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FUSRAP TECHNICAL MEMORANDUM

TO: Eric T. Newberry

FROM: Laura M. Artates

DATE: June 30, 1994

SUBJECT: Environmental Surveillance Data for Niagara Falls Storage Site (NFSS), 1993

Prepared By <i>L. Artates (gs)</i>	Team Lead Approval <i>[Signature]</i>	Project Engineer Approval <i>J L M Lyman</i>	Project Manager Approval <i>Paul R. [Signature]</i>
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INTRODUCTION

This memorandum presents the environmental surveillance results for 1993 at the Niagara Falls Storage Site (NFSS). The primary use of NFSS has been the storage of radioactive residues produced as a by-product of uranium production. All onsite areas of residual radioactivity above guidelines have been remediated. Materials generated during remediation are stored onsite in the waste containment structure (WCS). DOE maintains an environmental surveillance program at NFSS to identify and quantify the effect of the WCS on the surrounding environment and the public health in order to ensure that both are adequately protected from site contamination and to determine whether activities at the site are in compliance with applicable federal, state, and local standards and requirements. This program is designed to detect and quantify unplanned releases and evaluate potential contaminant migration pathways. The environmental surveillance program includes sampling networks for radon concentrations in air; external gamma radiation exposure; and total uranium and radium-226 concentrations in surface water, sediment, and groundwater. Several metals and total organic carbon are also measured in the groundwater. Field measurements in groundwater include pH, temperature, specific conductivity, dissolved oxygen, oxidation/reduction, and turbidity.

The environmental surveillance program is implemented by three primary components; the Environmental Monitoring Plan (EMP) with applicable addendums, environmental instruction guides, and work instructions. *The Environmental Monitoring Plan for the Niagara Falls Storage Site* (DOE/OR/21949-309) identifies the rationale and design criteria for the surveillance program, the location and frequency of sampling and analysis, specific sampling and analysis procedures and quality assurance measures. Environmental monitoring instruction guides, derived from EPA and DOE sampling guidance documents, describe the appropriate sample collection methods to be used for collecting, preserving, and shipping environmental samples.

Purpose:

This memorandum, prepared in conjunction with the *Niagara Falls Storage Site Environmental Surveillance Report for Calendar Year 1993* (DOE/OR/21949-379), presents the methods of analysis, analysis results, and data quality objectives for environmental surveillance activities conducted at NFSS in 1993.

Selection of Sampling Points:

Sixty-four sampling devices at 37 sampling stations are located at monitoring points determined to be most effective in detecting potential releases from the WCS as documented in the Environmental Monitoring Plan. In locating the sampling stations, the surveillance program considers factors such as wind directions, site terrain, and the potential paths through which water flows on and off the site. Figures 1 through 3 show the environmental surveillance locations at NFSS. Table 1 presents a summary of the surveillance program for 1993.

To monitor for external gamma exposure and radon concentrations in air, 34 locations adjacent to the WCS and along the fenceline at the edge of the NFSS property were used. Ten other monitoring devices were placed at locations away from NFSS to determine the natural background for the area. The onsite detectors were positioned to detect the maximum potential exposure level to the site personnel. Tissue-equivalent thermoluminescent dosimeters (TETLDs), used to detect gamma radiation, were positioned about 3 ft above the ground surface to monitor exposure to the critical organ nearest the contamination. The radon cups used to measure atmospheric radon concentrations were positioned about 5 ft above the ground surface to detect radon concentrations in the breathing zone for the average person. The detection devices were in place 24 hours a day, year round. The eleven fenceline locations represent the closest that a member of the public could come to the WCS.

Radon flux measurements at the surface of the pile are made twice a year as part of the NESHAPs compliance program. Radon flux is measured using activated charcoal canisters placed on the surface of the pile at 50-ft intervals for an exposure period of 24 hours.

A system of wells is used to monitor for contamination in groundwater. Eight wells are used to sample the shallow groundwater beneath the perimeter of the WCS. One well is used to sample the deep groundwater under the site, and one background well is located in an area known to be unaffected by the site. This background well measures the amounts of radioactive and chemical constituents that occur in the local environment. By comparing the samples from the background well with the samples from the other wells, a determination can be made as to whether or not contaminants at the site are affecting groundwater quality.

This same "before and after" principle is used in monitoring the effect of the WCS on surface water and sediment. A background sampling location monitors surface water and sediment unaffected by NFSS; four other locations monitor the surface water and sediment in places that might be affected by materials stored on the site.

In addition to routine environmental monitoring, a special study was conducted at NFSS during the 1993 surveillance period in response to an Observation Report (OR-93-115). This OR noted that sampling for thorium-230 (Th-230) had not been done in the past and asked if it should

be part of environmental surveillance at NFSS. Thorium-230 has not been included as part of the program at NFSS due to characteristics exhibited by residues present in the storage pile and past remediation experiences at the site. The activity level of Th-230 in the residues is typically 10 times less than that of Ra-226. Since thorium is typically less soluble in the environment than radium and is primarily an alpha emitter, radium was used as a tracer for radioactive contamination during remediation of the site. Radium-226 concentrations in groundwater, surface water, and sediment are measured annually. As part of the response to the OR (CCN 109800), samples were collected and analyzed for Th-230 from selected wells around the containment structure, and from surface water and sediment locations most likely to reveal migration. Results showed that the highest concentrations of Th-230 in the groundwater, surface water, and sediment were 2.4 pCi/L, 0.5 pCi/L, and 1.01 pCi/g, respectively. These results indicate that Th-230 does not pose a threat to human health or the environment at NFSS and the current Environmental Surveillance Program is adequate for the primary contaminants of concern.

Analysis of gross beta from the lower groundwater system in well OW-15A was also performed as part of a continuing study initiated in 1990. In 1990, samples from specific locations were analyzed for gross alpha and beta. The gross beta results for well OW-15A were elevated (210 pCi/L). Because this well is located in the lower groundwater system, the source of contamination was thought to be potassium-40 and/or natural thorium. Therefore, samples were taken in 1991 from this well and were analyzed for potassium-40 and isotopic thorium. Results indicated that these radionuclides were not causing the elevated levels. Gross beta results from 1990 to the present are presented in Table 2. The analysis of radionuclides for this well indicate that contaminants of concern cannot account for the measured gross beta levels. Further data collection is necessary to resolve this issue.

Selection of Analytical Methods:

Parameters of concern to the NFSS environmental surveillance program are presented in Table 3. The analytical methods chosen to quantify these parameters were selected using criteria such as regulatory requirements, method sensitivity and cost-effectiveness. Chemical parameters were measured using EPA approved methods. Methods used to quantify radiological parameters were derived from and based on EPA drinking water methods and procedures from DOE's Environmental Measurements Laboratory. Table 4 outlines the analytical methods and detection limits used to measure water quality parameters and field measurements taken for groundwater in 1993.

METHODOLOGY

Field methods and techniques used to collect, preserve and ship environmental samples are based on the protocols recommended in Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (EPA, 1990), A Compendium of Superfund Field Operations Methods (EPA, 1987) and DOE Order 5400.1. These methods are implemented through the use of FUSRAP work instructions.

Data submittals from analytical laboratories were reviewed for subcontract and method compliance (SW-846 for chemical data, ES/ER/TM-16 for radiochemical data). Data useability flags, defined in Table 5, were assigned to each data record as appropriate. All non-rejected data

records were compiled and reported by sample matrix; groundwater, sediment, surface water, radon and external gamma.

Quality assurance requirements for DOE owned or operated sites are prescribed in DOE Order 5700.6. The FUSRAP Quality Assurance program describes the approach for implementing the requirements of that order. For environmental surveillance activities at NFSS, the specific quality assurance measures are captured in the site data quality objectives (DQOs) listed in Table 3.

