

**FUSRAP
NIAGARA FALLS STORAGE SITE**

**2003
ENVIRONMENTAL SURVEILLANCE
TECHNICAL MEMORANDUM**



**US Army Corps
of Engineers ®**
Buffalo District

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ACRONYMS

AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
ANL	Argonne National Laboratory
ARAR	applicable or relevant and appropriate requirement
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	chain of custody
DCG	derived concentration guide
DOE	Department of Energy
DQO	data quality objective
EA	environmental assessment
EDE	effective dose equivalent
EE/CA	engineering evaluation/cost analysis
EIS	environmental impact statement
EML	Environmental Measurements Laboratory
ESP	environmental surveillance plan
FFA	federal facility agreement
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FSRD	Former Sites Restoration Division
FUSRAP	Formerly Utilized Sites Remedial Action Program
GC-EC	gas chromatography/electron capture
GC/MS	gas chromatography/mass spectrometry
GFAA	graphite furnace atomic adsorption
HWP	hazardous work permit
ICPAES	inductively coupled plasma atomic emission spectrophotometry
ID	identification
IG	instruction guide
KPA	kinetic phosphorescence analysis
LCS	laboratory control sample
LEL	lower explosive limit
LOOW	Lake Ontario Ordnance Works
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MDA	Minimal Detectable Activity
MED	Manhattan Engineer District
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NFSS	Niagara Falls Storage Site
NHPA	National Historic Preservation Act
NIST	National Institute for Standards and Technology
NL	National Lead
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	Nuclear Regulatory Commission

(Continued)

NYSDEC	New York State Department of Environmental Conservation
PERALS	photon/electron-rejecting alpha liquid scintillation
PI	project instruction
PP	project procedure
PPE	personal protective equipment
QA	quality assurance
QAP	Quality Assurance Plan
QAT	Quality Assurance Team
QC	quality control
RCRA	Resource Conservation and Recovery Act
RI/FS	remedial investigation/feasibility study
ROD	Record of Decision
RPD	relative percent difference
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SRM	standard reference material
SSHR	site safety and health representative
S/RID	Standards/Requirements Identification Document
TCLP	toxicity characteristics leaching procedure
TDS	total dissolved solids
TETLD	tissue-equivalent thermoluminescent dosimeter
TLD	thermoluminescent dosimeter
TOC	total organic carbon
TOX	total organic halides
TPH	total petroleum hydrocarbons
TSCA	Toxic Substances Control Act
USACE	United States Army Corps Of Engineers
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound
WCS	waste containment structure

EXECUTIVE SUMMARY

In 1974, the Atomic Energy Commission (AEC), a predecessor to the U.S. Department of Energy (DOE), instituted the Formerly Utilized Sites Remedial Action Program (FUSRAP). This program is now managed by United States Army Corps of Engineers (USACE) to identify, and cleanup, or otherwise control sites where residual radioactivity remains from the early years of the nation's atomic energy program or from commercial operations causing conditions that Congress has authorized USACE to remedy under FUSRAP. In October 1997, Congress transferred the responsibility for FUSRAP from the DOE to the USACE.

This memorandum presents and interprets analytical results and measurements obtained as part of the 2003 environmental surveillance program for the Niagara Falls Storage Site (NFSS) under the FUSRAP. Because radioactive wastes and residues are stored in the waste containment structure (WCS) at NFSS, the environmental surveillance program at the site includes sampling of air, water, and streambed sediment to ensure that onsite waste does not pose a threat to human health and the environment. The discussion below provides a comparative analysis of local background conditions and regulatory criteria to results reported for external gamma radiation and for samples from the media investigated. Data tables and figures referenced in the text are included at the end of this document.

DOE and United States Environmental Protection Agency (USEPA) guidelines are presented throughout this report for comparative purposes in evaluating environmental surveillance data. The USACE continues to compare data with DOE guidelines because even though the facility is owned by the Federal Government and is currently maintained by the USACE, DOE has property accountability. However, those values are provided for comparative purposes only. The final selected remedy will be presented in the Proposed Plan, which the public will be able to comment on, and final Applicable or Relevant and Appropriate Requirements (ARARs) will be presented in the ROD. Results from the 2003 surveillance program at NFSS indicate that no measured parameter exceeded DOE guidelines, and no dose calculated for potentially exposed members of the general public exceeded DOE or USEPA limits.

Prior to transfer of the FUSRAP to USACE in 1997, reports were generated based on DOE Orders and guidance. DOE Orders are not applicable to the activities of the US Army Corps of Engineers as the USACE is not under the authority or direction of the DOE. However, the surveillance data continues to follow a format similar to that of the previous DOE reports to provide the reader with consistent presentation of data and to facilitate historical comparison between reports.

1.0 INTRODUCTION

Niagara Falls Storage Site (NFSS) is located in the Town of Lewiston in northwestern New York State, northeast of Niagara Falls and south of Lake Ontario (Figure 1 - Appendix A). NFSS is a 190-acre site which includes: one former process building (Building 401), one office building (Building 429), an equipment shed, and a 9.9-acre waste containment structure (WCS). The property is fenced, and public access is restricted.

Land use in the region is primarily rural residential; however, the site is bordered by a chemical waste disposal facility (CWM Chemical Services, Inc.) on the north, a solid waste disposal facility (Modern Corporation, Inc.) on the east and south, and a Niagara Mohawk Power Corporation right-of-way on the west. The nearest residential areas are approximately 1.1-km southwest of the site; the residences are primarily single-family dwellings.

Beginning in 1944, NFSS was used as a storage facility for low-level radioactive residues and wastes. The residues and wastes are the process by-products of uranium extraction from pitchblende (uranium ore). The residues originated at other sites and were transferred to NFSS for storage in buildings and onsite pits and surface piles. From 1953 to 1959 and 1965 to 1971, Building 401 was used as a boron-10 isotope separation plant.

Since 1971, activities at NFSS have been confined to residue and waste storage and remediation. All onsite and offsite areas with residual radioactivity exceeding Department of Energy (DOE) guidelines were remediated between 1955 and 1992; materials generated during remedial actions (approximately 195,000 m³) are encapsulated in the WCS, which is specifically designed to provide interim storage of the material.

1.1 Measured Parameters

The key elements of the 2003 environmental surveillance program at NFSS were:

- measurement of external gamma radiation;
- measurement of radon gas concentrations in air (combined contributions from radon-220 and radon-222);
- monitoring of radon-222 flux (rate of radon-222 emission from the WCS);
- sampling and analysis of surface water for isotopic uranium (U-234, U-235, U-238) & total uranium summation of: U-238 + U-235 + U-234, isotopic thorium (Th-228, Th- 230, Th-232) and isotopic radium (Ra-224, Ra-226, Ra-228) (referred to collectively as radioactive constituents);
- sampling and analysis of streambed sediments for radioactive constituents; and
- sampling and analysis of groundwater for radioactive constituents, metals, and water quality parameters.

1.2 Unit Conversions

The tables listed in Appendix A (Table A.1&2, Page T-1) list the units of measurement and appropriate abbreviations used in this document. Conventional units for radioactivity are used because the regulatory guidelines are generally provided in these terms; Système Internationale (SI) units of measurement are used in the discussion of all other parameters. Unit conversions will be provided in the text for water level information only.

2.0 REGULATORY GUIDELINES

The primary regulatory guidelines that affect activities at FUSRAP sites are found in Federal statutes and in Federal, state, and local regulations. Regulatory criteria that were used to evaluate the results of the 2003 environmental surveillance program at NFSS are summarized below, categorized by media and parameters. In several cases DOE guidelines continue to be identified in the technical memorandum for comparison purposes of historical data collected by DOE or their contractors. USACE is not under the authority of the DOE Orders or directives and must rely on other applicable Federal or state regulations in relation to surveillance of the WCS. The values are for comparison only.

2.1 External Gamma Radiation and Air (Radon Gas and Airborne Particulate)

The regulatory guideline criteria used in evaluation of the calculated maximum doses from external gamma radiation and inhalation of radioactive particulate and the measured concentrations of radon gas include DOE guidelines, United States Environmental Protection Agency (USEPA) standards, and USEPA guidance.

2.1.1 DOE Order 5400.5

Dose limits for members of the public from DOE operations at DOE-owned and DOE-operated facilities are presented in this DOE Order. The primary dose limit is expressed as an effective dose equivalent. The limit of 100-mrem effective dose equivalent above background in a year from all sources (excluding radon) is specified in this Order; external gamma radiation dose and the calculated doses from airborne particulate releases are included in the calculation of the effective dose equivalent total. Also, this calculation includes contributions from other pathways, such as ingestion.

DOE limits for radon concentrations in air from DOE operations at DOE-owned and DOE-operated facilities are also presented in Order 5400.5. Based on the radioactive constituents in the wastes contained in the WCS, it is unlikely that radon-220 would be emitted from the WCS due in part that radon-220 half-life is approximately 55.6 seconds and would decay prior to permeating through the WCS cap; it is, however, likely that radon-222 could be emitted. The DOE limits for radon-222 concentrations in the atmosphere above facility surfaces or openings in addition to background levels are: 100 pCi/L at any given point; an annual average concentration of 30 pCi/L over the facility site; and an annual average concentration of 3.0 pCi/L at or above any location outside the facility site. To provide a conservative basis for comparison, on-site radon concentrations are evaluated against the off-site limit of 3.0 pCi/L above background.

2.1.2 USEPA Standards and USEPA Guidance

A Physician's Guide - Radon: The Health Threat with a Simple Solution

The USEPA also sets a guidance action level of 4.0 pCi/L for radon concentrations in indoor air (homes), providing another conservative basis for comparison. Although these limits are specific to indoor air, they provide a conservative basis for comparison to the outdoor air results obtained during environmental surveillance activities, for details see Appendix C. For further comparison, the average radon level in homes is about 1.25 pCi/L. (USEPA 1993).

Clean Air Act

Section 112 of the Clean Air Act authorized the USEPA to promulgate the National Emission Standards for Hazardous Air Pollutants (NESHAPs) which are given in 40 CFR 61.

Compliance with Subpart H (for nonradon, radioactive constituents) is verified by applying the USEPA-approved CAP88-PC model. Compliance with Subpart Q is verified by annual monitoring of the WCS for radon-222 flux.

