



SHIELD SOURCE INCORPORATED

April 2002

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# **ENVIRONMENTAL MONITORING PROGRAM ANNUAL REPORT**

## **YEAR 2002**

**Submitted to:**

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## **1. INTRODUCTION**

### **1.1 Purpose**

This Environmental Monitoring report is to be the environmental monitoring portion of Shield Source Incorporated (SSI) 2002 Annual Report. This report contains a summary of the environmental monitoring results including stack emissions, air, water, milk and vegetation monitoring data. Stack emissions have been compared with the environmental monitoring data and dose to the receptor group has been calculated.

### **1.2 Background Information**

Golder Associates was retained to review the Shield Source Environmental Monitoring Program (EMP) and produced a revised EMP including new Derived Release Limits (DRL) for implementation in 2000 (Golder 2000). The CNSC reviewed this report and provided a list of comments and suggestion in a letter to Shield Source (CNSC 2000). SSI/ Golder incorporated the changes suggested by the CNSC (CNSC 2000) in the proposed EMP and recalculated the DRLs under separate cover in July 2001 (Golder 2001). CNSC reviewed the revised documents and made an additional list of comments in a letter to SSI (CNSC August 2002). CNSC concluded that the calculations for the proposed DRLs for HTO and HT emissions for SSI were acceptable and it was requested that SSI commence the preparation of a formal training program and implement the proposed EMP sampling regime. However, CNSC requested SSI to address the comments and to submit revised EMP and DRL documents for final approval. Therefore, SSI/Golder submitted the revised documents in November 2002.

### **1.3 Land Use Within the Monitoring Program Area**

On February 30, 2001, [REDACTED] of Golder Associates' Whitby Office accompanied by the Production Supervisor of SSI, conducted a land use survey within the monitoring program area. Specifically, the land use survey was conducted in eastern North Monaghan Township, adjacent to the SSI facility, and in western Otonabee Township, within a 10 km radius of the SSI facility. The portions of the two townships included in the survey are located in the prevailing down-wind direction from the SSI facility. The description of the land use within the monitoring area was given in SSI's report entitled "2000 Annual Report On Environmental Monitoring Program" submitted by Golder in April 2001.

SSI conducted a second survey in November 2001 finding no changes from the initial survey. A third survey was conducted in December 2002 finding no changes from the initial survey.

### **1.4 Environmental Monitoring Locations**

The sampling locations and distances from the stack are summarized in Table 1. There are a total of 24 stations in which the following samples are collected:

- 7 stations at which both ambient air and water samples were collected,
- 2 stations at which ambient air, ambient water and vegetation samples were collected,
- 1 station at which an ambient water and a vegetation sample was collected,
- 6 stations at which just ambient air samples were collected,
- 7 stations at which just water samples were collected, and
- 1 station at which a milk sample was collected.

A map of the environmental monitoring area is attached in Appendix I.

**Table 1**  
**SSI EMP Sampling Locations**

STATION	SSI Revised Locations	Water Old	Air Old	Veg Old	Milk Old	LOCATION	Approx. Distance From SSI Stack (m)	Direction
1	W1,A1	(W17)				Background Sample 16Km NE of stack	16000	North-east
2	W2	(W16)				Field Sample Transferred to New Container In The Field		
3	WG3,WW3,A3	(W15)	(A1)			Well house	120	North-east
4	A4		(A2)			Hydro Pole	150	South-east
5	W5, A5	(W5)	(A4)			Tap water Airport Terminal/Environment Canada Fence	240	South-east
6	W6	(W6)				Airport Rd culvert	870	South-east
7	W7	(W7)	(A7)	(V7)		Cavan Creek	1500	South-west
8	W8	(W8)	(A13)			Fazerville Access	2500	South
9	A9		(A5)			Sign at Airport Entrance	210	South-east
10	WG10, A10,V10	(W1)	(A11)	(V1)		Pond across from SSI	220	East
	WW10					Well at House across from SSI	220	East
11	A11		(A3)			Chain link fence Mel O'Brien Way	200	North-west
12	W12,A12,V12	(W3)	(A12)	(V3)		Tree line west of stack	210	South-west
13	W13,A13,	(W2)	(A8)			Tree line south west of stack	570	South-west
14	A14		(A6)			Sign at corner of Mel O'Brien Way	150	North-east
15	W15,V15	(W4)		(V4)		Culvert - Mervin Line west	500	North-west
16	W16 ,A16	(W9)	(A10)			Mervin Line - Otonabee River	1625	North-east
17	W17	(W10)				Culvert at Hwy 115 access	1250	North
18	W18,A18	(W11)	(A15)			Culvert Beardsmore Rd	1500	North
19	W19	(W12)				Worboyt Court	1875	North
20	W20	(W13)				Monaghan Rd - Otonabee River	5000	North-east
21	A21		(A14)			Mahood Line	3110	North-east
22	W22,A22	(W14)	(A9)			Matchette Line	2560	East
23	M23					████████ Dairy Farm	2864	South-east
BLANK	TRAVEL BLANK					Sample Prepared With Same Medium, Carried to Field, Taped and Packaged in Field		

**Note:** Samples are labelled as follows: Air Samples = A(station number), Water Samples = W(station number),  
Vegetation Samples - V(station number), Milk Samples = M(station number)  
SSI Revised Locations - refers to sampling location numbers assigned by SSI (2000)  
Old – refers to sampling location number originally assigned by Twin Oaks Consulting (1997)

## 2. SUMMARY OF ENVIRONMENTAL MONITORING RESULTS

### 2.1 Samples

Ambient Air, Water and Milk samples were collected monthly by SSI staff and sent to Monserco Laboratories for analysis. Vegetation Samples were collected during harvest time (August through to November). Stack emissions were measured continuously from the SSI facility. The sampling program consists of 5 types of samples collected - stack emissions, ambient air samples, ambient water samples, milk and vegetation samples. The sampling results are described below.