RESULTS

External Gamma

Results for external gamma exposure rate monitoring in 1993 are presented in Table 6; corresponding sample locations are shown in Figures 1 and 2. The 1993 averages presented in Table 6 have the average background value (80 mR/yr) subtracted out to show the site's incremental contribution. Dosimeters were removed and analyzed in the middle and end of 1993. Dosimeters retrieved and analyzed in July are used to project the expected annual exposure rate. This provides early indication of changes that might have occurred at the site during the first six months of the year. Dosimeters retrieved and analyzed at the end of the year are used for dose calculations. The results given in Table 6 showed exposure rates at the site fenceline indistinguishable from background. Measurements at NFSS ranged from 0 mR/yr (i.e., indistinguishable from background) at a location on the fence line to 9 mR/yr adjacent to the WCS. Although the dosimeters used for monitoring are state-of-the art, the accuracy is approximately ± 25 percent at rates between 0 and 100 mR/yr. Trend analysis is presented for 1988-1993 in Table 7.

Radon

Results of radon concentration monitoring at NFSS in 1993 are presented in Table 8; corresponding sample locations are shown in Figures 1 and 2. Detectors were removed and analyzed quarterly in 1993. These results were about the same as in previous years, with no significant levels above background. Radon concentration measurements are averaged for each location and reported as a yearly average concentration. Trend analysis is presented for 1988-1993 in Table 9.

Radon flux results for the WCS in 1993 are presented in Table 10. The charcoal canisters to measure radon flux were set out on the pile semiannually (spring and fall) for 24 hours, consistent with NESHAPs requirements. The highest radon flux reading was 1.43 pCi/m²-s, which was well below the NESHAPs guideline of 20 pCi/m²-s for average radon-222 flux from a containment structure. Locations of radon flux canisters are shown in Figure 3.

Groundwater

Results of groundwater monitoring for radionuclides in 1993 are presented in Table 11 (average backgrounds have not been subtracted). Sample locations are shown in Figures 1 and 2. Analysis showed that all concentrations were well below DOE guidelines of 600 pCi/L for total uranium and 100 pCi/L for radium-226. Overall, radionuclide concentrations measured in

groundwater associated with NFSS are low and have been consistently low since monitoring began. Included with the standard sampling results are the results for gross beta and thorium-230, as discussed previously in the special study. Trend analysis for radium-226 and total uranium is presented for 1988-1993 in Tables 12 and 13, respectively.

Chemical data for 1993 are presented in Tables 14 and 15. Applicable regulatory guidelines for chemical parameters as action levels for water media are presented in Table 16. Field parameters measured for groundwater samples were specific conductivity, pH, temperature, dissolved oxygen, and turbidity. Laboratory analysis results for groundwater include total organic carbon, copper, lead, and vanadium. Water quality parameters in selected wells were also analyzed. These parameters were calcium, potassium, magnesium, sodium, bicarbonate, carbonate, chloride, nitrate, sulfate, and total dissolved solids. All of these parameters were within expected ranges, and were consistent with results from previous years.

Surface Water and Sediment

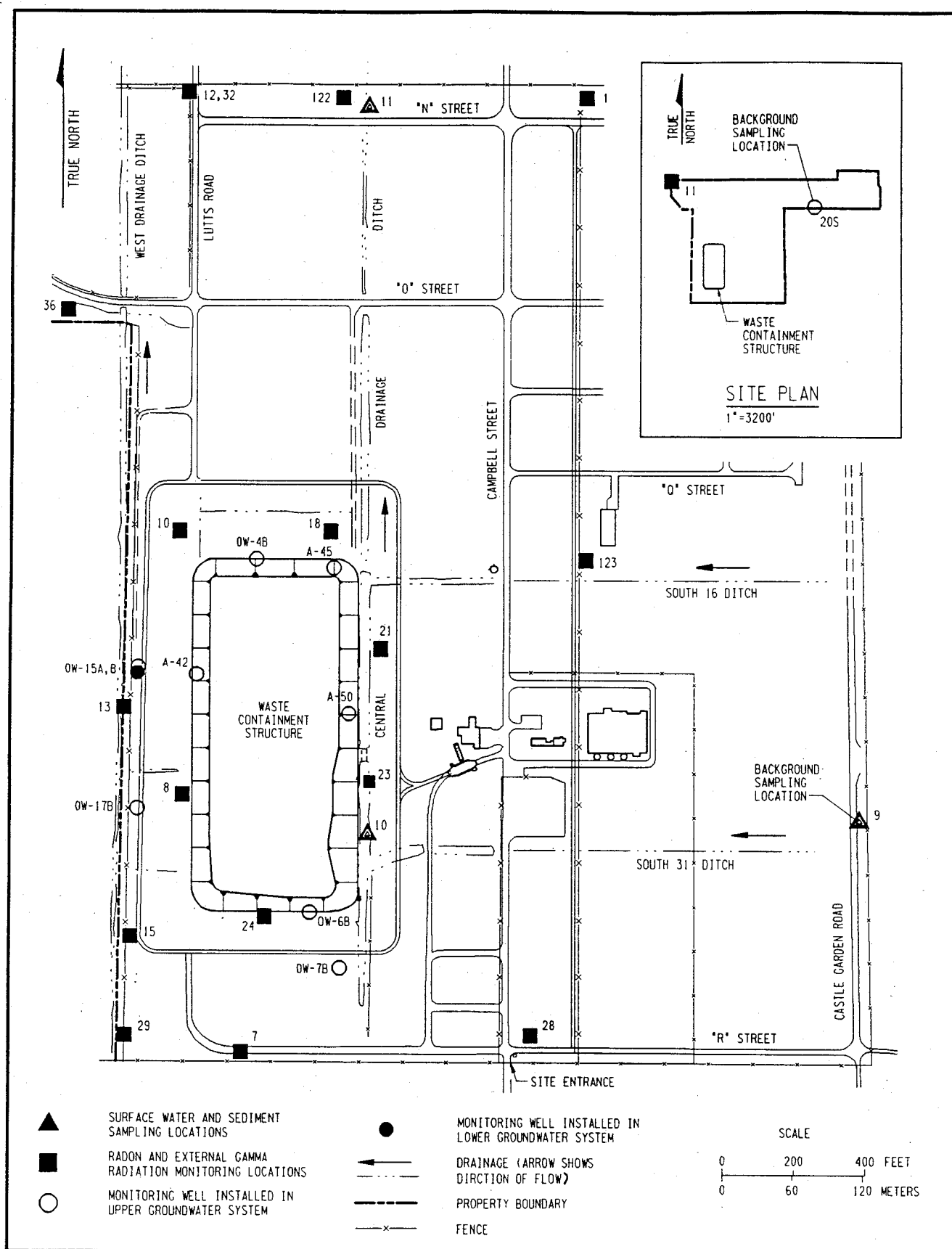
The results of radiological sampling of surface water and sediment during 1993 are presented in Table 17. Figures 1 and 2 show the corresponding sampling locations. Analysis of both media yielded results that were essentially the same as background and below guidelines and standards. These results are consistent with monitoring results from previous years (background concentrations have not been subtracted). Both media were analyzed for radium-226 and total uranium, and selected locations were analyzed for thorium-230. All measured concentrations were well below the DOE guidelines. Trend analysis for radium-226 and total uranium is presented for surface water and sediments for 1988-1993 in Tables 18 and 19, respectively.

SUMMARY

Results of radiological sampling and analysis at NFSS show that concentrations of radionuclides of concern were not significantly different from background or surveillance results from previous years. Surveillance results from gamma exposure, radon, groundwater wells, surface water, and sediment show that NFSS is making no significant contribution to the radioactivity in the environment. The 1993 radiological surveillance program at NFSS has also shown the radiological dose to the total population as essentially zero and that NFSS is in compliance with all applicable DOE radionuclide guidelines.

