Critical Contaminant/Critical Pathway Analysis - Surface Water Transport for Nonradioactive Contaminants (U)

by

K. F. Chen

Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29808

MASTER

DOE Contract No. **DE-AC09-89SR18035**

This paper was prepared in connection with work done under the above contract number with the U. S. Department of Energy. By acceptance of this paper, the publisher and/or recipient acknowledges the U. S. Government's right to retain a nonexclusive, royalty-free license in and to any copyright covering this paper, along with the right to reproduce and to authorize others to reproduce all or part of the copyrighted paper.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Um

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

This report has been reproduced directly from the best available copy.

Available to DOE and DOE contractors from the Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831; prices available from (615) 576-8401.

Available to the public from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

DISCLAIMER

**Portions of this document may be illegible
in electronic image products. Images are
produced from the best available original
document.**

**CRITICAL CONTAMINANT/CRITICAL
PATHWAY ANALYSIS - SURFACE WATER
TRANSPORT FOR NONRADIOACTIVE
CONTAMINANTS (U)**

Kuo-Fu Chen

Technical Reviewer

Dan P. Griggs Date October 28, 1996
D. P. Griggs

Approval

Robert P. Addis Date 11/6/96
R. P. Addis, Manager, Environmental Transport Group

A. L. Boni Date 11-7-96
A. L. Boni, Manager, Environmental Technology Section

NOVEMBER 1996

Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808

SAVANNAH RIVER SITE

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC09-89SR18035

Key Words

WASP5 CRITICAL CONTAMINANT OUTFALLS HEALTH RISK CANCER
--

Retention: Lifetime

**CRITICAL CONTAMINANT/CRITICAL
PATHWAY ANALYSIS - SURFACE WATER
TRANSPORT FOR NONRADIOACTIVE
CONTAMINANTS (U)**

Kuo-Fu Chen

Issued: NOVEMBER 1996

SRTC

**SAVANNAH RIVER TECHNOLOGY CENTER
AIKEN, SC 29808
Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808**

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC09-89SR18035

ABSTRACT

The health risks for an individual exposed to contaminants released from SRS outfalls from 1989 to 1995 were estimated. The exposure pathways studied are ingestion of drinking water, ingestion of contaminated fish and dermal contact with contaminants in water while swimming. The estimated incremental risks for an individual developing cancer vary from 3.E-06 to 1.0E-05. The estimated total exposure chronic noncancer hazard indices vary from 6.E-02 to 1.E-01.

The critical contaminants were ranked based on their cancer risks and chronic noncarcinogenic hazard quotients. For cancer risks, the critical contaminants released from SRS outfalls are arsenic, tetrachloroethylene, and benzene. For chronic noncarcinogenic risks, the critical contaminants released from SRS outfalls are cadmium, arsenic, silver, chromium, mercury, selenium, nitrate, manganese, zinc, nickel, uranium, barium, copper, tetrachloroethylene, cyanide, and phenol.

The critical pathways in decreasing risk order are ingestion of contaminated fish, ingestion of drinking water and dermal contact with contaminants in water while swimming.

TABLE OF CONTENTS

1. INTRODUCTION	1
2. CALCULATIONS	2
2.1 Source Term	3
2.2 Concentration at US Highway 301	3
2.3 Residential Exposure: Ingestion of Contaminants in Drinking Water	3
2.4 Residential Exposure: Ingestion of Contaminants in Fish	4
2.5 Residential Exposure: Dermal Exposure While Swimming	4
2.6 Carcinogenic Effects	5
2.7 Noncarcinogenic Effects	6
2.8 Aggregate Risks for Multiple Contaminants	6
2.9 Combining Risks Across Exposure Pathways	7
2.10 Ranking for Contaminants and Pathways	8
3. CONCLUSIONS	8
REFERENCES	10

LIST OF TABLES

Table 1 Contaminants Released from the Savannah River Site Outfalls	12
Table 1 (Continued) Contaminants Released from the Savannah River Site Outfalls	13
Table 1 (Continued) Contaminants Released from the Savannah River Site Outfalls	14
Table 1 (Continued) Contaminants Released from the Savannah River Site Outfalls	15
Table 1 (Continued) Contaminants Released from the Savannah River Site Outfalls	16
Table 1 (Continued) Contaminants Released from the Savannah River Site Outfalls	17
Table 2 Calculated Source Terms for Contaminants Released from SRS Outfalls	18
Table 3 Calculated Concentrations at US Highway 301	19
Table 4 Calculated Exposures from Ingestion of Carcinogenic Contaminants in Drinking Water	20
Table 5 Calculated Exposures from Ingestion of Noncarcinogenic Contaminants in Drinking Water	21
Table 6 Calculated Carcinogenic Contaminant Exposures from Ingestion of Contaminated Fish	22
Table 7 Calculated Noncarcinogenic Contaminant Exposures from Ingestion of Contaminated Fish	23
Table 8 Calculated Exposures from Dermal Contact with Carcinogenic Contaminants in Water While Swimming	24
Table 9 Calculated Exposures from Dermal Contact with Noncarcinogenic Contaminants in Water While Swimming	25

Table 10 Contaminants' Toxicity	26
Table 11 Estimated Cancer Risk for Contaminants Released from SRS Outfalls	27
Table 11 (continued) Estimated Cancer Risk for Contaminants Released from SRS Outfalls	28
Table 11 (continued) Estimated Cancer Risk for Contaminants Released from SRS Outfalls	29
Table 11 (continued) Estimated Cancer Risk for Contaminants Released from SRS Outfalls	30
Table 12 Estimated Chronic Noncarcinogenic Hazard Quotients for Contaminants Released from SRS Outfalls	31
Table 12 (continued) Estimated Chronic Noncarcinogenic Hazard Quotients for Contaminants Released from SRS Outfalls	32
Table 12 (continued) Estimated Chronic Noncarcinogenic Hazard Quotients for Contaminants Released from SRS Outfalls	33
Table 12 (continued) Estimated Chronic Noncarcinogenic Hazard Quotients for Contaminants Released from SRS Outfalls	34
Table 13 Critical Contaminant Ranking Based on Total Exposure Cancer Risk	35
Table 14 Critical Contaminant Ranking Based on Total Exposure Hazard Quotient	36

CRITICAL CONTAMINANT/CRITICAL PATHWAY ANALYSIS - SURFACE WATER TRANSPORT FOR NONRADIOACTIVE CONTAMINANTS (U)

Kuo-Fu Chen

**Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808**

1. INTRODUCTION

A complete and thorough critical-contaminant/critical-pathway analysis for routine environmental releases is required by the Savannah River Site (SRS) Environmental Monitoring Plan Corrective Action Plan (ESH-EMS-94-0129). The results will serve as the rationale and design criteria for the SRS Environmental Monitoring Program. The Environmental Monitoring Section requested the Environmental Technology Section to perform the following tasks: 1) identify, evaluate, and compile Savannah River data, aqueous contaminant source terms, and river use data; 2) calculate historic doses, prospective doses, and risks associated with the doses; and 3) determine critical contaminants and critical pathways.

The contaminants released from SRS outfalls from 1989 to 1995 were compiled and the release rates (kg/day) for these contaminants were calculated based on historical records measured by the SRS Environmental Protection Department.

The transport of the contaminants via the Savannah River from SRS to the US Highway 301 bridge were simulated by the WASP5 computer code [1, 2]. WASP5 is a US Environmental Protection Agency (EPA) water quality analysis program that simulates pollutant transport through surface water. WASP5 uses a finite difference method to solve the advective transport equation. The concentrations of the contaminants at US Highway 301 were calculated.

The health risks for an individual exposed to contaminants released from SRS outfalls from 1989 to 1995, through various exposure pathways were estimated. The exposure pathways studied are ingestion of drinking water, ingestion of contaminated fish and dermal contact with contaminants in water while swimming. The estimated incremental risks for an individual developing cancer vary from $3.E-06$ to $1.0E-05$. The estimated total exposure chronic noncancer hazard indices vary from $6.E-02$ to $1.E-01$.

The critical contaminants were ranked based on their cancer risks and chronic noncarcinogenic hazard quotients. For cancer risks, the critical contaminants released from SRS outfalls are arsenic, tetrachloroethylene, and benzene. For chronic noncarcinogenic risks, the critical contaminants released from SRS outfalls are cadmium, arsenic, silver, chromium, mercury, selenium, nitrate, manganese, zinc, nickel, uranium, barium, copper, tetrachloroethylene, cyanide, and phenol.

The critical pathways in decreasing risk order are ingestion of contaminated fish, ingestion of drinking water and dermal contact with contaminants in water while swimming.

2. CALCULATIONS

The following procedure was used to estimate the health risks for an individual who consumes drinking water and fishes from the Savannah River, and swimming in the Savannah River downstream from SRS at the US Highway 301 bridge. These risks are resulted from exposures to the non-radioactive contaminants released from SRS outfalls.

1. Release rates (kg/day) of contaminants from SRS outfalls were compiled and quantified.
2. The total release rate for each contaminant released from SRS as a whole was calculated.
3. Contaminant transport via the Savannah River from SRS to the US Highway 301 bridge was simulated, and contaminant concentrations at this location were calculated.
4. Exposures from ingestion of water and fish, and swimming for each noncarcinogenic and carcinogenic contaminant were calculated.
5. The cancer risks from ingestion of drinking water, ingestion of contaminated fish and dermal contact while swimming for each contaminant were calculated.
6. The noncarcinogenic hazard quotients from ingestion of drinking water, ingestion of contaminated fish and dermal contact while swimming for each contaminant were calculated.
7. Aggregate cancer risks and noncancer hazard quotients for multiple contaminants were calculated.
8. Critical contaminants were ranked based on cancer risks and noncancer hazard quotients.

Detailed explanations of each calculation step in this procedure follow.

2.1 Source Term

The release rate for contaminant i from outfall j is calculated as:

$$p_i^j = uc_i^j Q^j \quad (1)$$

where

p_i^j = Contaminant Release Rate, kg / day

c_i^j = Contaminant Concentration, mg / l

Q^j = Discharge Flow Rate, 10^6 gallon / day

u = Unit Conversion Factor

Table 1 lists the contaminants released from SRS outfalls. The historical records of the measured contaminant concentrations and the discharge flow rates were obtained from SRS Environmental Data reports [3 - 9].