### 2.2 Stack Emissions

SSI monitors both Tritium Gas (HT) and Tritium Oxide (HTO) continuously. Total (HT+HTO) stack emissions are recorded daily and HTO activity readings are measured on the last day of a seven-day interval. The weekly HTO and HT emissions are then calculated. The weekly and yearly HTO and HT stack emissions were summarized and compared to the Monitored and Modeled Derived Emissions Limit (DEL) values calculated by Golder Associates (Golder 2002) as well as the Administrative Limit (AL) set by SSI.

#### 2.2.1 Results

Monthly tritium stack emissions for the period between environmental monitoring sampling dates are presented in Table 2.

**Table 2**  
**Monthly Tritium Stack Emissions**

DATE		HTO Released (Bq)	HT Released (Bq)	Total Activity (Bq)
Date From	Date To			
20-Dec	22-Jan	1.19E+12	4.34E+12	5.53E+12
23-Jan	19-Feb	1.42E+12	1.01E+13	1.15E+13
20-Feb	21-Mar	1.28E+12	1.09E+13	1.22E+13
22-Mar	23-Apr	1.91E+12	1.16E+13	1.35E+13
24-Apr	23-May	1.48E+12	8.78E+12	1.03E+13
24-May	25-Jun	1.95E+12	7.92E+12	9.87E+12
26-Jun	23-Jul	1.56E+12	6.41E+12	7.97E+12
24-Jul	27-Aug	2.58E+12	1.28E+13	1.54E+13
28-Aug	24-Sep	2.25E+12	8.31E+12	1.06E+13
25-Sep	23-Oct	2.30E+12	1.21E+13	1.44E+13
24-Oct	20-Nov	2.15E+12	9.41E+12	1.16E+13
21-Nov	18-Dec	2.87E+12	9.90E+12	1.28E+13
Total		2.29E+13	1.13E+14	1.36E+14
Average		1.91E+12	9.38E+12	1.13E+13
Maximum		2.87E+12	1.28E+13	1.54E+13
Minimum		1.19E+12	4.34E+12	5.53E+12

The highest release of HTO occurred during the sampling period of November 21 to December 18, 2002, when an activity of  $2.87 \times 10^{12}$  Bq was recorded. This corresponds with the maximum monthly average of tritium in ambient air samples. The highest release of HT and consequently the maximum average total activity released occurred during the sampling period of July 24 to August 27, 2002, when an activity of  $1.28 \times 10^{13}$  Bq (HT) and  $1.54 \times 10^{13}$  (Total Activity) was recorded. This corresponds to average levels of tritium in ambient air and water samples.

The minimum stack emission for HTO and HT was found during the sampling period of December 20, 2001 to January 22, 2002 ( $1.19 \times 10^{12}$  Bq and  $4.34 \times 10^{12}$  Bq). This corresponds with average levels of tritium in water and slightly below average levels of tritium in ambient air monitoring data.

No discernable variation with season was observed in the data.

### 2.2.2 DRL and AL

Weekly and yearly HTO and HT emission are summarized and compared to the Derived Release Limit (DRL) (monitored and modeled) and the Administrative Limit (AL) values as calculated by Golder Associates (November 2002). The SSI Radiation Safety Manual-Rev.9 indicates that the AL is 1% of the DEL. However Rev. 11 of the Radiation Safety Manual proposes a more realistic AL of 50% based on the revised DELs. A summary of the weekly and yearly DEL and AL values (Bq) are included in Table 3.

**Table 3**  
**Weekly and Yearly DEL and AL Values**

Description	Golder (Monitored)		Golder (Modeled)	
	DEL (Bq)	AL (Bq) (50%)	DEL (Bq)	AL (Bq) (50%)
HTO /Week	2.3E+12	1.2E+12	1.9E+12	9.5E+11
HT/Week	9.2E+18	4.6E+18	6.5E+17	3.3E+17
HTO/Year	1.2E+14	6.0E+13	1.0E+14	5.0E+13
HT/Year	4.8E+20	2.4E+20	3.4E+19	1.7E+19

### 2.2.3 Exceedences of DRL and AL

#### Yearly Stack Emissions

The total HTO and HT stack emissions for 2002 did not exceed the yearly DRLs or ALs calculated by Golder. (Table 4)