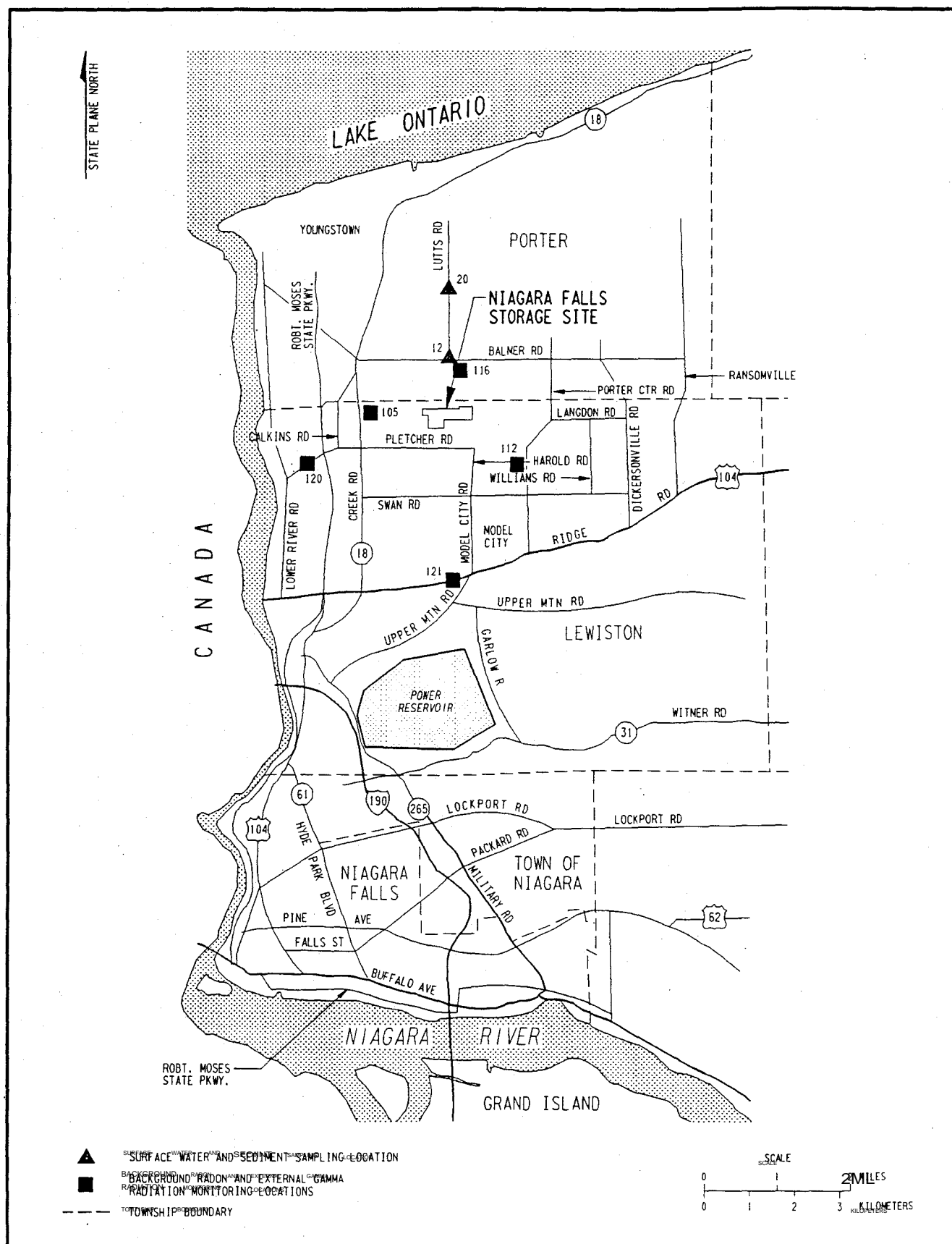
Results of chemical sampling and analysis at the site show concentrations of all parameters were consistent with previous years and were at levels below those that would require action.

The data quality objectives, as outlined in Table 2, were met for the 1993 surveillance program at NFSS.



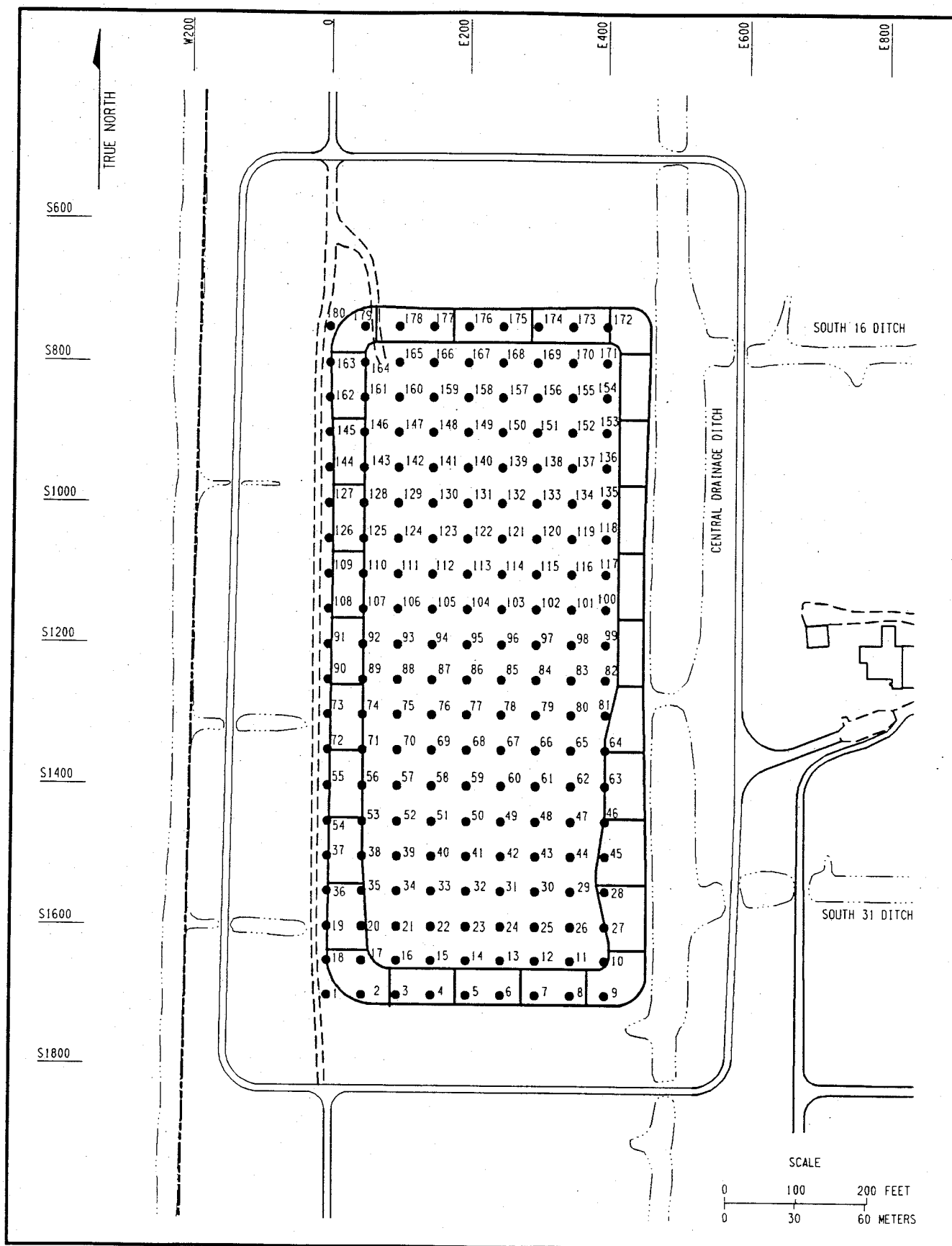
R45F002.DGN

Figure 1
Radon, External Gamma Radiation, Surface Water, Sediment,
and Groundwater Environmental Surveillance Locations at NFSS



R45004.DGN

Figure 2
 Offsite Surface Water, Sediment Sampling, Background Radon,
 and External Gamma Radiation Monitoring Locations at NFISS



158F032.DGN

Figure 3
Radon Flux Monitoring Locations for the
NFSS Waste Containment Structure

Table 1
NFSS Environmental Surveillance Program Summary for 1993

Sample Type	Number of Sampling Locations	Analyses Performed	Frequency of Sampling for Chemical Analyses	Frequency of Sampling or Detector Exchanges for Radiological Analyses
Radon	22*	Radon concentrations in air	Not applicable	Quarterly
Radon flux	180	Radon flux from Surface of WCS	Not applicable	Semiannually
External gamma radiation	22**	External gamma radiation exposure rates	Not applicable	Semiannually
Groundwater	10***	Metals, total organic carbon, radium-226, total uranium (groundwater quality parameters - bicarbonate, carbonate, chloride, nitrate, sulfate, total dissolved solids)	Annually (Three wells annually)	Annually Not applicable
Surface water and sediment	5***	Radium-226, total uranium	Not applicable	Annually

Quality Controls

* All locations have environmental duplicates.