(See Appendix A, TABLES Section, Table B, Page T-1)

2.2 Sediment, Surface Water, and Groundwater - Radioactive Constituents

Regulatory criteria for evaluating the measured concentrations of radionuclides in sediment, surface water, and groundwater at NFSS are as follows:

2.2.1 DOE Order 5400.5

This Order provides guideline limits for radioactive constituents in water and soil at DOE-owned and DOE-operated facilities. The environmental surveillance program does not include analysis of onsite soils; however, because there are no standards for sediment, DOE historically used the residual soil cleanup guideline criteria specified in DOE Order 5400.5. The USACE is continuing that process. However, those values are provided for comparative purposes only. ARARs and cleanup goals will be presented in the proposed plan, which the public will be able to comment on. These standards will then be presented in the record of decision (ROD).

DOE Order 5400.5 states that the guideline for residual concentrations of radium-226, radium-228, thorium-230 and thorium-232 in surface soil is 5 pCi/g above background, based on an average of the first 15-cm of soil below the surface. For subsequent 15-cm depth intervals (subsurface soils), the specified limit is 15 pCi/g above background. Because surveillance sediment samples are collected from the first 15-cm of sediment only the surface soil criteria are used. If both thorium-230 and radium-226 or both thorium-232 and radium-228 are present and not in secular equilibrium, the appropriate guideline is applied as a limit for the radionuclide with the higher concentration. If other mixtures of radionuclides occur, the Order

prescribes that the data be evaluated by the sum-of-the-ratios (SOR) method. By this method, the above-background concentration of each of the radionuclides is divided by its respective criterion, and the ratios are summed. If the result is greater than 1, the mixture of radionuclides fails the sum-of-the-ratios test and is considered to exceed the soil guidelines. DOE Order 5400.5 does not give concentration limits for uranium in soils or sediment. Therefore, the analytical data will only be compared to historical levels and not a standard.

DOE-derived concentration guides (DCGs) for radionuclides in water are used to evaluate analytical data for surface water and groundwater at NFSS and are cited in the appropriate data tables in this report. These guidelines are also presented in the Order. The DCG for each radionuclide represents the concentration that would result in a dose of 100 mrem during a year by ingestion of water, conservatively calculated for continuous exposure conditions. For mixtures of radionuclides in water, the sum of the ratios of each concentration to the DCG must not exceed 1.

2.2.2 Safe Drinking Water Act (SDWA)

SDWA is the primary federal law applicable to the operation of a public water system and the development of drinking water quality standards [*USEPA Drinking Water Regulations and Health Advisories* (USEPA 1996)]. The regulations in 40 CFR Part 141 (National Primary Drinking Water Regulations) set maximum permissible levels of organic, inorganic, radionuclides (including uranium and combined radium) and microbial contaminants in drinking water by specifying the maximum contaminant level (MCL) for each. MCLs have been established (promulgated) for combined concentrations of radium-226 and radium-228. The USEPA National Primary Drinking Water Regulation for Radionuclides (Final Rule – effective 2003) states a MCL of 30µg/L for total uranium. Although groundwater at NFSS is not a public drinking water supply, MCLs for drinking water are used as a conservative basis for evaluation of analytical results, maintaining consistency with previous reports and facilitating trend analysis. (See Table C in Appendix A, TABLES section, page T-2.)

2.3 Groundwater - Chemical Parameters

Although groundwater at NFSS is not a public drinking water supply, state and Federal standards (Table D, Appendix A) are used as a basis for evaluation of chemical analytical results. Following public comment on the Proposed Plan and selection of cleanup goals/ARARs, those standards will be presented in the ROD.

2.3.1 Safe Drinking Water Act

As indicated previously, the SDWA is the primary federal law applicable to the operation of a public water system and the development of drinking water quality standards (USEPA 1996). The regulations set MCLs for organic, inorganic, radiological and microbial contaminants in drinking water. In some cases, secondary maximum contaminant levels (SMCLs), which are

not federally enforceable (40 CFR 143.1), are provided as guidelines for the states. SMCLs are provided for a conservative comparison of analytical results and to provide consistency with previous reports and facilitate trend analysis.

2.3.2 New York State Department of Environmental Conservation (NYSDEC) Water Quality Criteria for Groundwater

NYSDEC has adopted the federal SDWA standards into its own regulations in Title 6 New York Codes of Rules and Regulations (NYCRR) Parts 700-705, "Water Quality Regulations for Surface and Groundwater" (NYSDEC 1996). In addition, NYSDEC has independently established standards for some constituents.

At NFSS, because of uniformly poor groundwater quality and availability in the general region, the shallow groundwater resources are of little consequence. Regional studies and studies conducted near the site (La Sala 1968; Wehran 1977; Acres American 1981) conclude that groundwater quality is poor near the site because of high mineralization. Additionally, local studies (Wehran 1977 and Acres American 1981) indicate that the permeabilities of the shallow groundwater systems are sufficiently low that it is not practicable to obtain groundwater from these systems for water supply. Onsite permeability testing at NFSS confirms the low permeabilities.

To apply established standards, the State of New York categorizes groundwater resources by groundwater quality and use.

The DOE conducted a well survey in 1988 and inventoried eight wells within 4.8 km of the site, none of which were reported as drinking water but mainly irrigation (DOE 1994b). Based on the DOE report, the NYSDEC Class GA groundwater standards represent a conservative basis for comparing analytical results because the ambient groundwater at NFSS does not meet the Class GA standards. Both the shallow and deep groundwater units at the NFSS exhibit over 1000 mg/L TDS and the deep groundwater commonly over 100 mg/L Chloride, which indicates that the site groundwater can be classified as saline or Class GSA (NYCRR 701.16). However, to establish a basis for comparison of analytical results, Class GA (groundwater) water quality standards for some constituents were obtained from the NYSDEC document.

The Division of Water Technical and Operational Guidance Series (TOGS) specifically addresses source drinking water standards (*NYSDEC –6 NYCRR Part 703 Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations* (August 1999)). These standards have been used to establish additional Class GA (related, conservative case) state water quality standards for comparison of analytical results.

3.0 SAMPLING LOCATIONS AND RATIONALE

Radioactive materials that exceed DOE cleanup guidelines at NFSS are stored in the WCS. Exposure of members of the public to this radioactively contaminated material at NFSS is unlikely because of site access restrictions (e.g., fences) and engineering controls (e.g., pile covers). However, potential pathways include direct exposure to external gamma radiation; inhalation of air containing radon or radioactively contaminated particulates; and contact with, or ingestion of, contaminated surface water, streambed sediments, or groundwater. The environmental surveillance program at NFSS has been developed to provide surveillance of these exposure routes through periodic sampling and analysis for radioactive and chemical constituents. Figure 2, Appendix A, presents the environmental surveillance program at NFSS and indicates sampling locations and media. Table 1, Appendix A, summarizes the environmental surveillance program at NFSS for external gamma radiation, radon gas, surface water, sediment, and groundwater.

External gamma radiation monitoring and radon gas measurements occur at fenceline locations surrounding the NFSS as well as interior portions of the site, including the perimeter of the WCS, to assess potential exposures to the public and site workers. Measurement of radon-222 flux is conducted annually at discrete grid intersections on the WCS (Appendix A, Figure 2, page F-2).

Groundwater monitoring wells have been selected to assess background, downgradient, and source-area (near the WCS) groundwater quality conditions in the upper groundwater system (Appendix A, Figure 2, page F-2). Groundwater monitoring includes analysis for radioactive constituents, water quality parameters, and metals. The upper groundwater system would provide the earliest indication in the unlikely event of a breach of the WCS. The lower groundwater system is not monitored because past analytical results from the upper groundwater system have not indicated migration of radioactive material from the WCS.

Surface water and streambed sediment sampling of radioactive constituents is conducted along the drainage ditch system in upstream, onsite, and downstream locations (Appendix A, Figure 2) to assess the migration of constituents in these media should any occur.

4.0 SURVEILLANCE METHODOLOGY

Under the NFSS environmental surveillance program, standard analytical methods approved and published by USEPA and the American Society for Testing and Materials (ASTM) are used for chemical (i.e., all nonradiological) analyses. The laboratories conducting the radiological analyses adhere to USEPA-approved methods and to procedures developed by the Environmental Measurements Laboratory (EML) and ASTM. A detailed listing of the specific procedures and the data quality objectives for the surveillance program is provided in the *Environmental Surveillance Plan* (BNI 1996a).

All 2003 environmental surveillance activities at NFSS were conducted in accordance with the *Environmental Surveillance Plan* (BNI 1996a) and the instruction guides (IGs) listed in Table E in Appendix A (page T-3). The IGs are based on guidelines provided in *RCRA Ground Water Monitoring: Draft Technical Guidance* (USEPA 1992b); *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (SW-846; USEPA 1992c); and *A Compendium of Superfund Field Operations Methods* (USEPA 1987).

5.0 ANALYTICAL DATA AND INTERPRETATION OF RESULTS

This section presents the data and interpretation of results for the environmental surveillance program at NFSS. Data for 2003 are presented in Tables 2 through 10 (Appendix A).

In data tables containing analyses for radioactive constituents, some results may be expressed as negative numbers. This phenomenon occurs if the average background activity of the laboratory counting instrument exceeds the measured sample activity. In such cases of statistical variation of counting, when this instrument background activity is subtracted from the sample activity, a negative number results. For the purposes of interpretation, all values below the baseline minimum detectable activity (MDA) are interpreted as having an unknown value between zero and the MDA. Such a value is referred to as a non-detect in the text discussion.

For direct comparison of analytical results to the DOE soil guideline limits and the DCGs, and subsequent assessment of potential impact, background radioactivity in surface water, sediment, and groundwater is not subtracted from the 2003 results. The analytical results and the site background results are both provided in the data tables. However, for simplicity of presentation, only the analytical results (without the background subtracted) will be discussed in the text of this document.

The historical background concentration for each radioactive analyte is determined from background sampling results from 1992 to 2003, unless otherwise noted. For gamma dose rates subtracting the calculated background from the sampling results for 2003 then gives an estimate of the above-background concentration of the measured constituent at each location; see Table 2 External Gamma Radiation Dose Rates (Appendix A, page T-7). When background is subtracted from the sampling result, it is possible that a negative number will be obtained much the same as a negative value may be obtained when the laboratory subtracts instrument background from a sample measurement. A negative number is considered indistinguishable from background.

Some of the historical data from NFSS used a method for analysis of total uranium, which yields results in $\mu\text{g/L}$, and $\mu\text{g/g}$ for water and sediment samples, respectively. To allow direct comparison of results to the DCGs and soil guidelines, the data was converted to pCi/L and pCi/g , as appropriate. The specific activity for total uranium in drinking water sources has been estimated to be about $0.9 \text{ pCi}/\mu\text{g}$ (USEPA 2000), which is the factor used to convert groundwater data from pCi/L to $\mu\text{g/L}$ in this report.

