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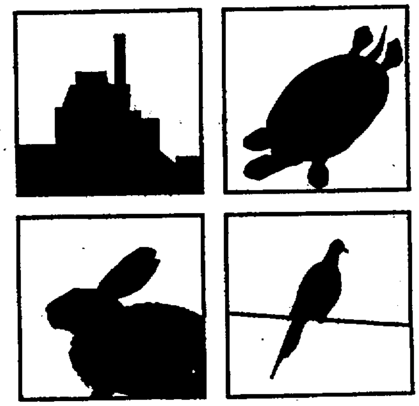

SRS Urban Wildlife

Environmental Information Document

Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808

SAFETY • RESPONSIBILITY • SECURITY
SRS
SAVANNAH RIVER SITE

Prepared for the U.S. Department of Energy under Contract No. DE-AC09-96SR18500

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John J. Mayer and Lynn. D. Wike

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Contents

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Executive Summary

Wildlife species have been present on the SRS prior to the time of government acquisition. Use or occupation of developed Site areas by wildlife species has not been investigated to date. The purpose of this report is to document the composition and diversity of the various species of wildlife found in and using these "urbanized" portions of the SRS.

An additional purpose for this report was to provide information in support of the development of Site environmental impact studies associated with proposed actions at SRS. Approximately 80-90 percent of the recent projects at SRS were located within previously developed areas. However, recent impact assessments of DOE proposed actions/projects at SRS demonstrate the paucity of known information regarding the presence of urban wildlife species on Site. Preliminary investigations toward documenting this urban use by the Site's wildlife populations indicated that the perceived absence of these species in the Site's developed areas was inaccurate.

Methods of data collection relied upon both existing information and field observation/sampling specific to the preparation of this report. Data were categorized into one of ten subhabitat types defined for the Site's developed areas. These included: interiors of buildings and structures, exteriors of buildings and structures, landscaped areas around buildings and structures, landscaped areas/lawns, construction laydown yards or salvage storage areas, roads and parking lots, storm water runoff or drainage ditches, storm water runoff retention basins, settling and seepage basins, and reactor 183/186 basins. Relative species abundance was also subjectively assigned to one of four categories (i.e., abundant, common, uncommon, or rare) based on the field data collection. Types of use noted for SRS wildlife species within Site urban areas were classified into one of eight general categories. These included the following: foraging and feeding; shelter; courting and mating; denning, nesting, or egg laying; rearing or development of young; loafing, resting, perching, or roosting; transient and dispersal; and presence only/no documented specific use.

The presence of wildlife species in developed areas on the SRS is more commonplace than had been previously documented. In general, the overall percent taxonomic composition of the urban species is very similar to that of the overall taxonomic composition for SRS wildlife. A total of 153 species were documented as using developed areas of SRS. This total included 16 species of amphibians, 25 species of reptiles, 91 species of birds, and 21 species of mammals. Most of these species were found to use terrestrial subhabitats with landscaping located away from buildings and other structures. As the developed or structural aspect of the subhabitats became more complex or built-up, the species diversity of urban wildlife decreased. The majority of wildlife species found in urban subhabitats on the SRS were classified as uncommon. This decreased to common and then rare. Abundant was the least frequent level of presence. The most common use of the urban subhabitats was for foraging and feeding. The least frequent type of use was for reproductive activities.

Only two Federally-protected species, the American alligator and the bald eagle, were documented as using areas in and around the developed portions of the Site. Neither species was determined to have any more than an uncommon or rare presence in SRS developed areas. No state-listed protected species have been found in any of the urban subhabitats on Site.

The potential impacts which could result from the presence of urban wildlife within the Site developed areas can be either positive or negative, and affect either the human environment or the wildlife species themselves. The potential impacts to humans in urban subhabitats on the SRS resulting from wildlife can be classified into several categories: contaminant transport, physical harm, disease transmission, and destruction of property. The potential impacts to wildlife species can also be placed into two general categories as follows: physical harm and contaminant exposure.

The management of wildlife in SRS developed areas tends to fall into one of two objectives, discouraging or encouraging the presence of certain species. These objectives are encompassed by two general extremes of management strategies, control or enhancement. Pest and damage control of wildlife species within urban environments tends to be either proactive or reactive. Environmental or habitat enhancements can be either intentional or unintentional.

The results of the surveys conducted during this study indicate that the use of the developed areas of SRS by wildlife species is more common than had been previously reported. The presence of wildlife species in developed or urban areas of the SRS can be expected to be a long-term aspect of the Site's environmental diversity.

Acknowledgments

We thank the U. S. Department of Energy for access to lands and facilities under their control. We appreciate and acknowledge discussions with R. K. Abernethy which identified the need for this report and directly led to the decision to initiate this study. We are especially grateful for the information provided by A. S. Allen, P. E. Johns, and R. A. Kennamer regarding the occurrence of a number of species discussed in this report. We appreciate the cooperation and assistance of a number of people who provided us with a variety of information which was used in this report. We are very grateful for the help provided by the following persons: J. J. Banks, C. E. Braun, I. L. Brisbin, Jr., A. L. Bryan, Jr., J. B. Gladden, J. C. Kilgo, E. Kilpatrick, E. T. LeMaster, F. D. Martin, C. E. Murphy, Jr., D. V. Osteen, R. C. Tuckfield, and W. T Watters. D. E. Gordon, E. B. Hart, J. C. Kilgo, B. C. Marcy, Jr., F. D. Martin, and D. V. Osteen provided advice and helpful criticism on an earlier draft of this report. Funding for this study was provided by Contracts DE-AC09-88SR18035 and DE-AC09-96SR18500 between the Westinghouse Savannah River Company and the U. S. Department of Energy.

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Introduction

Wildlife species have been a component of the lands encompassing the Savannah River Site (SRS), located near Aiken, South Carolina (Figure 1), since prior to the acquisition of the area by the Federal government in 1951 (Jenkins and Provost, 1964; Langley and Marter, 1973). The present taxonomic diversity of wildlife on the SRS is largely a result of the wide variety and mosaic of habitats found on Site. The SRS now supports at least minimal populations of 43 species of amphibians, 58 species of reptiles, 213 species of birds, and 54 species of mammals. These populations include a number of commercially and recreationally important birds and mammals as well as several threatened and endangered species (Wike et al., 1994).

Most studies conducted on SRS wildlife populations have dealt with those individuals or species inhabiting the undeveloped portions of the Site. Probably because of the fact that the developed areas comprise less than five percent of the total Site area and most ecological research endeavors to study a species within "natural settings," habitats in and around the developed areas or facilities at SRS have received little attention from researchers. This same discrepancy in wildlife research or studies of developed versus undeveloped (or natural) environments on SRS has been historically mirrored on a national scale within the United States (Robinson and Bolin, 1984). In deference to this apparent widespread bias, the occupation and use of the SRS by wildlife species has expanded over time to include many of the Site's cleared and developed or "urbanized" areas.

The purpose of this report is to document the composition and diversity of urban wildlife found on the SRS. Within the context of this report, the term "urban wildlife" is defined as those species of amphibians, reptiles, birds or mammals which inhabit or periodically use in some manner the developed areas of the SRS. This report comprises a first broad look at this ecotypic component of the SRS wildlife but is not intended to be a totally comprehensive discussion or presentation of this topic.

A further purpose for the preparation of this report is to provide informational support for the development of Site environmental impact studies associated with U. S. Department of Energy (DOE) proposed actions at SRS. Approximately 80-90 percent of the recently proposed renovation or construction projects at SRS are located within previously developed areas of the Site (Meadors et al., 1993; Mayer, 1996). Recent impact assessments of DOE proposed actions/projects (e.g., DOE, 1993, 1994, 1995) demonstrate the paucity of known information regarding the presence of urban wildlife species on SRS. Preliminary investigations made toward documenting the wildlife use of SRS urban habitats indicated that the perceived absence of these species in the Site's developed areas was both incorrectly reported and grossly overstated.

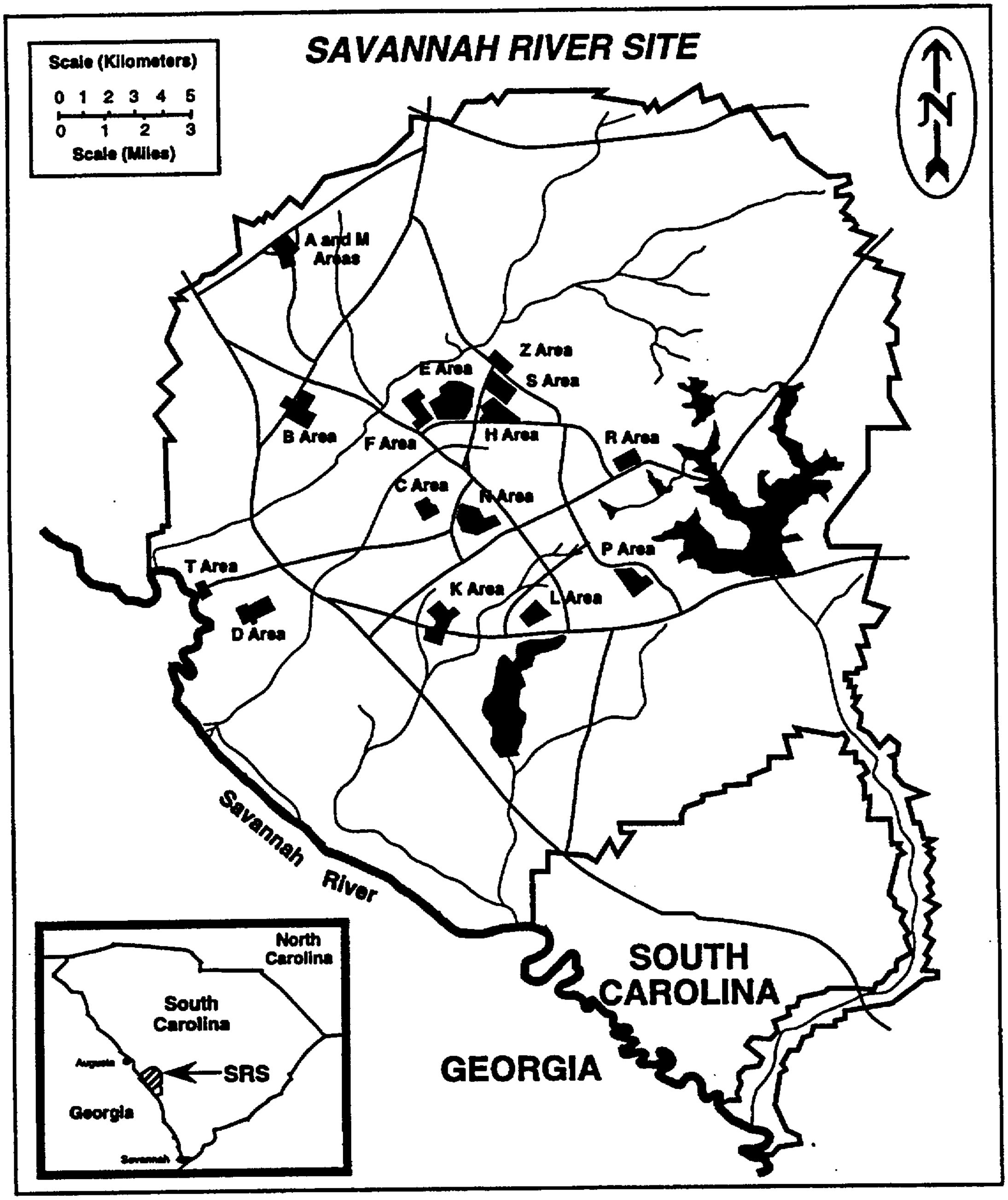


Figure 1. Map of the Savannah River Site, South Carolina, illustrating the locations of the developed areas on site.

Methods

Within the context of this report, the definition of "urban areas" encompasses any cleared and developed portions of the SRS which realize moderate to heavy levels of human activity on a daily basis. The specific subject areas of the SRS surveyed in this report were as follows: A Area, B Area, C Area, D Area, E Area, F Area, H Area, K Area, L Area, M Area, N Area, P Area, R Area, T Area, and Z Area (Figure 1). The Savannah River Forest Station, SRS Railroad Classification Yard, and other smaller developed areas or structures (e.g., laboratory facilities, security barricades, observation towers, power/communications transmission towers, domestic water towers, shuttle stops, storage facilities, pumphouses, and power substations) at remote locations were not included.

The presence of wildlife species in developed areas on the SRS was determined through several means as follows: documentation in the existing literature; observations (either random or through the use of specific methods) made during the course of this study; reliable sightings reported by other biologists on the Site, interviews with Site personnel, and field sign or evidence of the presence of a species found during this study. Records were categorized as to species, type of use, season of use, area of observation, and type of subhabitat (i.e., specific components or subportions of the SRS urban environment) being used. Unfortunately, most existing literature records were not detailed to this extent as to be completely useful for this study.

Methods of data collection specific to the four SRS vertebrate classes of wildlife encompassed by this report consisted of the following:

- **Amphibian Sampling/Survey Methods** - included acoustic surveys for spring/summer choruses of anurans, use of minnow traps to sample basins, and visual surveys of aquatic habitats (e.g., storm water runoff retention basins) in the spring and summer for sightings or field sign.

- **Reptile Sampling/Survey Methods** - included visual surveys of appropriate subhabitats in the spring and summer months for either sightings or field sign.

- **Bird Sampling/Survey Methods** - included pedestrian and vehicular observational surveys during early morning hours; identification of species through characteristic vocalizations.

- **Mammal Sampling/Survey Methods** - included visual surveys of appropriate subhabitats for either sightings or field sign; sampling using live traps (i.e., Sherman folding live traps) for small mammal species in appropriate subhabitats.

The overall developed habitat found on the SRS is far from being a uniform urbanized environment. As such, it is important to understand how and where each species uses or occupies components or subportions of these developed areas. To this end, ten subhabitats were developed for use in this study. The delineation of these ten subhabitats within the urban environment on the SRS were defined as follows:

- **Interiors of Buildings and Structures** - included any areas enclosed by the walls, sides, or roofs of a building or structure. This included areas located both within and outside of fenced security areas.

- **Exteriors of Buildings and Structures** - included the outside or exposed portions of buildings and structures (e.g., towers, elevated water tanks, aboveground fuel/solvent storage tanks), including wall and roofs, walkways, porches, and any structural features associated with these areas (e.g., window ledges, ventilation housing, air conditioning units, roof drains, light fixtures, stationary ladders, guard rails, eaves, overhangs, etc.). This included areas located both within and outside of fenced security areas.

- **Landscaped Areas around Buildings and Structures** - included the landscaped and maintained (e.g., lawn area mowed, bushes and shrubs trimmed on a scheduled basis) areas immediately adjacent ($\leq$10 m) to buildings and structures; can include areas with trees, shrubs, bushes, or herbaceous ground cover in addition to grass-covered areas. This included areas located both within and outside of fenced security areas. This also included areas associated with sidewalks and walkways adjacent to buildings and structures.

- **Landscaped Areas/Lawns** - included the landscaped and maintained (e.g., lawn area mowed, bushes and shrubs trimmed on a scheduled basis) areas located away from (>10 m) either buildings or structures; can include areas with trees, shrubs or herbaceous ground cover in addition to grass-covered areas. This included areas located both within and outside of fenced security areas. This also included areas associated with sidewalks and walkways.

- **Construction Laydown Yards or Salvage Storage Areas** - included those construction laydown yards, with either construction materials or equipment present, or salvage storage areas. This also included office trailers in these areas.

- **Roads and Parking Lots** - included both paved and graveled roads and parking lots in developed areas on Site; also encompasses the shoulders and rights-of-way adjacent to these areas. This included areas located both within and outside of fenced security areas. This subhabitat did not include portions of roads situated between developed areas on Site.

- **Storm Water Runoff or Drainage Ditches** - included the grass-covered or engineered ditches located in developed areas to control and channel storm water runoff. This included the deeper grass-covered swales that are adjacent to roadways and which collect water following rainfall events.

- **Storm Water Runoff Retention Basins** - included the engineered and typically fenced storm water runoff retention basins located in or immediately adjacent to developed areas on the SRS. These areas can include both open and shrub-scrub wetland habitat. This subhabitat classification also included sedimentation basins.

- **Settling and Seepage Basins** - included the open water habitat of the settling and seepage basins found in developed areas on Site. Typically, these basins on SRS are fenced and uncovered. This subhabitat type also included the ash basins in D Area and P Area.

- **Reactor 183/186 Basins** - included the open water area within these reactor basins. The structural components of the basins would be included in either one of the first two subhabitats defined above.

The species abundance within Site urban areas is likely to vary depending upon a number of parameters including season, subhabitat, time of day, etc. To at least minimally address this issue, four categories of qualitative abundance of species occurrence were developed in support of this study. These categories were defined as follows:

- **Abundant** - easily or very frequently observed in urban subhabitats on the SRS
- **Common** - observed in urban subhabitats on the SRS on a regular or occasional basis
- **Uncommon** - seldom or infrequently observed in urban subhabitats on the SRS
- **Rare** - only a limited number (e.g., less than five) of reports of this species ever using urban subhabitats on the SRS

The assignment of species abundance categories was based subjectively on the observational and other data collected during the course of this study.

The specific types of use noted for SRS wildlife species within Site urban areas are an important aspect of the presence of these animals. Such activities would ultimately determine how these species might be impacted, or just as significant, how these species might impact any humans encountered or facilities used in the SRS developed areas. In support of this aspect of the present study, eight categories of specific type of use were developed. The different types of use were generalized to be applicable among the four vertebrate classes being studied. The types of use were categorized as follows:

- **Foraging, Feeding** - actions/behaviors associated with acquiring and consuming food resources
- **Shelter** - actions/behaviors associated with seeking temporary shelter; would include daily dens or burrows used for shelter only
- **Courting, Mating** - actions/behaviors associated with mate selection and breeding
- **Denning, Nesting, or Egg Laying** - actions/behaviors associated with producing and initially rearing hatchlings or neonates
- **Rearing or Development of Young** - actions/behaviors associated with either the altritial or precocial rearing of immature or subadult individuals
- **Loafing, Resting, Perching, Roosting** - actions/behaviors associated with occupying a position from brief to extended periods of time
- **Transient, Dispersal** - actions/behaviors associated with traveling across or through a developed area
- **Presence Only/No Documented Specific Use** - documented only presence in developed areas, no specific actions/behaviors noted or observed

Observational and other data collected during the course of this study provided the basis for the assignment of specific types of use to an individual species. In some cases, if a type of use was observed in a developed subhabitat (e.g., egg laying by bullfrogs in a storm water

retention basin), then subsequent types of use were assumed (e.g., development of young bullfrogs in a storm water retention basin).

Results

Data were collected and compiled between August 1, 1994 and August 1, 1997. A total of 153 species of wildlife were found in and immediately around the developed portions of the Site (Tables 1, 2, 3, and 4). Of the total number of species in each vertebrate class of wildlife found on the SRS, the following percentages were found to occur in developed areas on Site: amphibians - 37.2 percent; reptiles - 43.1 percent; birds - 42.7 percent; and mammals - 38.9 percent (Figure 2). Most (58.3 percent) of these species were considered to be uncommon in developed areas (Figure 3). Some (27.8 percent) were considered to be common. A smaller number (16.0 percent) were considered to be rare. Only a few (4.2 percent) were considered to be abundant.

Of the total number of SRS areas included in this study, A Area was documented as having the highest number of vertebrate species (Tables 1, 2, 3, and 4). This was probably the result of this developed area having the highest data collection effort rather than a absolute higher numbers of species. Of the eight subhabitats surveyed, the landscaped areas away from buildings and other structures had the highest level of use (69.9 percent) (Table 5; Appendix A). The lowest use (4.6 percent) based on the number of species recorded was the 186/183 basins. The most commonly observed type of use by these species was foraging or feeding (98.0 percent), while the lowest documented use, at 30.1, percent, was courting or mating (Table 6; Appendix B).

Species Accounts:

The following are individual accounts of the various species documented during the course of this study and report preparation. These accounts include pertinent aspects of the use of SRS urban subhabitats by these species and present information that might be useful to assessment of potential impacts of proposed DOE actions on the Site's developed areas. Information or data not attributed to an identified citation are a result of the present study.

Amphibians -

Spotted Salamander - The spotted salamander is considered to be uncommon on the SRS, with its distribution being largely restricted bottomland hardwood forests along streams and the Savannah River floodplain. This species has not been found in upland temporary ponds. Migrating adults and egg masses have been found from January to March, and juveniles metamorphose in May and June (Gibbons and Semlitsch, 1991). Spotted salamanders have been found in a few storm water runoff retention basins on Site.

Mole Salamander - The mole salamander is found in every SRS aquatic habitat in which fish are not present. Adults migrate to breeding sites from October through March, emigrating into the surrounding terrestrial habitats in late winter or spring after breeding. The emigration of recently metamorphosed individuals from the breeding sites takes place from May to September (Gibbons and Semlitsch, 1991). Adult mole salamanders have been found in storm water runoff retention basins within the Site's developed areas.

Marbled Salamander - This salamander species breeds in both temporary ponds and Carolina bays on the SRS. Migration to the breeding sites begins in August, with the peak occurring in October. Males leave the sites after breeding, with the females waiting to emigrate after sufficient water is present to lay their eggs. Metamorphosed immatures move in to lands surrounding the breeding site in late spring or early summer (Gibbons and

Table 1

Listing of SRS Urban Amphibian Species.

Common Name	Scientific Name	Abundance in Developed Areas[a]	Area of Observation
Spotted Salamander	*Ambystoma maculatum*	Uncommon	S, Z
Mole Salamander	*Ambystoma talpoideum*	Uncommon	B, S, Z
Marbled Salamander	*Ambystoma opacum*	Uncommon	Z
Eastern (Red-Spotted) Newt	*Notophthalmus viridescens*	Uncommon	A, Z
Easten Spadefoot Toad	*Scaphiopus holbrooki*	Uncommon	Z
Southern Toad	*Bufo terrestris*	Common	A, B, F, H, N, S, Z
Southern Cricket Frog	*Acris gryllus*	Uncommon	N
Cope's Gray Treefrog	*Hyla chrysoscelis*	Common	A, B, F, H, Z
Green Treefrog	*Hyla cinerea*	Common	A, D
Barking Treefrog	*Hyla gratiosa*	Common	A, B, F, H, Z
Squirrel Treefrog	*Hyla squirrella*	Uncommon	A
Spring Peeper	*Pseudacris crucifer*	Uncommon	A
Eastern Narrow-Mouthed Toad	*Gastrophryne carolinensis*	Uncommon	A, Z
Bullfrog	*Rana catesbianea*	Common	B, D, N, R, Z
Bronze (Green) Frog	*Rana clamitans*	Common	Z
Southern Leopard Frog	*Rana utricularia*	Common	B, F, H, N, S, Z

[a] Abundance refers to the presence in the appropriate subhabitat(s) within developed areas

Table 2

Listing of SRS Urban Reptile Species.

Common Name	Scientific Name	Abundance in Developed Areas[a]	Area of Observation
American Alligator	*Alligator mississippiensis*	Uncommon	A, D, F, H, L, M, P, T
Common Snapping Turtle	*Chelydra serpentina*	Uncommon	A, B, C, D, F, H, K, L, M, N, P, R, S, T, Z
Eastern Box Turtle	*Terrepene carolina*	Uncommon	A
Yellow-bellied Turtle	*Trachemys scripta*	Common	A
Green Anole	*Anolis carolinensis*	Common	A, B
Eastern Fence Lizard	*Sceloporus undulatus*	Uncommon	A
Southeastern Five-lined Skink	*Eumeces inexpectatus*	Uncommon	A
Ground Skink	*Scincella laterialis*	Uncommon	A
Eastern Hognosed Snake	*Heterodon platyrhinos*	Uncommon	A, B, C, D, F, H, K, L, M, N, P, R, S, T, Z
Banded Water Snake	*Nerodia fasciata*	Common	A, B, C, D, F, H, K, L, M, N, P, R, S, T, Z
Red-bellied Water Snake	*Nerodia erythrogaster*	Uncommon	H
Scarlet Snake	*Cemophora coccinea*	Uncommon	C, F, H, K, L, P
Scarlet Kingsnake	*Lampropeltis triangulum*	Uncommon	A, C, F, H, K, L, P, R
Rainbow Snake	*Farancia erytrogramma*	Rare	K
Rat Snake	*Elaphe obsoleta*	Uncommon	A, B, C, D, F, H, K, L, M, N, P, R, S, T, Z
Corn Snake	*Elaphe guttata*	Uncommon	A, B, C, D, F, H, K, L, M, N, P, R, S, T, Z
Pine Snake	*Pituophis melanoleucus*	Uncommon	C, F, H, K, L, P, R
Black Racer	*Coluber constrictor*	Uncommon	E, H
Coachwhip	*Masticophis flagellum*	Uncommon	A
Ring-necked Snake	*Diadophis punctatus*	Uncommon	A
Brown Snake	*Storeria dekayi*	Uncommon	A
Pygmy Rattlesnake	*Sistrurus miliarius*	Uncommon	A, B, H, P
Cottonmouth	*Agkistrodon piscivorus*	Uncommon	A, B, C, D, F, H, K, L, M, N, P, R, S, T, Z
Canebrake Rattlesnake	*Crotalus horridus*	Uncommon	A, B, C, D, F, H, K, L, M, N, P, R, S, T, Z
Copperhead	*Agkistrodon contortrix*	Uncommon	A, B, C, D, F, H, K, L, M, N, P, R, S, T, Z

[a] Abundance refers to the presence in the appropriate subhabitat(s) within developed areas

Table 3

Listing of SRS Urban Bird Species.

Common Name	Scientific Name	Residency Status[a]	Abundance in Developed Areas[b]	Area of Observation
Pied-billed Grebe	*Podilymbus podiceps*	PR	Uncommon	A, D, P, R
Double-crested Cormorant	*Phalacrocorax auritus*	WV	Uncommon	R
Great Blue Heron	*Ardea herodias*	PR	Uncommon	N
Green Heron	*Butorides striatus*	SR	Uncommon	N
Great Egret	*Casmerodius albus*	PR	Common	N
Tricolor Heron	*Hydranasca tricolor*	PR	Rare	N
Yellow-crowned Night Heron	*Nycticorax violaceus*	PR	Rare	T
Canada Goose	*Branta canadensis*	WV	Rare	A
Snow/Blue Goose	*Chen caerulescens*	TV/WV	Rare	F, H
Mallard	*Anas platyrhynchos*	WV/SR	Uncommon	D
Pintail	*Anas acuta*	WV	Rare	D
Green-winged Teal	*Anas crecca*	WV	Uncommon	D
Blue-winged Teal	*Anas discors*	WV	Rare	F, H
American Wigeon	*Anas americana*	WV	Rare	D
Gadwall	*Anas strepera*	WV	Rare	D
Northern Shoveler	*Anas clypeata*	TV/WV	Rare	D
Wood Duck	*Aix sponsa*	PR	Uncommon	A, D, N, S
Redhead	*Aythya americana*	TV	Rare	D
Ring-necked Duck	*Aythya collaris*	WV	Uncommon	C, D, K, L, P, R
Lesser Scaup	*Aythya affinis*	WV	Common	D, T
Bufflehead	*Bucephala albeola*	WV	Common	A, D, F, H, P
Ruddy Duck	*Oxyura jamaicensis*	WV	Rare	D, T
Hooded Merganser	*Lophodytes cucullatus*	WV	Common	D, P
Red-breasted Merganser	*Mergus serrator*	TV	Rare	D
Turkey Vulture	*Cathartes aura*	PR	Common	A, B, C, D, E, F, H, K, L, M, N, P, R, S, T, Z
Black Vulture	*Coragyps atratus*	PR	Common	A, B, C, D, E, F, H, K, L, M, N, P, R, S, T, Z
Mississippi Kite	*Ictinia mississippiensis*	SR	Uncommon	D, T
Cooper's Hawk	*Accipiter cooperi*	PR	Rare	A
Red-tailed Hawk	*Buteo jamaicensis*	PR	Uncommon	A, B, C, D, F, H, K, L, M, N, P, R, S, T, Z
Red-shouldered Hawk	*Buteo lineatus*	PR	Uncommon	A, D, T
Bald Eagle	*Haliaeetus leucocephalus*	WV	Rare	A, H, P
Northern Harrier	*Circus cyaneus*	WV	Uncommon	A, C, D, E, H, N, P, R, S, Z
American Kestrel	*Falco sparverius*	PR	Uncommon	A, C, D, K, L, N

Table 3

Listing of SRS Urban Bird Species (Continued).

Common Name	Scientific Name	Residency Status[a]	Abundance in Developed Areas[b]	Area of Observation
Northern Bobwhite	*Colinus virginianus*	PR	Uncommon	A
Eastern Wild Turkey	*Meleagris gallopavo*	PR	Uncommon	A, B, C, K, P
American Coot	*Fulica americana*	WR	Uncommon	C, K, L, P, R
Killdeer	*Charadrius vociferus*	PR	Common	A, B, E, F, H, N, S, Z
Least Sandpiper	*Calidris minutilla*	WV	Uncommon	B, F, H
Ring-billed Gull	*Larus delawarensis*	WV	Rare	A
Rock Dove	*Columba livia*	PR	Abundant	A, B, C, D, E, F, H, K, L, M, N, P, R, S, T, Z
Mourning Dove	*Zenaida macroura*	PR	Common	A, B, C, D, F, H, K, L, M, N, P, R, S, T, Z
White-winged Dove	*Zenaida asiatica*	TV	Rare	A
Barn Owl	*Tyto alba*	PR	Uncommon	C, N
Screech Owl	*Otus asio*	PR	Uncommon	S
Barred Owl	*Strix varia*	PR	Uncommon	C
Common Nighthawk	*Chordeiles minor*	SR	Common	A
Chimney Swift	*Chaetura pelagica*	SR	Common	A, F
Ruby-throated Hummingbird	*Archilochus colubris*	SR	Uncommon	A
Belted Kingfisher	*Ceryle alcyon*	PR	Uncommon	Z
Common Flicker	*Colaptes auratus*	PR	Uncommon	A
Pileated Woodpecker	*Dryocopus pileatus*	PR	Uncommon	A
Red-bellied Woodpecker	*Melanerpes carolinus*	PR	Uncommon	A
Eastern Kingbird	*Tyrannus tyrannus*	SR	Common	A, B, C, F, H
Great Crested Flycatcher	*Myiarchus crinitus*	SR	Uncommon	A, B, H
Horned Lark	*Eremophila alpestris*	WV	Rare	A
Barn Swallow	*Hirundo rustica*	SR	Common	A, B, C, E. F, K, H, L, P, R, S, Z
Tree Swallow	*Tachycineta bicolor*	TV	Uncommon	A
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	SR	Common	A, B, E, H
Purple Martin	*Iridoprocue bicolor*	SR	Common	A
Blue Jay	*Cyanocitta cristata*	PR	Uncommon	A, E, H
Common Crow	*Corvus brachyrhynchos*	PR	Abundant	A, B, C, D, E, F, H, K, L, M, N, P, R, S, T, Z
Fish Crow	*Corvus ossifragus*	SR	Common	A, B, C, D, F, H, K, L, M, N, P, R, S, T, Z
Tufted Titmouse	*Parus bicolor*	PR	Uncommon	A
Brown-headed Nuthatch	*Sitta pusilla*	PR	Uncommon	A

Table 3

Listing of SRS Urban Bird Species (Continued).

Common Name	Scientific Name	Residency Status[a]	Abundance in Developed Areas[b]	Area of Observation
House Wren	*Troglodytes aedon*	WV	Uncommon	B
Bewick's Wren	*Thryomanes bewickii*	WV	Rare	B
Carolina Wren	*Thryothorus ludovicianus*	PR	Uncommon	A
Northern Mockingbird	*Mimus polyglottos*	PR	Abundant	A, B, C, D, E, F, H, K, L, M, N, P, R, S, T, Z
Gray Catbird	*Dumetella carolinensis*	WV	Uncommon	A
Brown Thrasher	*Toxostoma rufum*	PR	Uncommon	A
American Robin	*Turdus migratorius*	PR	Abundant	A, B, C, D, E, F, H, K, L, M, N, P, R, S, T, Z
Eastern Bluebird	*Sailia sialis*	PR	Common	A, B, E, F
Cedar Waxwing	*Bombycilla cedrorum*	WV	Uncommon	A
Loggerhead Shrike	*Lanius ludovicianus*	PR	Common	A, B, E, H, N, S, Z
European Starling	*Sturnus vulgaris*	PR	Abundant	A, B, C, D, E, F, H, K, L, M, N, P, R, S, T, Z
White-eyed Vireo	*Vireo griseus*	SR	Uncommon	A
Common Yellowthroat	*Geothlypis trichas*	SR	Rare	A
House Sparrow	*Passer domesticus*	PR	Abundant	A, B, C, D, H, K, L, M, N, P, R, S, T, Z
Eastern Meadowlark	*Sturnella magna*	PR	Uncommon	A, B, E
Red-winged Blackbird	*Agelaius phoeniceus*	PR	Common	A, H, S, Z
Common Grackle	*Quiscalus quiscula*	PR	Common	A, E, F, S, Z
Brown-headed Cowbird	*Molothrus ater*	WV	Uncommon	A, B, E
Northern Cardinal	*Cardinalis cardinalis*	PR	Uncommon	A, B
Indigo Bunting	*Passerina cyanea*	SR	Rare	A, F
House Finch	*Carpodacus mexicanus*	PR	Common	A
Pine Siskin	*Carduelis pinus*	WV	Uncommon	A
American Goldfinch	*Carduelis tristis*	PR	Common	A
Rufous-sided Towhee	*Pipilo erythrophthalmus*	PR	Uncommon	A
Dark-eyed Junco	*Junco hyemalis*	WV	Uncommon	A
Chipping Sparrow	*Spizella passerina*	PR	Common	A
White-throated Sparrow	*Zonotrichia leucophrys*	WV	Uncommon	A

[a] Residency status abbreviations are as follows: PR - permanent resident; SR - summer resident; TV - transient visitant; WV - winter visitant

[b] Abundance refers to the presence in the appropriate season(s) and subhabitat(s) within developed areas

Table 4

Listing of SRS Urban Mammal Species.

Common Name	Scientific Name	Abundance in Developed Areas[a]	Area of Observation
Virginia Opossum	*Didelphis virginiana*	Common	A, B, C, D, E, F, H, K, L, M, N, P, R, S, T, Z
Eastern Mole	*Scalopus aquaticus*	Uncommon	B, K
Southern Short-tailed Shrew	*Blarina carolinensis*	Uncommon	H
Least Shrew	*Cryptotis parva*	Uncommon	E
Eastern Pipistrelle	*Pipistrellus subflavus*	Uncommon	B, F, K, M
Eastern Cottontail	*Sylvilagus floridanus*	Common	A, B, E, F, H
Eastern Gray Squirrel	*Sciurus carolinensis*	Uncommon	A, B
Southern Flying Squirrel	*Glaucomys volans*	Rare	A
Cotton Mouse	*Peromyscus gossypinus*	Common	A, E
Cotton Rat	*Sigmodon hispidus*	Uncommon	A
House Mouse	*Mus musculus*	Common	A, B, C, D, E, F, H, K, L, M, N, P, R, S, T, Z
Norway Rat	*Rattus norvegicus*	Uncommon	A, B, C, D, F, H, K, L, M, N, P, R, S
Coyote	*Canis latrans*	Uncommon	A, B, E, P, T
Feral Dog	*Canis familiaris*	Uncommon	A, B, C, D, E, F, H, K, L, M, N, P, R, S, T, Z
Gray Fox	*Urocyon cinereoargenteus*	Common	A, B, C, D, E, F, H, K, L, M, N, P, R, S, T, Z
Bobcat	*Felis rufus*	Rare	D
Feral Cat	*Felis catus*	Common	A, B, C, D, E, F, H, K, L, M, N, P, R, S, T, Z
Striped Skunk	*Mephitis mephitis*	Common	A, B, C, D, E, F, H, K, L, M, N, P, R, S, T, Z
Raccoon	*Procyon lotor*	Common	A, B, C, D, E, F, H, K, L, M, N, P, R, S, T, Z
Wild Pig	*Sus scrofa*	Uncommon	F, S
White-tailed Deer	*Odocoileus virginianus*	Uncommon	A, N, Z

[a] Abundance refers to the presence in the appropriate subhabitat(s) within developed areas

Table 5

Summary of Wildlife Usage of SRS Urban Subhabitats.