The total release rate of contaminant i from SRS is obtained by adding the release rates from each outfall:

$$P_i = \sum_{j=1}^n p_i^j \quad (2)$$

Table 2 shows the calculated total release rates (source terms) from SRS for each contaminant from 1989 to 1995.

2.2 Concentration at US Highway 301

With the contaminant release rate (source term) calculated by Equation 2 and the average of the Savannah River daily average flow measured at Augusta, Georgia gauge station for the year in study [10 - 16], WASP5 simulates the contaminant transport from SRS to US Highway 301 and calculates C_i , the contaminant concentration in the Savannah River at US Highway 301. Table 3 presents the calculated concentrations.

2.3 Residential Exposure: Ingestion of Contaminants in Drinking Water

The residential average daily intake for ingestion of contaminant i in drinking water is calculated by [17]:

$$DI_i = \frac{C_i \times IR \times EF \times ED}{BW \times AT} \quad (3)$$

where

- DI_i = Daily intake (exposure) of Contaminant i , mg/kg-day
- C_i = Concentration of Contaminant i , Calculated by WASP5, mg/l
- IR = Ingestion Rate, 2 liters per day
- EF = Exposure Frequency, 365 days per year
- ED = Exposure Duration, 30 years
- BW = Body Weight, 70 kg
- AT = Averaging Time (period over which exposure is averaged)
 - = 30 year x 365 day/year for noncarcinogenic effects
 - = 70 year x 365 day/year for carcinogenic effects

Tables 4 and 5 show the calculated exposures for ingestion of carcinogenic and noncarcinogenic contaminants in drinking water, respectively.

2.4 Residential Exposure: Ingestion of Contaminants in Fish

The residential average daily intake for ingestion of contaminant i in contaminated fish is calculated by [18]:

$$DI_i = \frac{C_i \times BF \times IR \times FI \times EF \times ED}{BW \times AT} \quad (4)$$

where

- DI_i = Daily intake (exposure) of Contaminant i , mg/kg-day
- C_i = Concentration of Contaminant i , Calculated by WASP5, mg/l
- BF = Bioaccumulation Factor, l/kg
- IR = Ingestion Rate, kg/meal
- FI = Fraction ingested (unitless)
- EF = Exposure Frequency, meals/year
- ED = Exposure Duration, 30 years
- BW = Body Weight, 70 kg
- AT = Averaging Time (period over which exposure is averaged)
 - = 30 year x 365 day/year for noncarcinogenic effects
 - = 70 year x 365 day/year for carcinogenic effects

The bioaccumulation factor, BF, is contaminant specific and is obtained from Reference 19. The product of ingestion rate, IR, and exposure frequency, EF, is kilogram of fish consumed per year and is provided by Reference 20 as 19 kg/day. The fraction ingested, FI, is assumed be one. Tables 6 and 7 show the calculated exposures for ingestion of carcinogenic and noncarcinogenic contaminants in fish, respectively.

2.5 Residential Exposure: Dermal Exposure While Swimming

The residential exposure for dermal contact with contaminant i in water while swimming is calculated by [18]:

$$DI_i = \frac{C_i \times SA \times K \times ET \times EF \times ED \times CF}{BW \times AT} \quad (5)$$

where

- DI_i = Daily intake (exposure) of Contaminant i , mg/kg-day
- C_i = Concentration of Contaminant i , Calculated by WASP5, mg/l
- SA = Total body surface area, m^2
- K = Permeability constant, cm/hr
- ET = Exposure time, hr/day
- EF = Exposure Frequency, day/year
- ED = Exposure Duration, 30 years
- CF = Conversion factor, 10^{-3} l/cm³
- BW = Body Weight, 70 kg
- AT = Averaging Time (period over which exposure is averaged)
 - = 30 year x 365 day/year for noncarcinogenic effects
 - = 70 year x 365 day/year for carcinogenic effects

Reference 17 gives the total body surface area, SA , of $1.94 m^2$ and the permeability constant, K , of 1.5×10^{-3} cm/hr. The product of exposure time, ET , and the exposure frequency, EF , is the number of swimming hours per year and is 8.9 hr/year for site specific value [20]. Tables 8 and 9 show the calculated exposures for dermal contact of carcinogenic and noncarcinogenic contaminants while swimming, respectively.

Based on the intake or exposure calculated from Equations 3 to 5, the health risk for carcinogenic and noncarcinogenic effects associated with a particular contaminant can be determined.

2.6 Carcinogenic Effect

Risks for carcinogens are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen. The slope factor (SF) converts estimated daily intakes averaged over a lifetime of exposure (given by Equations 3 to 5) to an incremental risk of an individual developing cancer. The linear low-dose cancer risk equation is

$$Risk_i = DI_i \times SF_i \quad (6)$$

where

- $Risk_i$ = A unitless probability of an individual developing cancer resulted from exposure of contaminant i
- SF_i = Slope factor for contaminant i (mg/kg-day)⁻¹
- DI_i = Chronic daily intake averaged over 70 years, mg/kg-day

The slope factor shown in Table 10 for a particular contaminant is obtained from References 21 and 22. Table 11 presents the calculated cancer risks for contaminants released from SRS outfalls from 1989 to 1995.

2.7 Noncarcinogenic Effects

Currently, the EPA does not use a probabilistic approach to estimate the potential for noncarcinogenic health effects. Instead, the potential for noncarcinogenic effects is evaluated by comparing an exposure level (intake) over a specified time period (e.g., a lifetime) with a reference dose derived for a similar exposure period [17]. This ratio of exposure to toxicity is called a hazard quotient and is expressed as:

$$NHQ_i = \frac{DI_i}{RfD_i} \quad (7)$$

where

- NHQ_i = Noncancer Hazard Quotient for Exposure of contaminant i
- DI_i = Daily intake (exposure level) of contaminant i
- RfD_i = Reference dose for contaminant i

DI_i and RfD_i are expressed in the same units and represent the same chronic exposure period. The reference dose (RfD) for a particular contaminant is obtained from References 21 and 22.

The noncancer hazard quotient assumes that there is a level of intake or exposure (i.e., RfD) below which it is unlikely for even sensitive populations to experience adverse health effects. If the intake level (DI) exceeds this threshold (i.e., if NHQ exceeds unity), there may be concerns for potential noncancer effects. Table 12 shows the calculated chronic noncarcinogenic hazard quotients for contaminants released from SRS outfalls from 1989 to 1995.

2.8 Aggregate Risks for Multiple Contaminants

Multiple contaminants are released from SRS outfalls. To assess the overall potential for cancer and noncancer effects posed by multiple contaminants, EPA [23] has developed guidelines for the health risk assessment of chemical mixtures.

The total incremental individual lifetime cancer risk for simultaneous exposure to several carcinogens is approximated by summation of the risks for all the contaminants

$$Risk_T = \sum_{i=1}^m Risk_i \quad (8)$$

where

$Risk_T$ = Total cancer risk

$Risk_i$ = Cancer risk for contaminant i

Table 11 presents the calculated total cancer risks for simultaneous exposure to contaminants released from SRS outfalls from 1989 to 1995.

To assess the overall potential for noncarcinogenic effects posed by multiple contaminant intakes (Exposures), a hazard index (HI) approach has been developed based on EPA's Guidelines for Health Risk Assessment of Chemical Mixtures. This approach assumes that simultaneous subthreshold exposures to several contaminants could result in an adverse health effect. It also assumes that the magnitude of the adverse health effect will be proportional to the sum of the hazard quotients.

$$HI = \sum_{i=1}^m NHQ_i \quad (9)$$

where

HI = Chronic noncarcinogenic hazard index for exposure to multiple contaminants

NHQ_i = Chronic noncarcinogenic hazard quotient for contaminant i

Table 12 shows the calculated chronic noncarcinogenic hazard indices for simultaneous exposure to contaminants released from SRS outfalls from 1989 to 1995.

2.9 Combining Risks Across Exposure Pathways

EPA [17] assumes that the total cancer risks from various exposure pathways are approximated to be additive, as long as the risks are for the same individual and time period. The cancer risk equation for multiple pathways is expressed as:

$$\text{Total Exposure Cancer Risk} = \sum_i Risk_{(\text{pathway})_i} \quad (10)$$

Table 11 presents the calculated total exposure cancer risks for multiple exposure pathways to contaminants released from SRS outfalls from 1989 to 1995.

The hazard index equation for multiple pathways is given by Reference 17 as:

$$\text{Total Chronic Noncarcinogenic Exposure Hazard Index} = \sum_i \text{Hazard Index}_{(\text{pathway})_i} \quad (11)$$

Table 12 shows the calculated total chronic noncarcinogenic hazard index for multiple exposure pathways to contaminants released from SRS outfalls from 1989 to 1995.

2.10 Ranking for Contaminants and Pathways

Tables 13 and 14 show the ranking of the critical contaminants released from SRS from 1989 to 1995. The ranking is based on the cancer risk and the chronic noncarcinogenic hazard quotient. For cancer risks, the critical contaminants released from SRS outfalls are arsenic, tetrachloroethylene, and benzene. For noncarcinogenic risks, the critical contaminants released from SRS outfalls are cadmium, arsenic, silver, chromium, mercury, selenium, nitrate, manganese, zinc, nickel, uranium, barium, copper, tetrachloroethylene, cyanide, and phenol.

Ingestion of contaminated fish poses higher risk than drinking water and swimming because the contaminants tend to accumulate in the tissue of the fish. Swimming poses the least risk to an individual because fewer contaminants are permeated through the skin.

3. CONCLUSIONS

The health risks for an individual exposed to contaminants released from SRS outfalls from 1989 to 1995 through various exposure pathways were estimated. The exposure pathways studied are ingestion of drinking water, ingestion of contaminated fish and dermal contact with contaminants in water while swimming. The estimated total incremental lifetime exposure cancer risks vary from 3.E-06 to 1.0E-05. The estimated total exposure chronic noncancer hazard indices vary from 6.E-02 to 1.E-01.

The contaminants released from SRS outfalls were ranked. The ranking is based on the cancer risk and the chronic noncarcinogenic hazard quotient. For cancer risks, the critical contaminants released from SRS outfalls are arsenic, tetrachloroethylene, and benzene. For noncarcinogenic risks, the critical contaminants released from SRS outfalls are cadmium, arsenic, silver, chromium, mercury, selenium, nitrate, manganese, zinc, nickel, uranium, barium, copper, tetrachloroethylene, cyanide, and phenol.