** One location has an environmental duplicate, and one location has a matrix spike and matrix spike duplicate.

*** One location has an environmental duplicate.

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Table 2
Concentrations of Gross Beta in Lower
Groundwater Well OW-15A for available years.

1990	1992	1993
210 pCi/L	61.60 pCi/L	131.3 pCi/L

The average gross beta levels from all other wells in 1990 was 17.6 pCi/L \pm 9.4.

Gross beta was not measured in 1991.

There is no specific guideline for this parameter.

Table 3
Data Quality Objectives for the NFSS Site

Category	Analytical Parameter	Analytical Level	Analytical Technique	Method	Detection Limit	Quality Indicator Goals	
						Precision	Completeness
FIELD MEASUREMENTS							
Radiological Measurements							
Air	TETLD	II	Thermoluminescence	N/A	20 mR/yr	<_20%	75%
	Radon-222	II	Track-etch	N/A	3 pCi/L/d	<_20%	75%
Chemical Measurements							
Groundwater	Dissolved Oxygen	II	Electrometric	EPA 360.1	0.5 mg/L	<_20%	75%
	Oxidation/Reduction	II	Electrometric	N/A	N/A	<_20%	75%
	Turbidity	II	Electrometric	EPA 180.1	0.1 NTU	<_20%	75%
	Temperature	II	Electrometric	EPA 170.1	N/A		
	Spec. Conductivity	II	Electrometric	EPA 120.1	1.0	<_20%	75%
	pH	II	Electrometric	EPA 150.0	N/A	<_20%	75%
Surface Water	Temperature	II	Electrometric	EPA 170.1	N/A		
	Spec. Conductivity	II	Electrometric	EPA 120.1	1.0	<_20%	75%
	pH	II	Electrometric	EPA 150.0	N/A	<_20%	75%
LABORATORY MEASUREMENTS							
Radiological Analyses							
Groundwater	Total Uranium	III	Kinetic phosphoresc.	ASTM D-5174 ^a	0.03 µg/L	+_2 sigma	75%
	Radium-226	III	Alpha spectroscopy	EPA RA-05	0.5 pCi/L	+_2 sigma	75%
Surface Water	Total Uranium	III	Kinetic phosphoresc.	ASTM D-5174 ^a	0.03 µg/L	+_2 sigma	75%
	Radium-226	III	Alpha spectroscopy	EPA RA-05	0.5 pCi/L	+_2 sigma	75%
Sediment	Total Uranium	III	Kinetic phosphoresc.	ASTM D-5174 ^a	0.1 µg/g	+_2 sigma	75%
	Radium-226	III	Gamma spectrometry	EPA C-02	0.5 pCi/g	+_2 sigma	75%
Chemical Analyses Groundwater	Total Organic Carbon	III	Persulfate oxidation	EPA 415.1	0.5 mg/L	<_20%	75%
	Copper	III	ICPAES ^b	EPA 200.7	25 µg/L	<_20%	75%
	Lead	III	Atom Absorption	EPA 200.7	3 µg/L	<_20%	75%
	Vanadium	III	ICPAES ^b	EPA 200.7	50 µg/L	<_20%	75%

^aASTM - American Society for Testing and Materials.

^bICPAES - Inductively coupled plasma atomic emission spectrophotometry.

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Table 4

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**Analytical Methods for Water Quality Parameters of
Groundwater Samples from NFSS in 1993**

Analytical Parameter	Analytical Technique	Method	Detection Limit
Bicarbonate	Potentiometric	EPA 310.1	0.5 mg/L
Carbonate	Potentiometric	EPA 310.1	0.5 mg/L
Sulfate	Turbidimetric	EPA 9038	2.5 mg/L
Chloride	Colorimetric	EPA 9251	0.25 mg/L
Nitrate	Colorimetric	EPA 352.2	0.02 mg/L
Total Dissolved solids	Gravimetric	EPA 160.1	5 mg/L

Table 5
Data Qualification Codes*

U	Indicates undetected analyte
J	Indicates estimated detectable analyte
UJ	Indicates estimated non-detected analyte
R	Indicates rejected analyte result
=	Indicates no problems with the analytical result
B	Indicates that the blank associated with these samples is contaminated
F	Filtered
UF	Unfiltered

*To be used to define data useability flags in Tables 11 and 14.

Table 6

External Gamma Radiation Levels at NFSS, 1993

Location Number			Half-year Average (mR/yr) (predicted yearly average)			Full-year Average (mR/yr) actual yearly average (used for dose calculations)		
Fence Line (average background subtracted)			Station Result	Duplicate		Station Result	Duplicate	Avg
1			0	0		0	0	0
7			0	0		0	0	0
11			0	0		0	0	0
12			0	0		0	0	0
13			0	0		0	0	0
15			0	0		0	0	0
28			0	1		0	0	0
29			0	0		0	1	0.5
36			0	0		0	0	0
122			0	0		0	0	0
123			0	0		0	0	0
Average -								0
On Site (average background subtracted)			Station Result	Duplicate		Station Result	Duplicate	Avg
8			0	0		0	0	0
10			0	0		0	0	0
18			9	0		5	5	5
21			0	0		0	8	4
23			0	0		0	0	0
24			0	0		0	0	0
Average -								1.5
Background			Station Result	Duplicate		Station Result	Duplicate	Avg
105			72	70		65	68	66.5
112			71	68		68	69	68.5
116			68	70		66	72	69
120			95	95		97	89	93
121			105	106		100	107	103.5
Average Background								80.1

Site monitoring locations are shown in Figures 1 & 2.

Table 7
Trend Analysis for External Gamma Radiation Exposure Rates^a
at NFSS, 1988-1993

Sampling Location ^b	Average Annual Rate					Average Annual Rate
	1988	1989	1990	1991	1992	1993
(Rates are in mR/yr)						
Property Line (measured background subtracted)^c						
1	11	0 ^d	1	5	0	0
7	7	2	2	6	0	0
11	5	0	0	0	0	0
12	8	0	0	5	0	0
13	6	1	0	3	0	0
15	14	3	2	11	0	0
28	10	2	4	10	0	0
29	10	0	1	3	0	0.5
36	10	0	1	5	0	0
122 ^e	--	--	--	--	0	0
123 ^e	--	--	--	--	0	0
Background						
105	64	65	60	67	65	67
112	70	60	61	77	72	69
116	65	64	55	67	70	69
120 ^f	--	83	80	89	92	93
121 ^f	--	87	83	95	99	104
					Average	80

Source for 1988-1992 data: DOE/OR/21949-367.

^aThe DOE guideline is 100 mrem/yr above background. One mrem is approximately equivalent to 1 mR.

^bSampling locations are shown in Figures 1 and 2.

^cAverage annual measured background has been subtracted from property-line readings.

^dA zero value indicates that the level was equal to average background at this location.

^eStation established in January 1992.

^fStation established in April 1988.

Table 8
Radon Concentrations in Air at NFSS (pCi/L)

Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	1993 average
Property Line					
1	<0.4	0.4	<0.3	<0.4	0.4
7	<0.4	0.5	0.5	<0.4	0.5
11	<0.4	0.4	<0.3	<0.4	0.4
12	<0.4	0.5	0.4	<0.4	0.4
13	<0.4	0.5	<0.3	<0.4	0.4
15	<0.4	0.5	0.4	<0.4	0.4
28	<0.4	0.4	<0.3	<0.4	0.4
29	<0.4	0.6	<0.3	<0.4	0.4
36	<0.4	0.4	0.4	<0.4	0.4
122	<0.4	0.4	<0.3	<0.4	0.4
123	<0.4	0.4	<0.3	<0.4	0.4
Quality Control					
32 ^a	<0.4	0.5	0.5	<0.4	0.5
On-site					
8	<0.4	0.5	0.5	<0.4	0.5
10	<0.4	0.6	<0.3	<0.4	0.4
18	<0.4	0.3	<0.3	<0.4	0.4
21	<0.4	0.3	<0.3	<0.4	0.4
23	<0.4	0.5	0.4	<0.4	0.4
24	<0.4	0.4	0.4	<0.4	0.4
Background					
105	<0.4	0.3	0.4	<0.4	0.4
112	<0.4	0.4	0.4	<0.4	0.4
116	<0.4	0.3	0.4	<0.4	0.4
120	<0.4	<0.3	<0.3	<0.4	0.4
121	<0.4	0.4	0.4	<0.4	0.4

^aStation 32 is a quality control station for station 12.

