A PRELIMINARY ASSESSMENT OF THE AQUATIC IMPACTS OF A PROPOSED DEFENSE WASTE PROCESSING FACILITY AT THE SAVANNAH RIVER PLANT

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HALKARD E. MACKEY, JR. A Preliminary Assessment of the Aquatic Impacts of a Proposed Defense Waste Processing-Facility at the Savannah River Plant

A review of the literature indicates that a significant body of descriptive information exists concerning the aquatic ecology of Upper Three Runs Creek and Four Mile Creek of the Savannah River Plant south of Aiken, South Carolina. This information is adequate for preparation of an environmental document evaluating these streams. These streams will be impacted by construction and operation of a proposed Defense Waste Processing Facility for solidification of high level defense waste. Potential impacts include (1) construction runoff, erosion, and siltation, (2) effluents from a chemical and industrial waste treatment facility, and (3) radionuclide releases. In order to better evaluate potential impacts, recommend mitigation methods. and comply with NEPA requirements, additional quantitative biological information should be obtained through implementation of an aquatic baseline program.

TABLE OF CONTENTS

•	Page
ACKNOWLEDGEMENTS	ii
PREFACE	iii
CHAPTER 1. INTRODUCTION	1
Purpose	1
CHAPTER 2. AQUATIC ASSESSMENT	6
Need for the Environmental Assessment Availability of Aquatic Information Summary of the Aquatic Ecology of Upper	6 7
Three Runs Creek and Four Mile Creek	9
CHAPTER 3. PROJECTED DWPF AQUATIC RELEASES	13
Present Releases to Upper Three Runs Creek and Four Mile Creek	13 13
CHAPTER 4. FUTURE AQUATIC INFORMATIONAL NEEDS	24
CONCLUSION	32
APPENDIX (DRAFT)	35
2.7.2 AQUATIC ECOLOGY	
2.7.2.1 Introduction 2.7.2.2 Prior Biological and Water Quality Investigations 2.7.2.3 Primary Producers 2.7.2.4 Consumers 2.7.2.5 Rare or Unique Biota 2.7.2.6 Reserve Areas 2.7.2.7 Existing Stresses on the Biological Systems 2.7.2.8 References FIGURES	
TABLES	

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PREFACE

The following Technical Report was written as the result of tenure as a Faculty Research Participant at the Savannah River Laboratory during the summer of 1979. Assignments during that tenure consisted of contributions to various chapters of the draft environmental document for a Defense Waste Processing Facility (DWPF) proposed for construction at the Savannah River Plant, Aiken, South Carolina. cant contributions were made to the Aquatic Ecology Section Information included in this section describes the 2.7.2. surface drainage, prior biological investigations, producer organisms, consumer organisms, rare and endangered biota, and existing stresses on the streams affected by construction and operation of the DWPF. Descriptive information was also developed on potential impacts to Upper Three Runs Creek and Four Mile Creek by the DWPF project. Recommendations for future aquatic monitoring programs were made.

CHAPTER 1. INTRODUCTION PURPOSE

The principal purpose of this report was to assess the availability of information on the aquatic ecology of streams potentially impacted by a Defense Waste Processing Facility (DWPF) proposed for the Savannah River Plant (SRP) south of Aiken, South Carolina. This information, if adequate, was to be used to prepare Section 2.7.2, Aquatic Ecology, of the environmental document for this facility. The draft of Section 2.7.2 is enclosed as the Appendix to this report.

Needs for additional information on the aquatic ecology were to be identified. Secondarily, descriptions of potential aquatic impacts from the DWPF were to be developed, a preliminary estimate of these impacts made, and a monitoring program suggested.

BACKGROUND INFORMATION ON SRP AND THE DWPF

Since 1953, the Savannah River Plant (SRP) has been producing special nuclear materials, primarily plutonium and tritium, for defense purposes. The SRP facilities were constructed and operated by DuPont Company initially for the Atomic Energy Commission (AEC) and now for the Department of Energy (DOE). The SRP site occupies an area of about 300 square miles along the Savannah River, about 25 miles downstream

from Augusta, Georgia. SRP includes a nuclear fuel fabrication plant, three operating production reactors, two fuel reprocessing plants (F and H Areas), a facility for production of heavy water, and waste tank storage facilities (Figure 2.7.2.1-1).

Since shortly after operations began, an acidic, highly radioactive liquid waste has been generated during the chemical processing of fuels and targets after irradiation in the SRP nuclear reactors. This acidic waste is made alkaline and is stored in large underground tanks of approximately 1 million gallons each. An insoluble precipitate, consisting primarily of aluminum and iron hydroxides and containing most of the radioactivity, settles to the bottom of the tanks as a sludge. The supernate, consisting primarily of sodium nitrate, sodium nitrite, sodium aluminate, sodium hydroxide, sodium carbonate, sodium sulfate and containing some soluble radioisotopes such as cesium and ruthenium, is removed and concentrated by evaporation. The supernate is concentrated to a dissolved salt concentration of approximately 48 percent by weight and then returned to the waste tanks. The concentrated solution solidifies to a damp salt cake upon cooling. Thus the inventory of high activity waste at the Savannah River Plant consists of a sludge fraction, a salt fraction, and unevaporated liquid. chemical composition of the waste varies due to the type of material irradiated and the specific chemical process used for recovery. The radioactivity level of the waste varies because of the type of fuel or target irradiated and elapsed time since irradiation (ERDA, 1977).

Five different designs of waste tanks are presently in use.

By 1987, it is planned to have all of the radioactive waste stored in Type III and IIIA tanks which have double steel walls and are enclosed in an outer concrete tank. Older tanks will be chemically cleaned and retired from service. Approximately 22 million gallons of wastes are currently in storage in waste tanks (ERDA, 1977).

Planning for disposition of SRP wastes was begun as early as 1959, and in 1971, the Division of Waste Management and Transportation was formed in the AEC to plan for the long-term management of defense waste nationwide. One plan considered for SRP was storage of waste as a liquid in a deep-mined cavern under the SRP site. In 1972 that option was deferred in favor of an investigation of the conversion of SRP waste to a solid form (Bradley and Corey, 1976).

In an initial evaluation of solidification, various forms and processes for handling high level wastes were evaluated with emphasis on the applicability of these waste forms and processes to SRP wastes. This evaluation showed that the presence of soluble salts, such as NaNO3 and Na2CO3 presented difficulties if these salts had to be incorporated into a high-integrity form such as glass or concrete. Processes for segregating the soluble salts from the radionuclides were suggested based upon physical separation of insoluble sludge and supernate via centrifugation and filtration and separation of soluble radionuclides in the supernate (principally Cs-137) by ion exchange. Subsequent studies demonstrated that separation was feasible and that

concrete was an acceptable waste form, but that glass had higher integrity. Glass had greater leach resistance in water and did not off gas when heated. SRL also made an overall evaluation of the costs and risks of various options for long-term management of SRP wastes. This evaluation included options such as onsite bedrock storage and continued tank storage, as well as solidification (DOE, 1978a).

In 1977 a reference solidification plan was selected for further development. This plan involved (1) incorporation of radionuclides into glass and shipment to a Federal repository, (2) return of decontaminated supernate as a damp salt cake to onsite bulk storage in tanks, and (3) processing of all wastes more than five years old.

Construction of the Defense Waste Processing Facility is proposed to carry out this process. The DWPF will be located at a new site (200-S Area) on the SRP site in proximity to the F and H Areas. The waste processing facility is designed for an instantaneous rate of 12 gpm. The aged waste will be separated into two fractions, a supernate fraction and a sludge-slurry fraction, for feed to the DWPF. The supernate fraction is composed of aged decanted supernate and redissolved salt cake. The sludge-slurry fraction is a water slurry of sludge whose volume is twice that of the original in-tank settled sludge volume. The process is designed to reduce the cesium, strontium, and plutonium content of the supernate to levels as low as is

reasonably achievable. The radioactive borosilicate glass, containing greater than 99 percent of the radioactivity, will be contained in a (2-ft diameter, 10-ft long) steel canister which will be encapsulated in a steel overpack. One hundred and sixty-five gallons of glass will be loaded into each canister. The glass form will be shipped to a Federal repository following temporary onsite storage. Decontaminated clarified supernate will be dewatered in existing interim waste management facilities and stored as a damp cake in new or existing Type III and IIIA underground storage tanks.

The DWPF is projected to be completed in December, 1987. Site specific studies, including the continuation and completion of soils investigations and seismic survey work and preparation of a Safety Analysis Report, are to be completed in early 1980. These studies also include geologic investigation, groundwater and surface water hydrology, vibratory ground motion, faulting, and quality assurance assessment. Process development is proceeding. Project authorization is planned for fiscal year 1982 with construction startup shortly thereafter.

CHAPTER 2. AQUATIC ASSESSMENT NEED FOR THE ENVIRONMENTAL DOCUMENT

The National Environmental Policy Act of 1969 (NEPA) requires that all Federal agencies include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a statement of the environmental impact of that proposed action. Section 2.7.2, Aquatic Ecology, was thus prepared to document baseline aquatic ecological data for the DWPF site, and provide the basis for evaluating the potential environmental impacts of the proposed facility.

Licensing of a Department of Energy (DOE) high level waste processing facility is not required. No specific regulatory document exists for preparation of environmental assessments for a facility such as the DWPF. Thus judgments for preparation of Section 2.7.2 of the environmental document were based upon generally recognized requirements for other types of facilities within the nuclear industry. Information needed for Section 2.7.2 of the environmental document was therefore evaluated against this generally perceived regulatory framework. Guidelines for preparation of Section 2.7.2 of the environmental document were drawn from the following:

o NRC, Regulatory Guide 4.2, Revision 2, Preparation of Environmental Reports for Nuclear Power Stations.

- O NRC, Regulatory Guide 4.9, Revision 1, Preparation of Environmental Reports for Commercial Uranium Enrichment Facilities.
- NRC, Regulatory Guide 4.11, Terrestrial Environmental Studies for Nuclear Power Stations.
- O CEQ, Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act, 1978.
- O DOI, A Systems Approach to Ecological Baseline Studies, FWS/OBS-78/21, States, et al., 1978.

The Environmental Report, <u>Nuclear Fuel Recovery and Recycling Center</u>, by the Exxon Corporation was also used as a model for preparation and evaluation of materials for various sections of the environmental document, including Section 2.7.2, Aquatic Ecology. However, the data treatment has been adapted to reflect the differences between the subjects of these guides and the DWPF with respect to its unique purpose and processes and its mechanisms for environmental impact.

AVAILABILITY OF AQUATIC INFORMATION

Section 2.7.2, Aquatic Ecology, is included as an appendix to this report. It is a summary of the physical, chemical, and biological information on those streams most likely to be impacted by construction and operation of the DWPF. These streams include Upper Three Runs Creek and Four Mile Creek and their tributaries.

Although no one document exists which describes the aquatic baseline information available on these two streams, numerous research studies, surveys, and monitoring programs have been conducted on them, Table 2.7.2.2-2. These data once consolidated

provide an excellent descriptive body of information for these streams. In addition, these data are supplemented by Philadelphia Academy of Natural Sciences surveys which began on the Savannah River prior to operation of the SRP and continue today, Table 2.7.2.2-1.

The primary sources of data for development of Section 2.7.2 are summarized in the following:

- O Baseline studies on the aquatic environment of the Savannah River between river miles 123 and 162 were initiated by the Academy of Natural Sciences of Philadelphia (ANS) in 1951-1952, and have been continued on an operational monitoring basis to the present.
- O Diatometer studies were begun in 1953 by ANS as a means to continously record possible changes in the river as reflected by changes in the diatom community. Quarterly reports of these studies are available from E. I. du Pont de Nemours and Company.
- O Numerous baseline surveys of aquatic and terrestrial biota were conducted by biologists from the University of South Carolina and the University of Georgia under contract to the Atomic Energy Commission during the period 1951-1960.
- O Studies on thermally stressed ecosystems, succession of terrestrial systems, population dynamics and other ecological problems have been performed by the Savannah River Ecology Laboratory, established in 1961 and operated by the University of Georgia.
- O Detailed studies of water quality and stream transport of materials have been conducted by the Environmental Transport Division of the Savannah River Laboratory. These studies were initiated in 1972.
- O Upper Three Runs Creek became a National Hydrologic Bench-Mark Stream in 1966 and data on physical and chemical parameters are available since then.
- O The Savannah River Plant site was established as the first National Environmental Research Park (NERP) in 1972 and NERP baseline studies have been conducted since then on very diverse groups of organisms.

- O Routine sampling at several stream stations have been performed on a quarterly to monthly basis since 1951 in conjunction with monitoring radioactive releases by the Environmental Monitoring Program of the Health Protection Department of the Savannah River Plant.
- O The Flowing Streams Laboratory established in 1972 by SRL provides information for Upper Three Runs Creek.
- O The Corps of Engineers has prepared environmental reports on the Savannah River Basin.
- O Environmental reports have been prepared for the A. W. Vogtle Nuclear Plant and the Barnwell Nuclear Fuel Plant.
- O Information on the aquatic ecology of these streams is also available in Section 3.4.13 of the Safety Analysis Report for the DWPF. This information was developed by D'Appolonia Consulting Engineers, Inc. (Murdock, 1980).

In this body of information every major group of organism is included. It should be noted that the biological information is qualitative and descriptive in content and that very few quantitative studies have been done. The physical and chemical data are primarily available from the SRP and USGS monitoring programs.

SUMMARY OF THE AQUATIC ECOLOGY OF UPPER THREE RUNS CREEK AND FOUR MILE CREEK

Upper Three Runs Creek is a slightly dystrophic stream which drains from the Aiken Plateau and crosses a series of terraces before entering the Savannah River, Figure 2.7.2.1-1. The stream is slightly acid and carries a relatively low load of suspended and dissolved organics compared to other streams of the southeastern Atlantic Coastal Plain, Table 2.7.2.7-7. The water of Upper Three Runs Creek is thus soft, clear, and usually low in

nutrients. The temperature ranges from approximately 6 to 26 degrees Centigrade during the year. Effluents to Upper Three Runs Creek are received through Tims Branch, downstream from the DWPF site, Table 2.7.2.7-6. These effluents include process wastes, process cooling water, and surface runoff. Surface runoff occurs from F and H Areas also, Table 2.7.2.7-6. Upper Three Runs Creek has never received cooling water discharges from the production reactors of SRP. The water is thus of high quality; exceeding in many cases even in its natural condition the National Interim Primary Drinking Water Standards (EPA, 1976).

Biologically Upper Three Runs is also unique. Approximately 60 species of fish have been reported from Upper Three Runs Creek, Table 2.7.2.4-2, many of which are characteristic of cool, first and second order streams. Recent insect surveys (see Sub-section 2.7.2.4 C. Macroinvertebrates) have shown that the insect community consists of a rich variety of climbers, clingers, and sprawlers. Species, more typical of northern and mountain streams, were found to exist along with southern lowland species of insects. Algal and macrophytic information, although fragmentary (see Sub-section 2.7.2.3 Primary Producers), likewise indicates a diverse community.

Upper Three Runs Creek is thus an excellent example of the once unpolluted, blackwater drainage systems typical of the smaller Coastal Plain waterways of the southeastern United States. Its status as a relatively undistrubed stream enhances its value as a research site and comparison stream for other streams on the SRP site.

Four Mile Creek lies entirely within the SRP site, Figure 2.7.2.1-1. It receives discharges from the major plant separations facilities in F and H Areas, Table 2.7.2.7-6. Thus its pH, temperature, and load of dissolved and suspended matter tend to be higher than Upper Three Runs Creek, see Tables 2.7.2.7-3 and 2.7.2.7-9. Also below the confluence of Four Mile Creek with the canals for discharge of cooling water from C Reactor, the water quality is markedly changed. Temperatures occasionally exceed 50 degrees Centigrade in this section of Four Mile Creek, see Tables 2.7.2.3-3. and 2.7.2.7-9. Such conditions have prevailed since the early 1950's. The native swamp forest has been eliminated and only organisms, such as Gambusia affinis, a fish tolerant of thermal extremes, persist in the lower stream reaches. Organisms occurring upstream from the thermally stressed reaches of Four Mile Creek are essentially isolated from aquatic populations in the Savannah River and its other tributaries. Fewer fish species occur in Four Mile Creek than Upper Three Runs Creek with 20 to 30 species being reported by various sources (see Sub-sections 2.7.2.4 A. Fish Populations and Table 2.7.2.4-2). The other biota of Four Mile Creek including algae, macrophytes, and macroinvertebrates are also less well known than for Upper Three Runs Creek.

In addition to industrial discharges and reactor cooling water discharges, Four Mile Creek also receives radionuclide releases from F and H Area facilities, burial grounds, seepage basins, and C Reactor, Tables 2.7.2.7-12, 2.7.2.7-14, and 2.7.2.7-15.

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CHAPTER 3. PROJECTED DWPF AQUATIC RELEASES

PRESENT RELEASES TO UPPER THREE RUNS CREEK AND FOUR MILE CREEK

Of the five tributaries on the SRP site, two of these streams, Upper Three Runs Creek and Four Mile Creek, are close to the F and H separations areas and will receive effluents from the proposed DWPF (Figure 2.7.2.1-2). One of the tributaries of Upper Three Runs Creek receives industrial wastes from the fuel fabrication facilities (M-Area) and the Savannah River Laboratory. Four Mile Creek lies south of F and H Areas and receives effluents from F and H separations areas and the cooling water discharge from C Reactor. drainage from both F and H Areas flows toward Four Mile Creek and Upper Three Runs Creek. Because of the water table contours, drainage from the F Area tank farm into the ground divides with some drainage flowing toward each of the two creeks. The various aquatic discharges to Upper Three Runs Creek and Four Mile Creek are summarized in Table 1 of this chapter. Efforts are continuing by the SRP to improve containment of coal pile runoff, ash pile stabilization, neutralization of demineralizer effluents, containment of water treatment sludge, containment of reactor cooling basin sediment, and pH control of ash basin effluents.

PROJECTED RELEASES FROM THE DWPF

Effluents released from the DWPF will occur during two phases of activity, construction and operation. Figure 1 and Table 1 of this chapter show the anticipated types of effluents during these two phases. Table 2 also contains a judgment of their potential importance to aquatic impacts of Upper Three Runs Creek and Four

Mile Creek. Mitigation of each of these impacts is planned and is summarized in the following paragraphs.

Erosion Control

Control of soil erosion is maintained during the construction period. As site grading progresses, cutoff ditches and diversion berms are used to minimize erosion and to direct storm runoff to sediment-retention basins. Areas stripped of vegetation are protected with straw mulch or stone coverings depending on the activity in the area. Effluents from the sediment-retention basins will be directed to Upper Three Runs Creek.

As grading is completed, seeding of the area is done. Landscaping consists of grassing and stabilizing all areas affected by construction of the DWPF, but does not include trees, shrubs, or special plantings. All areas inside the exclusion fence are landscaped to varying degrees. Steep slopes, as a result of excavation or backfill, receive special treatment. All cleared areas outside the exclusion fence are landscaped to check erosion.

Storm Sewer Facilities

These facilities provide a system for collection and disposal of stormwater runoff. The system extends over the entire DWPF Area. Rainwater runoff collection lines from coal storage, ash disposal basins, cold feed storage and all other locations where water may pick up chemical contamination are excluded from the stormwater collection facilities. Likewise erosion protection facilities are excluded. Sanitary sewer lines are not included. The storm sewer

system consists of inlet structures and gratings, underground storm drain lines, storm sewer outfall structures, manholes, and storm gratings. The storm sewers are a gravity flow collection system designed to remove all surface runoff from a 10-year frequency storm. The flow from areas surrounding the railroads, roads, truck unloading, tank farm and shops where storm water may be chemically contaminated will be directed through diversion boxes to the equalization tanks at the chemical and industrial waste treatment facility.

In order to reduce the capacity required for the equalization tanks, a minimum of three drainage systems is planned. The equalization tanks will be sized for one area's contaminated flow for 30 minutes of a 10-year frequency storm plus the other contaminated quantities. The remaining open areas and roof drains will be collected and released outside the area. All surface runoff will ultimately be carried away by Upper Three Runs Creek. The outfall structures will be reinforced concrete headwalls with properly graded and riprapped ditches and banks to eliminate erosion.

Sanitary Sewers and Sewage Treatment Facilities

These facilities provide a system for collection, treatment, and disposal of the sanitary wastes generated in the DWPF Area. Sanitary sewers are gravity flow conduits of clay pipe for collection and transfer of sewage to a surge tank and pumping station located adjacent to the sanitary treatment facility. The sewers are capable of accommodating sewage rates of 40 gallons per person per day for a work force of 500 persons.

A prefabricated activated-sludge treatment oyotem including

an aeration chamber, clarifier chamber, a sludge holding tank, and chlorine contact tank is provided. The effluent from the chlorine contact tank is deposited on a maintained spray field at a rate to eliminate runoff. The sludge is pumped from the sludge holding tank into mobile tanks and disposed of on the sludge drying beds of the chemical and industrial waste treatment facility. No new or additional releases to Upper Three Runs Creek are anticipated.

Ash Disposal Basin

The ash disposal basin provides space for landfill of ash and separation of the water used for transporting the ash from the power area. This facility consists of lined basins, a concrete sump for recirculating sluice water, and monitoring wells. The ash disposal basin provides a 2.9 million cubic feet of storage which equals 8 years of operation at an average load of 130,000 pounds per hour. The basins will be located to permit future expansion for 20 years of operation. Two earthen lagoons with 1.45 million cubic feet of capacity are provided. The lagoons are lined with a five foot clay liner. Erosion protection is provided on graded areas and banks. Monitoring wells are used to assure that the liner is not leaking. The sluice water and any rainwater collected in the basin is recirculated for ash sluicing. The overflow or blowdown is treated in the chemical and industrial waste treatment facility.

Chemical and Industrial Waste Treatment Facility

These facilities provide treatment for non-radioactive contaminated waste water generated from chemical operations and rainwater run-off in the S Area. The contaminated water to be treated includes ash basin blowdown, boiler blowdown, water treatment regenerates, cold

feed spills and washdowns, mock-up building and apron effluent, truck unloading and pad effluents, coal pile run-off, cooling tower blowdown, equipment cooling water and chemical-contaminated storm water. These waste water streams are blended in an equalization basin, then neutralized in a two-stage agitated system using 20 percent caustic or concentrated $\mathrm{H}_2\mathrm{SO}_4$. The stream is clarified in gravity settlers with polyelectrolyte flocculation as required. The supernate from the settlers is filtered, monitored and pumped to Four Mile Creek. The sludge from the settlers is pumped to the drying beds and run-off is returned to the settlers. sludge is removed to a landfill area. Facilities provided are sized to handle a design flow of 250 gpm (maximum) containing suspended solids in the range of 500 to 1000 ppm. Fluctuations in pH as low as 1 and as high as 14 are provided. It is expected that the pH will normally range between 3-4 or higher. Waste treatment effluent quality design goals are:

- o Total suspended solids less than 10 ppm
- o pH between 6-9
- o Oil and grease less than 10 ppm
- o Heavy metals concentrations less than the values listed below:

Arsenic	0,5	ppm
Barium	10.0	ppm
Cadmium	0.10	ppm
Chromium	0.5	ppm
Lead	0.5	ppm
Mercury	0.02	ppiii
Selenium	0.10	ppm
Silver	0.50	ppm

The design goals listed above for effluent quality should be viewed as tentative until such time as the actual parameters required for compliance with applicable regulations can be determined.

Estimated Radionuclide Releases

The annual discharge of radioactivity contaminants to the atmosphere and plant streams are shown in Table 3 of this chapter. The anticipated releases from the DWPF are compared with the SRP releases for 1979 in Table 4 of this chapter. The estimated atmospheric release of tritium from the DWPF is several orders of magnitude less than the normal SRP releases. The estimated aquatic release of tritium from the DWPF is about one-half of of the normal SRP releases. The releases of fission products, uranium, and transuranics are a few to several orders of magnitude below the current SRP aquatic releases.

TABLE 1. AQUEOUS DISCHARGES FROM SRP FACILITIES TO UPPER THREE RUNS CREEK AND FOUR MILE CREEK 1

Area	Discharge To	Cooling Water	Reactor Cooling. Mater	Ash Basin and Acid Basin Discharge	Demineralizer Regenerants	Mater Treatment Chemicals	Coal Pile Runoff	Ash Pile Runoff	Low-Level Radioactivity	Process Chemicals	Sewage Plant Discharge	Laboratory Reagents	Storm Sewers	Undefined or Undetermined* Source
А	Tim's Branch (Upper Three Runs Creek)	×		·			⊗		х			x	x	х
	SRL Seepage Basin								x					
М	Tim's Branch (Upper Three Runs Creek)	х				i			х				х	
<u>.</u>	Settling Basin								x	. x	-			
	Upper Three Runs Creek			8	Ø	8		⊗ -					х	
F	Four Mile Creek	х		8			8		х.		8		х	х
	Seepage Basins								х			х		
	Upper Three Runs Creek								·				х	
Н	Four Mile Creek	х		8	⊗	8	⊗		х		⊗		х	
	Seepage Basins							į	x					
C .	Four Mile Creek		×	•	⊗	⊗ `	Ø		х				x	<u></u>
Central Shops	Four Mile Creek												х	х
тс	Upper Three Runs Creek	x									x		×	
DWPF	Upper Three Runs Creek												+	
:	Four Mile Creek	\oplus		⊕		Ф	⊕	•	+				+	

 $^{^{1}}$ Sources DOE (1978b) for current releases and future reductions (x and \bigotimes).

x Current releases.

Reductions or eliminations planned to current releases.

⁺ Future releases from the DWPF.

igoplus Future releases from the Chemical and Waste Water Treatment Facility of the DWPF as a combined effluent.

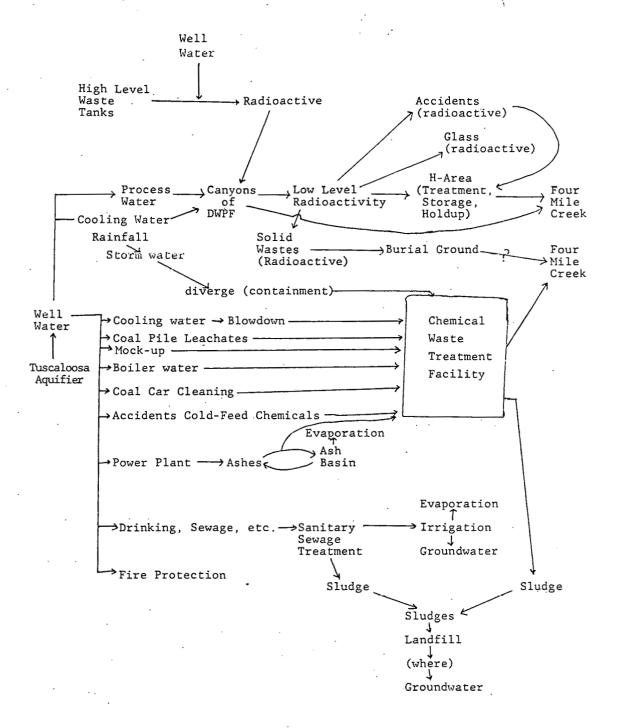


FIGURE 1. GENERAL WATER USE FLOW AND EFFLUENTS FROM THE PROPOSED DWPF

Table 2. Impacts to Upper Three Runs Creek and Four Mile Creek from the Proposed DWPF.

Drainage	Upper Three Rui	ns Creek	Four Mile Creek	c		
or Effluent	Phas	se	Phase			
Туре	Construction	Operational	Construction	Operational		
Erosional Runoff	Problem	Limited	Very minimal	Very minimal		
Storm Sewer Effluents	Problem	Limited	None	None		
Sanitary Sewage	None	None	None	None		
Chemical and Industrial Wastes			·			
a. Ash Basin						
b. Boiler Water						
c. Cooling Water Blowdown						
d. Coal Pile Leachates	- None	None	None	Limited		
e. Coal Car Cleaning	•					
f. Accidental Spillage of Cold-feed Chemicals			-			
Radioactive Releases (Normal Operations)	None	None	None	Limited		

Table 3. Comparison of Radioactive Releases From Present SRP Operations And The DWPF.

•	Atmospheric,	Curies/Yr.	Liquid, Curies/Yr.			
	SRP ^à	DWPF ^C	SRPa	$\mathit{DWPF}^{\mathcal{C}}$		
3 _H	3.8×10^{5}	3.7×10^2	4.0×10^4	1.5×10^4		
Fission Products ^b	1.11 x 10 ⁰	1.9×10^{-1}	7.7×10^{-1}	1.2×10^{-3}		
Uranium	3.1×10^{-3}	8.2×10^{-11}	5.6×10^{-2}	1.0×10^{-11}		
Transuranics	8.5×10^{-3}	5.3×10^{-5}	5.8×10^{-3}	6.6×10^{-6}		

a. 1978 releases.

b. Particulates (does not include noble gases).

c. Estimates, subject to change.

Table 4. Estimated Annual Releases to the Environment from the Defense Waste Processing Facility.^a

	Point of Relea	
<u>Radionuclide</u>	Atmospheric, Ci/yr	Aqueous, Ci/yr
TOTALS:		
Tritium	3.684×10^2	1.537 x 10 ⁴
Fission Products		1.237×10^{-3}
Uranium	8.230×10^{-11}	1.045×10^{-11}
Actinides	5.307×10^{-5}	6.568×10^{-6}

These releases assume full-time operation. Actual releases are expected to be no more than 75% of these values; therefore they are estimates subject to change.

CHAPTER 4. FUTURE AQUATIC INFORMATIONAL NEEDS

Since primarily descriptive biological data are available for Upper Three Runs Creek and Four Mile Creek and quantitative data are generally not available on the biota of these streams, an aquatic baseline and monitoring program should be established. This program would support further site characterization for the DWPF and provide additional information for preparation of the required environmental impact statement.

Furthermore, although no specific guides exist for such a facility as the DWPF, environmental surveillance programs similar to those designed for nuclear power plants or uranium enrichment facilities are envisioned. For example NRC Regulatory Guide 4.2 calls for the determination of important species and their relative abundances, their habitat uses and requirements, their normal seasonal population fluctuations, and any pre-existing environmental stresses and effects on the ecology of the organisms. NRC Regulatory Guide 4.8 states that the natural variation in ecosystems should be known and that indicator monitoring programs should be established. Typically a two-year monitoring program is recommended prior to construction and operation (NRC Regulatory Guide 4.1).

Data collection for an aquatic baseline and monitoring program for the DWPF would fall into three general areas: physical and chemical, radiological, and biological. The program does not have to be all inclusive, but should reflect sound judgement between anticipated impacts and selection of species for inclusion in the baseline study. The anticipated impacts to Upper Three Runs Creek are essentially erosion and siltation from construction activities. The anticipated impacts to Four Mile Creek are increased chemical releases and radionuclide releases. Criteria for selection of species to be included in a baseline study as defined by NRC Guides include (1) Species that are valuable recreationally or economically, (2) Species that are endangered or threatened, (3) Species that are important to the structure and function of 1 and 2 above, (4) Species that are critical to the structure and function of the ecosystem, (5) Species that serve as indicators of important changes in ecosystems; that is, indicator species, and (6) Species that may accumulate biocides and/or radionuclides. Researchers in general should collect enough samples of sufficient size to determine species composition, seasonal trends, diversity measurements, and habitat preference. Emphasis should be placed on selection of indicator groups and/or species which would serve to measure environmental perturbations.