SRS Urban Subhabitat	Percent of Each Taxa				
	Amphibians (N=16)	Reptiles (N=25)	Birds (N=91)	Mammals (N=21)	Total (N=153)
Interiors of Buildings and Structures	6.3	64.0	9.9	47.6	23.5
Exteriors of Buildings and Structures	12.5	68.0	30.8	57.1	38.6
Landscaped Areas around Buildings and Structures	18.8	88.0	41.8	76.2	51.6
Landscaped Areas/Lawns	12.5	96.0	69.2	85.7	69.9
Construction Laydown Yards or Salvage Storage Areas	0.0	24.0	13.2	23.8	15.0
Roads and Parking Lots	12.5	28.0	38.5	61.9	37.3
All Terrestrial Subhabitats	10.4	61.3	33.9	58.7	39.3
Storm Water Runoff or Drainage Ditches	25.0	8.0	13.2	28.6	15.7
Storm Water Runoff Retention Basins	93.8	24.0	26.4	19.0	32.0
Settling and Seepage Basins	50.0	20.0	24.2	4.8	23.5
Reactor 183/186 Basins	0.0	0.0	7.7	0.0	4.6
All Aquatic Subhabitats	42.2	13.0	17.9	13.1	18.9

Table 6

Summary of Specific Types of Use[a] Observed for SRS Urban Wildlife.

Type of Use[a]	Percent of Each Taxa				
	Amphibians (N=16)	Reptiles (N=25)	Birds (N=91)	Mammals (N=21)	Total (N=153)
Foraging, Feeding	100.0	100.0	98.9	90.5	98.0
Shelter	100.0	84.0	47.3	76.2	62.7
Courting, Mating	100.0	16.0	17.6	47.6	30.1
Denning, Nesting, Egg-laying	100.0	12.0	19.8	52.4	31.4
Rearing or Development of Young	100.0	12.0	19.8	52.4	31.4
Loafing, Resting, Perching, Roosting	100.0	28.0	73.6	57.1	66.7
Transient, Dispersal	100.0	80.0	76.9	85.7	81.0
Presence Only, No Documented Specific Use	0.0	0.0	1.1	0.0	0.7

[a] Defined on page 8 of this report

Semlitsch, 1991). A few individual adult marbled salamanders have been observed in storm water runoff retention basins.

Eastern (Red-spotted) Newt - Eastern or red-spotted newts are found throughout the SRS. Adults migrate to aquatic sites during the fall and winter. Breeding occurs from February through May. Terrestrial stages (i.e., efts) can be found on roadways during rainy periods in fall through winter (Gibbons and Semlitsch, 1991). This species has been observed in storm water runoff retention basins on Site.

Eastern Spadefoot Toad - The eastern spadefoot toad is typically observed in breeding choruses following heavy periods of rain. This species often breeds in temporary habitats flooded by these rains. Choruses can be heard from February through March following rainy periods. Large choruses have been found in manmade habitats (Gibbons and Semlitsch, 1991). Breeding populations of this toad have been heard in storm water runoff retention basins on Site.

Southern Toad - This is the most conspicuous amphibian on Site during the warm months of the year (Gibbons and Semlitsch, 1991). Individuals were commonly observed in developed areas on sidewalks, roads, parking lots, and landscaped areas/lawns during warm nights. This is especially true during periods of rain or high humidity. Calling males can be heard in developed areas of the SRS during the spring months (i.e., late March through May). With the exception of reactor 183/186 basins, breeding can occur in any of the aquatic subhabitats found in the urban areas on Site. Large congregations of larval southern toads have been observed in storm water runoff retention basins in the spring.

Southern Cricket Frog - The southern cricket frog is very common and widespread on SRS. Calling by this species is heard from spring to late summer (Gibbons and Semlitsch, 1991). Both adults and larvae of this frog species have found in storm water runoff retention basins on Site.

Cope's Gray Treefrog - This species has been found throughout the SRS (Gibbons and Semlitsch, 1991). Calling is heard in the late spring and early summer. Choruses of this species have been heard in a variety of urban subhabitats, primarily in storm water runoff retention, settling, and seepage basins.

Green Treefrog - Large choruses of this species can be found on Site during the late spring and summer months (Gibbons and Semlitsch, 1991). Individuals and choruses can be heard calling in storm water runoff retention basins. Larval green treefrogs have been found in ash basins on Site (Rowe et al., 1996).

Barking Treefrog - A locally common species in wetlands on the Site. Individuals are occasionally found on highways during rainy periods in the spring (Gibbons and Semlitsch, 1991). Choruses and breeding occurs during the spring and summer. Calling individuals can be heard in spring on the exteriors of buildings and in landscaped areas adjacent to buildings.

Squirrel Treefrog - This species is found in a variety of habitats on the SRS. Individuals are frequently found on roads at night and during rainy periods (Gibbons and Semlitsch, 1991). Individuals or choruses can be heard calling in spring in ditches along roadside and around parking lots in developed areas on the SRS.

Spring Peeper - Spring peeper is widespread on Site but is most common in temporary ponds during the breeding season. Calling of both individuals or choruses can be heard

from November to March (Gibbons and Semlitsch, 1991). Developed subhabitats used by this species include roadside ditches, storm water runoff basins, and seepage and settling basins.

Eastern Narrow-mouthed Toad - This amphibian is ubiquitous on the SRS. Choruses of this species can be heard on Site from late spring through summer. Individuals are frequently encountered on roads during rainy periods (Gibbons and Semlitsch, 1991). Small choruses of eastern narrow-mouthed toads have been observed in storm water runoff basins on Site. Individuals have also been found inhabiting temporary flooded portions of landscaped areas.

Bullfrog - Although widespread throughout wetlands on the SRS, this species is seldom if ever the most abundant species present at any one location (Gibbons and Semlitsch, 1991). Both individuals and small choruses have been heard in storm water runoff retention basins. This species has also been found in seepage, settling, and ash basins on Site (Ashley et al., 1984; Rowe et al, 1996). Calling by males begins in April and extends through the summer months. Breeding can occur in moderate-sized temporary ponds with as few as ten individuals (Gibbons and Semlitsch, 1991). Although typically not found in or around buildings or structures on Site, one individual was found occupying and calling from the disassembly basin in R Area.

Bronze (Green) Frog - The bronze frog is found in a variety of both temporary and permanent wetlands on the SRS. Calling by males can be heard throughout the summer (Gibbons and Semlitsch, 1991). This species has been observed in storm water runoff basins on Site.

Southern Leopard Frog - This species is present in virtually every aquatic habitat found on the SRS. The leopard frogs have two peaks of reproduction, one in January-March and the second in September-October (Gibbons and Semlitsch, 1991). These frogs use both ditches and the various basins found in developed areas.

Reptiles -

American Alligator - A population of between two and three hundred American alligators inhabits the SRS (Gibbons and Semlitsch, 1991). These animals are typically found in several of the various aquatic habitats located on Site. Most alligators that have been reported as being discovered in developed areas were found inhabiting either storm water runoff retention or settling/seepage basins located in several of the operations areas (e.g., M, D, L and H areas) at SRS. However, adult alligators will disperse over land, and a few incidents of such animals moving through developed areas of the SRS (e.g., in front of 703-46A) have occurred. The most notable such incident occurred on May 15, 1991 when two large male alligators (one 3.4 meters in length, and the other 2.7 meters in length) were discovered trying to simultaneously climb over two different portions of the outer perimeter fence around P Area. Both of these animals were captured and relocated to a nearby wetland area. Typically, alligators are observed only as individuals when found in SRS developed areas.

Common Snapping Turtle - This turtle species may be found in or near almost any aquatic habitat on the SRS. Individuals are frequently encountered on Site moving overland (Gibbons and Semlitsch, 1991). Solitary turtles are typically observed in developed areas during such dispersals between wetland habitats. Age/size categories ranging from juveniles to adults have been discovered during this terrestrial movement. In such instances, these individuals have been seen on and around streets, parking lots, sidewalks, and even within buildings with open access.

Eastern Box Turtle - Although widely distributed across the Site, the box turtle does not appear to be found in large numbers on the SRS. Typically, this species is found only as individuals. These animals have been observed crossing roads during the morning hours, especially on sunny days after a rain (Gibbons and Semlitsch, 1991). Roadkills of this turtle species in developed areas are only infrequently observed. Densities of this species are probably highest in the upland forested habitat around the northern perimeter of the Site, which includes the 3/700 Area.

Yellow-bellied Turtle - This is the most frequently encountered turtle on the SRS and is found in any aquatic habitat on Site that has standing water year-round (Gibbons and Semlitsch, 1991). Within developed areas, yellow-bellied turtles are found primarily in a variety of basins (e.g., SRL basins). Both individuals and groups of this species have been observed in these basin subhabitats (Ashley et al., 1984; Du Pont, 1985).

Green Anole - These lizards are ubiquitous on the SRS and may be active year-round on warm days. This species is found in locally-restricted large populations in the developed areas on Site. One such localized population is found behind the SREL Waterfowl Facility in the upper 3/700 Area (Gibbons and Semlitsch, 1991). This species is commonly attracted to buildings and structures on Site. Individuals are frequently observed sunning on exteriors of buildings or in the immediately adjacent landscaped vegetation.

Eastern Fence Lizard - This lizard is generally restricted to disturbed areas on Site where ground cover is available. Small concentrations of fence lizards may be found at most old home sites, brush piles, and bridges on the SRS (Gibbons and Semlitsch, 1991). A number of fence lizards have been observed in the salvage yard in lower 3/700 Area.

Southeastern Five-lined Skink - This skink is widespread in relatively dry upland habitats having sandy soil. It can also be found in the transition zone between the swamp terrace and upland forest (Gibbons and Semlitsch, 1991). The southeastern five-lined skink is observed in landscaped subhabitats adjacent to and away from buildings and other structures.

Ground Skink - The ground skink occurs in all forested habitats on the SRS. It can also be found in open areas where sufficient ground cover is present (Gibbons and Semlitsch, 1991). This lizard has been found in a variety of landscaped subhabitats and both on the outside and inside of SRS buildings.

Eastern Hognosed Snake - This species is typically found in sandy habitats such as scrub oak/longleaf pine and abandoned open fields on the SRS. Individuals are frequently observed during daylight hours on roads, being most active from April through October (Gibbons and Semlitsch, 1991). Although uncommon by frequency of observation, individuals have been seen in all of the developed areas on Site. This snake is typically reported as present in the landscaped areas around buildings.

Banded Water Snake - The banded water snake is present and often common in almost all permanent or temporary aquatic habitats on SRS (Gibbons and Semlitsch, 1991). This species is commonly observed as individuals in storm water runoff basins and ditches located within most of the developed areas on Site. This snake may also be found in settling and seepage basins. The banded water snake is also the most commonly encountered species of snake found inside of buildings on SRS.

Red-bellied Water Snake - This snake is found in both large and small aquatic habitats on Site. It is also found in upland areas located several hundred meters away from any

permanent water. The red-bellied water snake is not abundant at any one location (Gibbons and Semlitsch, 1991). This species has been found in both storm water runoff retention basins and settling and seepage basins in SRS developed areas.

Scarlet Snake - This species is found throughout the SRS, but is most often found in sandy habitats. The scarlet snake is extremely nocturnal and seasonal (i.e., April through September) in their activity patterns (Gibbons and Semlitsch, 1991). To date, individuals occupying developed habitats of the Site have only been found inside buildings in the reactor and separations areas within the central core area of SRS. Perhaps because of their secretive behavior, this snake is considered to be uncommon in these areas.

Scarlet Kingsnake - Within the undeveloped portions of the SRS, this snake is restricted to sandy areas and open pine habitats (Gibbons and Semlitsch, 1991). Scarlet kingsnakes have been found crossing roads mostly at night. Individual scarlet kingsnakes have been found in the administration/materials area, both separations areas and most of the reactor areas. These animals were reported from both the interior of buildings and in the landscaped areas immediately adjacent to buildings. In one such incident, a juvenile individual was found under a desk in the interior of Building 742-A on August 26, 1996. This animal was captured and released outside.

Rainbow Snake - The rainbow snake is typically found in and around various aquatic habitats on the SRS. Individuals of this species have been observed in the spring and early summer months (Gibbons and Semlitsch, 1991). Most likely to be found in the aquatic subhabitats, this species has only been reported rarely within developed areas of the Site. One individual was discovered in a K-Area building.

Rat Snake - This species has been found in a wide variety of both terrestrial and subaquatic habitats on the SRS (Gibbons and Semlitsch, 1991). Most individuals found in developed areas have been observed during the daylight hours. Typically, this snake is seen in landscaped areas and on or around the exterior of buildings and structures. A few individuals have been found inside of buildings with open access to the outside.

Corn Snake - This snake is found throughout the SRS in dry, terrestrial habitats. Corn snakes are generally associated with woodland habitats, including pine and hardwood forests. This species is active mostly at night from April to September (Gibbons and Semlitsch, 1991). Individuals are typically observed in landscaped areas within developed areas. Others have been found crossing sidewalks and roads and under objects (e.g. construction materials) lying on the ground next to or up against buildings or structures.

Pine Snake - The pine snake is restricted in its distribution on the SRS to sandy habitats. A mostly fossorial species, this snake is encountered during daylight hours between the months of June and October (Gibbons and Semlitsch, 1991). Most sightings of this snake have been in the reactor and separations areas in the central portion of the Site. When observed in developed subhabitats, individuals of this species are typically found in landscaped areas.

Black Racer - Black racers can be found in any terrestrial habitat on the SRS. This species is active throughout the year, but is most frequently encountered between the months of April to November (Gibbons and Semlitsch, 1991). Most black racers are observed in landscaped areas, often when objects (e.g., construction materials) are moved. Several individuals have been found inside office trailers in H Area and buildings in E Area.

Coachwhip - Although preferring sandy habitats, this snake may be found throughout the SRS. Strictly a diurnal species, coachwhips are most active from May through September (Gibbons and Semlitsch, 1991). Individuals of this species are typically found in landscaped areas; however, one was discovered inside Building 703-A.

Ringneck Snake - The ringneck snake on the SRS is found primarily in woodland areas with heavy ground litter; however, this species also inhabits pine-dominated habitats. This snake has been reported to be active year-round (Gibbons and Semlitsch, 1991). In the developed portions of the Site, individual ringneck snakes have been observed in construction laydown yards, salvage storage areas, and landscaped areas adjacent to buildings (e.g., among planted shrubs and bushes).

Brown Snake - This species is found in a variety of terrestrial and aquatic habitats on the SRS where abundant ground cover and litter are available. Although observed throughout the year, these snakes appear to be most active between May and October (Gibbons and Semlitsch, 1991). Both populations and individual brown snakes are frequently encountered in debris-covered areas within developed portions of the Site (Gibbons, 1977). This includes construction laydown yards, salvage storage areas, and among planted shrubs and bushes in landscaped areas adjacent to buildings.

Pygmy Rattlesnake - The pygmy rattlesnake is an uncommon venomous species found mostly in turkey oak/longleaf pine habitats in the northern portion of the SRS. However, this snake is occasionally observed in a variety of other habitats found on Site, including wet areas within wooded habitats or swamps. This species is primarily nocturnally active in late summer and early fall (Gibbons and Semlitsch, 1991). Individual pygmy rattlesnakes have been found in landscaped areas and while crossing sidewalks and roads in B Area, 3/700 Area, P Area, and H Area.

Eastern Cottonmouth or Water Moccasin - The cottonmouth is one of the most frequently observed snakes in aquatic habitats on the SRS. It has been found in association with almost every wet habitat type on Site. Although nocturnally active throughout the year, most individuals of this species are encountered from March until November (Gibbons and Semlitsch, 1991). Typically found in the aquatic subhabitats, cottonmouths have in a few instances been reported in terrestrial subhabitats within the developed areas of the Site. Several have been found inside Site buildings.

Canebrake Rattlesnake - This species is found in a wide variety of terrestrial habitats on the SRS. Primarily active in early evening or at night, it is observed between May and November (Gibbons and Semlitsch, 1991). Individuals have been observed in various subhabitats within the developed portions of SRS. One immature canebrake was found sunning on a sidewalk in TNX. Adult canebrakes have been discovered next to the first-floor breezeway between Buildings 773-41A and 773-42A, and within the reactor vessel containment housing in Building 105-C.

Copperhead - This venomous snake is widespread on the SRS. Most commonly encountered during the months of April through September, the copperhead is found in any of the terrestrial habitats present on Site (Gibbons and Semlitsch, 1991). Individuals have been observed in landscaped areas, and crossing roads and sidewalks in developed areas. Although usually nocturnal, most specimens of this species found in developed areas are discovered during the day.

Birds -

Pied-billed Grebe - The pied-billed grebe is a fairly common species on the SRS (Norris, 1963). In some locations (e.g., Par Pond), this aquatic bird has been reported as an abundant year-round resident (Mayer et al., 1984). Between one and three grebes have been observed loafing in storm water runoff, settling, seepage, ash, and 186 basins. The use of Site settling basins by this species dates back to the late 1950s and early 1960s (Norris, 1963). The observed level of use of Site basins by pied-billed grebes is infrequent.

Double-crested Cormorant - The double-crested cormorant is a winter visitor to the Site and is commonly observed in a variety of open water habitats. Reported to have been found on Site shortly after the acquisition of the Site lands by the Federal government (Norris, 1963), individuals have been reported in all of the open water types of subhabitats within the SRS developed areas. Cormorants have been observed roosting along the edges and foraging for fish within 186/183 basins.

Great Blue Heron - A fairly common wading bird species on the SRS, the great blue heron may be found in any aquatic habitat on Site that is well suited to their methods for seeking prey (Norris, 1963). Previously reported to be most common during warm months, individuals of this species have been observed foraging in the shallow areas of storm water runoff and seepage basins on SRS throughout the year. This heron, an extremely wary solitary predator, appears to avoid SRS basins with ongoing human activity more so than any other wading birds found on Site.

Green Heron - Although listed as uncommon on Site, this SRS summer resident is found in a variety of aquatic habitats (Norris, 1963; Wike et al., 1994). Individuals have been observed foraging in storm water runoff basins and along roadside ditches.

Great Egret - The great egret is the most visible and common species of wading bird observed foraging on the SRS in warmer months (Norris, 1963). Although reported as being present in foraging congregations as large as 14 in undeveloped wetlands on Site (Norris, 1963), only individuals or pairs of this species have typically been observed in the edges of SRS storm water runoff and seepage basins. Great egrets have also occasionally been observed foraging in stormwater drainage ditches along roads in developed portions of the Site.

Tricolor Heron - This wading bird species is generally not commonly observed either on or in the area surrounding the SRS. Documented in undeveloped aquatic habitats on Site (Bryan et al, 1996), tricolor herons are typically not encountered in the developed areas on Site; although, a few individuals have been observed foraging in storm water runoff basins.

Yellow-Crowned Night Heron - Reported for some types of SRS wetland habitats (e.g., Carolina bays), yellow-crowned night herons do not appear to be common on Site. Being largely nocturnal, this summer visitor may actually be more common than is currently perceived. A number of individuals have been found dead in T Area after apparently striking overhead powerlines during the night. This species may also be nocturnally using aquatic subhabitats (e.g., storm water runoff basins) in that Site area.

Canada Goose - This large migratory waterfowl species is an infrequent but persistent winter visitor to the SRS (Norris, 1963; Mayer et al., 1984; Mayer et al., 1986b; Wike et al., 1994). With the establishment of a resident, non-migratory population of giant Canada geese (*Branta canadensis maxima*) on the Richard B. Russell Reservoir north of SRS on

the Savannah River, it is now possible to see both individuals and small groups of this species throughout the year on Site. This species uncommonly uses both terrestrial and aquatic subhabitats in the developed portions of the Site. In 1956, one individual was observed loafing in a settling basin on Site (Norris, 1963). A few instances have been noted of small flocks of this species foraging on extensive areas of maintained lawns on the SRS (e.g., in front of 703-46A near SRS Road 1). In May and June of 1996, two adults with a brood of goslings were observed a number of times walking in and around 3/700 Area from next to Building 737-A/SREL down to the gasoline station (Building 715-A).

Snow/Blue Goose - Although only a rare transient visitor to the area, both color phases (i.e., blue goose and snow goose) have been sighted on the SRS (Norris, 1963; Mayer et al., 1986b). This species appears regularly within the Atlantic Flyway, although in low numbers (Bellrose, 1976). A few individuals of this species have been observed loafing in settling and seepage basins (Mayer et al., 1986b).

Mallard - Locally common in a wide variety of wetland and open water habitats on the SRS during the winter (Norris, 1963; Mayer et al., 1986b). This species is more abundant in smaller emergent wetlands (e.g., Carolina bays) and forested riverswamp than in the larger open water cooling reservoirs on Site. Individual and flocks of up to 42 mallards have been observed loafing in settling and seepage basins (Mayer et al., 1986b), and loafing and foraging in storm water runoff and ash basins. Although persistent in occurrence, this use of SRS urban subhabitats by this species is uncommon in frequency.

Pintail - Pintails are infrequent winter visitors to the Site, and have been reported in several types of aquatic habitats (Norris, 1963; Mayer et al., 1986b). Only a few individuals of this species of dabbling duck have been observed either loafing in settling and seepage basins (Mayer et al., 1986b), or foraging in ash basins on the SRS.

Green-winged Teal - This small dabbling duck species has been reported as commonly occurring in both Par Pond and Steel Creek Delta (Norris, 1963; Mayer et al., 1986b). Typically observed as either individuals and pairs, this winter visitor have also been observed on a few occasions loafing in settling, seepage, and ash basins on Site (Mayer et al., 1986b).

Blue-winged Teal - The blue-winged teal is a winter visitor that is commonly observed in a variety of aquatic habitats on SRS (Norris, 1963; Mayer et al., 1986b; Wike et al., 1994). This species has been reported as loafing in settling and seepage basins (Norris, 1963; Mayer et al., 1986b). These sightings have included both individual birds and small groups of this teal species.

American Wigeon - This species has been reported as uncommon but persistent in its occurrence on the SRS (Norris, 1963; Mayer et al., 1986b; Wike et al., 1994). Although more common in shallow wetlands, this duck has been reported in association with a variety of aquatic habitats on Site (Norris, 1963; Mayer et al., 1986b). A few small flocks of up to 15 wigeon have been observed loafing in settling, seepage, and ash basins (Mayer et al., 1986b).

Gadwall - The gadwall is a common winter visitor to the Site. This species has been reported in a number of aquatic habitats and locations on the SRS (Norris, 1963; Mayer et al., 1986b). Between one and three gadwalls have been observed on a few occasions loafing in settling, seepage, and ash basins on Site (Mayer et al., 1986b).

Northern Shoveler - A widespread but infrequent winter visitor to the Site, the northern shoveler has been reported in a number of aquatic habitats and locations on the SRS

(Norris, 1963; Mayer et al., 1986b). A few individual shovelers have been observed loafing in settling, seepage, stormwater runoff, and ash basins (Mayer et al., 1986b).

Wood Duck - The wood duck is the most abundant resident waterfowl species present on the SRS (Norris, 1963; Mayer et al., 1986b; Wike et al., 1994). It is also the only waterfowl species to breed in substantial numbers on Site (Mayer et al., 1986b). It has been observed in almost any type of aquatic habitat found on Site (Norris, 1963; Mayer et al., 1986b; Wike et al., 1994). To date, only foraging and loafing activities by this species have been observed within developed areas on Site. One storm water runoff basin (i.e., in N Area next to SRS Road 5) was observed as being used by a single hen as brood rearing habitat in 1994. Individual and flocks of up to 14 wood ducks have been found loafing in settling and seepage basins (e.g., SRL basins next to SRS Road A-1), storm water runoff basins and ditches, ash basins, and in 186 basins. Wood ducks are occasionally killed after striking overhead powerlines in developed Site areas.

Redhead - This species is a very uncommon winter visitor to the SRS. Most observations have taken place on Par Pond. A few individual redheads have been observed loafing in settling and seepage basins (Mayer et al., 1986b).

Ring-necked Duck - The ring-necked duck is the second-most abundant species of waterfowl found in the open water habitats (e.g., Par Pond, Pond B, Pond C and L-Lake) on Site. This species is also an infrequent visitor to some of the larger waterfowl roosts and foraging areas in the Savannah River swamp (Mayer et al., 1986b). Solitaries and small groups of up to four individuals of this diving duck species have been observed loafing in 186/183, settling, seepage, and ash basins (Norris, 1963; Mayer et al., 1986b).

Lesser Scaup - This duck is the most abundant waterfowl species observed in open water habitats on the SRS. Aerial surveys over Par Pond have resulted in total daily counts of this species approaching 3,000 individuals (Mayer et al., 1984; Mayer et al., 1986b). As with the ring-necked duck, some use of other aquatic habitats by this species also occurs on SRS (Mayer et al., 1986b). Individual and flocks of up to 30 lesser scaup have been observed loafing in settling and seepage basins. Based on a sample of 34 observations, an average flock size of seven lesser scaup have been documented as using the 400-D Area ash basin. A few individuals have been found dead after apparently striking powerlines in T Area.

Bufflehead - Early reports of this species describe its presence on the SRS as scarce (Norris, 1963). Having similar habitat preferences as the two previous species, buffleheads are now one of the four most common waterfowl species found in open water habitats on Site. This species also uses other wetland habitats on the SRS to a lesser degree (Mayer et al., 1986b). Individual and flocks of up to 23 buffleheads have been commonly observed loafing in settling, seepage, 186/183, and ash basins on Site. Based on 74 observations of buffleheads using the P-Area ash basin, the 400-D Area ash basin, and the F/H Area seepage basins prior to closure, the average flock size was 4.1 birds.

Ruddy Duck - Formerly uncommon (Norris, 1963), the ruddy duck is now one of the four most abundant diving duck species on Site (Mayer et al., 1986b). Found primarily in open water habitats, this species is also present in most types of wetlands available on the SRS. A few individual ruddy ducks have been observed loafing in settling, seepage, 186/183, and ash basins (Mayer et al., 1986b). Several individuals have been discovered after apparently fatally striking powerlines in T Area.

Hooded Merganser - Next to the wood duck, the hooded merganser is the only other waterfowl species known to consistently nest on the SRS (Fendley, 1978; Mayer et al.,

1986b). However, by comparison, the local reproductive effort by this merganser species is limited at best (Fendley, 1978). This species is found in a wide variety of habitats on Site (Norris, 1963; Mayer et al., 1986b). Individuals and flocks of up to 30 hooded mergansers have been observed loafing in settling, seepage, and ash basins (Mayer et al., 1986b). Based on 17 observations, the average flock size of hooded mergansers in Site ash basins was 8.5 birds.

Red-breasted Merganser - The red-breasted merganser has only been reported from a limited number of observations on the SRS. Most of these have been on Par Pond. A few individual birds have been observed loafing in settling, seepage, and ash basins on Site (Mayer et al., 1986b).

Turkey Vulture - This species is common locally and across the Site. A permanent resident, the turkey vulture has been documented to nest on the SRS (Norris, 1963). Typically, either individuals or pairs of turkey vultures are observed foraging across the Site. They are most commonly seen soaring above SRS developed areas, and occasionally feeding on roadkills. Infrequently, these birds will roost on buildings and other structures (e.g., radio towers).

Black Vulture - The black vulture is very common on Site. Norris (1963) estimated that this species was four to five times more numerous than the turkey vulture. More tolerant of human activity than the turkey vulture, the black vulture has been reported using developed Site areas in a number of ways. The black vultures forage across Site, including in all of the developed areas. This species has been observed feeding on road-killed mammals in developed areas on a fairly regular basis. This species may be observed as individuals, but they are more commonly found in flocks of two or more birds. These birds perch on buildings, radio and water towers, and telecommunications, light or power poles. One nested on a tower in 400-Area. In both developed and undeveloped areas on Site, black vultures roost in substantial numbers. A major black vulture roost existed for many years on the top of the 105-R building and the superstructure of the 183/186 basins in R Area. With the increased activity in R Area associated with the cleanup and decontamination and decommissioning of that facility, the numbers observed using this roost have decreased.

Mississippi Kite - This raptor is observed on a persistent but not frequent basis in the Site along the Savannah River (Norris, 1963). Mostly observed from late spring through early fall, the Mississippi kite is typically observed as individuals and small groups soaring in the sky above D and T Areas. Some individuals have been observed perching in trees in T Area. On one occasion, three individuals were observed soaring together over 400-D Area. Specific use of the subhabitats in developed areas on Site by this species is probably minimal.

Cooper's Hawk - This hawk is a uncommon permanent resident on Site (Norris, 1963). Individual Cooper's hawks have been seen foraging in landscaped portions along roadways within the Site's developed areas. Although common in the area, this species is only rarely observed in Site developed subhabitats.

Red-tailed Hawk - The red-tailed hawk is a common permanent resident on the SRS and is found in a variety of habitats on Site (Norris, 1963). A conspicuous large raptor, this species is frequently seen soaring/foraging in the more open portions of developed areas on Site. Red-tailed hawks are also commonly seen perching on power/telecommunication poles and trees overlooking these open areas. A few hawks have been seen actively feeding on roadkills in developed areas. These birds are occasionally found injured or as roadkills in parking lots after being struck during foraging activities. Individuals and pairs of red-tailed hawks have been observed being mobbed by crows and

various passerine species (e.g., northern mockingbirds) in landscaped areas and on the tops of buildings in developed areas. Although known to nest on Site (Norris, 1963), no red-tailed hawks nests have been reported to date in any of the developed SRS subhabitats.

Red-shouldered Hawk - This species is reportedly common on the SRS adjacent to the Savannah River (Norris, 1963). Consistent with this finding, although observed in several of the Site's developed areas, the red-shouldered hawk is most frequently observed in D and T Areas. Both individuals and pairs of birds have been seen soaring above or perching in these Site locations.

Bald Eagle - This federally-listed threatened raptor has been observed in increasing numbers on the SRS since 1959 with the filling of Par Pond (Mayer et al, 1985, 1986a). Three bald eagle nests, all located in remote areas of the Site, were discovered in 1986, 1990, and 1996, respectively (Mayer et al., 1988; Wike et al., 1994; Hart et al., 1996). Typically observed in areas of minimal human activity, only three reported bald eagle sightings have taken place in developed areas on the SRS. One was observed soaring at a low elevation and then flying over H Area. The second was observed flying low over a roadway adjacent to the upper 3/700 Area. The third was an adult repeatedly circling over P Area on a June day in 1996. Although it is possible that some foraging by this species (e.g., feeding on roadkills) may occur in SRS developed areas, given this bird's shy nature, instances of such activity would be rare at best.

Northern Harrier - The northern harrier is a common winter visitor to the SRS (Norris, 1963). Typically observed between October and May, individual northern harriers can occasionally be seen foraging over and in the more open landscaped areas situated away from buildings and other structures. On two occasions, solitary harriers were seen flying only a few meters above the pavement over parking lots in A Area. Areas in and around the H Separations Area, DWPF (S Area), Saltstone Facility (Z Area), Reactor Areas (e.g., R, P and C Areas), and Solid Waste Disposal Facility (E Area) provide such habitat for this species. This raptor has also been observed perching or roosting in trees at the edges of open subhabitat type in these areas.

American Kestrel - This species is an uncommon permanent resident on Site (Norris, 1963). Individual American kestrels forage in the open landscaped portions of the developed areas on the SRS. This small falcon is observed roosting or perching both on overhead wires and the tops of fences. It is most often seen perching on transmission wires within the powerline rights-of-way around the various reactor areas on Site. These birds have also been known to nest on tall SRS buildings and structures in the spring. Examples of this activity include the 105 buildings in both C and L Areas, and a dismantled tower in the 400-D Area. Fledgling kestrels have been found in D Area, K Area, and N Area (Allen, 1996).

Northern Bobwhite - The bobwhite is a common permanent resident on the SRS in areas of suitable habitat. Densities of this species in undeveloped portions of the Site during the mid 1950s were estimated to be 12 to 19 birds per 100 acres (Norris, 1963). This game species is infrequently observed in the fringes of the landscaped portions of the developed areas away from both buildings and human activity. A couple of small coveys (i.e., less than six birds in each covey) have been observed in the maintained lawns surrounding the radio antennas in the northwest corner of the upper part of 700-A Area. This species is also seen along roadsides near the boundaries of SRS developed areas.

Eastern Wild Turkey - Present in the local area when the Site was established (Norris, 1963), the SRS population of this large game bird species has increased substantially during the late 1980s and early 1990s. As a result of this increase, both flocks and

individual birds have been observed during daylight hours foraging in landscaped areas and along shoulders of roads near edges of developed portions of the Site. One flock of wild turkeys was seen on a regular basis during 1993 foraging on a grass-covered open area immediately in front of Building 705-3C. This flock became very habituated to the presence of people, and even began accepting handouts of food. Also during the 1990s, the incidence of vehicle collisions involving wild turkeys dramatically increased in and around SRS developed areas.

American Coot - The American coot is a very abundant species on the ponds and cooling reservoirs on Site (Norris, 1963; Mayer et al., 1984, 1986). Typically a winter resident, this bird is present year-round on Par Pond (Mayer et al., 1984). It has also been observed in the large waterfowl roosting area in the Steel Creek delta area (Mayer et al., 1986b). Commonly found on the SRS between October and May, individuals and small groups of this species have been observed loafing in 183/186 basins, storm water runoff basins; and settling and seepage basins (e.g., SRL basins).

Killdeer - Reported as uncommon on SRS during the late 1950s and early 1960s (Norris, 1963), the killdeer is still relatively uncommon in undeveloped areas of the Site. In contrast to this general pattern, however, this species have become common in SRS developed subhabitats. Individuals or pairs of this species are typically observed during the day foraging on lawns, landscaped areas, and around parking lots and roads. Vocalizations of individuals flushed into the air from these subhabitats are frequently heard in the spring and summer months. Killdeer nests have been found around the edges of gravel parking lots in Site areas. Nesting in these developed subhabitats was reported as early as the late 1950s (Norris, 1963). At least limited nesting attempts by this species have also been anecdotally reported on flat graveled building roofs on Site.

Least Sandpiper - Least sandpipers were first reported on the SRS in 1960 (Norris, 1963). This species is present on the Site as a transient visitor during migration. Individual least sandpipers have been seen around the edges of Site storm water runoff retention basins.

Ring-billed Gull - This sea gull is an uncommon winter visitor to the SRS (Norris, 1963). Typically seen at large and small open water Site impoundments and along the Savannah River, this species is also rarely observed in the more open developed subhabitats. Ring-billed gulls have been seen both perching on light poles and foraging around vehicles in large Site parking lots.

Rock Dove or Common Pigeon - This non-native species is an abundant year-round resident in all SRS developed areas. In contrast to the present situation, Norris (1963) did not even identify this species as being present in the local area during the late 1950s and early 1960s. It currently commonly forages around parking lots, roadsides, and landscaped subhabitats within the Site's developed areas. Pigeons have been observed both as individuals and flocks of up to 25 to 40 birds. This bird roosts and nests in large, open bays and loading dock areas of SRS warehouses. Examples of ongoing roosting/nesting areas on Site include 105-K building, DWPF, 105-C building, the open bay of F wing of Building 773-A, the roof of Building 730-4B, and the D-Area powerhouse. Problems often result in the removal or reduction of specific flocks. Typically such actions do not have a long lasting impact; the species recolonizes the location and the numbers build back up over time. An ongoing example of this has been the use of the open bay of F wing in Building 773-A. Occasionally, an individual will find its way into the interior of a building. One pigeon twice entered the Separations Engineering Developments facility within the F wing of Building 773-A. There are both sanitation and health concerns with the presence of large, long-term roosting/nesting

colonies of this species. Pigeons are occasionally seen perching on overhead power or telecommunications wires and poles, and light poles in SRS developed areas. Small flocks have also been observed around the edges of storm water runoff retention basins.

Mourning Dove - This game species is common on the SRS and present year-round (Norris, 1963). Both resident and migratory birds from the north use the Site. The mourning dove has been observed in the developed portions of the SRS both as individuals and small flocks of up to a dozen birds. These birds forage along shoulders of Site roads and parking lots, and in the landscaped and lawns in developed areas. Mourning doves are also seen watering at the edges of storm water runoff basins. Individuals or small flocks of these birds have been observed roosting or perching in tall pines and on overhead power or telecommunications wires and poles, the tops of wire fencing, and light poles in developed subhabitats. Although known to nest in the local vicinity, no mourning dove nests have been documented in SRS developed areas to date.

White-winged Dove - The only observation of this western species on Site was in a developed area in the Spring of 1994. This individual was observed at a feeder adjacent to SREL. This is the first and only known record for this species in South Carolina (Buhlmann et al., 1995).

Barn Owl - A permanent resident of the lands encompassing the SRS (Norris, 1963), vocalizations of the barn owl have been heard at the forested edges of open landscaped areas on Site. This species is uncommon in SRS developed areas. Individual barn owls are infrequently found injured or as roadkills in parking lots after being struck during night foraging flights. No roosting or nesting in Site buildings or structures by this species has been reported to date.

Screech Owl - The screech owl is a permanent resident of the SRS (Norris, 1963). This species has been documented as nesting in wood duck boxes on Site. Not typically observed in the SRS developed areas, the occurrence of this owl is similar to the circumstances stated for the barn owl. Vocalizations of individual screech owls are occasionally heard in landscaped portions of the Site with standing timber. No nesting by this species in developed areas on Site has been noted to date.

Barred Owl - This species of owl is reportedly fairly common in bottomland forested habitats on Site (Norris, 1963). This owl is also the most frequently seen or heard owl in SRS developed areas. The barred owl is also the most common road-killed owl species resulting from foraging over Site roads and parking lots in developed areas. Individual barred owls are occasionally seen making foraging flights around dusk over the more open landscaped portions of the developed areas on Site.