Table 9
Trend Analysis for Radon Concentration^{a,b}
at NFSS, 1988-1993

Sampling Location ^c	Average Annual Concentration					Average Annual Concentration
	1988	1989	1990	1991	1992	1993
(Concentrations are in 10^{-9} $\mu\text{Ci/ml}$)						
1	0.5	0.4	0.3	0.4	0.4	0.4
7	0.4	0.8	0.3	0.4	0.4	0.5
11	0.2	0.4	0.4	0.6	0.3	0.4
12	0.3	0.5	0.3	0.4	0.4	0.4
13	0.5	0.7	0.3	0.8	0.3	0.4
15	0.3	0.4	0.4	0.5	0.4	0.4
28	0.3	0.5	0.4	0.6	0.4	0.4
29	0.3	0.8	0.7	0.6	0.3	0.4
36	0.3	0.4	0.3	0.5	0.3	0.4
122	--	--	--	--	0.5	0.4
123	--	--	--	--	0.3	0.4
Quality Control						
32	0.3	0.6	0.3	0.6	0.3	0.5
Background						
105	0.4	0.4	0.3	0.4	0.4	0.4
112	0.3	0.3	0.4	4	0.3	0.4
116	0.3	0.3	0.3	0.6	0.3	0.4
120	0.5	0.5	0.3	0.3	0.3	0.4
121	0.5	0.4	0.3	0.3	0.3	0.4

Source for 1988-1992 data: DOE/OR/21949-367.

^a 1×10^{-9} $\mu\text{Ci/ml}$ is equivalent to 0.037 Bq/L and 1 pCi/L. The DOE guideline is 3.0×10^{-9} $\mu\text{Ci/ml}$.

^bMeasured background has not been subtracted. Note: Concentrations at some stations were below values of background stations.

^cSampling locations are shown in Figures 1 and 2.

^dStation established in January 1992.

^eStation established in April 1988.

Table 10

Annual Radon Flux Monitoring Results NFSS, 1993

Sample ID	Radon Flux pCi/sq m/s	Sample ID	Radon Flux pCi/sq m/s	Sample ID	Radon Flux pCi/sq m/s
202-RF-001	0.92 ± 0.03	202-RF-034	0.67 ± 0.03	202-RF-066	0.61 ± 0.03
202-RF-002	0.52 ± 0.02	202-RF-035	0.70 ± 0.03	202-RF-093	0.69 ± 0.03
202-RF-003	0.62 ± 0.02	202-RF-036	0.68 ± 0.03	202-RF-094	0.65 ± 0.03
202-RF-004	0.52 ± 0.02	202-RF-037	0.68 ± 0.03	202-RF-095	0.97 ± 0.03
202-RF-005	0.74 ± 0.03	202-RF-038	0.73 ± 0.03	202-RF-096	0.61 ± 0.03
202-RF-006	0.63 ± 0.02	202-RF-039	0.53 ± 0.02	202-RF-097	0.63 ± 0.03
202-RF-007	0.58 ± 0.02	202-RF-040	0.56 ± 0.02	202-RF-098	0.61 ± 0.03
202-RF-008	0.43 ± 0.02	202-RF-041	0.58 ± 0.03	202-RF-099	0.77 ± 0.03
202-RF-009	0.50 ± 0.02	202-RF-042	0.75 ± 0.03	202-RF-100	0.75 ± 0.03
202-RF-010	0.65 ± 0.03	202-RF-043	1.22 ± 0.03	202-RF-101	0.69 ± 0.03
202-RF-011	0.70 ± 0.03	202-RF-044	0.73 ± 0.03	202-RF-102	0.63 ± 0.03
202-RF-011	0.78 ± 0.03	202-RF-044	0.68 ± 0.03	202-RF-103	0.56 ± 0.03
202-RF-012	0.71 ± 0.03	202-RF-045	0.59 ± 0.03	202-RF-104	0.77 ± 0.03
202-RF-013	0.79 ± 0.03	202-RF-046	0.63 ± 0.03	202-RF-105	0.70 ± 0.03
202-RF-014	0.81 ± 0.03	202-RF-047	0.77 ± 0.03	202-RF-106	0.62 ± 0.03
202-RF-015	0.74 ± 0.03	202-RF-048	0.69 ± 0.03	202-RF-107	0.80 ± 0.03
202-RF-016	0.71 ± 0.03	202-RF-049	0.96 ± 0.03	202-RF-108	1.13 ± 0.04
202-RF-017	0.55 ± 0.02	202-RF-050	0.55 ± 0.03	202-RF-109	0.68 ± 0.03
202-RF-018	0.69 ± 0.03	202-RF-050	0.52 ± 0.02	202-RF-110	0.67 ± 0.03
202-RF-019	0.70 ± 0.03	202-RF-051	0.64 ± 0.03	202-RF-111	0.66 ± 0.03
202-RF-020	0.78 ± 0.03	202-RF-052	0.60 ± 0.03	202-RF-112	0.58 ± 0.03
202-RF-021	0.81 ± 0.03	202-RF-053	0.74 ± 0.03	202-RF-113	0.72 ± 0.03
202-RF-022	0.86 ± 0.03	202-RF-054	0.79 ± 0.03	202-RF-114	0.61 ± 0.03
202-RF-023	0.69 ± 0.03	202-RF-055	0.90 ± 0.03	202-RF-115	0.55 ± 0.03
202-RF-024	0.71 ± 0.03	202-RF-056	0.65 ± 0.03	202-RF-116	0.55 ± 0.03
202-RF-025	0.89 ± 0.03	202-RF-057	0.69 ± 0.03	202-RF-117	0.93 ± 0.03
202-RF-026	0.85 ± 0.03	202-RF-058	0.63 ± 0.03	202-RF-118	0.55 ± 0.03
202-RF-026	0.81 ± 0.03	202-RF-059	0.63 ± 0.03	202-RF-119	1.04 ± 0.03
202-RF-027	0.68 ± 0.03	202-RF-060	0.69 ± 0.03	202-RF-120	0.55 ± 0.03
202-RF-028	0.64 ± 0.03	202-RF-061	0.82 ± 0.03	202-RF-121	0.81 ± 0.03
202-RF-029	0.88 ± 0.03	202-RF-062	0.97 ± 0.03	202-RF-122	0.85 ± 0.03
202-RF-030	0.79 ± 0.03	202-RF-063	0.68 ± 0.03	202-RF-067	0.49 ± 0.03
202-RF-031	0.65 ± 0.03	202-RF-064	0.81 ± 0.03	202-RF-068	0.53 ± 0.03
202-RF-032	0.79 ± 0.03	202-RF-065	0.76 ± 0.03	202-RF-069	0.59 ± 0.03
202-RF-033	0.56 ± 0.02	202-RF-066	0.67 ± 0.03	202-RF-069	0.38 ± 0.02

Table 10 (continued)