The time frame for such a baseline and monitoring program would be at least one year before construction begins in order to include season variations and patterns in the data base. Two years

would be possible in this case. Re-evaluation followed by continuation into the construction phase of the project is anticipated. A time frame for a biological baseline and monitoring program for the DWPF is shown as follows:

September1979	+ 2 years → + 5-6 years →	
Plan Baseline Study	Conduct Monitor → Baseline → Construction → Study Phase	Indicator Monitoring, Operational Phase

The physical and chemical data collection program would be designed to take advantage of data as currently collected in the monitoring program of Health Protection (SRP). For example, the current water quality monitoring program on Four Mile Creek is probably adequate for monitoring purposes. Water quality data for a variety of parameters are taken at Highway A-7 on Four Mile Creek. Increased sampling frequency to weekly intervals would be desirable to better reflect natural variations.

Current water quality monitoring stations exist on Upper
Three Runs Creek at Highway 278, the Flowing Streams Laboratory,
and Highway 125, as well as Tim's Branch near the Flowing Streams
Laboratory. These locations should be adequate for monitoring
water quality on the main body of Upper Three Runs Creek. However,
the major aquatic impacts from construction activities at S-Area
will occur to a tributary north of S-Area which feeds Upper Three
Runs Creek. Therefore, two monitoring stations on this tributary

are recommended. One of these would be near Road F, north of S-Area, and one near the confluence of the unnamed tributary and Tinker Creek. Another station on a tributary west of Highway 4 would be needed also.

Because of highly variable conditions in these tributaries, at least weekly samples should be made for the following parameters:

Water volume (flow rate)
Temperature
pH
Dissolved solids
Alkalinity
Hardness
Conductivity
Suspended solids
Volatile solids
Total dissolved solids
Ammonia
Sodium
Turbidity

Fixed Residue
BOD
Lignin
Chloride
Nitrate N
Nitrite N
Sulfate
Sulfide
Total Phosphate
Aluminum
Calcium
Total Iron
Heavy metals

These parameters should provide a base against which to measure predicted impacts of increased runoff, erosion, siltation, turbidity, and solids loading during construction and later releases during operation.

Radionuclides will need to be monitored in these streams prior to operation. Upper Three Runs Creek currently receives no releases in the vicinity of the proposed DWPF and should not receive any during operation of the DWPF. Four Mile Creek already receives releases from F and H Areas and these will increase with the completion of the DWPF. Again advantage should be taken of monitoring programs by Health Protection already in place. The current monitoring program on Four Mile Creek should be adequate for monitoring purposes.

The current monitoring program on Upper Three Runs Creek is probably adequate for the main stream. However, since the unnamed tributary north of S-Area could potentially receive low level releases or accidental releases of radionuclides from S-Area operations, baseline information is necessary. Weekly samples are recommended at the water quality stations at Road F and near the junction of the unnamed tributary with Tinker Creek. Activity to be checked for includes the following:

Alpha pCi/l Nonvol Beta pCi/l 89,90Sr pCi/l 137Cs pCi/1 U/Pu pCi/1

Two types of biological sampling programs are recommended. Several groups of organisms could be surveyed utilizing reconnaissance field surveys. These include the macrophytes, macroinvertebrates (other than insects), fish, herpetofauna, and birds and mammals associated with water. However, the periphyton and insects would be surveyed more intensely and quantified. These two groups would tend to have sufficient numbers to allow quantitative sampling of populations and provide potential measures of anticipated impacts in these small streams. They also lend themselves to easy collection and the use of artificial substrates such as with diatometers. Potentially impacted sites and control sites should be selected on Four Mile Creek and tributaries to Upper Three Runs Creek for these two groups for a total of 6 to 8 sites. These could correspond to the water quality sites where possible. Weekly samples of periphyton and biweekly sampling of insects would be recommended and should

provide sufficient data to demonstrate seasonal trends and natural variability. Table 1 of Chapter 4 presents a proposed sampling schedule for the biological groups of interest.

TABLE 1 PROJECTED BIOLOGICAL SAMPLING SCHEDULE

	Group		Sampling Trequency (Minimum)	Data Obtained
I.	Pro	ducers		
	Α.	Periphyton	Weekly, Artifical Substrates	Species composition, Relative abundance, Habitat preference, Diversity indices, Productivity, Biomass, Indicator associations
unless need		unless needs an	umerated with the periphyton rise otherwise. Not as flowing ecosystems.	
	C.		of streams in oreference to in	onnaissance walk-throughs question with special ndication of distribution and listing of any rare streams.
II.	Con	sumers		
	Α.	Zooplankton	Sampling can be	e reduced or eliminated in effort.
	В.	Macroinvertebrates (Insecta)	Weekly, Light trap and/or artifical substrates	Species composition, Relative abundance, Habitat preference, Diversity indices, Secondary productivity, Indicator species,
		•		Biomass
	C.	Macroinvertebrates (Other than insects)	Reconnaissance surveys at least quarterly with special reference to distribution by habitat type and listing of any rare types found in the streams.	
	D.	Fish	reference to	onnaissance with special distribution by habitat type f any rare types found in the
	E.	Avifauna	to reflect mig patterns. Emp	e surveys with sampling periods gration, breeding, and use phasis on those species related pitats or those that are rare.

TABLE 1 PROJECTED BIOLOGICAL SAMPLING SCHEDULE (continued)

	Sampling	··
	Frequency	Data
Group	(Minimum)	Obtained

II. Consumers (contd)

F. Herpetofauna

Reconnaissance surveys on a monthly basis with special reference to distribution by habitat type, waterway use, indicator species, or rare and endangered species.

G. Mammals

Reconnaissance surveys with emphasis on those species related to aquatic habitats or to uncommon types.

III. Decomposers

Sewage Indicators (Fecal Coliforms)

Weekly

At Station 7 of Health
Protection on Four Mile Creek
and at the two new stations
on the tributary to Upper
Three Runs Creek

CONCLUSIONS

A significant body of descriptive information exists concerning the aquatic ecology of Upper Three Runs Creek and Four Mile Creek. These two streams are potentially impacted by construction and operation of the proposed Defense Waste Processing Facility, a facility designed for solidification of high level liquid wastes. All major groups of organisms have been surveyed or studied to varying degrees in these two The descriptive biological information is thus sufficient for preparation of Section 2.7.2, Aquatic Ecology, of the environmental document for the DWPF. Macroinvertebrate information on Four Mile Creek and algae data on both creeks are not adequate, however. Quantitative biological baseline data will be needed for these two groups for both streams or their tributaries near S-Area. Cursory surveys of vertebrate activity and macrophytic occurrence will also be needed as supplements to the present information. biological data, once available, will provide additional information for preparation of a project specific Environmental Impact Statement for the DWPF and subsequent monitoring programs to evaluate actual impacts during construction and operation of the facility.

Physical and chemical water quality has been monitored on a regular basis on both of these streams. Furthermore, the present SRP, aquatic chemical and physical monitoring program

combined with three or four new stations on the tributaries draining the DWPF site should provide adequate monitoring programs for impact evaluation during construction and operation of the DWPF.

Since Upper Three Runs Creek is a relatively undisturbed and unpolluted blackwater stream, it has value as a research tool and comparison stream for other streams on the SRP site. Efforts to minimize potential construction erosion and siltation and operational discharges from chemical treatment facilities, sewage treatment, and stormwater runoff are planned. However, Four Mile Creek receives thermal effluents from C Reactor and chemical and radionuclide releases from F and H separations areas. Four Mile Creek will receive additional chemical and radionuclide releases once operation of the DWPF begins.

REFERENCES TO CHAPTERS 1 THROUGH 4

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APPENDIX

DRAFT

SECTION 2.7.2, AQUATIC ECOLOGY

of the

ENVIRONMENTAL DOCUMENT

for the

DEFENSE WASTE PROCESSING FACILITY

2.7.2 AQUATIC ECOLOGY

2.7.2.1 Introduction

- A. Surface Drainage
- B. Savannah River
- C. Savannah River Plant Tributaries
- D. Streams Near the DWPF Site Upper Three Runs Creek Four Mile Creek
- E. Savannah River and Upper Three Runs Creek Swamp Bottomlands

2.7.2.2 Prior Biological and Water Quality Investigations

2.7.2.3 Primary Producers

- A. Algal and Diatom Populations Savannah River Upper Three Runs Creek Four Mile Creek
- B. Macrophytes
 Upper Three Runs Creek
 Four Mile Creek

2.7.2.4 Consumers

- A. Fish
- B. Fish Species of Special Concern
 Shortnose Sturgeon
 American Shad
 Channel Catfish
 Striped Bass
 Blueback Herring
 Mosquito Fish
- C. Macroinvertebrates
 Savannah River
 Upper Three Runs Creek
 Four Mile Creek
- D. Protozoa and Other Microinvertebrates
- E. Amphibians and Reptiles
 Alligator (Alligator mississipiensis)
- F. Waterfowl and Other Birds
- G. Mammals of Interest

Beaver (<u>Castor canadensis</u>)
Otter (<u>Lutra canadensis</u>)
Mink (<u>Mustela vison</u>)
Muskrat (<u>Ondatra zibethica</u>)
Raccoon (<u>Procyon lotor</u>)

2.7.2.5 Rare or Unique Biota

2.7.2.6 Reserve Areas

- A. Beech-Hardwood Forest Reserve
- B. Mixed Swamp Forest Reserve

2.7.2.7 Existing Stresses on the Biological Systems

- A. Savannah River Water Quality
- B. Water Quality of DWPF Streams
- C. Radioactivity of SRP Streams Savannah River-Radioactivity Tritium Balance in Streams and River Migration of Radioactivity from Separations Areas Seepage Basins
- D. Radionuclides in Fish
- E. Polychlorinated Biphenyls (PCB's) in Fish
- F. Mercury in Fish
- G. Pesticides in River and Streams
- H. Fecal Coliform Bacteria in River and Streams
- I. Landfill near Upper Three Runs Creek

2.7.2.8 References

2.7.2 AQUATIC ENVIRONMENT

2.7.2.1 Introduction

A. Surface Drainage

The Savannah River flows southeastward from its point of origin at the junction of the Tugaloo and Seneca Rivers to the Atlantic Ocean, a distance of about 200 miles. Downstream from Augusta, the river, in a stage of early to middle maturity, meanders across a belt 4 to 5 miles wide. The gradient is low, only about I foot per mile in the vicinity of the Savannah River Plant. In this region, the Savannah River Plant adjoins the Savannah River for 17 miles. The principal tributaries to the Savannah River in the SRP area are Upper Three Runs Creek, Four Mile Creek, Pen Branch, Steel Creek, and Lower Three Runs Creek. These tributaries flow in a southwesterly direction almost at right angles to the direction of flow of the main river channel. The longest tributary, Upper Three Runs Creek, drains most of that part of the SRP in Aiken County and drains areas to the west, north, and east of the proposed DWPF. Four Mile Creek drains areas to the south of the DWPF.

B. Savannah River

As noted above, the headwaters of the Savannah River are in the Blue Ridge Mountains of North Carolina, South Carolina, and The river empties into the Atlantic Ocean near Savannah, Georgia. Georgia. Two large reservoirs, Clark Hill Reservoir and Hartwell Reservoir, upstream from the Savannah River Plant provide hydroelectric power, flood control, and recreation (Langley and Marter, 1973). Operation of these reservoirs has stabilized the river flow at nearby Augusta, Georgia, to an average of 10,570 (300 m³) cubic feet per second (cfs) for the water years 1962 to 1978 (Langley and Marter, 1973; SAR, 1980). Furthermore they have influenced both the biological and water quality characteristics of the Savannah River. Suspended sediment load has been reduced. Species composition in the river has likely been altered. The Savannah River has also been subjected to other alterations during this period -- treatment of municipal sewage discharged to the river has improved during the last ten to fifteen years (EPA, 1971, Hawkins, 1976); channel modifications downstream have improved drainage, thereby reducing flooding frequency and duration in the swamp forest; and farmland has been abandoned and forestland has been cleared for urbanization and industrialization. Each of these processes has undoubtedly caused changes in the river ecosystem.

C. Savannah River Plant Tributaries

The five main streams on Savannah River Plant site are Upper Three Runs Creek, Four Mile Creek, Pen Branch, Steel Creek, and Lower Three Runs Creek, Figure 2.7.2.1-1. They originate on the Aiken Plateau and descend 100 to 200 feet before discharging to the Savannah River. On the Plateau, they are generally clear except during periods of high water. Rainfall infiltration and seepage through sandy soil furnishes the streams with a relatively constant flow of water throughout the year. All of these tributaries except Upper Three Runs Creek have been influenced by reactor cooling water discharges. These discharges, many times the natural stream flows, cause the streams to overflow their original banks along much of their length. Fish life is also restricted in the lower reaches of these streams.

D. Streams Near the DWPF Site

The Defense Waste Processing Facility (DWPF) site is situated near the center of the Savannah River Plant. The DWPF site is approximately nine miles from the Savannah River and slightly more than a mile from Upper Three Runs Creek and Four Mile Creek, as shown in Figure 2.7.2.1-2. This figure shows the topography of the Savannah River Plant site and the drainages which flow through the DWPF area. The DWPF site is located on an area of high ground north of the existing 200-H Area. Because the DWPF site is located on a topographic high point on the divide between the two small watersheds, the site is not susceptible to flooding from the Savannah River, Upper Three Runs Creek, or the small tributary to Tinker Creek. A small wetland or Carolina Bay, known locally as Sun Bay, occurs on the site and has been modified by a former drainage ditch and site selection surveys.

Upper Three Runs Creek

Upper Three Runs Creek, the longest of the plant streams, differs from the other four plant streams in two respects. It is the only one with headwaters originating outside the SRP site and is the only one that has never received heated discharges of cooling water from the production reactors (ERDA, 1977). Upper Three Runs Creek drains a total area of approximately 190 square miles (Giesy and Briese, 1978). Its significant tributaries are Tinker Creek, a lengthy headwaters branch, and Tims Branch. Tims Branch receives industrial wastes from fuel fabrication facilities (Savannah River Plant M-Area) and the Savannah River Laboratory. Subsequently, Tims Branch flows through a small impoundment, Steed Pond. The M-Area effluent flow averages about one cfs. Tims Branch flows at between one and one-half and two cfs below Steed Pond and about four cfs

before discharging into Upper Three Runs Creek near Road C (SAR, 1980).

Upper Three Runs Creek was designated as a National Hydrologic Bench-Mark Stream by the United States Geological Survey in 1966, and a recording station was established where Route 278 crosses the stream. In bench-mark streams, the water quality, temperature, and flow are measured monthly. The drainage area above this monitoring station is 87 square miles and the average discharge from 1966 to 1976 was 112 cfs which represents 17.5 inches per year from the drainage basin (SAR, 1980). Approximately 36 percent of the rainfall within this basin becomes runoff.

The flow and temperature of Upper Three Runs Creek are monitored near the Highway 125 crossing. The flow ranges between 190 and 520 cfs and averages 265 cfs. The average temperature for 1959 to 1966 was 16.9 degrees Centigrade with a maximum monthly average of 23.0 degrees Centigrade in July (Langley and Marter, 1973).

The valley of Upper Three Runs Creek is asymmetrical with steep southeastern banks having abrupt relief of 100 to 120 feet and gently sloping northwestern banks. It is bordered by extensive swamps one-half to three-fourths mile wide. The stream valley has a low gradient with a meandering and interbraided channel especially in the lower reaches. The swamp forest of the floodplain consists primarily of bald cypress and tupelo gum, while the bottomland hardwoods associated with the stream are mostly sweet gum, oak, and beech.

Four Mile Creek

The drainage area of Four Mile Creek lies entirely within the SRP site and receives discharges from major plant facilities. It drains into an extensive swamp that borders the Savannah River on the South Carolina side. Four Mile Creek has a length of about 15 miles and drains about 35 square miles (Langley and Marter, 1973). It receives heated discharge from C Reactor and wastes from F and H Areas. The average flow upstream of any plant discharge is less than 0.5 cfs and is increased by F and H effluents and drainage to about 20 cfs just above the confluence with the C Reactor discharge. After the junction with the C Reactor cooling water, the creek flows about 7 miles before entering the river swamp (Langley and Marter, 1973).

Temperatures in the reach immediately downstream from C Reactor are extreme, occasionally exceeding 50 degrees Centigrade during

summer months (Gibbons and Sharitz, 1974, Brown, et al., 1972). Such conditions have prevailed since the early 1950's, resulting in alteration of the natural stream in numerous ways. The native swamp forest has been eliminated; the stream is mostly unshaded; and only organisms highly tolerant of thermal extremes persist in the lower stream reaches. Organisms occurring upstream from the thermally stressed reaches are essentially isolated from aquatic populations in the Savannah River and its other tributaries. Many of these organisms are actually the aquatic phase of terrestrial species. However, during periods of reactor shutdown when the cooling water flow and temperature are reduced, numerous species readily reinvade the stream (McFarlane, 1976)

E. Savannah River and Upper Three Runs Creek Swamp Bottomlands

A swamp lies in the floodplain along the South Carolina side of the Savannah River. This river swamp and a bottomland hardwood forest occupy about 10 square miles of SRP. A small embankment or natural levee, 18 to 35 feet above the river level, has built up along the river. Three natural breaches in the levee allow discharge of stream water to the river. The waters from Beaver Dam Creek and Four Mile Creek combine and flow through the swamp parallel to the river before discharging. Beaver Dam Creek receives effluent from the heavy water production process and the associated power generating plant in D Area, while Four Mile Creek receives thermal discharge from C Reactor.

Macrophytes growing in the swamp, in areas receiving sufficient sunlight, include water milfoil (Myriophyllum heterophyllum), rushes (Juncus spp.), bladderwort (Utricularia spp.), smartweed (Polygonum spp.), riverweed (Podostemum ceratophyllum), and cattail (Typha latifolia). Whipple (1978) lists, Table 2.7.2.1-1, the common shrubs and herbaceous plants of the bottomlands of Upper Three Runs Creek. Landers, et al., (1977) list the common emergent vascular macrophytes of the swamp bottomlands.

Those sections of the swamp land, such as the delta area of Four Mile Creek which receive heated effluent, have been modified, because of the thermal loading, flooding, and increased siltation (Straney, et al., 1974; Sharitz, et al., 1974b). Approximately I square mile of the total swamp and hardwood forest have been killed by the standing hot water effluents from the Savannah River Plant. Slight to moderate tree kill has occurred throughout another 6.5 square miles (Gibbons and Sharitz, 1974). Throughout much of the area of intense effect, temperatures are too high to allow the growth of vascular plants in the water or on the associated sediments (Straney, et al., 1974). Periods of prolonged or excessive flooding are detrimental, especially to hardwood species, so that even the flood tolerant bald cypress and tupelo gum are stunted

and eventually killed if high water levels persist through several growing seasons. These species also require a drier period with exposed sediments if seed germination and seedling establishment is to be successful (Sharitz, et al., 1974b).

Prolonged flooding not only destroys vegetation along the floodplains, but also scours the banks. Sediments are deposited downstream in the delta areas of the swamp (Langley and Marter, 1973). Heavy siltation results in tree kill also. Hundreds of limbless dead trees stand where they formed a canopy at one time throughout the area. Vascular plants can be found growing above the water level on small islands formed by the fallen logs and stumps (Sharitz, et al., 1974a, 1974b).

The Upper Three Runs Creek swamp, which has not received thermal reactor effluents, has a floristic composition typical of mixed hardwood swamp forests in the coastal plain of the southeast. Hardwoods were lumbered from the Upper Three Runs Creek swamp in the 1800's and early 1900's but little disturbance has occurred for the past 50 years (Swails, et al., 1957; Porter, et al., 1958; Whipple, 1978). Woody plants, primarily trees, shrubs, and woody vines, dominate the flora. The canopy of this forest consists of bald cypress (Taxodium distichum), tupelo gum or water tupelo (Nyssa aquatica), red maple (Acer rubrum), and species of ash (Fraxinus spp.). In the Upper Three Runs Creek swamp bald cypress and tupelo gum line the stream channels (Whipple, 1978) and occupy pools and flooded depressions (Sharitz, et al., 1974a). Sweet gum (Liquidambar styraciflua), river birch (Betula nigra), and ironwood (Carpinus caroliniana) occur in areas subject to occasional flooding. Beneath the canopy, woody vines of Similax dominate the ground flora. ·Herbaceous cardinal flower (Lobelia cardinalis) and panic grass (Panicum spp.) are common. swamp hardwood forests, shading by the canopy and occasional flooding cause reduced growth of the ground flora (Sharitz, et al., 1974a). Poison ivy (Rhus radicans) can be abundant and Spanish moss (Tillandsia usneiodes) occurs on the trees (Hoy, 1953). Hoy (1953) lists various grasses, reeds, rushes, sedges, and in some areas dwarf palmettos (Sabal minor) as members of the undergrowth. Occasional upland ridges also support water oak (Quercus nigra), willow oak (Quercus phellos) and sweet gum (Sharitz, et al., 1974b).

Three bottomland communities are described briefly for the Beech-Hardwood Forest Reserve along Upper Three Runs Creek, the Mixed Swamp Forest Reserve, and the Cypress Grove Reserve by SREL (1979). Whipple (1978) lists the common species in locations ranging throughout the bottomlands of Upper Three Runs Creek and details the location of four permanent plot areas within that drainage.

Water levels during the winter floods in parts of Upper Three Runs Creek may be 12 to 16 feet above the summer level and may exceed the height of the butt swell of the bald cypress and tupelo gum by more than 2 feet (Langley and Marter, 1973). During the summer the swamp drains and most of the forest floor is exposed (Sharitz, et. al., 1974a).

2.7.2.2 Prior Biological and Water Quality Investigations

Numerous investigations of water quality and biological conditions of SRP site streams have been conducted both prior to and since initiation of Savannah River Plant operations. The primary sources of data are summarized by the following:

- Baseline studies on the aquatic environment of the Savannah River between river miles 123 and 162 were initiated by the Philadelphia Academy of Natural Sciences (ANS) in 1951-1952, and have been continued on an operational monitoring basis to the present.
- Diatometer studies were begun by the ANS in 1953 as a means to continuously record possible changes in the river as reflected by changes in the diatom community. Quarterly reports of these studies are available from E. I. du Pont de Nemours and Company.
- Numerous baseline surveys of aquatic and terrestrial biota were conducted by biologists from the University of South Carolina and the University of Georgia under contract to the Atomic Energy Commission during the period 1951-1960.
- Studies on thermally stressed ecosystems, succession of terrestrial systems, population dynamics and other ecological problems have been performed by the Savannah River Ecology Laboratory which was established in 1961 and is operated by the University of Georgia.
- Detailed studies of water quality and stream transport of materials have been conducted by the Environmental Transport Division of the Savannah River Laboratory. These studies were initiated in 1972.
- Upper Three Runs Creek became a National Hydrologic Bench-Mark Stream in 1966 and data on physical and chemical parameters are available from the USCS.

- The Savannah River Plant site was established as the first National Environmental Research Park (NERP) in 1972 and NERP baseline studies have been conducted since then.
- e Routine sampling at several stream stations have been performed on a quarterly to monthly basis since 1951 in conjunction with monitoring radioactive releases by the Environmental Monitoring Program of the Health Protection Department of the Savannah River Plant. (Ashley, 1972; Ashley and Zeigler, 1973, 1974, 1975, 1976, 1978).
- The Flowing Streams Laboratory established in 1972 by SRL provides information for Upper Three Runs Creek.

The most complete data on biological characteristics of the Savannah River are contained in the report series prepared by the Philadelphia Academy of Natural Sciences (ANS). These surveys have been conducted on a semiregular basis since 1951. survey was made by sampling selected stream stations during all four seasons. A complete report was prepared to present results of this pre-operational survey (ANS, 1953). In subsequent years, the practice has been to conduct cursory surveys on an annual basis and a more complete survey, including sampling during at least two seasons, approximately every three to five years. The more complete surveys are then reported by means of a summary report which also provides comparison of the data with that of prior years (ANS, 1953, 1957, 1961, 1967, 1970a, 1974, 1977). Table 2.7.2.2-1 is an inventory of the surveys utilized and a breakdown of the sampling periods in these reports. The most recent cursory survey was in 1977.

Biological components investigated during each ANS survey included algae and diatoms, protozoa, macroinvertebrates (including aquatic insects), fishes, bacteria (occasionally), and limited water quality and physical measurements. Sampling, preservation, and laboratory methodology are described in each report. Emphasis was placed on an inventory methodology at each station and on taxonomic identification of all species collected. The data are semi-quantitative at best.

Initially, five stations were sampled by the ANS. Stations were located on Upper Three Runs Creek and the Savannah River in a reach extending upstream and downstream from the Savannah River Plant. The station on Upper Three Runs Creek was abandoned after 1956, and additional stations have been added on the Savannah River in recent years (ANS, 1974). The location of Station 4 was not noted nor were any data from this location reported. Station 5 was moved in 1960 because the river channel was straightened and

the meander on which the station had been located became an oxbow lake off the main channel. The river mile locations specified for the stations were therefore revised in 1960. Detailed descriptions of the sampling stations are provided in each ANS report.

More detailed studies on the biota, as well as some chemical and physical parameters of potentially impacted waterways, are given in Table 2.7.2.2-2. These cover a variety of topics such as fish species surveys, movements, and responses to thermal stress; surveys of amphibian and reptilian populations; bird and waterfowl diversity; furbearer populations; insect distribution; crustacean species; swamp bottomland composition; and water chemistry. Information on macrophytes is limited and data on the biota of the upper reaches of the non-thermally impacted portions of Four Mile Creek are fragmentary.

2.7.2.3 Primary Producers

Algae, macrophytes (aquatic vascular plants), and detritus serve as the base of the food web in aquatic environments. In flowing environments, attached algae (periphyton) assume a greater role in food production than floating algae (phytoplankton), since the latter develop in areas of still water or where flow is limited and reduced. Much of the phytoplankton of the Savannah River consist of detached periphytic forms, as well as forms that are discharged from the reservoir behind Clark Hill Dam and tributaries of the river. Backwater areas, swamps, and marshy areas adjacent to the river also provide suitable habitats for phytoplankton which enter the river as free-floating algal forms. Clark Hill Dam, constructed in 1951, resulted in increased diversity in the periphyton community of the river because of decreased turbidity and an associated increase in light penetration. More recent decrease in diversity has been attributed to an increase in organic loading of the river (ANS, 1970b).

Macrophytes are distributed in shallow areas of reduced current such as in oxbows, behind sand bars, around spur dikes, in swamp areas and along the shallow margins of the tributaries.

A. Algae and Diatom Populations

Data from ANS studies from 1951 through 1976 have been used to assess the algae and diatom populations of streams located at the SRP site. These findings are summarized by family and are presented in Table 2.7.2.3-1. The number of species represented in ANS collections are presented in Figure 2.7.2.3-1. The collections upon which the data are based were made in a variety of ways. At each station, material was taken from various

habitats—by scraping submerged surfaces, by collecting water and sediments, and by collecting mats and filaments of algae visible in the water. The methods of collection varied due to physical conditions (e.g., water level) and individual investigator preferences. Major changes in laboratory procedures, which influence success in taxonomic identification, were made in 1956. Specifically, after 1956, at least six specimens of any species were necessary in the composite samples for inclusion in the list of species. Details of methodology are given by Patrick, et al., 1967.

Savannah River

Examination of Table 2.7.2.3-1 reveals little consistency in the patterns of dominance by groups of numbers of species from station to station or from year to year. However, diatoms have been the dominant group in most years. Blue-greens are the second most common group. The most diverse algal flora consistently occurs during summer, coincident with low flow and less turbid water, which permit greater light penetration.

The lowest numbers of species encountered were in sampling years 1968 and 1976 (cursory sampling). The greatest numbers were encountered in 1960 and 1965. The occurrence of greater numbers of species in 1960 and 1965 was attributed mostly to diatom species, but also coincided with a profuse growth of blue-green algae-primarily of the genera Microcoleus and Lyngbya. The yellow-green alga Vaucheria sp. was notably rare or present in limited numbers during these years (ANS, 1961).

The dominant species varied from station to station in the ANS surveys, but dominance was confined to only a few species in each group. Dominant diatoms were usually Nitzschia palea, Navicula mutica, Achnanthes biporama, A. lanceolata, Melosira varians, M. distans, and Gomphonema parvulum. Among the green algae, Oedogonium, Spirogyra, and Stigeoclonium were consistently the most abundant species. Of the yellow-greens, Vaucheria was consistently present. The greatest variability in dominant species occurred among the blue-green algae. Microcoleus vaginatus and Schizothrix calcicola were most frequently the dominant blue-greens. Oscillatoria retzii, S. rubella, Lyngbya putealis, and Phormidium spp. were also frequently dominant locally.

Similar listings of common algae from the Savannah River were given in the Environmental Report for the Alvin W. Vogtle Nuclear Plant (AWV, 1972). These are summarized in Table 2.7.2.3-2.

Upper Three Runs Creek

Collections were made on Upper Three Runs Creek (ANS Station 2) from 1951 through 1956. Collections from four surveys at this station during the 1951 - 1952 period yielded 124 species--more than from any other location sampled. Surveys in the summer of 1955 and the spring of 1956 yielded 99 and 94 species, respectively. In all collections, diatoms were the dominant component of the flora. greater number of species occurred in winter, because in summer the stream is mostly shaded by the heavy overstory of bottomland hardwoods. The most abundant diatom species are Gomphonema olivaceum, G. turris, and the genera Eunotia, Pinnularia, and Frustulia. species composition is distinctively different from that of the Savannah River, and is characteristic of cool, slightly dystrophic and shaded waters. The yellow-green algae, Vaucheria spp., occurred in occasional mats during summer and blue-green algae were rare (ANS, 1953; 1957).

Harvey (1975) in baseline studies of Upper Three Runs Creek prior to operation of the Flowing Streams Laboratory listed the common algae of that stream. Attached algae were very common in open areas of the stream. Diatoms were most abundant with Eunotia, Gomphonema, and Tabellaria being dominant. The most common green algae were Spirogyra, Oedogonium, Mougeotia, Draparnaldia, and Stigeoclonium. The yellow-green algae, Vaucheria, was common on the sandy bottom. Three red algae, Tuomeya, Audouinella, and Batrachospermum, were present, but not in great abundance. The blue-green algae represented by Oscillatoria, Schizothrix, and Microcoleus were very scarce. The algal composition thus reflects the excellent water quality of this soft, black-water stream.

Four Mile Creek

No sampling has been conducted with regularity on Four Mile Creek. In the zone of thermal stress, only the thermophilic bluegreen algae Phormidium sp. and Oscillatoria sp. survive regularly along the shoreline in waters exceeding 50 degrees Centigrade. The filamentous green algae, Spirogyra sp. and Potamogeton diversifiora, are abundant in cooler regions where temperatures are commonly within 30 to 37 degrees Centigrade (Gibbons and Sharitz, 1974). Upstream in the non-thermal reaches, diatoms might be expected to be the predominant and most diverse primary producer, but populations would not be dense due to the heavy shading from the hardwood overstory. Blue-greens of the genera Microcoleus, Schizothrix, and Oscillatoria may be found on decaying organic surfaces such as submerged logs and leaf litter.

Patrick (1974) summarized the effect of abnormal temperatures on algal communities in general. Brown, et al. (1972) summarized

the thermal effluents from C Reactor on Four Mile Creek. Typical temperatures are shown in Table 2.7.2.3-3.

