

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

by

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MASTER

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

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SAVANNAH RIVER SITE

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Key Words

WASP5 CRITICAL CONTAMINANT OUTFALLS HEALTH RISK CANCER
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Retention: Lifetime

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

Kuo-Fu Chen

Issued: NOVEMBER 1996

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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.

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

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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:

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

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.
- ok 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.
- ok 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.
- ok 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.
- ok 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.
- ok 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																
OOD	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		
U3O8	Uranium																
ZN	Zinc																

Table 1 (continued)														
Contaminants Released from the Savannah River Site Outfalls														
OUTFALLS														
CONTAMINANT	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
AG Silver														
AL Aluminum														
AN Ammonia														X
AS Arsenic														X
BA Barium														
BEN Benzene														
BOD Biochemical Oxygen Demand						X	X			X	X			
C Carbon														
CD Cadmium														
CHL Chlorine							X							
CN Cyanide														
COO 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
U308 Uranium														X
ZN Zinc														X

Table 1 (continued)														
Contaminants Released from the Savannah River Site Outfalls														
OUTFALLS														
CONTAMINANT	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
AG Silver														
AL Aluminum		X	X										X	
AN Ammonia		X	X										X	
AS Arsenic														
BA Barium														
BEN Benzene														
BOD Biochemical Oxygen Demand	X													
C Carbon						X	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	
PB Lead		X	X										X	
PERCL Tetrachloroethylene														
PHE Phenol														
PHOS Phosphate														
SE Selenium														
SO4 Sulfate													X	
TCE 1,1,1-Trichloroethane														
TRIOL 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															
									</								

		Table 1 (continued)															
		Contaminants Released from the Savannah River Site Outfalls															
		OUTFALLS															
		T-005	T-007	X-004	X-008	X-011	X-013	X-014	X-014 etp	X-014 or	Y-001	A-001A	A-028	A-029	K-018	X-008A	
CONTAMINANT																	
AG	Silver																
AL	Aluminum				X								X		X		
AN	Ammonia																
AS	Arsenic																
BA	Barium												X				
BEN	Benzene							X	X	X							
BOD	Biochemical Oxygen Demand	X	X			X		X	X	X	X				X	X	
C	Carbon							X	X	X							
CD	Cadmium																
CHL	Chlorine		X										X		X		
CN	Cyanide																
COO	Chemical Oxygen Demand																
CR	Chromium																
CU	Copper																
DO	Dissolved Oxygen																
FE	Iron				X												
FEC	Fecal Coliform					X									X	X	
HG	Mercury							X									
MG	Magnesium																
MN	Manganese																
NI	Nickel																
NO3	Nitrate																
O&G	Oil & Grease	X		X	X			X			X			X			
PB	Lead																
PERCL	Tetrachloroethylene																
PHE	Phenol							X		X		X					
PHOS	Phosphate																
SE	Selenium																
SO4	Sulfate																
TCE	1,1,1-Trichloroethane																
TRICL	Trichloroethylene											X			X	X	
TSS	Total Suspended Solid	X	X	X	X		X	X			X		X		X	X	
U3O8	Uranium																
ZN	Zinc																

Table 2
Calculated Source Terms for Contaminants Released from SRS Outfalls

Contaminant	1989	1990	1991	1992	1993	1994	1995
	kg/day	kg/day	kg/day	kg/day	kg/day	kg/day	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							
U308	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

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			Total Exposure Cancer Risk
	Drinking Water	Ingestion of Fish	Swimming	
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 Fish	Swimming Fish	Total Exposure Hazard Index	Drinking Water	Ingestion of Fish	Swimming Fish	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 Fish	Swimming Fish	Total Exposure Hazard Index	Drinking Water	Ingestion of Fish	Swimming Fish	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 Fish	Swimming Fish	Total Exposure Hazard Index	Drinking Water	Ingestion of Fish	Swimming Fish	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

Contaminant	1995			Total Exposure Hazard Index
	Drinking Water	Ingestion of Fish	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	NO3 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
U3O8 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
BA 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
AG 1.23E-04	AG 9.67E-05	BA 7.23E-05	BA 4.81E-05	NI 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: Hazard Quotient

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