Sample ID	Radon Flux pCi/sq m/s	Sample ID	Radon Flux pCi/sq m/s	Sample ID	Radon Flux pCi/sq m/s
202-RF-070	0.77 ± 0.03	202-RF-125	0.98 ± 0.04	202-RF-156	0.66 ± 0.03
202-RF-071	0.74 ± 0.03	202-RF-126	0.98 ± 0.04	202-RF-157	1.01 ± 0.04
202-RF-072	1.02 ± 0.03	202-RF-126	0.90 ± 0.03	202-RF-158	0.86 ± 0.04
202-RF-073	0.88 ± 0.03	202-RF-127	0.70 ± 0.03	202-RF-159	0.95 ± 0.04
202-RF-074	0.72 ± 0.03	202-RF-128	0.85 ± 0.03	202-RF-160	0.80 ± 0.03
202-RF-075	0.57 ± 0.03	202-RF-128	0.86 ± 0.03	202-RF-160	0.68 ± 0.03
202-RF-076	0.60 ± 0.03	202-RF-129	0.65 ± 0.03	202-RF-161	0.74 ± 0.03
202-RF-077	0.72 ± 0.03	202-RF-130	0.67 ± 0.03	202-RF-162	0.85 ± 0.04
202-RF-078	0.53 ± 0.03	202-RF-131	0.74 ± 0.03	202-RF-163	0.88 ± 0.04
202-RF-078	0.74 ± 0.03	202-RF-132	0.62 ± 0.03	202-RF-164	0.56 ± 0.03
202-RF-079	0.83 ± 0.03	202-RF-133	0.66 ± 0.03	202-RF-164	0.59 ± 0.03
202-RF-080	0.66 ± 0.03	202-RF-134	0.91 ± 0.03	202-RF-165	0.68 ± 0.03
202-RF-081	0.72 ± 0.03	202-RF-135	0.73 ± 0.03	202-RF-165	0.58 ± 0.03
202-RF-082	0.70 ± 0.03	202-RF-136	0.72 ± 0.03	202-RF-166	0.72 ± 0.03
202-RF-083	0.76 ± 0.03	202-RF-137	0.76 ± 0.03	202-RF-167	0.65 ± 0.03
202-RF-083	0.59 ± 0.03	202-RF-138	0.71 ± 0.03	202-RF-168	0.80 ± 0.03
202-RF-084	0.63 ± 0.03	202-RF-139	0.61 ± 0.03	202-RF-169	0.66 ± 0.03
202-RF-085	0.65 ± 0.03	202-RF-140	0.85 ± 0.03	202-RF-170	0.79 ± 0.03
202-RF-086	0.66 ± 0.03	202-RF-141	0.78 ± 0.03	202-RF-171	0.77 ± 0.03
202-RF-087	0.64 ± 0.03	202-RF-142	0.63 ± 0.03	202-RF-171	0.74 ± 0.03
202-RF-088	0.60 ± 0.03	202-RF-143	0.79 ± 0.03	202-RF-172	0.75 ± 0.03
202-RF-088	0.52 ± 0.03	202-RF-144	0.81 ± 0.03	202-RF-173	0.73 ± 0.03
202-RF-089	1.43 ± 0.04	202-RF-144	0.93 ± 0.04	202-RF-174	0.82 ± 0.04
202-RF-090	0.82 ± 0.03	202-RF-145	0.79 ± 0.03		
202-RF-091	0.66 ± 0.03	202-RF-146	0.78 ± 0.03		
202-RF-092	0.62 ± 0.03	202-RF-147	1.09 ± 0.04		
202-RF-175	0.66 ± 0.03	202-RF-148	0.92 ± 0.04		
202-RF-176	0.62 ± 0.03	202-RF-148	0.85 ± 0.03		
202-RF-177	0.62 ± 0.03	202-RF-149	0.99 ± 0.04		
202-RF-178	0.71 ± 0.03	202-RF-150	1.26 ± 0.04		
202-RF-179	0.80 ± 0.03	202-RF-151	0.83 ± 0.03		
202-RF-180	0.77 ± 0.03	202-RF-152	1.01 ± 0.04		
202-RF-180	0.64 ± 0.03	202-RF-153	0.92 ± 0.04		
202-RF-123	0.74 ± 0.03	202-RF-154	0.74 ± 0.03		
202-RF-124	0.80 ± 0.03	202-RF-155	0.67 ± 0.03		

Sample IDs in bold are duplicate samples for QC purposes.

Table 11**Radionuclides in Groundwater at the Niagara Falls Storage Site, 1993**

Note: Well OW-15A is a deep groundwater well
Well 20S is a background location
Well A-44 is a quality control location for A-42
Table 5 lists the codes used.

Table 12
Trend Analysis for Radium-226 Concentrations^{a,b}
in Groundwater at NFSS, 1988-1993

Sampling Location ^c	Average Annual Concentration ^d					Concentration ^d
	1988	1989	1990	1991	1992	1993
(Concentrations are in 10 ⁻⁹ μCi/ml)						
Upper Groundwater System						
OW-4B	0.3	0.5	0.3	1	0.2	0.09
OW-7B	0.4	0.5	0.3	0.3	0.9	0.08
OW-15B	0.6	0.8	0.4	0.3	0.4	0.2
OW-17B	0.3	0.4	0.4	0.3	0.2	0.1
A-42	0.5	0.6	0.9	0.5	0.7	0.4
20S ^e	-- ^f	-- ^f	0.4	0.4	0.3	0.1
Lower Groundwater System						
OW-15A	0.5	0.4	0.5	0.7	1	5.28

Source for 1988-1992 data: DOE/OR/21949-367.

^a 1×10^{-9} μ Ci/ml is equivalent to 0.037 Bq/L and 1 pCi/L. The DCG is 100×10^{-9} μ Ci/ml. See Appendix E for information on half-life.

^bMeasured background has not been subtracted.

^cSampling locations are shown in Figures 1 and 2. Sampling locations that no longer exist because of adjustments in the monitoring program or changes resulting from remedial actions are not reported in trend tables. Data from these locations would not be valid for comparison or trends.

^dRadium-226 concentrations were determined by emanation during 1988 through 1990 and the first three quarters of 1991 and by alpha spectroscopy during the fourth quarter of 1991 through 1993.

^eBackground well.

^f(--) indicates that a well was not established and sampled until fourth quarter 1990.

Table 13
Trend Analysis for Total Uranium Concentrations^{a,b}
in Groundwater at NFSS, 1988-1993

Sampling Location ^c	Average Annual Concentration ^d					Concentration ^d
	1988	1989	1990	1991	1992	1993
(Concentrations are in 10^{-9} $\mu\text{Ci/ml}$)						
Upper Groundwater System						
OW-4B	7	7	6	6	18	26
OW-7B	5	3	9	12	2	22
OW-15B	7	14	7	17	9	13
OW-17B	8	8	6	6	7	7
A-42	55	67	76	57	76	53
20S ^e	-- ^f	-- ^f	9	6	8	13
Lower Groundwater System						
OW-15A	4	3	3	3	2	3.1

Source for 1988-1992 data: DOE/OR/21949-367.

^a 1×10^{-9} $\mu\text{Ci/ml}$ is equivalent to 0.037 Bq/L and 1 pCi/L. The DCG is 600×10^{-9} $\mu\text{Ci/ml}$.

^bMeasured background has not been subtracted.

^cSampling locations are shown in Figures 1 and 2. Sampling locations that no longer exist because of adjustments in the monitoring program or changes resulting from remedial actions are not reported in trend tables. Data from these locations would not be valid for comparison or trends.

^dTotal uranium concentrations were determined by using fluorometric analysis during 1988 through 1990 and the first three quarters of 1991 and by kinetic phosphorescence analysis during the fourth quarter of 1991 through 1993.

^eBackground well.

^f(--) indicates that well was not established and sampled until 1990.

Table 14**Chemical Analysis Results for Groundwater at the Niagara Falls Storage Site, 1993**

Note: Well OW-15A is a deep groundwater well
Well 20S is a background location
Well A-44 is a quality control location for A-42
Table 5 lists the codes used.