Tansey and Fliermans (1978) reported that condensed foam taken from the surface of thermal effluents contained high concentrations of algae, fungi, protozoa, and invertebrates that cannot grow at lower temperatures. Many of these organisms were apparently healthy (e.g., normally pigmented algae, motile protozoa, and intact cytoplasm).

Vanderbosch (1977) in a survey of the periphytic diversity of two sites from Upper Three Runs Creek, a thermal site on Four Mile Creek, and several sites along a small post-thermal tributary of Four Mile Creek (Castor Creek), listed the common genera of periphytes and indicated their relative abundance. In Upper Three Runs Creek at least 27 genera were collected with Eunotia, Tabellaria, Oedegonium, Draparnaldia, Zygnema, Mougeotia, Microcystis, Lyngbya, and Chroococcus being abundant. The thermal portion of Four Mile Creek had only 11 genera with Fragillaria, Oedegonium, Stigeoclonium, Schizomeris, and Oscillatoria as common. In addition to these genera Lyngbya, Arthrospira, and Spirogyra were frequently observed in the non-thermal portions of Four Mile Creek. Castor Creek was collected more intensely thus yielding 49 genera; the most common being Asterionella, Tabellaria, Synedia, Frustulia, Desmidium, Oscillatoria, and Chroococcus.

B. Macrophytes

Hoy (1953) gave an early description of the aquatic and semiaquatic habitats of the SRP-site. Aquatic habitats include both ponds and streams as well as a large transition area along them. The aquatic flora also depends somewhat on the depth of the water and the swiftness of the current. In ponds the typical fanwort (Cabomba caroliniana), swamp loosestrife (Recodon verticillatus), water pennywort (Hydrocotyle umbellata), golden club (Orontium aquaticum), arrowhead (Sagittaria latifolia), and sedges (Cyperus spp.) occur. In streams the more common plants are species of water weeds, buttonbush, water pepper (Polygonum hydropiperoides), tape grass (Vallisneria americana), and a number of sedges. These streams are often bordered by blackberry brambles (Rubus spp.), tangled masses of smilax (Smilax smallii), and thickets of devil'swalking-stick (Aralia spinosa). In some ponds, the white water lily (Nymphaea odorata) is an evident aquatic plant (Gibbons, 1970).

In a more recent survey of the Savannah River, eight macrophytes were identified for the Savannah River (AWV, 1972, 1974). The distribution of these plants along the river was spotty. Large concentrations were found in areas of less current, in oxbows, behind sand bars, and around spur dikes. All eight were rooted except Lemna sp., which, although having rootlets, floats on the surface and comes into the river from tributary creeks. The sessile plants are listed in Table 2.7.2.3-4.

Angerman and Jones (1979) are currently characterizing the plant communities of the SRP site and plan to include macrophytes in their descriptions.

Upper Three Runs Creek

The stream bottom is mostly shifting sand with almost no rocks. Occasional fallen limbs and logs occur. Where the forest canopy is open, rooted vegetation such as <u>Vallisneria americana</u> and <u>Potamogeton epihydrus</u> occur. Small flood plains are dominated by <u>Orontium aquaticum</u>, <u>Sagittaria latifolia</u>, <u>Ludwigia</u> sp., and <u>Polygonum sp. (ANS, 1951)</u>. Submerged logs support a luxuriant growth of several higher aquatic plants. The riverweed, <u>Podestemon ceratophyllum</u> and <u>Micranthemum umbrosina</u> were especially abundant (ANS, 1951).

Morse, et al. (1979) and Cain (1977) indicated the importance of macrophytes in providing habitats for macroinvertebrates, especially insects.

Four Mile Creek

Areas near C Reactor thermal discharges routinely have temperatures exceeding 50 degrees Centigrade. In such areas thermophilic bacteria and algae become the dominant organism living in the water itself. Throughout much of this area of intense effect, temperatures are too high to allow the growth of any vascular plants in the water or on the associated sediments (Sharitz, et al., 1974a; Bourque and Esch, 1974).

Cain (1977) in Castor Creek, a small tributary which enters Four Mile Creek south of C Reactor, noted the presence of 17 macrophytes in this branch.

2.7.2.4 Consumers

A. Fish

Aquatic habitats for fish on the plantsite are numerous and diversified. They consist of natural and thermally stressed flowing

streams and rivers, ambient temperature and thermally stressed reservoirs, Carolina Bays, abandoned farm ponds, swamp channels, and oxbow lakes (Langley and Marter, 1973).

Fish populations have been investigated more than any other group of biota in the streams of the Savannah River Plant. Preoperational studies initiated by ANS in 1951 included fish surveys (ANS 1951, 1952a, 1952b), which have been continued on a generally regular basis on the Savannah River to the present. Other surveys include those made by Freeman (1954), Smith, et al., (1973), McFarlane (1976), and Bennett and McFarlane (1979). Clugston (1973a) included a general listing of SRP fish also. The Environmental Report (AWV, 1972) and The Final Environmental Statement for the Alvin W. Vogtle Nuclear Plant (AWV, 1974), the Barnwell Nuclear Fuel Plant Environmental Report (BNFP, 1971), the Barnwell Environmental Statement (BNFP, 1974) and Cooley and Farnworth (1974) list the fish of the Savannah River. Dahlberg and Scott (1971a, 1971b) give the freshwater fish for Georgia and list the introduced freshwater fish of the Savannah River.

More specific features have been addressed by other research-Humphries (1965) examined the movement of channel catfish in Upper Three Runs Creek and the Savannah River. McFarlane, Frietsche, and Miracle (1978) quantified the impact of impingement and entrainment of SRP operations on Savannah River fish and noted the role of Upper Three Runs Creek in the spawning of fish. quito fish (Gambusia affinis) populations have been studied by Falke and Smith (1974) and Ferens and Murphy (1974) in Upper Three Runs Creek and the thermal zones of Four Mile Creek. The biochemical genetics of sunfish from Upper Three Runs Creek, Four Mile Creek, and thermal water sources were conducted by Yardley, et al. (1974). McFarlane (1976) examined the fish diversity of thermally and non-thermally impacted streams of the SRP. Tinney and Gibbons (1977) examined the invasion of post-thermal habitats by fish during periods of reactor shutdown. Thompson and Gibbons (1978) examined the fish diversity of a small thermally isolated tributary of Four Mile Creek.

Streams of the southeastern Atlantic Coastal Plain are noted for their diverse fish fauna. Dahlberg and Scott (1971) reported 102 species from the Savannah River drainage basin. McFarlane (1976) reported that 64 of these occur in the environs of the Savannah River Plant, and that 79 species have been reported one or more times. Bennett and McFarlane (1979) list 80 species in the most up-to-date survey of the SRP site. Their listing is given in Table 2.7.2.4-1. Table 2.7.2.4-2 is a summary list of fish species compiled from reports of ANS (1953, 1957, 1961, 1967, 1970a, 1974, and 1977); Freeman (1954); and McFarlane (1976). A total of 106 species from the Savannah River, Upper Three Runs Creek, and Four Mile Creek are listed. Attempts have been made in

Table 2.7.2.4-2 to eliminate obvious duplication through elimination of synonomy in taxonomic names. Table 2.7.2.4-3 presents synonomy and revisions in the taxonomy of fishes relevant to these surveys. Names used are those adopted by the American Fisheries Society (AFS, 1970). Numbers of fish species represented in ANS collections are shown in Figure 2.7.2.4-1.

None of the above authors except Freeman (1954) has reported species abundance. Normally, only presence or absence were indicated. Furthermore, a variety of collection techniques were utilized including hook and line, seining, electrofishing and toxification with rotenone. ANS collections included rotenone toxification as a standard technique every year except the initial year of study (i.e., 1951). The collections were made at different times of the year; by different field crews; and at different locations with a lack of assurance of a consistent level of effort. Even without species abundance data, however, it is still possible to note the disappearances of some species from collections, as well as the appearance of others. In ANS collections on the Savannah River, the following species have not been collected since 1960, although each occurred regularly in collections from several stations before that date:

- Channel catfish (Ictalurus punctatus)
- White crappie (<u>Pomoxis annularis</u>)
- 3. Johnny darter (Etheostoma nigrum)

The white catfish (Ictalurus catus) has not been taken since 1951 and the quillback (Carpoides cyprinus) has not been taken since 1956. The ohoopee shiner (Notropis leedsii) was not collected for twenty years (1956-1976), but was taken from all stations before 1956 and again at all stations in 1976. Since the late sixties there has been a steady decline in the frequency of occurrence of the bow fin (Amia calva). During the same approximate period that the aforementioned species began to disappear from collections, several other species which had not previously been collected began to appear and have been present consistently since about 1965. These include:

- Rosyface chub (Hybopsis rubrifrons)
- 2. Creek chubsucker (Erimyzon oblongatus)
- Linde topminnow (Fundulus lineolatus)

This change in composition was approximately coincident with dredging and channel straightening on the Savannah River and the completion of the Hartwell Reservoir upstream. Species most affected by

these disturbances have apparently left partially unexploited niches, which permitted other species to increase in numbers and/or distribution.

Looking only at the number of species in ANS collections for the time period (1951-1976), data from all the Savannah River sampling stations follow a similar pattern (Figure 2.7.2.4-1). A dramatic increase in number of species collected during the second sampling period (1955-1956) is apparent. The increase can be explained on the basis of revised methodology (i.e., incorporating rotenone toxification) and stabilization of water level and reduced silt load resulting from operation of Clark Hill Dam. Since 1960, species numbers have gradually declined and become more variable from station to station and from one sampling year to the next, but the number of species recorded at a given station has generally remained in the range of 30 to 40. The decline in species numbers in collections after 1960 is thought to be attributable to substrate removal and disturbance and siltation resulting from channel modifications between 1956 and 1960.

At Station 2 on Upper Three Runs Creek, 25 species were reported from the 1951-1952 collections by ANS. The second collection by ANS (1955) yielded 20 species, and sampling subsequently was discontinued until 1976, when 28 species were collected at a single sampling in the spring. There is no historic evidence of changes in the Upper Three Runs Creek watershed to which any significant changes in species numbers may be attributed.

Although species diversity in the streams is slightly less than in the river, a substantial complement of species seldom encountered in the river dominate the detritivore, top carnivore, and minnow assemblages of the streams (DOE, 1978). Upper Three Runs Creek and the adjoining swamp lands serve as important breeding and spawning habitats for shad, herring, striped bass, and channel catfish. American eel also occurs in its waters.

Four Mile Creek apparently had a diverse fish fauna before becoming thermally impacted by C Reactor cooling waters. Freeman (1954) reported 33 species from Four Mile Creek. Freeman (1954) reported the American eel as catadromous from Four Mile Creek. Anadromous blueback herring occurred there also (Smith, et al., 1973). These listings indicate that originally fish moved freely throughout Four Mile Creek. Today fish inhabit the lower reaches near the Savannah River swamp and backwater pools (Langley and Marter, 1973). McFarlane (1976) indicates that even the nonthermal tributaries of thermally stressed streams have lost several headwater species, apparently due to isolation by the thermal effluent.

With the exception of the mosquito fish, Gambusia affinis, few fish occur in the main stream of Four Mile Creek when thermal effluent is present. Mosquito fish are abundant in shallow peripheral areas at temperatures up to about 41°C (Falke and Smith, 1974; Ferens and Murphy, 1974; and McFarlane, 1976). A few centrarchids may be present at lower temperatures. During reactor shutdown, the stream returns to ambient temperature and is invaded rapidly by fish from nonthermal areas (Tinney and Gibbons, 1977). Centrarchids, especially spotted sunfish and redbreast sunfish, are common during shutdown. They are eliminated as soon as the reactor effluent begins again. The diversity and abundance of species in the headwater tributaries of Four Mile Creek upstream from the thermal effluent are greatly reduced in contrast to comparable areas of Upper Three Runs Creek. McFarlane (1976) collected only four species (Esox niger, Notropis lutipinnis, Notropis hypselopterus, and Gambusia affinis) from the upper tributaries of Four Mile Creek. This may be a low estimate, however, because Thompson and Gibbons (1978) collected 11 species (Anguilla rostrata, Aphredoderus sayanus, Erimyzon oblongus, E. sucetta, Esox americanus, Gambusia affinis, Ictalurus natatis, Lepomis auritus, L. gulosus, L. punctatus and Micropterus salmoides) from a small tributary, Castor Creek, of Four Mile Creek.

Gambusia affinis is an important mosquito control fish. Its eurythermal nature makes it a potentially useful species in thermally affected waters. At the highest temperatures in sampling areas from Four Mile Creek, it was the only fish present (Falke and Smith, 1974; Ferens and Murphy, 1974; McFarlane, 1976).

The fish community of the SRP swamp is poorly known. Its utilization as a spawning zone and nursery for anadromous shad and herring has been noted. The influences of thermal effluent releases upon spawning success, species movement, and composition are unknown (DOE, 1978).

B. Fish Species of Special Concern

McFarlane, et al. (1978) summarized much of the impact of SRP operations on fishes of the Savannah River. They list as fish of special concern the shortnose sturgeon (Acipenser brevirostrum), the American Shad (Alosa sapidissima), the channel catfish (Ictalurus punctatus), the striped bass (Morone saxatilis), and the blueback herring (Alosa aestivalis), and possibly the American eel (Anguilla rostrata). Of these the American shad, the striped bass, and the blueback herring are anadromous; that is, migrating from saltwater to freshwater for spawning. Other anadromous species near the SRP include hogchokers (Trinectes maculatus) and hickory shad (Alosa mediocris). The American eel is catadromous;

that is, migrating from freshwater to saltwater for spawning. Upper Three Runs Creek and an adjacent floodplain serve as a spawning zone and nursery for striped bass (McFarlane, et al., 1978; Langley and Marter, 1973; Clugston, 1973a). The catadromous American eel occurs in Upper Three Runs Creek (Langley and Marter, 1973; Freeman, 1954).

The only significant commercial species are the American shad and channel catfish (Goodwin and Adams, 1969). These are exploited to a limited degree by local fishermen. Sport fishermen are the principal consumers of other river fishes, principally sunfishes and crappie. Striped bass are popular quarry of fishermen in the Augusta area.

Shortnose Sturgeon

The Shortnose sturgeon is the only endangered species of fish known from the Savannah River (FWS, 1979). It is restricted to the tidewaters and has not been reported near the SRP.

American Shad

This anadromous species ascends the Savannah River in early spring as far as the dams upstream from the SRP permit. Thus it spawns above or near the SRP. The semi-buoyant eggs are carried downstream past the SRP and can become entrained on intake facilities. Few shad larvae hatch near SRP. Juveniles migrate back up the river and are attracted to the intake canals; however, they are only rarely impinged. A few adults, typically emaciated, are impinged late in the spawning season. American shad commonly die following their once-in-a-lifetime spawning in southern rivers. Repeated lifetime spawning has been noted for the Savannah River (Cooley and Farnworth, 1974). Thus the impact of the SRP upon the American shad is limited to entrainment of shad eggs for a three-month period (McFarlane, et al., 1978).

Channel Catfish

This fish is exploited to a limited degree by local fishermen. Catfish spawn in nests which they construct and they guard their eggs and young. Humphries (1965) detailed movements of channel catfish in Upper Three Runs Creek and the Savannah River. These fish move into Upper Three Runs Creek in the spring for spawning in May and June. They move downstream and out of the stream later in June and July with few remaining year round in the stream.

Striped Bass

The striped bass has unique spawning habits in the Savannah River. Some individuals spend most of the year in upstream waters and migrate downstream for spawning. Since the striped bass is a free spawner, the eggs must be suspended in the water as they float downstream before hatching. The eggs are heavier than water (specific gravity - 1.005), thus there must be vertical turbulence and a sufficiently long stretch of unimpeded stream bed for the eggs to travel before they hatch 36-72 hours after being laid. The last eggs to be observed in the river usually are found at the end of May (Cooley and Farnworth, 1974).

Spawning can occur in a portion of a channel upstream from SRP; congregating occurring near the outfalls of the Augusta canal and the New Savannah Bluff Lock and Dam (McFarlane, et al., 1978; Dudley, et al., 1977). Upper Three Runs Creek is reported also to serve as a spawning zone and nursery for striped bass (Langley and Marter, 1973; Clugston, 1973a). Dudley, et al. (1975, 1977) noted that the Little Black River, a small branch of the Savannah River near Savannah, Georgia, is the most important spawning ground for striped bass in the Savannah River.

Blueback Herring

This forage fish in the Savannah River has no commercial or sport fishing value and is essentially unexploited. It ascends the river to spawn in late spring. The eggs are adhesive and not entrained but larval fish are entrained. Juvenile fish are typically not impinged (McFarlane, et al., 1978).

Mosquito Fish

The mosquito fish, because of its eurythermal nature, makes it a useful species in thermally affected waters such as Four Mile Creek where it may be the only fish present (Falke and Smith, 1974; Ferens and Murphy, 1974; McFarlane, 1976). It occurs in large numbers along the shallow peripheral areas at temperatures in excess of 40 degrees Centigrade.

C. Macroinvertebrates

Macroinvertebrates as discussed herein include all the invertebrates with the exception of protozoa. In the ANS collections, data for aquatic insects and other invertebrates were reported separately. These data have been combined in Table 2.7.2.4-4. The two groups occupy similar habitats -- they are associated with

the substrate; they are relatively stationary except as movement may occur with downstream drift; and they are subject to impact from similar factors (e.g., substrate disturbance and predation by fish). Functionally, they are diverse and fulfill the niches of predators, grazers, filter feeders, and in the case of insects, are not confined to the aqueous medium for their entire life cycle. Collections for macroinvertebrates were made in a variety of ways, including scraping of substrates, dip nets, Needham Scraper, dredge samples, and sieves. A complete description of field and laboratory procedures for ANS collections is given by Patrick, et al. (1967). The number of aquatic macroinvertebrate species represented in ANS collections are shown in Figure 2.7.2.4-2.

Gold (1952) contains limited data on invertebrates of the Savannah River and its tributaries and also provides an interesting historical reference.

Savannah River

A summary of insect and noninsect aquatic invertebrates collected from 1951 through 1976 is presented in Table 2.7.2.4-4. There is a dominant pattern evident from the table, which began in the mid-fifties (i.e., 1955-1956). The greatest number of species collected in a single sampling year was during the initial year of the study (1951-1952). Immediately thereafter, the total number of species collected at every station declined to less than half that of the initial year. Apparent recovery from this decline did not occur until the early sixties. Complete recovery has not taken place even after 25 years. The reduction in the number of species during the 1950's has been attributed to dredging in the river, which had been initiated by 1955 (Patrick, et al., 1967). Stabilization of river discharge and elimination of habitat through reduction in flooding of back-levee sloughs and ponds may also have contributed to the decline. The groups most affected by the river dredging were rotifers, Baetid and Heptagenid mayflies, Perlid Plecopterans, Odonates, Hemipterans, Dystiscid and Gyrinid Coleopterans, and the Chironomids (formerly Tendipids).

Because macroinvertebrates play an important role in the aquatic ecosystem, reduction in their diversity and abundance in the Savannah River may be responsible for subsequent changes in fish populations. The elimination of food supply and of selective grazers and predators may well be responsible for the variability and instability of other trophic levels. The most dramatic reduction in populations and species among the noninsectan fauna occurred in the crustacea, the oligochaete worms and pelecypods. These groups are sensitive to siltation. Pulmonate gastropods were also less abundant, but were able to survive by attachment to

several areas of riprap placed prior to 1951 for channel stabilization (Patrick, et al., 1967).

Of the insectan fauna, beetles comprised the greatest number of species, when all surveys are considered. Mayflies (Ephemeroptera) and dragonflies (Odonata) were represented by the largest number of species among the earlier surveys. Following the drastic decline in species in the period 1955 through 1960, the Diptera were represented by the most species (Patrick, et al., 1967), indicating a general decline in environmental quality.

Georgia Power Company, in conducting surveys of the Savannah River in 1971 and 1972 (AWV, 1972, 1974), summarized the benthic invertebrates as shown in Table 2.7.2.4-5.

The Savannah River supports a diverse benthic fauna in the vicinity of the SRP site. Most of the suitable habitat is associated with areas of shallow water with silted substrate or in marshy areas and quiet backwaters. The bottom of the river consists primarily of shifting sand that does not provide optimum habitat for bottom-dwelling invertebrates. The natural history of the more common invertebrates of the Savannah River is given by the following synopsis (AWV, 1972, 1974).

Scud - Hyallela

Habitat Preference - Mostly confined to the substrate in a wide variety of unpolluted streams, lakes, ponds, and brooks.

Feeding habits - Omnivorous, general scavengers. They will consume all kinds of plant and animal matter. Only rarely do they attack and feed on living animals.

Breeding - Breeding takes place between February and October, depending on water temperature. Each female averages 15 broods in 150 days of breeding season.

Leech - Hirudinea

Habitat Preference - Ponds, marshes, lakes, and slow streams where plants, stones and debris afford concealment.

Feeding habits - Blood suckers, scavengers and predators.

Breeding - Most leeches enclose eggs in a cocoon which is deposited on or in the substrate between May and August. Some species produce batches of eggs for periods of five to six months, and empty cocoons may be found as late as October and November.

Midges - Chironomidae

- Habitat Preference Larvae occur everywhere in aquatic vegetation and on the bottom of all types of bodies of fresh water.
- Feeding Habits Larvae chiefly herbivorous and feed on algae, higher aquatic plants, and organic detritus. Some are predaceous.
- Breeding Some species may have a number of generations each year, and may emerge as adults in such numbers as to become pests around lake and stream-side areas.

Planeria - Dugesia

Habitat Preference - May be found on or under stones in water with velocity up to 80-100 cm/sec.

Feeding habits - Living, dead or crushed animal matter.

Breeding - Sex organs develop in cool months, lay eggs in May and June. Organs degenerate with warm weather; other reproduction by fission all year long.

Aquatic Earthworms - Oligochaeta .

Habitat Preference - Mud and debris of pools, ponds, streams and lakes.

Feeding habits - Mud, leaves, etc. which settle out of the

Breeding - Cocoons of embryos are deposited on rocks, vegetation, debris in late summer and early fall.

Snails - Physa and Gyraulus-

Habitat Preference - Shallow areas of reasonably clean, alkaline streams and lakes. In greatest abundance near moderate amounts of aquatic vegetation and organic debris.

Feeding Habits - Living algae on submerged surfaces. Also dead algae and dead animal material.

Breeding - Oviposition occurs in spring and may continue into summer and early fall.

Dance Flies - Empididae

Habitat Preference - Adults frequent moist situations. Some species live along seashore. Larvae are aquatic.

Feeding Habits - Adults feed on small invertebrates at water's edge, larvae have been known to feed on larvae of Simulium in swift streams.

Breeding - The immæture stages of most groups, where known, breed in damp earth, decaying wood or vegetation, usually in wooded areas or under bark of trees.

Black Flies - Simuliidae

Habitat Preferencee-C Larvae occur in the shallows of swift water. They are tightly attached to rocks and vegetation. Adults live near the stream or river.

Feeding Habits - Plankton and organic debris strained from water by anterior fans.

Breeding - May be from one to several generations per year, and adultspmay be present in such numbers during certain times of the year as to be unbearable. Females produce irritating bites on warm blooded animals, and smay cause damage to livestock.

Caddisfly - Cheumatopsyche

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Habitat Preference-lliarvae live in retreats constructed of a net spuncing the current of smaller and warmer rivers that yhydropsyche.

Feeding Habits - Dadtoms, algae and higher plants.

Breeding - Adults of rawl into water and lay eggs on or under sticks or stones.

Caddisfly - Hydropsyche

Habitat Preference — harvae build tubelike retreat concealed in a crevice wor camouflaged by bits of wood, vegetation or other material. Most often found in larger, cooler streams than the Cheumatopsyche.

Feeding Habits - Feed on a preponderance of diatoms, other algae, and higher plants.

Breeding - Adults agtach eggs to submerged objects.

Caddisfly - Neureclipsis

Habitat Preferencea← Larvae build retreats such as silken tunnels on aquatic plants or burrow into sandy stream beds. Most abundant in rivers of moderate to rapid flow.

Feeding Habits - Diatoms, algae and higher plants. Breeding - Adults attach eggs to submerged objects.

Caddisfly - Oecetis

Habitat Preferencel- The larvae build a case which is constructed of rand grains cemented together. Abundant in streamskand lakes in well-aerated water.

Feeding Habits - Predaceous on other invertebrates. Breeding - Adults attach eggs to submerged objects.

Aquatic snails (Gastropoda) have been collected by the ANS in surveys of the Savannah River since 1952. Wood and Wineriter (1979) conducted a more recent survey of the gastropods in 1976 and 1977 including four sites from Upper Three Runs Creek and one site from Four Mile Creek. Adults of Campeloma decisum and Lyogyrus granum and eggs of Physella sp. were taken from Upper Three Runs Creek and adults of Campeloma decisum from Four Mile Creek.

Upper Three Runs Creek

A few early surveys of invertebrates are available for Upper Three Runs Creek. The freshwater sponges of the SRP site including species for Upper Three Runs Creek and Four Mile Creek were listed by Penny (1954) and for South Carolina in general by Penny (1956). Cross (1955) completed a taxonomic survey of the dragonflies (Odonata) of Upper Three Runs Creek and Four Mile Creek. Scott, et al. (1959) listed mayfly nymphs of the genus Tortopus as common near the mouth of Upper Three Runs Creek and the Savannah River (see also Gold, 1952). Collections of macroinvertebrates from Upper Three Runs Creek were also taken at Station 2 by ANS in 1951, 1955, and 1956. These data as noted earlier are summarized in Tables 2.7.2.4-4 and Figure 2.7.2.4-2.

Insect surveys from Upper Three Runs Creek are numerous. Scott, et al. (1959) noted the presence of nymphs of the mayfly genus Tortopus from clay banks near the mouth of Upper Three Runs Creek. Cross (1955) listed a number of dragonfly species collected from Upper Three Runs Creek and Four Mile Creek observed in a survey of the SRP site. Collections or sightings of adults were common near numerous small ponds on these waterways at that time. Howell and Gentry (1974) in a survey of Upper Three Runs Creek collected 545 insect individuals representing 54 species. In their collections, stoneflies (Plecoptera), dragonflies (Odonata), mayflies (Euphemeroptera), caddis flies (Trichoptera), and aquatic truebugs (Hemiptera) were well represented with fewer individuals of aquatic flies (Diptera) and aquatic beetles (Coleoptera). diversity index for aquatic insects was 4.4 in Upper Three Runs Creek, 3.2 in Steel Creek (a post-thermal recovery stream), and 1.2 in Pen Branch (a thermal stream similar to Four Mile Creek).

Aquatic insects were collected from as many different habitats as possible in Upper Three Runs Creek and from two of its main tributaries, Tinker Creek and Mill Creek, by Harvey (1975). Both Upper Three Runs Creek and Tinker Ceeek have large areas of

sand, soft silt, and occasional patches of rock substrate. All streams contained logs, sticks, and limbs which were excellent substrates for many insects. The mayflies, represented by 27 species, were very common in all tributaries. Hexagenia, Isonychia, Dolania, and Stenonema were the most common genera in Upper Three Runs Creek. Caddis flies (27 species) were equally diverse; Triaenodes, Molanna, Pycnopsyche, Hydropsyche, and Phylocentropus were well represented. The most common stoneflies were Togoperla, Pteronarcys, Acroneuria, and Perlesta. Twenty-six species of midges were found in Upper Three Runs Creek. Dragonflies, damselflies, spongilla flies, and aquatic bugs were represented by fewer species.

The aquatic insects of Upper Three Runs Creek were again surveyed by Morse, et al. (1979) from September 1976 to August 1977, using a variety of collection methods ranging from benthic net collections to light traps. These studies are continuing. At least 321 species of aquatic insects other than Diptera were identified from 28,178 specimens from six sites. Of the more common species, collected in benthic samples, the majority (21 of 25 species) are either climbers, clingers, or sprawlers which require solid substrate habitats of various types. The other 4 species are burrowers in the sandy stream bottom. These 25 species also represent a broad range of functional groups with organisms in the stream feeding on drifting detritus, periphyton, allochthonous materials, and other macroinvertebrates. Vascular plant herbivores are relatively less common. Trichopterans are the primary filterers and shredders. Species of elmid beetles and mayflies constitute the most significant sediment feeders and scrapers of periphyton. The primary predators are stoneflies and gomphid dragonflies.

The aquatic insect fauna of the Upper Three Runs Creek drainage basin is unique. It not only includes rare species, but also contains species not often found living together in the same freshwater system. This spring fed stream is colder and generally clearer than most surface waters at its low elevation. As a result, many typically northern and mountain species co-exist here with southern lowland species. For example, the species of the dragonfly genus Ophiogomphus are distributed mainly in northern North America; the beetle Oulimnius latiusculus is rarely found away from fast-flowing Appalachian streams; the caddisfly Lepidostoma carrolli was previously known only from Maine, New Jersey, and Tennessee; the caddisfly Hydroptila strepha only from New Hampshire, Pennsylvania, Maine and a mountain stream in Pickens County, South Carolina, and the caddisfly Triaenodes inflexus only from the mountains of South Carolina and Tennessee. On the other hand, the caddisflies Chimarra florida, Neureclipsis melco, and Agarodes libalis are know only from a few similarly spring-fed, lowland, southeastern streams. Four species of elmid beetles

(Gonielmis dietrichi, Stenelmis antennalis, S. convexula, and Microcylloepus pusillus lodingi) are characteristically found only in the Gulf region (Morse, et al., 1979).

It is clear that the insect fauna of Upper Three Runs Creek and its tributaries are unusual, reflecting the probability that the various ecological parameters of the stream are peculiar and highly variable from one spot to another and that taken together have persisted here for a very long time. Insect species discovered in the study by Morse, et al. (1979) include a new species of the beetle genus Stenelmis, at least three new species of Trichoptera, one new species of the mayfly genus Pseudocloeon, and apparently a new genus of Chironomidae. Other species are very rare or their populations in Upper Three Runs Creek are far removed from their usual ranges. There are new state records for a number of species despite intensive aquatic insect collecting in recent years over much of the rest of South Carolina (DOE, 1978).

Hobbs, et al. (1977) in a survey of the SRP site listed nine decapod crustaceans for Upper Three Runs Creek including, Palaemonetes paludosus, Cambarus latimanus, Procambarus hirsutus, Faxonella clypeata, Procambarus troglodytes, Procambarus pubescens, Procambarus acutus acutus, Procambarus raneyi, and Cambarus sp. He gave a brief description of their life history and ecology.

Four Mile Creek

Less information is available on the macroinvertebrate populations in Four Mile Creek. The available data indicate that invertebrate populations downstream from the heated effluents from C Reactor are limited. Upstream, populations are more restricted in their diversity and abundance due to the isolating influence of high temperatures on recruitment from downstream. The insect fauna are expected to be better developed than the fish fauna due to the ability of insects to reinvade during adult flight (McFarlane, 1976). Howell and Gentry (1974) noted a marked decline in insect diversity in the thermally impacted Pen Branch with the most common insects being aquatic true-bugs (Hemiptera) and flies (Diptera, primarily Chironomidae). Almost 96 percent of the aquatic insects collected in the thermal stream were of two species, a corixid backswimmer (Hemiptera) and a chironomid (Diptera) (Gibbons and Sharitz, 1974; Howell and Gentry, 1974).

Nymphs of dragonflies from Four Mile Creek have been used to study the effects of thermal effluents by a variety of investigators (Martin and Gentry, 1974; Garten and Gentry, 1976; and Martin, et al., 1976).