Common Nighthawk - The common nighthawk is a frequently observed summer resident on Site (Norris, 1963). Typically present between April and September, individuals or groups of up to ten individuals of this species are normally observed making foraging flights at dusk in open portions of developed areas on the SRS. The presence of this species in developed areas on Site dates back to 1957 (Norris, 1963). One anecdotal report noted the presence of a common nighthawk nest being found on a flat building roof top in upper 700-A Area.

Chimney Swift - This species is a fairly common summer resident of the Site (Norris, 1963). Noted earlier to roost and nest in the chimneys of the abandoned buildings on Site, the chimney swift currently utilizes SRS industrial stacks for this purpose. Large numbers (i.e., 50-100 birds) used to be seen leaving the 232-F stack (i.e., prior to its demolition) at dawn to begin their daily foraging flights. Other structures on SRS (e.g., air strippers)

have also been observed to receive some use as roosting/nesting sites by this species. Dead trees or snags in landscaped areas with standing timber may also be used by chimney swifts.

Ruby-throated Hummingbird - These small birds are a fairly abundant summer resident on Site between April and September. Commonly found in broadleaf forested habitat with suitable flowers for foraging purposes (Norris, 1963), the ruby-throated hummingbird is also occasionally observed foraging around flowers or artificial feeders in the developed areas of the Site. One such feeder, where this species was frequently seen, was located in the upper 700-A Area.

Belted Kingfisher - This permanent resident is found at open bodies of water and along streams on Site (Norris, 1963). Uncommon in developed areas on the SRS, a few individual belted kingfishers have been observed foraging in storm water runoff retention basins.

Common Flicker - The flicker is a common permanent resident in forested habitats on Site (Norris, 1963). In contrast to this, individuals and pairs of this species are only infrequently observed foraging on lawns or on trees in landscaped areas. Typically, these subhabitats are near substantial forested areas (e.g., Parrott Park in upper 3/700 Area).

Pileated Woodpecker - This woodpecker is a common permanent resident on the SRS (Norris, 1963). Typically an inhabitant of mature forested habitats, the pileated woodpeckers has been observed foraging on trees in landscaped areas around the margins of Site's developed areas. One adult was seen foraging around vehicles in a parking lot in the upper 3/700 Area.

Red-bellied Woodpecker - The red-bellied woodpecker is an abundant permanent resident of the Site, and is found in variety of terrestrial habitats (Norris, 1963). It is often observed foraging in stands of trees and on telephone poles within the developed areas on the SRS.

Eastern Kingbird - This species is common in relatively open areas on Site (Norris, 1963). An SRS summer resident, the eastern kingbird is normally seen between March and October (Norris, 1963). Individuals and pairs are observed perching on overhead power and telephone wires and poles, the tops of metal traffic signs, along the tops of fences, and on the edges of buildings roofs. This species has also been noted foraging in the shrubs and bushes immediately adjacent to building and structures, and on lawns in open areas. Some nesting and brood rearing by this species takes place in shrubs, bushes, and mature trees in landscaped areas between the months of April and September. Individual or pairs of eastern kingbirds have been observed mobbing crows in the areas around buildings on Site.

Great Crested Flycatcher - The great crested flycatcher is an abundant summer resident of open deciduous and mixed pine-hardwood forested uplands on Site (Norris, 1963). Usually present on Site between April and September, this species uses developed areas for foraging and nesting. Foraging takes place on landscaped areas and around road sides and at the edges of parking lots. Nesting has been documented in bluebird nest boxes erected in the Site's developed areas. Individuals or pairs of this species have been observed perching on overhead power and telephone wires and poles, and on the tops of security fences.

Horned Lark - The horned lark is an uncommon winter visitor to the Site. Present in the local area between November and February, it has been observed foraging on lawns in developed areas on Site (Norris, 1963).

Barn Swallow - Reported earlier as only a transient visitor (Norris, 1963), the barn swallow is currently a common summer resident. This species is present in several of the Site's developed areas between April and September. Barn swallows are frequently seen as either individuals or small flocks foraging in the air above parking lots, landscaped areas, and basins. This species also nest under awnings or overhangs of Site buildings. A notable example of this activity is the awning over the front of the 708-A cafeteria building. Barn swallows nest in SRS developed areas from late April until early June.

Tree Swallow - The tree swallow are uncommon transient visitors at the SRS (Norris, 1963). Between one and three individuals of this species have been seen foraging above open landscaped areas and parking lots at SRS. Observations of this swallow species in Site developed subhabitats are made primarily during the spring months.

Northern Rough-winged Swallow - This species of swallow is a common summer resident on Site (Norris, 1963). Individual and paired rough-winged swallows have been observed foraging above various subhabitats in the developed areas on the SRS. Such observations were made on a frequent basis in spring and early summer. Northern rough-winged swallows nest in Site developed areas from March through June. These nests are built within drain pipes and air ducts/louvers located on the sides of buildings.

Purple Martin - The purple martin is a common summer resident of the SRS. It's presence in association with buildings on Site was reported as early as the late 1950s (Norris, 1963). This species is occasionally observed perching on overhead power and telephone wires. Purple martins have also been observed perching or diurnally roosting on the support wires and structural cross pieces of the radio antennas in the northwest corner of the upper part of 700-A Area. Nesting by this species has been documented in developed areas when either martin houses or gourd trees have been provided (Norris, 1963). One such martin gourd tree has been maintained behind the SREL facility in upper 700-A Area since the early 1980s. Within two years of being erected, this gourd tree has had successive use by this species every year since.

Blue Jay - Blue jays are very common permanent residents, found in a variety of wooded habitats on Site (Norris, 1963). Being opportunistic predators, both individuals or small groups of this species are regularly observed foraging in landscaped areas and lawns in developed areas of the SRS. These birds are also infrequently seen perching on overhead power and telecommunications wires, and along the tops of fences in these areas. Individual or pairs of blue jays have been seen mobbing larger birds (e.g., red-tailed hawks or common crows) either flying over or perching on structures, buildings, or trees in developed areas.

Common Crow - This species is an abundant permanent resident found in a variety of habitats on the SRS (Norris, 1963). These birds are frequently observed in several of the subhabitats within the Site's developed areas. Vocalizations of this species are commonly heard in developed areas. Both individuals and flocks of common crows are often observed perching on or calling from poles, buildings, and towers. Crows are observed infrequently perching on overhead power and telecommunications wires. Previously documented as breeding locally (Norris, 1963), one common crow nest was found on the top of a storage tank in S Area. As scavengers, crows are often seen feeding on roadkills in the developed areas of the Site. This behavior has resulted in at least a few crows being hit and killed by passing vehicles. Common crows regularly exhibit mobbing behavior on

raptors discovered in the developed areas. In turn, common crows are likewise observed as being mobbed by smaller birds (e.g., northern mockingbirds) in these same areas. Crows have been observed foraging in and around open dumpsters or garbage cans adjacent to Site buildings, on lawns in landscaped areas, and along roadsides and in parking lots, including on, around, and under parked vehicles.

Fish Crow - Fish crows are common summer residents on Site. These birds are among the first "spring arrivals", with records as early as January (Norris, 1963). Smaller relatives of the common crow, this species is typically identified by its characteristic call. The use of SRS developed areas by these birds is essentially the same as that described for the common crow. Both individuals and flocks of as many as 46 fish crows have been observed in SRS urban subhabitats.

Tufted Titmouse - The tufted titmouse is a common SRS permanent resident (Norris, 1963). This species occupies a variety of both upland and bottomland habitats throughout the Site. In spite of this general abundance, the tufted titmouse is only infrequently seen in SRS developed subhabitats. All of those observations were made in landscaped areas located away from buildings and other structures.

Brown-headed Nuthatch - This species of nuthatch is a common permanent resident on the SRS (Norris, 1963). Individuals and pairs of this species have been observed in developed subhabitats on Site on only a few occasions. In one instance, a pair of brown-headed nuthatches was seen successively foraging down the exteriors of several telephone poles.

House Wren - The house wren is an uncommon winter visitor found on SRS. This species was documented in earlier reports as occasionally using developed areas on Site (Norris, 1963). The house wren has been observed foraging in and around shrubs and bushes in landscaped portions of SRS urban subhabitats.

Bewick's Wren - This wren was an uncommon winter visitor to the Site (Norris, 1963). Populations of this species appear to be decreasing in areas east of the Appalachians (Robbins et al., 1983). Reports exist from the 1950s and 1960s for this species being observed foraging in landscaped areas around buildings on Site (Norris, 1963). There have been no recent reports of this species occurring in SRS developed areas.

Carolina Wren - Carolina wrens are common permanent residents in this area. This wren is found around shrubs and bushes in landscaped areas. Carolina wren nests have been found in a number of the old buildings on Site (Norris, 1963).

Northern Mockingbird - Mockingbirds are abundant permanent residents on the SRS. Even earlier reports have this species present in developed areas on Site (Norris, 1963). These birds are widespread and found in all of the developed areas included in the present study. Mockingbirds are usually observed as individuals, pairs, or groups of up to four birds. This species forages in landscaped areas and lawns, in shrubs and bushes immediately adjacent to building and structures, around equipment on building roofs, and around roads and parking lots. These birds nest in shrubs, bushes, and trees in landscaped areas from March through October. Nest sites include vegetation both adjacent to and far removed from buildings or other structures. Caring for nestlings and rearing of fledglings by parents also takes place within the landscaped subhabitats. Mockingbird parents are seen attending to and feeding fledglings from May into November. Territorial males are seen calling from a number of structures (e.g., lamp poles, trees, building corners, roofs of parked vehicles) all year. Mockingbirds are frequently observed roosting or perching on overhead wires, poles, buildings, and towers. From one to three mockingbirds have been

observed mobbing larger birds (e.g., common crows) in various subhabitats within the Site's developed areas. Individual mockingbirds are also frequently observed guarding certain species of ornamental fruiting trees against use by other birds. Common examples of this are the four fire-thorn trees (*Cotoneaster pyracantha*) adjacent to the driveway in front of Building 703-46A. Individuals mockingbirds guarding those trees have been observed fending off the foraging attempts of entire flocks of 25-50 cedar waxwings. Mockingbird parents caring for recently-fledged nestlings have also been known to mob and attack human pedestrians inadvertently passing too close to the flightless immature birds (e.g., between Buildings 703-A and 703-46A).

Gray Catbird - This species is locally common during the spring migration, but is scarce in the winter on the SRS (Norris, 1963). Typically observed in forested areas with dense understory vegetation, catbirds are found in association with a variety of habitats on Site. Within developed areas, catbirds are observed in landscaped areas located both adjacent to and away from buildings and structures. This uncommon urban species is usually found foraging among or perching in landscaped shrubs and bushes.

Brown Thrasher - The brown thrasher is a common permanent resident on Site, with a documented presence around developed areas dating back to the late 1950s (Norris, 1963). In the fall, the local populace of this species is increased by migrants. Individual brown thrashers have been observed foraging in landscaped areas adjacent to and away from Site buildings and structures. This species also nests in bushes and shrubs located in landscaped areas adjacent to and away from buildings in SRS developed areas.

American Robin - The robin is an abundant permanent resident of the Site, with observations of this species being made during every month of the year. This species can be found in a variety of habitats (Norris, 1963). Typically observed as either individuals or pairs, robins have been seen on Site in flocks of up to approximately fifty individuals during the peak of migration. This species is most often seen foraging on lawns in the landscaped portions of the developed areas. These birds regularly nest in shrubs and bushes adjacent to buildings and in trees located in landscaped areas during April through August. One pair nested consecutively for several years on an awning over a doorway going into Building 703-A. Occasionally this species has been found nesting inside large open bays or other areas of Site buildings, and on the support structures under exterior staircases. Young robins are fledged in these developed subhabitats from May through September. Robins are frequently observed perching on telephone wires, fences, and buildings within SRS developed areas.

Eastern Bluebird - These birds are abundant permanent residents of the area encompassing the SRS (Norris, 1963). Eastern bluebirds are typically observed as either individuals or pairs of birds. This species is commonly seen foraging in the landscaped areas and around parking lots in developed areas. Nesting by the eastern bluebird on the SRS was documented as early as 1956 (Norris, 1963). A number of nest boxes have been provided on wooden telephone poles in developed areas. These birds use these boxes on a regular basis for nesting in the spring and summer. Parents rear their fledglings around the landscaped areas and buildings. Eastern bluebirds are often seen perching on overhead wires, fences, trees, and buildings in the Site's developed areas.

Cedar Waxwing - The cedar waxwing is a frequent but irregularly observed winter visitor to the Site. Arriving as early as October and remaining as late as May (Norris, 1963), most cedar waxwings are seen on Site between December and March. Both individuals and flocks of up to 60 or more birds have been seen foraging in the Site's developed areas. This foraging typically takes place in the shrubs, bushes, and small trees in the landscaped portions of the developed areas.

Loggerhead Shrike - The loggerhead shrike was reported to have been common in relatively open habitats on Site during the late 1950s and early 1960s (Norris, 1963). More recently, because of the present forested condition of most of the SRS, this species is not as common across the entire Site as was previously reported. In contrast to this general pattern, this predatory species may be observed on a regular basis in several of the more open developed areas on Site. The loggerhead shrike is usually observed as individuals, and infrequently in pairs and threes, perching on the tops of chain-link fences (i.e., the barbed wire strands), metal traffic signs, and overhead wires. Some individuals have been seen perched on the top of poles and in trees. Foraging by loggerhead shrikes takes place in the open landscaped areas. Most recent sightings have been in A, B and E Areas in developed areas with extensive or open lawns. Consistent with this bird's documented behavior elsewhere, shrikes have been repeatedly seen to store insects (e.g., coleopterans) and small vertebrates (e.g. eastern bluebirds) on barbs of barbed wire strands along fence tops (e.g., in the upper 700-A Area). One pair of loggerhead shrikes was reported to have nested in a chinaberry (*Melis azedarach*) and trumpet vine (*Campsis radicans*) thicket in B Area (Komoroski, 1995).

European Starling - This introduced species is an abundant permanent resident of the Site (Norris, 1963). Starlings have been observed both as individuals and flocks in a variety of subhabitats within Site developed areas. These birds are frequently seen foraging in landscaped areas/lawns both adjacent to and away from buildings and structures. This species was documented as nesting on Site structures as early as the 1950s (Norris, 1963). Locations of these nests are in crevices of building exteriors, on top of awning/roofing support beams, and ledges/eaves on the upper portion of the exterior of Site buildings. Solitary nests have also been observed in cavities (behind metal plates) in power poles. Occasionally, starlings will either roost or nest inside buildings with large open access (e.g. large warehouse bay doors; F Wing of Building 773-A). Infrequently, these birds may enter and become trapped inside Site buildings. One such individual even made it's way down into and ultimately died in the low level counting facility in Building 735-A. Flocks of these birds are regularly observed perching or roosting on overhead power or telecommunications wires and poles, and support wires and structural crosspieces of large radio towers.

White-eyed Vireo - The white-eyed vireo is a common summer resident of the SRS in deciduous forested habitat, especially in areas of scrubby growth along stream corridors. Locally present year-round, this species is typically seen on Site between February and October (Norris, 1963). Individuals and pairs of this species have been observed foraging in landscaped areas of the Site, primarily in and around shrubs and bushes located away from buildings and structures. These birds have been documented to nest on Site (Norris, 1963). The white-eyed vireo also has been observed in trees during nesting season in the landscaped areas of the upper 3/700 Area.

Common Yellowthroat - This warbler species is a permanent resident on Site. The common yellowthroat is common in a variety of habitats associated with ecotones (Norris, 1963). Within SRS developed areas, this species has only been observed in landscaped areas with an overstory tree canopy (e.g., Parrott Park in upper 3/700 Area).

House Sparrow - This introduced species has been documented as being a common permanent resident of the SRS since the mid 1950s. The reported presence of house sparrows in the Site's developed areas also dates back to this same time (Norris, 1963). This species is frequently observed as either individuals or flocks foraging in the landscaped portions and along roadsides, parking lots, and under and around parked vehicles. House sparrows have been observed perched on overhead power and

telecommunication wires. These birds are also commonly seen foraging at feeders maintained by Site personnel (e.g., outside of SREL and Building 735-A. House sparrow flocks as large as 50-60 have been observed in these locations. This species is also sometimes seen in mixed flocks with chipping sparrows. House sparrows breed and nest in SRS developed areas between the months of March and October. These birds nest in vegetation in landscaped areas and lawns adjacent to buildings and on building exteriors (e.g. Building 703-A). Occupied house sparrow nests have been observed on window ledges, around light fixtures, on or under window-mounted air conditioning units, in or under exterior heating, ventilation and air conditioning units located on building roof tops, inside air ducts opening to building exteriors, on top of horizontal portions of gutter down spouts, under roofs of shuttle stops/shelters in parking lots. This species is sometimes found nesting upon rafters and internal structural supports within Site buildings having large open access (e.g., warehouses in N Area). On occasion, individual house sparrows will gain entry and become trapped within buildings with limited access. A dead house sparrow was discovered in the Separations Engineering Developments facility within the F-Wing of Building 773-A.

Eastern Meadowlark - This species is an uncommon permanent resident of the Site in open areas. The Site populations of this species also includes migrants from the north during the non-breeding season (Norris, 1963). Individuals or small groups of eastern meadowlarks have been observed foraging in the more open landscaped portions of the Site's developed areas. No eastern meadowlark nests have been discovered to date in developed subhabitats on Site, although this species is known to nest in the local area (Norris, 1963).

Red-winged Blackbird - Red-winged blackbirds are very common permanent Site residents. These birds are the most numerous avian species found breeding in aquatic habitats on the SRS (Norris, 1963). This species is typically found foraging, breeding and nesting in storm water runoff basins. Infrequently, these birds are seen either foraging or perching in landscaped portions, roadsides, and the edges of parking lots. Flocks of red-winged blackbirds are present in these terrestrial subhabitats during the winter migration. During spring months, vocalizations of this species are often heard in landscaped subhabitats in SRS developed areas.

Common Grackle - These birds are fairly common permanent residents of the Site (Norris, 1963). Both individuals and flocks have been seen foraging and roosting in the landscaped subhabitat located away from Site buildings and structures. Individuals have been observed perched on and vocalizing from light and power poles. During winter migration, flocks of common grackles numbering in size between 25 to 100 or more birds have been observed. These noisy flocks seem to roost only briefly in the larger trees in the landscaped areas before moving on.

Brown-headed Cowbird - Brown-headed cowbirds are locally common winter visitors in the area encompassing the SRS. This species tends to prefer open expanses of herbaceous habitat. Breeding activity among these birds has been reported locally (Norris, 1963). Individuals and flocks have been observed foraging in landscaped areas and at feeders maintained within developed portions of the Site. Large flocks of up to fifty of more brown-headed cowbirds have been observed in these areas during fall migration.

Northern Cardinal - Abundant on Site, the northern cardinal is a permanent resident of edge and deciduous forest habitats on SRS. The early use of Site developed areas by this species was documented by Norris (1963). Cardinals are typically observed as individuals or male-female pairs foraging in landscaped areas and lawns adjacent to and away from

buildings. Although documented as nesting on Site, no evidence of this activity has been found to date in developed areas.

Indigo Bunting - The indigo bunting is a fairly common summer resident on the SRS. This species prefers shrub/scrub habitat on Site. Only a few individuals of this species have been documented for developed subhabitats on SRS. These were all adult birds seen in landscaped areas around the fringes of A and F Areas.

House Finch - This species is commonly found on Site in developed areas. House finches have been observed foraging in the landscaped areas adjacent to buildings, and along the edges of road and parking lots. This species nests in the shrubs and bushes adjacent to buildings and structures from March through July. Males are seen and heard calling from the tops of buildings, power/light poles, wires, and trees in Site developed areas. Both breeding and rearing/feeding of fledglings takes place on and around the exteriors of buildings and in landscaped areas. These birds also perch on overhead power and telecommunications wires and on fences. Flocks of up to 30-40 house finches are seen in these developed subhabitats during the winter months.

Pine Siskin - This finch is an uncommon winter visitor to the Site. Pine siskins have been observed locally foraging in landscaped areas and at artificial feeders (Norris, 1963). It has infrequently been observed foraging among stands of trees in landscaped areas with substantial canopies (e.g., Parrott Park in upper 3/700 Area).

American Goldfinch - The American goldfinch is a permanent local resident, whose numbers and flock sizes fluctuate seasonally (Norris, 1963). Typically observed in small to medium sized flocks, this species is often observed foraging and perching in landscaped areas. Bird feeders are heavily used by flocks of goldfinches. These birds are also seen along roadsides and at the edges of parking lots.

Rufous-sided Towhee - The rufous-sided towhee is a common permanent resident at SRS (Norris, 1963). Individual towhees are observed foraging among bushes and shrubs in the landscaped areas adjacent to buildings. This species perches on overhead wires, fences and trees in developed areas.

Dark-eyed Junco - This species is a common winter visitor to the SRS. Juncos are observed on Site between November and April (Norris, 1963). Typically seen in small flocks, these birds forage in the landscaped areas both adjacent to and away from buildings and other structures.

Chipping Sparrow - This sparrow is a common permanent resident on the SRS (Norris, 1963). Individuals and flocks of up to 50 chipping sparrows have been observed foraging on open lawns, around shrubs and bushes, among trees, and at feeders. Although this species breeds locally, there are no reports of nesting by chipping sparrows in Site developed areas.

White-throated Sparrow - The white-throated sparrow is a common winter visitor to the SRS (Norris, 1963). Preferring the cover of undergrowth and brush, individuals and pairs of this species have been observed along the margins of SRS landscaped areas.

Mammals -

Virginia or Common Opossum - This native marsupial is common throughout the SRS and is found in a variety of habitats. Known to thrive in and adapt to suburban habitats (Cothran et al., 1991), opossums are found in all of the developed areas on Site.

Typically encountered only as individuals, this species is regularly observed foraging at night in landscaped areas, and in areas around buildings and structures. This activity has been noted both outside of and within Site fenced security areas. Opossums have also been found feeding in open dumpsters and garbage cans. Occasionally, these animals are seen during the daylight hours after being flushed from their dens or disturbed. Some denning and reproductive activities occur within developed subhabitats. Infrequently, these mammals are found inside buildings with readily-available or open access (e.g., one adult was found to have entered the 708-A Cafeteria Building on October 15, 1996). This species is commonly found as roadkills due to their habit of foraging for carrion along roads (Cothran et al., 1991).

Eastern Mole - This species is found throughout the SRS, but is most abundant on the Sunderland Terrace (Cothran et al., 1991). Suitable habitat appears to be a combination of abundant invertebrate soil fauna and a substrate above the water table and which will support a permanent burrow system. Eastern moles have been found in landscaped areas and along the sides of roads in Site developed areas.

Short-Tailed Shrew - The shrew is probably the most common mammal on the SRS (Cothran et al., 1991). Although primarily abundant in moist habitats, is present in most terrestrial habitats. This species has been trapped in landscaped areas adjacent to and away from SRS buildings.

Least Shrew - Less common than the previous species, this small insectivore is most commonly found in association with grasses and herbaceous vegetation. This shrew has been trapped in landscaped areas between the vaults in E Area.

Eastern Pipistrelle - The eastern pipistrelle is found locally but not in large numbers (Cothran et al., 1991). These bats roost on structures located on the exterior and interior of Site buildings. In fall, cold-stressed individuals are occasionally found around landscaped areas, lawns and sidewalks. Removals of nuisance roosting individuals have taken place in various buildings located in 300/M-Area, F Area, K Area and B Area.

Eastern Cottontail - These medium-sized rabbits are abundant in upland habitats on the SRS. Often found in urban environments (Cothran et al., 1991), eastern cottontails are found in all of the developed areas on Site. This species is most often observed as individuals foraging at dawn or early evening hours within landscaped areas and on lawns. Occasionally, these rabbits are seen during the middle of the day foraging on lawns on overcast, warm weather, and, more infrequently, on clear, sunny days. Sightings of foraging animals have occurred both outside and within fenced security areas on Site. These animals have accidentally set off alarms within exclusion zones around the Tritium Facility Complex in H Area. Some reproduction and rearing of young by this species takes place within SRS developed areas, with a number of litters are produced annually. Multiple litters of eastern cottontails were produced in the springs of 1995 and 1996 in the area immediately around Buildings 773-41A and 773-42A. Nests are typically located in shrubs and bushes both adjacent to and away from buildings on Site. Forms or day beds are also located in the same type of subhabitat as the nests. Eastern cottontails are regularly found as roadkills, especially on roads passing through locations with extensive areas of maintained lawns (e.g., in front of Building 703-46a).

Eastern Gray Squirrel - Gray squirrels are found throughout the SRS, most commonly in hardwood stands (Cothran et al., 1991). Perhaps because of the limited availability of suitable habitat (i.e., hardwood stands of the right successional stage or age), this species is widespread but uncommon in developed areas on Site. Gray squirrels are typically observed as individuals. Foraging, reproduction and denning occurs within these

deciduous stands. Leaf nests are observed in large deciduous trees in landscaped areas of the marginal portions of SRS developed areas. Foraging or searching for den sites may also result in these mammals seeking access to building interiors. Some foraging by this species has also been observed near roads and parking lots on Site. Some gray squirrels have also been seen foraging at bird feeders maintained in Site developed areas.

Southern Flying Squirrel - The southern flying squirrel is a widespread but secretive rodent found on the SRS. This species is most often found in deciduous forests, but are common in pine-hardwood areas on the SRS. Although southern flying squirrels reportedly often nest in buildings (Cothran et al., 1991), these animals are thought to be rare in Site developed areas. One adult individual was observed traveling through the Savannah River Technology Center (SRTC) technical area in April of 1997.

Cotton Mouse - This small rodent is one of the most numerous species of mammals on the Site. The cotton mouse is found to occupy a variety of bottomland and upland habitat types (Cothran et al., 1991). This species has been trapped in landscaped portions of the Site developed areas, primarily in areas dominated by shrubs or bushes.

Cotton Rat - This medium-sized rat is found in a variety of habitats on the SRS, although it seemingly prefers old fields (Cothran et al., 1991). Individuals have been observed in landscaped areas and lawns adjacent to Site buildings.

House Mouse - Local populations of this non-native species are presently found only in buildings and other development sites on SRS (Cothran et al., 1991). House mice are found throughout developed areas on the SRS. These mammals are present in and around buildings and other structures. This is the most common rodent encountered during interior pest controls activities on Site.

Norway Rat - The introduced Norway rat (also known as the sewer or brown rat) has been present on the lands encompassed by the SRS since prior to the purchase of the Site by the Federal government. Having a distribution which is closely associated with human habitations, this species has to date only been captured within buildings on Site (Cothran et al., 1991). Although widespread, this species is not commonly encountered within Site developed areas.

Coyote - The coyote has only recently expanded its range to include the area encompassing the SRS (Cothran et al., 1991). To date, individual coyotes have been observed foraging at night around garbage cans and dumpsters in T-Area, in parking lots in P Area, and around the landscaped fringes of A Area. Currently, the Site population of this species is in very low numbers. With an ability to adjust to inhabiting urban environments, the coyote may use a number of the Site developed subhabitats.

Feral Dog - These introduced canids have been found on the Site since the early 1950s (Jenkins and Provost, 1964; Cothran et al, 1991). Both feral and free-ranging domestic dogs are present in all of the SRS developed areas. The Site population of these animals is undoubtedly supplemented annually by domestic individuals wandering onto SRS lands, unwanted pets being released on SRS, and unrecovered hunting dogs from the public fall hunts on Site. The presence of a long-term, sustaining, truly feral population of this carnivore on the SRS is questionable. Individuals and small packs of these animals have been seen within and adjacent to SRS developed areas. Normally diurnally active, these dogs have been seen at night foraging or moving around in developed Site areas. This species is typically observed around parking lots and laydown yards. These animals also seek shelter in open buildings and under office trailers. Foraging by these animals is often near Site dumpsters.

Gray Fox - The gray fox is abundant on the SRS and uses several habitat types on Site (Cothran et al., 1991). Typically seen as individuals, and occasionally as pairs, this mammal is found in all of the developed areas on Site. Normally nocturnally active, these animals are occasionally seen in the early morning or late evening hours. A variety of behaviors exhibited by the gray fox, including foraging, denning, mating and caring for neonates, takes place within SRS developed areas. One adult female maintained a den site and reared two litters of pups within the fenced security portion of F Area over a period of two years. Such den sites are usually around or under building or structure foundations. Gray fox have been seen on a number of occasions foraging at night around trash cans and dumpsters in A Area. Infrequently, these small carnivores are found as roadkills in developed areas on Site.

Bobcat - This furbearer has been present on the SRS since the early 1950s (Cothran et al., 1991). Bobcats are typically not seen around areas of human activity, including most of the developed areas on Site. Being active at night, this secretive mammal is rarely seen around the fringes of the urban subhabitats on the SRS. A few of these animals have been found as roadkills on roadways entering developed Site areas.

Feral Cat - Feral cats have been present on the SRS since the early 1950s (Cothran et al., 1991). This introduced species is found in all of the developed areas on Site. This listing includes both truly feral individuals and unwanted domestic cats released on Site. The Site's developed areas are used for foraging, denning and reproductive activities. These animals are largely nocturnally active, but are also regularly seen during daylight hours. Feral cats are very common in N Area because of the presence of large warehouses with ready or open access and abundant prey. Typically observed as individuals, feral cats are frequently seen around equipment and construction material piles and under office trailers in laydown yards. These animals are also seen around parking lots probably because of the readily available cover of running under the vehicles parked in these areas. Dumpsters provide a food source for these cats. Feral cats are also often provided food scraps by concerned Site employees. The existence of a long-term or sustaining feral population of domestic cats on the SRS is very questionable.

Striped Skunk - This species is fairly common on the SRS (Cothran et al., 1991). Striped skunks are found in all of the developed areas on Site. These animals use these areas for foraging and occasionally denning activities. This species is essentially nocturnal, although they are sometimes seen during the day (Cothran et al., 1991). They are socially solitary, and are typically encountered only as individuals within the Site's developed areas. Striped skunks frequently present a problem by entering buildings with open access seeking shelter or searching for food (Cothran et al., 1991). Several striped skunks have been roadkilled within developed areas on Site.

Raccoon - Raccoons are a commonly observed species which are found throughout the Site (Cothran et al., 1991). These medium-sized mammals are present in all of the developed areas on Site. Individuals or small groups are typically observed foraging in open dumpsters and garbage cans on Site. Raccoons also forage around storm water runoff retention basins and settling and seepage basins. Occasionally, individuals will establish den sites in or under buildings or large equipment. Raccoons may enter open access buildings, where human presence is not evident, during their nocturnal foraging. This species is infrequently killed on roads by vehicles during foraging within developed areas.

Wild Pig - This non-native species has been present on the SRS since the time of acquisition of the Site by the Federal government in the early 1950s (Cothran et al., 1991;

Mayer and Brisbin, 1991). Found throughout most of the Site, wild pigs are uncommon in the edges of developed areas. Extensive rooting damage by this species has been found around storm water runoff ditches and retention basins, and along roadway rights-of-way at the perimeter of SRS facilities and developed areas.

White-tailed Deer - The white-tailed deer is found throughout the SRS (Cothran et al., 1991). This species is very common on Site. Individuals and small groups of up to four individuals have been observed foraging at dusk in the landscaped areas and lawns situated at the boundaries of developed areas on Site. These animals have also been sighted in and around storm water runoff basins. Tracks have been found crossing graveled and unpaved parking lots within developed areas on Site.

Discussion

The use of the developed or "urban" subhabitats on the SRS by wildlife species is more commonplace than has been previously reported. This general situation (i.e., an abundance of wildlife species being present in urban environments) has only within the past two decades been recognized on a national level to exist, even among wildlife management and ecology professionals (Gill and Bonnett, 1973). The increasing interest in urban wildlife resources within the science of wildlife management has even resulted in the establishment of the National Institute of Urban Wildlife (Robinson and Bolin, 1984). The findings on species composition and levels of use within the present study are comparable with studies conducted elsewhere (VanDruff, 1979).

The common use of SRS developed areas by local wildlife is not entirely unexpected. This use is undoubtedly driven by the fact that this federal site is, as a whole, a mosaic of urban islands surrounded by largely undeveloped expanses, rather than the reverse typically seen in most areas of urban sprawl or metropolitan centers. Lacking the urban gradient typically leading up to highly-developed industrial sites in most areas, the SRS developed areas would be expected to have and support a larger number of wildlife species that would not normally be found in such urban subhabitats. As a component of this, the areal extent of a specific developed area may also be a factor in determining the species composition (e.g., the smaller the developed area, the greater the potential for wildlife species). In addition, spacious landscaped habitat within the developed areas contribute further to the resulting positive mosaic enhancing the wildlife environment present in these locations of the SRS.

Review of Taxa

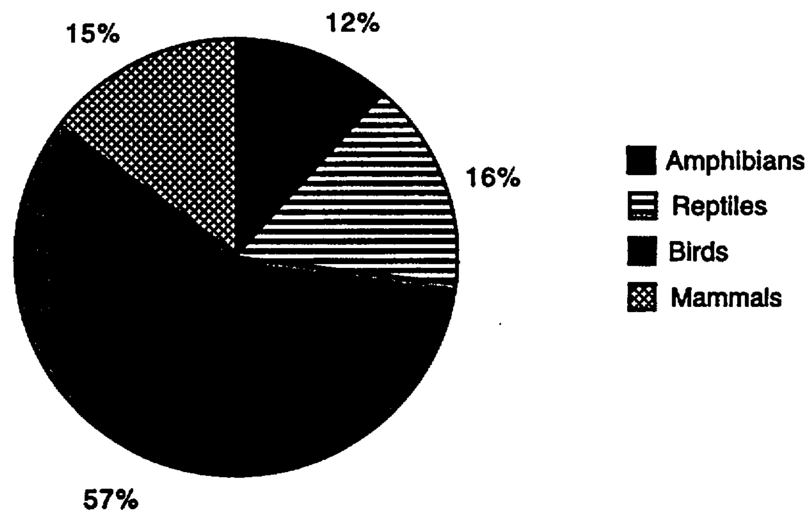
Overall, the percent taxonomic composition of the urban species is very similar to that of the overall taxonomic composition for SRS wildlife (Figure 2). This is not only shown by the total percent species composition, but also the sequential order of species abundance (i.e., birds are the largest taxon, down to amphibians being the smallest). Again, this is not entirely unexpected, since the urban taxonomic component is merely a subset of the total local pool of species.

Given the right circumstances, the potential does exist for any wildlife species found on the SRS to be observed or encountered in one of the Site's developed areas. Although, it should also be noted that, depending upon the species in question, some such occurrences may not be very likely. With the exception of a few species (e.g., house sparrow, house finch, rock dove, house mouse, Norway rat, and feral cat), subjective observations indicate that densities of most wildlife species found on the SRS are higher in undeveloped areas than in developed areas. This difference, however, was not quantified during the course of this study.

Because of primary reliance on observational data, findings reported herein may be somewhat biased toward the more conspicuous species. For this reason, some species may appear to be less common in urban subhabitats than they really are. The absence or minimal presence of such species might be a function of these animals being secretive or cryptic in their behavioral patterns rather than actually being scarce.

The presence of each taxonomic class of wildlife is a product of their capability to successfully function or survive within the urban environment. This is further translated into the ability of these classes to be able to use, not just survive, in these areas. Summaries are presented for each class of wildlife species present as follows:

SRS Total Wildlife Species



SRS Urban Wildlife Species

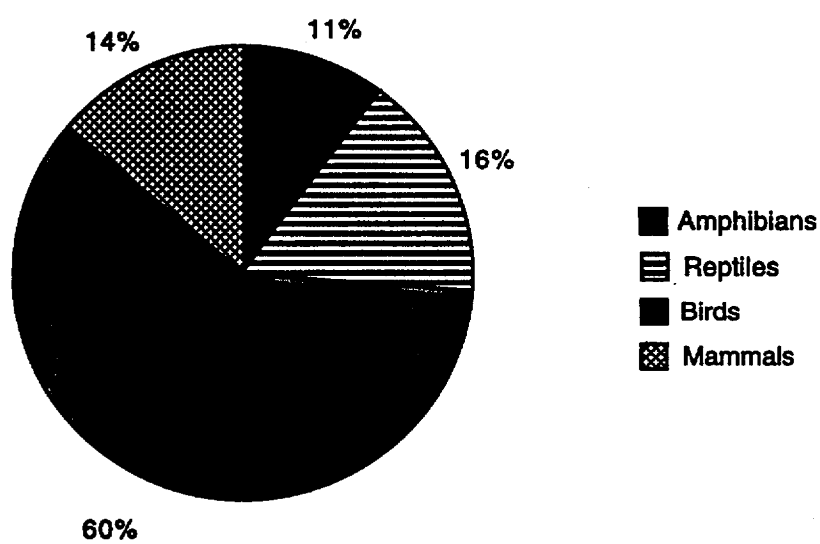


Figure 2. Comparison of total species composition of SRS wildlife (N=368) versus SRS urban wildlife species (N=153).