Table 14

Type	Smp_id	Analyte	Result	Units	BNI Flag
IN	158-A42-GW	BICARBONATE	430.000	MG/L	
IN	158-A42-GW	BICARBONATE	430.000	MG/L	
IN	158-A44-GW	BICARBONATE	430.000	MG/L	
IN	158-A44-GW	BICARBONATE	440.000	MG/L	
IN	158-OW15A-GW	BICARBONATE	350.000	MG/L	
IN	158-OW15A-GW	BICARBONATE	80.000	MG/L	
IN	158-OW17B-GW	BICARBONATE	470.000	MG/L	
IN	158-OW17B-GW F	BICARBONATE	440.000	MG/L	
IN	158-A42-GW	CARBONATE	10.000	MG/L	
IN	158-A42-GW	CARBONATE	10.000	MG/L	
IN	158-A44-GW	CARBONATE	10.000	MG/L	
IN	158-A44-GW	CARBONATE	10.000	MG/L	
IN	158-OW15A-GW	CARBONATE	2.000	MG/L	
IN	158-OW15A-GW	CARBONATE	1.000	MG/L	
IN	158-OW17B-GW	CARBONATE	0.500	MG/L	
IN	158-OW17B-GW F	CARBONATE	0.500	MG/L	
IN	158-A42-GW	CHLORIDE	9.600	MG/L	
IN	158-A42-GW	CHLORIDE	9.700	MG/L	
IN	158-A44-GW	CHLORIDE	9.000	MG/L	
IN	158-A44-GW	CHLORIDE	10.300	MG/L	
IN	158-OW15A-GW	CHLORIDE	66.700	MG/L	
IN	158-OW15A-GW	CHLORIDE	71.100	MG/L	
IN	158-OW17B-GW	CHLORIDE	8.600	MG/L	
IN	158-OW17B-GW F	CHLORIDE	12.100	MG/L	
IN	158-A42-GW	NITRATE, AS N	0.022	MG-N/	
IN	158-A42-GW	NITRATE, AS N	0.024	MG-N/	
IN	158-A44-GW	NITRATE, AS N	0.020	MG-N/	
IN	158-A44-GW	NITRATE, AS N	0.020	MG-N/	
IN	158-OW15A-GW	NITRATE, AS N	0.210	MG-N/	R
IN	158-OW15A-GW	NITRATE, AS N	0.180	MG-N/	R
IN	158-OW17B-GW	NITRATE, AS N	0.100	MG-N/	
IN	158-OW17B-GW F	NITRATE, AS N	0.200	MG-N/	
IN	158-A42-GW	SULFATE	329.000	MG/L	
IN	158-A42-GW	SULFATE	316.000	MG/L	
IN	158-A44-GW	SULFATE	322.000	MG/L	
IN	158-A44-GW	SULFATE	328.000	MG/L	
IN	158-OW15A-GW	SULFATE	1190.000	MG/L	
IN	158-OW15A-GW	SULFATE	1150.000	MG/L	
IN	158-OW17B-GW	SULFATE	535.000	MG/L	
IN	158-OW17B-GW F	SULFATE	468.000	MG/L	
IN	158-A42-GW	TOTAL DISSOLVED SOLIDS	1140.000	MG/L	
IN	158-A42-GW	TOTAL DISSOLVED SOLIDS	1230.000	MG/L	
IN	158-A44-GW	TOTAL DISSOLVED SOLIDS	1250.000	MG/L	
IN	158-A44-GW	TOTAL DISSOLVED SOLIDS	1170.000	MG/L	
IN	158-OW15A-GW	TOTAL DISSOLVED SOLIDS	1790.000	MG/L	
IN	158-OW15A-GW	TOTAL DISSOLVED SOLIDS	1950.000	MG/L	
IN	158-OW17B-GW	TOTAL DISSOLVED SOLIDS	1080.000	MG/L	
IN	158-OW17B-GW F	TOTAL DISSOLVED SOLIDS	1110.000	MG/L	
IN	158-20S-GW	TOTAL ORGANIC CARBON	1.400	MG/L	
IN	158-A42-GW	TOTAL ORGANIC CARBON	3.300	MG/L	
IN	158-A44-GW	TOTAL ORGANIC CARBON	2.600	MG/L	
IN	158-A45-GW	TOTAL ORGANIC CARBON	2.000	MG/L	
IN	158-A50-GW	TOTAL ORGANIC CARBON	2.600	MG/L	
IN	158-OW04B-GW	TOTAL ORGANIC CARBON	1.900	MG/L	
IN	158-OW06B-GW	TOTAL ORGANIC CARBON	2.500	MG/L	

Table 14

(continued)

Type	Smp_id	Analyte	Result	Units	BNI Flag
IN	158-OW07B-GW	TOTAL ORGANIC CARBON	1.100	MG/L	
IN	158-OW15A-GW	TOTAL ORGANIC CARBON	2.600	MG/L	
IN	158-OW15B-GW	TOTAL ORGANIC CARBON	2.000	MG/L	
IN	158-OW17B-GW	TOTAL ORGANIC CARBON	2.000	MG/L	
ME	158-A42-GW	CALCIUM, SOLUBLE	156000.000	UG/L	
ME	158-A44-GW	CALCIUM, SOLUBLE	155000.000	UG/L	
ME	158-OW17B-GW F	CALCIUM, SOLUBLE	53900.000	UG/L	
ME	158-A42-GW	CALCIUM, TOTAL	156000.000	UG/L	
ME	158-A44-GW	CALCIUM, TOTAL	157000.000	UG/L	
ME	158-OW15A-GW	CALCIUM, TOTAL	264000.000	UG/L	
ME	158-OW15A-GW	CALCIUM, TOTAL	160000.000	UG/L	
ME	158-OW17B-GW	CALCIUM, TOTAL	56300.000	UG/L	
ME	158-20S-GW	COPPER, TOTAL	6.000	UG/L	
ME	158-A42-GW	COPPER, TOTAL	8.700	UG/L	
ME	158-A44-GW	COPPER, TOTAL	6.000	UG/L	
ME	158-A45-GW	COPPER, TOTAL	6.000	UG/L	
ME	158-A50-GW	COPPER, TOTAL	10.000	UG/L	
ME	158-OW04B-GW	COPPER, TOTAL	6.000	UG/L	
ME	158-OW06B-GW	COPPER, TOTAL	6.000	UG/L	
ME	158-OW07B-GW	COPPER, TOTAL	6.500	UG/L	
ME	158-OW15A-GW	COPPER, TOTAL	41.100	UG/L	
ME	158-OW15B-GW	COPPER, TOTAL	9.400	UG/L	
ME	158-OW17B-GW	COPPER, TOTAL	6.200	UG/L	
ME	158-20S-GW	LEAD, TOTAL	2.000	UG/L	UJ
ME	158-A42-GW	LEAD, TOTAL	2.000	UG/L	UJ
ME	158-A44-GW	LEAD, TOTAL	2.000	UG/L	UJ
ME	158-A45-GW	LEAD, TOTAL	2.000	UG/L	UJ
ME	158-A50-GW	LEAD, TOTAL	2.000	UG/L	UJ
ME	158-OW04B-GW	LEAD, TOTAL	2.000	UG/L	UJ
ME	158-OW06B-GW	LEAD, TOTAL	2.000	UG/L	UJ
ME	158-OW07B-GW	LEAD, TOTAL	2.000	UG/L	UJ
ME	158-OW15A-GW	LEAD, TOTAL	2.000	UG/L	UJ
ME	158-OW15B-GW	LEAD, TOTAL	4.400	UG/L	J
ME	158-OW17B-GW	LEAD, TOTAL	2.000	UG/L	UJ
ME	158-A42-GW	MAGNESIUM, SOLUBLE	2.000	UG/L	UJ
ME	158-A44-GW	MAGNESIUM, SOLUBLE	68900.000	UG/L	
ME	158-OW17B-GW F	MAGNESIUM, SOLUBLE	68300.000	UG/L	
ME	158-A42-GW	MAGNESIUM, TOTAL	149000.000	UG/L	
ME	158-A44-GW	MAGNESIUM, TOTAL	69500.000	UG/L	
ME	158-OW15A-GW	MAGNESIUM, TOTAL	68700.000	UG/L	
ME	158-OW15A-GW	MAGNESIUM, TOTAL	106000.000	UG/L	
ME	158-OW17B-GW	MAGNESIUM, TOTAL	86800.000	UG/L	
ME	158-A42-GW	POTASSIUM, SOLUBLE	146000.000	UG/L	
ME	158-A44-GW	POTASSIUM, SOLUBLE	4470.000	UG/L	
ME	158-OW17B-GW F	POTASSIUM, SOLUBLE	4940.000	UG/L	
ME	158-A42-GW	POTASSIUM, TOTAL	2560.000	UG/L	
ME	158-A44-GW	POTASSIUM, TOTAL	4130.000	UG/L	
ME	158-OW15A-GW	POTASSIUM, TOTAL	3790.000	UG/L	
ME	158-OW15A-GW	POTASSIUM, TOTAL	11900.000	UG/L	
ME	158-OW17B-GW	POTASSIUM, TOTAL	9580.000	UG/L	
ME	158-A42-GW	SODIUM, SOLUBLE	1860.000	UG/L	
ME	158-A44-GW	SODIUM, SOLUBLE	49300.000	UG/L	
ME	158-OW17B-GW F	SODIUM, SOLUBLE	48200.000	UG/L	
ME	158-A42-GW	SODIUM, TOTAL	75100.000	UG/L	
ME	158-A44-GW	SODIUM, TOTAL	49400.000	UG/L	
			47600.000	UG/L	