The insect fauna for the non-thermal portions of Four Mile Creek are not well known, but may be similar in part to Castor Creek. Cain (1977) surveyed the summer aquatic insects of Castor Creek, a small tributary, just south of C Reactor. The creek runs through a mixed pine and decidious woods and had been used to receive cooling water. A great amount of erosion occurred and as a result Castor Creek is now located in a ravine. The bed is sandy with small stones in some areas and beaver dams have modified the creek, creating a series of riffles and pools. Much of the creek is unshaded and has a diverse plant community with numerous species of macrophytes. Most of the insects collected from the creek inhabitated the vegetation or the debris and not the sandy bottom. Dragonflies (especially a species of the genus, Argia) and two species of caddisflies (Trichoptera; Hydropsyche spp.) were abundant. Only one species of stonefly occurred. Mayflies, aquatic Hemiptera, dobsonflies (Megaloptera), aquatic moths (Lepidoptera), beetles (Coleoptera), aquatic flies (Diptera, especially chironomids) were collected (Gillen, 1977a, 1977b).

Information on the insects of the upper reaches of Four Mile Creek south of F and H Areas is not available. However, Hobbs, et al. (1977) reported two species of decapod crustaceans from Four Mile Creek, <u>Cambarus latimanus</u> and <u>Procambarus hirsutus</u>. Both were from the non-thermally stressed areas south of F and H Areas. Their presence would indicate that a macroinvertebrate food supply exists.

D. Protozoa and Other Microinvertebrates

Protozoa have been surveyed since 1951 in the Savannah River and are listed in the various ANS surveys and summaries. The most important summaries are those of the ANS (1970b) and Patrick, et al. (1967). All major groups (i.e., ciliates, flagellates, and sarcodinids) are well represented. Table 2.7.2.4-6 lists the common species found in the Savannah River.

Rotifers, crustacean nauplii, copepods, and cladocerans commonly occur in Savannah River waters in addition to the protozoa. A species list of the rotifers can be found in Patrick, et al., 1967.

E. Amphibians and Reptiles

A recent account of the state herpetofauna of South Carolina has not been published. The most pertinent regional work is Reptiles and Amphibians of Alabama by Mount (1975). Gibbons and Patterson (1978) and Gibbons (1977) contain the most up-to-date listings of reptiles and amphibians for the SRP and an excellent listing of pertinent references. Freeman (1955a, 1955b, 1955c,

1956) listed the amphibians and reptiles found on the SRP from early surveys of the plant site. Penney (1952) listed the amphibians and reptiles for South Carolina plus gave a bibliographic listing. Gibbons (1970) and Bennett, et al. (1970) discuss the typical biota of a small lake, Ellenton Bay, on the SRP site with particular emphasis on aquatic turtle activity. Bourque and Esch (1974) discuss the occurrance of parasites in turtles from thermally altered and natural aquatic communities.

Extensive habitats are available for amphibians and reptiles which frequent or rely on aquatic environments. Upper Three Runs Creek plus the mile or more of cypress-gum swamp associated with it afford unique habitats for herpetological study. Aquatic and semi-aquatic reptilian and amphibian species undoubtedly constitute a major animal component of this stream community.

Brisbin, et al. (1974) listed among the aquatic snakes of the SRP site the Rainbow snake (Abastor erythrogrammus), Cotton-mouth (Agkistrodon piscivorus), Mud snake (Farancia abacura), Red-bellied water snake (Natrix erythrogaster), Banded water snake (Natrix sipedon), and Brown water snake (Natrix taxispilota). The common water snake (Natrix fasciata) occurs with regularity in the swamplands (SREL, 1979).

Alligator (Alligator mississipiensis)

The American alligator is listed as endangered by the Fish and Wildlife Service, Department of Interior (FWS, 1979).

Freeman (1955c) reported two specimens of alligator in early surveys of the plant site. In 1963, Jenkins and Provost, estimated that about two dozen alligators occur on the SRP. Sightings included individuals on Lower Three Runs Creek, Par Pond, Steel Creek, and one at "Kennedy's Pond" on Upper Three Runs Creek. More recent estimates (Murphy and Brisbin, 1974; Murphy, 1979a, 1979b) raise this estimate to approximately 100 adult animals in the Par Pond reservoir system.

Alligator activity in Four Mile Creek is unlikely above the creek delta because of the thermal effluent from C Reactor.

Murphy (1979b) in repeated visits to the Four Mile Creek delta did not observe any alligators. Upper Three Runs Creek upstream from Road F and Tinker Creek are not suitable for alligators because of the swift current and steep banks. However, dammed portions of the stream may support limited numbers of alligators. Upper Three Runs Creek between Road F and Road A would be classified as marginal alligator habitat. That portion of Upper Three Runs Creek downstream from Road A is also marginal, but limited alligator activity could occur, particularly in oxbow lakes. No

alligators were observed by Murphy (1979b). Nests have been found near Upper Three Runs Creek (Gibbons and Patterson, 1978).

The Savannah River swamp would appear to be suitable alligator habitat with slow-moving channels, deepwater sloughs, nesting areas, and prey species, such as gar and turtles. However, alligators are only rarely observed in the swamp and only low densities would be expected in that portion of the river swamp which borders the SRP site (Murphy, 1979b). Beaver Dam Creek, near Four Mile Creek, however does have a moderate alligator population (Murphy, 1979b).

F. Waterfowl and Other Birds

Waterfowl form a conspicuous segment of the fauna on the SRP. It is estimated that approximately 10,000 ducks and coots (Fulcia americana) over winter in the area. Most occur on Par Pond and other larger ponds and Carolina Bays which dot the SRP. Perhaps 2,000 over winter in the lower swamp bottomlands and on the Savannah River. Included in the migratory species are Black Ducks (Anas rubripes), Mallards (Anas platyrhymchos), Gadwall (Anas strepera), Pintail (Anas acuta), Bladpate (Mareca americana), Blue-winged Teal (Anas discors), Green-winged Teal (Anas carolinensis), Wood Ducks (Aix sponsa), Shoveller (Spatula clypeata), Ruddy Ducks (Oxyura jamaicensis), Ringnecked Ducks (Aythya collaris), Lesser Scaup (Aythya affinis), American Mergansers (Mergus merganser), and Piedbilled Grebes (Podilymbus podiceps). Fewer than a dozen Canada Geese (Branta canadensis), Blue Geese (Chen caerulescens), and Snow Geese (Chen hyperborea) were recorded in 1960 and 1961 (Jenkins and Provost, 1963). Two species of ducks, wood ducks and, infrequently, mallards, have been recorded as nesting in the SRP area. Wood ducks are by far the most common nesters with perhaps 500 as residents. This number increases in winter from migration. A few Mississippi Kites (Ictinia mississippiensis) are resident in the swamplands. No heron rookeries are known for the SRP although several species of egrets, herons, and ihis are seen (Jenkins and Provost, 1963; Stranley, Briese, and Smith, 1974). Brisbin (1974) described the abundance and diversity of waterfowl inhabiting heated and unheated portions of Par Pond. For a more complete listing of the birds of the SRP area the listings by Norris (1953) should be consulted. Cooley and Farnworth (1974) list the birds for the Savannah River basin.

The bird populations of the Four Mile Creek swampland are expected to be similar to those of the thormally impacted Fen Branch as described by Stranley, Briese, and Smith (1974). Woodpeckers, for example, take advantage of standing dead trees for food and shelter in thermally affected areas of the swamp and show increases in their populations. Opening of the canopy also leads

to an increase in the numbers of crows and herons. However, a decline or loss of most of the small passerines, as common to the canopy and understory of Upper Three Runs Creek, has occurred. The remaining passerines find limited sites for perching and feeding in the sparse vegetation growing in the silt around the dead trees of the thermally impacted swamp.

G. Mammals of Interest

Beaver (Castor canadensis)

Beaver colonies are scattered throughout the SRP site, including the tributaries of Upper Three Runs Creek, Castor Creek, the non-thermal portions of Four Mile Creek, and the river swamp (Fitzgerald, 1979). The slow moving streams and dense soil banks are good habitat for beaver. Most of these animals utilize lodges, although at times bank dens are seen. For example, on the one mile length of Castor Creek, a tributary of Four Mile Creek, 22 beaver dams were noted (Cain, 1977). Extensive habitat is available and flooding conditions make travel easy for these animals. Girdled or barked sweetgum, holly, alder, dogwood, yellow poplar, and bluebeech are seen and even occasionally pines are girdled (Fitzgerald, 1979; Jenkins and Provost, 1963). During the summer months aquatic vegetation is utilized more heavily (Jenkins and Provost, 1963). Beaver were taken in 1977 in the SRP monitoring program from Tims Branch of Upper Three Runs Creek and Four Mile Creek (Ashley and Zeigler, 1978).

Otter (Lutra canadensis)

Otter have been sighted or listed in a variety of locations including Upper Three Runs Creek (SREL, 1979). The number of otters has been estimated at 75 to 100 animals on the SRP (Jenkins and Provost, 1963). Fitzgerald (1979) reported otter tracks on Tim's Creek of Upper Three Runs Creek and on the non-thermal segments of Four Mile Creek. This animal has esthetic appeal and as such is a desirable member of the fauna.

Mink (Mustela vison)

Mink have been sighted and taken in traps on the SRP but extensive studies along the streams have not been conducted (Jenkins and Provost, 1963).

Muskrat (Ondatra zibethica)

Although SRP is barely within the range of the muskrat no signs of the animal were found by Jenkins and Provost (1963). Forestry Project records indicate sightings on three occasions.

Raccoon (Procyon lotor)

Intensive studies of raccoons in the south-central portion of the SRP on the Sunderland Coastal Terrace indicated that this area of about 2,100 acres is good-to-fair raccoon habitat. habitat is adjacent to the Savannah River floodplain between Pen Branch and Four Mile Creek and is typical of ecological conditions on approximately one fourth or 52,000 acres of the SRP. Using a variety of trapping, as well as mark-and-recapture techniques. Jenkins and Provost (1963) estimated that the total raccoon population on the SRP is approximately 13,000 animals or about 64 animals per square mile in the more favorable habitats. Raccoons made up of 21 percent of the furbearers collected by Wood and Odum (1965) in a survey of the fox, bobcat, skunk, and opossum populations of the SRP. Their numbers appeared to fluctuate very little over the time period from 1954 to 1962. They also noted more animals within the terrace subregion of the SRP. Fitzgerald (1979) noted the wide occurrance of raccoon as evidenced by tracks along the waterways of the SRP site.

2.7.2.5 Rare or Unique Biota

The South Carolina Wildlife and Marine Resources Department maintains a listing of confirmed sightings and collections of biota assigned as endangered, threatened, or of special concern on a statewide, regional, or national basis (Greeter, 1979). Table 2.7.2.5-1 is a listing of rare or unique aquatic species occurring or expected to be found in streams of Aiken, Barnwell, and Allendale Counties. The existence of seven species of vascular aquatic plants having special status has been confirmed in the area. Three other species of vascular aquatic plants are considered as possible endemics. Of these only pink tickseed (Coreopsis rosea) has been collected on the SRP site (Langley and Marter, 1973).

Among the herpetiles, five aquatic vertebrates are of concern or endangered. Of these only the American alligator (Alligator mississippiensis) is on the federal list of endangered species (FWS, 1979). As noted in Subsection 2.7.2.4, the American alligator has wide distribution on the SRP site. The spotted turtle (Clemmys guttata) has been reported from Upper Three Runs Creek (Greeter, 1979). Gibbons and Patterson (1978) report that the few specimens that have been collected have come from specimens picked

up on highways; Freeman (1955b) also collected one specimen of this species. The eastern bird-voiced frog (Hyla avivoca) is locally common with the greatest concentrations apparent in the river swamp, particularly in association with cypress trees. A large chorus of these frogs has been observed behind the Hog Barn near Road A-13 (Gibbons and Patterson, 1978). The subspecies H. a. ogechiensis has not been reported for the SRP site. The eastern tiger salamander (Ambystoma tigrinum tigrinum) is found throughout the SRP site (Gibbons and Patterson, 1978). The Pine barrens tree frog (Hyla andersoni) has not been reported for the SRP site.

Other listings of endangered, threatened, rare, or species of special concern for the Savannah River basin can be obtained from such sources as BNFP (1971), and Cooley and Farnworth (1976).

2.7.2.6 Reserve Areas

Two Reserve Areas are of special concern because of their proximity to Upper Three Runs Creek (Beech-Hardwood Forest Reserve) and Four Mile Creek (Mixed Swamp Forest Reserve).

A. Beech-Hardwood Forest Reserve

The Beech-Hardwood Forest Reserve covers 118 acres of flood-plains and ravines northeast of Road A and east of Upper Three Runs Creek. Approximately one-half of the reserve lies within the floodplain of Upper Three Runs Creek. Logging has occurred in the past and most of the logging was apparently limited to the flood-plain. The floodplain forest is dominated by red maple (Acer rubrum), yellow poplar (Liriodendron tulipifera), Southern magnolia (Magnolia grandiflora), and sweetgum (Liquidamba styraciflua). Common mammals include among others, otter (Lutra canadensis) and raccoon (Procyon lotor). Cottonmouths (Agkistrodon piscivorous), brown water snakes (Natrix taxispilota), and aquatic turtles are common. The dwarf waterdog (Necturus punctatus), and aquatic sal-amanders occur also (SREL, 1979).

B. Mixed Swamp Forest Reserve

The Mixed Swamp Forest Reserve covers 91 acres of aquatic, semi-aquatic, and terrestrial habitat. The reserve is bordered on the northeast by Road A-13 southwest of the Four Mile Creek delta and extends from the roadway into the floodplain of the Savannah River. The dominant overstory growth in this area consists of bald cypress (Taxodium distichum), water tupelo (Nyssa aquatica), sweetgum (Liquidambar styraciflua), willow oak (Quercus phellos),

swamp chestnut oak (Q. michauxii), and water oak (Q. nigra). The understory species vary from reeds and sedges in the damper portions to saw palmetto (Serenoa repens) and grass on higher areas. Common mammals include among others otter (Lutra canadensis) and raccoon (Procyon lotor). The great blue heron (Ardea herodias) feeds in the sloughs and cypress ponds of the swamp. The cotton-mouth (Agkistrodon piscivorous), snapping turtle (Chelydra serpentina), bullfrog (Rana catesbeiana), and common water snake Natrix fasciata) are common. The bird-voiced tree frog (Hyla avivoca), an uncommon resident of southern river swamps, is known to breed throughout the Savannah River floodplains (SREL, 1979).

2.7.2.7 Existing Stresses on the Biological Systems

A. Savannah River Water Quality

Historically, the Savannah River has been subjected to many factors that affect the water quality (EPA, 1971; Hawkins, 1976). Completion of the Clark Hill Dam upstream caused the silt load and turbidity to decrease. The downstream reaches were dredged for improvement of channel alignment and navigability (1951 to 1956). The dredging caused a temporary increase in suspended load, turbidity and dissolved nutrients. Improved water treatment by municipalities has reduced nutrient and BOD loading, but industrilization in the basin has brought about additional waste loading. Variability in the ranges of all parameters has been reduced over the last 15 years, primarily as a result of flow stabilization by upstream control structures. Water quality data for water year 1978 for the Savannah River upstream and downstream from the Savannah River Plant are provided in Tables 2.7.2.7-1 and 2.7.2.7-2, respectively.

In general, the river has a slightly acid pH, but there is considerable variation in the data. The Savannah River water is relatively soft, well oxygenated and low in chemical and biological oxygen demand. Temperature, as shown in Tables 2.7.2.7-1 and 2.7.2.7-2, ranges from a low of 8 to 9 degrees Centigrade (February to March) to a high of greater than 24 degrees Centigrade (August to September). The net increase in water temperature of the Savannah River from above to below the Savannah River Plant is approximately 1.2 degrees Centigrade for the month of July 1977. Of this, about 0.8 degree Centigrade is attributed to natural increase from lessening of the grade, slowing of current, and exposure to warm air and sunshine. The remaining 0.4 degree Centigrade increase can be attributed to the influx of cooling water effluent from Four Mile Creek and other streams draining from the Savannah River Plant (Brown, et al., 1972; USGS, 1978b).

The Savannah River has been designated by the South Carolina Department of Health and Environmental Control as a Class B stream -- suitable for domestic supply usage -- from Jackson, South Carolina, to U.S. Highway 17 near Savannah, Georgia (ER, 1978). Upper Three Runs Creek and Four Mile Creek are not classified because of their restricted public access.

B. Water Quality of DWPF Site Streams

Water quality monitoring programs presently administered on the Savannah River Plant include monthly measurements of standard water quality parameters at the following stations:

- 1. Upper Three Runs Creek at Route 278
- 2. Upper Three Runs Creek at Road A
- 3. Upper Three, Runs at Road C, Flowing Streams Laboratory
- 4. Upper Three Runs, Tims Branch at Road C
- 5. Four Mile Creek at Road A-7
- 6. Four Mile Creek at Mouth
- 7. Savannah River above the Savannah River Plant
- 8. Savannah River below the Savannah River Plant

The ranges of the monthly measurements and annual means are reported for each station. Water quality data for Upper Three Runs Creek, Four Mile Creek, and the Savannah River below the Savannah River Plant are summarized for the years 1974 through 1977 in Table 2.7.2.7-3.

To complement the data described above, cursory field investigations and water sampling of minor streams draining the DWPF site and near vicinity were conducted (SAR, 1980). These data are reported in Table 2.7.2.7-4. Descriptions of the sampling locations are provided in Table 2.7.2.7-5 and Figure 2.7.2.1-2.

Effluents to site streams originating on the Savannah River Plant are designated under NPDES permit SC 0000175 by the U.S. Environmental Protection Agency, Region IV, Atlanta, Georgia. Seventeen of the designated discharges originate on Four Mile Creek, Upper Three Runs Creek, or the Savannah River in the reach between these two streams. These are identified in Table 2.7.2.7-6 by NPDES outfall number, source, receiving stream, and the estimated volume and type of waste. The discharges include cooling water effluents, wastes from water treatment facilities, and surface runoff from coal piles and ash dumps associated with power generating facilities at the Savannah River Plant.

Effluents to Upper Three Runs Creek are received through Tims Branch. These include process wastes, cooling water and surface runoff, which range in total discharge from approximately 200 to 1,000 gallons per minute. Runoff occurs from F and H Areas also (Table 2.7.2.7-6). Water quality data for Upper Three Runs Creek are presented in Table 2.7.2.7-7.

The most significant influence on the water quality of Four Mile Creek is the volume of once through cooling water it receives from the C Reactor (Brown, et al., 1972). Temperatures in the stream may range from less than 10 degrees Centigrade during reactor shutdown in winter to greater than 40 degrees Centigrade during summer. Gibbon and Sharitz (1974) report temperatures in excess of 50 degrees Centigrade. Mean summer temperatures are in excess of 34 to 38 degrees Centigrade. Below the receiving point of the heated effluent, Four Mile Creek is not considered a natural stream and the monitoring point for purposes of permitting is its confluence with the Savannah River (Table 2.7.2.7-8).

C Reactor cooling water is discharged at an elevation of 248 ft mean sea level to an 80-ft-wide canal structure, flows through it for about 2500 ft, and converges with a small branch of the creek. The canal contains several letdown structures, which aid in erosion prevention and accommodate the drop to the natural stream bed elevation. The effluent then joins with the main branch of Four Mile Creek and flows about seven miles before emptying into the swamp nine to twelve hours after discharge from the reactor heat exchangers. The effect of this increased water flow on flow patterns in the swamp and routes to the points of discharge to the river are discussed by Gibbons and Sharitz (1974) and Sharitz, et al. (1974a,b).

Thermal data on Four Mile Creek during C Reactor operation are summarized in Tables 2.7.2.3-3 and 2.7.2.7-9, showing three typical temperature profiles from the reactor outfall to a point just above Cassels' Pond (Brown, et al., 1972). The creek, at least from the point of C Reactor discharge to the lower reaches, no longer sustains a viable fish population.

Above the receiving point of the cooling water (i.e., Road A-7), the stream differs from other natural streams in the area. Effluents from F and H Areas cause an increase in hardness, nutrient content and levels of trace metals. Compared to Upper Three Runs Creek, pH is higher, and total dissolved solids and volatile solids normally are higher. Water quality data for Four Mile Creek are presented in Table 2.7.2.7-10.

C. Radioactivity of SRP Streams

Savannah River - Radioactivity

The SRP is drained by five streams that flow to the Savannah River. The primary sources of the radioactivity that reaches the

river are the reactor facilities. Tritium accounts for the largest quantity of radioactivity released by the reactors to the effluent streams.

River water is sampled above and below the plant and analyzed weekly. Concentrations of alpha, nonvolatile beta emitters, and tritium in river water are summarized in Ashley (1972) and Ashley and Zeigler (1973, 1974, 1975, 1976, 1978). The alpha and beta values represent the radioactivity associated with dissolved and suspended solids and are near or less than the sensitivity of analysis. Upstream measurements are attributed to natural radioactivity and worldwide fallout from nuclear weapons tests. Downstream measurements reflect these sources plus releases from SRP.

Tritium, trace amount of Cs-137, and Sr-90 were the only radionuclides of SRP origin detected in river water at the downstream location. Sr-90 and tritium from worldwide fallout were also detected in river water upstream from SRP effluents. Average concentrations of all radionuclides found in river water during 1978 are given in Table 2.7.2.7-11.

Tritium Balance in Streams and River

Since 1964 tritium released to plant streams from all known sources has been compared with that analyzed in streams at Road A locations and in the river below SRP at Highway 301. Data for 1977 are presented in Table 2.7.2.7-12. Previous comparison of tritium releases with measurements of tritium in plant streams and the river are summarized in Table 2.7.2.7-13. The overall difference (1964-1977) between measured released and the total measured at Road A locations is <1% and at the Highway 301 Savannah River bridge, <6%. Contributions by stream source are given in Table 2.7.2.7-14.

Migration of Radioactivity from Separations Areas Seepage Basins

Migration of activity from F- and H-Area seepage basins is measured with continuous flow recorders and samplers in Four Mile Creek. Total radioactivity measured in 1977 was: Sr-90, 0.65 Ci from F Area, and 0.01 Ci from H Area; tritium, 3657 Ci from F Area and 4526 Ci from H Area. Cs-137 from seepage basins is obscured by the desorption of Cs-137 from the streambed.

Tritium, Sr-90, and Cs-137 in Four Mile Creek during 1977 are shown in Table 2.7.2.7-15. Ground water from H-Area basin 1 enters Four Mile Creek between sampling locations 2 and 3 and from H-Area

basin 4 between sampling locations 3 and 4. Ground water from F-Area basins enters Four Mile Creek between sampling locations 6 and 7 (Figure 2.7.2.7-1).

Between 1954 and 1977, the F-Area seepage basins received approximately 40.7 Ci of Sr-90, and the H-Area basins approximately 36.6 Ci.

D. Radionuclides in Fish

Fish are trapped in plant effluent streams and in the Savannah River upstream, adjacent to, and downstream from the SRP effluents. Individual whole fish are analyzed by gamma spectrometry for Cs-137 and other gamma-emitting radionuclides; bone from each specimen is composited monthly for Sr-89,90 analysis. Fish flesh samples are also freeze-dried for tritium analysis.

During 1977, the radioactivity in bone and flesh showed only minor contribution by SRP. Thirty-seven river fish (20 collected above, 7 adjacent to, and 10 below the plant) were radioanalyzed. Concentrations of Cs-137 in all fish were near or less than the sensitivity of analysis (approximately 0.2 pCi/g). Tritium in fish from the river reflect SRP contribution to tritium concentration in the water. The 1977 results are similar to those observed during the past 7 years as shown in Table 2.7.2.7-16. Maximum concentrations of Cs-137 and tritium in plant stream fish were measured in fish collected in Four Mile Creek. These concentrations were 16 pCi/g of Cs-137 in a bream, and 6 pCi/mL of tritium in a bass (Ashley and Zeigler, 1978).

Summaries for fish for 1977 are shown in Table 2.7.2.7-17.

E. Polychlorinated Biphenyls (PCB's) in Fish

Because annual analyses of sediment from SRP streams and the Savannah River have shown some low concentrations of polychlorinated biphenyls and because fish concentrate PCB's, five samples of bream, sucker, or pike from plant streams and the Savannah River were collected during March, 1977, and analyzed by Stewart Laboratories, Inc., of Knoxville, TN. Collections were made in Four Mile Creek, above and below the C-Area cooling water effluent, Tims Branch, and in the river above and below SRP. All sample results were less than 0.05 ppm. Although the Environmental Protection Agency has not established maximum contaminant levels for PCB's in drinking water regulations, the Food and Drug Administration has recommended a 5 ppm tolerance level for PCB's in fish and recently proposed a change to 2 ppm.

F. Mercury in Fish

Mercury was detected in river and stream fish in analyses beginning in July, 1971, and the levels in fish have changed very little since that time. Initially, individual fish were analyzed. In 1972, fish samples were analyzed quarterly by species composites - bream, bass, and catfish. From 1973 through 1975, species composites were analyzed semiannually; and in 1976 and 1977, plant streams and river fish were again analyzed individually. Annual mercury averages for three species of river fish, bass, bream, and catfish are shown in Table 2.7.2.7-18 and 2.7.2.7-19. In 1977, maximum concentrations of mercury measured in river fish were 1.9 µg/g in bream and catfish collected upstream from the plant at the control river location, and $1.8~\mu\mathrm{g/g}$ in catfish collected downstream at Highway 301. Stream fish showed a maximum mercury concentration of 1.8 μg/g in Par Pond bass. contribution of the burial ground to mercury levels of Four Mile Creek has been estimated at approximately 0.2 ppb (Orebaugh and Hale, 1976).

G. Pesticides in River and Streams

Arrangements were made in 1971 for the United States Geological Survey (USGS) Water Quality Laboratory, Washington, DC (now located in Atlanta, GA), to analyze water and sediment from SRP streams and the Savannah River for pesticides. Water samples were previously analyzed for pesticides by the Federal Water Pollution Control Administration (now Environmental Protection Agency) at Athens, GA, and all results were less than sensitivity of analyses. Gas chromatographic analyses in 1977 also show concentrations of pesticides in river water both upstream and downstream from the plant to be less than the sensitivity of analyses (<0.05 $\mu g/L$). The analyses performed on the water and sediment samples collected from seven plant streams and two river locations for 25 pesticides and polychlorinated biphenyls (PCB's) under contract with the U.S. Department of Interior Water Quality Laboratory in Atlanta, GA, are shown in Table 2.7.2.7-20 (Ashley and Zeigler, 1978).

River sediment collected upstream from SRP in 1977 showed trace quantities of dieldrin, DDD, DDE, and DDT. Low concentrations of several pesticides were detected in sediment from one stream (Pen Branch at road A). Four water samples from monitoring wells around the pesticide container landfill were also analyzed. Trace dieldrin (0.22 μ g/L) was reported for one well. This pesticide is not used at SRP. Some pesticides and herbicides are used moderately, however, where insect and vegetation control is necessary for security and safety. Some herbicide and chemical treatment is also carried on by the U.S. Forest Service in timber management but the use is limited. Results of the river sediment analyses by the USGS

laboratory are shown in Table 2.7.2.7-21. No pesticide concentrations were given for Upper Three Mile Creek for October, 1975, through September, 1978, in samples taken at Highway 278 (USGS, 1977, 1978a, 1979). The pattern of concentrations detected in sediment continues to indicate that offplant sources are the primary contributors. Possible offsite sources for pesticides found in the river include domestic and industrial discharges and drainage from urban and agricultural areas.

H. Fecal Coliform Bacteria in River and Streams

Water samples are collected weekly from the Savannah River and SRP streams and analyzed for fecal coliform. More fecal coliforms are present in river water upstream of SRP (320 colonies/100 mL) than in downstream samples (100 colonies/100 mL). The lower downstream concentrations are influenced by river water that is heated in the reactor areas and discharged from SRP back into the river.

Concentrations of coliforms in SRP effluent streams averaged 34 colonies/100 mL in Pen Branch at road A to 130 colonies/100 mL in the D-Area effluent. The D-Area value is slightly higher than that in the control location on Upper Three Runs Creek at road F (74 colonies/100 mL). Summaries for plant streams for 1977 are given in Table 2.7.2.7-22.

I. Landfill near Upper Three Runs Creek and Road C

Samples are collected from one sanitary landfill well per month on a rotating basis to provide three samples per year for each of the four wells. Samples are filtered with "Millipore" (0.45 μ) filter paper before being analyzed for metals because tests in 1975 indicated that elevated aluminum, total iron, and lead were present in the solids fractions of the samples. Data for 1977 are summarized in Ashley and Zeigler (1978). Metals and other analyses are within ranges found in plant streams.