- **Amphibians** - Having a small body size and environmental moisture requirements, and not being highly mobile, amphibians as a group are limited in the extent to which these species can use urban subhabitats. Of the total number of amphibian species found locally, only 37.2 percent have been found in developed areas. The frogs, 61.5 percent of the local amphibian fauna, make up 75.0 percent of this vertebrate class found in urban subhabitats. In general, amphibian species would be largely limited to using the aquatic subhabitats in SRS developed areas. In almost all cases, these animals would be effectively permanent residents because of their environmental requirements. Undoubtedly, because of the cryptic behavior exhibited by many of these species (e.g., salamanders), the numbers present in SRS urban aquatic subhabitats are higher than was determined during the course of this study. The presence of this taxon is largely limited to the fringes of the SRS developed areas. Because of their moisture requirements, limited corridor access to aquatic subhabitats located in the interior of the larger developed areas would be available to these species. Exceptions to these limitations would include the southern toad and the barking treefrog. Both of these species appear to have successfully established themselves in a number of terrestrial subhabitats within the Site developed areas.

- **Reptiles** - Lacking the environmental moisture limitations of the previous class, reptiles have a higher percent presence in urban subhabitats. A total of 43.1 percent of SRS reptilian species are found in developed areas on Site. Although generally cryptic in nature, reptiles are also more mobile than amphibians. These abilities give this taxon the capacity to effectively function as either residents or transients within Site developed subhabitats. Reptiles are found in all of the terrestrial and almost all of aquatic subhabitats on SRS. Being very mobile, the potential exists for almost unlimited corridor access to interior portions of the larger developed areas. Comprising 62.0 percent of the local reptilian fauna, snakes made up 68.0 percent of the urban species identified. Snakes also had the broadest range of subhabitats used, including the interior of Site buildings.

- **Birds** - This is most abundant group of wildlife species found on the SRS. This dominance is replicated among the urban wildlife species found on Site, with birds having the highest percent presence of any of the four wildlife classes. Birds are the most highly mobile and conspicuous group of wildlife species found on the SRS, including urban subhabitats. Because of their mobility, the unquestioned potential exists for all bird species on Site to fly over developed areas on SRS at some time. This activity, however, would not necessarily constitute a specific use within the context of this report. Because of their ability to fly, there would be no effective corridor restrictions on this taxon. It is possible to see birds almost anywhere outside of buildings or in landscaped areas. Most of the bird species found in urban subhabitats are present only as transients. Only 19.8 percent of the birds using SRS developed areas were found to reside or nest there. In contrast to the two previous wildlife classes discussed, the more common subtaxa of birds found on the SRS were not similarly represented among the urban species. For example, the passerines comprise 53.6 percent of the total number of bird species documented as being found on the SRS, while only 42.9 percent of the urban bird species found are passerines.

- **Mammals** - The presence of this last class of wildlife species tends to fall into two levels of use based on size and mobility. The smaller and less mobile species tend to be resident. In contrast, the larger, more mobile species tend to be transient in their use of SRS urban subhabitats. Behaviorally, most local mammal species tend

to be cryptic or avoid contact with people. In spite of their mobility, most larger mammal species have limited corridor access to the interior of larger developed areas because of their behavioral avoidance of man. Therefore, the larger species are limited to fringe or marginal portions of the SRS developed areas. The rodent order, comprising 31.5 percent of the total SRS mammalian fauna, made up 28.6 percent of the urban mammal species found.

Approximately 1.9 percent of the birds and 4.8 percent of the mammals found on the SRS are non-native or exotic species which have become established locally. No non-native species of amphibians or reptiles have been established in the area around the SRS. Often such foreign species are commensals with man's developed habitats, surviving and thriving better in urban subhabitats rather than in rural undeveloped areas. One might expect that such a species would therefore have a higher percent frequency associated with its presence in urban areas of the SRS. In fact, percent frequency of exotic birds and mammals is more than double the Site as a whole (i.e., 4.4 percent - birds, 23.8 percent - mammals).

Protected Wildlife Species - One of the primary regulatory concerns in looking at wildlife species using urban subhabitats on the SRS is the presence of protected species. Within the context of this report, the term protected species would include species of wildlife which are afforded regulatory protection from harm or harassment on either a federal or state of South Carolina basis. The presence of such species in developed subhabitats on Site could have the potential to negatively impact these species, depending upon their level and location of use.

Two Federally-protected species, the American alligator and the bald eagle, have been documented as using areas in and around the developed portions of the Site. Neither species, however, is determined to have any more than an uncommon or rare presence in SRS urban subhabitats. In general, projects taking place within the developed areas of SRS should not have any negative impact on either of these species. The one possible exception to this would be the prolonged presence of alligators in seepage and settling basins around the separations areas. Because of the presence of contaminants in these basins, the potential exists for this species to realize impacts due to either uptake or exposure. Presence of perimeter fences and the active removal of animals found in these basins, however, has effectively reduced the potential for such impacts.

To date, no state-listed protected species has been found in any of the SRS developed areas. Of those state-listed organisms known to occur on or around the SRS, none would likely use any of the urban subhabitats for extended periods.

Use of Subhabitats

In general, it has been shown that the more uniform an environment is, the less diverse the local species composition will be. It is therefore not surprising that urban environmental monocultures have been shown to result in a very limited species diversity (Robinson and Bolin, 1984). As with undeveloped areas, the more diverse a developed or urban area is, the more diverse the species composition.

Within an urban environment, species utilization is typically subhabitat dependent. For example, large open warehouse bays typically attract use by only rock dove and European starlings, whereas landscaped areas with shrubs and trees present will attract a much larger number of species. In fact, many of the species found in landscaped subhabitats will not use subhabitats dominated by buildings, paved areas, or other manmade structures. The brown thrasher and white-eyed vireo are two examples of such species. There are even suites of species (e.g., insectivorous avian guild) associated with certain types of

subhabitats (e.g., landscaped areas with shrubs, bushes, or trees present) within developed areas. Thus, changing the subhabitats result in changes in the suites of species found in that area. To follow up on the aforementioned example, the elimination of landscape woody vegetation around buildings results in the effective elimination of the presence of insect-eating species of birds.

Terrestrial vs. Aquatic Groupings of Subhabitats - In general, one can divide the urban subhabitats sampled during this study into either terrestrial or aquatic groupings. The terrestrial subhabitats would include the following: interiors and exteriors of buildings and structures, landscaped areas around and away from buildings and structures construction laydown yards and salvage storage areas, and parking lots and roads. The aquatic subhabitats would encompass the following: storm water runoff or drainage ditches, storm water runoff retention basins, settling or seepage basins, and 186/183 basins. All SRS developed areas have available terrestrial subhabitats, while most have aquatic subhabitats (Table 7). The level of use of these various subhabitats within SRS developed areas may be determined by simple availability. Several species use both general types of subhabitats. Most, however, are found in either one general type or the other. The general level of use and greatest species diversity in either terrestrial or aquatic subhabitats appears to be highest in the most naturally vegetated subhabitats (i.e., landscaped areas away from buildings and structures and storm water runoff retention basins, respectively) (Figure 3; Table 5).

- **Terrestrial** - Based on the number of species present, the use of the terrestrial subhabitats was highest in natural (e.g., landscaped) areas versus the more structurally-developed subhabitats (e.g., buildings, parking lots) (Table 5). Because of close proximity of some of these two types of terrestrial subhabitats, some spillover does occur from one to the other. However, this effect is only realized along the margins of the more structurally-developed subhabitats. In general, the more diverse or extensive landscaping is, the more diverse the number of species found. The same is true for landscaped subhabitats with little to no maintenance and for landscaped areas which have been established for a long period of time. Areas with more varied landscaping (e.g., T Area and portions of A Area) have more diverse avifauna than more uniformly developed areas with little to no landscaping (e.g., F and H Areas). This general effect can be seen as one travels from landscaped areas away from buildings into the interiors of buildings (Figure 3).

- **Aquatic** - The observed variation in species diversity in aquatic subhabitats is comparable to that stated for terrestrial subhabitats, in that it decreases with the increased structural development of this general habitat type (Figure 3). In addition, the design of the more structurally-developed aquatic subhabitats (e.g., settling/seepage and 186/183 basins) do not lend themselves to use by many aquatic or semi-aquatic wildlife species. For example, settling and seepage basins have sides too steep to provide shallow wading habitat for certain species (e.g., wood storks) and only limited habitat for other species (e.g., most wading bird species). The 186/183 basins are too deep for use by any of the wading bird species. Conversely, however, these deep, open water subhabitats are ideal for waterfowl species. Structurally-developed subhabitats also do not have the vegetated cover (e.g., stands of emergent macrophytes) provided in most storm water runoff retention basins.

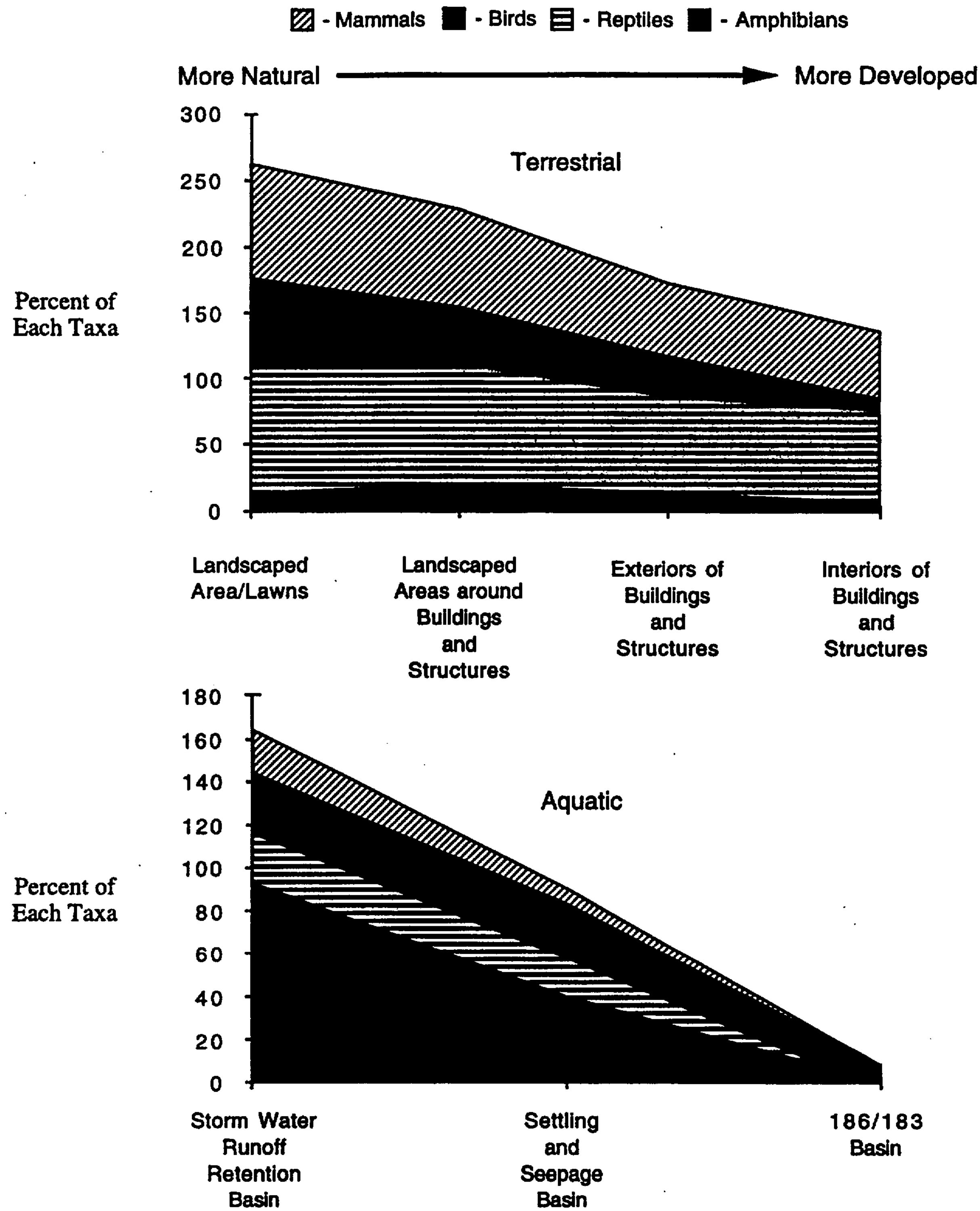


Figure 3. Declining diversity gradient of SRS urban wildlife species going from more natural to more developed/structural subhabitats. Data are separated into terrestrial (above) and aquatic (below) subhabitats.

Table 7

SRS Area Listing of Urban Subhabitats Present.

SRS Developed Area	SRS Urban Subhabitats									
	Interiors of Buildings and Structures	Exteriors of Buildings and Structures	Landscaped Areas around Buildings and Structures	Landscaped Areas & Lawns	Construction Laydown Yards or Salvage Storage Areas	Roads and Parking Lots	Storm Water Runoff or Drainage Ditches	Storm Water Retention Basins	Settling or Seepage Basins	Reactor 183/186 Basins
A	X	X	X	X	X	X	X	X	X	
B	X	X	X	X	X	X	X	X		
C	X	X	X	X	X	X	X		X	X
D	X	X	X	X		X	X		X	
E	X	X	X	X		X	X	X		
F	X	X	X	X	X	X	X	X	X	
H	X	X	X	X	X	X	X	X	X	
K	X	X	X	X		X	X	X	X	X
L	X	X	X	X	X	X	X		X	X
M	X	X	X	X	X	X	X	X	X	
N	X	X	X	X	X	X	X	X	X	
P	X	X	X	X		X	X	X	X	X
R	X	X	X	X		X	X			X
S	X	X	X	X	X	X	X	X		
T	X	X	X	X	X	X	X	X	X	
Z	X	X	X	X		X	X	X	X	
Percent of Areas with Above SubHabitat	100	100	100	100	63	100	100	75	75	31

Type of Use

Of the seven specific types of use of urban areas on the SRS by wildlife species, foraging/feeding had the highest frequency of occurrence at 98.6 percent. The next highest was transient/dispersal at 82.6 percent. Both of these types of use would entail an animal moving through but not necessarily remaining in a developed area. With the exception of those species who are resident within urban subhabitats, these types of use would most likely be temporary in nature. The next most frequent urban types of use were resting (i.e., loafing, resting, perching, and roosting) and shelter at 65.9 percent and 65.2 percent, respectively. Both of these general types of use would necessitate an animal remaining sedentary in one of the urban subhabitats for at least a short period of time. The types of use present at the lowest frequency were all associated with reproductive activities (i.e., courting, mating, denning, nesting, egg-laying, rearing and development of young). These types of use had frequencies of between 29.7 percent and 31.2 percent. In general, such activities would require these animals be present in the developed subhabitats for prolonged periods of time.

Potential Impacts

The potential impacts which could result from the presence of urban wildlife within Site developed areas can be either positive or negative, and affect either the host human environment or the wildlife species themselves. The realm of potential consequences of such impacts can be as severe as to be life threatening for both affected groups.

Impacts to Humans - The potential impacts to humans in urban subhabitats on the SRS resulting from wildlife can be classified into several categories: contaminant transport, physical harm, disease transmission, and destruction of property. These potential impacts are discussed in the following paragraphs:

- **Contaminant Transport** - Several of the urban subhabitats are represented by locations which are contaminated by hazardous constituents and/or radionuclides. Use of these areas by urban wildlife can result in these animals becoming contaminated. If these individuals then leave the Site, this could result in the transport of contaminants to other locations. This transport could be as simple as to end in a location immediately outside of the source facility or to an offsite location. The specifics of this impact would depend upon species in question. Although the magnitude of this type of potential impact is not well understood, such contaminant transport has been documented at SRS. In 1982, radionuclide-contaminated yellow-bellied turtles were found to have migrated from the SRL basins to a farm pond located off-site (Ashley et al., 1984). Migratory waterfowl have been shown to use seepage and settling basins on Site, and to uptake contaminants (Mayer et al., 1986b). Both turtles and waterfowl have the potential to enter the human food chain. Problems have occurred at the West Valley Demonstration Project in upstate New York, when barn swallows collected contaminated nesting material (i.e., mud) from settling basins on Site and used that material to construct nests with elevated levels of radioactivity. Such contaminant transport scenarios could be as improbable as rodents becoming contaminated inside of a building, leaving the building, being eaten by a feral cat, which might then be adopted by a sympathetic employee and taken off Site.

- **Physical Harm** - Physical harm or injury to humans may typically be realized in the form of either bites or attacks by urban wildlife. Based on data compiled by Chamberlain et al. (1982), this type of impact made up slightly more than one percent of the urban wildlife damage incidents reported. The obvious wildlife

species potentially to be involved on SRS in such an incident would include mammalian carnivores (e.g., raccoons, feral dogs, and feral cats) and both poisonous and nonpoisonous snakes. There has never been an incident of someone being bitten by poisonous snakes anywhere on Site except when the individual has been attempting to catch or actually handle the animal. Since striped skunks occur within a variety of terrestrial urban subhabitats, there is also a potential for an employee to be sprayed. The potential also exists for an employee to be hurt (e.g., bitten, sprayed, clawed, etc.) while trying to aid a sick or injured animal. Although such an incident has not occurred at SRS, one did take place at the West Valley Demonstration Project, where an employee trying to assist an injured feral cat was severely scratched and clawed by the animal. In addition, humans can be injured due to unsafe conditions created by urban wildlife. An example of this would be areas with a buildup of avian fecal material under overhead wires, subroofing structures or support beams or under roosting/perching trees overhanging sidewalks. Such conditions can be slippery and may result in humans falling.

- **Disease Transmission** - The use of urban subhabitats by wildlife species can lead to conditions resulting in disease transmission of zoonotic pathogens. For example, the unsanitary conditions (i.e., fecal material buildup) found under pigeon roosts within enclosed buildings have been shown to have elevated airborne levels of bacteria. Weber (1979) reported that pigeons can transmit more than thirty different diseases and pathogens to humans. Similar conditions exist around house sparrow nests in shuttle stops. In addition, there are parasites around nesting material in roost/nest sites. Problems also occur with dead animals in building interiors or landscaped areas around buildings creating odor problems and unsanitary conditions. Decomposing rodents and feral cats resulted in trailers in H and C Areas being temporarily uninhabitable by employee occupants. Certain wildlife species (e.g., raccoons, striped skunks) present in urban areas on the SRS may transmit rabies by biting humans or other animals.

- **Destruction of Property** - The destruction of property is unquestionably the most frequent (98 percent) negative impact which wildlife species have been shown to cause within urban environments (Chamberlain et al., 1982). In general, this has not been significant on the SRS. Some impacts have been found to occur on equipment, resulting in operational malfunction (e.g., house sparrow nests in HVAC systems causing the system to shutdown; nests of house sparrows and northern rough-winged swallows plugging up roof drain pipes). Other operational impacts have also occurred such as eastern cottontails setting off exclusion area alarms around the Tritium Facility Complex. The presence of a number of medium-sized species (e.g., opossums, eastern cottontails, gray fox, raccoons) within limited access to security areas demonstrates the fact that perimeter fences are ineffective means as a 100% effective deterrent for wildlife movement.

Impacts to Urban Wildlife - The potential impacts to wildlife species may also be placed into two general categories as follows: physical harm, and contaminant exposure. These impacts are discussed as follows:

- **Physical Harm** - This impact in the form of either accidental or intentional injury or death is probably the most common negative impact to urban wildlife species on the SRS. This can take on a variety of forms including Site personnel intentionally beating or killing animals, collisions of birds with buildings (e.g., large windows) and structures (e.g., overhead wires), and collisions with vehicles (i.e., roadkills). SRS employees intentionally injuring or killing wildlife species in urban subhabitats is an infrequent occurrence.

Typically, such incidents result from Site personnel perceiving that an animal is a potential deadly threat and not being aware of Site procedures concerning animal control. Two such incidents were reported in 1996. On August 7, 1996, an adult canebrake rattlesnake approximately 110 cm in total length was discovered during the early evening hours next to the first-floor breezeway between Buildings 773-41A and 773-42A, within the SRTC technical area. The janitorial personnel who discovered the snake, subsequently killed it. On September 14, 1996, a 46-centimeter long juvenile American alligator was discovered in T Area. Fearing the potential for someone to be injured, an area supervisor instructed an employee to kill the animal. In spite of being severely beaten, the young alligator was rescued by SRS security personnel and placed in captivity to recover.

Collisions of birds with buildings have been documented to occur on Site, but the level of this type of impact is unknown. Species observed striking buildings or windows tend to be small (e.g., ruby-throated hummingbirds, northern mockingbirds, American robins, brown thrasher), while birds striking overhead wires are larger (e.g., great blue heron, American coot, yellow-crowned night heron, wood ducks, lesser scaup, and ruddy ducks). Roadkills within developed areas on Site have the potential to affect all amphibians, all reptiles, predatory and scavenging bird species, game birds, and all mammals. Roadkills, however, occur at a fairly low frequency in SRS developed areas.

- **Contaminant Exposure** - Those species discussed in the previous paragraph on contaminant transport also have the potential to be negatively impacted by exposure to radionuclides or hazardous materials in certain urban subhabitats. This is especially true for those aquatic and semi-aquatic wildlife species using or inhabiting settling and seepage basins on Site. Aside from being documented as having elevated body burdens of contaminants (Ashley et al., 1984; Du Pont, 1985), most SRS wildlife species have not been documented to have any significant negative impacts from the subject exposures. Rowe et al. (1996), however, did demonstrate that larval bullfrogs in ash basins exhibited an increased deformity in the mouth structure, making these individuals less effective in their foraging efforts. A potential advantage to having certain wildlife species present in subhabitats where there is a possibility for environmental hazards or contaminant uptake, is the use of these species as environmental indicators or sentinel species. Recently, a number of amphibian species have been used as bioindicators of environmental stress (Hall and Mulhern, 1984; Freda, 1991; Dunson et al., 1992).

General Issues regarding SRS Urban Wildlife

The presence of wildlife in developed areas on SRS presents a unique set of challenges toward the treatment of these species compared to similar practices over most of the physical area of the Site. Not the least of these is the incident-specific decision regarding whether or not an animal either belongs or should be allowed to remain in an urban area on Site. Largely, such decisions rest upon whether the species involved is functioning as a pest.

Because of the developed/undeveloped mosaic nature of the SRS, management of the Site's wildlife may require a more holistic approach apart from the apparent bias implied by the research activities at SRS. Attributes such as the presence of wildlife impart a more positive and acceptable work environment. The management of wildlife in SRS developed areas tends to fall into one of two objectives, discouraging or encouraging the presence of

certain species. These objectives are encompassed by two general extremes of management strategies, control or enhancement.

Control Strategy - Pest and damage control of wildlife species within urban environments tends to be either proactive or reactive. Proactivity seeks to prevent or discourage wildlife from using an area, while reactive control efforts are implemented in a case-by-case basis in response to specific problems. Each of these general types of pest control are discussed below:

- **Proactive Control Efforts** - This type of pest control strategy is implemented in anticipation of a problem. Such efforts include erecting physical barriers around areas or facilities to prevent animal access. Deterrents can also be placed to discourage use by certain wildlife species. Deer-proof fencing along heavily-traveled right-of-way or bird-proof covers over louvers are examples of this type of control effort. Another example is the presence or absence of vegetation immediately surrounding a building. While seemingly insignificant, this may make a significant difference in wildlife species use and abundance. Absence of natural vegetation adjacent to buildings has been shown to result in a complete lack of the insectivorous guild of birds (DeGraaf and Wentworth, 1981).

- **Reactive Control Efforts** - The second type of pest control strategy is simply to respond to pest incidents on an individual basis. This may entail either removal of the animal through trapping or shooting, or elimination of the individuals in question through poisoning. Use of snap-traps for rodents or shooting problem pigeons with pellet guns are examples of such reactive control methods.

The control strategies employed on the SRS are largely reactive methods. Two separate subcontracts are let for small pest (insects and rodents) and larger animal (reptiles, birds and medium-to-large mammals) control activities on Site. The rodents control efforts entail the use of glueboards to catch and remove mice and rats in buildings and other structures. The large animal control is implemented on an incident specific basis. The results of this effort in 1996 are provided in Table 8. With the exception of the incidents involving pigeons, most of these control activities were simply to remove animals which were found in urban subhabitats. The highest frequency (23.7 percent) was the presence of snakes in buildings. No people were injured during any of these incidents; however, as discussed previously, one snake was killed and one alligator was injured as a result of Site employees reacting to the presence of these animals.

Enhancement Strategy - Once the decision has been made to manage for the presence of certain species, the strategy is simply to implement modifications in the urban subhabitat(s) potentially used by any one species to encourage it's continued or prolonged use. Environmental or habitat enhancements may be either intentional or unintentional.

Most such enhancements at SRS are unintentional, in terms of improved habitat conditions for wildlife. Based on the increased number of species observed, most urban wildlife exhibits a preference toward subhabitats with landscaping (i.e., lawns, bushes, shrubs, and trees) implemented as a component of developed areas. Landscaping is typically used to provide esthetic visual amenities for humans rather than to provide wildlife habitat. Whether intentional or unintentional, landscaping provides a natural aspect to urban subhabitats. This functions as an attractant for a number of wildlife species. Other types of unintentional habitat enhancements are less esthetically pleasing than landscaping. Disposal of rubbish, especially food scraps, provides a potential forage resource for some scavenger species. Buildings or structures with ready-available access provides shelter or roosting areas for wildlife species tolerant of human activity. Coincidental rubbish

Table 8

Summary of Reported Animal Control Incidents[a] within SRS Urban/Developed Areas During Calendar Year 1996.

Type of Incident	Number	Percent Occurence	Species Involved (Number of Incidents)
Turtles in Buildings	1	1.1	common snapping turtle (1)
Snakes around Buildings	6	6.5	banded water snake (2); canebrake rattlesnake (4)
Snakes in Buildings	22	23.7	banded water snake (8); black racer (1); copperhead (1); corn snake (1); eastern hognosed snake (4); red-bellied snake (1); ring-necked snake (1); scarlet kingsnake (1); unknown (4)[b]
Snakes around Vehicles	1	1.1	canebrake rattlesnake (1)
Alligators in Basins	1	1.1	American alligator (1)
Alligators around Buildings	2	2.2	American alligator (2)
Birds around Buildings	4	4.3	American robin (1); killdeer (1); northern mockingbird (2)
Birds in Buildings	12	12.9	American robin (1); barn swallow (5); brown-headed cowbird (1); northern mockingbird (1); rock dove (4)
Injured/Dead Birds	4	4.3	American coot (1); wild turkey (1); great blue heron (1); unknown (1)[b]
Mammals around Buildings	17	18.3	common opossum (1); eastern cottontail (3); feral cat (8); feral dog (4); gray fox (1)
Mammals in Buildings	13	14.0	common opossum (1); little brown bat (2); feral cat (7); raccoon (2); striped skunk (1)
Injured/Dead Mammals	10	10.8	eastern cottontail (1); coyote (2); bobcat (1); feral cat (1); raccoon (2); striped skunk (2); white-tailed deer (1)
Total	93	100.0	-

[a] Does not include incidents involving rodents
[b] Reported but never found

accumulation and building access can often provide various pests with all of the resources necessary to survive.

On the other hand, some intentional enhancement of Site urban areas for wildlife does occur on the SRS. One of the approved manners in which this occurs is putting up bluebird boxes and purple martin houses in some areas. Nesting by these species and others produce young on an annual basis within the urban areas on Site. Other intentional enhancement takes place which is not approved. This includes intentional feeding of certain species (e.g., bird feeders or handouts to feral cats and dogs) within urban subhabitats on Site.

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Conclusions

Results of the surveys conducted during this study indicate that the use of the developed areas of SRS by wildlife species is more common than had been previously reported. Sufficient habitat diversity does exist within the developed areas of the Site to support use by these species on a seasonal, and in some cases, a year-round basis. As such, the potential impacts to these species need to be considered prior to proposed actions being implemented in these areas.

The presence of wildlife species in developed or urban areas of the SRS is a long-term aspect of the Site's environmental diversity. In addition, as long as areas provide shelter (e.g., building with open or ready access) and food (accessible garbage cans and dumpsters), many of these species will continue to find their way into and use the developed subhabitats on the SRS.

As stated in the Introduction, this report constituted only a first broad look at this component of the SRS wildlife. More quantified studies are needed to fully understand the role of these species within SRS urban or developed areas.

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APPENDIX A

Species Listing of Urban Subhabitats Used by SRS Wildlife

Table A-1

Species Listing of Urban Subhabitats Used by SRS Wildlife.

Species (Common Name)	SRS Urban Subhabitats									
	Interiors of Buildings and Structures	Exteriors of Buildings and Structures	Landscaped Areas around Buildings and Structures	Landscaped Areas & Lawns	Construction Laydown Yards or Salvage Storage Areas	Roads and Parking Lots	Storm Water Runoff or Drainage Ditches	Storm Water Runoff Retention Basins	Settling or Seepage Basins	Reactor 183/186 Basins
Spotted Salamander								X	X	
Mole Salamander								X	X	
Marbled Salamander								X	X	
Eastern (Red-spotted) Newt								X		
Easten Spadefoot Toad								X		
Southern Toad			X	X		X	X	X	X	
Southern Cricket Frog								X	X	
Cope's Gray Treefrog								X	X	
Green Treefrog								X	X	
Barking Treefrog		X	X							
Squirrel Treefrog						X	X	X		
Spring Peeper							X	X		
Eastern Narrow-mouthed Toad								X		
Bullfrog	X	X	X	X				X		
Bronze (Green) Frog							X	X		
Southern Leopard Frog								X	X	
American Alligator		X	X	X		X		X	X	
Common Snapping Turtle	X	X	X	X		X		X		
Eastern Box Turtle			X	X		X				
Yellow-bellied Turtle				X				X	X	
Green Anole	X	X	X	X	X					
Eastern Fence Lizard				X	X					

Table A-1

Species Listing of Urban Subhabitats Used by SRS Wildlife (Continued).

Species (Common Name)	SRS Urban Subhabitats									
	Interiors of Buildings and Structures	Exteriors of Buildings and Structures	Landscaped Areas around Buildings and Structures	Landscaped Areas & Lawns	Construction Laydown Yards or Salvage Storage Areas	Roads and Parking Lots	Storm Water Runoff or Drainage Ditches	Storm Water Runoff Retention Basins	Settling or Seepage Basins	Reactor 183/186 Basins
Southeastern Five-lined Skink			X	X						
Ground Skink	X	X	X	X						
Eastern Hognosed Snake	X	X	X	X						
Banded Water Snake	X	X	X	X			X	X	X	
Red-bellied Water Snake								X	X	
Scarlet Snake	X	X	X	X						
Scarlet Kingsnake	X	X	X	X						
Rainbow Snake	X	X	X	X						
Rat Snake	X	X	X	X						
Corn Snake	X	X	X	X	X	X				
Pine Snake			X	X						
Black Racer	X	X	X	X	X					
Coachwhip	X	X	X	X						
Ring-necked Snake	X	X	X	X	X					
Brown Snake			X	X	X					
Pygmy Rattlesnake			X	X		X				
Cottonmouth	X	X	X	X			X	X	X	
Canebrake Rattlesnake	X	X	X	X		X				
Copperhead	X	X	X	X		X				
Pied-billed Grebe								X	X	X
Double-crested Cormorant		X								X
Great Blue Heron								X	X	

Table A-1

Species Listing of Urban Subhabitats Used by SRS Wildlife (Continued).

Species (Common Name)	SRS Urban Subhabitats									
	Interiors of Buildings and Structures	Exteriors of Buildings and Structures	Landscaped Areas around Buildings and Structures	Landscaped Areas & Lawns	Construction Laydown Yards or Salvage Storage Areas	Roads and Parking Lots	Storm Water Runoff or Drainage Ditches	Storm Water Runoff Retention Basins	Settling or Seepage Basins	Reactor 183/186 Basins
Green Heron							X	X		
Great Egret							X	X	X	
Tricolor Heron								X		
Yellow-crowned Night Heron								X		
Canada Goose				X					X	
Snow/Blue Goose									X	
Mallard								X	X	
Pintail									X	
Green-winged Teal									X	
Blue-winged Teal									X	
American Wigeon									X	
Gadwall									X	
Northern Shoveler								X	X	
Wood Duck							X	X	X	X
Redhead									X	
Ring-necked Duck									X	X
Lesser Scaup									X	
Bufflehead									X	X
Ruddy Duck									X	X
Hooded Merganser									X	
Red-breasted Merganser									X	
Turkey Vulture		X		X		X				

Table A-1

Species Listing of Urban Subhabitats Used by SRS Wildlife (Continued).

Species (Common Name)	SRS Urban Subhabitats									
	Interiors of Buildings and Structures	Exteriors of Buildings and Structures	Landscaped Areas around Buildings and Structures	Landscaped Areas & Lawns	Construction Laydown Yards or Salvage Storage Areas	Roads and Parking Lots	Storm Water Runoff or Drainage Ditches	Storm Water Runoff Retention Basins	Settling or Seepage Basins	Reactor 183/186 Basins
Black Vulture		X		X		X		X		
Mississippi Kite				X						
Cooper's Hawk				X		X				
Red-tailed Hawk		X		X		X				
Red-shouldered Hawk				X						
Bald Eagle				X		X				
Northern Harrier				X				X		
American Kestrel		X	X	X		X				
Northern Bobwhite				X						
Eastern Wild Turkey				X		X				
American Coot								X	X	X
Killdeer		X	X	X	X	X	X			
Least Sandpiper								X		
Ring-billed Gull				X		X				
Rock Dove	X	X	X	X		X		X		
Mourning Dove		X	X	X	X	X	X	X		
White-winged Dove			X							
Barn Owl				X		X				
Screech Owl				X		X				
Barred Owl				X		X				
Common Nighthawk		X								
Chimney Swift	X	X	X	X						

Table A-1

Species Listing of Urban Subhabitats Used by SRS Wildlife (Continued).

Species (Common Name)	SRS Urban Subhabitats									
	Interiors of Buildings and Structures	Exteriors of Buildings and Structures	Landscaped Areas around Buildings and Structures	Landscaped Areas & Lawns	Construction Laydown Yards or Salvage Storage Areas	Roads and Parking Lots	Storm Water Runoff or Drainage Ditches	Storm Water Runoff Retention Basins	Settling or Seepage Basins	Reactor 183/186 Basins
Ruby-throated Hummingbird			X	X		X				
Belted Kingfisher								X		
Common Flicker			X	X						
Pileated Woodpecker				X		X				
Red-bellied Woodpecker				X						
Eastern Kingbird		X	X	X		X				
Great Crested Flycatcher			X	X		X				
Horned Lark			X	X						
Barn Swallow	X	X	X	X		X		X		
Tree Swallow				X		X				
Northern Rough-winged Swallow	X	X	X	X	X	X		X		
Purple Martin		X	X	X						
Blue Jay			X	X						
Common Crow		X	X	X	X	X	X	X		
Fish Crow		X	X	X	X	X	X	X		
Tufted Titmouse			X	X						
Brown-headed Nuthatch			X	X						
House Wren		X	X	X						
Bewick's Wren				X						
Carolina Wren		X	X	X				X		
Northern Mockingbird	X	X	X	X	X	X				

Table A-1

Species Listing of Urban Subhabitats Used by SRS Wildlife (Continued).

Species (Common Name)	SRS Urban Subhabitats									
	Interiors of Buildings and Structures	Exteriors of Buildings and Structures	Landscaped Areas around Buildings and Structures	Landscaped Areas & Lawns	Construction Laydown Yards or Salvage Storage Areas	Roads and Parking Lots	Storm Water Runoff or Drainage Ditches	Storm Water Runoff Retention Basins	Settling or Seepage Basins	Reactor 183/186 Basins
Catbird			X	X						
Brown Thrasher		X	X	X						
American Robin	X	X	X	X	X	X	X	X		
Eastern Bluebird			X	X	X	X	X			
Cedar Waxwing			X	X						
Loggerhead Shrike		X	X	X	X	X				
European Starling	X	X	X	X	X	X		X		
White-Eyed Vireo				X						
Common Yellowthroat				X						
House Sparrow	X	X	X	X	X	X				
Eastern Meadowlark				X						
Red-winged Blackbird			X	X		X		X		
Common Grackle				X		X				
Brown-headed Cowbird	X	X	X	X						
Northern Cardinal			X	X		X				
Indigo Bunting				X	X		X		X	
House Finch		X	X	X						
Pine Siskin				X						
American Goldfinch			X	X		X	X			
Rufous-sided Towhee			X	X						
Dark-eyred Junco		X	X	X		X	X			
Chipping Sparrow		X	X	X		X				
White-throated Sparrow				X						

Table A-1

Species Listing of Urban Subhabitats Used by SRS Wildlife (Continued).