The calculated chronic noncancer hazard quotients for dermal contact with contaminants in water while swimming vary from 4E-06 to 1E-05, for ingestion of drinking water vary from 1E-02 to 3E-02, for ingestion of fish vary from 5E-02 to 8E-02.

The calculated cancer risks for dermal contact with contaminants in water while swimming vary from $3\text{E-}10$ to $1\text{E-}09$, for ingestion of drinking water vary from $7\text{E-}07$ to $3\text{E-}06$, for ingestion of fish vary from $2\text{E-}06$ to $8\text{E-}06$.

REFERENCES

1. Ambrose, R. B., Wool, T. A., and Martin, J. L., "The Water Quality Analysis Simulation Program, WASP5, Part A: Model Documentation; Part B: Input Dataset," Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Athens, Georgia, September 20, 1993.
- ✓ 2. Chen, Kuo-Fu, "Revised STREAM Code and WASP5 Benchmark," WSRC-RP-95-598, May 1995.
- ✓ 3. Cummins, C. L., Martin, D. K., and Todd, J. L., "SRS Environmental Data for 1989," WSRC-IM-90-60, Volume II, Figures and Data Tables.
- ✓ 4. Cummins, C. L., Martin, D. K., and Todd, J. L., "SRS Environmental Data for 1990," WSRC-IM-91-28, Volume I, Environmental Monitoring, Compliance, and Research. *Summary Pamphlet only*
- ✓ 5. Arnett, M. W., Karapatakis, L. K., Mamtey, A. R., Todd, J. L., "SRS Environmental Report for 1991," WSRC-TR-92-186.
- ✓ 6. Arnett, M. W., "SRS Environmental Report for 1992," WSRC-TR-93-077.
- ✓ 7. Arnett, M. W., "SRS Environmental Report for 1993," WSRC-TR-94-077.
- ✓ 8. Arnett, M. W., "SRS Environmental Report for 1994," WSRC-TR-95-077.
- ✓ 9. Arnett, M. W., "SRS Environmental Report for 1995," WSRC-TR-96-0077.
10. Bennett, C. S., Cooney, T. W., Jones, K. H., Church, B. W., and Murray, G. L., "Water Resources Data South Carolina, Water Year 1989," USGS Water-Data Report SC-89-1.
11. Bennett, C. S., Cooney, T. W., Jones, K. H., Conrads, P. A., "Water Resources Data South Carolina, Water Year 1990," USGS Water-Data Report SC-90-1.
12. Bennett, C. S., Cooney, T. W., Jones, K. H., Conrads, P. A., "Water Resources Data South Carolina, Water Year 1991," USGS Water-Data Report SC-91-1.
13. Bennett, C. S., Cooney, T. W., Jones, K. H., Gissendanner, J. W., "Water Resources Data South Carolina, Water Year 1992," USGS Water-Data Report SC-92-1.
14. Bennett, C. S., Cooney, T. W., Jones, K. H., Drewes, P. A., "Water Resources Data South Carolina, Water Year 1993," USGS Water-Data Report SC-93-1.

- ok 15. Cooney, T. W., Jones, K. H., Drewes, P. A., Gissendanner, J. W., and Church, B. W., "Water Resources Data South Carolina, Water Year 1994," USGS Water-Data Report SC-94-1
- ok 16. Flow for 1995 provided by Frank Melandez from USGS New Ellenton Field Office.
- ok 17. "Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final," EPA/540/1-89/002. December 1989.
- DOE 18. "Plant-Wide Baseline Human Health Risk Assessment, Portsmouth Gaseous Diffusion Plant, Piketon, Ohio," Volume 1, DOE/OR/11-1403/V1&D1, POEF-ER-4625/V1&D1, August 29, 1995.
- LLNL ✓ 19. Thompson, Stanley E., Burton, C. Ann, Quinn, Dorothy J. and Ng, Yook C., "Concentration Factors of Chemical Elements in Edible Aquatic Organisms," UCRL-50564 Rev. 1, TID-4500, UC-48, October 10, 1972.
- ✓ 20. Hamby, David M., "Land and Water Use Characteristics in the Vicinity of the Savannah River Site (U)," WSRC-RP-91-17, March 1991.
- ok 21. "Health Effects Assessment Summary Tables, FY-1995 Annual," EPA/540/R-95/036, May 1995.
- ok 22. "Electronic Handbook of Risk Assessment Values", Volume 5, Issue 5, March 15, 1996.
- ok 23. "Guideline for the Health Risk Assessment of Chemical Mixtures," 51 Federal Register 34014, September 24, 1986.

		Table 1													
		Contaminants Released from the Savannah River Site Outfalls													
		OUTFALLS													
		A-001	A-003	A-005	A-011	A-014	A-015	C-001	C-003	C-004	C-004A	D-001	D-001A	D-001B	D-001C
CONTAMINANT															
AG	Silver														
AL	Aluminum													X	
AN	Ammonia														
AS	Arsenic														
BA	Barium														
BEN	Benzene														
BOD	Biochemical Oxygen Demand	X		X	X	X	X				X		X		
C	Carbon														
CD	Cadmium														
CHL	Chlorine														
CN	Cyanide														
COD	Chemical Oxygen Demand														
CR	Chromium		X												
CU	Copper														
DO	Dissolved Oxygen														
FE	Iron													X	
FEC	Fecal Coliform			X			X				X		X		
HG	Mercury														
MG	Magnesium													X	
MN	Manganese													X	
NI	Nickel														
NO3	Nitrate														
O&G	Oil & Grease	X	X	X	X	X		X	X	X		X			X
PB	Lead														
PERCL	Tetrachloroethylene	X	X	X	X	X									
PHE	Phenol														
PHOS	Phosphate														
SE	Selenium														
SO4	Sulfate													X	
TCE	1,1,1-Trichloroethane	X	X		X	X									
TRICL	Trichloroethylene	X	X	X	X	X									
TSS	Total Suspended Solid	X	X	X	X	X	X	X	X	X	X	X	X	X	X
U3O8	Uranium														
ZN	Zinc													X	

Table 1 (continued)
Contaminants Released from the Savannah River Site Outfalls

		OUTFALLS													
		D-003	D-005	D-006	DW-001	DW-002	DW-003	DW-004	F-001	F-002	F-003	F-003A	F-005	F-007	F-008
CONTAMINANT															
AG	Silver														
AL	Aluminum														X
AN	Ammonia														X
AS	Arsenic														
BA	Barium														
BEN	Benzene														
BOD	Biochemical Oxygen Demand						X	X			X	X			
C	Carbon														
CD	Cadmium														
CHL	Chlorine							X							
CN	Cyanide														
COD	Chemical Oxygen Demand														
CR	Chromium														X
CU	Copper														X
DO	Dissolved Oxygen														
FE	Iron														
FEC	Fecal Coliform			X			X					X			
HG	Mercury														X
MG	Magnesium														
MN	Manganese														X
NI	Nickel														X
NO3	Nitrate														X
O&G	Oil & Grease	X		X		X		X	X	X	X		X	X	X
PB	Lead														X
PERCL	Tetrachloroethylene														
PHE	Phenol														
PHOS	Phosphate														
SE	Selenium														
SO4	Sulfate														
TCE	1,1,1-Trichloroethane														
TRICL	Trichloroethylene														
TSS	Total Suspended Solid	X	X	X	X		X	X	X	X	X	X	X	X	X
U3O8	Uranium														X
ZN	Zinc														X

Table 1 (continued)
Contaminants Released from the Savannah River Site Outfalls

		OUTFALLS													
		F-008A	F-012	F-013	FS-001	FS-002	H-002	H-003	H-004	H-006	H-007	H-008	H-008A	H-012	H-013
CONTAMINANT															
AG	Silver														
AL	Aluminum		X	X										X	
AN	Ammonia		X	X										X	
AS	Arsenic														
BA	Barium														
BEN	Benzene														
BOD	Biochemical Oxygen Demand	X													X
C	Carbon						X	X		X					
CD	Cadmium														
CHL	Chlorine										X				
CN	Cyanide														
COD	Chemical Oxygen Demand						X			X					
CR	Chromium		X	X										X	
CU	Copper		X	X										X	
DO	Dissolved Oxygen														
FE	Iron														
FEC	Fecal Coliform	X			X	X									X
HG	Mercury		X	X										X	
MG	Magnesium														
MN	Manganese		X	X										X	
NI	Nickel		X	X										X	
NO3	Nitrate		X	X										X	
O&G	Oil & Grease						X	X	X	X	X	X	X	X	
PB	Lead		X	X										X	
PERCL	Tetrachloroethylene														
PHE	Phenol														
PHOS	Phosphate														
SE	Selenium														
SO4	Sulfate													X	
TCE	1,1,1-Trichloroethane														
TRICL	Trichloroethylene														
TSS	Total Suspended Solid	X	X	X			X		X		X	X	X	X	X
U3O8	Uranium		X	X										X	
ZN	Zinc		X	X										X	

[illegible]

		Table 1 (continued)													
		Contaminants Released from the Savannah River Site Outfalls													
		OUTFALLS													
		M-004	M-005	P-005	P-007	P-013	P-014	P-019	PP-001	S-002	S-008	S-011	S-014	SC-004	T-001
CONTAMINANT															
AG	Silver	X												X	
AL	Aluminum	X			X					X					
AN	Ammonia														
AS	Arsenic													X	
BA	Barium													X	
BEN	Benzene														
BOD	Biochemical Oxygen Demand						X			X	X	X	X		
C	Carbon												X		
CD	Cadmium	X												X	
CHL	Chlorine														
CN	Cyanide	X													
COD	Chemical Oxygen Demand														
CR	Chromium	X												X	
CU	Copper	X													
DO	Dissolved Oxygen													X	
FE	Iron				X					X					
FEC	Fecal Coliform						X					X			
HG	Mercury													X	
MG	Magnesium														
MN	Manganese														
NI	Nickel	X													
NO3	Nitrate	X												X	
O&G	Oil & Grease	X		X	X	X		X	X	X	X		X		
PB	Lead	X												X	
PERCL	Tetrachloroethylene		X												
PHE	Phenol														
PHOS	Phosphate	X												X	
SE	Selenium													X	
SO4	Sulfate														
TCE	1,1,1-Trichloroethane														
TRICL	Trichloroethylene		X												
TSS	Total Suspended Solid	X		X	X	X	X	X		X	X	X			
U3O8	Uranium	X													
ZN	Zinc	X													