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FIGURES TO SECTION 2.7.2

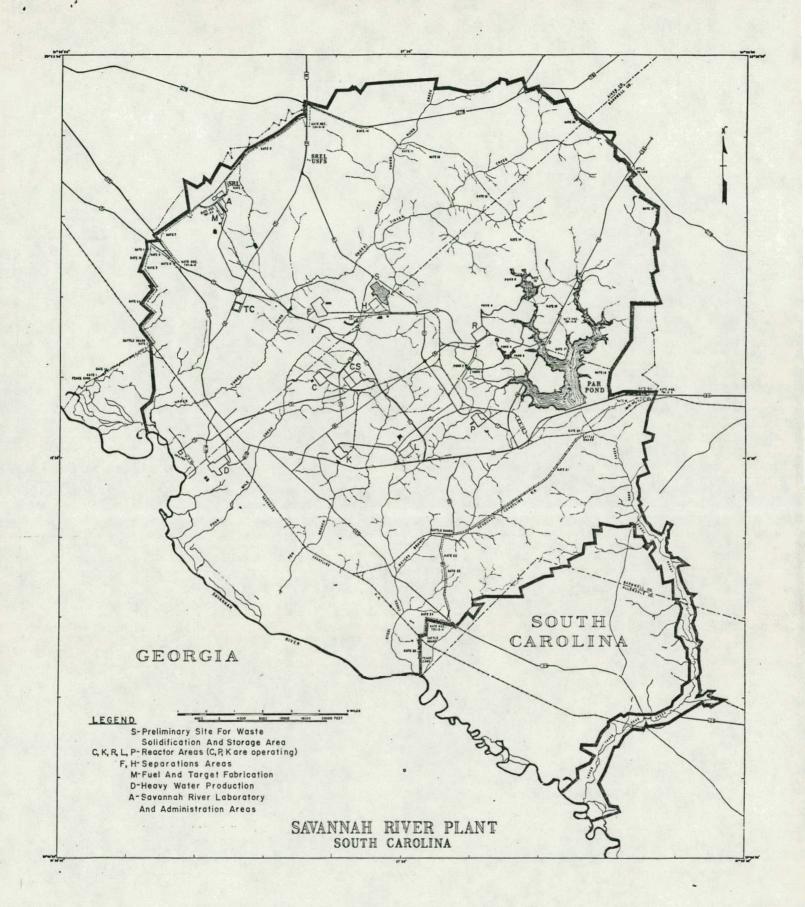


FIGURE 2.7.2.1-1. The Savannah River Plant Site

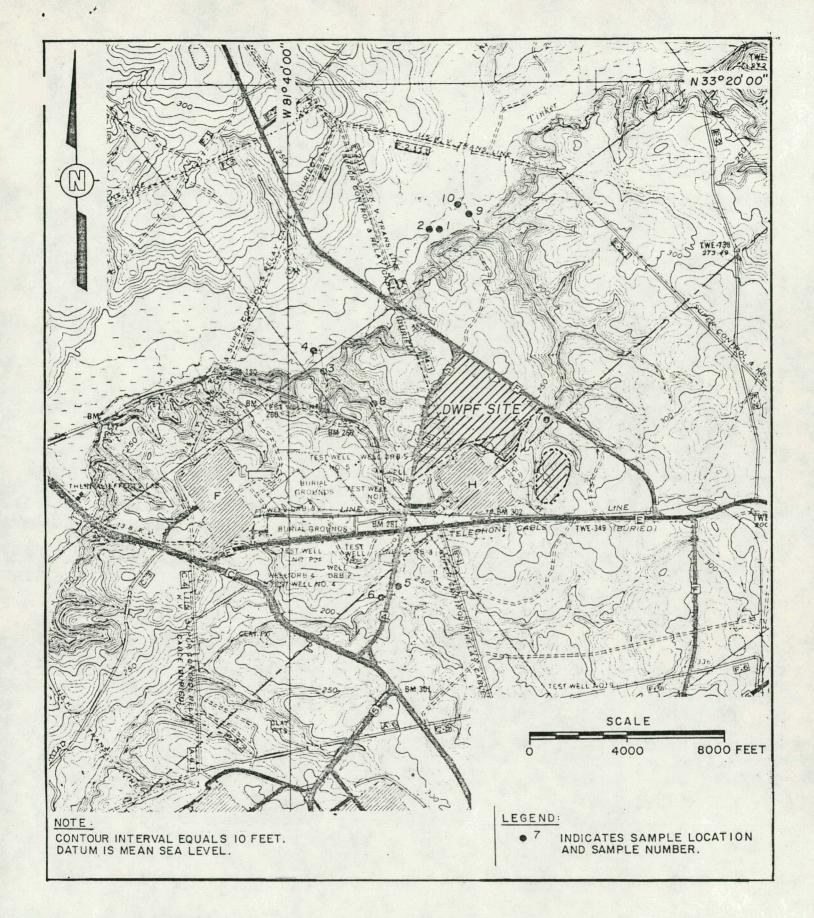


FIGURE 2.7.2.1-2. Savannah River Plant Defense Waste Processing Facility (DWPF Site) Water Quality Sampling Locations and Habital Descriptions, February 1979. (Source: SAR, 1980)

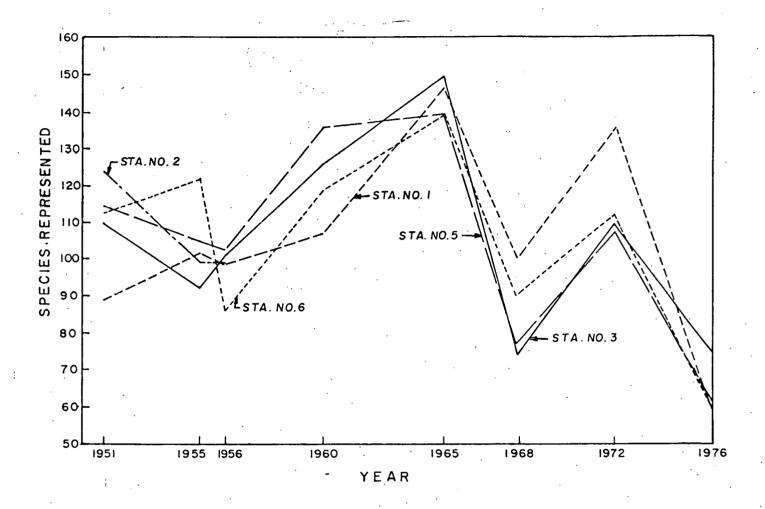


FIGURE 2.7.2.3-1. Number of Species of Algae and Diatoms in Academy of Natural Sciences Collections from the Savannah River (Stations 1, 3, 5, and 6) and Upper Three Runs Creek (Station 2). (SAR, 1980)

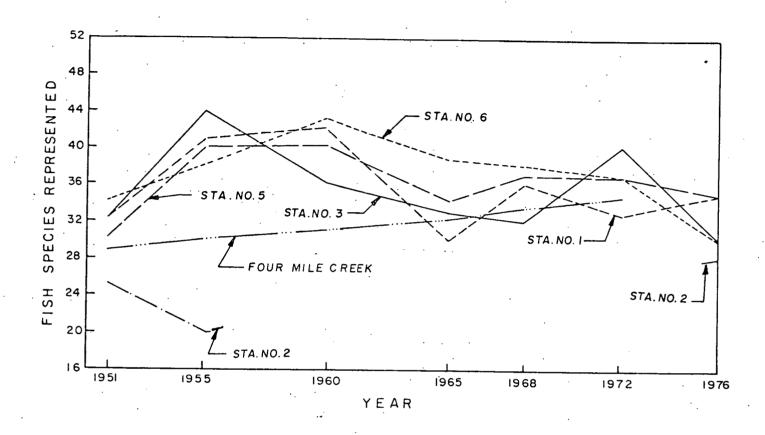


FIGURE 2.7.2.4-1. Number of Species of Fish in Academy of Matural Sciences Collections from the Savannah River (Stations 1, 3, 5, and 6) and Upper Three Runs Creek (Station 2). (SAR, 1980)

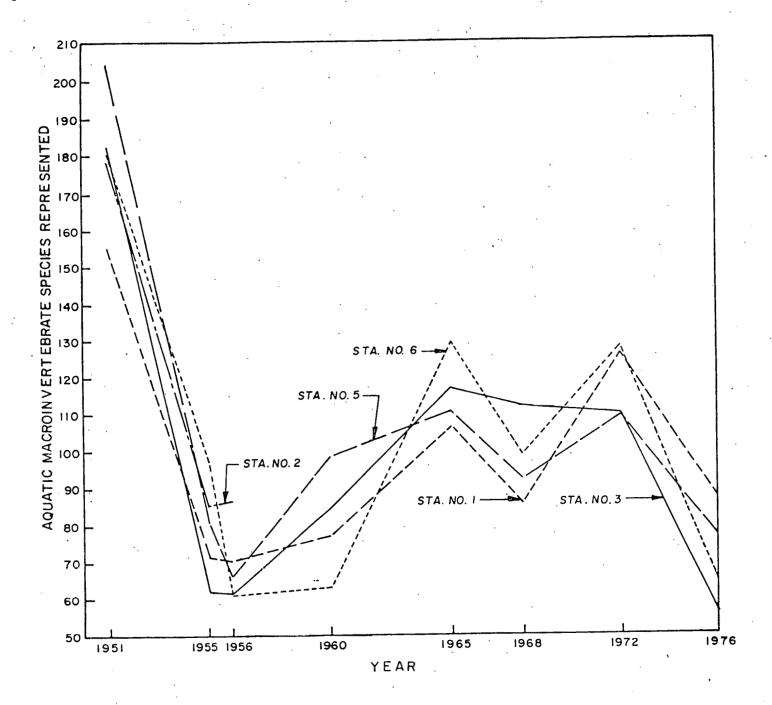


FIGURE 2.7.2.4-2. Number of Species of Macroinvertebrates in Academy of Natural Sciences Collections from the Savannah River (Stations 1, 3, 5, 6) and Upper Three Runs Creek (Station 2). (SAR, 1980)

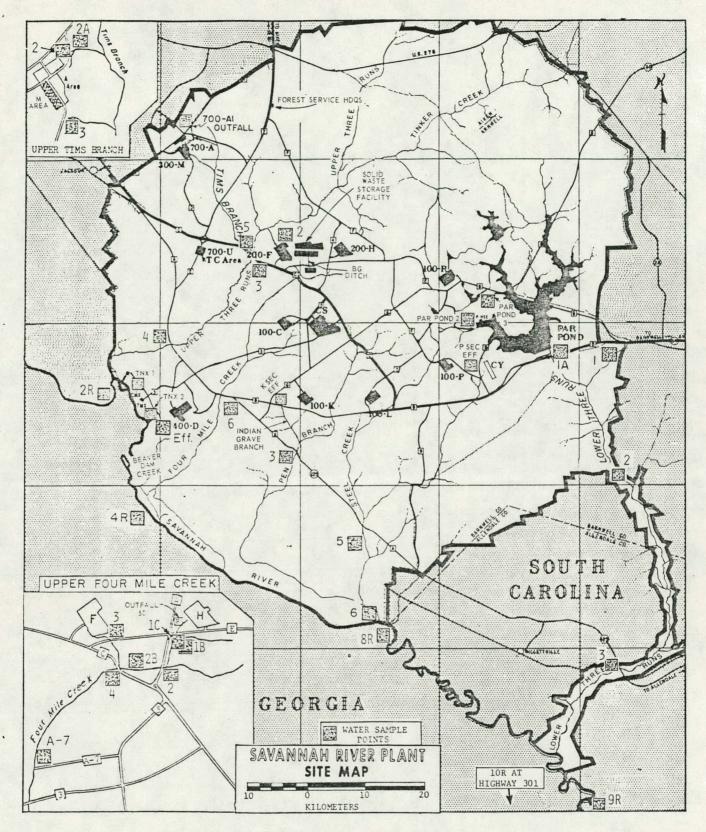


Figure 2.7.2.7-1 STREAM AND RIVER SAMPLE POINTS

TABLES TO SECTION 2.7.2

TABLE 2.7.2.1-1

Typical Trees, Shrubs, Vines, and Herbaceous Plants Found in Wet Areas along Upper Three Runs Creek (Modified from Whipple, 1978)

Trees	<u>Shrubs</u>	<u>Vines</u>	<u>Herbs</u>
Taxodium distichum	Itea virginica	Mikania scandens	Onoclea sensibilis
Nyssa aquatica	Ilex decidua	Ampelopsis arborea	Arundinaria gigantea
Fraxinus americana	t	Smilax sp.	Saururus cernuus
Betula nigra		Rhus radicans	Boehmera cylindrica
Ulmus americana		Campis radicans	Panicum sp.
Nyssa sylvatica			Violoa sp.
Quercus laurifolia			Leersia sp.
Acer rubrum	•		Polygonum sp.
Liquidambar styraciflua			Pilea pumila
			Ludwigia sp.
			Peltandra virginica
			Carex sp.
			Hypericum sp.
			Osmunda cinnamonea
			Orontium aquaticum

TABLE 2.7.2.2-1

Academy of Natural Sciences Aquatic Collections Reported, 1951-1977 (1)

Sampling	Sampling Stations by Quarter (2)																			
Year	1 2				3					5				6						
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1951-1952	x	x	x	x	x	x	X	x	x	x	x	x	x	x	x	X	x	x	x	x
1955-1956		x	x			x	x			x	x			x	x			x	x	
1960		x	x							x	x			x	x			x	x	
1965		x	x							x	x			x	x			x	x	
1968		x	x				٠		•	x	x			x	x			x	x	
1972		x	x		•					x	x			x	x			x	x	
1976			x								x				x				x	

⁽¹⁾ Sources: Academy of Natural Sciences of Philadelphia.

⁽²⁾ First Quarter Jan 1 - Mar 31
Second Quarter Apr 1 - June 30
Third Quarter July 1 - Sept 30
Fourth Quarter Oct 1 - Dec 31

TABLE 2.7.2.2-2

Snakes and other

reptiles

Entire SRP

Sources of Information for Characterization of the Baseline Aquatic Ecology of Streams Impacted by the Proposed DWPF

Subject	Comment and/or Location	Refereņce
Fish	•	
Fish	All streams - SRP	Freeman (1954)
Channel Catfish	Movements in Upper Three Runs Creek and the Savannah River	Humphries (1965)
Fish	General listing	Clugston (1973)
Fish	All SRP streams	McFarlane (1976)
Fish	Impingement and entrainment at SRP, migration and spawning Upper Three Runs Creek	McFarlane, Frietsche, and Miracle (1978)
Mosquito Fish (<u>Gambusia</u> <u>affinis</u>)	Fat content in <u>G</u> . <u>affinis</u> from Upper Three Runs Creek and Four Mile Creek	Falke and Smith (1974)
Mosquito Fish (<u>Gambusia</u> <u>affinis</u>)	Populations of \underline{G} . affinis in Four Mile Creek	Ferens and Murphy (1974)
Mosquito Fish (<u>Gambusia affinis</u>)	Genetic diversity on SRP site	Smith (1979)
Largemouth bass, mosquito fish, and bluegill	Biochemical genetics of sunfish from Upper Three Runs Creek, Four Mile Creek, and thermal waters.	Yardley, <u>et al</u> (1974)
Fish	Invasion of post-thermal habitats, Four Mile Creek	Tinney and Gibbons (1977)
Fish	Species diversity in Castor Creek, a tributary of Four Mile Creek	Thomson and Gibbons (1978)
Fish	All SRP streams, NERP baseline study	Bennett and McFarlane (1979)
Amphibians and Reptil	es	
Salamanders	Entire SRP	Freeman (1955a)
Toads and frogs	Entire SRP	Freeman (1956)
Amphibians and reptiles	Entire SRP	Gibbons and Patterson (1978)

Gibbons (1977)

Subject

Comment and/or Location

Reference

Amphibians and Reptiles contd

Turtles

Entire SRP

Freeman (1955b)

Turtle parasites

Collections from Upper Three Runs Creek Bourque and Esch (1974)

and Four Mile Creek of emydid turtles

and associated parasites

Alligators, lizards Entire SRP

and snakes

Freeman (1955c)

Alligators

Sighting on Kennedy's Pond in Upper

Jenkins and Provost (1963)

Three Runs Creek

Alligators

Entire SRP, including Upper Three Runs

Murphy (1979a,b)

Creek and Four Mile Creek

Birds

Birds

Entire SRP

Norris (1963)

Bird diversity

Bird diversity in Upper Three Runs

Straney, Briese, and Smith (1974)

Creek, cypress swamps versus thermally

impacted areas

Waterfowl

Entire SRP

Jenkins and Provost (1963)

Mammals

Furbearers

Beaver, mink, muskrat, otter, and

Jenkins and Provost (1963)

racoon for entire SRP

Racoon

Wood and Odum (1965)

Beaver, entire SRP

Fitzgerald (1979)

Acquatic Insects

Odonata

Taxonomic survey of Upper Three Runs

Cross (1955)

Creek and Four Mile Creek (dragonflies)

Aquatic insects

Common ones of Upper Three Runs Creek

Harvey (1975)

Aquatic insects

Diversity indices for thermally stressed Howell and Gentry (1974)

and natural creeks (Upper Three Runs

Creek)

Dragonfly nymphs

Thermal stress on dragonfly nymphs

Martin and Gentry (1974)

from Four Mile Creek

TABLE 2.7.2.2-2 (continued)

•		
Subject	Comment and/or Location	Reference
Aquatic Insects		•
Dragonfly nymphs	Thermal tolerances of dragonfly nymphs from Four Mile Creek	Martin, Garten and Gentry (1976)
Dragonfly nymphs	Thermal tolerances of dragonfly nymphs from Four Mile Creek	Garten and Gentry (1976)
Aquatic insects	Survey of Upper Three Runs Creek for one year (these studies are continuing)	Morse, <u>et al</u> (1979)
Aquatic insects	Castor Creek, a branch to Four Mile Creek	Cain (1977), Gillen (1977a, 1977b)
Macroinvertebrates		
Decapod crustaceans (crayfish)	Entire SRP	Hobbs, <u>et al</u> (1977)
Freshwater sponges	General	Penny (1954, 1956)
Aquatic snails (gastropods)	Entire SRP	Wood and Wineriter (1979)
Plants		
Periphyton	Upper Three Runs Creek, Four Mile Creek, and Castor Creek	Vanderbosch (1977).
Algae	Common ones of Upper Three Runs Creek	Macfie and Swails (1957)
Swamp bottomlands	General	Swails, <u>et al</u> (1957) Porter, <u>et al</u> (1958)
Swamp bottomlands	Thermal effects on vegetation (Four Mile Creek)	Sharitz, Gibbons, and Gause (1974)
. Swamp bottomlands	Thermal effects on vegetation	Sharitz, Irwin and Christy (1974)
Swamp bottomlands	Swamp bottomlands of Upper Three Runs Creek	Whipple (1978)
Swamp bottomlands	Preserve Areas, Beech-Hardwood Forest, Mixed Swamp Forest, Cypress Grove	SREL, 1979
Plant communities	Communities and macrophytes along Upper Three Runs Creek and Four Mile Creek (also entire SRP site)	Angerman and Jones (1979)

TABLE 2.7.2.2-2 (continued)

Subject	Comment and/or Location	Reference					
Bacteria and Fungi	·						
Thermophilic and thermotolerant fungi	Heated effluents of Four Mile Creek, Flowing Streams Laboratory, and non-thermal Upper Three Runs Creek	Tansey and Fliermans (1978), Tansey, et al (1979)					
Bacteria	Common genera from Upper Three Runs Creek and Tim's Branch	Cherry, <u>et al</u> (1974a, 1974b)					
Chemistry							
Dissolved organics	Amounts in Upper Three Runs Creek	Lewis and Tyburczy (1974)					
Lead and cadmium	Amounts concentrated with naturally occurring organics	Briese and Giesy (1975)					
Trace metals	Water chemistry and trace metal transport on Upper Three Runs Creek	Giesy and Briese (1978)					
Transuranic elements	Soil surveys and studies near F and H Areas and Four Mile Creek	Alberts and McCloud (1979)					
Water chemical and physical data	Upper Three Runs Creek as a Bench Mark Stream since 1966	Annual reports, USGS					
Water monitoring	Upper Three Runs Creek and Four Mile Creek	Annual reports, SRP					
Water data	Upper Three Runs Creek and Four Mile Creek	SAR (1980)					

TABLE 2.7.2.3-1

						-	-	-	-								RIVER	VANNAH 3	IVER		-	-		-		-		-				-	
		AROVI	E CONFL			-	E RUNS										-				UPPER THE	EE MUNE									UP		EE PUNS
TAXA (2)	1951	1935	1956		1 401TA		1972	15.76	1951	1955	1936		TION 3	1968	972	1976	1951	1955 1	956	960 19	S 1968	1972	1976 T	1951	1955	1956 1		1965 I	968 1	972 19	76 191	5TAT1	
									.,,,																,								
DIVISION CHLOROPHYTA (GREEN ALGAE)		7	-								777	14.7													0								
CLASS CHLOROPHYCEAE								-																	1								
ORDER TETRASPORALES					2																		1										
FAMILY Palmeliaceae							1								1															1			
FAMILY Tetrasporaceae	2		1		1	1	1		2			1	1			W.	3				1	1		1	1						2	2	
FAMILY Coccomyxaceae							1																1										
ORDER ULOTRICHALES																								12	1			2					
FAMILY Ulotrichaceae							3	1							1	1				1	,		-	1	1			1					
FAMILY Cylindrocapsaceae FAMILY Chartophoraceae	2			,	1	1	2	1		1			1	1	1	1	1	,	,	,			1	2	1	,	2	1	1	2	1 1		
ORDER MICROSPORALES							*	-	3								1		•														
FAMILY Microsporaceae	1								2								2						-	1						1		1	
ORDER ULVALES								1								1																	
FAMILY Schizomeridaceae								1				1		1	1	1					1			1					1	1			
ORDER CHAETOFHORALES																																	
FAMILY Protococcaceae																																1	
ORDER CLADOPHARALES					-											1							-							3	1		
FAMILY Cladophoraceae ORDER GEDGGONIALES				1	1	- 1	2									-															1		
FAMILY Dedogoniaceae	3	1	2	- 1	1	1	1	1	2		1	2	1	1	1	1	,	3	2	2	1 1	1	1	2	2		2	1	1	1	1	2	. 1
ORDER ZYGNEMATALES		110		17-11	E	1								7																			
FAMILY Zygnemataceae	4	1		1	1	1	1	1)	1		2	2	1	2	1	3	2		2	1 1	1	1	5	2		1	1	1	3	1	5	
FAMILY Desmidiaceae	6			2	3	. 1		1	10	2	1		3			1	14	3	1		2 1		17. 1	11	1			2				5	
FAMILY Meantmentaceme		2														13.3		1														5	1
ORDER CHLOROCOCCALES								-								2				1													
FAMILY Hydrodictyaceae																-	1			1			11	1									
FAMILY Coelastraceae FAMILY Cocystaceae							-		1									3						3	1							1 .	
FAMILY Scenedesmaceae							PUL.	5	1								4						No.	3								2	,
The second secon								9																	1								
CLASS CHAROPHYCEAE .																1																	
ORDER CHARALES																									1						200		
FAMILY Characeae														1		200					1											1	
	-	7				MINISTER .		-		-		-	-	-	-			-				-	-		-		-	-			-		-
DIVISION CHRYSOPHYTA (YELLOW-GREEN ALGAE)																																	
CLASS XANTHOPHYCEAE																																	
ORDER HETEROTRICHALES																							100										
FAMILY Telbonemataceae															1	1							5 -4										
ORDER HETEROSIPHUNALES FAMILY Vaucherinceae	1	1	1	1	1	1	1	1	1	1		1	1	1	1		1	1	1	1	1 1	1	1	1	1	1	1	1	1	ı		1	1
		-			-								-		-			-									Film						-
DIVISION BACILLARIOPHYTA (DIATOMS)																																	
CLASS BACILLARIOPHYCEAE	1																						0.0										
FAMILY Comfoodingscome	1	5	6	7		7	9	1	2	6	7	6	8	,	8	2	2	,	6	6	6 6	10	3	1		5	4	7		8	2	2	1
PAMILY Riddelphiacess	1	3	2	1			2	2	2	1	1		1		1	1	1	3	1	2	1 1	1	,	2	2	1	2	1	2		2		
FAMILY Fragierierese	10	6	3	n	15		11		10	,	8	10	13	1		,	8	'	,	11	9 6	11	1	12	,	,	10	!		*	3		1
FAMILY Eunotiaceae	2 2	3	'	,	1		,	3	6	,	,	1			,	4	5	11	'	8	7 4		3	3	14	,		8		:			16 1
FAMILY Achmanthaceae FAMILY Naviculaceae	18	34	:1	41	50	30	40	19	11	11	34	42	55	21	31	22	23	28	34		51 21	8 26	16	25	40	28	36	55	23	34	100		15 1 35 2
FAMILY Comphonemaceae	8	,	,	6	8	3.	5	-	3	6	6	,	11	6	4	5	8	4	,		111 2	4	3	5	6	6	9	9	5	3			6
FAMILY Cymbellaceae	1	5	5	-77	1	1	3	2	1	5	3	18/	,	2	2	2	1	2	2		4 3	1	1	3	3	4		3	3	2			3
FAMILY Epithemisceae							-1			1													1 -		1							1	
FAMILY Nitsschiacese	10	19	20	15	23	16	22	4	12	6	20	18	23	8	17	12	10	15	17	21	19 11	16	11	11	14	12	20	22	16	18	5	7	6
FAMILY Surfreliaceae	4	2	A	A	6	3	4	1	5		2	4	3	2	3	1	3	2	2	5	2 1	2	1	3	1	3	3	4	2	3	2	3	2
	-			-	-				-	-	-			-		-				-				-	-		-	-		_	-		-
DIVISION RHODOPHYTA (RED ALGAE)																Ung 3																	
ORDER BANCIALES	-														,	,		1	,	1	1 1	1	1		1		1	4	i	i	1		
FAMILY Erythrotrichiaceae ORDER NEMALIALES				1	1	1	1	1				1	1	1	1	1			1					1-15				1					
FAHILY Acrochaetiaceae																						1		NES						1			
FAMILY Lemeneacese	1,13,1				1	1		18								10				1	1							1			1		
FAMILY Batrachospermacese	1	1	1		1	1	1	1		1	1		1			13 6		1	1	1	1 1	1	1		1	1	1	1	1	1		1	
FAMILY Chantrenstancese	1	JA			1				1				-1				1				1			1				1				1	
	-	-			-	-		-		-	-	W. 1872			1000	-				-	-	-		-	-		-	-	-	-	-		
DIVISION CYANOPHYTA (BLUE-CREEN ALGAE)																																	
ORDER CHROGOCOCCALES	-	*																															
FAHILY Chrococcaceae						1		-1								14	1			-		1		1	1							1	
FAMILY Chapterstylonaceae						1		1	1								1			1							1				1		
FAMILY Entophysalidaceae FAMILY Clastidiaceae						1							. 1								1							1					
ORDER OSCIILATORIALES																- 3-												1		,			
PAHILY Oscillatoriscese	8	1	3		5	,	9	4	,	5			. 3	5	10	6	,			10	6 7	10	3	,	5	3		4	,	,	3	,	1
ORDER NOSTOCALES				100				1									100		-								720			1	1	1	
FAMILY Nostocaceae	1	. 2					2	100	2	1		1			3	1	2	2	1	3		3	1	3	1				2	1		1	
FAMILY Scytonesataceae	1				1		7-15	12	2	1		-11	- 1		1			1				1		1								1	
	1000							-	1						MA	The Mark	(45)			1				1			2 4					2	
FAMILY RIVULariaceas																																	
		-				-	-	-		-		-				-	-	-	-				-	-	-	-	119 "						-

⁽¹⁾ Source: The Academy of Natural Sciences of Philadesphia (1953, 1957, 1961, 1967, 1970, 1974, 1977). (See also SAR, 1980)
(2) Taxonomy as compiled by Ant la especial reports and therefore subject to inconsistencies.

TABLE 2.7.2.3-2
Algae of the Savannah River 1,2

Group	No. Species	More Common Species
Green´Algae	62	Oedogonium sp.
		Stigeoclonium lubricum
		Tetraspora gelatinosa
		Spirogyra sp.
Blue-green Algae	41	Microcoleus vaginatus
		Microcoleus lyngbyaceus
		Schizothrix calcicola
		Oscillatoria retzii
Red Algae	7	Bactrachospermum sp.
	٠	Compsopogon coeruleus
Diatoms	291	Navicula mutica
		Navicula lateropunctata
		Navicula germainii
		Navicula confervacea
		Nitzschia palea
•	•	Eunotia monodon
•	•	Achnanthes biporoma
		Achnanthes lanceolata
		Melosira varians
		Bacillaria paradoxa
Yellow-green Algae	1	<u>Vaucheria</u> sp.

¹AWV, 1972, 1974.

 $^{^2\}text{All}$ of these occur in ANS collections except $\underline{\text{N. germainii}}$

TABLE 2.7.2.3-3 $^{\rm 1}$ Typical Four Mile Creek Temperatures, $^{\rm O}{\rm C}$

Location	8/31/55	<u>8/66</u>	10/19/71
Reactor Outfall	56.1	71.4	69.0
SRP Road A	43.0	56.5	52.6
Railroad	-	50.5	46.6
Above Cassels' Pond	36.2	44.0	39.4

^{1.} Brown, <u>et al</u>, 1972

TABLE 2.7.2.3-4

Common Macrophytes Along the Savannah River¹

Scientific Name	Common Name	Rank²
Myriophyllum	Water milfoil	1
Sagittaria	Duck potato	4
<u>Ceratophyllum</u>	Hornwort	1
Pontederia	Pickerel weed	5
Anacharis	Water weed	3
Alternanthera	Alligator weed	2
Typha	Cattail	5

^{1.} AWV, 1972, 1974.

^{2.} Rank: 1 = most abundant, 2 = very abundant, 3 = abundant, 4 = not abundant, 5 = scarce.