Species (Common Name)	SRS Urban Subhabitats									
	Interiors of Buildings and Structures	Exteriors of Buildings and Structures	Landscaped Areas around Buildings and Structures	Landscaped Areas & Lawns	Construction Laydown Yards or Salvage Storage Areas	Roads and Parking Lots	Storm Water Runoff or Drainage Ditches	Storm Water Runoff Retention Basins	Settling or Seepage Basins	Reactor 183/186 Basins
Virginia Opossum	X	X	X	X	X	X	X			
Eastern Mole				X				X		
Southern Short-tailed Shrew			X	X						
Least Shrew				X						
Eastern Pipistrelle	X	X	X	X						
Eastern Cottontail			X	X		X	X			
Eastern Gray Squirrel	X	X	X	X		X				
Southern Flying Squirrel		X	X	X		X				
Cotton Mouse	X	X	X	X						
Cotton Rat			X	X						
House Mouse	X	X	X							
Norway Rat	X	X	X							
Coyote			X	X		X				
Feral Dog		X	X	X	X	X				
Gray Fox	X	X	X	X		X				
Bobcat				X		X				
Feral Cat	X	X	X	X	X	X				
Striped Skunk	X	X	X	X	X	X	X			
Raccoon	X	X	X	X	X	X	X	X	X	
Wild Pig						X	X	X		
White-tailed Deer				X		X	X	X		

APPENDIX B

Species Listing of Specific Types of Use Observed for SRS Urban Wildlife

Table B-1

Species Listing of Specific Types of Use Observed for SRS Urban Wildlife.

Species (Common Name)	Specific Type of Use							
	Foraging, Feeding	Shelter	Courting, Mating	Denning, Nesting, Egg-laying	Rearing or Development of Young	Loafing, Resting, Perching, Roosting	Transient, Dispersal	Presence Only, No Documented Specific Use
Spotted Salamander	X	X	X	X	X	X	X	
Mole Salamander	X	X	X	X	X	X	X	
Marbled Salamander	X	X	X	X	X	X	X	
Eastern (Red-spotted) Newt	X	X	X	X	X	X	X	
Easten Spadefoot Toad	X	X	X	X	X	X	X	
Southern Toad	X	X	X	X	X	X	X	
Southern Cricket Frog	X	X	X	X	X	X	X	
Cope's Gray Treefrog	X	X	X	X	X	X	X	
Green Treefrog	X	X	X	X	X	X	X	
Barking Treefrog	X	X	X	X	X	X	X	
Squirrel Treefrog	X	X	X	X	X	X	X	
Eastern Narrow-mouthed Toad	X	X	X	X	X	X	X	
Spring Peeper	X	X	X	X	X	X	X	
Bullfrog	X	X	X	X	X	X	X	
Bronze (Green) Frog	X	X	X	X	X	X	X	
Southern Leopard Frog	X	X	X	X	X	X	X	
American Alligator	X	X				X	X	
Common Snapping Turtle	X	X	X			X	X	
Eastern Box Turtle	X	X				X	X	
Yellow-bellied Turtle	X					X		
Green Anole	X							
Eastern Fence Lizard	X							

Table B-1

Species Listing of Specific Types of Use Observed for SRS Urban Wildlife (Continued).

Species (Common Name)	Specific Type of Use							
	Foraging, Feeding	Shelter	Courting, Mating	Denning, Nesting, Egg-laying	Rearing or Development of Young	Loafing, Resting, Perching, Roosting	Transient, Dispersal	Presence Only, No Documented Specific Use
Southeastern Five-lined Skink	X							
Ground Skink	X	X						
Eastern Hognosed Snake	X	X	X	X	X	X	X	
Banded Water Snake	X	X	X	X	X	X	X	
Red-bellied Water Snake	X	X	X	X	X	X	X	
Scarlet Snake	X	X					X	
Scarlet Kingsnake	X	X					X	
Rainbow Snake	X	X					X	
Rat Snake	X	X					X	
Corn Snake	X	X					X	
Pine Snake	X	X					X	
Black Racer	X	X					X	
Coachwhip	X	X					X	
Ring-necked Snake	X	X					X	
Brown Snake	X	X					X	
Pygmy Rattlesnake	X	X					X	
Cottonmouth	X	X					X	
Canebrake Rattlesnake	X	X					X	
Copperhead	X	X					X	
Pied-billed Grebe	X	X				X	X	
Double-crested Cormorant	X	X				X	X	
Great Blue Heron	X	X				X	X	

Table B-1

Species Listing of Specific Types of Use Observed for SRS Urban Wildlife (Continued).

Species (Common Name)	Specific Type of Use							
	Foraging, Feeding	Shelter	Courting, Mating	Denning, Nesting, Egg-laying	Rearing or Development of Young	Loafing, Resting, Perching, Roosting	Transient, Dispersal	Presence Only, No Documented Specific Use
Green Heron	X	X				X	X	
Great Egret	X	X				X	X	
Tricolor Heron	X	X				X	X	
Yellow-crowned Night Heron	X	X				X	X	
Canada Goose	X	X				X	X	
Snow/Blue Goose	X	X				X	X	
Mallard	X	X				X	X	
Pintail	X	X				X	X	
Green-winged Teal	X	X				X	X	
Blue-winged Teal	X	X				X	X	
American Wigeon	X	X				X	X	
Gadwall	X	X				X	X	
Northern Shoveler	X	X				X	X	
Wood Duck	X	X				X	X	
Redhead	X	X				X	X	
Ring-necked Duck	X	X				X	X	
Lesser Scaup	X	X				X	X	
Bufflehead	X	X				X	X	
Ruddy Duck	X	X				X	X	
Hooded Merganser	X	X				X	X	
Red-breasted Merganser	X	X				X	X	
Turkey Vulture	X	X				X	X	

Table B-1

Species Listing of Specific Types of Use Observed for SRS Urban Wildlife (Continued).

Species (Common Name)	Specific Type of Use							
	Foraging, Feeding	Shelter	Courting, Mating	Denning, Nesting, Egg-laying	Rearing or Development of Young	Loafing, Resting, Perching, Roosting	Transient, Dispersal	Presence Only, No Documented Specific Use
Black Vulture	X	X				X	X	
Mississippi Kite	X						X	
Cooper's Hawk	X					X	X	
Red-tailed Hawk	X					X	X	
Red-shouldered Hawk	X					X	X	
Bald Eagle								X
Northern Harrier	X						X	
American Kestrel	X			X	X	X	X	
Northern Bobwhite	X						X	
Eastern Wild Turkey	X						X	
American Coot	X					X	X	
Killdeer	X	X	X	X	X	X	X	
Least Sandpiper	X					X	X	
Ring-billed Gull	X					X	X	
Rock Dove	X	X	X	X	X	X	X	
Mourning Dove	X	X				X	X	
White-winged Dove	X					X	X	
Barn Owl	X						X	
Screech Owl	X						X	
Barred Owl	X						X	
Common Nighthawk	X			X	X		X	
Chimney Swift	X	X	X	X	X	X	X	

Table B-1

Species Listing of Specific Types of Use Observed for SRS Urban Wildlife (Continued).

Species (Common Name)	Specific Type of Use							
	Foraging, Feeding	Shelter	Courting, Mating	Denning, Nesting, Egg-laying	Rearing or Development of Young	Loafing, Resting, Perching, Roosting	Transient, Dispersal	Presence Only, No Documented Specific Use
Ruby-throated Hummingbird	X						X	
Belted Kingfisher	X					X		
Common Flicker	X							
Pileated Woodpecker	X							
Red-bellied Woodpecker	X							
Eastern Kingbird	X	X	X	X	X	X		
Great Crested Flycatcher	X					X		
Horned Lark	X							
Barn Swallow	X	X	X	X	X	X		
Tree Swallow	X					X	X	
Northern Rough-winged Swallow	X	X	X	X	X	X	X	
Purple Martin	X	X	X	X	X	X		
Blue Jay	X							
Common Crow	X		X	X	X	X	X	
Fish Crow	X					X	X	
Tufted Titmouse	X					X		
Brown-headed Hathatch	X							
House Wren	X							
Bewick's Wren	X							
Carolina Wren	X							
Northern Mockingbird	X	X	X	X	X	X	X	

Table B-1

Species Listing of Specific Types of Use Observed for SRS Urban Wildlife (Continued).

Species (Common Name)	Specific Type of Use							
	Foraging, Feeding	Shelter	Courting, Mating	Denning, Nesting, Egg-laying	Rearing or Development of Young	Loafing, Resting, Perching, Roosting	Transient, Dispersal	Presence Only, No Documented Specific Use
Catbird	X						X	
Brown Thrasher	X	X	X	X	X	X		
American Robin	X	X	X	X	X	X	X	
Eastern Bluebird	X	X	X	X	X	X		
Cedar Waxwing	X						X	
Loggerhead Shrike	X					X		
European Starling	X	X	X	X	X	X	X	
White-eyed Vireo	X					X	X	
Common Yellowthroat	X					X	X	
House Sparrow	X	X	X	X	X	X	X	
Eastern Meadowlark	X					X	X	
Red-winged Blackbird	X	X	X	X	X	X	X	
Common Garckle	X					X	X	
Brown-headed Cowbird	X					X	X	
Northern Cardinal	X					X	X	
Indigo Bunting	X							
House Finch	X	X	X	X	X	X	X	
Pine Siskin	X							
American Goldfinch	X					X	X	
Rufous-sided Towhee	X					X	X	
Dark-eyed Junco	X					X	X	
Chipping Sparrow	X	X				X	X	

Table B-1

Species Listing of Specific Types of Use Observed for SRS Urban Wildlife (Continued).

Species (Common Name)	Specific Type of Use							
	Foraging, Feeding	Shelter	Courting, Mating	Denning, Nesting, Egg-laying	Rearing or Development of Young	Loafing, Resting, Perching, Roosting	Transient, Dispersal	Presence Only, No Documented Specific Use
White-throated Sparrow	X						X	
Virginia Opossum	X	X					X	
Eastern Mole	X	X	X	X	X	X	X	
Southern Short-tailed Shrew	X	X	X	X	X	X	X	
Least Shrew	X	X	X	X	X	X	X	
Eastern Pipistrelle	X	X				X	X	
Eastern Cottontail	X	X	X	X	X	X	X	
Eastern Gray Squirrel	X	X	X	X	X	X	X	
Southern Flying Squirrel							X	
Cotton Mouse	X	X	X	X	X	X	X	
Cotton Rat	X	X					X	
House Mouse	X	X	X	X	X	X		
Norway Rat	X	X	X	X	X	X		
Coyote	X						X	
Feral Dog	X	X	X	X	X	X	X	
Gray Fox	X	X		X	X	X	X	
Bobcat							X	
Feral Cat	X	X	X	X	X	X		
Striped Skunk	X	X					X	
Raccoon	X	X					X	
Wild Pig	X						X	
White-tailed Deer	X						X	

WSRC-TR-2001-00145

INSTREAM BIOLOGICAL ASSESSMENT OF NPDES POINT SOURCE DISCHARGES AT THE SAVANNAH RIVER SITE, 2000

by
WINONA L. SPECHT and
MICHAEL H. PALLER
SAVANNAH RIVER TECHNOLOGY CENTER

Approved by: [signature]
John B. Gladden, Section Manager
Environmental Analysis Section
Savannah River Technology Center

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ADC & Reviewing Official: J B Gladden, Mgr.
(Name and Title)
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WESTINGHOUSE SAVANNAH RIVER COMPANY
SAVANNAH RIVER SITE
AIKEN, SC 29808

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Executive Summary

Fish and macroinvertebrates were collected at unimpacted reference locations and downstream of NPDES discharges in Upper Three Runs and its tributaries, Fourmile Branch, Pen Branch/Indian Grave Branch, and Steel Creek/Meyers Branch to determine if the receiving streams have been impacted by the NPDES discharges. The results of the macroinvertebrate and fish surveys conducted during this study were generally in close agreement. Both indicated that most SRS streams were characterized by high biotic integrity and unaffected by SRS NPDES discharges. Possible exceptions included Crouch Branch, McQueen Branch, and Tims Branch, all of which are tributaries of Upper Three Runs. The fish data indicated that these three streams did not differ significantly from the control, while the macroinvertebrate data indicated possible impairment. Of the three, only Crouch Branch was identified as degraded in the earlier (1997-1998) survey. Subsequent investigations in Crouch Branch identified elevated concentrations of copper from the H-02 outfall as the primary cause of the degradation, although habitat degradation resulting from stormwater runoff also is a factor in the midreaches of the stream. In Tims Branch, a series of beaver dams that have been constructed just upstream from the sampling location subsequent to the 1997-1998 biological survey appear to be responsible for the perturbation. Dissolved oxygen levels below the dams are low enough to stress many species of aquatic biota. The source of perturbation in McQueen Branch is unknown, but may be due to habitat degradation that resulted during the construction of the Defense Waste Processing Facility (DWPF) in the late 1980's. In 2000, the sampling location in McQueen Branch was moved approximately 1 km upstream from the original sampling location, due to inundation of the 1997 sampling location by beaver dams. Stream habitat at the new location is somewhat degraded, due to channel erosion and scouring. However, this location is also closer than the original sampling location to the two NPDES outfalls that discharge to the stream, so impacts due to NPDES discharges cannot be ruled out. Biological impairment was also observed in upper Fourmile Branch and upper Steel Creek. Neither of these locations are downstream from NPDES discharges. Depressed biotic integrity in upper Fourmile Branch was related to factors other than NPDES discharges including low dissolved oxygen and elevated concentrations of iron. Fish sampling indicated that biotic integrity decreased in upper Steel Creek between 1997 and 2000, but this trend was not seen in the macroinvertebrate data. Reasons for the change in fish biotic integrity are unclear but may include reservoir impoundment related effects and naturally occurring habitat factors. Any impacts in Steel Creek are unrelated to NPDES discharges, since there have been no effluent discharges to this reach of Steel Creek since 1998.

1.0 Introduction

The Savannah River Site (SRS) currently has 31 NPDES outfalls that that have been permitted by the South Carolina Department of Health and Environmental Control (SCDHEC) to discharge to SRS streams and the Savannah River. In order to determine the cumulative impacts of these discharges to the receiving streams, a study plan was developed to perform in-stream assessments of the fish assemblages, macroinvertebrate assemblages, and habitats of the receiving streams. These studies were designed to detect biological impacts due to point source discharges. Sampling was initially conducted between November 1997 and July 1998 and was repeated in

the summer and fall of 2000. A total of 18 locations were sampled (Table 1, Figure 1). Sampling locations for fish and macroinvertebrates were generally the same. However, different locations were sampled for fish (Road A-2) and macroinvertebrates (Road C) in the lower portion of Upper Three Runs, to avoid interference with ongoing fisheries studies at Road C. Also, fish were sampled in Fourmile Branch at Road 4 rather than at Road F because the stream at Road F was too narrow and shallow to support many fish. Sampling locations and parameters are detailed in Sections 2 and 3 of this report. In general, sampling locations were selected that would permit comparisons upstream and downstream of NPDES outfalls. In instances where this approach was not feasible because effluents discharge into the headwaters of a stream, appropriate unimpacted reference were used for comparison purposes. This report summarizes the results of

Table 1. Sampling Locations for NPDES Biological Monitoring

LOCATION	SITE #	STATUS
Upper Three Runs Watershed		
Upper Three Runs, Road 8-1	3	Reference
Upper Three Runs, Road C (macroinvertebrates only)	2	Downstream from all discharges
Upper Three Runs, near Road A-2 (fish only)	18	Downstream from all discharges
Tims Branch near Road 2	1	Downstream from all discharges
Mill Creek, at Telephone Cable Crossing	4	Reference
McQueen Branch at Road F*	5	Downstream from all discharges
Crouch Branch, Road 4	6	Downstream from all discharges
Fourmile Branch Watershed		
Fourmile Branch, Road F (macroinvertebrates only)	7	Reference
Fourmile Branch, Road C	8	Downstream from F/H Areas
Fourmile Branch, Road A-6*	9	Downstream from all discharges but C-Area
Fourmile Branch, Road A	16	Downstream from all discharges
Pen Branch Watershed		
Pen Branch, Road C	10	Reference
Pen Branch, Road B	11	Reference
Indian Grave Br. near cooling tower	12	Downstream from all discharges
Pen Branch, Road A (macroinvertebrates only)	13	Downstream from all discharges
Pen Branch Road A13.2 (fish only)		Downstream from all discharges
Steel Creek Watershed		
Steel Creek, near Road C	14	Downstream from P-Area; upstream from L Lake
Meyers Branch, Old Dunbarton Rd.	15	Reference

*Location changed from 1997-1998 sampling program

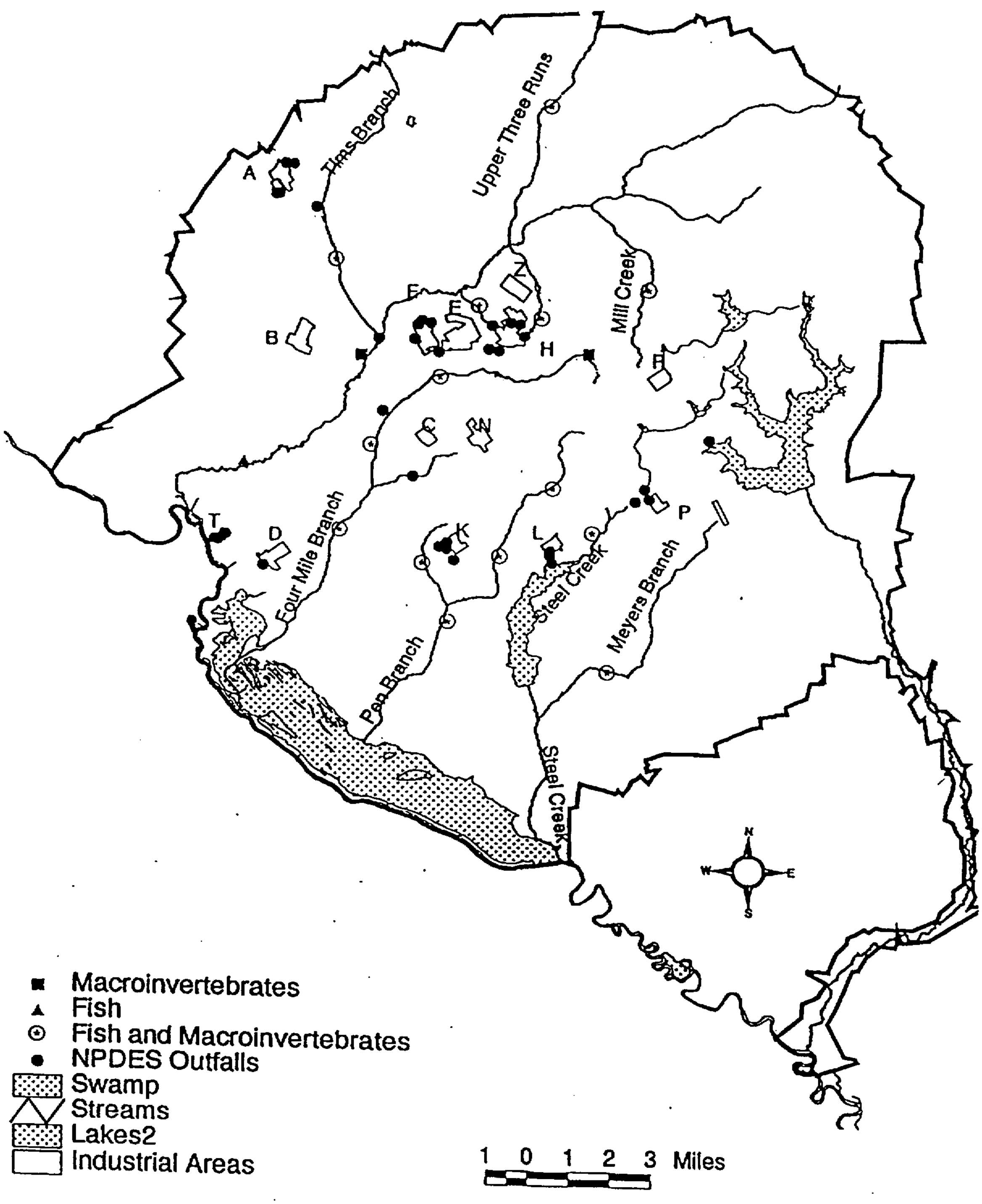

Figure 1. Map of the Savannah River Site showing sampling stations for fish and macroinvertebrates

the sampling that was conducted in 2000 and also compares these data to the data that were collected in 1997 and 1998.

1.1 Changes in NPDES Outfalls, 1997-1998 vs. 2000

Two NPDES outfalls have been eliminated from the SRS inventory since completion of the 1997-1998 biological survey: M-04, which discharged process wastewater from the Liquid Effluent Treatment Facility in M-Area to Tims Branch via the A-11 outfall and L-08, which discharged cooling water and stream water from L Area to L Lake.

2.0 Descriptions of Streams, Effluents, and Sampling Locations.

2.1 Upper Three Runs/Tributaries

Upper Three Runs is a fifth order stream that originates approximately 12 km north of the northern boundary of SRS and flows generally south, entering the Savannah River at River Mile (RM) 157.2 (Figure 1). Tributaries of Upper Three Runs that enter the stream along its flow path from north to south through the Savannah River Site include Tinker Creek, with its major tributaries of Mill Creek, Reedy Branch and McQueen Branch; Crouch Branch; and Tims Branch. With the exception of McQueen Branch, which enters Tinker Creek just before its confluence with Upper Three Runs, Tinker Creek and its tributaries have been largely uninfluenced by SRS activities, and these streams receive no NPDES discharges.

McQueen Branch originates just east of H-Area and flows generally northwest for about 4 km to its confluence with Tinker Creek. As shown in Table 2, McQueen Branch receives the discharge from the H-07 and S-04 NPDES discharges. These discharges consist primarily of neutralized wastewater, cooling water and storm water. McQueen Branch was also impacted by scouring and siltation during construction of the DWPF during the 1980's and early 1990's. Between 1987 and 1991 mean annual total suspended solids concentrations in the creek during high rain events (>1 cm in 24 hours) ranged between 153 and 256 mg/l, as compared to pre- and post-construction concentrations of 11 to 59 mg/l (Savannah River Ecology Laboratory, 1995) .

Crouch Branch is a small tributary of Upper Three Runs that originates just northwest of H-Area and flows northwest for about 2 km to Upper Three Runs. Crouch Branch receives NPDES discharges from the H-02 and H-04 outfalls, which primarily contain cooling water, steam condensate, Consolidated Incinerator Facility (CIF) treated wastewater, and stormwater. Crouch Branch was also impacted by scouring and siltation during construction of the DWPF. Between 1987 and 1991 mean annual total suspended solids concentrations during high rain events ranged between 120 and 401 mg/l, as compared to baseline levels of <15 mg/l (Savannah River Ecology Laboratory, 1995)

Tims Branch originates near A Area and flows southeast for about 8 km, entering Upper Three Runs just upstream from the Road C bridge. Tims Branch is the receiving stream for 4 NPDES outfalls (A-01, A-01A, A-11, and M-05), and a large portion of the flow in Tims Branch is comprised of NPDES effluents. These effluents include cooling water condensates, and water from lab drains, floor drains, two air strippers, an effluent

Table 2. SRS NPDES Outfalls, Receiving Streams and Contributing Waste Streams

Outfall	Receiving Stream	Inputs
Upper Three Runs Watershed (UTR)		
A-01	Tims Branch	cooling water, lab drains, air stripper effluent from A-01A, steam & A/C condensates
A-01A	Tims Branch via A-01	air stripper
A-11	Tims Branch	floor drains, condensate. Well flush water, cooling water, treated wastewater from M-04 and M-05
M-05	Tims Branch via A-11	air stripper effluent
F-01	UTR tributary	cooling water, blowdown, storm water
F-02	UTR tributary	cooling water, blowdown, storm water
F-03	UTR tributary	cooling water, steam condensate, blowdown, process water
F-05	UTR tributary	cooling water, steam condensate, storm water
H-02	Crouch Branch	cooling water, storm water
H-04	Crouch Branch	cooling water, storm water, Consolidated Incineration Facility wastewater, steam condensate
H-07	McQueen Branch	cooling water, blowdown, storm water
S-04	McQueen Br. tributary	neutralization waste water, cooling water, storm water
H-16	UTR	F/H Effluent Treatment Facility
Beaver Dam Creek Watershed (BDC)		
D-01A	BDC via D-01	sanitary effluent
Fourmile Branch Watershed (FMB)		
F-08	FMB tributary	cooling water, steam condensate, process wastewater, laundry effluent, water tank overflow, storm water
G-10	FMB	sanitary
H-08	FMB tributary	cooling water, steam condensate, ash basin, lab drains, storm water
H-12	FMB tributary	cooling water, In-Tank Precipitation Facility neutralized flush water, storm water
Pen Branch (PB)/Indian Grave Branch (IGB) Watershed		
K-06	IGB tributary	cooling water, blowdown, powerhouse waste, storm water
K-10	IBG	Infrequent diversion from K-18
K-12	IGB via K-18	sanitary
K-18	IGB	reactor cooling water basins, cooling water, sanitary from K-12
Steel Creek Watershed (SC)		
L-07	L-Lake	sanitary from L-07A, 186 basins, floor drains, storm water
L-07A	L-Lake via L-07	sanitary
Lower Three Runs Watershed (LTR)		
PP-01	Par Pond	rinse water and backwash from drinking water filter system
Savannah River (SR)		
X-04	SR swamp	welding quench sink water, steam condensate, storm water
X-08	SR	cooling water, sanitary from X-08A, process water, TNX Effluent Treatment Plant effluent from X-08B, air stripper effluent from X-08C
X-08A	SR via X-08	sanitary
X-08B	SR via X-08	TNX Effluent Treatment Plant effluent
X-08C	SR via X-08	air stripper effluent
X-19	SR	treated groundwater

treatment facility, and various other sources (see Table 2). Tims Branch also received inputs of metals from M Area during its early years of operation, and some of the metals (primarily aluminum, nickel, and uranium) are present in elevated concentrations in the depositional areas of Tims Branch.

Four NPDES discharges from F-Area (F-01, F-02, F-03 and F-05), consisting mainly of noncontact cooling water, blowdown, and steam condensate are discharged to flow paths that lead to Upper Three Runs. The H-16 outfall, which is the effluent from the F/H Effluent Treatment Facility (ETF) is the only NPDES outfall that discharges directly into Upper Three Runs. H-16 enters the stream just downstream from the Road C bridge. All NPDES effluents enter the portion of Upper Three Runs between its confluence with Tinker Creek and just downstream from the Road C bridge. In all, 13 NPDES outfalls enter the Upper Three Runs watershed (see Table 2). The upstream reference location in Upper Three Runs was the Road 8-1 bridge. Sampling locations downstream from SRS discharges include the Road C bridge (macroinvertebrates only), which is just downstream from the most-downstream NPDES discharge (H-16) as well as just downstream from Tims Branch, the most downstream tributary that contains NPDES discharges (Figure 1, Table 2) and near Road A-2 (fish only). Fish were sampled near Road A-2 instead of Road C because fish are routinely collected at Road C by the Environmental Monitoring Section (EMS) of WSRC, which may alter the community structure of the fish community at this location. Also sampled were Crouch Branch at Road 4, Tims Branch near Road 2, and McQueen Branch at Road F. In the 1997-1998 sampling program, McQueen Branch was sampled at Road Z. Since that time, beaver activity in the vicinity of Road Z has resulted in the formation of beaver ponds that provide aquatic habitat that is substantially different from that of the reference stream (Mill Creek); therefore the sampling location in McQueen Branch was moved upstream to Road F. Upstream reference locations for Crouch, McQueen, and Tims Branches were not available, since effluents discharge into the headwaters of all three of these tributaries. Mill Creek, an unimpacted tributary of Upper Three Runs, was sampled as a reference location for the tributaries of Upper Three Runs. However, Mill Creek is somewhat larger than the 3 streams that receive NPDES discharges.

2.2 Fourmile Branch

Fourmile Branch is a third order stream that originates southeast of H-Area and flows generally west and southwest for about 25 km, entering the Savannah River at RM 150.6, just across the river from the Vogtle Nuclear Power Plant. The first five km of the stream receive no NPDES discharges. Four NPDES outfalls (F-08, G-10, H-08 and H-12) discharge to Fourmile Branch and all of the discharges are to the portion of the stream located between just upstream from Road 4 to approximately 1 km upstream from Road A-7. NPDES discharges to the stream include cooling water, ash basin overflows, treated sanitary wastewater from the new central sanitary treatment plant, storm water and other miscellaneous sources (see Table 2). Fourmile Branch also receives inputs from the F/H seepline, which is primarily encompassed by the area between Roads 4 and C-4. Shallow groundwater from the old F/H seepage basins and the old Burial Ground outcrops near this section of Fourmile Branch. This water contains elevated levels of tritium, as well as above-background concentrations of some metals and other contaminants. The portion of Fourmile Branch from

approximately 0.5 km downstream from Road 3 to the Savannah River was subject to very high temperatures and flows until 1984, when the operation of C Reactor was discontinued. The habitat of the post-thermal streams still differs substantially from the habitat in streams that were not exposed to high temperatures and flows, primarily with respect to canopy cover, the composition of stream substrate, in-stream structure (size and amount of woody debris, etc.), and riparian vegetation. These habitat differences have had lasting influence on the biotic communities of the post-thermal streams.

Sampling locations in Fourmile Branch included Road F (macroinvertebrates only), which is upstream from all SRS discharges; Road C, which is downstream from the H-Area discharges; Road A-6 which is downstream from the F-Area outfall and sanitary treatment plant, but upstream of where the C-Area outfalls previously entered Fourmile Branch, and Road A, which is downstream from all SRS discharges, and is a post-thermal location. In the 1997-1998 round of sampling, macroinvertebrates were sampled at Road A-7, and fish were sampled at Road A-6 because there was better access. For consistency, in this round of sampling both fish and macroinvertebrates were sampled at Road A-6. Road A-6 is located approximately 300 m upstream from Road A-7 and contains similar habitat. In 1997-1998 fish were sampled near Road 4 (located between Road F and Road C). However, this location was not sampled in 2000 because it had been impounded by beavers and converted into a series of ponds and swamps. The IBI used on the SRS was developed for free flowing streams and would not be expected to produce accurate results for standing waters (Paller et al. 1996).

2.3 Pen Branch/Indian Grave Branch

Pen Branch is a third order stream that originates near the intersection of Roads F and 6 and flows generally southwest for approximately 17 km to the Savannah River swamp, exiting the swamp to the Savannah River via Steel Creek. Indian Grave Branch is a small tributary of Pen Branch that is located just west of K Area. It is about 4 km long and flows generally south, merging with Pen Branch approximately one km upstream of Road A. Four NPDES discharges (K-06, K-10, K-12, and K-18) enter Indian Grave Branch from K Area (Table 2); no effluents discharge directly to Pen Branch. The discharges to Indian Grave Branch consist primarily of cooling water, powerhouse wastewater, storm water, and a small quantity of treated sanitary effluent. Indian Grave Branch was also the receiving stream for the thermal discharge from K Reactor, which operated until 1988. Like Fourmile Branch, Indian Grave Branch and the portion of Pen Branch that was impacted by thermal discharge have very different habitat than the non-thermal streams. These habitat differences need to be considered when interpreting biological data from the post-thermal streams.

Sampling locations in Pen Branch and Indian Grave Branch included Pen Branch at Roads C and B, which are both upstream from all SRS discharges, Pen Branch at Road A (macroinvertebrates only), which is downstream from Indian Grave Branch and all SRS discharges, and Indian Grave Branch near the cooling tower, which is downstream of all existing K-Area NPDES discharges to this tributary. Fish were sampled near Road A in 1997-1998 but not during 2000 because beavers had impounded the stream near Road A converting it to a pond-like environment unsuitable for analysis with the IBI. During 2000, fish samples were instead collected near Road

A13.2, which is located downstream of Road A. Because effluents discharge into the headwaters of the stream, no upstream reference location could be sampled in Indian Grave Branch.

2.4 Steel Creek/Meyers Branch

Steel Creek is a third order stream that originates west of P Reactor and flows south for about 18 km, entering the Savannah River at RM 141.6. A portion of Steel Creek was impounded in 1985 to form L Lake, a 1000 acre cooling reservoir. The lake has not received thermal discharges since 1988. Meyers Branch is a major tributary of Steel Creek that originates east of P Reactor and flows generally southwest for about 12 km, merging with Steel Creek approximately one km downstream from the L-Lake dam. Steel Creek is the receiving stream for two NPDES outfalls (L-07 and L-07A; Table 2). The discharges consist primarily of cooling water, building drains, stormwater, and a small volume of treated sanitary effluent. In the past, the upper reach of Steel Creek upstream from L Lake received NPDES discharges from several outfalls in P Area, but this portion of Steel Creek has received no NPDES discharges since January 1998. However, during the fall of 2000, water from the Savannah River was diverted to L Lake via the P-19 outfall during an extended pumping outage that prevented pumping river water to L Lake via the L-07 outfall. Meyers Branch has been largely unimpacted by SRS activities.

Sampling locations in Steel Creek and Meyers Branch included Steel Creek near Road C, which is downstream from the P-Area discharges into Steel Creek but upstream from L Lake and Meyers Branch at old Dunbarton Road. Two NPDES outfalls from L Area discharge to L Lake, which is located downstream from the sampling location in Steel Creek. However, the volume of the discharges is small and would be diluted by the entire volume of L Lake prior to discharging into lower Steel Creek. Lower Steel Creek was not sampled because previous studies indicated that the stream community was influenced by the lentic community of L Lake, and it would be impossible to distinguish between possible outfall impacts and the greater influence of L Lake discharges into the stream. Meyers Branch at old Dunbarton Road was sampled as a reference location for Steel Creek and some of the other sampling locations.

2.5 Other Water Bodies/NPDES Discharges

A number of NPDES outfalls discharge to other locations on the SRS (Table 2). Outfall D-01A consists of treated sanitary discharge that is discharged to the D-01 outfall. Outfall PP-01 consists of a very small amount of backwash water from a drinking water filter system at the Par Pond laboratory that discharges to Par Pond. However, neither Beaver Dam Creek nor Par Pond/Lower Three Runs were included in the permit condition that requires biological sampling. Six outfalls from TNX discharge indirectly to the Savannah River. Due to the small volume of effluent in relation to the large dilution factor provided by the river, and because previous studies have not detected any impact from SRS operations to the Savannah River, studies in the Savannah River were not included in this study, but a discussion of previous biological studies conducted on the Savannah River is presented in Section 4.5.

3.0 Methods

3.1 Habitat Evaluation/Water Chemistry

Physical habitat data were collected from each fish assemblage sample site to assist in the interpretation of the biological data. These data were collected from transects running across the stream perpendicular to the direction of water flow. Except at the sample sites in Upper Three Runs, there were three transects evenly spaced within each 50 m section for a total of nine habitat transects per site. Because of the difficulty in obtaining habitat data from Upper Three Runs, which was comparatively deep and wide, there were only two evenly spaced habitat transects per site in this stream. The following habitat data were collected at each transect:

1) Stream width (distance from waters edge to waters edge).
2) Depth of the stream (nearest 0.01 m) at a minimum of approximately 20%, 40%, 60%, and 80% of the distance from the left bank to the right bank.
3) Current velocity (cm/s) at each point where depth was measured. Where depth equaled or exceeded 0.6 m, two current velocity measurements were taken, one at 0.2 times the depth and one at 0.8 times the depth. Where the depth was less than 0.6 m, only one measurement was taken at 0.6 times the distance from the surface.
4) Predominant substrate types (mud, sand, gravel, rocks) in the vicinity of the transect (i.e., 3 m upstream from the transect and 3 m downstream from the transect). Visual estimate.
5) Bottom area (nearest 5%) covered by debris (detritus and leaves). Visual estimate.
6) Number of logs (i.e., recumbent wood in excess of 6 cm in diameter) in the vicinity of the transect.
7) Number of stumps in the vicinity of the transect.
8) Number of cypress knees in the vicinity of the transect.
9) Bottom area (nearest 5%) covered by fibrous root systems. Visual estimate.
10) Bottom area (nearest 5%) covered by brush piles/log jams. Visual estimate.
11) Aquatic macrophyte cover (nearest 5%) and the predominant types (submerged, emergent, floating) in the vicinity of the transect. Visual estimate.
12) Amount of stream surface (nearest 5%) overhung by low growing riparian vegetation (e.g. shrubs, grasses, and small trees) in the vicinity of the transect. Visual estimate.
13) Canopy cover (nearest 5%) and the predominant canopy types (cypress/tupelo forest, hardwood forest, pine forest) in the vicinity of the transect. Visual estimate.
14) Bank erosion on a scale of zero (none) to severe (three). Visual Estimate.

To maintain consistency and facilitate comparisons among sample reaches, all habitat variables requiring visual estimation (i.e., 4, 5, 8, 9, 10, 11, and 12) were recorded by the same person.

Physical and chemical data collected in conjunction with the biological data included water temperature, dissolved oxygen, pH and specific conductance. These data were collected by ETT Environmental, Greenville, SC (SCDHEC Certification # 23104) at the time that the multiplate samples were retrieved. Temperature was measured to the nearest degree using a mercury thermometer, dissolved oxygen was measured using a YSI Model 51B dissolved oxygen meter, pH was measured using a Fisher Model 1001

pH meter, and specific conductance was measured using a VWR Model 604 conductivity meter.