Table 1 (continued)												
Contaminants Released from the Savannah River Site Outfalls												
OUTFALLS												
CONTAMINANT	T-005	T-007	X-004	X-008	X-011	X-013	X-014	etc	X-014	or	Y-001	X-008A
AG Silver												
AL Aluminum				X								
AN Ammonia												
AS Arsenic												
BA Barium												
BEN Benzene							X		X			
BOD Biochemical Oxygen Demand	X	X				X	X		X			
C Carbon							X		X			
CD Cadmium												
CHL Chlorine		X										
CN Cyanide												
COO Chemical Oxygen Demand												
CR Chromium												
CU Copper												
DO Dissolved Oxygen												
FE Iron				X								
FEC Fecal Coliform						X						
HG Mercury							X					
MG Magnesium												
MN Manganese												
NI Nickel												
NO3 Nitrate												
O&G Oil & Grease	X		X	X			X				X	
PB Lead												
PERCL Tetrachloroethylene												
PHE Phenol							X		X			
PHOS Phosphate												
SE Selenium												
SO4 Sulfate												
TCE 1,1,1-Trichloroethane												
TRICL Trichloroethylene												
TSS Total Suspended Solid	X	X	X	X		X	X				X	
U3O8 Uranium												
ZN Zinc												

Table 2
Calculated Source Terms for Contaminants Released from SRS Outfalls

	Contaminant	1989 kg/day	1990 kg/day	1991 kg/day	1992 kg/day	1993 kg/day	1994 kg/day	1995 kg/day
AG	Silver	1.53E-01	4.15E-01	1.57E-01	1.26E-01	6.45E+01	1.02E-01	6.05E+01
AL	Aluminum	6.54E+00	8.93E+00	8.15E+00	3.84E+00	2.99E+01	2.59E+01	4.56E+01
AN	Ammonia	1.31E+00	1.08E+00	3.43E+00	5.57E+00	2.95E+00	3.24E+00	7.50E+00
AS	Arsenic	9.15E-01	7.78E-01	9.42E-01	7.56E-01	1.72E+00	1.02E+00	3.66E+00
BA	Barium	4.79E+00	3.21E+00	3.93E+00	2.75E+00	4.38E+00	2.70E+00	2.45E+00
BEN	Benzene	3.86E-04	3.77E-05	1.59E-04	4.62E-05	5.00E-05	2.12E-05	8.52E-05
C	Carbon	5.61E+00	9.26E-01	1.08E+00	7.20E-01	1.16E+00	6.54E-01	3.24E-01
CD	Cadmium	3.05E+00	2.59E+00	3.14E+00	2.52E+00	3.45E+00	2.05E+00	9.16E-01
CHL	Chlorine	2.92E-01	2.12E-01	2.55E-01	2.83E-01	9.89E+00	1.10E+01	9.15E+00
CN	Cyanide	4.94E-04	1.71E-04	1.17E-04	2.69E-04	3.73E-04	2.16E-04	6.06E-04
CR	Chromium	8.48E+00	5.70E+00	6.71E+00	5.43E+00	1.09E+01	4.80E+00	2.07E+00
CU	Copper	4.10E-01	5.08E-01	2.20E-01	3.81E-01	3.14E-01	2.38E-01	2.73E-01
FE	Iron	2.52E+00	8.17E+00	7.57E+00	1.24E+00	1.58E+01	2.26E+00	1.01E+02
HG	Mercury	3.28E-02	1.08E-01	6.57E-02	3.86E-02	1.51E-01	3.11E-02	5.77E-02
MN	Manganese	2.92E-01	5.33E-01	4.87E-01	3.40E-01	5.07E-01	3.36E-01	3.21E+00
NI	Nickel	1.13E+00	1.26E+00	1.03E+00	4.73E-01	8.80E-01	7.59E-01	1.92E-01
NO3	Nitrate	1.20E+02	7.01E+01	6.42E+01	9.01E+01	1.31E+02	1.23E+02	1.06E+02
O&G	Oil & Grease	2.12E+03	1.23E+03	3.33E+03	3.20E+03	9.32E+02	1.48E+03	8.25E+02
PB	Lead	2.17E+00	2.51E+00	2.17E+00	1.21E+00	8.42E-01	5.32E+00	3.89E+00
PERCL	Tetrachloroethylene	2.04E-02	2.00E-02	2.03E-02	2.54E-02	4.07E-02	2.39E-02	6.20E-02
PHE	Phenol	1.10E-03	1.78E-04	3.76E-04	2.31E-04	9.99E-05	1.19E-04	4.07E-04
PHOS	Phosphate	3.83E+01	1.70E+01	3.82E+01	8.27E+00	1.08E+01	7.53E+00	2.68E+01
SE	Selenium	1.83E+00	1.56E+00	1.88E+00	1.51E+00	1.72E+00	1.23E+00	3.66E+00
SO4	Sulfate	1.80E+03	3.03E+02	8.67E+01	2.12E+01	1.00E+02	2.66E+01	4.74E+02
TCE	1,1,1-Trichloroethane	1.74E-02	1.42E-02	1.40E-02	1.79E-02	1.68E-02	1.28E-02	4.79E-02
TRICL	Trichloroethylene	5.59E-02	2.94E-02	2.03E-02	3.19E-02	4.85E-02	1.03E-01	5.85E-02
U3O8	Uranium	5.73E-01	1.12E+00	2.70E-01	3.85E-01	1.22E+00	4.15E-01	1.18E+01
ZN	Zinc	1.30E+00	2.77E+00	1.60E+00	1.67E+00	2.01E+00	1.90E+00	2.78E+00

Table 3
Calculated Concentrations at US Highway 301

Contaminant	1989 mg/l	1990 mg/l	1991 mg/l	1992 mg/l	1993 mg/l	1994 mg/l	1995 mg/l
AG	8.719E-06	1.596E-05	6.417E-06	4.900E-06	2.168E-03	4.106E-06	2.191E-03
AL	3.737E-04	3.435E-04	3.330E-04	1.494E-04	1.005E-03	1.038E-03	1.652E-03
AN	7.498E-05	4.141E-05	1.399E-04	2.166E-04	9.903E-05	1.297E-04	2.718E-04
AS	5.230E-05	2.992E-05	3.850E-05	2.939E-05	5.797E-05	4.105E-05	1.328E-04
BA	2.737E-04	1.237E-04	1.604E-04	1.068E-04	1.472E-04	1.084E-04	8.896E-05
BEN	2.229E-08	1.538E-09	6.536E-09	1.945E-09	1.680E-09	8.019E-10	3.261E-09
C	3.204E-04	3.561E-05	4.421E-05	2.799E-05	3.906E-05	2.622E-05	1.172E-05
CD	1.744E-04	9.973E-05	1.283E-04	9.799E-05	1.161E-04	8.227E-05	3.320E-05
CHL	1.671E-05	8.152E-06	1.043E-05	1.100E-05	3.325E-04	4.416E-04	3.316E-04
CN	2.800E-08	6.539E-09	4.902E-09	1.050E-08	1.244E-08	8.821E-09	2.210E-08
CR	4.844E-04	2.194E-04	2.740E-04	2.114E-04	3.656E-04	1.925E-04	7.511E-05
CU	2.343E-05	1.955E-05	8.994E-06	1.483E-05	1.055E-05	9.527E-06	9.899E-06
FE	1.440E-04	3.141E-04	3.094E-04	4.810E-05	5.315E-04	9.044E-05	3.657E-03
HG	1.874E-06	4.163E-06	2.682E-06	1.502E-06	5.084E-06	1.248E-06	2.091E-06
MN	1.669E-05	2.051E-05	1.990E-05	1.323E-05	1.704E-05	1.346E-05	1.165E-04
NI	6.452E-05	4.859E-05	6.547E-05	1.841E-05	2.959E-05	3.045E-05	6.963E-06
NO3	6.878E-03	2.698E-03	2.623E-03	3.503E-03	4.404E-03	4.920E-03	3.839E-03
O&G	1.211E-01	4.724E-02	1.359E-01	1.245E-01	3.133E-02	5.939E-02	2.989E-02
PB	1.241E-04	9.652E-05	8.878E-05	4.706E-05	2.829E-05	2.133E-04	1.408E-04
PERCL	1.164E-06	7.712E-07	8.292E-07	9.888E-07	1.368E-06	9.590E-07	2.248E-06
PHE	6.286E-08	6.923E-09	1.552E-08	8.946E-09	3.361E-09	4.811E-09	1.486E-08
PHOS	2.188E-03	6.556E-04	1.559E-03	3.218E-04	3.621E-04	3.019E-04	9.694E-04
SE	1.046E-04	5.983E-05	7.700E-05	5.878E-05	5.797E-05	4.926E-05	1.328E-04
SO4	1.026E-01	1.167E-02	3.541E-03	8.248E-04	3.374E-03	1.068E-03	1.719E-02
TCE	9.949E-07	5.446E-07	5.719E-07	6.951E-07	5.636E-07	5.128E-07	1.735E-06
TRICL	3.195E-06	1.130E-06	8.292E-07	1.242E-06	1.631E-06	4.136E-06	2.118E-06
U3O8	3.273E-05	4.309E-05	1.104E-05	1.498E-05	4.085E-05	1.664E-05	4.277E-04
ZN	7.442E-05	1.067E-04	7.762E-05	6.492E-05	6.742E-05	7.627E-05	1.006E-04

Table 4
Calculated Exposures from Ingestion of Carcinogenic Contaminants in Drinking Water