5.1 External Gamma Radiation

External gamma radiation dose rates are measured using thermoluminescent dosimeters (TLDs) in place at NFSS continuously throughout the year. Each TLD measures a cumulative dose over the period of exposure (approximately six months). When corrected for

background and normalized to exactly one year's exposure, these detectors provide a measurement of the annual external gamma radiation dose at that location. TLD results for the 2003 external gamma radiation dose (both raw and corrected data) are summarized in Table 2, External Gamma Radiation Dose Rates (Appendix A, page T-7).

The corrected data are used to calculate the external gamma radiation dose rate at both the nearest residence and the nearest commercial/industrial facility to determine the hypothetical maximally exposed individual (MEI). Net monitoring results (average normalized location minus average normalized background reading) that are less than zero are retained as negative values for calculational purposes. The dose rate is a function of the site fenceline dose, the distance of the individual from the fenceline, and the amount of time the individual spends at that location. Occupancy of the nearest residence is assumed to be 24 hours/day, 365 days/year, while occupancy of the nearest commercial/industrial facility is assumed to be 40 hours/week, 50 weeks/year. Results of this calculation are expressed as a maximum dose rate to the individual (mrem/year).

Based on 2003 external gamma radiation results, the hypothetical MEI would be a commercial/industrial worker conservatively assumed to work at a location 150 feet east of the site perimeter fence for 40 hours/week, 50 weeks/year, with a dose rate of 0.002 mrem/year (1,020 feet from the TLD monitoring line (Appendix B, CY2003 CALCULATION OF EXTERNAL GAMMA RADIATION DOSE RATES FOR NIAGARA FALLS STORAGE SITE (NFSS), section 4.2)). The dose rate at the nearest residence located 3,600 feet southwest of the site conservatively assumed to reside at the location 24 hours/day, 365 days/year, would be 0.000037 mrem/year (Appendix B, CY2003 CALCULATION OF EXTERNAL GAMMA RADIATION DOSE RATES FOR NIAGARA FALLS STORAGE SITE (NFSS), section 4.1). Both dose rate values are well below the DOE guideline of 100 mrem/year (for all pathways, excluding radon).

5.2 Radon Gas

Based on the radioactive constituents in the wastes contained in the WCS, it is unlikely that radon-220 would be emitted from the WCS; however, it is possible that radon-222 would be emitted. Air surveillance is conducted to determine the concentration of radon gas at NFSS using Radtrak® detectors that are designed to measure alpha particle emissions from both isotopes of radon (radon-220 and radon-222) and to collect passive, integrated data throughout the period of exposure. Because radon-220 is not a contaminant of concern at NFSS (due to the relatively low concentrations of radium-228 and the short half-life of radon-220), all concentrations are conservatively assumed to be radon-222. Results of semiannual monitoring for 2003 are presented in Table 3 (Appendix A, page 8); the corresponding surveillance locations are shown in Figure 2, Appendix A.

Consistent with results from previous years, most of the radon-222 results from the 2003 environmental surveillance program were at or below the detection limit (0.20 pCi/L), although for some monitoring stations the reported concentrations in the second half of the year were somewhat higher than those for the first half of the year. All of the on-site results (ranges

from non-detect to 0.3 pCi/L) were less than the DOE off-site limit of 3.0 pCi/L above background (background ranges from less than 0.2 to 0.3 pCi/L).

Radon monitoring at NFSS is performed at a level that is representative of the human breathing zone (1.7 meters above ground level). Radon concentration diminishes significantly as distance from the ground increases and mixing with ambient air takes place.

5.3 Radon-222 Flux

Measurement of radon-222 flux provides an indication of the rate of radon-222 emission from a surface. Radon-222 flux is measured with activated charcoal canisters placed at 15-m grid across the surface of the WCS for a 24-h exposure period. Measurements for 2003 are presented in Table 4; measurement locations are shown in Figure 2, Appendix A.

Measured results for 2003 ranged from below the average background (0.082) to 1.42 pCi/m²/s, with an average result of 0.080 pCi/m²/s (or the same as background). As in previous years, these results are well below the 20.0 pCi/m²/s standard specified in 40 CFR Part 61, Subpart Q, as well as comparable to background and demonstrate the effectiveness of the containment cell design and construction in mitigating radon-222 migration.

5.4 Airborne Particulate Dose

To determine the dose from airborne particulates potentially released from NFSS during 2003, airborne particulate release rates were calculated using historical data for site soil contamination and weather data from the National Weather Service. (Contributions from radon gas, which is not a particulate, are not considered in this calculation.) The total airborne particulate release rate is then entered into the USEPA's CAP88-PC (version 2.0) computer model to perform two calculations:

1. The first calculation estimates resultant doses from airborne particulates to hypothetical individuals at the distances to the nearest residences and to the nearest commercial/industrial facilities as measured from a central location onsite (center of the WCS). Hypothetical doses are then corrected for residential occupancy (conservatively assumed to be 24 hours/day, 365 days/year) and commercial/industrial facility occupancy (40 hours/week, 50 weeks/year). The hypothetical individual receiving the higher of these calculated doses is then identified as the hypothetical MEI for airborne particulate dose.
2. The second calculation estimates the hypothetical airborne particulate collective dose to the population within 80 km of the site using a population file (using 2000 census, and includes information for both New York State and the Province of Ontario) to determine the number of people in circular grid sections fanning out to 80 km from the center of site.

The first calculation (Appendix C) indicates that the 2003 airborne particulate dose to the hypothetical MEI, an occupant at the commercial/industrial facility 275 meters east of the WCS, was 0.018 mrem per year assuming 2000 hours worked per year. These values are well below the 10 mrem per year standard, individual dose, specified in 40 CFR, Part 61, Subpart H, and the DOE Order 5400.5. The second calculation indicates that the hypothetical airborne particulate collective dose to the population within 80 km of the site was 0.15 person-rem per year. This compares to a yearly background dose to the same population of 3,150,000 person-rem per year, (see Figure 8, Appendix A). Details of the calculations, including methodology are presented in Appendix C (FUSRAP CY2003 NESHAP ANNUAL REPORT FOR NIAGARA FALLS STORAGE SITE (NFSS)).

5.5 Surface Water and Sediment

In 2003, annual surface water and sediment samples were collected at five locations: SWSD009 and SWSD021 at the upstream fenceline; SWSD010 and SWSD022 onsite along the central drainage ditch; and SWSD011, downstream along the central drainage ditch. Surface water and sediment sampling location SWSD009 was selected as a background location because it is at the upstream boundary of the South 31 drainage ditch, a drainage, which eventually joins the central drainage ditch. Surface water and sediment sampling location SWSD021 was selected as a background location because it is located upstream, along the NFSS fenceline, where the central drainage ditch first enters the property. Sampling locations are presented in Figure 2, Appendix A.

Surface water and sediment samples were analyzed for radium-226, radium-228, thorium-230, thorium-232, uranium-234, uranium -235, and uranium-238. The 2003 environmental surveillance analytical results for surface water and sediment samples are presented in Appendix A, Tables 5 and 6, respectively. Analytical results for surface water in 2003 are compared with the DOE DCGs for radium-226, radium-228, thorium-230, thorium-232, and total uranium (sum of the uranium-234, -235, and -238 isotopes). Because there are no established limits for sediments, DOE historically used the surface soil criterion of 5 pCi/g as a basis of comparison of radium-226, radium-228, thorium-230 and thorium-232 analytical results. The historic values are being used as a basis for comparison of total uranium analytical results in sediment.

Background concentrations were determined by averaging historical analytical results for the appropriate constituents at surface water/sediment sampling locations SWSD009 and SWSD021. For total uranium and radium-226, background concentrations include data from 1992 through 2003 for surface water and sediment. Because analysis for thorium-232 first began in 1995 in sediment and 1996 in surface water, background concentrations for thorium-232 were determined from analytical results from 1995 and/or 1996 through 2003, as appropriate. Similarly, background concentrations for radium-228 and thorium-230 were determined from analytical results beginning in 1997.

5.5.1 Surface Water

In 2003 as in previous years surface water analytical results were consistently less than the DOE DCGs and were generally indistinguishable from the historical background (upstream) concentrations. Measured results (with background not subtracted) are provided in Table 5, Appendix A and discussed below:

- The 2003 on-site analytical results for radium-226 concentrations in surface water are consistent with historical results and are indistinguishable from background. Radium-226 results from upstream (background) locations SWSD009 and SWSD021 were 0.19 and 0.45 pCi/L, respectively, falling within the historical background range of non-detect to 1.81 pCi/L. The 2003 results of analysis for radium-226 in samples collected at downstream locations (SWSD010, SWSD011, and SWSD022) ranged from 0.00 (field duplicate sample for SWSD011) to 0.68 pCi/L. The radium-226 DOE DCG is 100 pCi/L.
- The 2003 on-site analytical results for radium-228 concentrations in surface water are consistent with historical results and are indistinguishable from background. Radium-228 results from upstream (background) locations SWSD009 and SWSD021 were 0.51 and 0.77 pCi/L, respectively, comparing favorably with the historical background range of non-detect to 0.69 pCi/L. The 2003 results for radium-228 in samples collected at downstream locations (SWSD010, SWSD011, and SWSD022) ranged from 0.13 (field duplicate sample for SWSD011) to 1.18 pCi/L. The radium-228 DOE DCG is 100 pCi/L.
- The 2003 results for thorium-230 in samples collected at downstream locations (SWSD010, SWSD011, and SWSD022) ranged from 0.4 to 0.638 pCi/L, are consistent with historical results and are indistinguishable from background. Thorium-230 results from upstream (background) locations SWSD009 and SWSD021 were 0.48 and 0.60 pCi/L, respectively, comparing favorably with the historical background range of non-detect to 1.20 pCi/L. The thorium-230 DOE DCG is 300 pCi/L.
- The 2003 on-site analytical results for thorium-232 concentrations in surface water were 0.09 to 0.12 pCi/L (duplicate of field sample SWSD011), and are consistent with historical results and are indistinguishable from background (0.09 and 0.28 pCi/L). The historical background concentration for thorium-232 ranges from non-detect to 0.13 pCi/L. The DOE DCG for thorium-232 is 50 pCi/L.
- The 2003 on-site analytical results for total uranium in surface water, ranging from 7.08 to 7.39 pCi/L, are consistent with historical results and are indistinguishable from background (4.13 and 17.7 pCi/L). The historical background concentration for total uranium ranges from 2.77 to 25.6 pCi/L. The DOE DCG for total uranium is 600 pCi/L.