3.2 Macroinvertebrates

3.2.1 Sampling Methods

Sampling and identification of macroinvertebrates for this sampling program were performed by ETT Environmental (SCDHEC Certification # 23104). At each sampling location, five replicate Hester-Dendy multiplate samplers (Figure 2), each having a surface area of 0.179 m^2 were deployed and allowed to colonize for 28 days. The samplers were retrieved and returned to the laboratory for processing. In the laboratory, the samplers were disassembled and organisms gently removed from the plates using a soft brush or a stream of water from a wash bottle. Organisms were preserved in 70% ethanol until identified to the lowest practical taxon (usually genus).

Although multiplate samplers provide a uniform substrate for macroinvertebrate sampling, the species composition and relative abundance of macroinvertebrate assemblages collected from multiplate samplers differ from natural substrates. Some taxa are over-represented on multiplate samplers, while other taxa are under-represented or completely absent. In order to perform a thorough assessment of the macroinvertebrate community at each sampling site, qualitative sampling of natural substrates was also performed. At the time that the multiplates were retrieved, sampling of natural substrates (leaf packs, snags, root mats, woody debris, etc.) present at the sampling site was performed for one man hour per sampling station, and macroinvertebrates present on the substrates were collected, preserved, and returned to the laboratory for identification.

3.2.2 Data Analysis

Descriptive Parameters - The multiplate data were analyzed for the parameters listed in Table 3. In addition, SCDHEC's Bioclassification of Streams Procedure (SCDHEC, 1998) was performed on both the quantitative and qualitative data. This procedure assigns numerical scores to North Carolina biotic index values (Lenat, 1993) and EPT taxa richness values. The two scores are then averaged to obtain a Bioclassification score, which ranges from 5 (excellent) to 1 (poor). The scores of sampling sites located downstream from NPDES discharges are then compared to the scores of reference sites, using the following decreases in Bioclassification scores to assess the level of impairment:

Level of Impairment	Decrease in Bioassessment Score
Unimpaired	≤ 0.4
Slightly impaired	0.6 - 1.4
Moderately impaired	1.6 - 2.4
Severely impaired	≥ 2.6

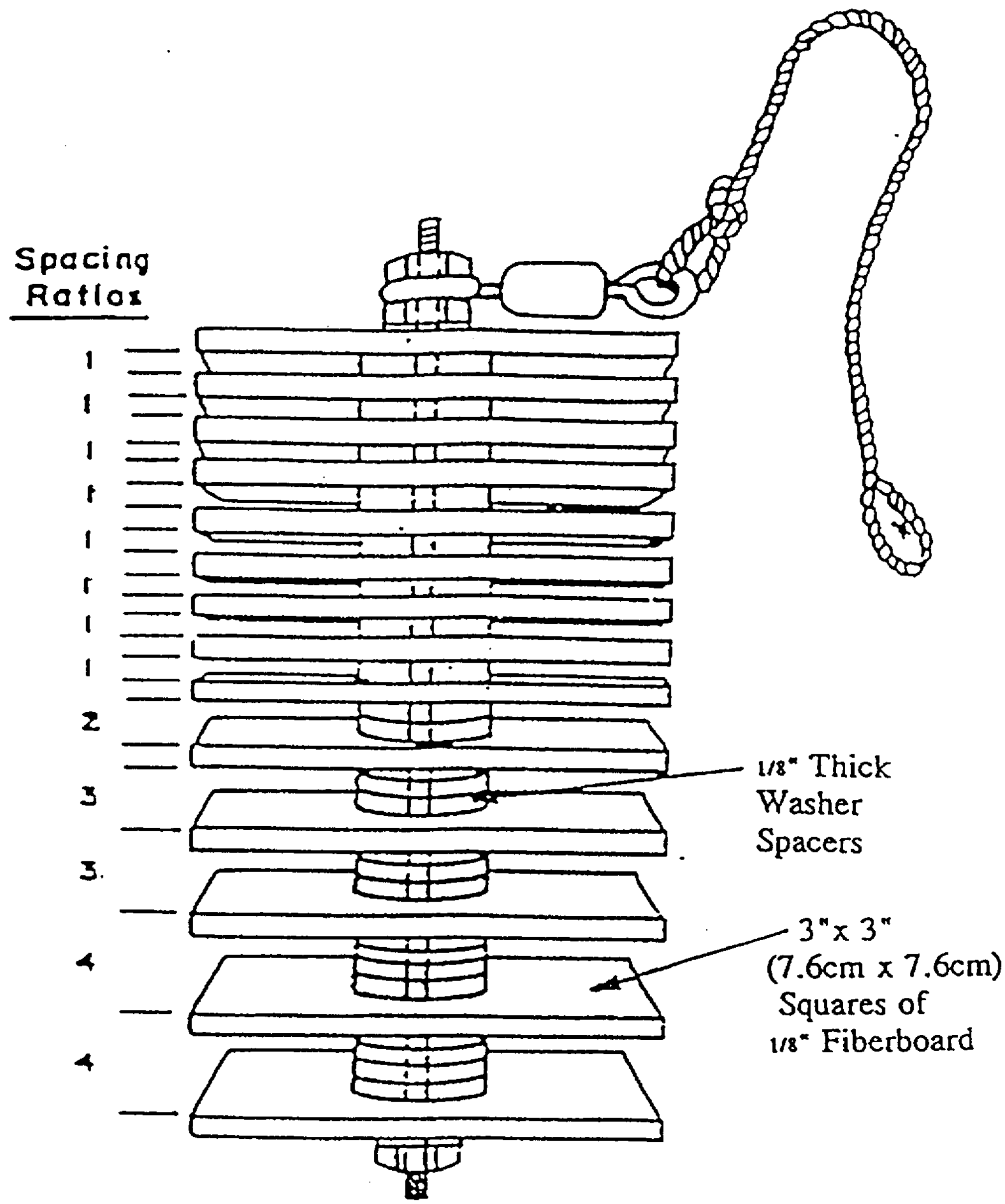

Figure 2. Hester-Dendy Multiplate Sampler

Table 3. Metrics for Macroinvertebrate Multiplate and Qualitative Data

Quantitative (Multiplate) Data
Total number of taxa
Mean Number of taxa/sampler
Mean density of organisms (number/m^2)
Biomass (g ash-free dry weight/m^2)
Total number of EPT (Ephemeroptera, Plecoptera, Trichoptera) taxa
Relative abundance (%) of major taxonomic groups
Relative abundance (%) of functional feeding groups
Relative abundance (%) of functional feeding group biomass
Listing of dominant taxa (>5% abundance)
North Carolina Biotic Index (NCBI; Lenat, 1993)

Qualitative Data
Total number of taxa
Total number of EPT taxa
North Carolina Biotic Index (NCBI)

3.3 Fish

3.3.1 Sampling Methods

Fish assemblages were sampled at 15 sites. Five of these (one in Mill Creek, one in Meyers Branch, two in Pen Branch, and one in Upper Three Runs) were located upstream from SRS NPDES outfalls (Figure 1). The other sites were located downstream from SRS NPDES discharges. With the exception of the uppermost portion of Fourmile Creek, all stream reaches sampled for macroinvertebrates were also sampled for fish; although, in some cases, the exact locations sampled differed slightly (Figure 1).

Three 50 m stream segments were electrofished at each sample site. All sites except for those in Upper Three Runs were sampled with a Coffelt backpack electrofisher powered by a generator, a Smith-Root backpack electrofisher powered by a battery, or a Smith-Root backpack electrofisher powered by a generator. A single pass was made through each 50 m segment at each site while moving upstream. All microhabitats were carefully sampled in an effort to obtain as many species and individuals as possible by collecting them with dip nets after they had been stunned by DC current. At relatively narrow sites (under 4-5 m) we used one backpack electrofisher and a two or three person crew. At wider sites, two back pack electrofishers and two crews were used, with a crew covering each bank as both moved upstream simultaneously. To sample Upper Three Runs, the widest (up to 20 m in the sample areas) and deepest stream (up to 2.1 m), a 4.5 m boat with a boat mounted generator and a Smith-Root electrofisher was used. Each bank was sampled separately in Upper Three Runs using the previously described protocol. All fish were identified to species and released.

3.3.2 Data Analysis

Fish assemblage data were analyzed using the Index of Biotic Integrity (IBI). The IBI is a bioassessment method used to assess the biotic integrity of streams. Biotic integrity is the ability of a stream to support a self sustaining biological community and ecological processes typical of undisturbed, natural conditions (Angermeier and Karr 1994). The IBI uses fish assemblage data to assess biotic integrity. It is composed of a number of community, population, and organism level variables that are ecologically important and sensitive to environmental disturbances of various types. These variables are measured at assessment sites, compared to those in a range of similar but undisturbed benchmark sites, and the results summarized in a single number that reflects the extent to which the assessment site resembles the benchmark. The IBI has been endorsed by the USEPA (Plafkin et al. 1989) and has been adapted for use throughout the United States and in a number of foreign countries. It has been modified for use in SRS streams where it accurately discriminated undisturbed sites from sites affected by physical habitat alterations and chemical pollution (Paller et al. 1996).

The IBI was calculated using methods presented in Paller et al. 1996 and Paller and Dyer 1997. IBI metrics and scoring criteria for the metrics are listed in Table 4. This methodology adjusts for differences in stream size and sample area making it possible to directly compare IBI values from streams and sample areas of different size. The highest IBI value that can be obtained is 50. The IBI was calculated for each 50 m segment at each location. The statistical significance of differences between the average IBI at the undisturbed sample sites and the average IBI at the sample site receiving NPDES discharges was assessed with the Kruskal-Wallis test ($P \leq 0.05$), although results must be treated with caution because of small sample sizes. In addition, the average IBI at each sample site was compared to IBI values at 29 undisturbed locations sampled during previous sampling programs. These data (hereafter referred to as historical data) are described more fully in Paller and Dyer (1997).

4.0 Results

A master species list, containing all of the macroinvertebrate taxa collected from both quantitative and qualitative sampling can be found in Table 5. A list of dominant species, which included any species that comprised 5% or more of the organisms collected from quantitative or qualitative sampling of natural substrates can be found in Table 6. The remaining macroinvertebrate data are organized into three tables, by watershed (Upper Three Runs; Fourmile Branch; Pen Branch/Indian Grave Branch, and Steel Creek/Meyers Branch). Also included are summary data from the 1997 survey, for comparison.

4.1 Upper Three Runs Watershed

4.1.1 Macroinvertebrates - Upper Three Runs and Tributaries

As discussed in Section 2.1, sampling was performed at two locations in Upper Three Runs: Road 8-1, which is upstream from all NPDES discharges to the stream and just downstream from Road C, which is downstream from all NPDES discharges and tributaries that receive

Table 4. Metrics and scoring criteria used in the Index of Biotic Integrity (IBI) as modified by Paller et al (1996). The modified IBI is calculated by summing the scores for the individual metrics.

	Scoring criteria		
Metrics	1	3	5
Species richness			
Adjusted number species[a]	<70	70-90	>90
Adjusted number cyprinid species[a]	<55	55-80	>80
Adjusted number piscivorous species[a]	<65	65-85	>85
Number darter species	0	1-2	≥3
Number madtom species	0	1	≥2
Number intolerant species	0	1	≥2
Species composition			
Percent tolerant species	>15	5-15	<5
Percent sunfish species	>45	25-45	<25
Trophic composition			
Percent insectivorous cyprinids	<20	20-35	>35
Percent generalized insectivores	>75	50-75	<50
Fish abundance (Number/100 m^2)			
Stream orders 1-3, ≥4 passes	<25		≥25
Stream orders 1-3, 1 pass	<10		≥10
Stream order 4, ≥4 passes	<5		≥5
Stream order 4, 1 pass		<2	
Fish condition			
Percent with disease or anomalies	>5	>2-5	0-2

[a] Species number expressed as a percentage of the number of species expected in an unimpacted stream after adjusting for the effects of sample area, stream order, and sampling effort (Paller et al. 1996). Maximum percentage equals 100.

discharges. With respect to most of the parameters that were measured, Upper Three Runs at Road 8-1 and Road C were fairly similar (Table 7). Slightly more taxa were collected at Road C than at Road 8-1 in the quantitative sampling (33 vs. 29), but the reverse was seen for the qualitative data (52 at Road C; 56 at Road 8-1) and for qualitative and quantitative data combined (64 at Road C; 70 at Road 8-1). Eleven EPT taxa were collected at Road C; nine were collected at Road 8-1. The North Carolina biotic index was 5.78 at Road C, and was slightly lower (better) at Road 8-1 (5.53). By far, the most dominant group of taxa at both locations were dipteran midges (about 80% at both locations), with Orthocladiinae being the most dominant group of midges 51.9% at Road 8-1; 67.3% at Road C. Tanytarsini and Chironomini midges

Table 5. Master Species List for Quantitative/Qualitative Sampling Combined, November 2000

	Upper Three Runs System						Fourmile Branch System				Pen Branch System				Steel Cr. Sys.	
	Upper Three Runs Rd. 8-1	Upper Three Runs Rd. C	Mill Creek	Tims Branch Rd. 2	McQueens Branch Rd F	Crouch Branch Rd. 4	Fourmile Branch Rd. F	Fourmile Branch Rd. C	Fourmile Br. Rd. A-6	Fourmile Branch Rd. A	Pen Branch Rd. C	Pen Branch Rd. B	Pen Branch Rd. A	Indian Grave Branch	Steel Cr. near Rd. C	Meyers Branch
ORDER EPHEMEROPTERA (mayflies)																
Acerpenna pygmaea	x															
Baetis dubium		x														
Baetis frondalis	x									x					x	x
Baetis intercalaris			x					x		x	x	x	x	x		
Baetis nr. punctiventris	x									x			x			
Baetis propinquus												x	x			
Caenis diminuta	x	x	x	x										x		x
Dannella simplex													x			
Ephemerella catawba/inconstans				x								x	x		x	
Ephemerella nr. doris									x							
Eurylophella		x	x							x					x	
Hexagenia	x	x	x													
Isonychia		x								x					x	
Leptophlebia			x					x			x					
Neoephemera youngi		x							x				x			
Paraleptophlebia	x	x	x						x							x
Stenonema modestum/smithae	x	x	x	x				x	x	x	x	x	x	x	x	x
ORDER PLECOPTERA (stoneflies)																
Acroneuria abnormis	x	x											x			
Allocapnia	x	x	x		x			x		x	x	x	x	x	x	x
Clioperla clio			x								x	x	x		x	
Eccoptura xanthenes			x													
Haploperla brevis									x							
Isoperla bilineata															x	
Isoperla dicala		x	x									x	x			
Paragnetina fumosa	x	x											x			
Perlesta placida	x	x	x									x	x		x	
Pteronarcys	x	x														
Taeniopteryx		x	x						x	x	x	x	x	x		
Taeniopteryx nr. metequi		x	x										x			
ORDER TRICHOPTERA (caddisflies)																
Agarodes libalis	x															
Anisocentropus pyraloides			x													
Brachycentrus nigrosoma	x	x											x			
Brachycentrus numerosus		x														

Table 5. Master Species List for Quantitative/Qualitative Sampling Combined, November 2000

	Upper Three Runs System						Fourmile Branch System				Pen Branch System				Steel Cr. Sys.	
	Upper Three Runs Rd. 8-1	Upper Three Runs Rd. C	Mill Creek	Tims Branch Rd. 2	McQueens Branch Rd F	Crouch Branch Rd. 4	Fourmile Branch Rd. F	Fourmile Branch Rd. C	Fourmile Br. Rd. A-6	Fourmile Branch Rd. A	Pen Branch Rd. C	Pen Branch Rd. B	Pen Branch Rd. A	Indian Grave Branch	Steel Cr. near Rd. C	Meyers Branch
ORDER TRICHOPTERA (cont.)																
Cernotina									x	x				x		x
Cheumatopsyche		x	x		x	x			x	x	x	x	x	x	x	x
Chimarra aterrima		x	x							x				x	x	x
Chimarra socia													x			
Diplectrona modesta	x															
Heteroplectron americanum											x					
Hydropsyche betteni										x				x	x	
Hydropsyche elissoma	x	x														
Hydropsyche nr. venularis													x			
Hydroptila														x		
Lepidostoma		x														
Limnephilidae										x						
Lype diversa			x				x		x			x			x	
Macrostemum carolina	x															
Micrasema rusticum																x
Micrasema wataga	x	x														
Neureclipsis		x														
Oecetis sp.			x						x						x	
Oxyethira			x					x	x					x		
Oxyethira janella													x			
Phylocentropus	x		x									x				x
Polycentropus		x														
Ptilostomis							x									x
Pycnopsyche															x	
Triaenodes			x									x				x
ORDER ODONATA (dragonflies)																
Aeshna umbrosa							x									
Anax junius	x															
Anax longipes							x									
Argia sedula	x					x		x	x	x				x		
Argia sp			x							x		x				
Boyeria vinosa	x	x	x					x				x			x	
Calopteryx dimidiata	x	x						x	x		x	x	x		x	
Cordulegaster maculata			x		x	x										x
Enallagma divagans							x	x	x	x		x		x	x	x
Enallagma traviatum			x													

Table 5. Master Species List for Quantitative/Qualitative Sampling Combined, November 2000

	Upper Three Runs System						Fourmile Branch System				Pen Branch System				Steel Cr. Sys.	
	Upper Three Runs Rd. 8-1	Upper Three Runs Rd. C	Mill Creek	Tims Branch Rd. 2	McQueens Branch Rd F	Crouch Branch Rd. 4	Fourmile Branch Rd. F	Fourmile Branch Rd. C	Fourmile Br. Rd. A-6	Fourmile Branch Rd. A	Pen Branch Rd. C	Pen Branch Rd. B	Pen Branch Rd. A	Indian Grave Branch	Steel Cr. near Rd. C	Meyers Branch
ORDER ODONATA (cont.)																
Erythrodiplax connata																x
Gomphus lividus			x					x	x			x				x
Hagenius brevistylus		x														
Libellula sp.	x													x		x
Macromia sp.			x												x	x
Neurocordulia virginiensis	x	x								x						
Ophiogomphus mainensis											x					
Progomphus		x	x								x					
ORDER HETEROPTERA (true bugs)																
Corixidae																x
Mesovelia mulsanti									x	x	x				x	
Metrobates hesperius									x	x						
Ranatra															x	
Rhagovelia obesa	x	x			x											
Trepobates											x					
O. MEGALOPTERA (hellgrammites)																
Sialis	x	x							x							
Corydalus cornutus						x		x								
Nigronia serricornis	x	x						x								
ORDER COLEOPTERA (beetles)																
Agabus/Ilybius				x			x									
Anchytarsus bicolor						x						x				
Ancyronyx variegatus		x	x	x				x			x					
Berosus sp.									x							
Coptotomus sp.							x									
Curculionidae														x		
Dineutus discolor	x															
Dineutus sp.							x		x							
Dubiraphia bivittata								x								x
Dubiraphia sp.	x															
Ectopria sp.	x		x													
Hydrochus sp.													x			
Hydroporus sp.			x	x			x	x			x	x				x
Hydroporus sp. 2	x															

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Table 5. Master Species List for Quantitative/Qualitative Sampling Combined, November 2000

	Upper Three Runs System						Fourmile Branch System				Pen Branch System				Steel Cr. Sys.	
	Upper Three Runs Rd. 8-1	Upper Three Runs Rd. C	Mill Creek	Tims Branch Rd. 2	McQueens Branch Rd F	Crouch Branch Rd. 4	Fourmile Branch Rd. F	Fourmile Branch Rd. C	Fourmile Br. Rd. A-6	Fourmile Branch Rd. A	Pen Branch Rd. C	Pen Branch Rd. B	Pen Branch Rd. A	Indian Grave Branch	Steel Cr. near Rd. C	Meyers Branch
ORDER COLEOPTERA (cont.)																
Macronychus glabratus		X	X						X	X	X	X	X			
Microcylloepus pusillus			X					X		X			X			
Optioservus sp.		X													X	
Oulimnius sp.	X															
Peltodytes sexmaculatus													X	X		
Peltodytes sp.						X										
Rhantus callidus																X
Sperchopsis tessellatus		X														
Stenelmis crenata		X														
Stenelmis sinuata								X								
Stenelmis sp.		X	X	X	X			X	X	X		X	X			X
ORDER DIPTERA - other than midges																
Antocha sp.				X									X			
Bezzia sp.		X									X					
Chaoborus sp.															X	
Chelifera sp.	X															
Culex sp.	X						X			X						
Ectemnia invenusta	X	X														
Hemerodromia	X		X	X		X			X			X				
Hexatoma		X	X		X											X
Limoninae										X						
Palpomyia			X									X				
Probezzia																X
Prosimulium														X		
Simulium jonesi			X													
Simulium nr. tuberosum	X	X	X		X					X		X	X		X	X
Simulium nr. venustum	X	X	X							X		X		X		X
Simulium sp.									X							
Tipula (Yamatotipula)			X										X			
Tipula (Nippotipula)					X								X			
ORDER DIPTERA - (Tanypodinae)																
Ablabesmyia janta gp.						X										
Ablabesmyia mallochi	X		X					X	X	X		X	X	X	X	X
Ablabesmyia nr. monilis														X		
Clinotanypus pinguis	X	X							X					X		

Table 5. Master Species List for Quantitative/Qualitative Sampling Combined, November 2000

	Upper Three Runs System						Fourmile Branch System				Pen Branch System				Steel Cr. Sys.	
	Upper Three Runs Rd. 8-1	Upper Three Runs Rd. C	Mill Creek	Tims Branch Rd. 2	McQueens Branch Rd F	Crouch Branch Rd. 4	Fourmile Branch Rd. F	Fourmile Branch Rd. C	Fourmile Br. Rd. A-6	Fourmile Branch Rd. A	Pen Branch Rd. C	Pen Branch Rd. B	Pen Branch Rd. A	Indian Grave Branch	Steel Cr. near Rd. C	Meyers Branch
Tanypodinae (cont.)																
Conchapelopia/Meropelopia	x		x			x		x	x	x		x	x			x
Helopelopia sp.																x
Labrundinia pilosella	x		x	x		x		x		x	x	x	x	x	x	x
Paramerina sp.	x					x										
Procladius sp.									x				x			
Zavrelimyia			x							x	x			x		x
ORDER DIPTERA - (Orthocladiinae)																
Brillia flavifrons	x	x	x									x				x
Corynoneura nr. taris		x	x	x	x	x		x	x	x	x		x		x	x
Corynoneura sp. 4			x			x			x			x		x	x	x
Cricotopus bicinctus	x	x				x		x	x	x		x	x	x	x	x
Cricotopus/ Orthocladius annectens	x														x	
Diamesinae - Potthastia longimana	x											x	x	x	x	
Eukiefferiella													x			
Genus nr. Paracladius													x			
Nanocladius					x			x					x	x	x	x
Orthocladius (Euorthocladius) sp.										x			x	x		
Orthocladius obumbratus										x						
Orthocladius sp.															x	
Parakiefferiella sp.		x	x				x	x	x	x					x	x
Parametriocnemus lundbecki	x	x	x	x	x	x			x	x	x	x	x	x	x	x
Psectrocladius sp.														x		x
Rheocricotopus robacki	x	x	x	x	x			x	x	x		x	x	x		x
Rheocricotopus tuberculatus				x							x					
Rheosmittia sp.																x
Synorthocladius semivirens	x	x												x		
Thienemanniella fusca gp.	x	x	x		x					x			x			x
Thienemanniella xena gp.	x	x	x		x			x	x	x		x	x	x	x	x
Tvetenia discoloripes gp.	x	x	x							x		x	x	x		x
Tvetenia paucunca gp.		x			x							x	x		x	
Unniella multivirga	x		x								x	x			x	x
ORDER DIPTERA - (Chironomini)																
Chironomus sp.				x	x	x	x	x	x		x				x	
Cladopelma sp.																x
Cryptochironomus fulvus gp.						x		x							x	

Table 5. Master Species List for Quantitative/Qualitative Sampling Combined, November 2000

	Upper Three Runs System						Fourmile Branch System				Pen Branch System				Steel Cr. Sys.	
	Upper Three Runs Rd. 8-1	Upper Three Runs Rd. C	Mill Creek	Tims Branch Rd. 2	McQueens Branch Rd F	Crouch Branch Rd. 4	Fourmile Branch Rd. F	Fourmile Branch Rd. C	Fourmile Br. Rd. A-6	Fourmile Branch Rd. A	Pen Branch Rd. C	Pen Branch Rd. B	Pen Branch Rd. A	Indian Grave Branch	Steel Cr. near Rd. C	Meyers Branch
Chironomini (cont.)																
Dicrotendipes nr neomodestus								x	x	x			x	x		x
Dicrotendipes simpsoni											x					
Microtendipes nr. rydalensis	x	x														
Microtendipes pedellus			x						x		x	x				x
Phaenopsectra flavipes	x		x			x		x	x		x	x				x
Polypedilum aviceps	x	x	x		x							x	x	x	x	
Polypedilum fallax	x				x	x			x		x	x				x
Polypedilum halterale								x		x		x		x		
Polypedilum illinoense	x	x	x		x		x		x	x	x				x	x
Stenochironomus			x													
Tribelos jucundum	x		x		x			x							x	
ORDER DIPTERA - (Tanytarsini)																
Cladotanytarsus	x		x													
Paratanytarsus	x						x									
Rheotanytarsus distinctissimus gp.	x	x	x	x	x			x	x	x	x	x	x	x	x	x
Tanytarsus	x	x	x		x			x	x	x	x	x	x	x	x	x
Tanytarsus sp. 2																x
Zavrelia															x	x
PHYLUM ANNELIDA (worms,leeches)																
Naididae				x												x
Nais sp.							x							x		
Tubificidae (w/o cap. setae)	x								x		x					
PHYLUM MOLLUSCA (clams, snails)																
Amnicola	x		x													
Campeloma decisum	x		x								x	x		x		x
Corbicula fluminea			x						x	x		x	x	x	x	
Ferrissia sp.																x
Physella								x	x						x	
Planorbella trivolvis										x				x		x
Sphaerium							x		x							x
CLASS CRUSTACEA/MISCELLANEOUS																
ACARI- Hydracarina			x							x			x	x		x
Cambarinae (female)		x	x		x			x			x	x	x	x		x

Table 5. Master Species List for Quantitative/Qualitative Sampling Combined, November 2000

	Upper Three Runs System						Fourmile Branch System				Pen Branch System				Steel Cr. Sys.	
	Upper Three Runs Rd. 8-1	Upper Three Runs Rd. C	Mill Creek	Tims Branch Rd. 2	McQueens Branch Rd F	Crouch Branch Rd. 4	Fourmile Branch Rd. F	Fourmile Branch Rd. C	Fourmile Br. Rd. A-6	Fourmile Branch Rd. A	Pen Branch Rd. C	Pen Branch Rd. B	Pen Branch Rd. A	Indian Grave Branch	Steel Cr. near Rd. C	Meyers Branch
CRUSTACEA/MISC. (cont.)																
Hyallela azteca				x				x	x	x			x	x	x	x
Palaemonetes paludosus	x	x	x							x	x	x	x			x
COLLEMBOLA																x
LEPIDOPTERA - *Parapoynx obscuralis*	x	x	x													
TOTAL NUMBER OF TAXA	70	64	72	18	23	19	16	38	48	50	35	50	56	46	49	66

Table 6. Dominant Taxa Collected on Multiplate Samplers (Quantitative) and from Qualitative Sampling of Natural Substrates, November 2000

	Upper Three Runs System						Fourmile Branch System				Pen Branch System				teel Cr. Syste	
	Upper Three Runs Road 8-1	Upper Three Runs Road C	Mill Creek at Telephone Cable Crossing	Tims Branch Road 2	McQueens Branch Road F	Crouch Branch Road 4	Fourmile Branch Road F	Fourmile Branch Road C	Fourmile Branch Road A-6	Fourmile Branch Road A	Pen Branch Road C	Pen Branch Road B	Pen Branch Road A	Indian Grave Branch Road B	Steel Creek east of Road C	Meyers Branch at Old Dunbarton Rd.
Annelida																
Naididae				ql												
Nais sp.							qn									
Crustacea																
Cambarinae											ql					
Hyalella azteca				ql						ql				qn ql	ql	
Palaemonetes paludosus											ql					
Mollusca																
Corbicula fluminea									ql	ql		ql				
Campeloma decisum											ql					
Sphaerium sp.							ql									
Ephemeroptera																
Baetis intercalaris										ql			qn			
Ephemerella catawba/inconstans															qn	
Ephemerella sp.				qn												
Leptophlebia sp.											qn					
Neoephemera sp.		ql														
Stenonema modestum/smithae			qn	qn							qn	qn			qn	
Plecoptera																
Acroneuria abnormis	ql															
Allocapnia sp.											qn	qn			ql	
Perlesta placida	ql											qn				
Trichoptera																
Brachycentrus nigrosoma	ql															
Cheumatopsyche spp.		ql			ql	ql							qn ql	ql		
Hydropsyche betteni														ql		
Hydropsyche elissoma	ql	ql														
Odonata																
Aeshna umbrosa							ql									
Anax longipes							ql									
Boyeria vinosa								ql								
Enallagma divagens								ql	ql							ql
Progomphus sp.											ql					

Table 6. Dominant Taxa Collected on Multiplate Samplers (Quantitative) and from Qualitative Sampling of Natural Substrates, November 2000

	Upper Three Runs System						Fourmile Branch System				Pen Branch System				Steel Cr. System	
	Upper Three Runs Road 8-1	Upper Three Runs Road C	Mill Creek at Telephone Cable Crossing	Tims Branch Road 2	McQueens Branch Road F	Crouch Branch Road 4	Fourmile Branch Road F	Fourmile Branch Road C	Fourmile Branch Road A-6	Fourmile Branch Road A	Pen Branch Road C	Pen Branch Road B	Pen Branch Road A	Indian Grave Branch Road B	Steel Creek east of Road C	Meyers Branch at Old Dunbarton Rd.
Heteroptera																
Mesovelia mulsanti											ql					
Coleoptera																
Ancyronyx variegatus				ql												
Dubiraphia bibittata																ql
Hydroporus sp.				ql			qn									
Stenelmis sp.				ql	qn			ql								
Non-Chironomid Dipterans																
Bezzia sp.											ql					
Culex sp.							ql									
Hemerodromia sp.				qn												
Simulium nr. tuberosum			ql										ql			
Simulium nr. venustum														ql		
Tipula sp.					qn											
Chironomidae																
Chironomini																
Chironomus sp.				qn			qn ql									
Dicrotendipes nr. neomodestus																qn ql
Microtendipes nr. rydalensis	qn															
Phaenopsectra flavipes											qn					
Polypedilum aviceps			qn ql		qn ql							ql	ql	ql	qn ql	
Polypedilum illinoense			qn		qn						ql					ql
Orthocladiinae																
Corynoneura nr. taris	qn	qn			qn	ql		qn			qn					
Corynoneura sp. 4						qn						qn ql				
Cricotopus bicinctus										ql			ql	qn		
Cricotopus/Orthocladius annectens	ql														ql	
Parametriocnemus lundbecki	qn ql										qn	qn ql	qn			qn
Rheocricotopus robacki	qn	qn			ql											
Rheocricotopus tuberculatus				ql												
Thienemanniella xena gp.	qn	qn						qn								
Tvetenia discoloripes gp.														ql		
Tvetenia paucuna gp..												ql				
Unniella multivirga															ql	

Table 6. Dominant Taxa Collected on Multiplate Samplers (Quantitative) and from Qualitative Sampling of Natural Substrates, November 2000

	Upper Three Runs System						Fourmile Branch System				Pen Branch System				Steel Cr. System	
	Upper Three Runs Road 8-1	Upper Three Runs Road C	Mill Creek at Telephone Cable Crossing	Tims Branch Road 2	McQueens Branch Road F	Crouch Branch Road 4	Fourmile Branch Road F	Fourmile Branch Road C	Fourmile Branch Road A-6	Fourmile Branch Road A	Pen Branch Road C	Pen Branch Road B	Pen Branch Road A	Indian Grave Branch Road B	Steel Creek east of Road C	Meyers Branch at Old Dunbarton Rd.
Tanypodinae																
Ablabesmyia mallochi									ql					qn		
Conchapelopia/Meropelopia						ql										
Labrundinia pilosella				ql												
Zavrelimyia											qn					
Tanytarsini																
Paratanytarsus							qn									
Rheotanytarsus distinctissimus gp.	qn	qn		qn				qn		qn		ql	qn ql	qn ql	ql	
Tanytarsus	qn ql		qn		ql			qn ql	qn ql	qn ql	qn ql	qn ql	qn ql	qn	ql	qn ql

qn - dominant (>5%) in quantitative (multiplate) samples

ql - dominant (>5%) in qualitative sampling of natural substrates

Table 7. Macroinvertebrate Data for Upper Three Runs/Tributaries, November 2000

	Upper Three Runs Creek System					
	Upper Three Runs at Rd. 8-1	Upper Three Runs at Rd. C	Mill Creek at Telephone Cable Crossing	Tims Branch at Road 2	McQueen Branch at Road F	Crouch Branch at Road 4
Parameter	MULTIPLATE (QUANTITATIVE DATA)					
Total # of Species	29	33	43	12	9	13
Mean Species per Replicate	13.4	14	15.4	4	2.4	6
EPT Index	9	11	15	3	0	0
Density (organisms/m^2)	1550.0	2241.7	1550.0	225.0	133.3	6800.0
Total Biomass (g)	0.1509	0.4055	0.0413	0.0039	0.0020	0.0212
NC Biotic Index	5.53	5.78	5.69	7.77	7.28	5.4
Relative Abundance of Major Taxonomic Groups						
Annelida (worms)	0	0.0	0.0	0.0	0.0	0.0
Mollusca (clams, snails)	0	0.0	0.0	0.0	0.0	0.0
Crustacea	0	0.0	0.0	3.7	0.0	0.0
Ephemeroptera	5.4	1.5	18.3	18.5	0.0	0.0
Plecoptera	7.0	10.4	12.4	0.0	0.0	0.0
Trichoptera	0.5	2.6	5.9	0.0	0.0	0.0
Megaloptera	0.5	0.4	0.0	0.0	0.0	0.0
Odonata	0.5	0.0	1.6	0.0	0.0	0.2
Heteroptera	0	0.0	0.0	0.0	0.0	0.0
Coleoptera	0	0.7	2.7	3.7	25.0	0.1
Diptera (excluding midges)	6.5	3.0	3.2	11.1	12.5	0.1
Diptera (midges)	79.6	81.4	55.9	63.0	62.5	99.5
Tanypodinae	1.6	1.5	4.8	0.0	0.0	2.5
Orthocladiinae	51.9	67.3	7.5	11.1	18.8	95.1
Chironomini	10.3	4.5	28.5	33.3	37.5	2.0
Tanytarsini	16.1	8.2	15.1	18.5	6.3	0.0
Relative Abundance of Functional Feeding Groups						
Collector-gatherers	58.9	69.1	32.5	40.7	43.8	96.0
Collector-filterers	21.0	11.9	22.6	18.5	6.3	0.0
Predators	10.8	9.7	15.1	11.1	0.0	3.5
Scrapers	2.4	1.1	10.2	9.3	12.5	0.0
Shredders	7.0	8.2	19.6	20.4	37.5	1.5
Relative Abundance of Functional Feeding Group Biomass						
Collector-gatherers	2.9	1.7	16.5	56.4	45.0	59.0
Collector-filterers	1.6	1.3	8.5	<0.1	<0.1	0.0
Predators	95.5	28.9	56.4	2.6	0.0	24.1
Scrapers	<0.1	0.3	11.1	20.5	45.0	0.0
Shredders	<0.1	67.8	7.5	20.5	10.0	17.0
	QUALITATIVE DATA					
Total # species	56	52	50	8	20	12
EPT Index	16	22	16	0	2	1
NC Biotic Index	4.94	4.38	4.99	6.95	6.25	8.17
QUALITATIVE AND QUANTITATIVE DATA COMBINED						
Total # species	70	64	72	18	23	19

were also abundant, comprising 4.5 to 16.1% of the organisms collected at the two locations. Plecoptera was the second most abundant group at both locations (7% at Road 8-1; 10.4% at Road C). Ephemeroptera were somewhat more abundant at Road 8-1 (5.4% than at Road C (1.5%). Dominant species collected included orthoclads (*Corynoneura* nr. *taris, Rheocricotopus robacki,* and *Thienemanniella xena* gp.) at both locations, as well as midges from other groups, including *Rheotanytarsus distinctissimus* gp., *Microtendipes*, and *Tanytarsus* (Table 6). The most abundant Plecoptera were *Acroneuria* and *Pteronarcys*. The most commonly collected Ephemeroptera was *Stenonema*. Both the density of organisms and total biomass were considerably higher at Road C than at Road 8-1 (Table 7). Density at Road C averaged 2241.7 organisms/m^2, as compared to 1550 at Road 8-1. Biomass at Road C averaged about 0.4 g/m^2, as compared to 0.15 g/m^2 at Road 8-1. With respect to functional feeding groups, collector-gatherers were the most abundant functional feeding group at both locations 59 to 69%, followed by collector filterers (12 to 21%) and predators (10 to 11%). Functional group biomass in Upper Three Runs was skewed in favor of shredders and predators, due primarily to the collection of a few large shredders, such as *Pteronarcys*, and a few large predators, such as *Acroneuria* (Plecoptera), and *Nigronia* (Megaloptera).