TABLE 2.7.2.4-1

A List of Fishes of the Savannah River Plant From Bennett and McFarlane (1979) $\,$

, ,		
<u>Family</u>	Species	Common Name
Acipenseridae	Acipenser oxyrhynchus	Atlantic Sturgeon
Lepisosteidae	Lepisosteus osseus Lepisosteus platyrhincus	Longnose gar Florida gar
Amiidae	Amia calva	Bowfin
Anguillidae	Anguilla rostrata	American eel
Clupeidae	Alosa aestivalis Alosa mediocris Alosa sapidissima Dorosoma cepedianum Dorosoma petenense	Blueback herring Hickory shad American shad Gizzard shad Threadfin shad
Umbridae	Umbra pygmaea	Eastern Mudminnow
Esocidae	Esox niger Esox americanus	Chain pickerel Redfin pickerel
Cyprinidae	Cyprinus carpio Hybognathus nuchalis Hybopsis rubrifrons Nocomis leptocephalus Notemigonus crysoleucas Notropis chalybaeus Notropis cummingsae Notropis emiliae Notropis hudsonius Notropis leedsi Notropis lutipinnis Notropis maculatus Notropis niveus Notropis petersoni Semotilus atromaculatus	Carp Silvery minnow Rosyface chub Bluehead chub Golden shiner Ironcolor shiner Dusky shiner Pugnose minnow Spottail shiner Sailfin shiner Ohoope shiner Yellowfin shiner Taillight shiner Whitefin shiner Coastal shiner Creek chub
Catostomidae	Carpiodea cyprinus Erimyzon oblongus Erimyzon sucetta Hypentelium nigricans Minytrema melanops Moxostoma anisurum	Quillback Creek chubsucker Lake chubsucker Northern hog sucker Spotted sucker Silver Redhorse

Family	<u>Species</u>	Common Name
Ictaluridae	Ictalurus brunneus Ictalurus catus Ictalurus natalis Ictalurus nebulosus Ictalurus platycephalus Ictalurus punctatus Noturus gyrinus Noturus insignis Noturus leptacanthus Pylodictus olivaris	Snail bullhead White catfish Yellow bullhead Brown bullhead Flat bullhead Channel Catfish Tadpole madtom Margined madtom Speckled madtom Flathead catfish
Amblyopsidae	Chologaster cornuta	Swampfish
Aphredoderidae	Aphredoderus sayanus	Pirate perch
Belonidae	Strongylura marina	Atlantic needlefish
Cyprinodontidae	<u>Fundulus</u> <u>lineolatus</u>	Lined topminnow
Poeciliidae	Gambusia affinis	Mosquitofish
Antherinidae	Labidesthes sicculus	Brook silversides
Percichthyidae	Morone chrysops Morone saxatilis	White bass striped bass
Centrarchidae	Acantharchus pomotis Centrarchus macropterus Elassoma zonatum Enneacanthus chaetodon Enneacanthus gloriosus Enneacanthus obesus Lepomis auritus Lepomis cyanellus Lepomis gihbosus Lepomis gulosus Lepomis macrochirus Lepomis macrochirus Lepomis microlophus Lepomis punctatus Micropterus salmoides Pomoxis nigromaculatus Pomoxis annularis	Mud sunfish Flier Banded pigmy sunfish Blackbanded sunfish Bluespotted sunfish Banded sunfish Redbreast sunfish Green sunfish Pumpkinseed Warmouth Bluegill Dollar sunfish Redear sunfish Spotted sunfish Largemouth bass Black crappie White crappie
Percidae	Etheostoma fricksium Etheostoma fusiforme Etheostoma hopkinsi Etheostoma inscriptum Etheostoma olmstedi Etheostoma serriferum Perca flavescens Percina nigrofasciata	Savannah darter Swamp darter Christmas darter Turquoise darter Tesselate darter Sawcheek darter Yellow perch Blackbanded darter

TABLE 2.7.2.4-1 (Con't)

Family

Species

Common Name

Mugilidae

Mugil cephalus

Striped mullet

Soleidae

Trinectes maculatus

Hogchoker

TAPLE 2.7.2.4-2
FISHES COLLECTED AT THE SAVANNAH RIVER PLANT

	Sept.					A			830				15.88			19	951-19	76(1)																		
SP	PECIES									411						SA	HANNAH																1			
SCIENTIFIC NAME (2)	CONTRACT VALUE	SPECIES	^	BOVE CO	NFLUE	ENCE WITH		1 THREE	RUNS		T. W				ALY			BELO	W CONFI	LUENCE V		PER THRE		AND FOU	R HILE	CREEK				1				ER THREE RUNS		CREEK
SCIENTIFIC NAME	COMMON NAME	PER	195	1 195	1	960 1965		948	1972	1976	1951	1955		STATIO			1972	1976	1951	1955		STATION :		1972	1976	1951	1955	-	STATIO			972 1976	1951-	1955 1974	1951-	1-
PHYLIN CHORDATA CLASS OSTEICHTHYES FAHILY LEPISOSTEIDAE Lepisosteus oculatus Lepisosteus oseus Lepisoateus platyrhineus	GARS Spotted gar Longnose gar Florida gar	3		:		•					173.					• ;	~.	17.0	;			1707	1700			:		:		•						•
FAMILY AMILDAE Amia calva	BOWFINS Bowfin	1													Hy			Hool										1		•						
PAHILY ANGUILLIDAE Anguilla rostrata	FRESHWATER EELS American eel	1																			•	•						•			N.		*,*			
FAMILY OPHICHTHIDAE Myrophia punctatus	SNAKE EELS Speckled worm esl	1																			1			2 40 5												
FAMILY CLUPEIDAE Alosa sestivalis Alosa chrysochioris Alosa mediocris Alosa sepidiasama Erevoortis tyrannus Dorosama cepedianus Dorosoma petenense	HERRINGS Blueback herring Skipjack herring Mickory shad American shad Atlantic menhaden Gizzard shad Threadfin shad	,				•			•		•		•				:	•		:	:															
FAMILY ENGRAULIDAE Anchoa mitchilli	ANCHOVIES Bay anchovy	1,													H												4						Part of			
FAMILY UMBRIDAE Umbra pygmaca	MUDMINNOWS Eastern mudminnow	1					1	• 1				1					a .													1						
FANILY ESOCIDAE Esox emericanus Esox niger	PIKES Redfin pickerel Chain pickerel	2		:		: :					:	3- 1	:			:	•		:		:		:	:	:	:	:		:	:			:::			:
FAMILY CYPRINIDAE Cyprinus carpio Hybopsathus nuchslis Hybopsis ambleps Hybopsis rubrifrons Noremi leptocephalus	MINNOWS AND CARPS Carp Silvery minnow Bigeye chub Rosyface chub Bluehead chub	24	:	:		: .		•	:		:							•	•		•					:		:					,,,			
Noremi micropogon Notemigonus crysoleucae Notropia ardena Notropia chalybacus Notropia cummingsae Notropia cummingsae Notropia emiliae Notropia bysolopterus Notropia bysolopterus	River chub Golden shiner Rosefin shiner Ironcolor shiner Dusky shiner Pugnose minnow Spottail shiner Smilfin shiner		:			:		•		:	:	:				•			:			1	•	:	:	:	:	:					::			
Notropis imaculatus Notropis ledicii Notropis lutipinnis Notropis maculatus Notropis niveus Notropis petersoni Notropis siplopterus Notropis siplopterus Notropis siones*	Ohoopee shiner Yellowfin shiner Taillight shiner Whitefin shiner Coastal shiner Spotfin shiner								•	i								:	•					•	:		:						:.			
Notropis xaenocephalus Pimephales vigilax Semotilus atromaculatus	Coosa shiner Bullhead minnow Greek chub				1									ART														V = 1								
FAMILY CATOSTOPHIAE Carpoides carpio Carpoides cyprimus Carpoides cyprimus Lingrom oblomgus Enlayeon sucertar Enlayeon sucertar Enlayeon sucertar Minytrens selanops Monatuma sepa	SUCKERS River carpsucker quillback Highfin carpsucker Creek chubsucker Lake chubsucker Northern hogsucker Spotted sucker					•			•									•		•		•		•									:.			
FAMILY ICTALURIDAE Ictalurus brunneus Ictalurus catus Ictalurus natalis Ictalurus natalis Ictalurus piatyeephalus Ictalurus punctatus Noturus grinnis Noturus insignis	FRESHMATER CATFISHES Snail bullhead White catfish Yellow bullhead Brown bullhead Flat builhead Channel catfish Tadpole madtom Margined madtom	es 11	:					•	•			•				•	:		:		:	:	:	:		:	:	:								77

TABLE 2.7.2.4-2

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Si	PECIES .														7	SAVAN	NAH RIVE	R											1		110					
SCIENTIFIC NAME (2)		SPECIES	^	BOVE CON	IFLUENC			R THRE	E RUNS								BELO	W CONFL	UENCE W	ITH UPF	ER THRE	E RUNS	AND FOU	R HILE	CREEK							UPPER	THREE	RUNS	FOUR P	
SCIENTIFIC NAME	COHNON NAME	FAMILY	1051	1065	1044		TION 1		1024				-	STATIO				1		-	TATION	-						STATION				1951-	STATION	2	1951- CRE	
FAMILY ICTALURIDAE (Cont.) Noturus leptacanthus Schilbendes marginatus* Schilbendes moilis*	Speckled madtom	7	1931	1955	1960	, 190	•	308	1971	1976	1931		1960	1965	1968	1972	1976	1951	1955	1960	1965	1968	1972	1976	1951	1955	1960	1963	1968	1972	1976	1953 x,*	1955	1974	1953	1974
Pylodictis olivaris FAMILY AMBLYOPSIDAE	Flathead catfish CAVEFISHES	1																																		
Chologester cornuta FAMILY APHREDODERIDAE	Swampfish PIRATE PERCHES	1 .																																		
Aphredoderus sayanus FAMILY BELONIDAE Stongylura marina	Pirate perch NEEDLEFISHES Atlantic needlefish	1									•		•		•	7.						•	•			•	•	•	•	•		*,*	•	-	*	
FAMILY CYPRINGDONTIDAE Fundulus disper*	KILLFISHES	3														i													•	•						
Fundulus lincoletus Fundulus nottii	Lined topminnow Starhead topminnow				•				•	•					•	•		D.				•		•					•	٠	•				*	
FAMILY POECILIIDAE Gambusia affinis	LIVEBEARERS Mosquitofish	1			•									٠			•		٠				٠						•			*,x				-
FAMILY ATHERINIDAE Lapidesthes sicculus	SILVERSIDES Brook silverside	1		•	•											٠			٠			٠	٠	٠							٠.	*,x			×	-
FAMILY PERCICHTYIDAE Morone saxatilis Morone chrysops	TEMPERATE BASSES Striped bass White bass	2										•																								
FAMILY CENTRACHIDAE Acantharchus prestis Centrachus macropterus Elassoma zonatum Enneacanthus chaetodon Enneacanthus gloriosus Enneacanthus obesus Lepenis muritus	SUNFISHES Mud sunfish Flier Banded pygmy sunfish Black-banded sunfish Buspotted sunfish Banded sunfish Redbreast sunfish	20						:	:	:	•	:				:									:				:	:		* *			× ×	
Leponis cyanellus Leponis gibboxus Leponis gilosus Leponis mercochirus Leponis merginetus Leponis merginetus Leponis merginetus Leponis microlopus Leponis punctatus Micropterus condicatus Micropterus punctulatus Micropterus punctulatus Micropterus punctulatus Micropterus almoides Fumoxis anigromaculatus Fumoxis anigromaculatus	Green aunfish Pumpkin seed Marmouth Bluegill boliar aunfish Longear sunfish Redear aunfish Redear bass Spotted sunfish Redeye bass Spotted bass Largemouth bass White crappie Black crappie		:		:							:			:	: : : : : : : : : : : : : : : : : : : :					: : :								:			***************************************			x x x	
FAMILY PERCIDAE	PERCHES	12										-		-	100	-		-	-						-				<u> </u>			-			×	
Mololopia barrattii* Etheostoma barrattii* Etheostoma fricksium Etheostoma fusiforme Etheostoma fusiforme Etheostoma lopylmsi Etheostoma nigrum Etheostoma districtium Poecilichthys fricksia*	Savannah darter Swamp darter Christmas darter Johnny darter Tessellated darter Saucheek darter				•					•	•	٠			•	•	•	:	•	•	•			•	:		•			. :				-		
Perca ilavecens Perca ilavecens Percina caprodes Percina nigrofasciata	Yellow perch Log perch Blackbanded darter			•				•		•		:	•		•				•	•	٠									•						
FAMILY SCIAENIDAE Aplodinotus grunniens	DRUMS Freehwater drum	1				,																										*.*				
FAMILY BOTHIDAE Paralichthys lethostigma	LEFTEYE FLOUNDERS Southern flounder	1				1																														
FAMILY SOLE DAE Trinectus fasciatus* Trinectus maculstus	SOLES Hogehoker	2			•						•	:							:															, .		
OTAL		106	31	40	42	29	9 :	36	33	34	32	43	35	32	32	40	30	30	40	41	33	37	37	35	35	39	43	39	36	37	30	45	19	16	27	33
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⁽¹⁾ Sources: + = The Academy of Matural Sciences of Philadelphia (1953, 1957, 1961, 1967, 1970, 1974, 1977). (See also SAR, 1980)

= Preman (1954).

- McFarlane (1976).

⁽²⁾ Taxonomy in accord with AFS, 1970.

TABLE 2.7.2.4-3 SYNONOMY AND REVISIONS IN TAXONOMY OF FISHES

REPORTED NAME (1)	SYNONYM OR REVISED NAME (2)	COMMON NAME (2)
Lepisosteus productus	Lepisosteus oculatus	Spotted gar
Pomolobus mediocris	Alosa mediocris	Hickory shad
Hybopsis bellica	Nocomis leptocephalus	Bluehead chub
Nocomis bellicus	Nocomis leptocephalus	Bluehead chub
Notropis imaculatus	Unidentified	_
Notropis stonei	Unidentified	
Opsopoeodus emiliae	Notropis emiliae	Pugnose minnow
Ameiurus nebulosus	Ictalurus nebulosus	Brown bullhead
Ameiurus platycephalus	Ictalurus platycephalus	Flat bullhead
Ictalurus lacustris	Ictalurus punctatus	Channel catfish
Schilbeodes leptacanthus	Noturus leptacanthus	Speckled madtom
Schilbeodes marginatus	Unidentified	
Schilbeodes mollis	Unidentified	
Fundulus dispar	Unidentified	
Roccus chrysops	Morone chrysops	White bass
Roccus saxatilis	Morone saxatilis	Striped bass
Chaenobryttus coronaris	Lepomis gulosus	Warmouth
Chaenobryttus gulosus	Lepomis gulosus	Warmouth
Mesogonistus chaetodon	Enneacanthus chaetodon	Blackbanded sunfish
Etheostoma barrattii	Unidentified	
Hololepis barattii	Unidentified	
Poecilichthys fricksia	Unidentified	<u>-</u>
Poecilichthys insriptum	Unidentified	
Boleosoma nigrum	Etheostoma nigrum	Johnny darter
Hadropterus nigrofasciatus	Percina nigrofasciata	Blackbanded darter
Trinectus fasciatus	Unidentified	

⁽¹⁾ Name from original ANS reports.

⁽²⁾ Name from American Fisheries Society, 1970.

TABLE 2.7.2.4-4
AQUATIC MACROINVERTEBRATES COLLECTED AT THE SAVANHAH RIVER PLANT, 1951-1976(1)

TAXA ⁽²⁾		ABI	OVE COMP		WITH U		LEE ALINS						TATION				BAVAN	BELO DASS		UENCE W	ITH UPP		E BUNS											THRFE BUN
	1951	1955	1955	1960	1965	1948	1972	1976	1931	1955	1956	1960	1965	1968	1972	1976	1951	1955	1936	1960	1965	1968	1972	1976	1951	1955	1956	1960	1963	1968	1972	1976		1955 19
PHYLUM PORTFERA Family Spongillidae	1	1	1	1	3	1	1	1	,	1	1	2	2	1	1	1	2	1	1	2	3	1	1		1		,		,	1	,		,	
PHILDS PLATHEININGS Family Catemolidae Family Delysilitidae Family Plegicatomidae Pamily Planaciidae	1	The state of the s	1	1	1	1	1 1	1	1		1	1	1	1	1	1	1	1		1	1 1		1	1	1				1		1		1 1	
PHYLUM NEMERTEA Family Tetrastementidas				i			1	I I					1										1		1			1	1	1		1		
PHYLIM ASCHILMINTHES C.ASS MYMATODA Family Mermithides C.ASS NEMATOPHORA Family Gordiides CLASS ROTIFERA Order Mediloides Order Mediloides Order Mediloides	1		1				1		,				1		1	1	1			1	1		1						i		1		,	
Family Floatulatitide Family Brachionidae Family Letaniidae Family Gastropodidee Family Mortomastidae Vamily Synchaetida Family Tricocertidae CLASS GASTROTRICHA	3 4 1 5 3	1			1				1 3 9 6 1	• ,			1				3 7 9 3	2			1				1 1 2 2	1							1	
PHTLUS ANNELIDA CLASS OLICICHATA Facily Lushriculidae Facily Maididae Facily Maididae Facily Monitodidae Facily Tublitodidae Facily Unserveddae Facily Hegascolecidae CLASS HINDINEA Facily Hegascolecidae Facily Hegascolecidae Facily Finestiphoniidae Facily Finestiphoniidae Facily Finesticolidae Facily Typobdediidae	2 2	1	1	1 1 2 2	1 1 1 1 1 1 1	1 3	2 1	1 2 1 1 1	1 1 1 1	1	1 1	1 2 1 2	1 2 1	1	1 1		1 1 1	1	1	3 2	2 1 3	1 2	1 1 2 1	1 1	1 1 1 1 1 2	1	1	1	1 1	. 2	1 1 1 5	1	1 1 1	1
FRILIM ARTIBOPODA SUBPRILIM TARDIGADA Family Hacrobiotidae SUBPRILIM CHILICRATA CLASS ARACHINDA Family Harridae Family Harridae Family Harridae Family Harridae Family Finnidae Family Finnidae Family Finnidae CLASS CRUSTACFA SUBPRILIM MADDISHLATA CLASS CRUSTACFA SUBCLASS BRANCHIOPDA Order Diplestrate Suborder Clafocera Family Sidiose Family Sidiose					ı	1	2 1 1	1 .i					2	1 1	1 1 1		•			1	1 1			1					1 2 1 1	1	1 1 2 1 1 1			
SUSCLASS OSTRACODA SUSCLASS COPPUDA FAMILY Cyclepidae SUSCLASS RALACOSTACEA Order Amphipods Family Talitrides Order Inopods Family Talitrides Order Inopods Family Analidae Order Decapoda Family Faliemosidae Family Faliemosidae Family Antactides		1	1 1 1 1	1	1	1	1 1	1	1 1 2 1	,		1	1 1 1	1	1 1 1 1 1 1	1 1 1	1 1 1 1	1 1 1	1	1 1 1	1 1 1 1	1 1	1 1 1	1 1 1	1 1 1 1	1 2 1		1	1 1 1	1 1		1		1

See footnotes at end of table.

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TATA (2)	1451				STATIO	H 1			1951	1955	1956	1960	STATION 1965	1968	1972	1976	1951			51	TATION 5			1976	1951	1955	1956		1965		1972	1976		1955	2
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CLASS INSECTA Order Ephanetopters																																			
Family Ephemericae Family Schmingiidae	2							1	1								3	1							3	2							1	1	2
family Tricorythodidae						1	1							1	1						75	1	1	1			,	1		. 1	1	1			
Family Carnidae Family Leptophlebildee		3			1	1	1			-1		1	1	1	1			1	2	.1	1	1	1	1				•							1
Family Sections Family Reprogentition	1	5	:	:	3		3	3	9 5	5	1 4	3	7	2 5	3 5	2	12	4	2	1 5	5	3	5		11 6	3	2	:		2 6	3	5	3	2 2	1
Family Ephemerellidan			1	1					,		1	1							1							1	1	1		1					1
Family Oligonout: 444 Family Rectiscides																			-							1							-		1
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Family Colonterygides Family Commagniousides		2			2		6	4			3	4		3	. 5	2	6	4	: 2	4		1		1		,	1	1	4	2	7	2	2	2	2
Family Comphides	1 ,		1		1		1	1 1		1	1 1	1	1				,	2		1	1		1	2	3	1	1		1		1	1 2		1 .	
Family Macromitées								2								1								1							1 2				
Family Cordulitées Family Libelluitées		1	. 1				2	2	2	2	2	1	1				3	2	1	4	1			1	2	2	,	1			1		4	2	1
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Family Pteronarcides									1								2	1	1	- 1			¥.		2	1							3	1	1
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Family Taemiopterygidae	1 1								1								1								1										
Family Remourides Family Capatides	1								1								1								1								1		
Family Isoperlidae Family Chloroperlidae	1								4								2							-	2								2	1	
Order Semiptera	100					E 1312													4		457												5		
Family Cerridae	,	2	3	2	3	9	7	,	3	1	2	2	3			2	6 .	1	2	2	2	,	1			2	1		. 2		,	FEE	1	1	
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Family Mesoveliidae Family Nydrometridae	1						1																	1						M.	1		1		
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Family Naucoridae							1							1	1					1		1		1									- 37		
Family Columbocoridae	1			1	1	1	1	1	1				1	1	2	1	1		1		1	1	2	1	1		1		1	1		1	1		
Family Motamectidae				1			1		1						- 1			1							1					1			1		
Fmily Nethridae Order Neutroptere	1								1		1			1																					
Family Stayridae Family Stalidae	1				1	1	1	1	He to				1	1	1					1					1				1						
Yamily Corydelides	1	1	1				1	1	1	1	1	1			1	1	2	1	1					1	2	1	1	1				1	2	1	
Order Lepidoptera Family Pyralides	-							1	1 111								1						1										100		
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Family Philopotamidae Family Paychowriidae	1	1	1	1	1	1	1	1	1	1	1	1	1	2			1	1	1	1	i	ı				1		1		1			3	2	
Family Polycentiopodidae Family Sydroperchidae		2	,	3		,	3	1		2		2			1 4	3	3	2		4	,	5	4	4	6		2	3	5	3	. 4	4		1	
Family Bydroptilidae		2			1		1			. 1	1	1		1				1	1		2	1					1	1	1						
Family Phryganeidae Family Limmephilidae	1								I Real																1								3	1	
Family Leptocerides	,	2	3	3	5	3	1	3	3	2	3		4		2	2	3	*	. 1	2	3	2	3	2	3	2	2	1	*	,	3	*	1	1	
Family Depidostrumetidae Family Brachycemeridae	1								1								1																2	1	
Family Molannidae Order Diptera	16.37																							300									1	1	
Family Taurdenidae															1		- 1								1								N.	1 3	
Family Tipulidae Family Culicidae	1	2	1		1	1	1		1			1	1		1		2						1		1							å Fy			
Family Charboridae Family Heleidae	1	1	,						1	1	- 2			1			1	1		1	1				1	1	2	1							
Family Ceratopogonidae						1	1							2								1	1	1			10		16	1	1		15		
Family Tendipedidae Family Chiromomidae	25	15	11	12	17	14	15	6	23	10	10	11	17	15	14	4	28	17	15	17	14	8	12	3	21	22	10	13	10	10	15	2		21	
Family Simulticae		1.		1	1	1	1	1	an l	1		ī	1	1	1	1				1	1	2	1	1				1	.1	1	1		1	1	
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Order Coleopters Family Omophrosidae									3																1							9-14			
Family Haliplides		1	1	1		2	2	4	1	1	1			,	3	1	3		1			1	3		1	1	1	-		2	3				
Family Cyrinidae Family Dytincidae	11	1	2 2	4 2	3	2 2	*	3 4	12	1	2	3	3	7 5	7	3	7	2	2	4	1		2	1	17	2	3	2	1 4	,	4	3	5	1	
Family Rydrophilidae	2			1	2	5	6	3	7	1		3	3	6	4	1	10	3	1 2	1	3	4	3	2	9	1	1		,	3	*	12	3	1	
Family Dryopidas Family Elmides	1	4	2	5	4	3	4	,		2	2				3	2	6	2	2	4	4		2	4	8		3	5	3		4	3			
Family Reteroceridae Family Eubriidae	2							4	(3)								The same																1		
MCCLDSCA				HAT.			T D				oth.		-							THE STATE OF	-			-		500	- 10			1	1				-
ASS GASTROPODA									1					T.			0															15/16			
Family Amnicolidate	1				1				2			1	1	1			1				1	1		1					1	1	1		1		
Family Sydrobition Family Pleutocertion							2	1	FIG.						2	1							2	1					,		1				
Family Fleurogeridae Family Viviperidae							1	1				913				1	.1					1	'n	1					1	1	1	1	1		
SUBCLASS PULMONATA		1		. 1		1	2	2		,			,	. 1	2	RE	. 2	1				1	1	1	1						1	56		1	
Family Ancylidae	1	1				1	1		1			1					1	1		1		1	1		1				1	1	1	1	1		
Family Physides Family Planoribides	1	1	1	1	2	1	1	1	1	1	1	1	2	1	3	1	1	1	1	1	2	2	3		1	1	1	1	3	1	1	1	1	1	
Family Succineitse			1										1				The same		1																
Family Unionidas	5		1		14	. 6		4	12	3		6	14	,	7	6	6	3	1		12			12	8	6	4	9	16			11	1		
Family Sphaereidee Family Corbiculidae	1	1	2	3	6	,	5	1	1		3	3		•	1	1		1		,	1	*		1	1					•	1	1	1		
ETTOPROCTA																HA																171			
Family Paludicellidae		1		2	2		1	1		1		1	1		1	1	1	1		1 1		1	,	1	1			1	1 2		1			1	
Family Flumatellidae Family Lophopodidae	1	1		2	,										, in	Tie													1						
SPECIES ENCOCYTERED	155	72	70	78	107	86	127	87	18)	62	61	84	118	113	110	34	206	85	66	98	111	93	110	77	161	96	60	63	129	78	127	64	178	82	84
							-				ALL DE		-			-		-					-	1	-							1000	10000		

⁽¹⁾ Annexes: The Academy of Satural Sciences of Philadelphia (1953, 1957, 1961, 1997, 1970, 1975, and 1977). (See also SAR, 1980) (2) TARRESSEY SE COMPILED BY ARE IN SEPARATE TRANSPORT OF COMPILED BY ARE IN SEPARATE SERVICES.)

TABLE 2.7.2.4-5

Macroinvertebrates in Savannah River near VNP site

A. violacea Enallagma civile E. signatum E. weewa Ischnura posita Basiaeschna janata Nasiaeschna janata Nosiaeschna janata Nosiaeschna janata Domongomphus armatus? Epicordulia princeps Neurocordulia alabamensis Macromia sp. Pachydiplas longipennis Sympetrum vicinium Libellula vibrans Perithemis tenera Ephemeroptera (mayflies) Ephoron sp. Caenis sp. Tricorythodes sp. Ephemerella temporalis Isoynchia sp.	Sialis sp. Corydalis cornutus Nigronia sp. Coleoptera (beetles) Peliodytes festivus P. simplex P. miticis Haliplus borealis H. triopsis Dineutes assimilis D. emarginatus D. horni D. carolinus D. analis Gyrinus spacus G. pectoralis G. lugens G. ventralis G. gibber Suphisellus gibbulus S. bicolor	Dubirophia vitata Trichoptera (caddis flies) Chimarra socia Neureclipsis sp. Phylocentropus sp. Polycentropus sp. Hydropsyche nr. cuanisa H. nr. frisoni H. orris Cheumatopsyche sp. Macronemum zebratum M. carolina Hydroptila sp. Leptocella nr. equisita Triaenodes tarda Athripsodes nr. transversus Oecetis nr. eddlestoni Pynopsyche sp. Lepidoptera (aquatic caterpillars Parargyractis sp.
E. signatum E. weewa Ischnura posita Basiaeschna janata Nasiaeschna pentacantha Boyeria vinosa Gomphus (Stylurus) lauvae Dromogomphus armatus? Epicordulia princeps Neurocordulia alabamensis Macromia sp. Pachydiplas longipennis Sympetrum vicinium Libellula vibrans Perithemis tenera Ephemeroptera (mayflies) Ephoron sp. Caenis sp. Tricorythodes sp. Ephemerella temporalis Isoynchia sp.	Nigronia sp. Coleoptera (beetles) Peltodytes festivus P. simplex P. mitticis Haliphus borealis H. triopsis Dineutes assimillis D. emarginatus D. horni D. carolinus D. analis Gyrinus spacus G. pectoralis G. lugens G. ventralis G. gibber Suphisellus gibbulus S. bicolor	Chimarra socia Neureclipsis sp. Phylocentropus sp. Polycentropus sp. Hydropsyche nt. cuanisa H. nt. frisoni H. orris Cheumatopsyche sp. Macronemum zebratum M. carolina Hydroptila sp. Leptocella nt. equisita Triaenodes tarda Athripsodes nt. transversus Oecetis nt. eddlestoni Pynopsyche sp. Lepidoptera (aquatic caterpillars Parargyractis sp.
E. weewa Ischnura posita Basiaeschna janata Nasiaeschna pentacantha Boyeria vinosa Gomphus (Stylurus) lauvae Dromogomphus armatus? Epicordulia princeps Neurocordulia alabamensis Macromia sp. Pachydiplas longipennis Sympetrum vicinium Libellula vibrans Perithemis tenera Ephemeroptera (mayflies) Ephoron sp. Caenis sp. Tricorythodes sp. Ephemerella temporalis Isoynchia sp.	Coleoptera (beetles) Peliodytes festivus P. simplex P. miticis Haliplus borealis H. triopsis Dineutes assimilis D. emarginatus D. horni D. carolinus D. analis Gyrinus spacus G. pectoralis G. lugens G. ventralis G. gibber Suphisellus gibbulus S. bicolor	Neureclipsis sp. Phylocentropus sp. Polycentropus sp. Hydropsyche nt. cuanisa H. nt. frisoni H. orris Cheumatopsyche sp. Macronemum zebratum M. carolina Hydroptila sp. Leptocella nt. equisita Triaenodes tarda Athripsodes nt. transversus Oecetis nt. eddlestoni Pynopsyche sp. Lepidoptera (aquatic caterpillars Parargyractis sp.
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Basiaeschna janata Nasiaeschna pentacantha Boyeria vinosa Gomphus (Stylurus) lauvae Dromogomphus armatus? Epicordulia princeps Neurocordulia alabamensis Macromia sp. Pachydiplax longipennis Sympetrum vicinium Libellula vibrans Perithemis tenera Ephemeroptera (mayflies) Ephoron sp. Caenis sp. Tricorythodes sp. Ephemerella temporalis Isoynchia sp.	Peliodytes festivus P. simplex P. miticis Haliplus borealis H. triopsis Dineutes assimilis D. emarginatus D. horni D. carolinus D. analis Gyrinus spacus G. pectoralis G. lugens G. ventralis G. gibber Suphisellus gibbulus S. bicolor	Polycentropus sp. Hydropsyche nr. cuanisa H. nr. frisoni H. orris Cheumatopsyche sp. Macronemum zebratum M. carolina Hydroptila sp. Leptocella nr. equisita Triaenodes tarda Athripsodes nr. transversus Oecetis nr. eddlestoni Pynopsyche sp. Lepidoptera (aquatic caterpillars Parargyractis sp.
Nasiaeschna pentacantha Boyeria vinosa Gomphus (Stylurus) lauvae Dromogomphus armatus? Epicordulia princeps Neurocordulia alabamensis Macromia sp. Pachydiplas longipennis Sympetrum vicinium Libellula vibrans Perithemis tenera Ephemeroptera (mayflies) Ephoron sp. Caenis sp. Tricorythodes sp. Ephemerella temporalis Isoynchia sp.	P. simplex P. miticis Haliplus borealis H. triopsis Dineutes assimilis D. emarginatus D. horni D. carolinus D. analis Gyrinus spacus G. pectoralis G. lugens G. ventralis G. gibber Suphisellus gibbulus S. bicolor	Hydropsyche nr. cuanisa H. nr. frisoni H. orris Cheumalopsyche sp. Macronemum zebratum M. carolina Hydroptila sp. Leptocella nr. equisita Triaenodes tarda Athripsodes nr. transversus Oecetis nr. eddlestoni Pynopsyche sp. Lepidoptera (aquatic caterpillars Parargyractis sp.
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Gomphus (Stylurus) lauvae Dromogomphus armatus? Epicordulia princeps Neurocordulia alabamensis Macromia sp. Pachydiplax longipennis Sympetrum vicinium Libellula vibrans Perithemis tenera Ephemeroptera (mayflies) Ephoron sp. Caenis sp. Tricorythodes sp. Ephemerella temporalis Isoynchia sp.	Haliplus borealis H. triopsis Dineutes assimilis D. emarginatus D. horni D. carolinus D. analis Gyrinus spacus G. pectoralis G. lugens G. ventralis G. gibber Suphisellus gibbulus S. bicolor	H. orris Cheumatopsyche sp. Macronemum zebratum M. carolina Hydroptila sp. Leptocella nr. equisita Triaenodes tarda Athripsodes nr. transversus Oecetis nr. eddlestoni Pynopsyche sp. Lepidoptera (aquatic caterpillars Parargyractis sp.
Dromogomphus armatus? Epicordulia princeps Neurocordulia alabamensis Macromia sp. Pachydiplax longipennis Sympetrum vicinium Libellula vibrans Perithemis tenera Ephemeroptera (mayflies) Ephoron sp. Caenis sp. Tricorythodes sp. Ephemerella temporalis Isoynchia sp.	H. triopsis Dineutes assimilis D. emarginatus D. horni D. carolinus D. analis Gyrinus spacus G. pectoralis G. lugens G. ventralis G. gibber Suphisellus gibbulus S. bicolor	Cheumatopsyche sp. Macronemum zebratum M. carolina Hydroptila sp. Leptocella nr. equisita Triaenodes tarda Athripsodes nr. transversus Oecetis nr. eddlestoni Pynopsyche sp. Lepidoptera (aquatic caterpillars Parargyractis sp.
Epicordulia princeps Neurocordulia alabamensis Macromia sp. Pachydiplas longipennis Sympetrum vicinium Libellula vibrans Perithemis tenera Ephemeroptera (mayflies) Ephoron sp. Caenis sp. Tricorythodes sp. Ephemerella temporalis Isoynchia sp.	Dineutes assimilis D. emarginatus D. horni D. carolinus D. analis Gyrinus spacus G. pectoralis G. lugens G. ventralis G. gibber Suphisellus gibbulus S. bicolor	Macronemum zebratum M. carolina Hydroptila sp. Leptocella nr. equisita Triaenodes tarda Athripsodes nr. transversus Oecetis nr. eddlestoni Pynopsyche sp. Lepidoptera (aquatic caterpillars Parargyractis sp.
Neurocordulia alabamensis Macromia sp. Pachydiplax longipennis Sympetrum vicinium Libellula vibrans Perithemis tenera Ephemeroptesa (mayflies) Ephoron sp. Caenis sp. Tricorythodes sp. Ephemerella temporalis Isoynchia sp.	D. emarginatus D. horni D. carolinus D. analis Gyrinus spacus G. pectoralis G. luggens G. ventralis G. gibber Suphisellus gibbulus S. bicolor	M. carolina Hydroptila sp. Leptocella nr. equisita Triaenodes tarda Athripsodes nr. transversus Oecetis nr. eddlestoni Pynopsyche sp. Lepidoptera (aquatic caterpillars Parargyractis sp.
Macromia sp. Pachydiplax longipennis Sympetrum vicinium Libellula vibrans Perithemis tenera Ephemeroptera (mayflies) Ephoron sp. Caenis sp. Tricorythodes sp. Ephemerella temporalis Isoynchia sp.	D. horni D. carolinus D. analis Gyrinus spacus G. pectoralis G. lugens G. ventralis G. gibber Suphisellus gibbulus S. bicolor	Hydroptila sp. Leptocella nt. equisita Triaenodes tarda Athripsodes nt. transversus Oecetis nt. eddlestoni Pynopsyche sp. Lepidoptera (aquatic caterpillars Parargyractis sp.
Pachydiplax longipennis Sympetrum vicinium Libellula vibrans Perithemis tenera Ephemeroptera (mayflies) Ephoron sp. Caenis sp. Tricorythodes sp. Ephemerella temporalis Isoynchia sp.	D. carolinus D. analis G. prinus spacus G. pectoralis G. lugens G. ventralis G. gibber Suphisellus gibbulus S. bicolor	Leptocella nr. equisita Triaenodes tarda Athripsodes nr. transversus Oecetis nr. eddlestoni Pynopsyche sp. Lepidoptera (aquatic caterpillars Parargyractis sp.
Pachydiplax longipennis Sympetrum vicinium Libellula vibrans Perithemis tenera Ephemeroptera (mayflies) Ephoron sp. Caenis sp. Tricorythodes sp. Ephemerella temporalis Isoynchia sp.	D. analis Gyrinus spacus G. pectoralis G. lugens G. ventralis G. gibber Suphisellus gibbulus S. bicolor	Triaenodes tarda Athripsodes 11. transversus Oecetis 11. eddlestoni Pynopsyche 5p. Lepidoptera (aquatic caterpillars Parargyractis 5p.
Sympetrum vicinium Libellula vibrans Perithemis tenera Ephemeroptera (mayflies) Ephoron sp. Caenis sp. Tricorythodes sp. Ephemerella temporalis Isoynchia sp.	Gyrinus spacus G. pectoralis G. lugens G. ventralis G. gibber Suphisellus gibbulus S. bicolor	Athripsodes m. transversus Oecetis m. eddlestoni Pynopsyche sp. Lepidoptera (aquatic caterpillars Parargyractis sp.
Libellula vibrans Perithemis tenera Ephemeroptera (mayflies) Ephoron sp. Caenis sp. Tricorythodes sp. Ephemerella temporalis Isoynchia sp.	G. pectoralis G. lugens G. ventralis G. gibber Suphisellus gibbulus S. bicolor	Oecetis nr. eddlestoni Pynopsyche sp. Lepidoptera (aquatic caterpillars Parargyractis sp.
Perithemis tenera Ephemeroptera (mayflies) Ephoron sp. Caenis sp. Tricorythodes sp. Ephemerella temporalis Isoynchia sp.	G. lugens G. ventralis G. gibber Suphisellus gibbulus S. bicolor	Pynopsyche sp. Lepidoptera (aquatic caterpillars Parargyractis sp.
Ephemeroptera (mayflies) Ephoron sp. Caenis sp. Tricorythodes sp. Ephemerella temporalis Isoynchia sp.	G. ventralis G. gibber Suphisellus gibbulus S. bicolor	Lepidoptera (aquatic caterpillars Parargyractis sp.
Ephoron sp. Caenis sp. Tricorythodes sp. Ephemerella temporalis Isoynchia sp.	G. gibber Suphisellus gibbulus S. bicolor	Parargyractis sp.
Caenis sp. Tricorythodes sp. Ephemerella temporalis Isoynchia sp.	Suphisellus gibbulus S. bicolor	Parargyractis sp.
Tricorythodes sp. Ephemerella temporalis Isoynchia sp.	S. bicolor	
Ephemerella temporalis Isoynchia sp.		
Isoynchia sp.	Hudrocanthus isicolos	Diptera (two-winged flies)
		Helius sp.
		Dicranoymia sp.
		Anopheles sp.
		Chaoborus punctipennis
- · · · ·		Palpomyia sp.
Callibaetis sp.		Bezzia or Probezzia sp.
Heptagenia nt. diabasia		Culicoides sp.
H. maculipennis		Atrichopogon sp.
 .		Coelotanypus concinnus
	Hydroporus diversicornis	Clinotanypus pinguis
	H. pulcher	Psectrotanypus sp.
Paragnetina kansensis	H. striatopunctatus	Tanypus carinatus
Hemiptera (bugs)	H. undulatus	T. carinatus
	H. wickhami .	Procladius bellus
	Hydrovatus pustulatus	Labrundinia pilosella
		Ablabesmyia mellochi
		. A. monilis
		Brillia sp.
		Corynoneura xena
		Cricotopus bicinctus
		C. fugus
		Orthocladius sp.
		Psectrocladius sp.
•		Eukiefferiella sp.
		E. sordens
		Rheorthocladius sp.
		Stenochironomus sp.
		Harnischia abortiva
		Sergentia jucundus
		Endochtronomus nigricans
		Polypedilum illinoense
		P. jallax
		Chironomus attenuatus
		Rheotanytarsus exiguus
Notonecta sp.		Calopectra guerla
N. irrorata		Simulium sp.
N. uhleri		Tabanus sp.
Trichocorixa calva	S. sinuata	•
Neuropters (dobson flies)		•
	Ancyronyx variegatus	
	Isoynchia sp. Pseudocloeon sp. Neocloen sp. Baetisa sp. Callibaetis sp. Heptagenia nt. diabasia H. maculipennis Plecoptera (stoneflies) Perlesta placida Paragnetina kansensis Hemiptera (bugs) Mesovelia mulsanti Hydrometra martini Gerris sp. G. canaliculatus G. nebularis G. remigis Limogonus hesione Trepobates inermis T. pictus Rheumatobates teniupes R. tileyl K. hungerfordl Vellia sp.? brachialis Microvolcia sp. Rhagovelia distincta Salda sp. Gelastocris oculatus Pelocoris femoratus Ranatra buenol Belostoma lutarium Notonecta sp. N. irrorata N. uhleri	Ephemerella temporalis Isoynchia sp. Pseudocloeon sp. Neocloen sp. Baetisa sp. Callibaetis sp. Callibaetis sp. Heptagenia nt. diabasia H. maculipennis Perlesta placida Paragnetina kansensis Hemiptera (bugs) Mesovelia mulsanti Hydrometra martini Gerris sp. G. canaliculatus G. nebularis G. conformis G. remigis Limogonus hesione Trepobates inermis T. pictus R. hungerfordl Vellia sp.? brachialis Microvolcia sp. Rhagovelia distincta Salda sp. Gelastocris oculatus Pelocoris femoratus Ranatra buenol Belostoma lutarium Notonecta sp. N. irrorata Neuroptera (dobson flies) Necolony sp. Peracopur varierantus Laccophillus maculosus Bidessus lacustris Collambus dissimilis Celima angusta Desmophachria convexa Hydroporus diversicornis H. striatopunctatus H. wickhami H. wickhami H. wickhami H. drovatus pustulatus Coptotomus interrogatus Rhanthus bistriatus Helophorius taberculatus Enochrus cinctus Enebulosus Enebulos