**Table 4**  
**Annual Stack Emission Compared with DEL and AL**

YEAR	TRITIUM OXIDE (HTO) PER YEAR (Bq)					TRITIUM GAS (HT) PER YEAR (Bq)				
	STACK EMISSION  (Bq)	GOLDER (Monitored)		GOLDER (Modeled)		STACK EMISSION  (Bq)	GOLDER (Monitored)		GOLDER (Modeled)	
		DRL	AL	DRL	AL		DRL	AL	DRL	AL
		1.2E+14	6.0E+13	1.0E+14	5.0E+13		4.8E+20	2.4E+20	3.4E+19	1.7E+19
		Exceedance of DEL or AL (% exceeded by)					Exceedance of DEL or AL (% exceeded by)			
2002	2.3E+13	--	--	--	--	1.1E+14	--	--	--	--

Weekly Stack Emissions

The weekly HTO and HT stack emissions for 2002 did not exceed the weekly DELs or ALs calculated by Golder (Table 5).

**Table 5**  
**Weekly Stack Emissions Compared with DEL and AL**

DATE	TRITIUM OXIDE (HTO) PER 7 <sup>(1)</sup> DAYS (Bq)				TRITIUM GAS (HT) PER 7 <sup>(1)</sup> DAYS (Bq)			
	STACK EMISSION	GOLDER		SSI AL	STACK EMISSION	GOLDER		SSI AL
		DEL Monitored	DEL Modelled			DEL Monitored	DEL Modelled	
		2.3E+12	1.9E+12	1.2E+12		9.2E+18	6.5E+17	4.6E+18
		Exceedance of DRL or AL (% exceeded by)				Exceedance of DRL or AL (% exceeded by)		
Jan 03 -								
Jan 08 -	3.2E+11	--	--	--	5.6E+11	--	--	--
Jan 15 -	2.7E+11	--	--	--	1.0E+12	--	--	--
Jan 22 -	1.2E+11	--	--	--	5.6E+11	--	--	--
Jan 29 -	3.2E+11	--	--	--	2.3E+12	--	--	--
Feb 05 -	1.7E+11	--	--	--	1.5E+12	--	--	--
Feb 12 -	6.6E+11	--	--	--	4.5E+12	--	--	--
Feb 19 -	2.7E+11	--	--	--	1.8E+12	--	--	--
Feb 26 -	2.5E+11	--	--	--	2.0E+12	--	--	--
Mar 05 -	2.8E+11	--	--	--	2.6E+12	--	--	--
Mar 12 -	3.5E+11	--	--	--	2.7E+12	--	--	--
Mar 19 -	3.2E+11	--	--	--	3.0E+12	--	--	--
Mar 26 -	2.9E+11	--	--	--	2.3E+12	--	--	--
Apr 02 -	2.8E+11	--	--	--	1.8E+12	--	--	--
Apr 09 -	3.2E+11	--	--	--	3.2E+12	--	--	--
Apr 16 -	6.4E+11	--	--	--	2.2E+12	--	--	--
Apr 23 -	4.6E+11	--	--	--	2.6E+12	--	--	--
Apr 30 -	3.3E+11	--	--	--	2.0E+12	--	--	--
May 07 -	3.5E+11	--	--	--	1.6E+12	--	--	--
May 14 -	3.7E+11	--	--	--	2.9E+12	--	--	--
May 21 -	3.1E+11	--	--	--	1.4E+12	--	--	--

**Table 5  
Weekly Stack Emissions Compared with DEL and AL (Cont'd)**

DATE	TRITIUM OXIDE (HTO) PER 7 <sup>(1)</sup> DAYS (Bq)				TRITIUM GAS (HT) PER 7 <sup>(1)</sup> DAYS (Bq)			
	STACK EMISSION	GOLDER		SSI	STACK EMISSION	GOLDER		SSI
		DEL Monitored	DEL Modelled	AL		DEL Monitored	DEL Modelled	AL
		2.3E+12	1.9E+12	1.2E+12		9.2E+18	6.5E+17	4.6E+18
Exceedance of DRL or AL (% exceeded by)				Exceedance of DRL or AL (% exceeded by)				
May 28 -	4.1E+11	--	--	--	2.8E+12	--	--	--
Jun 04 -	4.7E+11	--	--	--	2.6E+12	--	--	--
Jun 11 -	4.1E+11	--	--	--	1.1E+12	--	--	--
Jun 18 -	3.9E+11	--	--	--	1.3E+12	--	--	--
Jun 25 -	3.9E+11	--	--	--	9.0E+11	--	--	--
Jul 02 -	5.4E+11	--	--	--	3.3E+12	--	--	--
Jul 09 -	4.0E+11	--	--	--	1.1E+12	--	--	--
Jul 16 -	3.5E+11	--	--	--	1.4E+12	--	--	--
Jul 23 -	2.8E+11	--	--	--	6.3E+11	--	--	--
Jul 30 -	3.2E+11	--	--	--	8.6E+11	--	--	--
Aug 06 -	4.2E+11	--	--	--	1.8E+12	--	--	--
Aug 13 -	7.1E+11	--	--	--	4.2E+12	--	--	--
Aug 20 -	6.4E+11	--	--	--	3.0E+12	--	--	--
Aug 27 -	5.0E+11	--	--	--	2.9E+12	--	--	--
Sep 03 -	6.3E+11	--	--	--	2.4E+12	--	--	--
Sep 10 -	4.4E+11	--	--	--	2.2E+12	--	--	--
Sep 17 -	6.3E+11	--	--	--	1.8E+12	--	--	--
Sep 24 -	5.5E+11	--	--	--	1.9E+12	--	--	--
Oct 01 -	5.6E+11	--	--	--	2.5E+12	--	--	--
Oct 08 -	6.9E+11	--	--	--	3.9E+12	--	--	--
Oct 15 -	5.8E+11	--	--	--	2.6E+12	--	--	--
Oct 22 -	4.1E+11	--	--	--	2.6E+12	--	--	--
Oct 29 -	5.5E+11	--	--	--	2.9E+12	--	--	--
Nov 05 -	5.5E+11	--	--	--	1.9E+12	--	--	--
Nov 12 -	5.4E+11	--	--	--	1.4E+12	--	--	--
Nov 19 -	5.2E+11	--	--	--	3.2E+12	--	--	--
Nov 26 -	5.8E+11	--	--	--	2.6E+12	--	--	--
Dec 03 -	3.6E+11	--	--	--	2.5E+12	--	--	--
Dec 10 -	9.8E+11	--	--	--	2.5E+12	--	--	--
Dec 17 -	9.8E+11	--	--	--	2.3E+12	--	--	--
Dec 24 -	3.6E+11	--	--	--	2.1E+12	--	--	--
Dec 31 -	2.9E+11	--	--	--	1.7E+12	--	--	--