A few more taxa were collected by qualitative sampling of natural substrates at Road 8-1 than at Road C (56 vs. 52), but more EPT taxa were collected at Road C than at Road 8-1 (22 vs. 16), and Road C had a somewhat lower (better) biotic index (4.38 vs. 4.94 at Road 8-1; Table 7). The most common taxa collected from natural substrates included the midges *Cricotopus/Orthocladius annectens, Parametriocnemus lunbecki*, and *Tanytarsus*; the mayfly, *Neoephemera*;, the *stoneflies Acroneuria abnormis*, and *Perlesta placida*, and the caddisflies *Cheumatopsyche* and *Hydropsyche* (Table 6). In all, the macroinvertebrate data collected at Roads 8-1, which is upstream from all SRS discharges and Road C, which is downstream of all SRS discharges to the stream and all tributaries that contain NPDES discharges indicate that the two locations are very similar with respect to most of the parameters that were measured. The Bioclassification scores for Upper Three Runs indicate that the score for qualitative data for Road C was slightly higher (better) than Road 8-1 (4.5 vs. 4.0), while the scores for quantitative data were identical (4.0; Table 8). Therefore, there is no indication in the macroinvertebrate data that Upper Three Runs is being impacted by NPDES discharges to Upper Three Runs or its tributaries.

Tributaries of Upper Three Runs that were sampled include McQueen Branch, Crouch Branch, Tims Branch, and Mill Creek. Of these, only Mill Creek receives no NPDES discharges. Mill Creek is a high quality stream, and has a drainage area that is fairly similar to the size of the Tims Branch watershed, but is considerably larger than the watersheds of McQueen Branch and Crouch Branch. Since taxonomic richness generally increases with stream size, McQueen Branch and Crouch Branch would not be expected to have macroinvertebrate communities that are quite as diverse as Mill Creek. The macroinvertebrate data for these tributaries of Upper Three Runs are summarized in Table 7. The data from most of the parameters that were measured indicate that Mill Creek supports a much richer macroinvertebrate community than the three tributaries than receive NPDES discharges. A total of 43 taxa were collected from the multiplate samplers in Mill Creek, as compared to 12 in Tims Branch, 9 in McQueen Branch and 13 in Crouch Branch. For qualitative and quantitative combined,

Table 8. SCDHEC Bioclassification Scores for SRS Qualitative and Quantitative Data

	Qualitative Data				Quantitative Data			
Location	NCBI	EPT	Mean	Rating	NCBI	EPT	Mean	Rating
UTR Rd. 8-1	5	3	4.0	good	4	2	3.0	good/fair
UTR Rd. C	5	4	4.5	good/excellent	4	2	3.0	good/fair
Mill Creek	5	3	4.0	good	4	3	3.5	good -
Tims Branch	2	1	1.5	fair/poor	1.4	1	1.2	poor +
McQueen Br.	3	1	2.0	fair	2	1	1.5	fair/poor
Crouch Br.**	1	1	1.0	poor	5*	1*	3.0	good/fair
FMB Rd. F	1	1	1.0	poor	1	1	1.0	poor
FMB Rd. C	2	1	1.5	fair/poor	3	1	2.0	fair
FMB Rd. A-6	2	1	1.5	fair/poor	3	2	2.5	fair +
FMB Rd. A	2	1	1.5	fair/poor	3	2	2.5	fair +
Pen Br. Rd. C**	2	1	1.5	fair/poor	4	2	3.0	good/fair
Pen Br. Rd. B	4.6*	1.4*	3.0	good/fair	5*	2*	3.5	good -
Pen Br. Rd. A	3	2	2.5	fair +	4	3	3.5	good -
Indian Gr. Br.	2.6	1.6	2.1	fair	2	2	2.0	fair
Steel Creek	5*	2*	3.5	good	5*	2*	3.5	good -
Meyers Br.	2	2	2.0	fair	3	1.4	2.2	fair +

*Disparity of >2 units between NCBI and EPT scores
**disparity of >1 unit between Qualitative and Quantitative scores

72 taxa were collected from Mill Creek, 18 from Tims Branch, 23 from McQueen Branch, and 19 from Crouch Branch. More EPT taxa were also collected from multiplates in Mill Creek (15) than the other tributaries (0 to 3). The density of organisms on the multiplates averaged 1550 organisms/m^2 in Mill Creek, as compared to 225 in Tims Branch, 133.3 in McQueen Branch and 6800 organisms/m^2 in Crouch Branch. The community of Mill Creek was dominated by Ephemeroptera (18.3%; primarily *Stenonema;* Table 6), Plecoptera (12.4%) and Chironomini and Tanytarsini midges (28.5 and 15.1%). *Polypedilum* was the most abundant Chironomini midge in Mill Creek, while *Tanytarsus* was the most common Tanytarsini. Tims Branch was also dominated by these same groups, except that no Plecoptera were collected. Common mayflies in Tims Branch were *Ephemerella* and *Stenonema*; common midges were *Chironomus* and *Rheotanytarsus*. Dominant groups in McQueen Branch were Coleoptera (25%; primarily *Stenelmis*), and Chironomini (mostly *Polypedilum*) and Orthocladiinae (mostly *Corynoneura*) midges (37.5 and 18.8%). In Crouch Branch, midges accounted for 99.5% of the organisms collected from the multiplates. Most of the midges were the orthoclad, *Corynoneura*. Macroinvertebrate biomass in Mill Creek was higher (0.04 g/m^2) that in the tributaries that receive NPDES discharges (0.002 to 0.02 g/m^2). With respect to functional feeding groups, Mill Creek, Tims Branch and McQueen Branch were fairly similar, with collector-gatherers comprising 32.5 to 43.8% of the organisms collected, followed by shredders (19.6 to 37.5%) and collector filterers 6.3 to 22.6%. In Crouch Branch, 96% of the organisms collected were collector-gatherers. This was because almost all of the organisms collected from Crouch Branch were a single species of midge (*Corynoneura*). For the qualitative data, 50 species were collected from Mill Creek, 18 were collected from Tims Branch, 23 from McQueen

Branch, and 19 were collected in Crouch Branch (Table 7). More EPT taxa were collected in the qualitative samples from Mill Creek (16) than from the tributaries that receive NPDES discharges (0 to 2). The Bioclassification scores for Mill Creek were 4.0 and 3.5 for qualitative and quantitative sampling, respectively (Table 8). When compared to Mill Creek, the decreases in scores for the three tributaries that receive NPDES discharges are:

	Qualitative Data		Quantitative Data	
Stream	Decrease in Score	Level of Impairment	Decrease in Score	Level of Impairment
Mill Creek	Reference Stream			
Tims Branch	2.5	Moderate	2.3	Moderate
McQueen Br.	2.0	Moderate	2.0	Moderate
Crouch Br.	3.0	Severe	0.5	Slight

When compared to Mill Creek, the results of the qualitative and quantitative Bioclassification scores for Tims Branch and McQueen Branch concur that the streams are moderately impaired. The qualitative data for Crouch indicates severe impairment, while the quantitative data indicates slight impairment. This difference is a result of a low (good) biotic index value for the quantitative data for Crouch Branch. A large number of a single species of orthoclad midge (*Corynoneura*) were collected on the multiplate samplers. Lenat(1993) assigns a relatively good biotic index value (6.2) to this genus, which resulted in a good overall biotic index score. However, Geckler et al., 1976) reported that Orthocladiini chironomids are quite tolerant to copper, which may explain their abundance in Crouch Branch. The almost complete absence of EPT taxa and domination by a single taxon of orthoclad in the quantitative data, as well as a very low Bioclassification score for the qualitative data, all indicate that Crouch Branch is still impaired.

As discussed in Section 2.1, Mill Creek is considerably larger than Tims, Crouch and McQueen Branches. Therefore, The Bioclassification Scores of these tributaries were also compared to scores from Pen Branch at Road C. Although in a different watershed, this reach of Pen Branch is more comparable in size to these tributaries than is Mill Creek.

	Qualitative Data		Quantitative Data	
Stream	Decrease in Score	Level of Impairment	Decrease in Score	Level of Impairment
Pen Br. Rd. C	Reference Stream			
Tims Branch	0	Unimpaired	1.8	Moderately impaired
McQueen Br.	0	Unimpaired	1.5	Slight to moderately impaired
Crouch Br.	0.5	Very slightly impaired	0	Unimpaired

When compared to Pen Branch at Road C, the qualitative data indicates little impairment, while the quantitative data indicates no impairment for Crouch Branch, slight/moderate impairment for McQueen Branch, and moderate impairment for Tims Branch.

The data for the Upper Three Runs tributaries indicates that none of the tributaries that receive NPDES discharges support macroinvertebrate communities that are of the quality of that found in Mill Creek. However, the differences may be due, at least in part, to Mill Creek being a somewhat larger stream than the other three tributaries and also to habitat alterations. When compared to Pen Branch at Road C, the bioclassification scores indicate no impairment to slight impairment for all of the data except the Tims Branch quantitative data, which indicated moderate impairment. The location that was sampled in Tims Branch is located just downstream from the old Steeds Pond dam. Although the dam no longer impounds what was Steeds Pond, the portion of the stream that flows through the old pond bed of Steeds Pond is braided and has little canopy. Earlier macroinvertebrate surveys that were conducted in McQueen Branch in 1993 and 1994 (Specht, 1995a; Specht and Paller, 1995) both indicated that the macroinvertebrate community of the stream was more perturbed than was found in this study. As described in Section 2.1, both McQueen Branch and Crouch Branch were subject to high total suspended solids levels during construction of the DWPF (Savannah River Ecology Laboratory, 1995) and increased stormwater inputs. These conditions resulted in intense scouring and siltation, which have resulted in channel erosion and long-term habitat degradation. Other factors that may have affected the benthic communities in Tims, McQueen, and Crouch Branches are discussed in the Temporal Changes section that follows.

Temporal Changes in Upper Three Runs and Its Tributaries between 1997 and 2000 - The quality of the macroinvertebrate communities of both Tims Branch and McQueen Branch declined between the first macroinvertebrate survey that was conducted in 1997 (Table 9) and the survey that was conducted in November 2000 (Table 7). A significant change in the Tims Branch watershed was the construction of a wetland treatment system approximately 3 km upstream from the sampling location. The treatment system was constructed in 2000 to remove copper from NPDES outfall A-01. Although total suspended solids (TSS) levels were sometime elevated just downstream from the wetland during construction, most of the soil particles were trapped in two natural wetlands that are located between the constructed wetland and the macroinvertebrate sampling location in Tims Branch. Therefore, construction of the wetland is not believed to be the source of the perturbation in Tims Branch. Rather, the changes appear to be due to the construction of a series of beaver dams in the old pond bed of Steeds Pond, which is located just upstream from the sampling location. At the time of sampling, the water flowing out of the old pond bed appeared to contain an iron hydroxide floc, which suggests that the beaver ponds are probably producing anoxic conditions that are releasing ferrous iron from the pond sediments. Dissolved oxygen was only 64% of saturation (6.67 mg/l at a temperature of 13.3 °C), which suggests that during the warmer months, dissolved oxygen levels are probably too low to support most species of macroinvertebrates. In the past, similar conditions have been seen in areas downstream from beaver dams in Fourmile Branch and McQueen Branch. Beaver dams are usually transient, and the macroinvertebrate communities rebound when the beaver impoundments are no longer present. The permitted

Table 9. Macroinvertebrate Data for Upper Three Runs/Tributaries, November 1997

	Upper Three Runs at Rd. 8-1	Upper Three Runs at Rd. C	Mill Creek at Telephone Cable Crossing	Tims Branch Rd. 2	McQueen Br. near Z Area	Crouch Br. Rd. 4
	Site 3	Site 2	Site 4	Site 1	Site 5	Site 6
MULTIPLATE (QUANTITATIVE DATA)						
Total # species	27	37	20	17	11	5
Mean # species/replicate	5.4	7.4	4.0	3.4	2.2	1.0
EPT Index	15	16	9	3	5	0
Density (organisms/m^2)	93.3	232.0	112.0	73.3	53.3	8.9
Total biomass (g/m^2)	0.2590	0.2582	0.0518	1.0685	0.0317	0.0006
NC Biotic Index	3.70	4.84	4.87	6.72	5.18	8.88
Relative Abundance of Major Taxonomic Groups						
Annelida (worms)	0.0	0.5	0.0	25.8	0.0	0.0
Mollusca (clams, snails)	0.0	0.0	0.0	0.0	0.0	0.0
Crustacea	0.0	0.0	0.0	0.0	0.0	0.0
Ephemeroptera	10.7	11.0	55.4	1.5	64.6	0.0
Plecoptera	34.5	18.2	21.8	0.0	8.3	0.0
Trichoptera	23.8	9.6	5.0	9.1	10.4	0.0
Odonata	1.2	0.0	1.0	0.0	0.0	25.0
Heteroptera	0.0	0.0	0.0	0.0	0.0	0.0
Coleoptera	2.4	1.9	1.0	0.0	0.0	0.0
Diptera (excluding midges)	8.3	1.0	0.0	22.7	0.0	0.0
Diptera (midges)	16.7	57.9	12.9	39.4	12.5	75.0
Chironomini	3.6	6.2	8.9	1.5	0.0	62.5
Orthocladiinae	3.6	45.9	2.0	12.1	12.5	0.0
Tanypodinae	1.2	0.0	2.0	10.6	0.0	12.5
Tanytarsini	8.3	5.7	0.0	15.2	0.0	0.0
Other	2.4	0.0	2.9	1.5	4.2	0.0
Relative Abundance of Functional Feeding Groups						
Collector-gatherers	10.7	40.0	36.6	37.1	52.1	25.0
Collector-filterers	32.7	11.0	0.0	45.5	2.1	0.0
Predators	15.5	11.5	12.9	12.1	6.3	37.5
Scrapers	5.4	6.0	28.2	0.8	32.3	0.0
Shredders	35.7	32.3	24.3	4.5	7.3	37.5
Relative Abundance of Functional Feeding Group Biomass						
Collector-gatherers	0.3	7.8	22.6	0.3	26.4	<0.1
Collector-filterers	3.3	4.9	<0.1	0.8	2.0	<0.1
Predators	94.5	54.3	50.8	98.9	42.3	100.0
Scrapers	1.6	6.8	22.6	<0.1	26.4	<0.1
Shredders	0.3	26.2	4.1	<0.1	2.9	<0.1
QUALITATIVE DATA						
total # species	41	61	39	33	33	3
EPT Index	18	20	9	3	12	0
NC Biotic Index	4.76	4.45	5.62	6.37	5.39	7.6
QUALITATIVE AND QUANTITATIVE DATA COMBINED						
total # species	51	81	50	41	38	8

chemical constituents in the outfalls that discharge to Tims Branch (A-01 and A-11) are primarily metals. In addition, the old pond bed of Steeds Pond contains elevated concentrations of several metals (primarily nickel, aluminum, and uranium). In order to determine if the perturbation in Tims Branch was due to metals, on November 2, a water sample was collected from just downstream from the old Steeds Pond dam and analyzed for the metals most likely to be present in NPDES outfalls and in Steeds Pond sediments. This sample was collected at the same location that biological sampling had been performed.

Metal	Total (µg/l)	Dissolved (µg/l)
Copper	<10	<10
Zinc	19	9
Chromium	<20	<20
Nickel	26	15
Iron	3620	268
Aluminum	1620	<50
Manganese	67	<5
Uranium	<50	<50

The results indicate that total iron and aluminum were high (3620 and 1620 µg/l, respectively), but that none of the other metals that were measured, including dissolved iron, exceeded EPA water quality criteria. High total iron and aluminum are usually indicative of suspended soil particles in the water column, which probably occurs as water pours over the old spillway of the dam. Therefore, it does not appear that metals from NPDES outfalls are the source of the perturbation, and we conclude that low dissolved oxygen concentrations resulting from beaver impoundments are the most likely source of the perturbation in Tims Branch.

In McQueen Branch, the sampling location in 1997 was located near Z Area. This site has since be inundated by the pool of a beaver dam, so the sampling location for 2000 was moved upstream to Road F. The location that was sampled was impacted by high total suspended solids levels and increased flows during construction of the Defense Waste Processing Facility (DWPF) in the 1980's (Savannah River Ecology Laboratory, 1995) and as a result, has somewhat poorer habitat than the sampling location near Z Area. Substrate is primarily shifting sand or clay, and few leaf packs or root mats are present. The total absence of EPT taxa in the multiplate samples from McQueen Branch and relatively low Bioclassification scores for both the quantitative and qualitative data indicate possible impact. However, it is not known if the impact is due to poor habitat or NPDES discharges.

Results of biological sampling in 1997 indicated that Crouch Branch was severely impaired. Subsequent investigations found that the H-02 outfall, which discharges to Crouch Branch less than 50 m upstream from the Road 4 sampling location, contained elevated levels of copper (Specht, 1999). Source reductions of copper contributions to the H-02 outfall have reduced copper concentrations in the stream. Crouch Branch has improved considerably since it was sampled in 1997, but it is still moderately impaired. The number of taxa collected on multiplate samplers increased from 5 to 13; the number of taxa collected from natural substrates increased from 3 to 12, and the total

number of taxa collected from quantitative and qualitative samples combined increased from 8 to 19 (Tables 7 and 8). A macroinvertebrate survey performed at four locations in Crouch Branch in 1999 showed that the quality of the macroinvertebrate community improved with increasing distance from the outfall, and that the lower portions of the stream contained a reasonably diverse macroinvertebrate community. Near the creek mouth, 44 taxa were collected during qualitative sampling, including 11 EPT taxa (Specht, 1999).

Mill Creek, which is the unperturbed reference stream to which Tims, Crouch, and McQueen data were compared showed substantial increases in both species richness and density of organisms between 1997 and 2000 (Tables 7 and 8). The number of taxa collected from multiplate samplers increased from 20 to 43, the number of taxa collected during qualitative sampling increased from 39 to 50, and the total number of taxa collected in the quantitative and qualitative sampling combined increased from 50 to 72. The density of organisms on the multiplate samplers was 112 in 1997 and 1550 in 2000. No changes are known to have occurred in Mill Creek that would have improved conditions in the stream. The differences are probably attributable to normal temporal variations or sampling differences attributable to the relatively small number of samples that were collected. Both sets of samples were collected and identified by the same taxonomists (ETT Environmental, SCDHEC Certification # 23104), so the sampling techniques employed and level of taxonomic resolution should have been similar between the two studies.

The data from Upper Three Runs collected in 1997 and 2000 (Tables 7 and 8) are fairly similar, except that like Mill Creek, macroinvertebrate densities on multiplate samplers were about an order of magnitude higher in 2000 than in 1997 (93.3 and 232 organisms/m^2 in 1997 vs. 1550 and 2242 in 2000). In addition, the relative abundance of Ephemeroptera, Plecoptera and Trichoptera all decreased between 1997 and 2000. However, the net number of organisms in these groups actually increased somewhat. Their relative abundances were lower, because of the much higher numbers of midges that were collected in 2000. These differences are probably due to normal temporal variations in the stream.

4.1.2 Fish - Upper Three Runs and Tributaries

Fish assemblages in the Upper Three Runs Creek drainage were sampled at Upper Three Runs near Road 8-1, Upper Three Runs near Road A.2, Crouch Branch, McQueen Branch, Tims Branch, and Mill Creek. The sample stations at Upper Three Runs near Road A.2, Crouch Branch, Tims Branch and McQueen Branch were located downstream from NPDES outfalls (Figure 1). Because Mill Creek does not receive NPDES discharges and is largely undisturbed, it was considered a control site and was pooled with the other control sites for statistical comparisons. The sample station at Upper Three Runs near Road 8-1 was located upstream from the SRS NPDES outfalls but, as discussed below, was not pooled with the other control sites because it may have been influenced by offsite pollution and was difficult to effectively sample. These sample locations corresponded to the macroinvertebrate sampling locations except that the fish assemblage samples from the portion of Upper Three Runs potentially affected by NPDES discharges were collected near Road A.2 rather than near Road C. Road A.2 is approximately 9 km downstream from Road C. Fish assemblages were not

sampled near Road C to avoid interfering with other fish sampling programs being conducted in that area.

There were two changes in sampling locations between 1997 and 2000. The upstream sample station in Upper Three Runs was moved from Tyler Bridge Road to Road 8-1 because boat access was no longer possible near Tyler Bridge Road. The McQueen Branch sample station was moved from Z area to Road F because the stream reach near Z area was impounded by beaver dams. The IBI was designed for use in free flowing stream reaches and would not be expected to produce accurate results in standing water habitats.

The number of individual fish and number of species, respectively, collected from each site in the Upper Three Runs drainage were 367 and 15 for Mill Creek, 156 and 5 for McQueen Branch, 115 and 12 for Tims Branch, 58 and 9 for Crouch Branch, 268 and 19 for Upper Three Runs near Road A.2, and 217 and 10 for Upper Three Runs near Road 8-1. The most abundant species in the smaller tributaries, including Mill Creek, Crouch Branch, and McQueen Branch were yellowfin shiner, bluehead chub, pirate perch and various other smaller species as is typical of smaller streams on the SRS (Paller 1994). Tims Branch, the remaining small tributary, had fewer shiners and was numerically dominated by pirate perch. Upper Three Runs near Road A.2 supported a diverse assemblage numerically dominated by a variety of shiner and sunfish species. The assemblage at Upper Three Runs near Road 8-1 included fewer species and was numerically dominated by dusky, sailfin, and yellowfin shiners.

Average IBIs in Upper Three Runs were 42.0 near Road A.2 and 36.7 near Road 8-1. (Table 10). Neither value was significantly different from the IBIs at the four control sites, and both were within the range of IBIs for unimpacted sites in the historical data set (Figure 3). However, the IBI at Road 8-1 was substantially lower than the IBIs at the control sites (46-48) despite the fact that it, like the control sites, was upstream of all NPDES discharges. Sampling was difficult near Road 8-1 because of relatively deep water, strong currents, and extensive overhanging brush (Table 11), raising the possibility that reduced sampling efficiency may have depressed the IBI. Another possibility is that offsite point or nonpoint discharges may have affected fish assemblages near Road 8-1, although macroinvertebrate assemblages appeared healthy at this site.

The average IBI at Mill Creek, a control stream without NPDES outfalls, was the second highest recorded at any site (47.3) (Table 10). The average IBI in Crouch Branch, which receives NPDES discharges was nearly comparable, averaging 44.0. The average IBIs at McQueen Branch and Tims Branch, both of which receive NPDES discharges, were lower, averaging 38.0 and 35.3, respectively, although neither IBI significantly differed from the control sites. These moderately depressed IBIs indicate that Tims Branch and McQueen Branch do not possess the environmental quality characteristic of the reference streams. Large amounts of iron floc on the stream bed of Tims Branch suggest that habitat quality may have been diminished by the release of anoxic water from beaver ponds located upstream of the sample site (as described more fully in the preceding section). The situation in McQueen Branch was less clear. The narrow and shallow reach sampled in this stream (Table 11) offered comparatively poor habitat compared with the reference sites and undoubtedly reduced the IBI at this site.

Table 10. IBI values from stream sites receiving NPDES discharges (Y) and sites unaffected by NPDES discharges (N) during 1997 and 2000.

Sample site	NPDES	Rep. 1	Rep. 2	Rep. 3	Average	St. error
		1997				
Fourmile Branch Rd. 4	Y	18	26	22	22.0	2.3
Fourmile Branch Rd. C	Y	36	46		41.0	5.0
Fourmile Branch Rd. A.6	Y	42	48	38	42.7	2.9
Fourmile Branch Rd. A	Y	42	40	50	44.0	3.1
Steel Creek	Y	38	30	30	32.7	2.7
Pen Branch Rd. B	N	46	48	48	47.3	0.7
Pen Branch Rd. C	N	50	50	46	48.7	1.3
McQueen Branch	Y	44	42	30	38.7	4.4
Tims Branch	Y	40	38	38	38.7	0.7
Pen Branch Rd. A	Y	44	46	46	45.3	0.7
Indian Grave Branch	Y	44	46	44	44.7	0.7
Meyers Branch	N	44	46	46	45.3	0.7
Crouch Branch	Y	28	36	24	29.3	3.5
Upper Three Runs Rd. A2	Y	40	42	30	37.3	3.7
Upper Three Runs Tyler Br.	N	22	30	30	27.3	2.7
Mill Creek	Y	44	44	40	42.7	1.3
		2000				
Fourmile Branch Rd. C	Y	44	36	46	42.0	3.1
Fourmile Branch Rd. A.6	Y	46	44	48	46.0	1.2
Fourmile Branch Rd. A	Y	50	34		42.0	6.5
Steel Creek	Y	24	18	28	23.3	2.9
Pen Branch Rd. B	N	46	44	48	46.0	1.2
Pen Branch Rd. C	N	48	46	50	48.0	1.2
McQueen Branch	Y	38	38	38	38.0	0.0
Tims Branch	Y	40	30	36	35.3	2.9
Pen Branch Rd. A13.2	Y	50	46	50	48.7	1.3
Indian Grave Branch	Y	48	48	46	47.3	0.7
Meyers Branch	N	50	46	44	46.7	1.8
Crouch Branch	Y	46	42	44	44.0	1.2
Upper Three Runs Rd. A2	Y	48	40	38	42.0	3.1
Upper Three Runs Rd. 8-1	N	34	38	38	36.7	1.3
Mill Creek	Y	48	46	48	47.3	0.7

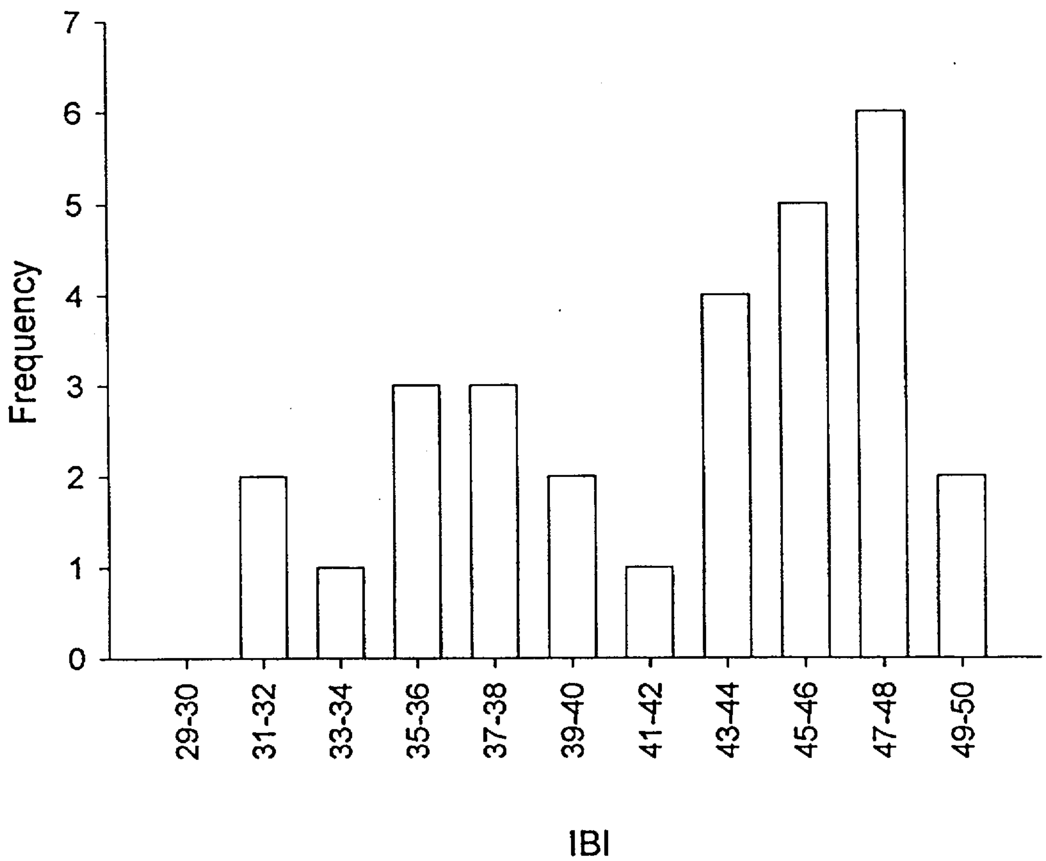

Figure 3. IBI values from undisturbed streams on and near the SRS sampled during previous studies.

Table 11. Means for Habitat Variables. Variables were measured at nine transects at each sample station except at Upper Three Runs Road 8-1 and Upper Three Runs Road A-2, where variables were measured at six transects

Variable	Tims Branch	Upper Three Runs Road 8-1	Upper Three Runs Road A.2	Mill Creek	McQueens Branch	Crouch Branch	Four Mile Creek Road C	Four Mile Creek Road A-6	Four Mile Creek Road A	Pen Branch Road C	Pen Branch Road B	Indian Grave Branch	Pen Branch Road A	Steel Creek	Meyers Branch
Width (m)	1.4	11.9	14.6	4.0	1.6	2.0	7.3	5.2	5.8	1.6	3.6	4.9	6.0	2.3	2.9
Depth (cm)	11.0	46.1	102.3	21.9	10.9	4.4	19.1	44.4	47.8	14.3	11.7	30.7	37.6	12.1	15.6
Current velocity (m/s)	0.33	0.37	0.45	0.50	0.17	0.65	0.35	0.38	0.48	0.03	0.10	0.16	0.36	0.31	0.25
Wood debris and leaves (%)*	7	10	13	16	4	4	11	16	5	51	4	6	4	3	10
Number logs and stumps**	0.9	1.5	4.1	3.0	1.8	2.1	7.4	2.4	2.1	2.3	1.7	3.1	1.0	1.2	2.3
Brush piles (%)*	6	15	18	4	7	4	11	6	8	9	8	9	7	7	14
Root masses (%)*	17	3	0.8	6	8	5	6	8	2	8	4	2.2	1	11	4
Macrophytes (%)*	1	24.2	0	0	0	0	3	19	13	0	0	10	10	0	0
Overhanging bank vegetation (%)*	3	26.9	2	4	1	3	6	13	13	2	7	17.4	20	6	3
Bank overhang (%)*	2	0.3	0	2	12	3	1	4	1	10	2	2.2	0	5	3
Canopy cover (%)*	91	49	75	84	95	92	88	54	42	95	87	58	28	91	97
Bank erosion***	0.7	0	0	0.6	1.9	1.3	0.8	1.1	0.0	0.1	0.3	0.6	0.0	1.9	0.3

* Percent variables refer to percent of stream bottom area covered by or overhung by the indicated variable

** Number of logs and stumps within a 3m band on either side of the transect (6 m in total).

*** Estimated on a scale of 0-3 with 3 most severe

Temporal changes between 1997 and 2000 - IBIs in Upper Three Runs were higher in 2000 than in 1997 (Table 10). The average IBI increased from 37.3 to 42.0 downstream from the NPDES discharges (Road A.2) and increased from 27.3 to 36.7 upstream from the NPDES discharges (Road 8-1). The latter increase may be attributable to a change in sample locations from Tyler Bridge Road in 1997 to Road 8-1 in 2000. The Road 8-1 site was easier to sample than the Tyler Bridge site because there was less overhanging brush, possibly resulting in the collection of more fish and more fish species. Whatever the cause, increases in the IBI both upstream and downstream from the NPDES discharges indicate that environmental quality has certainly not diminished, and may have improved, in Upper Three Runs.

The IBI in Crouch Branch increased substantially from an average of 29.3 in 1997 to 44.0 in 2000 (Table 10). Reductions in copper concentrations in discharges from the H-02 outfall probably contributed to this improvement. Improvement in the IBI, which is based on fish assemblage data, paralleled improvements in the macroinvertebrate assemblages collected from Crouch Branch. However, macroinvertebrate data still suggest moderate impairment in Crouch Branch in contrast to the IBI, which suggested that Crouch Branch was fully recovered by 2000. Differences in recovery rates indicated by fish and macroinvertebrates have been reported by other researchers (Yoder and Rankin 1995), and fish and macroinvertebrate results from Crouch Branch may become more congruent in the future.

Like the macroinvertebrate results, the IBI suggested that conditions in Tims Branch deteriorated slightly between 1997 and 2000. As previously described, this change was probably caused by the release of anoxic water from recently constructed beaver ponds located just upstream from the Tims Branch sample site. The most obvious manifestation of this perturbation was thick deposits of iron floc covering the stream bottom within the sample area.

4.2 Fourmile Branch Watershed

4.2.1 Macroinvertebrates - Fourmile Branch

As described in Section 2.2, macroinvertebrates were collected from four locations in Fourmile Branch. Road F is located upstream from all SRS discharges, Road A is located downstream from all NPDES outfalls, and Roads C and A-6 are located intermediately (Figure 1). All of the parameters that were measured indicate that the quality of Fourmile Branch's macroinvertebrate community improves in a downstream direction, and that the location in Fourmile Branch that is upstream from all NPDES discharges (Road F) is the most perturbed location that was sampled (Table 12). For the multiplate data, a total of 10 taxa were collected at Road F, 26 were collected at Road C, 30 were collected at Road A-6 and 35 were collected at Road A. Two EPT were collected at Road F, 5 were found at Road C, 9 at Road A-6 and 10 at Road A. The density of organisms on the multiplate samplers was also lowest at Road F (283.3 organisms/m^2, increasing to 1008.3 at Road C, 2608.3 at Road A-6, and 7366.7 at Road A. Macroinvertebrate biomass was relatively low at Road F (0.0056 g/m^2) and Road A-6 (0.0173 g/m^2), and much higher at Roads C and A (0.2227 and 0.2452 g/m^2). The biotic index was highest at Road F (8.81) and very similar at the other three locations (6.52 to 6.56). The qualitative data showed similar patterns, with 9 species

Table 12. Macroinvertebrate Data for Fourmile Branch, November 2000

	Road F	Road C	Road A-6	Road A
Parameter	MULTIPLATE (QUANTITATIVE DATA)			
Total # of Species	10	26	30	35
Mean Species per Replicate	4	9.6	10.8	17.2
EPT Index	2	5	9	10
Density (organisms/m^2)	283.3	1008.3	2608.3	7366.7
Total Biomass (g)	0.0056	0.2227	0.0173	0.2452
NC Biotic Index	8.81	6.52	6.56	6.55
Relative Abundance of Major Taxonomic Groups				
Annelida (worms)	5.9	0.0	0.0	0.0
Mollusca (clams, snails)	0.0	0.0	0.3	0.0
Crustacea	0.0	0.8	0.0	3.2
Ephemeroptera	0.0	5.0	2.6	5.4
Plecoptera	0.0	2.5	1.0	0.2
Trichoptera	5.9	1.7	4.2	2.5
Megaloptera	0.0	1.7	0.0	0.0
Odonata	0.0	0.0	0.0	0.8
Heteroptera	0.0	0.0	0.0	0.0
Coleoptera	32.4	5.0	0.6	0.1
Diptera (excluding midges)	2.9	0.0	1.0	1.8
Diptera (midges)	52.9	83.5	90.4	86.0
Tanypodinae	0	5.0	2.6	1.5
Orthocladiinae	2.9	23.1	9.6	9.8
Chironomini	44.1	5.0	5.1	0.9
Tanytarsini	5.9	50.4	73.2	73.8
Relative Abundance of Functional Feeding Groups				
Collector-gatherers	26.5	31.0	12.3	14.5
Collector-filterers	5.9	50.4	76.0	77.9
Predators	33.8	9.9	5.0	2.3
Scrapers	2.9	3.7	1.9	2.7
Shredders	30.9	5.0	4.8	2.5
Relative Abundance of Functional Feeding Group Biomass				
Collector-gatherers	8.9	32.4	27.7	39.6
Collector-filterers	0.0	0.9	45.7	11.9
Predators	16.1	66.2	10.4	10.0
Scrapers	<0.1	0.5	16.2	37.7
Shredders	75.0	0.1	<0.1	0.8
	QUALITATIVE DATA			
Total # species	9	15	27	31
EPT Index	0	0	2	5
NC Biotic Index	9.23	6.79	7.35	7.57
QUALITATIVE AND QUANTITATIVE DATA				
Total # species	16	38	48	50

collected at Road F, 15 at Road C, 27 at Road A-6, and 31 at Road A. No EPT were found at Roads F or C; 2 were collected Road A-6 and 5 at Road A. The biotic index values for the qualitative data were highest at Road F (9.23), lowest (but still high) at Road C (6.79) and intermediate at Roads A-6 and A (7.35 and 7.57). For both the qualitative and quantitative sampling combined, a total of 16 taxa were collected at Road F, 38 at Road C, 48 at Road A-6, and 50 at Road A. Dipterans (55.8%), Coleoptera (mostly *Hydroporus*; 32.4%), annelids (*Nais*; 5.9%), and Trichoptera (5.9%) were the only taxa collected at Road F. *Chironomus* was by far the most abundant midge at Road F, accounting for 44% of the organisms collected. *Chironomus* is considered to be a very pollution-tolerant taxon (Lenat, 1993) and it is particularly tolerant of low concentrations of dissolved oxygen. In contrast, the most common midge collected at the other three sampling locations was *Tanytarsus*. The community at Road C was dominated by midges (83.5%), Coleoptera (5%), and Ephemeroptera (5%). Midges were also the most abundant group collected at Road A-6 (90.4%), followed by Trichoptera (4.2%) and Ephemeroptera (2.6%). At Road A, the community was dominated by midges (86%) followed by mayflies (5.4%), Crustacea (*Hyalella*; 3.2%), and Trichoptera (2.5%).