5.5.2 Sediment

Concentrations of radium-226, radium-228, thorium-230, thorium-232, and total uranium in shallow sediment were less than the DOE surface soil guidelines and were generally indistinguishable from upstream (background) conditions. At all sampled locations, results were less than the DOE guideline for mixtures of radionuclides (using the sum-of-the-ratios method). Measured results (with background not subtracted) are presented in Table 6, Appendix A, page T-13, and discussed below:

- The 2003 analytical results for radium-226 in sediment are consistent with historical analytical results. Radium-226 results from upstream (background) locations SWSD009 and SWSD021 were 1.00 and 1.38 pCi/g, respectively, comparing favorably with the historical background range of 0.34 to 2.10 pCi/g. The 2003 results of analysis for radium-226 in samples collected at downstream locations (SWSD010, SWSD011, and SWSD022) ranged from 0.99 to 1.08 pCi/g. Historically, the concentration of radium-226 has ranged from non-detect to 2.90 pCi/g. All radium-226 concentrations in sediment were less than the DOE surface soil cleanup criterion of 5 pCi/g above background.
- The 2003 analytical results for radium-228 in sediment are consistent with historical analytical results. Radium-228 results from upstream (background) locations SWSD009 and SWSD021 were 0.788 and 0.814 pCi/g, respectively. The 2003 results for radium-228 in samples collected at downstream locations (SWSD010, SWSD011, and SWSD022) ranged from 0.911 to 1.25 pCi/g. Historically, the concentration of radium-228 has ranged from non-detect to 3.10 pCi/g. All radium-228 concentrations in sediment were less than the DOE surface soil cleanup criterion of 5 pCi/g above background.
- The 2003 analytical results for thorium-230 in sediment are consistent with historical analytical results. Thorium-230 results from upstream (background) locations SWSD009 and SWSD021 were 1.08 and 1.31 pCi/g, respectively. The 2003 results for thorium-230 in samples collected at downstream locations (SWSD010, SWSD011, and SWSD022) ranged from 1.02 to 2.44 pCi/g. Historically the concentration of thorium-230 has ranged from non-detect to 2.30 pCi/g. All thorium-230 concentrations in sediment were less than the DOE surface soil cleanup criterion of 5 pCi/g above background.
- The 2003 analytical results for thorium-232 in sediment are consistent with historical analytical results. Thorium-232 results from upstream (background) locations SWSD009 and SWSD021 were 1.07 and 1.65 pCi/g, respectively. The 2003 results for thorium-232 in samples collected at downstream locations (SWSD010, SWSD011, and SWSD022) ranged from 0.60 to 1.35 pCi/g. Historically, the concentration of thorium-232 has ranged from non-detect to 1.60 pCi/g. All thorium-232 concentrations in sediment were less than the DOE surface soil cleanup criterion of 5 pCi/g above background.
- The 2003 analytical results for total uranium in sediment are consistent with historical analytical results. Total uranium results from upstream (background) locations SWSD009

and SWSD021 were 3.74 and 2.64 pCi/g, respectively. The 2003 results for total uranium in samples collected at downstream locations (SWSD010, SWSD011, and SWSD022) ranged from 2.37 (duplicate of SWSD011) to 2.84 pCi/g. Historically the concentration of total uranium has ranged from non-detect to 9.13 pCi/g.

5.6 Groundwater

The locations of environmental surveillance groundwater monitoring wells at NFSS are shown in Figure 2, Appendix A. Background information, descriptions of activities performed under the groundwater surveillance program, and surveillance results are discussed below.

5.6.1 Groundwater Flow System

5.6.1.1 Natural System

Four unconsolidated units and one bedrock unit are readily identified in the subsurface at the site. The principle hydrostratigraphic zones include the following, from top to bottom: the Upper Aquifer (fill and Upper Clay Till Units), the aquitard or confining unit (Glacio-Lacustrine Clay and Middle Silt Till Units), and the Lower Aquifer (Alluvial Sand and Gravel, Basal Red Till and Upper Queenston Formation). *See Figure-7: Schematic of Conceptualized Hydrostratigraphy in Appendix A, page F-7.* Groundwater at NFSS occurs in two unconsolidated deposits and the shale bedrock. The unconsolidated deposits exhibit an upper groundwater system within the surficial brown clay till unit and a lower groundwater system within the sand and gravel unit, the underlying red till unit, and the weathered portion of the Queenston Shale bedrock. Regional groundwater flow in both the upper and lower groundwater systems is to the northwest towards Lake Ontario.

Surface drainage from the site originally entered Fourmile, Sixmile, and Twelvemile Creeks, which all flow northward to Lake Ontario. However a system of drainage ditches was installed in the 1940s to drain surface water to a central drainage ditch that now influences groundwater flow in the upper groundwater system near the WCS. Historically low concentrations of constituents in groundwater wells completed in the lower groundwater system and the continuously low concentrations of constituents monitored in the upper groundwater system indicate that annual monitoring of the lower groundwater system is not currently necessary. Since the wells monitoring the upper groundwater system provide an early detection network by which to monitor the performance of the WCS, the lower groundwater system is not routinely monitored as part of the environmental surveillance program. Special groundwater studies that are conducted periodically at NFSS typically include sampling and analysis of groundwater samples from the lower groundwater system. These studies help to verify the effectiveness of the upper groundwater system monitoring well network for monitoring WCS performance.

Background concentrations for the upper groundwater system were determined by averaging

1992 through 1997 analytical results for the appropriate constituents at the background monitoring well B02W20S. This well was selected as the background well because it is distant and is not downgradient from the WCS. Background groundwater was sampled in 2003 at an adjacent property (Modern Landfill); these data are being assessed to provide a better understanding of groundwater conditions at the NFSS.

5.6.1.2 Water Level Measurements

Water level measurements are obtained using an electronic depth-to-water meter. Ninety-one groundwater monitoring wells are used to monitor groundwater levels in both the upper and lower groundwater systems. These include 41 wells in the upper ground water system, 34 wells in the lower groundwater system, and 6 in the bedrock. As part of the remedial investigation process, ten new wells were installed at biased locations in September 2003; these data are not evaluated for this report.

The screened intervals for wells completed in the upper groundwater zone range from 1.7 to 8.4 m (5.5 to 27.6 ft) below ground surface. The screened intervals for wells completed in the lower groundwater zone range from 7.7 to 14.0 m (25.2 to 46.0 ft) below ground surface. The ninety-one total groundwater monitoring wells located throughout the property, as well as near the WCS and the northern fence line, indicate that the areal coverage for groundwater is adequate to monitor all areas of concern on the NFSS (Appendix A, Figure 2).

The vertical gradients calculated at groundwater monitoring well pairs indicate that during the first and second quarters the elevations in the upper system were almost uniformly greater than the corresponding measurements in the lower unit. However, in the third and fourth quarters the majority of elevations in the lower system were greater than those measured in the upper system. These data indicate that the direction and magnitude of the vertical gradient changes seasonally. While groundwater flow is primarily horizontal, vertical hydraulic gradients change the magnitude and direction of vertical flow and thus further impede the potential migration of contaminants into the lower units.

In the upper groundwater system, the depth to water ranged from 0.73 to 6.0 m (2.39 to 19.8 ft) below ground surface during 2003, and average quarterly water level fluctuations in the upper groundwater system were 2.1 m (6.9 ft). This system contained significant local high and low elevations during the June and October measurements, respectively. Shallow wells near the WCS also are affected by the watering the WCS to maintain the appropriate soil-moisture content in the capping material.

In the lower groundwater system, the depth to water ranged from 1.4 to 4.5 m (4.24 to 14.85 ft) below ground surface during the year. Average water level fluctuations in the lower groundwater system were 2.75 m (8.97 ft). Long-term water level data indicate that the upper groundwater system responds more rapidly to recharge than the lower groundwater system, which is under confining conditions. Groundwater-level fluctuations in the lower groundwater system are dampened by the Glacio-Lacustrine Clay Unit and intervening Middle Silt Till Unit,

which act as an aquitard between the Upper and Lower Aquifers and reduce seasonal recharge rates to the lower units.

Figures 3 through 6 in Appendix A show the piezometric surfaces and groundwater flow directions in the upper and lower units and their seasonally high and low groundwater conditions. ArcGIS® software was employed for all piezometric surface and groundwater flow diagrams.

5.6.1.3 Groundwater Flow

Groundwater occurs in layered glacial sediments composed of unconsolidated sand, silt, and clay. The two groundwater systems at the site are contained in the surficial clay till unit and the Lower Alluvial Sand and Gravel and bedrock unit. Hydrogeologic data indicate that the intervening Glacio-Lacustrine clay unit hydraulically separates the Upper Clay Till unit from the lower sand and gravel unit; the Glacio-Lacustrine clay is present across the entire site. The horizontal gradient in the upper system ranges between 0.002 and 0.007 and appears erratic. However, general trends towards the drainage ditch east of the WCS were consistently apparent. In the lower system, groundwater flow was generally north to northwest with local low points on the edge of the WCS. The approximate gradients range between 0.001 and 0.002. Dewatering activities at Modern Landfill are designed to minimize hydrostatic pressures on the developing cell liners, although no effects of these activities on groundwater flow at the NFSS were apparent in the 2003 measurements.

A groundwater flow velocity of 38 cm/yr (15 in/yr) has previously been estimated at NFSS (DOE 1994b). This velocity does not necessarily represent the rate at which a contaminant could migrate because contaminant-dependent transport factors such as retardation (caused by physical interactions such as contaminants binding to clay particles) can significantly slow the rate of transport.

Groundwater elevations measured during 2003 generally indicate a seasonal high condition occurred on June 23, 2003 and a seasonal low occurred on September 15, 2003. The high-water condition in the lower system ranged from 94.30 to 96.14 m (309.41 to 315.43 ft) above mean sea level. The low-water condition in the lower system ranged from 93.08 to 96.08 m (308.67 to 315.24 ft) above mean sea level. High-water elevations in the upper system ranged from 94.62 to 96.93 m (310.48 to 318.04 ft), whereas the low-water condition ranged from 92.15 to 96.54 m (302.35 to 316.75 ft) in the upper system. See Figures 3 through 6 in Appendix A for a graphical representation of these data.

The northwesterly groundwater flow in the upper water-bearing zone at the NFSS was evaluated against the annual sampling program results. Well OW07B currently is sampled for the ESP but historically has not produced elevated radio-isotopic results. This well consistently produces turbid samples with high specific conductance at low flow rates, which negatively affects sample quality and laboratory results. The nearby well OW13B currently is not sampled under the ESP but is a better candidate for surveillance than OW07B. Well

OW13B exhibits a higher hydraulic conductance (nearly three times that of OW07B) and is screened through a sand lens located above the contact with the underlying glacio-lacustrine clay aquitard. In addition, well OW13B is cross and downgradient of the WCS whereas OW07B is cross gradient of the WCS, thus making OW13B a better WCS surveillance well than OW07B. The USACE will sample OW13B in lieu of OW07B during future ESP groundwater monitoring efforts.

