randall E. Cross
Dept. of Biology
Univ. of South Carolina
at Beaufort
801 Carteret Street
Beaufort, SC 29902
843-521-4163
rcross@sc.edu

Earl J. Hayter
Civil Engineering Dept.
Clemson University
310 Lowry Hall
Clemson, SC 29634
864-656-3320
ejh@ces.clemson.edu

8. CONGRESSIONAL DISTRICT: Second, South Carolina

9. CRITICAL REGIONAL WATER PROBLEMS

The U.S. Geological Survey has identified "Aquatic and Environmental Protection" as one of its research priorities. Specifically, this priority area states "research needs in this area include studies of wetlands, swamps and marshes, fish and other biota, and the quality of life." The goal of the proposed study is within this research priority area.

The goal of the proposed two-year project is to study the ecological and morphological effects caused by the reduction in length of dirt causeways (accompanying bridge replacement) over a tidal waterway (Cowan Creek) and marsh in Beaufort County, South Carolina. Specific objectives to accomplish the stated goal include: 1) studying the effects of the bridge/causeway changes on tidal- and wind-induced circulation through Cowan Creek and the resulting morphologic changes in the creek and adjacent tidal marshes; 2) evaluating the change in the nektonic community in the creek and tidal marshes in terms of species composition and density;

3) determining whether the percentage of parasitized grass shrimp changes after the changes to the causeways; 4) monitoring the benthic meiofaunal community in the area by collecting sediment cores; 5) determining the amount of oyster spat settlement on the oyster beds in the creek; and 6) monitoring several surface water quality parameters to allow an assessment of changes associated with the altered hydraulics in Cowan Creek.

Based on previous research, the following changes are predicted to occur in Cowan Creek and the adjacent marshes after completion of the new bridge: 1) increases in water flow and sediment transport rates; 2) change in sediment composition; 3) change in marsh geomorphology and size (i.e., surface area); 4) change in habitat utilization by nekton; and 5) change in various water quality parameters. It is also anticipated that the increase in bridge deck elevation and length, and the potential increase in water depth under the bridge will make this creek a viable transportation route between Port Royal and St. Helena Sounds, thus restoring it to its historic importance. These changes would also enhance recreational usage and enable fisherman to catch the species known to exist there at present (Curran, in prep.). Some of this work will be directly comparable to the extensive survey conducted in a similar habitat in northern South Carolina (Ogburn *et al*. 1988). Our study will result in a better understanding of how causeways alter flow in tidal creeks and the concomitant change in sediment transport, water quality, sediment composition of marsh habitat, and nekton utilization of estuarine habitats.

Information Transfer Plan

Information related to this project will be made available both locally, nationally, and internationally. We will be working very closely with local concerned citizens who are interested in local environmental issues and this project in particular. We have already met with county government members and they have collectively indicated interest in the project. The local television and newspapers will be updated periodically on the progress and findings of the project. M.C. Curran has already been filmed by the local public TV station (WJWJ) during her first year of research. The university community will benefit from information presented during faculty and student seminars. We intend to continue this project in some form for several years and will incorporate many aspects of this project into laboratory and lecture sections of our courses in biology, environmental science, and marine science. Student participation will provide hands-on learning experiences in a real world situation and give a sense of continuity from one year to another. The USC Beaufort Student Environmental Awareness Club, which we advise, is active in environmental education of the community and will play a key role in disseminating information to the general public through activities associated with Earth Day, Water Festival, Shrimp Festival, and other community centered events. The faculty and students participating in the project will expand the scope of disseminated information to a national and international scale through poster sessions and talks given at regional and national scientific meetings (e.g., Estuarine Research Federation, Southeastern Estuarine Research Society, Benthic Ecology Meeting). Specifically, we will promote the dissemination and application of the results of the research in the following ways:

a. Place the results of our GIS study on the Web so that scientists, teachers, and concerned citizens can observe how the marsh system will change after the removal of earthen causeways. We will coordinate this effort with the Low Country Institute, which is conducting a watershed survey of Spring Island and will be supplying us with GIS facilities and expertise. We will work with the Low Country Institute to help educate school teachers about GIS and Web-based instruction so that they can access our information and use it in conjunction with the Spring Island program as part of their science curriculum. We will also incorporate our GIS information into our science courses at USC Beaufort. As many of our students are education majors and/or parents, we will reach a broad audience by incorporating this into our curriculum. We will be working with several local scientists regarding our GIS program in the Beaufort County area. Several of us will undergo GIS training in a manner, which will enable us to train other scientists and teachers in the area. Our previous discussions with the Low Country Institute have revolved around outreach programs that involve the scientific community and local citizens in water quality education. This collaboration between USC Beaufort and the Low Country Institute will facilitate a more in-depth study of our site on St. Helena and the watershed on Spring Island.

b. We will involve two South Carolina Governor's School students in our summer research. This will be one of the first opportunities that USC Beaufort has had to interact with some of the best high school students in the state. Each of these students will have a specific project (water/ sediment chemistry and larval/juvenile nekton ecology) that is necessary to our overall study of this environment. These students are required to complete a paper and present the information to their entire school body. We anticipate that their research will be presented at a regional meeting such as the Southeastern Estuarine Research Society (SEERS).

c. We have funds to involve approximately 4 USC Beaufort undergraduate students. Some of these students may choose to expand a particular aspect of our research for an independent study project. Some of these students have already attended a SEERS meeting and would be capable of presenting work at an upcoming meeting.

d. All of the PIs will be presenting their research at national meetings and publishing their work in appropriate journals. M.C. Curran and R. Cross have already presented results at SEERS. M.C. Curran will present the fish data at the American Society of Ichthyologists and Herpetologists Meeting in the summer of 1999.

USGS Summer Intern Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	6	0	0	0	6
Masters	1	0	0	1	2
Ph.D.	3	0	0	1	4
Post-Doc.	0	0	0	0	0
Total	10	0	0	2	12

Notable Awards and Achievements

The following achievements are a result of Kenneth Backman’s funded project:

Two presentations using data from this project were done at the 2001 Southeastern Recreation Research Conference, February 21-23, 2001, Asheville, North Carolina.

Davis, Jason and Backman, Kenneth F."Boaters and Marina Operators’ Perceptions of Water Quality in the Five Lake Savannah Watershed Region."

Walker, Joseph and Backman, Kenneth F. "Exploring the Effect of Trip Distance on Boater’s Pereception of Water Quality."

One poster presentation and proceedings publication were done using data from this project for the College of Health, Education, and Human Development Faculty Research Forum, Clemson University, March 31, 2001.

Backman, Sheila J. and Backman, Kenneth F. "Perceptions of Water Quality in the Five Lake Savannah Watershed Region," p. 3.

Two poster presentations using data from this project for the Clemson University Graduate Student Research Award Competition.

Davis, Jason, Walker, Joseph, Backman, Kenneth F. and Chao, Chih-Liang. "Boaters and Marina Operators’ Perception of Water Quality in the Five Lake Savannah Watershed Region."

Walker, Joseph, and Backman, Kenneth F. "Exploring the Effect of Trip Distance on Boater’s Perception of Water Quality."

One poster presentation using the data from this project was selected by the graduate deans of Clemson University to be on display April 19, 2001 at the Annual Catfish and Guts Dinner for the state legislatures. This poster was only one of twelve posters chosen for this event.

Davis, Jason, Walker, Joseph, Backman, Kenneth F. and Chao, Chih-Liang. "Boaters and Marina Operators’ Perceptions of Water Quality in the Five Lake Savannah Wateshed Region.

The SC Water Resources Center also received the "2000 Innovative Planning Technology Award" from the South Carolina Chapter of the American Planning Association. This award was the result of its role in a joint project with the Strom Thurmond Institute called "The Charleston 2030 Urban Growth Study."

Publications from Prior Projects

1. Backman, Sheila J. and Kenneth F. Backman, 2001. Perceptions of Water Quality in the Five Lake Savannah Wateshed Region, in College of Health, Education, and Human Development Faculty Research Forum, Clemson University, Clemson, South Carolina, p. 3.