^aMost abundant genera.

Protozoa in the Savannah River near VNP site $\cline{1}$

Protozoa	Astasia klebsi	Coleps biscuspis	Stentor coreruleus
Class Mastigophora	Anisonema acinus	C. elongatus	S. igneus
Choromulina ovalis	A. emarginatum	C. hirtus	S. mulleri
Oikomonas solcialis	Dinema griscolum	C. octospinus	S. polymorphus
O. termo	Heteronema acus	Enchelydium fusidens	S. pyriformis
Synura uvella	H. acutissimum *	E. virens	Halteria grandinella
Anthophysa vegetans	H. mutabile	Homalozoon vermiculare	Strobilidium gyrans
Monas guttula	Notosolenus apocamptus :.	Penardiella crassa	Oxytricha fallax
M. sociabilis	Peranema trichophorum	Spathidioides sulcata	O. setigera
M. socialis	Trentonia flagellata	Mesodinium pulex	Amphisiella oblonga
Ochromonas crenata	Gymnodinium fuscum	Amphileptus claparedei	Gastrostyla musconum
Cryptomonas erosa	G. palustre	Lionotus cygnus	Gonostomum strenuum
C. ovata	Gyrodinium hyalinum	L. fasciola	Holosticha discocephalu:
Chilomonas paramecium	Glenodinium cinctum	Loxophyllum meleagrus	H. vernalis
Cyathomonas truncata	Bodo amochinus	L. ulriculariae	Onychodromus grandis
Chlamdomonas globosa	B. caudatus	Trachelius ovum	Opisthotricha procera
C. gracilis	B. edax	Dileptus americanus	Pleurotricha grandis
C. monadina	B. globosus	D. anser	Stichotricha intermedia
Chlorogonium sp.	B. mutabilis	D. cygnus	Strongylidium crassum
Carteria globosa	B. obovatus	D. monilatus	Stylonichia mytilus
Gonium pectorale	Cercomonas crossicauda	Lox odes vorax	S. notophora
Mastigosphacra gobii	C. longicauda	Trochilia palustris	S. pustulata
Pandorina morum	Colponema sp.	Chilodonella cucullulus	S. putrina
Euglena acus	Rhynchomonas vasuta	C. fluviatilis	Tachysoma pellionella
E. caudata	Tetramitus rostratus	· Nassula aurea	Uroleptus mobilis
E. deses	Class Sarcodina	N. ornata	U. piscis
E. ehrenbergi	Amoeba dubia	Chilodontopsis vorax	Urosoma acuminata
E. fusca	A. gorgonia	Cyclogramma trichocystis	Urostyla sp.
E. klebsi	A. guttula	Orthodonella sp.	Euplotes eurystomus
E. minima	A. guittum A. proteus	Colpoda aspera	. E. petella
E. minuta	A. proteus A. radiosa	C. cucullus	E. plumipes
E. mutabilis	A. spumosa	C. inflata	Aspidisca costata
E. oxyuris	A. striata	Spirozona caudata	A. lynceus
E. pisciformis	A. vespertilio	Leptopharynx sp.	A. sulcata
E. platydesma	Dinamocha mirabilis	Colpidium colpoda	Saprodinium dentatum
E. rubra	Pelomyxa carolinensis	Glaucoma scintillans .	Pelodinium reniforme
E. spirogyra	Vahlkampfia limax	G. seiosa	Vorticella campanula
E. splendens	Vampyrella lateritia	Tetrahymena pyriformis	V. convaliaria
E. tripteris	Arcella dentata	Cohnilembus fusiformis	V. jloridensis
E. viridis	A. discoides	Philaster armata	V. kenti
Lepocinclis acicularis	A. mitrata	Paramecium aurelia	V. microstoma
L. ovum	A. vulgaris	P. bursaria	Vorticelia monilata
L. texta	Cochliopodium bilimbosum	P. caudatum	V. picta
Phacus acuminata	Difflugia constricta-	P. calkinsi	V. similis
P. alatus	D. corona	P. multimicronucleatum	Carchesium polypinum
P. brevicaudata	D. globulosa	Frontonia acuminata	Zoothamnium arbuscula
P. helicoides	D. oblonga	F. depressa	Dpistylis plicatilis
P. longicauda	D. spiralis	F. leucas	Ophrydium vernalis
P. oscillans	Centropyxis aculeata	Frontoniella complanata	Vaginicola annulata
P. pleuronectes	C. ecornis	Cinetochilum margaritaceum	V. longipes
P. pyrum	Euglypha cristata	Espejoia sp.	Cathurnia annulata
P. torta	Cyphoderia ampulla	Lembadium bullinum	C. ovata
P. triqueier	Acinophrys sol	I. magnum	Thuricola folliculata
Trachelomonas armata	Raphidocystis	Malacophrys rotans	Class Suctoria
Tracnetomonas armata T. hispida	• •	Platynematum sp.	Acineta sp.
T. horrida	Class Ciliata	Urocentrum turbo	Anarma brevis
T. oblonga	Holophrya lahiata	Pleuronema crassum	Hallezia brachypoda
T. saccata	Lacrymaria olor	Cristigera phoenix	•••
	Platyophrya lata	Cyclidium glaucoma	Podophrya fixa Paracineta sp.
T. urceolata	Prorodon discolor	C. litomesum	Trichophrya epistylidis
Trachelomonas verrucosa	P. griseus	C. musicola	i ricnoparya epistyilais

TABLE 2.7.2.5 -1

Rare or Unique Aquatic Species in Vicinity of Savannah River Plant (1)

•		(-)	
SCIENTIFIC NAME	COMMON NAME	PRESENT (2)	STATUS
MACROPHYTES			
<u>Coreopsis</u> rosea	Pink tickseed	. Х.	Statewide concern (Threatened)
<u>Ludwigia</u> <u>spathulata</u>	Spathulate seedbox	Х	Statewide concern (Threatened)
Echinodorus parvulus	Little burhead	X .	Statewide concern (Threatened)
Utricularia olivacea	Dwarf bladderwort	X	Statewide concern (Threatened)
Utricularia floridana	Florida bladderwort	X	Statewide concern (Endangered)
Myriophyllum laxum	Loose water-milfoil		National concern (Threatened)
Ptilimnium nodosum	Savannah bishop-weed	Х	Statewide concern (Endangered)
Mayaca fluviatilis	Stream bog-moss	٠.	Of concern (Unresolved)
Rhexia aristosa ·	Awn-petaled meadow beauty	Х	Regional concern (Threatened
Peltandra sagittaefolia	White arrow-arm		Regional concern (Threatened)
HERPTILES			
Alligator mississippiensis	American alligator	. X	Federal endangered
Clemmys guttata	Spotted turtle	Х	Special concern in S.C.
Hyla andersoni	Pine barrens tree frog		Endangered in S.C.
Ambystoma tigrinum tigrinum	E. tiger salamander	Χ	Special concern in S.C.
Hyla avivoca ogechiensis	E. bird-voiced tree frog		Special concern in S.C.
<u>Hyla</u> <u>avivoca</u>		.Х	

⁽¹⁾ Source: Greeter, 1979.

⁽²⁾ X - Confirmed in Aiken, Barnwell, or Allendale Counties, S.C.

TABLE 2.7.2.7-1

WATER QUALITY
SAVANNAH RIVER ABOVE SAVANNAH RIVER PLANT
WATER YEAR 1978(1)

			,		CONCENT	RATION BY M	ONTH					
PARAMETER	UNITS		. 1977				1978					
		OCTOBER	NOVEMBER AND DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBE
Temperature	*c	23.25	17.45	10.80	8.00	7.00	11.40	15.80	17.75	21.20	25.00	24.00
Яq	pH units	6.69	6.95	6.70	6.80	6.80	5.90	6.53	6.63	6.74	6.57	6.90
Dissolved Oxygen	mg/L	8.62	9.70 .	11.20	11.90	12.30	11.038	10.14	9.60	8.96	8.45	8.56
Alkalinity (CaCO3)	mg/L	16.5	15.3	16.0	10.9	10.9	0.7	15.7	12.3	18.0	16.8	18.5
Hardness	mg/L	13.70	13.00	13.50	10.00	11.10	11.90	18.20	10.10	13.80	14.80	14.25
Conductivity	μπηνοε	62.00	57.00	58.00	37.00	63.00	56.00	58.00	52.00	73.00	81.00	77.85
Suspended Solids	mg/L	12.00	19.50	11.00	25.00	23.00	74.00	17.00	28.00	18.00	13.00	13.50
Volatile Solids	mg/L	21.00	20.00	27.00	15.00	25.00	23.00	30.00	24.00	28.00	27.00	25.00
Total Dissolved Solids	mg/1	47.00	46.50	54.00	34.00	48.00	31.00	40.00	48.00	55.00	54.00	51.00
Fixed Residue	mg/L	26.00	26.50	27.00	19.00	23.00	8.00	10.00	24.00	27.00	27.00	26.00
BOD	mg/£	2.00	1.50	<1.0	<1.0	1.00	<1.0	2.50	1.00	2.00	1.00	0.50
Lignin	mg/1	1.10	<1.0	1.00	1.00	1.70	4.20	1.70	<1.0	1.30	1.10	1.10
Chloride (C1)	mg/L	3.50	7.50	3.80	3.50	5.00	3.60	4.60	3.20	6.20	5.30	6.00
Nitrite (80,-N)	mg/i	0.03	0.005	0.010	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	<0.02
Nitrate (NO,-N)	ng/1	0.40	0.50	<0.02	0.70	3.80	0.90	0.80	. 0.55	0.50	0.40	0.25
Sulfate (80,-8)	ng/L	4.60	4.30	4.60	5.60	5.50	4.70	6.90	5.20	5.10	4.20	5.25
Sulfide (S)	mg/1	<1.0	0.15	<1.0	<1.0	0.10	<1.0	<1.0	0.10	0.40	<1.0	0.20
Total Phosphate (PO ₄ -P)	mg/1	<0.02	0.15	<0.02	<0.02	<0.02	0.60	<0.02	<0.02	<0.02	0.40	0.25
Aluminum (A1)	mg/s	<0.5	<0.5	<0.5	<0.5	1.00	2.50	2.00	<0.5	<0.5	<0.5	<0.5
Azmonia (NH ₄) ⁽²⁾	mg/1	<0.1	0.05	0.10	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1
Calcium (Ca)	mg/£	2.0	1.70	1.90	1.30	1.90	1.80	1.70	1.40	1.62	1.95	2.80
Sodium (Na)	nag/t	8.40	6.65	7.20	4.00	7.50	6.70	8.70	6.50	10.25	9.85	9.30
Total Iron (Fe)	mg/1	0.1	0.1	0.2	0.4	0.40	1.50	1.10	0.54	0.65	<0.1	<0.1

⁽¹⁾ Source: SAR, 1980
(2) Inconsistently reported.

NOTE: Accuracy not always consistent with number of significant figures shown.

TABLE 2.7.2.7-2

WATER QUALITY
SAVANNAH RIVER BELOW SAVANNAH RIVER PLANT
WATER YEAR 1978(1)

					CONCENT	LATION BY MO	NTH ⁽²⁾	•		•		
PARAMETER	UNITS		1977				1978					
		OCTOBER	NOVEMBER AND DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	HAY	JUNE	JULY	AUGUST	SEPTEMBE
Temperature	•c	24.25	17.15	10.80	8.00	7.30	11.50	16.60	18.50	21.8	24.80	24.00
рН	рН	6.72	6.75	6.70	6.80	6.60	5.51	6.53	6.57	6.28	6.44	6.98
Dissolved Oxygen	mg/1	8.465	9.70	11.20	11.90	11.80	10.72	10.08	9.45	8.88	8.39	8.42
Alkalinity (CaCO3)	mg/L	16.50	13.00	16.00	10.90	13.10	0.90	16.80	13.50	10.10	13.50	18.80
Hardness	mg/t	13.30	14.05	13.50	10.00	11.50	11.10	. 20.20	12.70	11.20	13.80	13.80
Conductivity	aorimu	56.00	66.00	58.00	37.00	57.0	60.D	53.00	52.00	77.00	70.00	78.35
Suspended Solids	mg/t	10.00	15.00	11.00	25.00	15.00	33.00	25.00	19.00	22.00	20.0	18.5
Volatile Solids	mg/L	27.00	21.00	27.00	15.00	23.00	25.00	26.00	25.00	24.00	13.00	30.00
Total Dissolved Solids	mg/t	53.00	48.50	54.00	34.00	50.00	39.00	33.00	53.00	50.00 .	41.00	52.50
Total Solids	mg/L	NA	NA	I NA	NA	NA	` NA	NA	NA	NA	NA	NA
Fixed Residue	mg/£	26.00	27.50	27.00	19.00	27.00	14.00	7.0	28.00	26.00	28.00	. 22.50
COD	mg/t	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BOD	mg/t	1.00	1.00	<1.0	<1.0	1.00	<1.0	2.60	1.00	1.00	1.00	0.50
Lignin	mg/t	1.10	≺1.0	1.00	1.00	1.80	1.40	1.80	<1.0	1.20	1.00	1.05
Kjeldahl N	mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chloride (Cl)	mg/L	6.50	5.45	3.80	3.50	5.00	3.60	3.80	4.80	5.30 .	4.60	6.90
Nitrite (NO ₂ -N)	mg/L	0.010	0.005	0.10	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	<0.02
Mitrate (NO3-N)	mg/£	0.60	0.40	<0.02	0.70	2.30	0.60	0.40	0.56	0.20	0.40	0.20
Sulfate (80, -8)	mg/£	. 4.0	3.35	4.60	5.60	9.40	2.30	5.90	<2.0	4.50	4.0	5.35
Sulfide (S)	mg/£	<1.0	0.15	<1.0	<1.0	0.10	<1.0	<1.0	0.10	0.40	<1.0	0.10
Orthophosphate (O-PO ₄ -P)	mg/£	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Phosphate (PO _L -P)	mg/1	<0.02	0.15	<0.02	<0.02	<0.02	0.60	<0.02	<0.02	<0.02	0.50	0.375
Aluminum (Al)	mg/1	<0.5	<0.5	<0.5	<0.5	1.00	2.50	2.00	<0.5	<0.5	<0.5	<0.5
Ammonia (NH ₄) ⁽³⁾	mg/L	<0.1	0.05	0.10	<0.1	<0.1	0.2	<0.1	<0.1	. <0.1	<0.1	<0.1
Calcium (Ca)	mg/1	. 2.0	1.70	1.90	1.30	1.90	1.80	1.70	1.40	1.62	2.27	2.85
Sodium (Na)	mg/£	8.40	6.65	7.20	4.00	7.50	6.70	8.70	6.50	10.25	7.65	9.80
Total Iron (Fe)	mg/1	0.1	0.1	0.2	0.4	0.40	1.50	1.10	0.54	0.65	<0.1	<0.1
Lead (Pb)	mg/t	NA	NA	NA	NA	NA	NA.	NA .	NA	NA	NA	NA

⁽¹⁾ Source: SAR, 1980 (2) NA - Not Analyzed.

NOTE: Accuracy not always consistent with number of significant figures shown.

⁽³⁾ Inconsistently reported.

TABLE 2.7.2.7-3

HISTORICAL MATER QUALITY
1974-1977(1)
ANNUAL RANGES AND MEANS(2)

		UPP	ER THREE RUNS	- ROAD A			FOUR HILE	CREEK - MOU	тн	s	AVANNAH RIVE	R BELOW PLANT	
PARAMETER	UNITS	1974	1975	1976	1977	1974	1975	1976	1977	1974	1975	1976	1977
•		MIN-MAX (mean)	MIN-MAX (mean)	HIN-HAX (mean)	MIN-MAX (mean)	HLN-ḤAX (mean)	MIN-MAX (mean)	MIN-MAX (mean)	HIN-NAX (mean)	HIN-HAX (mean)	MIN-HAX (mean)	MIN-MAX (mean)	MIN-MAX (um.)
Discharge	1/80		7.53E + 11	1.92E + 11	2.78E + 11						1.298 + 13	1.25E + 13	1.198 + 13
Temperature ,	•с	9.0-24.0 (17.8)	11.1-23.0 (18.0)	10.0-24.0 (17.3)	6.0-26.0 (17.4)				i	11.0-26.0 (19.0)	10.0-25.3 (18.1)	· 8.3~25.8 (17.9)	5.6-26.6 (17.8)
pН	pH units	5.6-6.7		•	5.5-6.9 ()	6.4-7.5 ()			6.3-7.5	6.5-7.3 ()			6.3-6.8 ()
Dissolved Oxygen	mg/t	7.0-11.3 (8.5)	6.6-12.7 (8.91)	7.2-10.2 (8.89)	7.4-11.4 (8.99)					8.2-11.1 (9.4)	7.0-11.3 (9.44)	8.5-11.2 (9.58)	6.2-12.6 (9.71)
Alkalinity (CaCO ₃)	mg/1	1.9-6.0	2.0-11.0 (4.23)	3.0-5.0 (4.42)						11.7-26.9	3.1-38.0 (14.2)	10.4-17.0 (14.3)	7.8-19.5 (14.2)
Hardness (CaCO ₃)	mg/t									12.9-48.0 (28.0)	4.0-36.3	6.2-18.0 (11.8)	9.1-17.0 (13.5)
Conductivity	µmahos/cm					1				\$6.0-102 (73.0)	46.0-73.0 (63.0)	41.0-77.0 (54.5)	41.0-86.0 (60.2)
Suspended Solids	ong/t	3.0-54.0 (19.2)	1.0-42.0 (16.2)	1.0-31.0 (8.0)	1.0~54.0 (13.4)					(1-30 (12.0)	3.0-57.0 (15.8)	7.0-87.0 (19.2)	4.0-21.0 (14.1)
Volatile Solida	mg/L	8.0-46.0 (18.8)	12.0-61.0 (27.9)	9.0-25.0 (15.9)	12.0-36.0 (19.1)					<1-31.0 (16.0)	11.0-37.0	5.0-38.0 (21.5)	6.0-27.0 (20.5)
Total Dissolved Solids	=g / €	6.0-44.0 (24.8)	*-65.0 (34.8)	20.0-40.0 (28.9)	14.0-42.0 (29.5)					14.0-61.0 (34.0)	21.0-54.0 (40.6)	7.0-59.0 (39.2)	33.0-76.0 (46:8)
Total Solids	mg/t	14.0-82.0 (43.1)	31.0-83.0	26.0-64.0 (36.9)	21.0-92.0 (43.0)								
Fixed Residue	mg/L		16.0-18.0 (17.0)	16.0-41.0	8.0-59.0 (23.9)					(1-53.0 (19.0)	1.0-35.0 (16.7)	<1.0-26.0 (16.5)	12.0-51.0 (26.4)
СОВ	mg/L		5.0~34.2 (15.4)	5.0-23.0 (11.8)	5.0-22.0 (12.6)								
50D	mg/L	<1-2.0 (<1)	*-1.4 (0.108)	(1-1.0 (0.273)						(1-2 ((1)	*-2.0 (1.00)	<1-2.0 (1.23)	(1-3.0 (1.08)
Lignin	mg/t									<1-4.6 (<1)	*-1.9 (0.308)	(1-3.0 (0.569)	(1-1.3 (0.692)
Surfactant	ωg/t									<0.02-0.10 (0.07)	*~0.03 (0.005)		
Kjeldahl Nitrogen (N)	mg/t		*-1.0 (0.111)	(I)			•	•					
Fecal Coliform	c/100=1 ⁽³⁾									140-4,400	100-880		
Chloride (C1)	mg/L	1.8-6.0	1.5-3.7	1.5-2.5	1.9-2.5	3.8-7.5 (5.3)	3.0-7.5 (4.87)	2.8-6.0 (4.22)	0.5-10.5 (5.47)	4.2-7.0	2.9-7.5 (4.92)	2.5-6.0 (4.16)	0.5-7.5 (4.69)
Nitrite (NO ₂ -N)	mg/t	0.001-<0.05 ⁽⁴⁾ (<0.01)		<0.02 (<0.02)	<0.02 (<0.02)					<0.02-0.1 (0.05)	*-0.09 (0.027)	<0.02-0.3 (0.048)	<0.02-0.03 (0.005)
Nitrate (NO ₃ -N)	mg/L	0.004-0.20	*-0.14 (0.085)	<0.02~0.15 (0.099)	0.07-0.23					0.07-1.6	0.32-1.4 (0.726)	0.07-17.0 (1.73)	<0.02-2.0 (0.415)
Sulfare (SO ₄ -S)	mg/I	<1-3.6 (2.1)	1.0-4.1 (2.25)	<2-4.0 (1.23)	<2<2.0 (1.09)	2.9-7.3 (4.9)	*-6.4 (3.24)	2.6-5.6 (3.95)	3.0-10.1	2.3-6.4	2.0-11.0 (4.55)	2.6-7.4 (4.51)	2.0-5.6 (3.88)
Sulfide (S)	mg/L			(1-700 (58.3)	(1)	<0.1-0.4 (<0.1)	*-0.7	(1-0.7 ⁽⁴⁾ (0.069)	<1-0.3 (0.038)	<0.1-0.3 (<0.1)	*-0.5 (0.123)	(1-0.7 (0.054)	<1-0.7 (0.054)
Orthophosphete (O-PO ₄ -P)	my/L	0.004-0 03 (0.004)	±-0 07 (0.002)	(0.011)	(n,02 (<0.02)								
Total Phosphate (PO ₄ -P)	ug/t	0.01-0.11 (0.05)	4-0.06 (0.027)		<0.02-0.06 0.032			į		0.02-1.6	4-3.9 (0.500)	<0.02-1.5 (0.346)	<0.02-0.4 (0.154)
Aluziaum (AI)	eg/L	(0.5-(2 ⁽⁴⁾ ((0.5)		<0.5 (<0.5)	<0.5-2.0 (0.167)	<0.5 (<0.5)	*-1.6 (0.123)	<0.5 (<0.5)	<0.5 (<0.5)	(0.5	*-1.3 (0.177)	<0.5-1.0 (0.077)	<0.5 (<0.5)
Ammonia (NH ₄) ⁽⁴⁾	mg/ 1	0.004-<1	*-0.04 (0.01)	<0.1-0.02 (0.007)	(0.1-0.03 (0.011)					0.05-0.1	•-0.20 (0.025)	(0.1-0.2 (0.023)	<0.1-0.2 (0.015)
Calcium (Ca)	mg/t	1.23-1.7	1.3-1.8	1.1-2.3	0.2-5.5	1.2-2.8	1.2-2.5	1.6-2.5 (2.05)	1.4-2.3	1.3-2.7	1.6-2.5	1.7-2.8	1.4-2.6 (1.97)
Mercury (Hg)	æg/t	<0.0001-<0.01 (m+)	···· ,			(0.002 ((0.002)				<0.002 (<0.002)			
Sodium (Na)	mg/L	1.0-1.5	1.2-1.7	1.2-1.5	0.2-1.6	5.2-7.7	1.5-6.9	4.5-7.1 (5.49)	4.8-7.2 (6.19)	5.0-7.7	3.7-6.8 (5.58)	4.2-7.6 (5.58)	4.9-7.6 (6.35)
Total Iron (Fe)	mg/i	0.1-0.6	*-0.5 (0.154)	0.1-0.4 (0.25)	(0.1-2.1 (0.487)	(0.1-0.3 (0.2)	*-0.6		(0.1-1.2 (0.323)	<0.1-0.6 (<0.1)	*~0.70 (0.231)	(0.1-1.3 (0.362)	(0.1-1.2 (0.3)
Lead (Pb)	mg/i	(0.001-(0.5 ⁽⁴⁾		(0.3 ((0.5)	(0.5	'5.17		(0.30)	(0.343)				,

⁽¹⁾ Source: SAR, 1980 (2) means not reported. Blank spaces indicate no data available.
(3) c/100ml = colonies per 100 millimoters.
(4) Inconsistently reported.