**2.2.4 Data Trends**

Stack emission data did not show an identifiable correlation with seasonal change. A comparison of monthly HTO and HT stack emission values in 2002 with those from 2001 and 2000 shows no observable repetition of annual trends (Table 6).

**Table 6**  
**Yearly HTO & HT Comparison**

MONTH	HTO EMISSIONS			HT EMISSIONS		
	2002	2001	2000	2002	2001	2000
January	1.2E+12	2.2E+12	2.3E+12	4.3E+12	1.5E+13	1.3E+12
February	1.4E+12	2.4E+12	2.3E+12	1.0E+13	1.1E+13	6.6E+12
March	1.3E+12	2.1E+12	1.8E+12	1.1E+13	6.1E+12	2.4E+12
April	1.9E+12	2.6E+12	3.4E+12	1.2E+13	1.1E+13	7.8E+12
May	1.5E+12	3.0E+12	2.8E+12	8.8E+12	1.1E+13	5.8E+12
June	2.0E+12	1.9E+12	3.8E+12	7.9E+12	8.0E+12	3.5E+12
July	1.6E+12	3.0E+12	2.5E+12	6.4E+12	1.2E+13	2.7E+12
August	2.6E+12	2.2E+12	4.0E+12	1.3E+13	6.0E+12	4.9E+12
September	2.3E+12	2.3E+12	3.1E+12	8.3E+12	1.0E+13	9.3E+12
October	2.3E+12	1.9E+12	2.3E+12	1.2E+13	8.8E+12	1.1E+13
November	2.2E+12	1.7E+12	2.0E+12	9.4E+12	4.5E+12	1.3E+13
December	2.9E+12	1.7E+12	1.3E+12	9.9E+12	6.0E+12	1.7E+13
TOTAL:	2.3E+13	2.7E+13	3.2E+13	1.12E+14	1.09E+14	8.53E+13
AVERAGE:	1.9E+12	2.3E+12	2.6E+12	9.4E+12	9.1E+12	7.1E+12
MAX:	2.9E+12	3.0E+12	4.0E+12	1.3E+13	1.5E+13	1.7E+13
MIN:	1.2E+12	1.7E+12	1.3E+12	4.3E+12	4.5E+12	1.3E+12

## 2.3 Ambient Air Data

### 2.3.1 Sampling Method

Passive air monitors were used to assess tritium activity in air. The samplers consist of scintillation vials filled with distilled water and capped with a diffusion cap (designed by Ontario Hydro Technologies). Tritium oxide and tritium gas diffuse into the vial and dissolve in the distilled water. Ethylene glycol is added to the distilled water during the winter months to prevent freezing. The samplers are deployed one meter above the ground by attaching them to an available surface (post, tree). The sampler is attached so that it always faces the SSI facility. A small plastic plant pot is suspended in the inverted position over the sampler to protect it. The sampler is left for a one-month period and then retrieved for analysis. The sampling liquid is analyzed by scintillation counting.

The passive air monitoring data must be converted from Bq/L in sampling liquid to Bq/m<sup>3</sup> in air. There is no standardized and accepted calculation for this conversion. Numerous assumptions must be made in order to estimate the volume of air sampled by a passive device. The conversion calculation and the assumptions made are presented in Appendix II.

### 2.3.2 Sample Availability

There were 171 planned ambient air sample collections in 2002 and 161 actual collections performed. Therefore 94% of valid ambient air sample collection was achieved compared to planned collection.

### 2.3.3 Results

The ambient air monitoring data collected from January 2002 to December 2002 is provided in Table 7.

Based on the assumptions used to convert the passive sampling data from Bq/L in sampling liquid to Bq/m<sup>3</sup> in air, tritium activity in air averaged over the sampling period, was estimated to be less than 1 Bq/m<sup>3</sup> at all sample locations.