Contaminant	1989 mg/kg-day	1990 mg/kg-day	1991 mg/kg-day	1992 mg/kg-day	1993 mg/kg-day	1994 mg/kg-day	1995 mg/kg-day
AG	1.07E-07	1.95E-07	7.86E-08	6.00E-08	2.65E-05	5.03E-08	2.68E-05
AL	4.58E-06	4.21E-06	4.08E-06	1.83E-06	1.23E-05	1.27E-05	2.02E-05
AN	9.18E-07	5.07E-07	1.71E-06	2.65E-06	1.21E-06	1.59E-06	3.33E-06
AS	6.40E-07	3.66E-07	4.71E-07	3.60E-07	7.10E-07	5.03E-07	1.63E-06
BA	3.35E-06	1.51E-06	1.96E-06	1.31E-06	1.80E-06	1.33E-06	1.09E-06
BEN	2.73E-10	1.88E-11	8.00E-11	2.38E-11	2.06E-11	9.82E-12	3.99E-11
C	3.92E-06	4.36E-07	5.41E-07	3.43E-07	4.78E-07	3.21E-07	1.44E-07
CD	2.14E-06	1.22E-06	1.57E-06	1.20E-06	1.42E-06	1.01E-06	4.07E-07
CHL	2.05E-07	9.98E-08	1.28E-07	1.35E-07	4.07E-06	5.41E-06	4.06E-06
CN	3.43E-10	8.01E-11	6.00E-11	1.29E-10	1.52E-10	1.08E-10	2.71E-10
CR	5.93E-06	2.69E-06	3.36E-06	2.59E-06	4.48E-06	2.36E-06	9.20E-07
CU	2.87E-07	2.39E-07	1.10E-07	1.82E-07	1.29E-07	1.17E-07	1.21E-07
FE	1.76E-06	3.85E-06	3.79E-06	5.89E-07	6.51E-06	1.11E-06	4.48E-05
HG	2.29E-08	5.10E-08	3.28E-08	1.84E-08	6.23E-08	1.53E-08	2.56E-08
MN	2.04E-07	2.51E-07	2.44E-07	1.62E-07	2.09E-07	1.65E-07	1.43E-06
NI	7.90E-07	5.95E-07	8.02E-07	2.25E-07	3.62E-07	3.73E-07	8.53E-08
NO3	8.42E-05	3.30E-05	3.21E-05	4.29E-05	5.39E-05	6.02E-05	4.70E-05
O&G	1.48E-03	5.78E-04	1.66E-03	1.52E-03	3.84E-04	7.27E-04	3.66E-04
PB	1.52E-06	1.18E-06	1.09E-06	5.76E-07	3.46E-07	2.61E-06	1.72E-06
PERCL	1.43E-08	9.44E-09	1.02E-08	1.21E-08	1.68E-08	1.17E-08	2.75E-08
PHE	7.70E-10	8.48E-11	1.90E-10	1.10E-10	4.12E-11	5.89E-11	1.82E-10
PHOS	2.68E-05	8.03E-06	1.91E-05	3.94E-06	4.43E-06	3.70E-06	1.19E-05
SE	1.28E-06	7.33E-07	9.43E-07	7.20E-07	7.10E-07	6.03E-07	1.63E-06
SO4	1.26E-03	1.43E-04	4.34E-05	1.01E-05	4.13E-05	1.31E-05	2.10E-04
TCE	1.22E-08	6.67E-09	7.00E-09	8.51E-09	6.90E-09	6.28E-09	2.12E-08
TRICL	3.91E-08	1.38E-08	1.02E-08	1.52E-08	2.00E-08	5.06E-08	2.59E-08
U3O8	4.01E-07	5.28E-07	1.35E-07	1.83E-07	5.00E-07	2.04E-07	5.24E-06
ZN	9.11E-07	1.31E-06	9.50E-07	7.95E-07	8.26E-07	9.34E-07	1.23E-06

Table 5
Calculated Exposures from Ingestion of Noncarcinogenic Contaminants in Drinking Water

Contaminant	1989 mg/kg-day	1990 mg/kg-day	1991 mg/kg-day	1992 mg/kg-day	1993 mg/kg-day	1994 mg/kg-day	1995 mg/kg-day
AG	2.49E-07	4.56E-07	1.83E-07	1.40E-07	6.19E-05	1.17E-07	6.26E-05
AL	1.07E-05	9.81E-06	9.51E-06	4.27E-06	2.87E-05	2.97E-05	4.72E-05
AN	2.14E-06	1.18E-06	4.00E-06	6.19E-06	2.83E-06	3.71E-06	7.77E-06
AS	1.49E-06	8.55E-07	1.10E-06	8.40E-07	1.66E-06	1.17E-06	3.79E-06
BA	7.82E-06	3.53E-06	4.58E-06	3.05E-06	4.21E-06	3.10E-06	2.54E-06
BEN	6.37E-10	4.39E-11	1.87E-10	5.56E-11	4.80E-11	2.29E-11	9.32E-11
C	9.15E-06	1.02E-06	1.26E-06	8.00E-07	1.12E-06	7.49E-07	3.35E-07
CD	4.98E-06	2.85E-06	3.67E-06	2.80E-06	3.32E-06	2.35E-06	9.49E-07
CHL	4.77E-07	2.33E-07	2.98E-07	3.14E-07	9.50E-06	1.26E-05	9.47E-06
CN	8.00E-10	1.87E-10	1.40E-10	3.00E-10	3.55E-10	2.52E-10	6.31E-10
CR	1.38E-05	6.27E-06	7.83E-06	6.04E-06	1.04E-05	5.50E-06	2.15E-06
CU	6.69E-07	5.59E-07	2.57E-07	4.24E-07	3.01E-07	2.72E-07	2.83E-07
FE	4.11E-06	8.97E-06	8.84E-06	1.37E-06	1.52E-05	2.58E-06	1.04E-04
HG	5.35E-08	1.19E-07	7.66E-08	4.29E-08	1.45E-07	3.57E-08	5.97E-08
MN	4.77E-07	5.86E-07	5.69E-07	3.78E-07	4.87E-07	3.85E-07	3.33E-06
NI	1.84E-06	1.39E-06	1.87E-06	5.26E-07	8.45E-07	8.70E-07	1.99E-07
NO3	1.97E-04	7.71E-05	7.49E-05	1.00E-04	1.26E-04	1.41E-04	1.10E-04
O&G	3.46E-03	1.35E-03	3.88E-03	3.56E-03	8.95E-04	1.70E-03	8.54E-04
PB	3.55E-06	2.76E-06	2.54E-06	1.34E-06	8.08E-07	6.09E-06	4.02E-06
PERCL	3.33E-08	2.20E-08	2.37E-08	2.83E-08	3.91E-08	2.74E-08	6.42E-08
PHE	1.80E-09	1.98E-10	4.43E-10	2.56E-10	9.60E-11	1.37E-10	4.25E-10
PHOS	6.25E-05	1.87E-05	4.45E-05	9.19E-06	1.03E-05	8.63E-06	2.77E-05
SE	2.99E-06	1.71E-06	2.20E-06	1.68E-06	1.66E-06	1.41E-06	3.79E-06
SO4	2.93E-03	3.33E-04	1.01E-04	2.36E-05	9.64E-05	3.05E-05	4.91E-04
TCE	2.84E-08	1.56E-08	1.63E-08	1.99E-08	1.61E-08	1.47E-08	4.96E-08
TRICL	9.13E-08	3.23E-08	2.37E-08	3.55E-08	4.66E-08	1.18E-07	6.05E-08
U3O8	9.35E-07	1.23E-06	3.15E-07	4.28E-07	1.17E-06	4.75E-07	1.22E-05
ZN	2.13E-06	3.05E-06	2.22E-06	1.85E-06	1.93E-06	2.18E-06	2.87E-06

Table 6
Calculated Exposures to Carcinogenic Contaminants from Ingestion of Contaminated Fish

Contaminant	1989 mg/kg-day	1990 mg/kg-day	1991 mg/kg-day	1992 mg/kg-day	1993 mg/kg-day	1994 mg/kg-day	1995 mg/kg-day
AG	2.01E-05	1.17E-08	4.72E-09	3.61E-09	1.60E-06	3.02E-09	1.61E-06
AL	3.74E-03	1.09E-06	1.06E-06	4.76E-07	3.20E-06	3.31E-06	5.26E-06
AN							
AS	5.23E-03	9.54E-07	1.23E-06	9.37E-07	1.85E-06	1.31E-06	4.23E-06
BA	1.09E-03	1.58E-07	2.04E-07	1.36E-07	1.88E-07	1.38E-07	1.13E-07
BEN							
C	1.46E+00	5.16E-05	6.41E-05	4.06E-05	5.66E-05	3.80E-05	1.70E-05
CD	3.49E-02	6.36E-06	8.18E-06	6.25E-06	7.40E-06	5.24E-06	2.12E-06
CHL	8.36E-04	1.30E-07	1.66E-07	1.75E-07	5.30E-06	7.04E-06	5.28E-06
CN							
CR	9.69E-02	1.40E-05	1.75E-05	1.35E-05	2.33E-05	1.23E-05	4.79E-06
CU	1.17E-03	3.12E-07	1.43E-07	2.36E-07	1.68E-07	1.52E-07	1.58E-07
FE	1.44E-02	1.00E-05	9.86E-06	1.53E-06	1.69E-05	2.88E-06	1.17E-04
HG	1.87E-03	1.33E-06	8.55E-07	4.79E-07	1.62E-06	3.98E-07	6.66E-07
MN	6.68E-03	2.61E-06	2.54E-06	1.69E-06	2.17E-06	1.72E-06	1.49E-05
NI	6.45E-03	1.55E-06	2.09E-06	5.87E-07	9.43E-07	9.70E-07	2.22E-07
NO3							
O&G							
PB	1.24E-02	3.08E-06	2.83E-06	1.50E-06	9.02E-07	6.80E-06	4.49E-06
PERCL							
PHE							
PHOS	2.19E+02	2.09E-02	4.97E-02	1.03E-02	1.15E-02	9.62E-03	3.09E-02
SE	1.75E-02	3.18E-06	4.10E-06	3.13E-06	3.09E-06	2.62E-06	7.07E-06
SO4							
TCE							
TRICL							
U3O8	6.55E-05	2.75E-08	7.04E-09	9.55E-09	2.60E-08	1.06E-08	2.73E-07
ZN	1.49E-01	6.80E-05	4.95E-05	4.14E-05	4.30E-05	4.86E-05	6.41E-05

Table 7
Calculated Exposures to Noncarcinogenic Contaminants from Ingestion of Contaminated Fish