5.6.2 Groundwater Analytical Results

5.6.2.1 Field Parameters

Table 7, Appendix A summarizes field measurements (temperature, pH, specific conductivity, oxidation-reduction potential, and turbidity) for 2003 environmental surveillance sampling. These measurements represent water conditions at the time of sampling.

5.6.2.2 Water Quality Parameters

At NFSS, the upper groundwater system water quality indicates relatively recently recharged groundwater. The lower groundwater system water quality parameters indicate longer residence times or distance traveled. It is likely that the primary recharge of the lower groundwater system occurs at the base of the Niagara Escarpment, situated approximately 3.2 km south of the site (DOE 1994b). Water quality parameter data for 2003 are provided in Table 8, Appendix A.

Analytical results for sodium, sulfate, and total dissolved solids (TDS) were consistently above the drinking water standards in both the upgradient (background) and downgradient samples. These values indicate that groundwater in the area is naturally slightly saline and confirm the findings of the regional studies and studies conducted near the site that state groundwater quality is poor near the site because of high mineralization (La Sala 1968; Wehran 1977; Acres American 1981). Groundwater at NFSS is not used as a public water supply, although the comparison to the drinking water standard will continue to be used to provide a conservative evaluation of groundwater analytical results.

TDS, sulfate, and sodium were present onsite and upgradient (background) in concentrations exceeding NYSDEC water quality standards; there are no federal standards for these water quality parameters. TDS results in all wells including the background well frequently exceed the NYSDEC Class GA and Secondary National Drinking Water Quality standard of 500 mg/L; for example, A45 is highest at 1,800 mg/L of field samples and OW15B is lowest at 840 mg/L. Six of the seven wells exceeded the NYSDEC Class GSA water quality standard of 1000 mg/L for TDS. Sodium was detected in all wells, including the background well, at concentrations ranging from 39.9 mg/L to 83.4 mg/L. The results are consistently greater than the NYSDEC groundwater quality standard for sodium (20 mg/L). Sulfate also was detected in all wells at concentrations ranging from 305 mg/L to 777 mg/L. All wells had

sulfate concentrations greater than the NYSDEC groundwater quality standard for sulfate (250 mg/L).

5.6.2.3 Groundwater - Radioactive Constituents

In 2003, unfiltered groundwater samples collected from eight groundwater monitoring wells completed in the upper groundwater system were analyzed for radium-226, radium-228, thorium-230, thorium-232, uranium-234, uranium-235, and uranium-238. Environmental surveillance analytical results for radioactive constituents in groundwater are presented in Appendix A, Table 9. Only results for detected analytes are discussed.

Radium-226 concentrations in groundwater at NFSS have been consistently low, with all measured concentrations (background not subtracted) less than 1 pCi/L. Combined concentrations of radium-226 and radium-228 at NFSS are well below the SDWA MCL (5 pCi/L). Thorium-230 and -232 concentrations are well below DOE DCGs (300pCi/L and 50 pCi/L) and SWDA (15 pCi/L each) for drinking water. The 2003 total uranium analytical results are consistent with the historical results. Since 1992, total uranium concentrations in all sampled wells have been less than 60 pCi/L (background not subtracted) this is compared to the DOE DCG of 600 pCi/L for water.

All analytical results for radium-226, radium-228, thorium-230, thorium-232, and total uranium in groundwater were well below the DOE DCGs. At all sampled locations, results were less than the DOE guideline for mixtures of radionuclides (using the sum-of-the-ratios method). Current analytical results (background not subtracted) are summarized below.

Note: Groundwater at NFSS is not a drinking water source; samples at time of sampling are unfiltered (Samples A45,OW04B,and OW07B have both filtered and unfiltered results for comparison purposes. The filtered results are not included in ranges or averages of analytical results).

- The 2003 analytical results for radium-226 were all non-detect. The DOE DCG for radium-226 is 100 pCi/L above background (2003 background level: non-detect).
- The 2003 analytical results for radium-228 ranged from non-detect to 1.87pCi/L with an average value of 0.42 pCi/L. The DOE DCG for radium-228 is 100 pCi/L above background (2003 background level: non-detect).
- The 2003 analytical results for thorium-230 ranged from non-detect to 0.17 pCi/L with an average value of 0.05 pCi/L. The DOE DCG for thorium-230 is 300 pCi/L above background (2003 background level: 0.11 pCi/L).
- The 2003 analytical results for thorium-232 were all non-detect. The DOE DCG for thorium-232 is 50 pCi/L above background (2003 background level: non-detect).
- The 2003 analytical results for total uranium ranged from 5.66 to 51.56 pCi/L with an

average value of 21.48 pCi/L. The DOE DCG for total uranium is 600 pCi/L above background (background: 10.60 pCi/L). The USEPA National Primary Drinking Water Regulation for Radionuclides (Final Rule – effective 2003) states an MCL of 30 µg/L for total uranium, with an average result of 21.48 pCi/L (23.87 µg/L assuming a 0.9 mass:activity ratio). This is below the drinking water final ruling effective 2003. Two wells exceed this rule, A45 (29.10 pCi/L converted to 32.33 µg/L) and OW04B (51.56 pCi/L converted to 57.29 µg/L).

Note: The concentration (30 µg/L) is for comparative purposes only and includes background.

5.6.2.4 Groundwater - Chemical Constituents/Metals

The 2003 environmental surveillance analytical results for metals in groundwater are presented in Table 10, Appendix A, and discussed below.

Groundwater at NFSS is not used as a public drinking water supply, although sampling results are compared to the SDWA MCLs and New York State Water Quality Regulation Class GA standards as a conservative baseline. Copper was present in four groundwater monitoring wells sampled at NFSS and lead was present in three. However, but the 2003 analytical results indicate that neither the SDWA MCLs nor the New York State Water Quality Regulation Class GA standards for these metals were exceeded at any well. Vanadium was not detected in any of the eight wells sampled in 2003.

- In 2003 copper results ranged from non-detect to 114 µg/L. The SDWA MCL is 1,300 µg/L and the New York State Water Quality Regulation Class GA standard is 200 µg/L. Historically the concentration of copper has ranged from non-detect to 62.4 µg/L.
- In 2003 lead results ranged from non-detect to 2.21 µg/L. The SDWA MCL is 15 µg/L and the New York State Water Quality Regulation Class GA standard is 25 µg/L. Historically the concentration of lead has ranged from non-detect to 6.8 µg/L.
- In 2003, vanadium results were non-detected. Historically the concentration of vanadium has ranged from non-detect to 53.4 µg/L. Neither an SDWA MCL nor a New York State Water Quality Regulation Class GA standard has been established for vanadium.

6.0 CONCLUSIONS

6.1 External Gamma Radiation

The 2003 external gamma radiation dose rate to a hypothetical maximally exposed individual is negligible at a calculated value of less than 0.01 mrem/year for the nearest residence (Appendix B, CY2003 CALCULATION OF EXTERNAL GAMMA RADIATION DOSE RATES FOR NIAGARA FALLS STORAGE SITE (NFSS), section 4.1). The nearest off-site worker yields a dose of 0.002 mrem/year (section 4.2, of the above mentioned reference).

6.2 Radon Gas

Results of the 2003 radon gas surveillance program indicate radon gas emissions are comparable to or below background. The radon gas concentrations at the site were consistently low (non-detect to 0.3 pCi/L, including background (Appendix A, Table 3)) and in many cases were at or below the detection limit. All radon gas concentration analytical results at NFSS were well below the DOE limit for radon-222 of 3.0 pCi/L above background (Appendix A, Table 3).

6.3 Radon-222 Flux

The 2003 radon-222 flux measurements were indistinguishable from background. Results ranged from non-detect to 1.42 pCi/m²/s, with an average result of 0.080 pCi/m²/s (Appendix A, Table 4). The average value is less than one percent of the standard of 20 pCi/m²/s specified in 40 CFR Part 61, Subpart Q of the National Emission Standards for Hazardous Air Pollutants (NESHAPs), demonstrating the effectiveness of the containment cell design and construction in mitigating radon-222 migration.

6.4 Airborne Particulate Dose

The 2003 airborne particulate dose rate from the wind erosion of soil to a hypothetical maximally exposed individual is calculated at 0.018 mrem/year (Appendix C, FUSRAP CY2003 NESHAP ANNUAL REPORT FOR NIAGARA FALLS STORAGE SITE (NFSS), section 4.3). The hypothetical dose to the individual is negligible relative to the 10 mrem/year standard in 40 CFR Part 61, Subpart H of NESHAPs. The 2003 hypothetical airborne particulate collective dose to the population within an 80 km radius of the site is calculated at 0.15 person rem/year (Appendix C, FUSRAP CY2003 NESHAP ANNUAL REPORT FOR NIAGARA FALLS STORAGE SITE (NFSS), section 5.1).

6.5 Cumulative Dose from External Gamma Radiation and Airborne Particulates

The 2003 maximum cumulative external gamma radiation and airborne particulate dose to a hypothetical individual is 0.020 mrem/year (0.002 plus 0.018, Appendix B, CY2003

CALCULATION OF EXTERNAL GAMMA RADIATION DOSE RATES FOR NIAGARA FALLS STORAGE SITE (NFSS), section 4.2 and Appendix C, FUSRAP CY2003 NESHAP ANNUAL REPORT FOR NIAGARA FALLS STORAGE SITE (NFSS), section 4.3, respectively). This value is negligible when compared to the DOE limit of 100 mrem/year or national background dose of approximately 360 mrem/year.

6.6 Surface Water

In 2003, onsite radionuclide concentrations in surface water samples were consistent with historical results that are comparable to background and contribute negligibly to dose.

6.7 Sediment

In 2003, onsite radionuclide concentrations in sediment samples were consistent with historical results that are comparable to background and contribute negligibly to dose.

6.8 Groundwater

In 2003, levels of radionuclides in the upper water bearing zone do not pose an exposure risk. On-going investigations as part of the CERCLA remedial investigation of the site continue to monitor concentrations of radionuclides throughout NFSS. At this time, it appears that no radionuclides are migrating from the WCS into site groundwater resources.

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APPENDIX A

NFSS 2003 Environmental Surveillance Technical

Memorandum

Environmental Monitoring at NFSS

This appendix documents the results of non-routine environmental monitoring activities conducted in 2003 and supplements the environmental surveillance information included in the body of this technical memorandum. These activities are described to present a more complete picture of the site activities during the year and to provide technical reviewers with sufficient information to determine how much these activities influenced site conditions and ultimately the environmental surveillance program.