The highest annual average tritium activities were 1.95 Bq/m<sup>3</sup> and 1.44 Bq/m<sup>3</sup>, collected from sample stations 3 and 4, respectively. Sample stations 3 and 4 are located 120 meters northeast and 150 meters southeast of the SSI stack, respectively.

The maximum monthly average occurred from November 20, 2002 to December 18, 2002 with an average activity of 1.06 Bq/m<sup>3</sup>. This corresponds with the maximum monthly tritium oxide emission (2.9E+12 Bq).

There is moderate variability among the monthly measurements in the samples collected from the same location. However there does not appear to be a monthly tritium activity trend among these locations.

In general the tritium activity estimates in air decrease with progressive distance from the SSI stack.

**Table 7**  
**Ambient Air Monitoring Data (Bq/m<sup>3</sup>)**

Date	Stn 1	Stn 3	Stn 4	Stn 5	Stn 7	Stn 8	Stn 9	Stn 10	Stn 11	Stn 12	Stn 13	Stn 14	Stn 21	Stn 22	Avg/mo
	A1	A3	A4	A5	A7	A8	A9	A10	A11	A12	A13	A14	A21	A22	
20-Dec-01															
22-Jan-02	0.27	2.00	0.82	0.30	0.27	0.27	0.27	0.99	0.27	0.27	0.27	0.27	0.27	0.27	0.49
19-Feb-02	0.32	1.63	0.80	0.54	0.32	0.32	0.32	1.32	0.32	0.32	0.32	0.41	0.32	0.32	0.54
21-Mar-02	0.52	1.04	0.74	0.30	0.30	0.34	0.30	0.79	0.46	0.39	0.46	0.47	0.30	0.30	0.48
23-Apr-02	0.27	0.27	1.14	0.29	-	-	0.71	-	0.27	0.50	0.56	0.82	0.27	0.31	0.49
23-May-02	0.30	1.19	0.90	0.30	0.30	0.30	0.41	0.53	0.34	0.30	0.30	0.58	0.30	0.30	0.45
25-Jun-02	0.27	2.27	0.76	0.31	0.27	0.27	0.37	0.68	0.44	0.27	0.31	1.29	0.27	-	0.60
23-Jul-02	0.32	2.69	1.78	0.64	0.32	0.32	0.81	0.95	0.33	0.32	0.32	1.91	0.32	0.32	0.81
27-Aug-02	0.26	5.38	1.64	-	0.26	0.26	0.89	0.62	0.46	0.66	0.41	1.72	0.26	0.26	1.01
24-Sep-02	0.32	1.99	1.34	3.68	0.32	0.32	0.48	0.77	0.41	0.36	0.37	1.21	0.32	0.32	0.87
23-Oct-02	0.31	1.67	1.70	0.56	-	0.31	0.89	0.95	0.72	1.03	1.51	1.29	0.31	-	0.94
20-Nov-02	0.35	1.33	1.79	0.44	-	0.32	0.50	1.42	1.31	0.62	0.44	0.81	0.32	-	0.80
18-Dec-02	0.32	-	3.89	0.60	-	0.32	2.47	2.14	0.32	0.40	0.41	1.23	0.32	0.32	1.06
Average	0.32	1.95	1.44	0.73	0.30	0.31	0.70	1.01	0.47	0.45	0.47	1.00	0.30	0.30	0.71
Maximum	0.52	5.38	3.89	3.68	0.32	0.34	2.47	2.14	1.31	1.03	1.51	1.91	0.32	0.32	1.06
Distance from Stack m	16000	120	150	240	1500	2500	210	220	210	210	570	150	3110	2560	
Direction	NE	NE	SE	SE	S	S	E	NE	NW	SW	SW	NE	E	E	

Note: "-" no sample collected or analyzed

## **2.4 Ambient Water Monitoring**

### **2.4.1 Sampling Method**

Water samples were collected and analyzed on a monthly basis. Water samples were collected in suitable bottles and triple rinsed with the sample water. The water samples were analyzed by scintillation counting.

### **2.4.2 Sample Availability**

There were 228 planned water sample collections scheduled for 2002 with 206 actual collections performed. Therefore 90% of valid water sample collections were achieved compared to planned collection.

### **2.4.3 Results**

The ambient water monitoring data collected from January 2002 to December 2002 is provided in Table 8.

The highest annual average tritium activities detected in ambient water samples were from stations 3 and 10. Sample stations 3 and 10 are located 120 and 220 meters northeast of the SSI stack, respectively. The monthly measurements for ambient water from stations 3 and 10 tend to be greater than at other stations. Monthly well water samples were also taken at these two locations with results below detection limit.

The maximum monthly average tritium activity occurred from February 19, 2002 to March 21, 2002 with an average activity of 531 Bq/L. This corresponds with below average HTO emissions and below average ambient air monitoring results.

There is moderate variability among the monthly measurements in the samples collected from the same location. However there does not appear to be a monthly tritium activity trend among these locations.

Overall there is a distinct trend of decreasing activity in water with distance from the SSI stack.