Table 14

(continued)

Type	Smp_id	Analyte	Result	Units	BNI Flag
ME	158-OW15A-GW	SODIUM, TOTAL			
ME	158-OW15A-GW	SODIUM, TOTAL	186000.000	UG/L	
ME	158-OW17B-GW	SODIUM, TOTAL	185000.000	UG/L	
ME	158-20S-GW	VANADIUM, TOTAL	71300.000	UG/L	
ME	158-A42-GW	VANADIUM, TOTAL	9.000	UG/L	
ME	158-A44-GW	VANADIUM, TOTAL	17.900	UG/L	
ME	158-A45-GW	VANADIUM, TOTAL	23.700	UG/L	
ME	158-A50-GW	VANADIUM, TOTAL	33.400	UG/L	
ME	158-OW04B-GW	VANADIUM, TOTAL	27.500	UG/L	
ME	158-OW06B-GW	VANADIUM, TOTAL	35.200	UG/L	
ME	158-OW07B-GW	VANADIUM, TOTAL	27.600	UG/L	
ME	158-OW15A-GW	VANADIUM, TOTAL	29.300	UG/L	
ME	158-OW15B-GW	VANADIUM, TOTAL	47.200	UG/L	
ME	158-OW17B-GW	VANADIUM, TOTAL	17.400	UG/L	
			13.500	UG/L	

Table 15
Niagara Falls Storage Site Groundwater and
Surface Water Field Data, 1993

Location	pH	Specific Conductivity (μ mhos/cm)	Oxidation- Reduction Potential (mV)	Dissolved Oxygen	Dissolved Oxygen (mg/L)	Turbidity (NTU)
Wells						
OW-4B	6.9	3650	16	15.2	2.8	21
OW-6B	6.9	3010	-77	17	4	13
OW-7B	7.5	1770	na	20	na	30
OW-15A	6.8	5980	-111	11.6	0.5	>200
OW-15B	6.7	4400	5	18.7	5.2	21
OW-17B	6.2	2150	60	14.4	3	5
A-42	7.2	1180	na	19	na	23
A-45	6.8	2439	-12	11.5	1.3	57
A-50	6.7	2014	16	13.5	3.3	20
20S ^a	6.5	1403	31	14.8	2.7	22
Surface						
9 ^a	7.7	1230				
10	6.3	324				
11	7.4	660				
12	7.5	949				
20	7.7	625				

^a20S and 9 are background locations

Table 16
EPA and NYSDEC Guidelines as
Action Levels for Water Media

Constituent	EPA ^a	NYSDEC ^b (Class GA)
	Concentration ($\mu\text{g/L}$)	Standard Concentration ($\mu\text{g/L}$)
Copper	1,300	2,000
Lead	15	25
Vanadium	-- ^c	-- ^c

^aEPA 1991, "Maximum Contaminant Level Goals and National Primary Drinking Water Regulations for Lead and Copper; Final Rule," (40 CFR Parts 141 & 142) June 7.

^bNYSDEC 1991, "Water Quality Regulations for Surface Waters and Groundwaters," (6 NYCRR Parts 700-705 - September 1)

^cNo standards available.

Table 17
Radionuclide Concentrations in Surface Water
and Sediment

Sample Location	Radium-226	Total Uranium	Thorium-230
Surface Water	pCi/L	pCi/L	pCi/L
9 ^a	1	3.66	
10	0.78	2	
11	0.41	4.54	0.5
12	0.82	1.22	
13 ^b	0.03	1.22	
20	2.38	2.5	
Sediment	pCi/g	pCi/g	pCi/g
9 ^a	1.7	2.9	
10	1.5	1.76	
11	0.89	2.57	0.85
12	0.68	1.08	
13 ^b	0.91	1.29	
20	0.95	1.08	

^aLocation 9 serves as a background sampling station

^bQuality control station for location 12

Table 18
Trend Analysis for Total Uranium and Radium-226
Concentrations^{a,b} in Surface Water at NFSS, 1988-1993

Sampling Location ^c	Average Annual Concentration ^d					Concentration ^d
	1988	1989	1990	1991	1992	1993
<hr/>						
(Concentrations are in 10 ⁻⁹ μCi/ml)						
Total Uranium ^d						
9 ^e	8	9	7	5	6	4
10	7	21	5	8	8	2
11	10	16	9	13	7	5
12 ^f	6	10	9	4	0.9	1
20 ^f	7	4	8	4	0.9	2.5
Radium-226 ^g						
9 ^e	0.2	1.5	0.5	1	0.3	1
10	0.2	0.6	0.5	0.7	1	0.8
11	1	2.5	0.4	2	0.5	0.4
12 ^f	0.3	0.6	0.9	0.6	1.6	0.8
20 ^f	1	0.5	0.7	0.4	0.7	2.38

Source for 1988-1992 data: DOE/OR/21949-367.

^a 1×10^{-9} $\mu\text{Ci/ml}$ is equivalent to 0.037 Bq/L and 1 pCi/L. The DCGs for total uranium and radium-226 are 600×10^{-9} and 100×10^{-9} $\mu\text{Ci/ml}$, respectively.

^bMeasured background has not been subtracted.

^cSampling locations are shown in Figures 1 and 2.

^dTotal uranium concentrations were determined by using fluorometric analysis during 1988 through 1990 and the first three quarters of 1991 and by kinetic phosphorescence analysis (KPA) during the fourth quarter of 1991 through 1993. KPA is a much more sensitive method of analysis.

^eBackground, upstream sampling location established in October 1988 at the south 31 ditch; thus, data for 1988 represent one quarter's results, not average annual results.

^fOffsite, downstream sampling location.

^gRadium-226 concentrations were determined by emanation during 1988 through 1990 and the first three quarters of 1991 and by alpha spectroscopy during the

Table 19
Trend Analysis for Total Uranium and Radium-226
Concentrations^{a,b} in Sediments at NFSS, 1988-1993

Sampling Location ^c	Average Annual Concentration					Concentration
	1988	1989	1990	1991	1992	1993
(Concentrations are in pCi/g)						
Total Uranium						
9 ^d	2	2.6	3.7	7	7	3
10	2.7	8.8	1.8	4	4	2
11	1.5	2.1	2.5	4	4	3
12 ^e	1.9	1.4	1.7	3	3	1
20 ^e	1.8	1.5	1.6	3	4	1
Radium-226						
9 ^d	1.3	1	1	2	2	2
10	0.8	1.8	0.8	0.8	1	2
11	1	1.7	1	1	0.7	0.9
12 ^e	1.3	0.8	0.8	0.7	0.6	0.7
20 ^e	0.9	0.8	1	1	0.9	1

Source for 1988-1992 data: DOE/OR/21949-367.

^aOne pCi/g is equivalent to 0.037 Bq/g. The FUSRAP NFSS site-specific soil guideline for total uranium is 90 pCi/g, and for radium-226 is 5 pCi/g above background.

^bMeasured background has not been subtracted.

^cSampling locations are shown in Figures 1 and 2.

^dBackground, upstream sampling location established in October 1988 at the south 31 ditch; thus, data for 1988 represent one quarter's results, not average annual results.

^eOffsite, downstream sampling location.