Two distinct activities compose the FUSRAP monitoring program at NFSS: environmental monitoring and environmental surveillance. Environmental monitoring consists of measuring the quantities and concentrations of pollutants in solid wastes, liquid effluents, and air that are discharged directly to the environment from onsite activities. Environmental surveillance documents the effects, if any, of USACE activities on onsite and offsite environmental and natural resources. At FUSRAP sites, because there are typically no onsite waste treatment facilities with routine point discharges, the monitoring program consists primarily of environmental surveillance (BNI 1996). The Environmental Surveillance Technical Memorandum specifically reports the results of routine environmental surveillance sampling and, at applicable sites, includes information about routine environmental monitoring (stormwater discharges and radon flux measurement).

The three part remedial investigation that began in 1999 continued through the year 2003 at NFSS.

References

Bechtel National, Inc. (BNI), 1996. *Environmental Surveillance Plan, Appendix C2, 191-ESP, Rev. 0* (March 7).

FUSRAP NIAGARA FALLS STORAGE SITE

2003

TABLES

ENVIRONMENTAL SURVEILLANCE TECHNICAL MEMORANDUM



**US Army Corps
of Engineers** ®
Buffalo District

Table A.1**(Section 1.2 Unit Conversions)****Units of Measurement and Conversion Factors - Radioactivity**

Parameter	Conventional Units	SI Units	Conversion Factor
Dose	millirem (mrem)	milliSievert (mSv)	1 mrem = 0.01 mSv
Activity	picoCurie (pCi)	becquerel (Bq)	1 pCi = 0.037 Bq

Table A.2**Units of Measurement and Conversion Factors - Mass, Length, Area, and Volume**

Parameter	SI Units	English Units	Conversion Factor
Mass	gram (g)	Ounce (oz)	1 g = 0.035 oz
	kilogram (kg)	Pound (lb)	1 kg = 2.2046 lb
Length	centimeter (cm)	Inch (in.)	1 cm = 0.394 in.
	meter (m)	foot (ft)	1 m = 3.281 ft
	kilometer (km)	mile (mi.)	1 km = 0.621 mi.
Area	hectare (ha)	Acre	1 ha = 2.47 acres
Volume	milliliter (mL)	Fluid ounce (fl. oz.)	1 ml = 0.0338 fl. oz.
	liter (L)	gallon (gal)	1 L = 0.264 gal
	cubic meter (m ³)	Cubic yard (yd ³)	1 m ³ = 1.307 yd ³

Table B**(Section: 2.1.2 DOE Guidelines, USEPA Standards, Nuclear Regulatory Commission and Guidance – Clean Air Act)****Radiological Standards and Guidelines External Gamma Radiation and Air –**

Parameter	DOE Order 5400.5 ^a	Other Federal Standard or Guidelines
Radon-222 flux	20 pCi/m ² /s	20 pCi/m ² /s ^b
Radon-222	3.0 pCi/L ^c	-
Radionuclide emissions (airborne particulates and radioactive gases excluding radon-220 and radon-222)	10 mrem/y	10 mrem/y ^b
Effective dose equivalent (total contribution from all sources ^c)	100 mrem/y	100 mrem/y ^d

^a Guidelines provided in the DOE Order are above background concentrations or exposure rates.

^b Federal (USEPA) Standard from 40 CFR, Part 61, subparts H (radionuclide emissions) and Q (radon-222 flux).

^c Contributing sources at NFSS consist of external gamma radiation exposure, radionuclide emissions listed above, and ingested radionuclides in water and soil/sediment (listed in the following table).

^d Federal (Nuclear Regulatory Commission) Standard 10 CFR 20

^e The guideline of 3.0 pCi/L is based on an annual average value at or above any location outside of the facility site.

Table C**(Section: 2.2.2 Safe Drinking Water Act (SDWA))****Summary of Radiological Standards and Guidelines - Water and Sediment**

Parameter	DOE DCG ^a for Water ^b	Other Federal Standards	DOE Guideline Limit for Residual Radioactivity in Surface Soil ^{c,d}
Total uranium	600 pCi/L	30 µg/L ^e	90 pCi/g
Thorium-232	50 pCi/L	15 pCi/L ^f	5 pCi/g
Thorium-230	300 pCi/L	15 pCi/L ^f	5 pCi/g
Combined Radium-226&228	100 pCi/L	5 pCi/L ^e	5 pCi/g

a. DOE derived concentration guideline (DOE Order 5400.5) for drinking water. Groundwater at NFSS is not a drinking water source. The above concentration is for comparative purposes only.

b. Surface water and groundwater (non-drinking water values); criteria represent concentrations above background. If a mixture of radionuclides is present, the sum of the ratios of each isotope to its respective DCG must be less than one.

c. Above-background concentrations in soil, averaged over the topmost 15-cm of soil.

d. There are no standards for sediment; therefore, the DOE residual (radium and thorium) and site-specific (uranium) surface soil cleanup guideline criteria are used as a basis for evaluating analytical results for sediment. If a mixture of the radionuclides is present in soil, then the sum of the ratios of the concentration of each isotope to the allowable limit must be less than one. This guideline applies for total uranium in natural isotopic abundance.

e. (This regulation is effective December 8, 2003 –National Primary Drinking Water Regulations; Radionuclides; Final Rule (Federal Register- December 7, 2000. Current SDWA MCL for the combined concentration of radium-226 and radium-228 in drinking water (40CFR141.1) Groundwater at NFSS is not a drinking water source. The above concentration is for comparative purposes only.

f. “Adjusted” gross alpha MCL of 15 pCi/L, including Ra-226, excluding radon, and uranium –National Primary Drinking Water Regulations; Radionuclide; Final Rule (Federal Register- December 7,2000)

Table D**(Section: 2.3 Groundwater - Chemical Parameters)****Groundwater - Chemical Parameters**

Analyte	Related Regulations ^a	
	Federal (mg/L)	State ^c (mg/L)
Alkalinity, Total as CaCO ₃	NE	NE
Bicarbonate (HCO ₃)	NE	NE
Calcium (Ca)	NE	NE
Carbonate (CO ₃)	NE	NE
Chloride	250 ^d	250
Copper	1.3 ^e	0.2 ^e
Lead	0.015 ^e	0.025 ^e
Magnesium (Mg)	NE	NE
Nitrogen, Nitrate	10 ^b	10
Nitrogen, Nitrite	1 ^b	1
Phosphorous, Total	NE	NE
Potassium (K)	NE	NE
Sodium (Na)	NE	20
Solids, Total Dissolved (TDS)	500 ^d	500
Sulfate (SO ₄)	250 ^d	250
Vanadium	NE	NE

a. **Regulations presented pertain to drinking water quality and are listed for comparison only.**

No drinking water supply is obtained from groundwater at NFSS. NE - Not established.

b. Federal Safe Drinking Water Act maximum contaminant levels from USEPA Drinking Water Regulations (40CFR141.62)

c. Water Quality Criteria (class GA) per 6 NYCRR, Part 703.

d. National Secondary Drinking Water Regulations (40CFR143.3). These regulations primarily control and affect the aesthetic qualities of drinking water

d. Action Level

Table E**(Section: 4.0 SURVEILLANCE METHODOLOGY)****FUSRAP Instruction Guides Used for Environmental Surveillance Activities**

Document Number	Document Title
191-IG-007	Groundwater Level and Meteorological Measurements (BNI 1996b)
191-IG-011	Decontamination of Field Sampling Equipment at FUSRAP Sites (BNI 1996c)
191-IG-028	Surface Water and Sediment Sampling Activities (BNI 1993a)
191-IG-029	Radon/Thoron and TETLD Exchange (BNI 1993b)
191-IG-033	Groundwater Sampling Activities (BNI 1996d)

Table 1a
Environmental Surveillance Summary
External Gamma Radiation, Radon Gas, and Radon-222 Flux
Niagara Falls Storage Site

Measured Parameter	Station Identification	Number of Analyses or Measurements																Total Analyses per Year
		No. of Sample Locations				Sample Duplicate				Ship Blank				Contingency Sample				
		CY Quarter				CY Quarter				CY Quarter				CY Quarter				
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
LABORATORY MEASUREMENTS																		
External gamma radiation (TLDs) ^a	1, 7, 8, 10, 11, 12, 13, 15, 18, 21, 23, 24, 28, 29, 36, 105, 116, 120, 122, 123	20		20		1		1		1		1		20		20		84
Radon gas		20		20		1		1										42
Radon-222 flux	WCS ^b			183														183

a. TLD = Thermoluminescent Dosimeter.

b. Waste Containment Structure

Table 1b
Environmental Surveillance Summary
Groundwater
Niagara Falls Storage Site

Measured Parameter	Station Identification	Number of Analyses or Measurements																															
		No. of Sample Locations				Rinsate Blank				Trip Blank				Sample Duplicate				Matrix Spike				Matrix Spike Duplicate				Total Analyses per Year							
		CY Quarter				CY Quarter				CY Quarter				CY Quarter				CY Quarter				CY Quarter											
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4								
FIELD MEASUREMENTS																																	
Dissolved oxygen	A45, A50, OW04B, OW06B, OW07B, OW15B, OW17B,	8																														8	
Eh		8																														8	
Turbidity		8																															8
Temperature		8																															8
Specific conductivity	B02W20S	8																															8
pH		8																															8
LABORATORY MEASUREMENTS																																	
Radiological																																	
Uranium-234/235/238	A45, A50, OW04B, OW06B, OW07B, OW15B, OW17B, B02W20S	8				1								1				1				1				1						12	
Radium-226/228		8				1								1				1				1				1						12	
Thorium-230/232		8				1									1				1				1				1						12
Metals																																	
Copper		8				1								1				1				1				1						12	
Lead		8				1								1				1				1				1						12	
Vanadium		8				1								1				1				1				1						12	
Water Quality ^a		8				1								1				1				1								12			

a. Table 8 lists water quality parameters.