**Table 8  
Ambient Water Monitoring Data (Bq/L)**

	Stn 1	Stn 3		Stn 5	Stn 6	Stn 7	Stn 8	Stn 10		Stn 12	Stn 13	Stn 15	Stn 16	Stn 17	Stn 18	Stn 19	Stn 20	Stn 22	Avg/ mo	
DATE	W1	WELL3	WW3	W5	W6	W7	W8	WELL10	WW10	W12	W13	W15	W16	W17	W18	W19	W20	W22		
22-Jan-02	<50	<50	3805	<50	135	<50	<50	<50	1548	<50	275	83	<50	<50	<50	<50	<50	<50	<50	379
19-Feb-02	<50	<50	4257	<50	146	<50	<50	<50	118	51	<50	<50	<50	51	<50	<50	<50	<50	<50	292
21-Mar-02	<50	<50	4416	<50	159	<50	<50	<50	3630	398	183	113	67	78	67	<50	<50	<50	<50	531
23-Apr-02	<50	<50	5651	<50	131	<50	<50	<50	1432	472	270	155	<50	<50	63	90	<50	<50	<50	486
23-May-02	<50	<50	4693	<50	100	<50	<50	<50	1184	439	-	159	68	<50	<50	<50	<50	<50	<50	422
25-Jun-02	<50	<50	4514	<50	119	<50	<50	<50	1188	306	148	61	<50	<50	<50	<50	<50	<50	<50	385
23-Jul-02	<50	<50	2981	<50	54	<50	<50	<50	677	<50	-	<50	<50	<50	<50	<50	<50	<50	<50	259
27-Aug-02	<50	<50	<50	<50	63	<50	<50	<50	1393	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	129
24-Sep-02	<50	<50	-	<50	-	<50	<50	<50	1898	-	-	-	<50	-	<50	-	<50	<50	<50	217
23-Oct-02	<50	<50	<50	<50	78	<50	<50	<50	2373	-	4518	-	<51	<50	<50	70	<50	<50	<50	477
20-Nov-02	<50	<50	<50	<50	107	<50	<50	<50	1510	689	918	237	<50	<50	<50	63	<50	<50	<50	228
18-Dec-02	<50	<50	-	<50	-	-	<50	<50	-	-	-	-	<50	-	-	-	<50	<50	<50	49
Average	49	49	3046	49	109	49	49	49	1541	307	909	106	52	52	52	57	49	49	49	321
Maximum	49	49	5651	49	159	49	49	49	3630	689	4518	237	68	78	67	90	49	49	49	531
Distance from Stack m	16000	120		240	870	1500	2500	220		210	570	500	1625	1250	1500	1875	5000	2560		
Direction	NE	NE		SE	S	S	S	NE		SW	SW	NW	NE	N	N	N	NE	E		

- no sample collected or analyzed

## 2.5 Milk Samples

### 2.5.1 Sampling Method

Milk samples are collected from an area dairy farm in the prevailing wind direction and at locations closest to the SSI facility. Milk samples were collected in suitable sample bottles and analyzed for tritium by liquid scintillation counting.

### 2.5.2 Results

The milk monitoring data collected is provided in Table 9.

A survey of the surrounding area indicated that the closest dairy farm in the easterly wind direction is over 2800 m from the SSI stack. Tritium activity was below the detection limit; therefore results correspond to air and water monitoring data for this location area.

**Table 9**  
**Milk Monitoring Data (Bq/L)**

<b>DATE</b>	<b>Stn 23 M23</b>
22-Jan-02	<200
19-Feb-02	<200
21-Mar-02	<200
23-Apr-02	<200
23-May-02	<200
25-Jun-02	<200
23-Jul-02	<200
27-Aug-02	<200
24-Sep-02	<200
23-Oct-02	<200
20-Nov-02	<200
18-Dec-02	<200
Distance from Stack m	2864
Direction	SE

## 2.6 Vegetation Samples

### 2.6.1 Sampling Method

Vegetation samples such as apples, crab apples and grapes were collected. Samples were sealed in freezer bags and analyzed for tritium by liquid scintillation counting.

### 2.6.2 Results

The vegetation monitoring data collected is provided in Table 10.

The highest tritium activities were detected in samples from station 10. Sample station 10 is located 220 meters northeast of the SSI stack. This corresponds with maximum ambient water monitoring results for this location.

**Table 10**  
**Vegetation Monitoring Data (Bq/L)**

	<b>Stn 8</b>	<b>Stn 10</b>	<b>Stn 16</b>
<b>DATE</b>	<b>V8 Crab Apples</b>	<b>V10 Apples</b>	<b>V16 Grapes</b>
Aug 27, 02	<200	2300	210
Sep 24, 02	<200	2400	230
Oct 23, 02			<200
Nov 20, 02			200
Distance from Stack m	2500	220	1625
Direction	S	NE	NE

### 3. CALCULATED DOSES TO THE CRITICAL RECEPTOR

The model used to estimate doses to the critical receptor is presented in the Shield Source Inc. Proposed Environmental Monitoring Program. This model was submitted to REPD for review in May 2000, and was updated based on feedback from Mr. Michael James of the CNSC on July 16, 2002.