Contaminant	1989 mg/kg-day	1990 mg/kg-day	1991 mg/kg-day	1992 mg/kg-day	1993 mg/kg-day	1994 mg/kg-day	1995 mg/kg-day
AG	1.50E-08	2.74E-08	1.10E-08	8.42E-09	3.72E-06	7.05E-09	3.76E-06
AL	2.78E-06	2.55E-06	2.48E-06	1.11E-06	7.47E-06	7.72E-06	1.23E-05
AN							
AS	3.89E-06	2.22E-06	2.86E-06	2.19E-06	4.31E-06	3.05E-06	9.88E-06
BA	8.14E-07	3.68E-07	4.77E-07	3.18E-07	4.38E-07	3.22E-07	2.65E-07
BEN							
C	1.08E-03	1.20E-04	1.50E-04	9.47E-05	1.32E-04	8.87E-05	3.97E-05
CD	2.59E-05	1.48E-05	1.91E-05	1.46E-05	1.73E-05	1.22E-05	4.94E-06
CHL	6.21E-07	3.03E-07	3.88E-07	4.09E-07	1.24E-05	1.64E-05	1.23E-05
CN							
CR	7.20E-05	3.26E-05	4.08E-05	3.14E-05	5.44E-05	2.86E-05	1.12E-05
CU	8.71E-07	7.27E-07	3.34E-07	5.51E-07	3.92E-07	3.54E-07	3.68E-07
FE	1.07E-05	2.34E-05	2.30E-05	3.58E-06	3.95E-05	6.73E-06	2.72E-04
HG	1.39E-06	3.10E-06	1.99E-06	1.12E-06	3.78E-06	9.28E-07	1.55E-06
MN	4.96E-06	6.10E-06	5.92E-06	3.94E-06	5.07E-06	4.00E-06	3.47E-05
NI	4.80E-06	3.61E-06	4.87E-06	1.37E-06	2.20E-06	2.26E-06	5.18E-07
NO3							
O&G							
PB	9.23E-06	7.18E-06	6.60E-06	3.50E-06	2.10E-06	1.59E-05	1.05E-05
PERCL							
PHE							
PHOS	1.63E-01	4.88E-02	1.16E-01	2.39E-02	2.69E-02	2.25E-02	7.21E-02
SE	1.30E-05	7.43E-06	9.56E-06	7.30E-06	7.20E-06	6.12E-06	1.65E-05
SO4							
TCE							
TRICL							
U3O8	4.87E-08	6.41E-08	1.64E-08	2.23E-08	6.08E-08	2.47E-08	6.36E-07
ZN	1.11E-04	1.59E-04	1.15E-04	9.66E-05	1.00E-04	1.13E-04	1.50E-04

Table 8
Calculated Exposures from Dermal Contact with Carcinogenic Contaminants in Water While Swimming

Contaminant	1989 mg/kg-day	1990 mg/kg-day	1991 mg/kg-day	1992 mg/kg-day	1993 mg/kg-day	1994 mg/kg-day	1995 mg/kg-day
AG	3.79E-11	6.93E-11	2.79E-11	2.13E-11	9.42E-09	1.78E-11	9.52E-09
AL	1.62E-09	1.49E-09	1.45E-09	6.49E-10	4.37E-09	4.51E-09	7.18E-09
AN	3.26E-10	1.80E-10	6.08E-10	9.41E-10	4.30E-10	5.63E-10	1.18E-09
AS	2.27E-10	1.30E-10	1.67E-10	1.28E-10	2.52E-10	1.78E-10	5.77E-10
BA	1.19E-09	5.37E-10	6.97E-10	4.64E-10	6.39E-10	4.71E-10	3.86E-10
BEN	9.68E-14	6.68E-15	2.84E-14	8.45E-15	7.30E-15	3.48E-15	1.42E-14
C	1.39E-09	1.55E-10	1.92E-10	1.22E-10	1.70E-10	1.14E-10	5.09E-11
CD	7.58E-10	4.33E-10	5.57E-10	4.26E-10	5.04E-10	3.57E-10	1.44E-10
CHL	7.26E-11	3.54E-11	4.53E-11	4.78E-11	1.44E-09	1.92E-09	1.44E-09
CN	1.22E-13	2.84E-14	2.13E-14	4.56E-14	5.40E-14	3.83E-14	9.60E-14
CR	2.10E-09	9.53E-10	1.19E-09	9.18E-10	1.59E-09	8.36E-10	3.26E-10
CU	1.02E-10	8.49E-11	3.91E-11	6.44E-11	4.58E-11	4.14E-11	4.30E-11
FE	6.26E-10	1.36E-09	1.34E-09	2.09E-10	2.31E-09	3.93E-10	1.59E-08
HG	8.14E-12	1.81E-11	1.17E-11	6.53E-12	2.21E-11	5.42E-12	9.08E-12
MN	7.25E-11	8.91E-11	8.65E-11	5.75E-11	7.40E-11	5.85E-11	5.06E-10
NI	2.80E-10	2.11E-10	2.84E-10	8.00E-11	1.29E-10	1.32E-10	3.02E-11
NO3	2.99E-08	1.17E-08	1.14E-08	1.52E-08	1.91E-08	2.14E-08	1.67E-08
O&G	5.26E-07	2.05E-07	5.90E-07	5.41E-07	1.36E-07	2.58E-07	1.30E-07
PB	5.39E-10	4.19E-10	3.86E-10	2.04E-10	1.23E-10	9.27E-10	6.12E-10
PERCL	5.06E-12	3.35E-12	3.60E-12	4.30E-12	5.94E-12	4.17E-12	9.77E-12
PHE	2.73E-13	3.01E-14	6.74E-14	3.89E-14	1.46E-14	2.09E-14	6.46E-14
PHOS	9.51E-09	2.85E-09	6.77E-09	1.40E-09	1.57E-09	1.31E-09	4.21E-09
SE	4.54E-10	2.60E-10	3.35E-10	2.55E-10	2.52E-10	2.14E-10	5.77E-10
SO4	4.46E-07	5.07E-08	1.54E-08	3.58E-09	1.47E-08	4.64E-09	7.47E-08
TCE	4.32E-12	2.37E-12	2.48E-12	3.02E-12	2.45E-12	2.23E-12	7.54E-12
TRICL	1.39E-11	4.91E-12	3.60E-12	5.40E-12	7.09E-12	1.80E-11	9.20E-12
U3O8	1.42E-10	1.87E-10	4.80E-11	6.51E-11	1.77E-10	7.23E-11	1.86E-09
ZN	3.23E-10	4.64E-10	3.37E-10	2.82E-10	2.93E-10	3.31E-10	4.37E-10

Table 9
Calculated Exposures from Dermal Contact with Noncarcinogenic Contaminants in Water While Swimming

Contaminant	1989 mg/kg-day	1990 mg/kg-day	1991 mg/kg-day	1992 mg/kg-day	1993 mg/kg-day	1994 mg/kg-day	1995 mg/kg-day
AG	8.84E-11	1.62E-10	6.50E-11	4.97E-11	2.20E-08	4.16E-11	2.22E-08
AL	3.79E-09	3.48E-09	3.38E-09	1.51E-09	1.02E-08	1.05E-08	1.67E-08
AN	7.60E-10	4.20E-10	1.42E-09	2.20E-09	1.00E-09	1.31E-09	2.76E-09
AS	5.30E-10	3.03E-10	3.90E-10	2.98E-10	5.88E-10	4.16E-10	1.35E-09
BA	2.77E-09	1.25E-09	1.63E-09	1.08E-09	1.49E-09	1.10E-09	9.02E-10
BEN	2.26E-13	1.56E-14	6.63E-14	1.97E-14	1.70E-14	8.13E-15	3.31E-14
C	3.25E-09	3.61E-10	4.48E-10	2.84E-10	3.96E-10	2.66E-10	1.19E-10
CD	1.77E-09	1.01E-09	1.30E-09	9.93E-10	1.18E-09	8.34E-10	3.37E-10
CHL	1.69E-10	8.26E-11	1.06E-10	1.12E-10	3.37E-09	4.48E-09	3.36E-09
CN	2.84E-13	6.63E-14	4.97E-14	1.06E-13	1.26E-13	8.94E-14	2.24E-13
CR	4.91E-09	2.22E-09	2.78E-09	2.14E-09	3.71E-09	1.95E-09	7.61E-10
CU	2.38E-10	1.98E-10	9.12E-11	1.50E-10	1.07E-10	9.66E-11	1.00E-10
FE	1.46E-09	3.18E-09	3.14E-09	4.88E-10	5.39E-09	9.17E-10	3.71E-08
HG	1.90E-11	4.22E-11	2.72E-11	1.52E-11	5.15E-11	1.27E-11	2.12E-11
MN	1.69E-10	2.08E-10	2.02E-10	1.34E-10	1.73E-10	1.36E-10	1.18E-09
NI	6.54E-10	4.93E-10	6.64E-10	1.87E-10	3.00E-10	3.09E-10	7.06E-11
NO3	6.97E-08	2.73E-08	2.66E-08	3.55E-08	4.46E-08	4.99E-08	3.89E-08
O&G	1.23E-06	4.79E-07	1.38E-06	1.26E-06	3.18E-07	6.02E-07	3.03E-07
PB	1.26E-09	9.78E-10	9.00E-10	4.77E-10	2.87E-10	2.16E-09	1.43E-09
PERCL	1.18E-11	7.82E-12	8.41E-12	1.00E-11	1.39E-11	9.72E-12	2.28E-11
PHE	6.37E-13	7.02E-14	1.57E-13	9.07E-14	3.41E-14	4.88E-14	1.51E-13
PHOS	2.22E-08	6.65E-09	1.58E-08	3.26E-09	3.67E-09	3.06E-09	9.83E-09
SE	1.06E-09	6.06E-10	7.81E-10	5.96E-10	5.88E-10	4.99E-10	1.35E-09
SO4	1.04E-06	1.18E-07	3.59E-08	8.36E-09	3.42E-08	1.08E-08	1.74E-07
TCE	1.01E-11	5.52E-12	5.80E-12	7.05E-12	5.71E-12	5.20E-12	1.76E-11
TRICL	3.24E-11	1.15E-11	8.41E-12	1.26E-11	1.65E-11	4.19E-11	2.15E-11
U3O8	3.32E-10	4.37E-10	1.12E-10	1.52E-10	4.14E-10	1.69E-10	4.34E-09
ZN	7.54E-10	1.08E-09	7.87E-10	6.58E-10	6.83E-10	7.73E-10	1.02E-09