Table 1c
Environmental Surveillance Summary
Surface Water and Sediment
Niagara Falls Storage Site

Measured Parameter	Station Identification	Number of Analyses or Measurements																												Total Analyses per Year
		No. of Sample Locations				Rinsate Blank				Trip Blank				Sample Duplicate				Matrix Spike				Matrix Spike Duplicate								
		CY Quarter				CY Quarter				CY Quarter				CY Quarter				CY Quarter				CY Quarter								
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4					
FIELD MEASUREMENTS																														
<u>Chemical</u>																														
Dissolved oxygen	SWSD009 SWSD010 SWSD011 SWSD021 SWSD022		5																										5	
Eh			5																										5	
Turbidity			5																										5	
Temperature			5																										5	
Specific conductivity			5																										5	
pH		5																										5		
LABORATORY MEASUREMENTS																														
<u>Radiological</u>																														
Surface Water																														
Uranium-234/235/238	SWSD009 SWSD010 SWSD011 SWSD021 SWSD022		5											1				1					1						8	
Radium-226/228			5											1				1					1						8	
Thorium-230/232			5												1				1					1						8
Uranium-234/235/238			5				1								1				1					1						9
Radium-226/228		5				1								1				1					1						9	
Thorium-230/232		5				1								1				1					1						9	

Table 2
2003 External Gamma Radiation Dose Rates
Niagara Falls Storage Site

NFSS - 2003 Data (TLD Exposure from: Jan.07.2003 to Jan.06.2004)										
From 01/07/03 to 07/14/03 (188 days)				From 07/14/03 to 01/06/04 (176 days)						
Monitoring Location ^b		TLD ^a Dose Rate		Monitoring Location ^b		TLD ^a Dose Rate		Corrected Yearly Exposure		
		Total ^c	Above Background ^c			Total ^c	Above Background ^c			
		(mrem) ^f	(mrem/yr) ^g			(mrem) ^f	(mrem/yr) ^g			
NFSS	1	19.9	3.4	NFSS	1	22.5	0.5	42.6		
Perimeter	1	21.2	4.7	Perimeter	1	21.3	-0.7			
	7	18.4	1.9		7	15.3	-6.7	33.8		
	7	15.0	-1.5		7	18.8	-3.2			
	11	17.2	0.7		11	17.5	-4.5	36.9		
	11	20.0	3.5		11	18.9	-3.1			
	12	18.7	2.2		12	16.7	-5.3	39.7		
	12	24.0	7.5		12	19.7	-2.3			
	13	27.5	11.0		13	22.0	0.0	47.3		
	13	22.2	5.7		13	22.6	0.6			
	15	19.8	3.3		15	18.5	-3.5	36.2		
	15	15.0	-1.5		15	18.9	-3.1			
	28	23.1	6.6		28	26.7	4.7	49.2		
	28	22.1	5.6		28	26.2	4.2			
	29	20.2	3.7		29	21.0	-1.0	43.2		
	29	23.1	6.6		29	21.9	-0.1			
	36	18.7	2.2		36	16.4	-5.6	39.1		
	36	20.3	3.8		36	22.5	0.5			
	122	22.1	5.6		122	19.5	-2.5	40.4		
	122	18.1	1.6		122	20.9	-1.1			
	123	19.4	2.9		123	22.3	0.3	42.2		
123	19.6	3.1	123	22.8	0.8					
Average		20.3	3.8			20.6	-1.4	41.0		
WCS ^h	8	15.8	-0.7	WCS ^h	8	22.5	0.5	40.0		
Perimeter	8	19.8	3.3	Perimeter	8	21.6	-0.4			
	10	19.5	3.0		10	21.8	-0.2	36.8		
	10	13.9	-2.6		10	18.1	-3.9			
	18	16.7	0.2		18	18.3	-3.7	37.5		
	18	18.3	1.8		18	21.4	-0.6			
	21	19.9	3.4		21	25.9	3.9	44.7		
	21	18.9	2.4		21	24.4	2.4			
	23	24.5	8.0		23	20.2	-1.8	44.3		
	23	24.9	8.4		23	18.8	-3.2			
	24	19.2	2.7		24	25.4	3.4	45.1		
	24	17.3	0.8		24	28.0	6.0			
	Average		19.1		2.6			22.2	0.2	41.4
	Background	105	17.1		Background Locations	105	24.4		40.5	
	105	19.6	105			19.7				
116	15.5	116	18.7			36.4				
116	14.0	116	24.5							
120 ⁱ	16.2	120 ⁱ	22.8			38.5				
120 ⁱ	*Not found upon retrieval*		120 ⁱ	21.5						
Average		16.5	Average		22.0		38.5			
Background			Background							

a. TLD = Thermoluminescent dosimeter. There are two TLDs per monitoring location.

b. Monitoring locations are shown in Figure 2 (Appendix A - Figures).

c. Reported values are the average reading per TLD. There are two detection units per each device.

d. TLD are normalized to a one-year exposure.

Corrected yearly exposure = Biannual TLD readings averaged * 365 days/# of days of exposure.

Example (Location 1, First TLD):

$((19.9 + 21.2 \text{ mrem})/2 + ((22.5 + 21.3 \text{ mrem})/2) * 365 \text{ days per year} / (176+188 \text{ days}) = 42.6 \text{ mrem/year.}$

e. Average background (corrected) is subtracted from corrected yearly exposure.

Above-background exposure = corrected yearly exposure - corrected average background.

*Example (Location 1, First TLD): $38.6 \text{ mrem/year} - 32.0 \text{ mrem/year} = 6.6 \text{ mrem/year.}$

*Numbers in the above calculation are all rounded up to one decimal place.

f. mrem - millirem.

g. mrem/yr - millirem per year.

h. Monitoring locations along the perimeter of the waste containment structure (WCS).

i. Location was moved from next to brick building to fence line location. *Note: Brick is naturally radioactive. Results for this location will exhibit lower results than in previous years.*

Table 3
2003 Radon Gas ^a Concentrations
Niagara Falls Storage Site

NFSS - 2003 Data

Monitoring Location ^c	Monitoring Station	Average Daily Concentration (pCi/L) ^b		
		Start Dates ^d : End Dates ^d :	1/7/2003 7/14/2003	7/14/2003 1/6/2004
NFSS Perimeter	1		<0.2	<0.2
	7		<0.2	0.2
	11		<0.2	<0.2
	12		<0.2	<0.2
	12 (dup ^e)		<0.2	0.3
	13		<0.2	0.2
	15		<0.2	<0.2
	28		0.3	<0.2
	29		<0.2	<0.2
	36		<0.2	<0.2
	122		<0.2	0.3
	123		<0.2	<0.2
WCS ^f Perimeter	8		<0.2	0.2
	10		<0.2	0.2
	18		<0.2	<0.2
	21		<0.2	<0.2
	23		<0.2	<0.2
	24		<0.2	<0.2
Background	105		<0.2	0.2
	116		<0.2	<0.2
	120		<0.2	<0.2

- a. Radon gas concentrations in 2003 were measured with RadTrack detectors. These detectors measure the combined concentration of radon-220 and radon-222 in air.
- b. pCi/L - picocuries per liter.
- c. Monitoring locations are shown in Figure 2.
- d. Detectors were installed and removed on the dates listed.
- e. A quality control duplicate is collected at the same time and location and is analyzed by the same method for evaluating precision in sampling and analysis.
- f. Monitoring locations are at the perimeter of the waste containment structure (WCS).

Note: The DOE limit for radon-222 is 3.00 pCi/L above background.

(<0.2) Indicates detection limit is reported. Actual result is less than this value.

1 pCi = 0.037 becquerel

2003 Radon Flux Monitoring Results^a
Niagara Falls Storage Site

NFSS Radon Flux											
Sample ID		(pCi/m ² /s)		Sample ID		(pCi/m ² /s)		Sample ID		(pCi/m ² /s)	
1	0.147	±	0.068	41	0.070	±	0.026	81	0.066	±	0.053
2	0.159	±	0.095	42	0.030	±	0.045	82	0.113	±	0.071
3	0.102	±	0.076	43	0.819	±	0.043	83	0.077	±	0.053
4	0.010	±	0.032	44	0.016	±	0.046	84	0.006	±	0.033
5	0.042	±	0.042	45	0.227	±	0.032	85	0.054	±	0.040
6	0.038	±	0.041	46	0.091	±	0.047	86	0.039	±	0.059
7	0.079	±	0.050	47	0.124	±	0.057	87	0.114	±	0.051
8	0.131	±	0.071	48	0.111	±	0.066	88	0.055	±	0.055
9	0.044	±	0.056	49	0.072	±	0.048	89	0.066	±	0.056
10	0.108	±	0.071	50	0.044	±	0.043	90	0.148	±	0.047
10 DUP	0.100	±	0.053	50 DUP	0.046	±	0.063	90 DUP	0.112	±	0.074
11	0.158	±	0.089	51	0.060	±	0.037	91	0.157	±	0.064
12	0.142	±	0.078	52	0.054	±	0.048	92	0.062	±	0.036
13	0.069	±	0.046	53	0.061	±	0.034	93	0.104	±	0.097
14	0.136	±	0.055	54	0.145	±	0.085	94	0.061	±	0.040
15	0.063	±	0.049	55	0.166	±	0.040	95	0.035	±	0.048
16	0.106	±	0.089	56	0.007	±	0.042	96	0.517	±	0.040
17	0.033	±	0.039	57	0.112	±	0.057	97	0.016	±	0.047
18	-0.007	±	0.042	58	0.073	±	0.051	98	0.036	±	0.037
19	0.110	±	0.066	59	0.082	±	0.049	99	0.002	±	0.040
20	0.084	±	0.048	60	0.003	±	0.054	100	0.032	±	0.047
20 DUP	0.056	±	0.033	60 DUP	0.082	±	0.058	100 DUP	0.036	±	0.049
21	0.093	±	0.067	61	0.164	±	0.042	101	0.051	±	0.055
22	0.047	±	0.040	62	0.045	±	0.057	102	0.095	±	0.058
23	0.044	±	0.050	63	0.053	±	0.038	103	0.033	±	0.055
24	0.126	±	0.040	64	0.080	±	0.054	104	-0.004	±	0.028
25	0.100	±	0.057	65	1.419	±	0.118	105	0.019	±	0.063
26	0.084	±	0.049	66	0.075	±	0.047	106	0.106	±	0.072
27	0.050	±	0.064	67	0.008	±	0.041	107	0.017	±	0.049
28	0.089	±	0.044	68	0.100	±	0.051	108	0.182	±	0.054
29	0.062	±	0.051	69	0.041	±	0.038	109	0.116	±	0.086
30	0.087	±	0.052	70	0.451	±	0.040	110	0.086	±	0.050
30 DUP	0.164	±	0.066	70 DUP	0.040	±	0.042	110 DUP	0.052	±	0.056
31	0.094	±	0.064	71	0.035	±	0.047	111	0.027	±	0.045
32	0.133	±	0.075	72	0.002	±	0.040	112	0.016	±	0.040
33	0.094	±	0.061	73	0.120	±	0.053	113	0.072	±	0.057
34	0.049	±	0.052	74	-0.007	±	0.044	114	0.104	±	0.062
35	0.064	±	0.045	75	0.018	±	0.024	115	0.070	±	0.052
36	0.098	±	0.054	76	0.007	±	0.043	116	0.043	±	0.059
37	0.106	±	0.051	77	0.023	±	0.037	117	-0.002	±	0.036
38	0.054	±	0.054	78	0.115	±	0.059	118	0.022	±	0.051
39	0.018	±	0.023	79	-0.024	±	0.045	119	0.063	±	0.048
40	0.043	±	0.043	80	0.016	±	0.047	120	0.007	±	0.045
40 DUP	-0.006	±	0.051	80 DUP	0.017	±	0.054	120 DUP	-0.022	±	0.048