The doses to the critical receptor were calculated based on maximum activities in air and water measured in the monitoring program, at the location with the highest tritium activity levels in ambient air and water (station 3). This is to ensure of a wide margin of conservatism for the receptor exposure to tritium. The dose calculations assume that 50% of the vegetable and animal produce consumed originates from the vicinity of the Shield Source facility. The methodology is outlined in Appendix III.

The maximum measured activities in air and water are presented in Table 11.

**Table 11**  
**Maximum Activities of Tritium in Air and Water Measured**  
**during the 2002 Monitoring Program**

Form of Tritium	Activity in Water (Bq/L)	Activity in Air * (Bq/m <sup>3</sup> )	Monitoring Sample Locations
HTO	5651	1.45	Station 3, 120 m northeast
HT	-	3.93	

\*based on total activity of 0.79 Bq/m<sup>3</sup> using 27% HTO and 73% HT based on average stack emissions

The calculated long-term doses to the critical receptor do not exceed the annual public dose limit of 1 mSv per year (Table 12). Potential exposure to tritium through the consumption of local vegetation and animal produce is based on uptake modeling using the maximum observed activities in air and water.

**Table 12**  
**Estimated Doses of Tritium (HT) and Tritium Oxide (HTO) to the Critical Receptor Based on Maximum Monitored Activity in Air and Water at the Location with the Highest Concentrations (Station 3)**

Form of Tritium	Total Water Dose (mSv/yr)	Total Air Dose (mSv/yr)	Total Vegetation Dose (mSv/yr)	Total Animal Dose (mSv/yr)	Assumptions
HTO	9.83E-02	3.20E-04	7.76E-03	2.44E-02	50% of vegetables and animal produce from vicinity of site
HT	-	8.95E-08	-	-	
OBT	-	-	1.07E-02	5.51E-02	

A survey of the monitoring area indicated that at no time has a vegetable garden or livestock been observed at the critical receptor residence. The vegetation samples collected from this location were apples from a tree on the property. Although the estimated doses in Table 12 indicate that consumption of apples would not result in unacceptable exposure, residents of this property have confirmed that the apples are not consumed.

The contribution of each exposure pathway to total dose to the critical receptor is presented in Table 13. As expected, the majority of the dose is contributed by ingestion of food and water. The inhalation pathway contributes a very small proportion (0.2%) of the total dose.

**Table 13**  
**Total Tritium Dose (All Forms) to the Critical Receptor Resulting from Each Exposure Pathway: Air, Water, Vegetation, and Animal**

Total Dose to Child (mSv/yr)	Dose from Water		Dose from Air		Dose from Vegetation		Dose from Animal	
	(mSv/yr)	% of Total	(mSv/yr)	% of Total	(mSv/yr)	% of Total	(mSv/yr)	% of Total
0.197	0.098	50.0	0.00032	0.2	0.0185	9.4	0.0795	40.4

A comparison of modeled tritium activities in vegetation and milk with measured activities in fruit and milk shows that the model overestimates milk activities, and either overestimates or produces similar activities in fruit (Table 14). This comparison shows that the model predictions can be interpreted with confidence and that doses are not underestimated.

**Table 14**  
**Comparison of Modelled versus Measured Tritium Activity in Milk and Vegetation**

Measured (Mean, Bq/L)		Modeled (Total HTO and OBT, Bq/L)	
Milk	<200	Milk	3562
Crabapples	<200	“Vegetation”	2492
Apples	2350		
Grapes	210		

#### 4. SSI QA/QC

SSI's Quality Assurance (QA) program refers to a detailed protocol used to collect high quality environmental monitoring samples. Quality Control refers to the process by which this protocol is tested to ensure that the final samples are of the specified quality. SSI included field blanks, travel blanks and replicate samples in their sampling program in order to meet the requirements of the QA/QC program.

##### 4.1 Field Blanks

Fields blanks are used to detect incidental or accidental contamination of a sample during sample preparation, sampling, handling, storage, transport and analysis. A water sample field blank is prepared using the same sampling sink matrix used for collection of the environmental samples. At one randomly selected sampling location, the field blank is opened and transferred to an empty sampling container, sealed, placed in a plastic bag and placed in the transport carrier.

##### 4.1.1 Results

Table 15 shows the Field Blank results for 2002.

Tritium activity was below detection limit, therefore contamination of samples during sample sessions was not suspected.

**Table 15**  
**Field Blank Data (Bq/L)**

DATE	FIELD BLANK
	W2
22-Jan-02	<50
19-Feb-02	<50
21-Mar-02	<50
23-Apr-02	<50
23-May-02	<50
25-Jun-02	<50
23-Jul-02	<50
27-Aug-02	<50
24-Sep-02	<50
23-Oct-02	<50
20-Nov-02	<50
18-Dec-02	<50

##### 4.2 Travel Blanks

Travel blanks detect sample contamination during storage and transport. Travel blanks consist of bottles provided by a laboratory equipment supplier and filled by SSI off-site. They accompany empty sample bottles to the field site, where they are left intact and unopened inside the shipping

container. The unopened travel blanks are then returned to the analytical laboratory to be analyzed along with the collected samples.

#### 4.2.1 Results

Table 16 shows the Travel Blank results for 2002.