Table 10
Contaminants' Toxicity

Contaminant	RfD mg/kg/day	SF mg/kg-day
AG	5.00E-03	Not Available
AL	Compare to Permit	Compare to Permit
AN	Not Available	Not Available
AS	3.00E-04	2.00E+00
BA	7.00E-02	Not Available
BEN	Pending	3.00E-02
C	Compare to Permit	Compare to Permit
CD	5.00E-04	Not Available
CHL	Compare to Permit	Compare to Permit
CN	2.00E-02	Not Available
CR	5.00E-03	Not Available
CU	3.70E-02	Not Available
FE	Compare to Permit	Compare to Permit
HG	3.00E-04	None
MN	5.00E-03	Not Available
NI	2.00E-02	Not Available
NO3	1.00E-01	Pending
O&G	Compare to Permit	Compare to Permit
PB	Not Available	Not Available
PERCL	1.00E-01	5.00E-02
PHE	6.00E-01	None
PHOS	Compare to Permit	Compare to Permit
SE	5.00E-03	None
SO4	Compare to Permit	Compare to Permit
TCE	Under Review	Not Available
TRICL	Under Review	Under Review
U3O8	3.00E-03	Not Available
ZN	3.00E-01	None

Table 11
Estimated Cancer Risks for Contaminants Released from SRS Outfalls

Contaminant	1989				1990			
	Drinking Water	Ingestion of Fish	Swimming	Total Exposure Cancer Risk	Drinking Water	Ingestion of Fish	Swimming	Total Exposure Cancer Risk
AG								
AL								
AN								
AS	1.28E-06	3.33E-06	4.54E-10		7.33E-07	1.91E-06	2.60E-10	
BA								
BEN	8.19E-12		2.91E-15		5.65E-13		2.00E-16	
C								
CD								
CHL								
CN								
CR								
CU								
FE								
HG								
MN								
NI								
NO3								
O&G								
PB								
PERCL	7.13E-10		2.53E-13		4.72E-10		1.68E-13	
PHE								
PHOS								
SE								
SO4								
TCE								
TRICL								
U3O8								
ZN								
Total Risk	1.28E-06	3.33E-06	4.55E-10	4.62E-06	7.33E-07	1.91E-06	2.60E-10	2.64E-06

WESTINGHOUSE SAVANNAH RIVER COMPANY

WSRC-RP-96-555

Table 11 (continued)
Estimated Cancer Risks for Contaminants Released from SRS Outfalls

Contaminant	1991				1992			
	Drinking Water	Ingestion of Fish	Swimming	Total Exposure Cancer Risk	Drinking Water	Ingestion of Fish	Swimming	Total Exposure Cancer Risk
AG								
AL								
AN								
AS	9.43E-07	2.45E-06	3.35E-10		7.20E-07	1.87E-06	2.55E-10	
BA								
BEN	2.40E-12		8.52E-16		7.14E-13		2.53E-16	
C								
CD								
CHL								
CN								
CR								
CU								
FE								
HG								
MN								
NI								
NO3								
O&G								
PB								
PERCL	5.08E-10		1.80E-13		6.05E-10		2.15E-13	
PHE								
PHOS								
SE								
SO4								
TCE								
TRICL								
U3O8								
ZN								
Total Risk	9.43E-07	2.45E-06	3.35E-10	3.40E-06	7.20E-07	1.87E-06	2.56E-10	2.59E-06

Table 11 (continued)
Estimated Cancer Risks for Contaminants Released from SRS Outfalls

Contaminant	1993				1994			
	Drinking Water	Ingestion of Fish	Swimming	Total Exposure Cancer Risk	Drinking Water	Ingestion of Fish	Swimming	Total Exposure Cancer Risk
AG								
AL								
AN								
AS	1.42E-06	3.70E-06	5.04E-10		1.01E-06	2.62E-06	3.57E-10	
BA								
BEN	6.17E-13		2.19E-16		2.95E-13		1.05E-16	
C								
CD								
CHL								
CN								
CR								
CU								
FE								
HG								
MN								
NI								
NO3								
O&G								
PB								
PERCL	8.38E-10		2.97E-13		5.87E-10		2.08E-13	
PHE								
PHOS								
SE								
SO4								
TCE								
TRICL								
U3O8								
ZN								
Total Risk	1.42E-06	3.70E-06	5.04E-10	5.12E-06	1.01E-06	2.62E-06	3.57E-10	3.62E-06

Table 11 (continued)
Estimated Cancer Risks for Contaminants Released from SRS Outfalls

Contaminant	1995			
	Drinking Water	Ingestion of Fish	Swimming	Total Exposure Cancer Risk
AG				
AL				
AN				
AS	3.25E-06	8.46E-06	1.15E-09	
BA				
BEN	1.20E-12		4.25E-16	
C				
CD				
CHL				
CN				
CR				
CU				
FE				
HG				
MN				
NI				
NO3				
O&G				
PB				
PERCL	1.38E-09		4.88E-13	
PHE				
PHOS				
SE				
SO4				
TCE				
TRICL				
U3O8				
ZN				
Total Risk	3.25E-06	8.46E-06	1.15E-09	1.17E-05

Table 12
Estimated Chronic Noncarcinogenic Hazard Quotients for Contaminants Released from SRS Outfalls

Contaminant	1989				1990			
	Drinking Water	Ingestion of	Swimming Fish	Total Exposure Hazard Index	Drinking Water	Ingestion of Fish	Swimming	Total Exposure Hazard Index
AG	4.98E-05	3.00E-06	1.77E-08		9.12E-05	5.48E-06	3.24E-08	
AL								
AN								
AS	4.98E-03	1.30E-02	1.77E-06		2.85E-03	7.42E-03	1.01E-06	
BA	1.12E-04	1.16E-05	3.96E-08		5.05E-05	5.26E-06	1.79E-08	
BEN								
C								
CD	9.97E-03	5.19E-02	3.54E-06		5.70E-03	2.97E-02	2.02E-06	
CHL								
CN	4.00E-08		1.42E-11		9.34E-09		3.31E-12	
CR	2.77E-03	1.44E-02	9.82E-07		1.25E-03	6.53E-03	4.45E-07	
CU	1.81E-05	2.35E-05	6.42E-09		1.51E-05	1.96E-05	5.36E-09	
FE								
HG	1.78E-04	4.65E-03	6.33E-08		3.96E-04	1.03E-02	1.41E-07	
MN	9.54E-05	9.93E-04	3.38E-08		1.17E-04	1.22E-03	4.16E-08	
NI	9.22E-05	2.40E-04	3.27E-08		6.94E-05	1.81E-04	2.46E-08	
NO3	1.97E-03		6.97E-07		7.71E-04		2.73E-07	
O&G								
PB								
PERCL	3.33E-06		1.18E-09		2.20E-06		7.82E-10	
PHE	2.99E-09		1.06E-12		3.30E-10		1.17E-13	
PHOS								
SE	5.98E-04	2.60E-03	2.12E-07		3.42E-04	1.49E-03	1.21E-07	
SO4								
TCE								
TRICL								
U3O8	3.12E-04	1.62E-05	1.11E-07		4.10E-04	2.14E-05	1.46E-07	
ZN	7.09E-06	3.69E-04	2.51E-09		1.02E-05	5.29E-04	3.61E-09	
Hazard Index	2.11E-02	8.81E-02	7.50E-06	1.09E-01	1.21E-02	5.74E-02	4.28E-06	6.95E-02

Table 12 (continued)
Estimated Chronic Noncarcinogenic Hazard Quotients for Contaminants Released from SRS Outfalls

Contaminant	1991				1992			
	Drinking Water	Ingestion of	Swimming Fish	Total Exposure Hazard Index	Drinking Water	Ingestion of Fish	Swimming	Total Exposure Hazard Index
AG	3.67E-05	2.20E-06	1.30E-08		2.80E-05	1.68E-06	9.93E-09	
AL								
AN								
AS	3.67E-03	9.54E-03	1.30E-06		2.80E-03	7.29E-03	9.93E-07	
BA	6.55E-05	6.82E-06	2.32E-08		4.36E-05	4.54E-06	1.55E-08	
BEN								
C								
CD	7.33E-03	3.82E-02	2.60E-06		5.60E-03	2.91E-02	1.99E-06	
CHL								
CN	7.00E-09		2.48E-12		1.50E-08		5.32E-12	
CR	1.57E-03	8.15E-03	5.55E-07		1.21E-03	6.29E-03	4.29E-07	
CU	6.95E-06	9.04E-06	2.46E-09		1.15E-05	1.49E-05	4.06E-09	
FE								
HG	2.55E-04	6.65E-03	9.06E-08		1.43E-04	3.72E-03	5.08E-08	
MN	1.14E-04	1.18E-03	4.03E-08		7.56E-05	7.87E-04	2.68E-08	
NI	9.35E-05	2.43E-04	3.32E-08		2.63E-05	6.85E-05	9.33E-09	
NO3	7.49E-04		2.66E-07		1.00E-03		3.55E-07	
O&G								
PB								
PERCL	2.37E-06		8.41E-10		2.83E-06		1.00E-09	
PHE	7.39E-10		2.62E-13		4.26E-10		1.51E-13	
PHOS								
SE	4.40E-04	1.91E-03	1.56E-07		3.36E-04	1.46E-03	1.19E-07	
SO4								
TCE								
TRICL								
U3O8	1.05E-04	5.47E-06	3.73E-08		1.43E-04	7.43E-06	5.06E-08	
ZN	7.39E-06	3.85E-04	2.62E-09		6.18E-06	3.22E-04	2.19E-09	
Hazard Index	1.44E-02	6.63E-02	5.12E-06	8.07E-02	1.14E-02	4.91E-02	4.05E-06	6.05E-02

Table 12 (continued)
Estimated Chronic Noncarcinogenic Hazard Quotients for Contaminants Released from SRS Outfalls