TABLE 2.7.2.7-4
WATER QUALITY OF STREAMS NEAR DWPF SITE(1) (3)

		·			SAMPLE	IDENTIFIC	ATION			
PARAMETER	UNITS	1	2	3	4	· <u>5</u>	6	7	9	10
Field Temperature	°C	13.0	14.0	5.8	11.4	17.0	14.5	7.0	6.0	4.9
рН	pH units	3.90	5.80	5.40	4.80	6.10	6.35	5.60	6.20	5.90
Specific Conductance at 25°C	μmnhos/cm	74	21	43 .	21	74	59	31	41	31
Dissolved Oxygen	mg/l	6.6 ⁽²⁾	10.6 ⁽²⁾	13.5	11.8	9.8 ⁽²⁾	10.5 ⁽²⁾	11.2	11.6	12.2
Acidity	mg/£ as CaCO _q	, 10	<2	<2	· <2	<2	<2 [·]	<2	<2	<2
Alkalinity	mg/L as CaCO	0	6	6	4	6	6	7	6	. 5
Bicarbonate	mg/l	· 0	7	7	5 .	.7	7	9	7	6
Dissolved Solids at 180°C	mg/L	48	49	45	43	75	61	40	27	33
Chloride	mg/L	1.2	1.5	5.1	1.2	1.9	2.4	2.7	2.2	2.2
Sulfate	mg/l	10.5	6.0	5.5	5.0	15.5	11.5	4.5	11.0	3.5
Dissolved Metals:					•					
Calcium	mg/l	0.8	1.5	2.1	1.5	3.0	2.8	1.8	3.8	2.9
Iron	mg/£	0.10	0.07	0.08	0.06	0.06	0.08	0.10	0.05	0.15
Magnesium	mg/l	0.4	0.3	0:4	0.3	0.6	0.5	0.5	0.6	0.4
Potassium	mg/l	0.5	0.4	0.1	0.3	1.4	1.0	0.3	0.5	0.4
Sodium	mg/l	1.2	1.2	4.1	1.2	6.1	4.8	2.2	1.4	1.4

⁽¹⁾ See Figure 2.7.2.1-2 for location of sampling stations and Table 2.7.2.7-5 for description of stream conditions at each location. Water samples were collected 5-7 February 1979.

⁽²⁾D.O. not measured on same day sample was taken due to instrument malfunction.

⁽³⁾ Source: SAR, 1980

TABLE 2.7.2.7-5
HABITAT DESCRIPTIONS AT WATER SAMPLING STATIONS, FEBRUARY 1979(1)

STATICN	LOCATION	HABITAT TYPE	SUBSTRATE	STREAM WIDTH/DEPTH	STREAM GRADIENT (2)	POOL/RIFFLE RATIO	CURRENT (3)	CCVER	STREAMS LUES	SHAD ING	AQUATIC MACROPHYTES
D-1	Upper Three Runs, approx- 100 meters downstream of Tinker Creek	0xbow -	Leaf litter and organic muck	5.5 m/0.48 m	Not Applicable	None	None	Undercut tanks, logs, submerged branches, lesf litter	Banks vertical; wcoded (birch, red oak, sweet gum, pine) floodplain	1002	None
D-2	Upper Three Runs, approx- 30 meters downstream of Oxbow (Station 1)	Edge of large, permanent stream	Silt	Not Determined	1:1,200	Not Determined (visited during flooding)	Not Determined	-	Beavily wooded floodplain as at Station 1	. 100X	None
D-3	Unnamed tributary to Upper Three Runs	Small stream, perennial	Sand and grawel	2.2 m/0.18 m	1:160	Riffles entire	0.48	Undercut banks, logs, branches	Level floodplain; banks vertical; wooded (sweet gum, cak, pine, holly) with cpen understory	90 Z	None
0-4	Upper Three Runs, approx- 30 meters below unnamed tributary draining west of site	Large, permanent stream	Sand .	Not Determined	1:980	No riffles	Not Determined	-	Heavily wooded as at Stations 1 and 2	1001	None
D-5	Unnamed tributary, approx. 10 meters above confluence with Four Mile Creek	Mouth of small atream carrying effluent from H Area ⁽⁴⁾	Sand, gravel, and cobbles	2.46 m/0.20 m	1:180	No riffles, uniform flow	0.54	Undercut banks, logs, cobbles, overhanging logs submergent	Floodplain with mostly dead sweet gum stand; living oaks, basswood; reed and greenbriar understory	100%	None
D-6	Four-Mile Branch, approx. 9 meters downstream of unnamed tributary (Station 5)	Permanent stream receiving H-Ares effluent	Gravel, sand, silt, and leaf debris	3.66 m/0.30 m	1:210	No riffles, uniform flow	0.71	Bank overhang, brush, logs, leaf litter	Vertical banks; partially wooded and dead trees as at Station 5	40 Z	None
D-7	Unnamed tributary to Tinker Creek, approx. 45 meters upstream from Road F	Small stream, not permanent	Sand	1.5 m/0.08 m	1:80	None apparent	0.29	Bank overhang, logs, leaf litter	Vertical banks; wooded (sweet gum, oak, pine, basswood); dense understory of holly	1002	None
D-8	Unnamed tributary to Upper Three Runs	Upper reaches of small stream	Sand, little gravel	1.55 m/0.13 m	1:48	None apparent	0.41	Bank overhang, logs	Vertical banks; wooded {pine, beech, ash}; dense understory of holly and beech	801	Rone
D-9	Small unnamed tributary to Tinker "Teek (approx. 30 meters above con- fluence)	Small permanent stream	Sand, little silt	3.73 m/0.66 m	1:1,000	None apparent	0.27	Submerged logs, mossy banks	Wooded floodplain (birch, sweet gum, oak)	100%	None
D-10	Tinker Creek, upstream of confluence with Upper Three Runs	Mouth of large permanent stream	Not Determined	Approx. 12 meters in width under flooding conditions	1:1,280	Not Determined	Not Determined (flooded)	Not Determined	Wooded floodplain as at Stations I and 9	901	None

(1) SAR, 1980

⁽²⁾ Average stream gradients calculated from USGS map.
(3) Current is average of three (3) observations made during high water (February 5-8, 1979).

⁽⁴⁾ Savannah River Plant 200 H Area.

TABLE 2.7.2.7-6
DESIGNATED DISCHARGES TO ADJACENT SURFACE WATERS(1)

OUTFALL NO.	LOCATION	RECEIVING STREAM	ESTIMATED DISCHARGE RATE (gpm)	DISCHARGE TYPE	CONTROLS REQUIRED
007	C Area	Four Mile Creek	110,000	Cooling water	Temperature monitored
008	C Area	Four Mile Creek	No record	Cooling water	Temperature monitored
011	D Area	Beaver Dam Creek to Savannah River	922	Ash basin effluent	Suspended solids
012	F Area	Upper Three Runs Creek	7.12	Ash basin cffluent	Low pH
013	H Area	Four Mile Creek	81	Ash basin effluent	Low pH
016	C Area	Four Mile Creek	Runoff	Coal pile runoff	Suspended solids and pH
019 .	H Area	Four Mile Creek	Runoff	Coal pile runoff	Suspended solids and pH
020	F Area	Four Mile Creek	Runoff -	Coal pile runoff	Suspended solids and pH
. 021	A Area	Tims Branch to Upper . Three Runs Creek	5	Coal pile runoff	Suspended solids and pH
022	D Area	Beaver Dam Creek to Savannah River	Runoff	Coal pile runoff	Suspended solids and pH
023	C Area	Four Mile Creek	Runoff	Ash pile runoff	Suspended solids and pH
024	A Area	Tims Branch to Upper Three Runs Creek	Runoff	Ash pile runoff	Suspended solids and pH
025	D Area	Beaver Dam Creek to Savannah River	1,000 to . 10,000	Treatment plant filter backwash, deionizer regener- ants and precipi- tator blowdown	Suspended solids and pH
026	A Area	Tims Branch to Upper Three Runs Creek	100-800	Process sewer, cooling water and surface runoff	Not yet specified by EPA
027	M Area	Tims Branch to Upper Three Runs Creek	100-200	Process sewer, treatment plant, runoff	Not yet specified by EPA
028	D Area	Beaver Dam Creek to Savannah River	14,000 to 26,000	Process sewer	Not yet specified by EPA
031	C Area	Four Mile Creek	1,000 to 3,800	Process sewer	Not yet specified by EPA

(1) SOURCE: SAR, 1980

TABLE 2.7.2.7-7
WATER QUALITY
UPPER THREE RUNS CREEK AT ROAD A
WATER YEAR 1978(1)

•				. CONCENT	RATION B	Y MONTH (2)	•			•		
FARAMETER	UNITS		1977					•	1978				
		OCT.	NOV	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.
Temperature	°c	18.0	17.0	9.0	9.0	5.0	8.3	19.4	17.0	22.0	23.0	21.0	21.0
Н	pH Units	6.9	6.8	6.9	6.1	6.8	6.6	6.6	6.8	7.0	6.9	6.6	6.6
Dissolved Oxygen	mg√l	8.7	8.0	11.4	11.6	11.8	10.0	9.8	8.9	7.5	7.8	7.6	7.6
Alkalinity (CaCO ₃)	mg:/ℓ	5.0	6.0	NA	3.0	4.0	5.0	6.0	5.0	5.0	4.0	4.0	4.0
Suspended Solids	mg/l	5.0	2.0	39.0	8.0	4.0	4.0	5.0	15.0	52.0	8.0	8.0	9.0
Volatile Solids	mg/l	19.0	14.0	36.0	11.0	14.0	16.0	6.0	4.0	12.0	8.0	12.0	18.0
Total Dissolved Sclids	mg√l	27.0	29.0	42.0	28.0	24.0	30.0	18.0	27.0	27.0	21.0	31.0	29.0
Total Splids	mg/l	32.0	31.0	81.0	36.0	28.0	34.0	24.0	42.0	79.0	29.0	39.0	38.0
Fixed Residue	mg/l	13.0	17.0	45.0	25.0	14.0	18.0	18.0	37.0	67.0	21.0	27.0	20.0
COD .	mg/l	5.0	12.0	22.0	12.0	10.0	8.0	11.0	22.0	13.0 ·	. 6.0	8.0	9.0
Chlorid≈ (Cl)	mg/l	1.9	2.3	2.4	2.3	1.7	2.2	2.3	1.5	2.1	1.8	2.6	2.5
Nitrite (NO ₂ -N) .	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.0
Nitrate (NO ₃ -N)	πε∕£	0.14	0.070	0.23	0.19	0.14	0.16	0.11	0.07	0.09	0.16	0.10	0.1
Sulfate (SO ₄ -S)	mg/L	2.0	2.0	<2.0	2.0	<2.0	<2.0	2.0	<2.0	<2.0	<2.0	<2.0	4.0
Sulfide (S)	mg/l	<1.0	<1.0	<1.0	<1.0	NA	<1.0	<1.0	NA	на	NA	NA .	NA
Orthophosphate (0-PO ₄ -P)	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	0.02	<0.02	<0.02	<0.0
Total Phosphate (PO ₄ -P)	mg/l	0.030	0.040	<0.060	0.03	0.02	0.02	0.03	0.02	0.06	0.04	0.09	0.0
Aluminum (Al)	mg/L	<0.5	<0.5	2.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	:<0.5
Ammonia (NH ₄) ⁽³⁾	mg/l	0.010	0.010	<0.1	<0.1	0.020	0.010	0.02	0.04	0.02	0.01	0.03	0.0
Calcium (Ca)	mg/l	1.50	1.90	1.7	1.80	1.60	1.80	1.2	1.5	0.90	1.8	2.0	2.2
Sodium [Na)	mg/L	1.4	1.4	1.6	1.6	0.90	1.10	2.4	2.3	1.7	3.0	1.8	2.5
Total Iron (Fe)	mę/l	0.30	0.20	1.5	0.4	0.2	0.2	0.2	<0.1	0.5	0.3	<0.1	<0.1
Lead (Pb)	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

⁽¹⁾ Source: SAR, 1980
(2) NA - Not Analyzed.

⁽³⁾ Inconsistently reported.

TABLE 2.7.2.7-8

WATER QUALITY
FOUR MILE CREEK AT MOUTH
WATER YEAR 1978(1)

					CONCENT	RATION BY H	ОПТН	•				
PARAMETER	UNITS	ı	1977				1978	-				
		OCTOBER	HOVEMBER AND DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUCUST	SEPTEMBER
рН	pH units	6.75	6.70	6.63	6.76	6.54	6.53	6.43	6.26	6.62	6.47	6.71
Chloride (C1)	mg/#	8.10	6.85	5.00	4.50	2.50	3.60	6.00	4.30	5.30	5.30	3.95
Sulfate (SO ₄ -S)	mg/1	4.00	6.85	4.60	4.80	3.30	6.00	5.00	6.80	7.10	4.60	5.20
Sulfide (8)	mg/1	<1	0.15	<1	<1	0.20	ຸ ∢ 1 ົ	ζi (i	0.10	0.10	ζ1	0.10
Alumainums (Al)	mg/1	<0.5	<0.5	¹ <0.5	1.00	<0.5	2.50	1.50.	<0.5	<0.5	<0.5	<0.5
Calcium (Ca)	mg/1	1.90	1.95	1.90	1.30	1.90	1.74	1.90	1.70	1.65	2.17	2.55
Sodium (Na)	mg/1	7.10	6.05	6.60	4.30	6.0	6.70	. ,8.50	7.40	10.00	7.60	9.05
Total Iron (Fe)	. mg/4	0.30	0.20	0.40	0.40	0.30	1.48	1.20	0.810	0.65	<0.1	<0.1

(1) Source: SAR, 1980

NOTE: Accuracy not always consistent with number of significant figures shown.

TABLE 2.7.2.7-9 Dissolved Oxygen and Temperature Four Mile Creek (1960-1968 Average Values, $\pm l\sigma$; at Road A)

Temperatu	re, °C	Dissolved (· .	
<u>Maximum</u>	Mean	Minimum	Mean	
52 <u>+</u> 6	38.5 <u>+</u> 8	4.4 +0.5	6.6 <u>+</u> 0.9 (99	% Saturated)

Source: Brown, et al, 1972.

TABLE 2.7.2.7-10 WATER QUALITY
FOUR MILE CREEK AT ROAD A-7
WATER YEAR 1978(1)

	1)				CO	NCENTRATIO	и ву монтн	(2)				
PARAMETER	UNITS		1977						1978				
		OCTOBER:	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUCUST	SEPTEMBER
Discharge	1/100	9.62+38	1.1E+09	8.9E+08	1.3E+09	2.9E+09	1.6E+09	1.6E+09	1.2E+09	1.2E+09	7.3E+08	8.3E+08	7.6E+08
Temperature	*c	17.0	20.0	. 8.0	9.0	5.0	8.0	18.3	17.0	22.0	23.0	24.0	21.0
рН	pH units	6.80	6.50	7.0	7.0	7.4	. 6.5	7.0	6.2	5.8	6.2	6.3	. 6.5
Dissolved Oxygen	mg/1	7.30	6.60	11.7	11.8	11.4	10.8	11.0	8.3	8.0	7.9	7.1	6.4
Alkalinity (CaCO ₃)	mg/t	16.0	16.0	NA	6.0	5.0	7.0	8.0	13.0	12.0	15.0	12.0	12.0
Suspended Solids	mg/&	9.00	3.00	4.0	8.0	14.0	4.0	8.0	4.0	4.0	11.0	4.0	34.0
Volatile Solida	mg/f	29.0	30.0	44.0	24.0	. 24.0	24.0	11.0	4.0	11.0	23.0	24.0	28.0
Total Dissolved Solids	mg/i	63.0	70.0	98.0	53.0	50.0	52.0	21.0	38.0	75.0	6 <u>5</u> ,0	64.0	65.0
Total Solids	mg/L	72.0	73.0	102.0	61.0	64.0	56.0	30.0	42.0	80.0	76.0	68.0	99.0
Pixed Residue	mg/1	43.0	43.0	58.0	38.0	39.0	32.0	18.0	38.0	69.0	53.0	45.0	71.0
COD	mg/t	<5	5.0	<5.0	<5.0	<5.0	<5.0°	5.0	11.0	<5	<5	<5 -	43
Chloride (C1)	mg/1	3.20	3.60	3.2	2.5	2.5	2.7	2.9	1.6	2.2	3.5	3.4	4.6
Nitrite (NO ₂ -N)	mg/1	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.01	D.01	0.01	<0.02	<0.02
Nitrate (NO ₃ -N)	mg/L	3.00	3.97	4.35	3.93	3.75	3.87	3.75	2.0	3.99	3.84	2.25	3.2
Sulfate (SOL-S)	mg/1	8.00	6.00	7.0	<2.0	5.0	5.0	7.0	5.0	4.0	4.0	7.0	10.0
Sulfide (S)	mg/1	<1.0	<1.0	<1.0	<1.0	. NA	<1.0	<1.0	NA	NA.	NA.	RA	NA.
Orthophosphate (O-PO ₄ -P)	mg/#	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.06
Total Phosphate (PO ₄ -P)	mg/L	0.03	0.02	<0.02	0.02	0.03	0.02	. 0.01 .	<0.02	0.04	0.03	0.07	0.17
Aluminum (A1)	mg/f	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.8
Ammonia (NH ₄)(3)	mg/1	0.02	0.01	0.03	0.03	0.04	0.03	<0.1	0.05	0.03	0.01	<0.1	0.02
Calcium (Ca)	mg/4	3.10	3.70	3.1	3.5	2.4	2.7	4.4	3.7	3.0	5.7	6.5	4.2
Sodium (Na)	mg/1	7.80	9.2	9.8	9.6	4.3	6.6	11.0	13.4	12.3	20.0	15.0	16:0
Total Iron (Fe)	mg/L	0.50	0.10	<0.1 ⋅	<0.1	0.3	0.2	0.4	0.6	0.6	0.6	0.5	1.0
Lead (Pb)	mg/1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	NA .	<0.5	<0.5	<0.5

⁽¹⁾ Source: SAR, 1980
(2) NA - Not Analyzed.

NOTE: Accuracy not always consistent with number of signficant figures shown.

⁽³⁾ Not consistently reported.

TABLE 2.7.2.7-11

Radionuclides in Savannah River Water 1

	Minimum Level	Concertration, pCi/1 1 Mile Upstream from Upper Three Runs Creek R-2 (Control)			8 Miles Downstream from Lower Three Runs Creek at Highway 301 R-10			" of CG at	
Radionuclide	of Detection	<u>Max</u>	Min	\underline{Avg}	Max	Min	\underline{Avg}	Highway 301	
³H	300	2,400	<260	390	9,200	1,500	3,900	0.13	
^{3 5} S	5.0	ND			ND			<0.01	
⁵¹ Cr	4.3	ND			ND			<0.001	
⁵ ⁴ Mn	0.6	ND			NĎ			<0.0004	
^{6 0} Co	4.0	ND ,			ND		*	<0.005	
^{6 5} Zn	3.0	ND-			ND			<0.001	
⁸⁹ Sr	0.3	ND			ND			<0.001	
⁹⁰ Sr	0.02	1.8	<0.1	0.4	0.9	<0.1	0.3	0.10	
⁹⁵ Zr,Nb	0.5	ND			ND			<0.001	
103,196 Ru	3.2	ND			ND			<0.03	
131 [0.2	ND			ND ·			<0.07	
¹³⁷ Cs	<0.01	ND			0.022	0.008	0.015	<0.001	
¹⁴⁰ Ba, La	1.6	ND	•		ND	, ,	•	<0.01	
^{141,144} Ce	2.5	ND			ND		-	<0.02	
²³⁹ Np	2.2	ND .			ND			<0.002	

ND = Less than minimum level of detection.

¹Source: "Environmental Monitoring in the Vicinity of the Savannah River Plant," DPSPU 78-30-1, Health Physics Department, SRP, Aiken, South Carolina, 1978. 65 pp.

TABLE 2.7.2.7-12¹

Tritium Balance In Effluent Water For 1977

Releases		Ci
Reactor areas		
Disassembly basin purges (P and C Areas)		11,389
Miscellaneous releases		3,348
Reactor cooling water (C- and K-Area heat		
exchanger leakage)		8,908
Process sewer		988
Migration from 50-million-gallon containment		
basin (K Area)		8,400
Par Pond (Measured in Lower Three Runs Creek)		1,277
Heavy water area		1,140
Separations areas		
F and H Areas to Four Mile Creek		131
Migration from seepage basins to Four Mile Cree	k	
F Area	•	3,657
H Area		4,526
	Total →	43,764
Measured in effluent water		,
Streams at road A (38,599.Ci) + Heavy water area		
(1140 Ci)		39,739
River at Highway 301 (plant contribution)		42,513
1		•

¹Source: Ashley & Zeigler, 1978

TABLE 2.7.2.7-13 Tritium Balance Summary (1964-1977)

		Measured in Effluent Water, Ci						
<u>Yéar</u>	Releases, Ci ^a	Streams at Road A ^b	River at Highway 301°					
1964	120,000	131,600	140,000					
1965	108,000	109,470	100,200					
1966	85,000	97,800	78,000					
1967	70,600	76,900	68,500					
1968	63,800	67,250	61,800					
1969	64,600	64,000	58,100					
1970	37,900	43,168	31,800					
1971	38,200	44,700	39,100					
1972	46,800	47,300	45,300					
1973	71,100	62,800	61,100					
1974	59,900	54,600	46,000					
1975	55,600	50,000	49,500					
1976	59,600	47,400	51,100					
1977	43,800	39,700	42,500					
Total	→ 927,900	936,688	873,000					

 $[\]alpha$. Includes tritium migration from seepage basins. b. Tritium in streams at road A does not include 400-D releases.

c. Corrected for tritium in river water above plant.

¹Source: Ashley & Zeigler, 1978

TABLE 2.7.2.7-14

Tritium in Transport in Streams and Savannah River

Tritium in Transport in Streams and Savannah River, Ci/yr, for 1977^{1}

Location	$\underline{\mathit{Tritium}}$	9 0 Sr	137 _{Cs}
Four Mile Creek	17,415		
Pen Branch	12,839		
Steel Creek	7,068		. •
Lower Three Runs	1,277		
Total →	38,599		
River control	4,028	2.97	-
River downstream from plant (highway 301)	46,541	3.37	0.2
Apparent plant contribution at highway 301	42,513 ^a	0.40	0.2

a. Includes migration of tritium from seepage basins.

⁻ Less than minimum level of detection.

¹Source: Ashley and Zeigler, 1978.

TABLE 2.7.2.7-15 Radioactivity in Four Mile Creek, Ci $^{\rm 1}$

No.	Location	Tritium	⁹⁰ Sr	$\frac{137}{Cs}^{\alpha}$
1 2	H-Area effluent at road E Cooling tower effluent below	138	0.007	0.008
	H-Area retention basin	10	.005	.177
3	0.5 mi downstream from road E	454	.022	0.092
4	Above entry of F-Area effluent	4674	.021	<0.009
5	F-Area effluent at road E	9	.004	0.010
6	Below F-Area effluent at road C	5116	.044	.194
7	Downstream at road A-7	8773	0.698	0.154

lpha Desorption from stream bed (exception locations 1 and 5).

 $^{1 \\ \}text{Source:}$ Ashley and Zeigler, 1978

TABLE 2.7.2.7-16
Tritium in Fish 1

	River	Fish,	pCi/ml (Free water	r)	
	Above		Adja	Below		
	Plant		to P	lant	Plant	
<u>Year</u>	<u>Max</u>	<u>Avg</u>	<u>Max</u>	<u>Avg</u>	<u>Max</u>	<u>Avg</u>
1970	6	4	8	5	.11	5
1971	7	3	15	8	11	7
1972	9 .	4	16	7	17	8
1973	5	2	16	6	12	6
1974	8 .	4	54	12	12	8
1975	33	5	6	3	12	6
1976	9	5	10	5	16	8
1977	26	8	24	11	20	13

¹Source: Ashley and Zeigler, 1978

TABLE 2.7.2.7-17 Radioactivity in Fish pCi/g (Wet Weight)

		Number	09,90 Bone	Sr	1 3 7 C 6 Who 1 e	: Fish	³ H, pCi	i/ml lual Fish
Location	Species ^c	of Fish	· Max	Avg	Max	Ava	Max	Avg
Ponds								
Par Pond	Composite	18	. 17	<4	13	3		
Pond B	Composite	11	17	- 74	121	20	-	-
Streams	composite	**	_	_	121	20	_	_
Upper Three Runs	Bream '	1	_	_	<0.1	_	_	_
(Road A)	Catfish	3	_	_	0.5	0.3	_	-
Steeds Pond	Bream	2	_	_	<0.1	<0.1	_	_
Lower Three Runs	Bream	1	<3.0	<3.0	12.6	12.6	_	_
(Patterson's Mill)	Catfish	2	4.7	2.5	0.4	0.4	.14	13
(Road A)	Catfish	ĩ		2.3	0.5			13
. Steel Creek	Cattish .	1	-	_	0.5		_	_
(Road A)	Bream .	0	_	_	_	_	_	_
(11022 7.)	Catfish	ì	0.2	_	2.8	_	_	_
	Bream	i	-	_	3.9	_	1:0	_
Steel Creek	210000							
(Mouth)	Bream	5	10.2	5.3	1.0	0.4	219	146
(**************************************	Catfish	3	14.1	7.2	1.1	0.5	22	17
	Bass	Ō	-		_	-	_	-
Four Mile Creek		•						
(Road 3)	Bream	2	3.5	1.7	15.5	8.8	-	-
,	Catfish	0	_	_	_	-		_
	Bass	1	7.8	_	1.6	_	626	-
Cassels' Pond								•
(Four Mile Creek,	Bream	4	2.9	. 2.9	0.9	<0.1	17	13
3 mi below Road A)	Catfish	0	_	_	-	_	_	_
•	Bass	0		_	_	_	_	_
River								
2R	Bream	9	6.6	2.3	<0.2	<0.2	26	9
(1 mile upstream	Catfish	11	-	_	<0.1	<0.1	15	6
of plant)	Bass	0		-	-	_	_	_
•	Composite	20	<2.5	<2.5	_	_	_	-
* 8R	Bream	1	-	_	<0.2	<0.2	12	-
(Below Steel	Catfish	5	_	-	0.2	<0.1	24	11
Creek)	Bass	1	-	_	<0.1	<0.1	12	_
	Composite	7	5.4	3.3			_	-
1 OR .	Bream	2	-	`-	<0.2	<0.2	2	1
(Highway 301)	Catfish	7	-	_	<0.1	< 0.1	20	. 13
	Bass	1	-	-	<0.1	<0.1	-	-
	Composite	10	6.6	3.2	-	-		

a Monthly composite of bone from all species.b Individual whole fish except Par Pond and Pond B fish which are composited monthly for analyses.

c Bream - Shellcracker, bluegill, and redbreast (Lempomis).
Catfish - predominantly yellow cat (Ictalurus).
Bass - predominantly large mouth (Micropterus).

⁻ No sample or analysis.

¹Source: Ashley & Zeigler, 1978

TABLE 2.7.2.7-18 Mercury in Fish, $\mu g/g^{1}$

	River	Above	SRP	River Below SRP			Effluent Streams			
	Bass	Bream	Catfish	Bass	Bream	Catfish	Bass	Bream	Catfish	
1971	0.3	0.3	0.3	a	0.4	0.4	1.2	0.7	0.5	
1972	1.4	. 4	.6	а	. 4	.7	1.4	. 7	.6	
1973	1.1	.6	. 3	2.8	. 4	.4	2.5	.5	.7	
1974	0.8	. 3	. 2	1.1	.4	.5	1.6	. 7	. 7	
1975	.2	1	. 2	0.4	2	3	0.8	. 4	. 7	
1976	0.2	.2	0.2	. 4	.4	. 4	2.8	. 4	.2	
1977	a	0.6	1.5	0.5	0.4	0.6	1.0	0.4	0.4	

a No sample

¹Source: Ashley and Zeigler, 1978

TABLE 2.7.2.7-19
Mercury in Fish for 1977

		(Wet We										
	. No. o	No. of Fish Assayed		Bass			Bream		Catfish			
Location	Bass	Bream	Catfish	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
Savannah River								•				
R-2 above SRP	0	5	3	_	-	-	1.9	0.3	0.8	1.9	<0.3	1.3
R-4 adjacent to SRP	1	1	.2 ^a	<0.3	-	<0.3	0.4	-	0.4	0.7	<0.3	0.5
R-10 below SRP at Highway 301	0	0	4	. ·	-	-	-	-	-	1.8	<0.3	0.7
Plant Streams							• .					
Upper Three Runs Creek at Road A	1 .	1	0	0.8	_	0.8	<0.3	-	<0.3	 -	-	_
· Four Mile Creek at Cassels Pond	0	2	0	-	-	<u>:</u>	0.3	0.3	0.3	· -	-	-
Steel Creek at Road A	1	0	3 ^a	1.0	-	1.0		-	-	0.6	<0.3	0.5
Steel Creek Swamp	0	0	3	-	<u>.</u> .	-	· <u>, -</u>	-	-	0.4	0.2	0.3

⁻ No sample or analysis.

 1 Source: Ashley & Zeigler, 1978

^a Includes one sucker.

TABLE 2.7.2.7-20

Pesticide Analyses for 1977

Savannah River Sediment (µg/kg)

	River 2 (Upstream)	River 10 (Downstream)
DDD	1.9	-
DDE	0.5	-
DDT	3.5	<u>-</u>
Dieldrin	2.0	_
PCB	8	-

Stream Sediment (µg/kg)

	Four Mile Creek, Road A	Pen Branch Road A	Steel Creek Road A	Lower Three Runs, Road A	Upper Three Runs, Road F	Upper Three Runs, Road A	Par Pond Pumphouse
DDT	-	· · · · <u>-</u>	_	_	-	. -	-
DDE	_	2.8	-	-	-	-	_
DDD	-	0.4	· -	-		_	_
Dieldrin	-	2.6	-	-	- ·	-	_
PCB	-	-			-	-	-
Chlordane	-	1	-	-	-	-	_
Endrin	-	-	-	-	_	-	_

- Not detected

All river and stream water results were less than the sensitivity of the analyses.

 $^{^{1}}$ Source: Ashley & Zeigler, 1978

TABLE 2.7.2.7-21 $\label{eq:post_post_loss} \text{Pesticide Concentrations in River Sediment}^1\text{, } \mu\text{g/kg}^a$

		Above P		River Below Plant			
•	<u>1976</u>	<u>1977</u>	1978	<u>1976</u>	<u>1977</u>	<u>1978</u>	
DDD	4.6	1.9	Ъ	2.1	b	b	
DDE	2.2	0.5	0.5	2.3	ķ	ъ	
DDT	b	3.5	b	0.6	b	0.2	
Dieldrin	b	2.0	0.1	ь	b·	0.2	
PCB	Ъ	8.0	b	b	Ъ	Ъ	
Chlordane	b	Ъ	Ъ	ь	Ъ	1.0	

a River water results were less than the sensitivity of the analyses.

¹Source: "Environemntal Monitoring in the Vicinity of the Savannah River Plant," DPSPU 78-30-1, Health Physics Department, SRP, Aiken, South Carolina, 1978. 65 pp.

b Not detected.

TABLE 2.7.2.7-22
Fecal Coliform Bacteria in Savannah River and Plant Streams, Count/100 ml for 1977

	No. of Samples	Weekly Max	Min	Monthly Maximum Geometric ^a Mean	Arithmetic ^b Average
River 2, above plant	51	2200	10	620	320
River 10, below plant	51	1600	2	220	100
Upper Three Runs Creek at Road F	50	610	0	180	70
Upper Three Runs Creek at Road A	50	460	0	120	70
Beaver Dam Creek near swamp	51	1680	0	310	130
Four Mile Creek at Road A	50	960	0	200	30
Pen Branch at Road A	51	1600	0.	100	30
Steel Creek at Road A	51	1760	0	220	100
Lower Three Runs Creek at Road A	51	1200	0	180	100
Lower Three Runs Creek at Tabernacle Church Road	51	820	0	100	60

^a Maximum geometric mean of weekly values.

b Arithmetic average of weekly values.

¹Source: Ashley & Zeigler, 1978