Bioclassification scores for both the qualitative and quantitative data (Table 8) both indicate that Fourmile Branch at Road F was the most impaired location in the stream, with scores of 1.0 for both data sets. The qualitative data indicate that the quality of the other three locations was slightly better, with scores of 1.5 at all three locations. The quantitative data indicate more improvement at the downstream locations, with a score of 2.0 (fair) at Road C, and 2.5 at Roads A-6 and A.

The macroinvertebrate data clearly indicate that the region of Fourmile Branch that is upstream from all NPDES discharges is severely perturbed due to naturally occurring conditions and that the quality of the stream increases in a downstream direction. The portion of Fourmile Branch just upstream from Road F is a shallow stagnant marshy area. Dissolved oxygen in the stream at Road F was 4.85 mg/l in November (Table 13), which was only 45% saturation (based on a water temperature of 11.9 °C). During the summer months, oxygen concentrations of <1 mg/l have been measured at this location (Specht, 1995a). Numerous areas of Fourmile Branch that are downstream from Road F have been impounded by beaver dams, and it is likely that these dams result in low dissolved oxygen concentrations downstream from the impounded areas during the summer months. If the macroinvertebrate community is subjected to low dissolved oxygen concentrations periodically, it is likely that the community does not have time to recover completely during the cooler months.

Other studies conducted in Fourmile Branch at Road F indicate that *Ceriodaphnia dubia* does poorly when cultured in water from Fourmile Branch (Specht 1995b). During an investigation conducted for 12 months during 1994, water collected from this location was always either acutely or chronically toxic to *Ceriodaphnia*. In 1995, a Toxicity Identification Evaluation was performed to determine the cause of the toxicity (ETT Environmental, 1995a, 1995b). The results of the TIE indicated that naturally occurring iron was responsible for the observed toxicity. The iron is believed to leach from wetland soils, as a result of the low pH of the water.

Table 13. Physical/Chemical Data for SRS Sampling Locations, November 2000

Location	D.O. (mg/L)	Temperature (°C)	pH (s.u.)	Conductivity µmhos/cm
Upper Three Runs Creek at 8-1	9.18	16.0	5.04	20.0
Upper Three Runs Creek at Rd C	9.17	17.0	5.50	26.0
Mill Creek at Telephone Cable Rd.	9.01	12.5	6.50	109.0
Tims Branch at Road 2	6.67	13.3	5.78	53.0
McQueen Branch at Road F	9.06	13.0	6.33	65.0
Crouch Branch at Road 4	8.90	16.3	6.81	174.0
Fourmile Branch at Road F	4.85	11.9	3.78	118.0
Fourmile Branch at Road C	7.93	20.5	5.58	52.0
Fourmile Branch at Road A-6	8.42	18.5	6.26	173.0
Fourmile Branch at Road A	7.83	13.7	6.00	73.0
Pen Branch at Road C	7.36	16.8	6.52	86.0
Pen Branch at Road B	8.09	17.8	6.28	66.0
Pen Branch at Road A	9.46	15.3	6.18	80.0
Indian Grave Branch at Road B	8.20	19.3	6.29	105.0
Steel Creek	10.12	11.3	6.77	36.0
Meyers Branch at Old Dunbarton Rd.	7.70	17.4	6.08	56.0

In conclusion, the macroinvertebrate data from Fourmile Branch indicated that the upstream portions of Fourmile Branch are perturbed, but the perturbation is not related to SRS discharges, since the most upstream station, which is above all discharges to the stream, is the most perturbed. The impacts are most likely due to periodically low levels of dissolved oxygen, and possibly elevated concentrations of naturally occurring iron.

Temporal Changes in Fourmile Branch between 1997 and 2000 - The 1997 data also showed that the headwaters of Fourmile Branch were impaired due to naturally occurring conditions, and that the macroinvertebrate community of the stream improved markedly in a downstream direction (Specht and Paller, 1998). Overall, more taxa were collected, more EPT taxa were collected, and densities of organisms on multiplate samplers were considerably higher at all locations in 2000 (Table 12) than in 1997 (Table 14). A similar pattern was observed at most locations in the Upper Three Runs drainage (see Section 4.1.1), which suggests that the differences are due to natural temporal variability. The macroinvertebrate data from Fourmile Branch show no indications that SRS NPDES discharges are having an adverse effect on the macroinvertebrate community of the stream.

4.2.2 Fish - Fourmile Branch

Fish sampling station locations in Fourmile Branch differed slightly from macroinvertebrate sampling locations. Both fish and macroinvertebrate surveys were conducted near Road C, Road A-6, and Road A (Figure 1).

Table 14. Macroinvertebrate Data for Fourmile Branch, November 1997

	Road F	Road C	Road A-7	Road A
MULTIPLATE (QUANTITATIVE DATA)				
Total # species	5	11	26	29
Mean # species/replicate	1.0	2.2	5.2	5.8
EPT Index	0	1	9	7
Density (organisms/m^2)	5.6	17.8	341.0	229.0
Total biomass (g/m^2)	0.0061	0.0054	0.1226	0.0315
NC Biotic index	8.15	7.15	6.40	5.95
Relative Abundance of Major Taxonomic Groups				
Annelida (worms)	20.0	12.5	0.0	0.0
Mollusca (clams, snails)	20.0	0.0	1.0	1.9
Crustacea	0.0	0.0	0.0	1.5
Ephemeroptera	0.0	0.0	11.1	32.5
Plecoptera	0.0	6.3	2.9	0.5
Trichoptera	0.0	0.0	69.1	2.4
Odonata	0.0	6.3	0.0	0.5
Heteroptera	0.0	0.0	0.0	0.0
Coleoptera	0.0	12.5	2.3	0.5
Diptera (excluding midges)	20.0	0.0	7.2	0.0
Diptera (midges)	40.0	62.5	6.2	59.7
Chironomini	0.0	12.5	2.9	2.4
Orthocladiinae	20.0	6.3	3.3	37.9
Tanypodinae	0.0	6.3	0.0	1.0
Tanytarsini	20.0	37.5	0.0	18.4
Other	0.0	0.0	0.0	0.5
Relative Abundance of Functional Feeding Groups				
Collector-gatherers	40.0	28.1	11.1	58.0
Collector-filterers	20.0	37.5	74.9	20.4
Predators	20.0	18.8	1.0	2.4
Scrapers	20.0	3.1	7.7	14.8
Shredders	0.0	12.5	5.4	4.6
Relative Abundance of Functional Feeding Group Biomass				
Collector-gatherers	<0.1	9.3	7.4	42.5
Collector-filterers	<0.1	<0.1	63.1	5.4
Predators	100.0	81.5	15.9	7.0
Scrapers	<0.1	9.3	11.7	45.1
Shredders	<0.1	<0.1	1.9	<0.1
QUALITATIVE DATA				
Total # species	15	11	20	27
EPT Index	0	1	6	6
NC Biotic index	7.47	6.63	6.56	5.95
QUALITATIVE AND QUANTITATIVE DATA COMBINED				
Total # species	18	19	36	41

Macroinvertebrate surveys were also conducted near Road F (upstream from all NPDES discharges); however, fish surveys were not because the stream was too shallow and narrow (except in beaver ponds) to support many fish. The control sites used for statistical analysis of the Fourmile Branch sampling stations were the four in Pen Branch, Meyers Branch, and Mill Creek.

Numbers of fish and fish species, respectively, collected from the Fourmile Branch sample stations were 145 and 13 near Road C, 182 and 17 near Road A-6, and 221 and 17 near Road A. The most abundant species near Road C were yellowfin shiner, spotted sunfish, dusky shiner, and pirate perch. Dusky shiner, yellowfin shiner, redbreast sunfish, and pirate perch predominated near Road A-6, and yellowfin shiner, dusky shiner, bluehead chub, redbreast sunfish, and tesselated darter were most abundant near Road A.

The IBI at the Fourmile Branch sampling stations averaged 42.0 at Road A, 46.0 at Road A-6, and 42.0 at Road C (Table 10). None of these values differed significantly from the IBIs at the control sites. These results were generally similar to the macroinvertebrate results, which indicated that the mid and lower reaches of Fourmile Branch (Roads A-6 and A) were generally comparable to the reference sites. However the macroinvertebrate samples at Road C and Road F indicated significant degradation in the upper reaches of Fourmile Branch attributable to the release of anoxic water from beaver impoundments and iron leached from wetland soils. Fish samples taken from the Road 4 area in 1997 also indicated degradation in the upper reaches of Fourmile Branch, although this area was not sampled in 2000. The only substantial difference between the fish and macroinvertebrate samples was at Road C where the IBI indicated no degradation and the macroinvertebrate samples indicated the opposite. This difference may have resulted from more rapid recovery of the fish assemblage along the recovery gradient stretching from the degraded upstream to the comparatively undegraded downstream reaches of Fourmile Branch.

Temporal changes between 1997 and 2000 - IBIs at the sample sites near Roads C, A6, and A were similar between 1997 and 2000, indicating acceptable and relatively stable environmental quality in the mid and lower reaches of Fourmile Branch (Table 10). Temporal comparisons involving the IBI cannot be made for the upper portion of Fourmile Creek because this area was impounded by beavers by 2000. The beaver dam converted the stream reach near Road 4 into a comparatively large and deep pond which would not be expected to support the same species found in a free flowing stream and, therefore, could not be accurately analyzed using the IBI.

4.3 Pen Branch Watershed

4.3.1 Macroinvertebrates - Pen Branch/Indian Grave Branch

Macroinvertebrates were collected at four locations in the Pen Branch watershed: Pen Branch at Road C and Road B, both of which are upstream from all SRS discharges; Indian Grave Branch just downstream from the new cooling tower, which is downstream from all NPDES discharges from K Area; and Pen Branch at Road A, which is downstream from the confluence of Indian Grave Branch with Pen Branch, and

therefore downstream from all NPDES discharges to Pen Branch. Pen Branch at Road C is a small (second order) stream, with a dense canopy. No upstream reference location could be sampled on Indian Grave Branch, since the discharges from K Area enter the headwaters of the stream.

The macroinvertebrate data collected from the three locations in Pen Branch and from one location in Indian Grave Branch indicate that the locations were fairly similar with respect to many of the metrics that were measured (Table 15). Fewer taxa (24) were collected from multiplate samplers at the headwater station in Pen Branch (Road C) than at the other two locations in Pen Branch (34). A similar pattern was seen for the qualitative data, with 17 taxa collected at Road C, 28 at Road B, and 45 at Road A. For qualitative and quantitative sampling combined, the total number of taxa collected ranged from 35 at Road C to 56 at Road A. The number of EPT taxa collected in the quantitative and qualitative samples also both increased in a downstream direction (from 8 to 15 on the multiplates and from 2 to 12 in the qualitative samples The density of organisms collected from the multiplates also increased in a downstream direction, from 1191.7 organisms/m^2 at Road C to 5616.7 organisms/m^2 at Road A. Biomass showed a similar pattern, increasing from 0.0381 g/m^2 at Road C to 0.253 g/m^2 at Road A . Species composition differed among the three locations. The relative abundance of mayflies and stoneflies decreased in a downstream direction, while the abundance of Orthocladiinae and Tanytarsini midges increased, particularly at Road A. Caddisflies (primarily *Cheumatopsyche*) were much more abundant at Road A (13.9%) than at the other two locations (1.4 and 2.8%). These differences in species composition are due to differences in habitat and not effluent effects. Road A is located in the post-thermal portion of Pen Branch, and as such has a much more open canopy and a greater abundance of periphyton and other algae. This difference in habitat is reflected in the relative abundance of functional feeding groups. Collector-filterers (primarily Tanytarsini midges and filter-feeding caddisflies) were much more abundant at Road A (44.2%) than at the other two locations 8.4 and 13.5%). In contrast, Pen Branch at Road C which has a closed canopy, had only 8.4% collector filterers, but a much higher percentage of shredders (27.6%), which feed on inputs of leaf litter to the stream. Indian Grave Branch is the tributary of Pen Branch that receives NPDES effluents from K Area. Indian Grave Branch also is a post-thermal stream and has fairly similar habitat to that of Pen Branch at Road A, although it is somewhat smaller. The number of taxa collected from Indian Grave Branch was slightly lower than from Pen Branch at Road A, but comparable to the upper two Pen Branch stations, which are more similar in size to Indian Grave Branch. In Indian Grave Branch, 28 taxa were collected from multiplates, 35 from natural substrates, and 46 from multiplates and qualitative, combined. Nine EPT taxa were collected from multiplates, and 7 from natural substrates. Tanytarsini midges (primarily *Tanytarsus*) was the most abundant group, accounting for 51.2% of the macroinvertebrates collected from multiplates. Also abundant were orthoclad midges (16.2%; primarily *Cricotopus*) and amphipod crustaceans (*Hyalella azteca*; 10%). Like Pen Branch at Road A, Indian Grave Branch has a relatively open canopy, which has resulted in higher algal production. Filter-feeders comprised 53.5% of the organisms collected from Indian Grave Branch.

Bioclassification scores for Pen Branch and Indian Grave Branch (Table 8) indicate that the most upstream sampling location in Pen Branch (Road C) had the lowest score for both qualitative and quantitative data (1.5 and 3.0, respectively). For the qualitative

Table 15. Macroinvertebrate Data for Pen Branch/Indian Grave Branch and Steel Creek/Meyers Branch, November 2000

	Pen Branch System				Steel Creek Sys.	
	Road C	Road B	Road A	IGB	Steel Cr.	Meyers Branch
Parameter	MULTIPLATE (QUANTITATIVE DATA)					
Total # of Species	24	34	34	28	24	34
Mean # Species/ Replicate	10.2	14.6	19.8	13.8	9.4	19.2
EPT Index	8	10	15	9	11	6
Density (organisms/m^2)	1191.7	2100.0	5616.7	2833.3	983.3	7108.3
Total Biomass (g/m^2)	0.0381	0.0606	0.2530	0.0238	0.1369	0.0237
NC Biotic Index	5.8	4.69	5.87	6.95	5.04	6.46
Relative Abundance of Major Taxonomic Groups						
Annelida (worms)	0.0	0.0	0.0	0.3	0.0	0.0
Mollusca (clams, snails)	2.8	0.0	0.0	0.3	0.8	0.1
Crustacea	0.0	0.4	0.3	10.0	0.0	0.2
Ephemeroptera	24.5	22.2	11.1	2.6	52.5	3.8
Plecoptera	18.2	21.4	5.5	0.6	8.5	0.1
Trichoptera	1.4	2.8	13.9	3.2	12.7	1.3
Megaloptera	0.0	0.0	0.0	0.0	0.0	0.0
Odonata	0.0	1.2	0.0	0.9	0.0	0.0
Heteroptera	0.0	0.0	0.0	0.0	0.0	0.0
Coleoptera	3.5	1.2	1.2	0.0	0.0	0.2
Diptera (excluding midges)	0.0	1.6	0.3	0.3	1.7	0.1
Diptera (midges)	49.7	49.2	67.7	81.8	23.7	94.1
Tanypodinae	6.3	1.6	1.2	8.5	0.0	4.2
Orthocladiinae	16.8	29.0	31.9	16.2	6.8	15.6
Chironomini	19.6	7.5	3.9	5.9	14.4	12.8
Tanytarsini	7.0	11.1	30.7	51.2	2.5	61.5
Relative Abundance of Functional Feeding Groups						
Collector-gatherers	40.2	43.3	38.0	24.1	38.6	23.8
Collector-filterers	8.4	13.5	44.2	53.5	16.1	62.6
Predators	11.2	12.3	3.1	10.6	8.1	4.5
Scrapers	12.6	13.5	6.2	1.6	26.7	1.7
Shredders	27.6	17.5	8.5	10.1	10.6	7.4
Relative Abundance of Functional Feeding Group Biomass						
Collector-gatherers	26.0	29.5	83.4	74.2	32.7	43.5
Collector-filterers	2.1	4.0	9.3	10.5	24.4	41.4
Predators	9.7	26.9	3.4	7.1	2.0	4.2
Scrapers	49.6	29.5	3.1	8.2	39.9	8.0
Shredders	12.6	10.2	0.8	0.0	1.0	3.0
	QUALITATIVE DATA					
Total # species	17	28	45	35	37	46
EPT Index	2	6	12	7	9	9
NC Biotic Index	7.15	5.44	6.38	6.71	5.19	7.51
	QUALITATIVE AND QUANTITATIVE DATA COMBINED					
Total # species	35	50	56	46	49	66

data, Road B, which is also upstream from NPDES discharges, scored higher (3.0) than Road A (2.5), but the scores for the quantitative data were the same (3.5) for Roads B and A. Indian Grave Branch, which receives NPDES discharges from K Area scored lower (2.1 for qualitative; 2.0 for quantitative) than any of the Pen Branch sites. However, the difference is most likely related to habitat alterations that are the result of the long history of thermal discharges to the stream, and not to NPDES discharges.

In summary, the two stations that are downstream from NPDES discharges (Pen Branch at Road A and Indian Grave Branch) differ somewhat from the upstream stations, but the differences are due to habitat differences related to the post-thermal nature of these locations, and not to the effects of NPDES discharges. Species richness was actually highest at Road A, but the species composition differed from that of the upstream locations. However, the shift in species is to filter-feeding species that are utilizing the algae produced in the open-canopy habitat of the post-thermal streams and not to pollution-tolerant species.

Temporal Changes in Pen Branch/Indian Grave Branch - More taxa and more EPT taxa were collected from multiplate samplers at all locations in 2000 than in 1997 (Tables 15 and 16). In 1997 the total number of taxa at the four sampling locations in Pen Branch/Indian Grave Branch ranged from 10 to 23; in 2000 the range was 24 to 34. The number of EPT taxa collected in 1997 ranged from 3 to 7; in 2000 the range was 8 to 15. Macroinvertebrate densities were also much higher in 2000 (1191.7 to 5616.7) than in 1997 (95.6 to 163). The number of taxa collected from qualitative sampling of natural substrates ranged from 25 to 34 in 1997 and from 17 to 45 in 2000, which indicates that the number of taxa collected from natural substrates was fairly similar in both years. The total number of taxa collected from quantitative and qualitative sampling combined was slightly higher at three of the four stations in 2000 and slightly lower (35 vs. 38) at one location (Road C). Ephemeroptera (primarily *Baetis, Stenonema* and *Leptophlebia;* Table 6) comprised a lower percentage of the organisms collected at all Pen Branch locations in 2000 (2.6 to 24.5%) than in 1997 (9.3 to 62.5%). The relative abundances of Plecoptera and Trichoptera were fairly similar between years. The biggest shift in relative abundance occurred in the Tanytarsini midges, which comprised 0.9 to 17.4% of the macroinvertebrate collected from multiplates in 1997, but 7.0 to 51.2% in 2000. The relative abundances of functional feeding groups were very similar in 1997 and 2000.

4.3.2 Fish - Pen Branch/Indian Grave Branch

NPDES outfalls within the Pen Branch watershed discharge into Indian Grave Branch, a tributary of Pen Branch (Figure 1). One fish sampling station was located within Indian Grave Branch downstream of the outfalls and one was located in Pen Branch downstream from the confluence of Pen Branch and Indian Grave. Both were potentially subject to impacts from the NPDES outfalls, particularly the Indian Grave Branch station which was closest to the outfalls. There were two additional fish sampling stations in the Pen Branch drainage located above the confluence of Indian Grave Branch and Pen Branch (Pen Branch Rd. B and Pen Branch Rd. C) Because they were located in undisturbed areas and did not receive NPDES discharges, these sampling stations were considered reference sites and grouped with the other two reference sites (Meyers Branch and Mill Creek) for statistical testing.

Table 16. Macroinvertebrate Data for Pen Branch/Indian Grave Branch and Steel Creek/Meyers Branch, November 1997

	Pen Branch System				Steel Creek Sys.	
	Road C	Road B	Road A	IGB	Steel Cr.	Meyers Branch
Parameter	MULTIPLATE (QUANTITATIVE DATA)					
Total # of Species	10	21	22	23	17	18
Mean # Species/ Replicate	2.0	4.2	4.4	4.6	3.4	3.6
EPT Index	7	7	3	4	4	6
Density (organisms/m^2)	124.0	163.0	95.6	101.0	71.1	180.0
Total Biomass (g/m^2)	0.0513	0.0654	0.1356	0.0702	0.0428	0.0221
NC Biotic Index	5.51	5.16	6.54	6.58	5.81	4.81
Relative Abundance of Major Taxonomic Groups						
Annelida (worms)	0.0	0.0	0.0	1.1	0.0	.06
Mollusca (clams, snails)	0.0	0.7	2.3	1.1	3.1	0.0
Crustacea	0.0	0.7	0.0	1.1	0.0	0.0
Ephemeroptera	62.5	46.9	9.3	28.6	35.9	14.2
Plecoptera	15.2	19.7	0.0	0.0	23.4	9.3
Trichoptera	0.0	12.2	3.5	2.2	0.0	2.5
Megaloptera	0.0	0.0	0.0	0.0	0.0	0.0
Odonata	1.8	0.0	3.5	2.2	1.6	0.0
Heteroptera	0.0	0.0	0.0	0.0	0.0	0.0
Coleoptera	0.0	4.8	2.3	3.3	0.0	0.0
Diptera (excluding midges)	0.0	0.0	0.0	0.0	1.6	0.6
Diptera (midges)	20.5	15.0	76.9	60.4	32.8	72.8
Tanypodinae	0.0	7.0	2.3	7.7	3.1	3.1
Orthocladiinae	0.0	10.2	24.4	7.7	9.4	26.5
Chironomini	19.6	2.0	32.6	42.9	17.2	29.6
Tanytarsini	0.9	2.0	17.4	2.2	3.1	13.6
Relative Abundance of Functional Feeding Groups						
Collector-gatherers	42.4	36.4	40.7	46.2	34.4	49.2
Collector-filterers	0.9	15.0	20.9	3.3	4.7	15.4
Predators	3.6	5.4	8.1	12.1	9.4	6.2
Scrapers	29.9	23.1	8.1	16.5	21.1	6.8
Shredders	23.2	20.1	22.1	22.5	30.5	22.2
Relative Abundance of Functional Feeding Group Biomass						
Collector-gatherers	39.2	<0.1	3.3	87.0	23.6	50.7
Collector-filterers	1.4	50.5	0.9	1.1	<0.1	6.8
Predators	14.6	0.9	93	2.6	46.3	10.4
Scrapers	37.8	39.1	2.3	9.3	23.6	29.4
Shredders	7.0	9.5	0.5	<0.1	6.5	2.7
	QUALITATIVE DATA					
Total # species	34	34	30	25	33	40
EPT Index	9	7	7	7	6	17
NC Biotic Index	6.1	6.07	6.82	7.05	6.77	5.68
	QUALITATIVE AND QUANTITATIVE DATA COMBINED					
Total # species	38	44	45	38	41	47

Electrofishing yielded a total of 15 species and 238 individual fish from the Pen Branch reference site near Road C. The other Pen Branch reference site near Road B yielded 15 species and 243 individuals. The most abundant species at both locations were yellowfin shiner, bluehead chub, and pirate perch. Redbreast sunfish, spotted sunfish, and creek chubs were also well represented, especially at the sample site near Road C. The sites located downstream from the NPDES outfalls, Indian Grave Branch and Pen Branch near Road A13.2, supported somewhat more species (22 and 20 respectively) and were numerically dominated by dusky shiner, coastal shiner, spotted sunfish and a variety of other species. These differences in numbers and types of species supported by the reference sites and the other sites, which were located farther downstream, were a consequence of differences in stream size and habitat that naturally occur between the upper and lower reaches of streams (Paller 1994). The IBI takes such natural differences into account and generates a score based only on environmental quality (Paller et al. 1996)

The IBI at the Pen Branch reference sites (Roads C and B) averaged 48.0 and 46.0 (Table 10). IBI values in Indian Grave Branch and at Pen Branch near Road A13.2 were also quite high, averaging 47.3 and 48.7, respectively. These values are close to the maximum IBI value of 50 and reflect the high environmental quality of both the undisturbed upper reaches of Pen Branch and the downstream reaches that receive NPDES discharges. These results were comparable to the macroinvertebrate results, which also indicated high environmental quality at all sample areas in Pen Branch.

Temporal changes between 1997 and 2000 - The average IBI at the Pen Branch reference sites (Road C and Road B) differed little between 1997 and 2000, reflecting high environmental quality and stable conditions at both sites (Table 10). In contrast, IBIs at the Indian Grave Branch and Pen Branch Road A13.2 sites increased slightly between 1997 and 2000, from 44.7 to 47.3 and from 45.3 to 48.7, respectively. These increases reflect the continuation of a recovery trend that began when thermal discharge into these streams was discontinued with the shut down of K-Reactor, permitting recolonization by fishes and restoration of the habitat.

4.4 Steel Creek/Meyers Branch

4.4.1 Macroinvertebrates - Steel Creek/Meyers Branch

Macroinvertebrates were collected from two locations in the Steel Creek watershed: Steel Creek near Road C, which is downstream from all previous P-Area discharges to the stream and approximately one km upstream from the upper end of L Lake; and Meyers Branch at Old Dunbarton Road, which is essentially unimpacted by SRS activities. As discussed in Section 2.4, sampling was not performed farther downstream in Steel Creek, because NPDES discharges enter directly into L Lake, the NPDES discharges into the lake are minimal, and it would not be possible to distinguish between ecosystem changes resulting from the impoundment of Steel Creek and effluent effects. During the time that the multiplates were in Steel Creek, substantial volumes of water from the Savannah River were discharged down Steel Creek to provide water to L Lake. Therefore, both the discharge rate and water velocity were elevated. These factors can influence the kinds of taxa that inhabit the stream, and can also dislodge macroinvertebrates from the substrate. In Steel Creek, 24 taxa were

collected from the multiplate samplers, 37 were collected from qualitative sampling, and 49 were collected in all (Table 15). In Meyers Branch, 34 taxa were collected from the multiplates, 46 were collected during qualitative sampling, and 66 taxa were collected in all. More EPT taxa were collected from multiplates in Steel Creek than in Meyers Branch (11 taxa vs. 6), but an equal number of EPT taxa were collected from both streams in the qualitative sampling (9). The density of organisms on the multiplates was much higher in Meyers Branch (7108.3 organisms/m^2) than in Steel Creek (983.3 organisms/m^2). The lower densities in Steel Creek may have been related to the high flows resulting from river water being pumped to L Lake during the multiplate colonization period. The biotic index values were higher (poorer) in Meyers Branch than Steel Creek for both the multiplate data (6.46 vs. 5.04) and the qualitative sampling (7.51 vs. 5.19). The data indicate that Meyers Branch has a more diverse fauna than Steel Creek, and higher densities of organisms, but the high densities were attributable to a very few species of midges, which resulted in a relatively high biotic index value. The macroinvertebrate community on the multiplate samplers in Steel Creek was dominated by mayflies (52.5%; primarily *Stenonema and Ephemerella*; Table 6), midges (23.7%; primarily *Polypedilum*), caddisflies (12.7%) and stoneflies (8.5%). In Meyers Branch, 94.1% of the organisms collected were midges (primarily *Tanytarsus*, *Parametriocnemus,* and *Microtendipes*), with mayflies accounting for 3.8% of the macroinvertebrates that were collected from multiplates. The collector-gatherer functional feeding group was the most group in Steel Creek (38.6%), followed by scrapers (26.7%) and collector-filterers (16.1%). In Meyers Branch, collector filterers (mostly Tanytarsini midges) were dominant (62.6%), followed by collector gatherers.

The Bioclassification scores for Steel Creek were 3.5 (good) for both the qualitative and quantitative data sets (Table 8), while Meyers Branch, which is a reference site, scored 2.0 for the qualitative data and 2.2 for the quantitative data, which are both ratings of "fair". There is no ready explanation for the relatively low Bioclassification scores for Meyers Branch, since the stream receives no NPDES discharges and there are no other known sources of perturbation to the stream.

The macroinvertebrate communities of Steel Creek and Meyers Branch are quite different, but the differences appear to be due to differences in habitat, rather than to effluent effects. Steel Creek, which received small amounts of NPDES effluents from P Area until 1998, but presently receives no NPDES discharges, had fewer taxa than Meyers Branch, but much higher percentages of EPT taxa. The macroinvertebrate data from Steel Creek look remarkably similar to those of Mill Creek, which is an unperturbed tributary of Upper Three Runs.

Temporal Changes in Steel Creek and Meyers Branch - Like most of the other streams that were sampled, more taxa were collected from Steel Creek and Meyers Branch in 2000 than in 1997 (Tables 15 and 16). In the 2000 sampling of Steel Creek, 24 taxa were collected from multiplates, 37 from qualitative samples and 49 from quantitative combined, as compared to 17, 33 and 41 taxa, respectively, in 1997. In Meyers Branch in 2000, 34 taxa were collected from multiplates, 46 from qualitative sampling, and 66 from qualitative and quantitative combined, as compared to 18, 40, and 47 taxa, respectively, in 1997. The relative abundance of mayflies and caddisflies were considerably higher in Steel Creek in 2000 (52.5% and 12.7%, respectively) than in 1997 (35.9% and 0.0%), but the reverse was seen for stoneflies (8.5% in 2000 and

23.4% in 1997). In Meyers Branch, midges, and particularly Tanytarsini midges, were much more abundant in 2000 than in 1997. Tanytarsini midges made up 61.5% of the organisms collected from multiplates in Meyers Branch in 2000, as compared to just 13.6% in 1997. No explanation for the change is obvious. In Steel Creek, the distribution of organisms in functional feeding groups was fairly consistent between 1997 and 2000. In Meyers Branch, collector-filterers were much more abundant in 2000 (62.6%) than in 1997 (15.4%), while most other functional groups represented a smaller percentage of the organisms collected in 2000 than in 1997. The shift in functional group composition was due primarily to the large number of filter-feeding Tanytarsini midges that were collected in Meyers Branch.

4.4.2 Fish -- Steel Creek/Meyers Branch

Fish were collected from sample stations in the portion of Steel Creek upstream from L Lake (near Road C) and Meyers Branch. The sample station in Steel Creek was located approximately 1.75 km downstream from several former NPDES outfalls. The Meyers Branch station did not receive NPDES discharges and was largely undisturbed. It was considered a reference site and grouped with the other three reference sites for statistical analysis.

The assemblage of fish collected from Meyers Branch was typical of reference sites, consisting of 159 individual fish representing 15 species. The most abundant species were yellowfin shiner, bluehead chub, and creek chubsucker. In contrast, the fish sample from Steel Creek near Road C included only 28 individuals and eight species. It is unlikely that these low numbers were the result of inefficient sampling since sampling conditions at Steel Creek near Road C were good (comparatively shallow and clear water).

The mean IBI value for Steel Creek near Road C was 23.3 (Table 10). This value was significantly lower than the mean IBI for the four control sites. Furthermore, it was below the range of IBI values calculated for undisturbed streams in the historical data base (Figure 3) suggesting that biotic integrity in upper Steel Creek was poor. It is noteworthy that the Steel Creek was electrofished prior to the pumping of large volumes of Savannah River into Steel Creek to recharge L Lake (discussed in the preceding section). Therefore, this perturbation was not responsible for the low IBI in Steel Creek. Furthermore, Steel Creek has not received NPDES discharges since January 1988, indicating that poor biotic integrity in Steel Creek near Road C is unrelated to NPDES outfalls.

The low IBI from Steel Creek near Road C contrasts with the macroinvertebrate data from this site which do not indicate significant degradation. Reasons for this difference are unclear. Fish were collected in July and macroinvertebrates in November; however, there were no known changes in Steel Creek preceding or during this period that would account for the differences between the fish and macroinvertebrate results. It is important to consider that fish and macroinvertebrate bioassessments do not always agree because fish and macroinvertebrates respond differently to some environmental disturbances. Mount et al (1984) observed that fish were more sensitive to metal pollution than were macroinvertebrates, but macroinvertebrates were more sensitive to organic pollution than were fish. Yoder and Rankin (1995) observed differences in the rates of recovery of fish and

macroinvertebrates from the combined effects of several types of disturbance. Berkman et al. (1986) found that stream fish and invertebrate communities often responded differently to sedimentation and that invertebrates seemed more sensitive to this type of disturbance. The Ohio Department of Natural Resources samples both fish and macroinvertebrates and determines the level of impact based on the number of taxonomic groups that are degraded (Yoder and Rankin 1999). Based on this logic, a low IBI from Steel Creek indicates environmental degradation, although not as severe as if both fish and macroinvertebrate assemblages were degraded.

The low IBI in Steel Creek may be at least partly habitat related. The banks of Steel Creek were severely eroded (Table 11). The stream channel was cut more deeply than is typical of most SRS streams and bank collapse was evident in a number of areas raising the possibility of intermittent siltation and habitat instability. However, it cannot be definitively stated that habitat degradation was the sole cause of the low IBI observed in Steel Creek.

Temporal changes between 1997 and 2000 - The IBI in Steel Creek near Road C declined markedly between 1997 and 2000, from 32.7 to 23.3 (Table 10). Steel Creek near Road C was the only sample site to exhibit such a strong decrease in the IBI between years. The cause of this decrease is unknown.

4.5 Savannah River

All discharges from SRS NPDES outfalls ultimately flow into the Savannah River because all SRS streams are tributaries of the Savannah River. However, NPDES outfalls on SRS streams discharge into the upper or midreaches of these streams (Table 2), resulting in a long flow path to the Savannah River and considerable dilution of the effluents before they reach the river. Biological sampling has demonstrated that most of these outfalls have not affected their receiving streams. In the few cases where possible effects were observed (e.g., Crouch Branch), they were confined to headwaters and did not persist downstream. Therefore, it is reasonable to conclude that NPDES outfalls located on SRS streams have not affected the Savannah River.

Unlike the majority of the SRS NPDES outfalls, which discharge into tributary streams, there are six NPDES outfalls (Table 2) that are located near the Savannah River. Effluents from these outfalls are discharged into the Savannah River Swamp or flow directly into the Savannah River through a relatively short ditch. Upon entering the river, all effluents are highly diluted by mixing with Savannah River water. Previous biological surveys (1983 to 1985) indicated the presence of diverse and healthy fish and macroinvertebrate communities in the Savannah River with no evidence of impacts related to SRS NPDES discharges (Specht 1987).

5.0 Conclusions

The results of the macroinvertebrate and fish surveys conducted during this study were generally in close agreement. Both indicated that most SRS streams were characterized by high biotic integrity and unaffected by SRS NPDES discharges. Possible exceptions include Crouch Branch, McQueen Branch and Tims Branch. For Crouch Branch, the fish data indicate no impairment, while the macroinvertebrate data indicates possible impairment. Investigations conducted in Crouch Branch subsequent

to the 1997-1998 biological survey indicated that elevated concentrations of copper contributed by the H-02 outfall are responsible for much of the degradation, although erosion and scouring by stormwater runoff have also degraded habitat in the midreaches of Crouch Branch. Sampling conducted during 2000 indicated the fish community in Crouch Branch has fully recovered and the macroinvertebrate community has improved considerably. For Tims Branch, the fish data is not significantly different from the control, but the macroinvertebrate data indicates some impairment. Since 1997, several beaver dams have been constructed just upstream from the sampling location in Tims Branch. Dissolved oxygen concentrations below the dams are low, and this appears to be the cause of the perturbation in Tims Branch. For McQueen Branch, the fish data was not significantly different from the control, but the macroinvertebrate data indicates some impairment. For the sampling conducted in 2000, the sampling location in McQueen Branch was moved approximately 1 km upstream from the 1997 sampling location, due to inundation of this location by beaver dams. Stream habitat at the new location is somewhat degraded, due to channel scouring in the 1980's. However, this location is also closer to two NPDES discharges than the original sampling location, so impacts due to NPDES discharges cannot be ruled out. Degradation was also observed in upper Fourmile Branch and upper Steel Creek, neither of which presently receive NPDES discharges. Depressed biotic integrity in upper Fourmile Branch was related to factors other than NPDES discharges including low dissolved oxygen and elevated concentrations of iron. The IBI indicated that biotic integrity decreased in upper Steel Creek between 1997 and 2000. Reasons for this change are unclear but may include reservoir impoundment related effects and naturally occurring habitat factors.

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