Contaminant	1993				1994			
	Drinking Water	Ingestion of	Swimming Fish	Total Exposure Hazard Index	Drinking Water	Ingestion of Fish	Swimming	Total Exposure Hazard Index
AG	1.24E-02	7.45E-04	4.40E-06		2.35E-05	1.41E-06	8.32E-09	
AL								
AN								
AS	5.52E-03	1.44E-02	1.96E-06		3.91E-03	1.02E-02	1.39E-06	
BA	6.01E-05	6.26E-06	2.13E-08		4.42E-05	4.61E-06	1.57E-08	
BEN								
C								
CD	6.63E-03	3.45E-02	2.35E-06		4.70E-03	2.45E-02	1.67E-06	
CHL								
CN	1.78E-08		6.30E-12		1.26E-08		4.47E-12	
CR	2.09E-03	1.09E-02	7.41E-07		1.10E-03	5.73E-03	3.90E-07	
CU	8.15E-06	1.06E-05	2.89E-09		7.36E-06	9.57E-06	2.61E-09	
FE								
HG	4.84E-04	1.26E-02	1.72E-07		1.19E-04	3.09E-03	4.22E-08	
MN	9.74E-05	1.01E-03	3.45E-08		7.69E-05	8.01E-04	2.73E-08	
NI	4.23E-05	1.10E-04	1.50E-08		4.35E-05	1.13E-04	1.54E-08	
NO3	1.26E-03		4.46E-07		1.41E-03		4.99E-07	
O&G								
PB								
PERCL	3.91E-06		1.39E-09		2.74E-06		9.72E-10	
PHE	1.60E-10		5.68E-14		2.29E-10		8.13E-14	
PHOS								
SE	3.31E-04	1.44E-03	1.18E-07		2.81E-04	1.22E-03	9.99E-08	
SO4								
TCE								
TRICL								
U3O8	3.89E-04	2.03E-05	1.38E-07		1.58E-04	8.25E-06	5.62E-08	
ZN	6.42E-06	3.34E-04	2.28E-09		7.26E-06	3.78E-04	2.58E-09	
Hazard Index	2.93E-02	7.61E-02	1.04E-05	1.05E-01	1.19E-02	4.60E-02	4.22E-06	5.79E-02

Table 12 (continued)
Estimated Chronic Noncarcinogenic Hazard Quotients for Contaminants Released from SRS Outfalls

<u>Contaminant</u>	1995			Total Exposure Hazard Index
	Drinking Water	Ingestion of	Swimming Fish	
AG	1.25E-02	7.53E-04	4.44E-06	
AL				
AN				
AS	1.26E-02	3.29E-02	4.49E-06	
BA	3.63E-05	3.78E-06	1.29E-08	
BEN				
C				
CD	1.90E-03	9.88E-03	6.73E-07	
CHL				
CN	3.16E-08		1.12E-11	
CR	4.29E-04	2.23E-03	1.52E-07	
CU	7.64E-06	9.95E-06	2.71E-09	
FE				
HG	1.99E-04	5.18E-03	7.07E-08	
MN	6.66E-04	6.93E-03	2.36E-07	
NI	9.95E-06	2.59E-05	3.53E-09	
NO3	1.10E-03		3.89E-07	
O&G				
PB				
PERCL	6.42E-06		2.28E-09	
PHE	7.08E-10		2.51E-13	
PHOS				
SE	7.59E-04	3.30E-03	2.69E-07	
SO4				
TCE				
TRICL				
U3O8	4.07E-03	2.12E-04	1.45E-06	
ZN	9.58E-06	4.99E-04	3.40E-09	
Hazard Index	3.44E-02	6.19E-02	1.22E-05	9.63E-02

Table 13
Critical Contaminant Ranking Based on Total Exposure Cancer Risk

1989		1990		1991		1992		1993		1994		1995	
RISK		RISK		RISK		RISK		RISK		RISK		RISK	
AS	4.61E-06	AS	2.64E-06	AS	3.40E-06	AS	2.59E-06	AS	5.12E-06	AS	3.62E-06	AS	1.17E-05
PERCL	7.13E-10	PERCL	4.72E-10	PERCL	5.08E-10	PERCL	6.06E-10	PERCL	8.38E-10	PERCL	5.87E-10	PERCL	1.38E-09
BEN	8.19E-12	BEN	5.65E-13	BEN	2.40E-12	BEN	7.15E-13	BEN	6.17E-13	BEN	2.95E-13	BEN	1.20E-12
AG		AG		AG		AG		AG		AG		AG	
AL		AL		AL		AL		AL		AL		AL	
AN		AN		AN		AN		AN		AN		AN	
BA		BA		BA		BA		BA		BA		BA	
C		C		C		C		C		C		C	
CD		CD		CD		CD		CD		CD		CD	
CHL		CHL		CHL		CHL		CHL		CHL		CHL	
CN		CN		CN		CN		CN		CN		CN	
CR		CR		CR		CR		CR		CR		CR	
CU		CU		CU		CU		CU		CU		CU	
FE		FE		FE		FE		FE		FE		FE	
HG		HG		HG		HG		HG		HG		HG	
MN		MN		MN		MN		MN		MN		MN	
NI		NI		NI		NI		NI		NI		NI	
NO3		NO3		NO3		NO3		NO3		NO3		NO3	
O&G		O&G		O&G		O&G		O&G		O&G		O&G	
PB		PB		PB		PB		PB		PB		PB	
PHE		PHE		PHE		PHE		PHE		PHE		PHE	
PHOS		PHOS		PHOS		PHOS		PHOS		PHOS		PHOS	
SE		SE		SE		SE		SE		SE		SE	
SO4		SO4		SO4		SO4		SO4		SO4		SO4	
TCE		TCE		TCE		TCE		TCE		TCE		TCE	
TRICL		TRICL		TRICL		TRICL		TRICL		TRICL		TRICL	
U308		U308		U308		U308		U308		U308		U308	
ZN		ZN		ZN		ZN		ZN		ZN		ZN	

Table 14
Critical Contaminant Ranking Based on Total Exposure Hazard Quotient

1989		1990		1991		1992		1993		1994		1995	
HQ		HQ		HQ		HQ		HQ		HQ		HQ	
CD	6.18E-02	CD	3.54E-02	CD	4.55E-02	CD	3.47E-02	CD	4.12E-02	CD	2.92E-02	AS	4.56E-02
AS	1.79E-02	HG	1.07E-02	AS	1.32E-02	AS	1.01E-02	AS	1.99E-02	AS	1.41E-02	AG	1.33E-02
CR	1.72E-02	AS	1.03E-02	CR	9.72E-03	CR	7.50E-03	AG	1.31E-02	CR	6.83E-03	CD	1.18E-02
HG	4.82E-03	CR	7.78E-03	HG	6.90E-03	HG	3.87E-03	HG	1.31E-02	HG	3.21E-03	MN	7.60E-03
SE	3.20E-03	SE	1.83E-03	SE	2.35E-03	SE	1.80E-03	CR	1.30E-02	SE	1.51E-03	HG	5.38E-03
NO3	1.97E-03	MN	1.34E-03	MN	1.30E-03	NO3	1.00E-03	SE	1.77E-03	NO3	1.41E-03	U3O8	4.29E-03
MN	1.09E-03	NO3	7.71E-04	NO3	7.50E-04	MN	8.63E-04	NO3	1.26E-03	MN	8.78E-04	SE	4.06E-03
ZN	3.76E-04	ZN	5.39E-04	ZN	3.92E-04	ZN	3.28E-04	MN	1.11E-03	ZN	3.85E-04	CR	2.66E-03
NI	3.32E-04	U3O8	4.32E-04	NI	3.37E-04	U3O8	1.50E-04	U3O8	4.09E-04	U3O8	1.67E-04	NO3	1.10E-03
U3O8	3.28E-04	NI	2.50E-04	U3O8	1.11E-04	NI	9.48E-05	NI	3.41E-04	NI	1.57E-04	ZN	5.08E-04
BA	1.23E-04	AG	9.67E-05	BA	7.23E-05	BA	4.81E-05	BA	1.52E-04	BA	4.89E-05	BA	4.01E-05
AG	5.28E-05	BA	5.58E-05	AG	3.89E-05	AG	2.97E-05	BA	6.64E-05	AG	2.49E-05	NI	3.58E-05
CU	4.16E-05	CU	3.47E-05	CU	1.60E-05	CU	2.64E-05	CU	1.88E-05	CU	1.69E-05	CU	1.76E-05
PERCL	3.33E-06	PERCL	2.20E-06	PERCL	2.37E-06	PERCL	2.83E-06	PERCL	3.91E-06	PERCL	2.74E-06	PERCL	6.43E-06
CN	4.00E-08	CN	9.34E-09	CN	7.01E-09	CN	1.50E-08	CN	1.78E-08	CN	1.26E-08	CN	3.16E-08
PHE	2.99E-09	PHE	3.30E-10	PHE	7.39E-10	PHE	4.26E-10	PHE	1.60E-10	PHE	2.29E-10	PHE	7.08E-10
AL		AL		AL		AL		AL		AL		AL	
AN		AN		AN		AN		AN		AN		AN	
BEN		BEN		BEN		BEN		BEN		BEN		BEN	
C		C		C		C		C		C		C	
CHL		CHL		CHL		CHL		CHL		CHL		CHL	
FE		FE		FE		FE		FE		FE		FE	
O&G		O&G		O&G		O&G		O&G		O&G		O&G	
PB		PB		PB		PB		PB		PB		PB	
PHOS		PHOS		PHOS		PHOS		PHOS		PHOS		PHOS	
SO4		SO4		SO4		SO4		SO4		SO4		SO4	
TCE		TCE		TCE		TCE		TCE		TCE		TCE	
TRICL		TRICL		TRICL		TRICL		TRICL	TRICL	TRICL			

HQ: Harzard Quotient

**CRITICAL CONTAMINANT/CRITICAL PATHWAY ANALYSIS -
SURFACE WATER TRANSPORT FOR NONRADIOACTIVE
CONTAMINANTS(U)**

DISTRIBUTION

A. L. Boni, 773A
R. P. Addis, 773A
G. T. Jannik, 773A
W. H. Carlton, 773A
A. A. Simpkins, 773A
D. B. Moore-Shedrow, 773-A
J. B. Gladden, 773-42A
C. E. Murphy, Jr. 773-42A
W. A. Emel, 735-A
B. L. O'Steen, 773-A
A. J. Garrett, 773-A
D. W. Hayes, 735-A
D. P. Griggs, 773-A
C. H. Hunter, 773-A
Kuo-Fu Chen, 773-A

SRTC Records(4), 773-52A
ETG Records(5), 773-A