Tritium activity was below detection limits with the exception of the March 21, 2002 sampling session. Tritium was measured in the air travel blank at 418 Bq/L, indicating some contamination may have occurred during storage and transport. This result corresponds with the maximum monthly average activity in ambient water monitoring data. However, contamination of the water samples cannot be confirmed from these results.

**Table 16**  
**Travel Blanks Data (Bq/L)**

DATE	Water	Air
	Travel Blank	Travel Blank
22-Jan-02	<50	<50
19-Feb-02	<50	<50
21-Mar-02	<50	418
23-Apr-02	<50	<50
23-May-02	<50	<50
25-Jun-02	<50	<50
23-Jul-02	<50	<50
27-Aug-02	<50	<50
24-Sep-02	<50	<50
23-Oct-02	<50	<50
20-Nov-02	<50	<50
18-Dec-02	<50	<50

#### 4.3 Replicate Samples

Replicate samples are used to measure within-site variability. Replicate samples are collected by filling three containers at a single site (water), or by deploying three air samples. They are labelled individually and are submitted separately to the analytical laboratory.

##### 4.3.1 Results

Table 17 shows the Replicate Sample results for ambient air monitoring and Table 18 shows the Replicate Sample results for ambient water monitoring.

The replicate air samples showed low within-site variability, except for three occasions; March 21, October 23, and November 20 (Table 17). These three monitoring periods do not correspond consistently with higher stack emissions (Table 2). Water replicate samples were all less than the detection limits. All air sampling units are located on wooden posts in the same orientation, but

the replicate #1 collection unit is lower in elevation than replicates 2 and 3. The analytical laboratory was contacted and asked to re-run the November 21 samples, with the same results.

**Table 17**  
**Ambient Air Replicate Sample Data (Bq/m<sup>3</sup>)**

DATE	Station	Replicate 1	Replicate 2	Replicate 3	Standard Deviation
22-Jan-02	Stn 11	0.27	0.27	0.27	0
19-Feb-02	Stn 11	0.32	0.32	0.32	0
21-Mar-02	Stn 11	0.78	0.30	0.30	0.28
23-Apr-02	Stn 11	0.27	0.27	0.27	0
23-May-02	Stn 11	0.41	0.30	0.31	0.06
25-Jun-02	Stn 11	0.35	0.40	0.57	0.12
23-Jul-02	Stn 11	0.32	0.32	0.34	0.01
27-Aug-02	Stn 11	0.38	0.52	0.48	0.07
24-Sep-02	Stn 11	0.41	0.35	0.46	0.06
23-Oct-02	Stn 11	0.62	0.53	1.01	0.25
20-Nov-02	Stn 11	0.32	2.26	1.35	0.97
18-Dec-02	Stn 11	0.32	0.32	0.32	0

**Table 18**  
**Ambient Water Replicate Sample Data (Bq/L)**

DATE	Station	Replicate 1	Replicate 2	Replicate 3
22-Jan-02	Stn 3 well	<50	<50	<50
19-Feb-02	Stn 3 well	<50	<50	<50
21-Mar-02	Stn 3 well	<50	<50	<50
23-Apr-02	Stn 3 well	<50	<50	<50
23-May-02	Stn 3 well	<50	<50	<50
25-Jun-02	Stn 3 well	<50	<50	<50
23-Jul-02	Stn 3 well	<50	<50	<50
27-Aug-02	Stn 3 well	<50	<50	<50
24-Sep-02	Stn 3 well	<50	<50	<50
23-Oct-02	Stn 3 well	<50	<50	<50
20-Nov-02	Stn 3 well	<50	<50	<50
18-Dec-02	Stn 3 well	<50	<50	<50

## 5. LABORATORY QA/QC

Monserco Limited has provided quality control data for samples submitted to SSI in 2002. These data are summarized in Appendix IV – Laboratory Quality Control. The figure shows that sample analyses were between the laboratory's upper and lower confidence limits.

In addition, Monserco's interlaboratory comparisons are provided in Appendix IV. These comparisons indicate that Monserco is well-within the limits for relative bias and relative

precision as reported by the Radiation Protection Bureau's National calibration Reference Centre for Bioassay.

## 6. INCIDENTS

There were no incidents, anomalies or abnormal events affecting the data/results of the environmental monitoring program.

## 7. SUMMARY

Stack emissions did not exceed DELs or ALs at any time during the year.

The maximum monthly stack emission of tritium ( $1.54 \times 10^{13}$  Bq in July 24 to August 27, 2002) corresponded with average levels of tritium in both the water monitoring data and the ambient air monitoring data. Therefore, a correlation between the stack emissions and environmental results could not be made with the current data.

Overall there is a trend of decreasing activity in all types of samples with distance from the SSI stack. Tritium activity in most samples collected from locations greater than 900 meters from the SSI stack was less than the detection limit.

The estimated dose to the critical receptor (infant) living at the nearest residential dwelling based on the maximum measured activities in air and water was 0.2 mSv/year, which is below the annual dose limit to the general public of 1 mSv/year. A comparison of modeled tritium activities in milk and vegetation with measured activities in milk and fruit showed that the model overestimates milk activities and either overestimates or produces similar results to monitored activities in fruit. These comparisons provide validation of the model predictions.