2003 Radon Flux Monitoring Results^a
Niagara Falls Storage Site

NFSS Radon Flux												
Sample ID		(pCi/m ² /s)		Sample ID		(pCi/m ² /s)		Sample ID		(pCi/m ² /s)		
121	0.028	±	0.060	161	0.057	±	0.054					
122	0.060	±	0.048	162	0.169	±	0.091					
123	0.004	±	0.064	163	0.046	±	0.037					
124	0.005	±	0.032	164	0.025	±	0.062					
125	0.086	±	0.078	165	0.030	±	0.048					
126	0.055	±	0.040	166	0.007	±	0.048					
127	0.048	±	0.054	167	0.002	±	0.050					
128	0.002	±	0.047	168	0.090	±	0.074					
129	0.035	±	0.068	169	0.086	±	0.049					
130	0.087	±	0.067	170	0.039	±	0.045					
130 DUP	0.125	±	0.058	170 DUP	-0.009	±	0.040					
131	0.018	±	0.057	171	0.072	±	0.050					
132	0.023	±	0.039	172	0.206	±	0.114					
133	0.110	±	0.062	173	0.087	±	0.047					
134	0.051	±	0.031	174	0.138	±	0.080	Average:	0.080	(pCi/m ² /s)		
135	0.126	±	0.065	175	0.122	±	0.074	High	1.419	(pCi/m ² /s)		
136	0.019	±	0.032	176	0.128	±	0.091	Low	-0.046	(pCi/m ² /s)		
137	0.017	±	0.049	177	0.007	±	0.060					
138	0.074	±	0.061	178	0.011	±	0.110					
139	-0.046	±	0.053	179	0.067	±	0.027					
140	0.004	±	0.038	180	0.245	±	0.011					
140 DUP	0.054	±	0.046	180 DUP	0.233	±	0.064					
141	0.038	±	0.052	181 ^c	0.065	±	0.054					
142	0.033	±	0.049	182 ^c	0.122	±	0.083					
143	0.011	±	0.064	183 ^c	0.061	±	0.049					
144	0.081	±	0.067	Average	0.082							
145	-0.002	±	0.059	background								
146	0.049	±	0.057									
147	0.072	±	0.056									
148	0.103	±	0.073									
149	0.005	±	0.034									
150	0.049	±	0.049									
150 DUP	0.007	±	0.047									
151	0.019	±	0.033									
152	0.086	±	0.044									
153	0.009	±	0.063									
154	0.054	±	0.040									
155	0.029	±	0.048									
156	0.004	±	0.040									
157	0.095	±	0.053									
158	0.090	±	0.056									
159	0.051	±	0.070									
160	0.077	±	0.044									
160 DUP	-0.010	±	0.133									

NOTE: The EPA Standard for Radon-222 Flux is 20 pCi/m²/sec

a. Radon-222 flux was performed in Jul. 29-30, 2003

b. Every 10th canister is counted twice as a quality control (QC) duplicate to evaluate analytical precision

c. Background

Table 5
2003 Surface Water Analytical Results - Radioactive Constituents
Niagara Falls Storage Site

Page 1 of 2

Sampling Location	Date Collected	Analyte	Qualifier ^f	Result (pCi/L) ^a	Reporting Limit	MDA ^b (pCi/L) ^a	DCG ^c (pCi/L) ^a
SWSD009	5/15/2003	Radium-226	U	0.19 ± 0.20	1.00	0.29	100
Background	5/15/2003	Radium-228	U	0.77 ± 0.56	3.00	1.11	100
	5/15/2003	Thorium-230		0.60 ± 0.26	1.00	0.25	300
	5/15/2003	Thorium-232	U	0.09 ± 0.12	1.00	0.23	50
	5/15/2003	Uranium-234		1.90 ± 0.47	1.00	0.37	500
	5/15/2003	Uranium-235	U	0.19 ± 0.16	1.00	0.23	600
	5/15/2003	Uranium-238		2.02 ± 0.47	1.00	0.24	600
		<i>Total uranium^d</i>		4.11			600
SWSD021	5/15/2003	Radium-226		0.45 ± 0.30	1.00	0.37	100
Background	5/15/2003	Radium-228	U	0.51 ± 0.54	3.00	1.09	100
	5/15/2003	Thorium-230		0.48 ± 0.23	1.00	0.30	300
	5/15/2003	Thorium-232		0.28 ± 0.15	1.00	0.06	50
	5/15/2003	Uranium-234		9.26 ± 1.05	1.00	0.56	500
	5/15/2003	Uranium-235		1.16 ± 0.38	1.00	0.32	600
	5/15/2003	Uranium-238		7.28 ± 0.91	1.00	0.09	600
		<i>Total uranium^d</i>		17.7			600
SWSD010	5/15/2003	Radium-226	U	0.43 ± 0.34	1.00	0.51	100
	5/15/2003	Radium-228	U	0.62 ± 0.51	3.00	1.01	100
	5/15/2003	Thorium-230		0.41 ± 0.29	1.00	0.33	300
	5/15/2003	Thorium-232	U	0.09 ± 0.13	1.00	0.14	50
	5/15/2003	Uranium-234		3.97 ± 0.73	1.00	0.21	500
	5/15/2003	Uranium-235	U	0.15 ± 0.17	1.00	0.31	600
	5/15/2003	Uranium-238		2.95 ± 0.63	1.00	0.18	600
		<i>Total uranium^d</i>		7.07			600
SWSD011	5/15/2003	Radium-226		0.68 ± 0.30	1.00	0.23	100
	5/15/2003	Radium-228		1.02 ± 0.52	3.00	0.98	100
	5/15/2003	Thorium-230		0.64 ± 0.26	1.00	0.29	300
	5/15/2003	Thorium-232	U	0.09 ± 0.10	1.00	0.14	50
	5/15/2003	Uranium-234		3.44 ± 0.64	1.00	0.23	500
	5/15/2003	Uranium-235		0.77 ± 0.31	1.00	0.23	600
	5/15/2003	Uranium-238		3.07 ± 0.60	1.00	0.16	600
		<i>Total uranium^d</i>		7.28			600

Table 5
2003 Surface Water Analytical Results - Radioactive Constituents
Niagara Falls Storage Site

Page 2 of 2

Sampling Location	Date Collected	Analyte	Qualifier ^f	Result (pCi/L) ^a	Reporting Limit	MDA ^b (pCi/L) ^a	DCG ^c (pCi/L) ^a
Duplicate ^e SWSD1-SWSD011	5/15/2003	Radium-226	U	0.00 ± 0.43	1.00	0.50	100
	5/15/2003	Radium-228	U	0.13 ± 0.07	3.00	1.14	100
	5/15/2003	Thorium-230		0.54 ± 0.17	1.00	0.16	300
	5/15/2003	Thorium-232	U	0.12 ± 0.03	1.00	0.16	50
	5/15/2003	Uranium-234		3.24 ± 0.82	1.00	0.28	500
	5/15/2003	Uranium-235		0.29 ± 0.12	1.00	0.24	600
	5/15/2003	Uranium-238		3.66 ± 0.71	1.00	0.26	600
		<i>Total uranium^d</i>		7.19			600
SWSD022	5/15/2003	Radium-226	U	0.20 ± 0.23	1.00	0.37	100
	5/15/2003	Radium-228		1.18 ± 0.60	3.00	1.12	100
	5/15/2003	Thorium-230	U	0.40 ± 0.30	1.00	0.51	300
	5/15/2003	Thorium-232	U	0.09 ± 0.15	1.00	0.33	50
	5/15/2003	Uranium-234		3.76 ± 0.71	1.00	0.29	500
	5/15/2003	Uranium-235		0.42 ± 0.24	1.00	0.24	600
	5/15/2003	Uranium-238		3.21 ± 0.65	1.00	0.29	600
		<i>Total uranium^d</i>		7.39			600

a. pCi/L - picocuries per liter.

b. MDA - Minimum detectable activity.

c. DOE Derived Concentration Guide (DCG) for water.

d. Sum of uranium isotope concentrations.

e. A quality control duplicate is collected at the same time and location and is analyzed by the same method for evaluating precision in sampling and analysis (SWSD011).

f. Lab Qualifier: U - indicates that no analyte was detected above reporting limit (Non-Detect)

Table 6
2003

Sediment Analytical Results - Radioactive Constituents
Niagara Falls Storage Site

Sampling Location	Date Collected	Analyte	Qualifier [±]	Result (pCi/g) ^a	Reporting Limit (pCi/g) ^a	MDA ^b (pCi/g) ^a	Cleanup Criteria ^c (pCi/g) ^a
SWSD009 Background	5/15/2003	Radium-226		1.00 ± 0.26	1.00	0.09	5
	5/15/2003	Radium-228		0.79 ± 0.16	0.50	0.18	5
	5/15/2003	Thorium-230		1.08 ± 0.39	1.00	0.22	5
	5/15/2003	Thorium-232		1.07 ± 0.38	1.00	0.22	5
	5/15/2003	Uranium-234		1.94 ± 0.49	1.00	0.34	-
	5/15/2003	Uranium-235		0.56 ± 0.28	1.00	0.34	-
	5/15/2003	Uranium-238		1.24 ± 0.40	1.00	0.33	-
		<i>Total uranium^e</i>		3.74			90 ^d
SWSD021 Background	5/15/2003	Radium-226		1.38 ± 0.22	1.00	0.05	5
	5/15/2003	Radium-228		0.81 ± 0.11	0.50	0.09	5
	5/15/2003	Thorium-230		1.31 ± 0.42	1.00	0.34	5
	5/15/2003	Thorium-232		1.65 ± 0.46	1.00	0.22	5
	5/15/2003	Uranium-234		1.19 ± 0.42	1.00	0.36	-
	5/15/2003	Uranium-235		0.21 ± 0.18	1.00	0.19	-
	5/15/2003	Uranium-238		1.24 ± 0.42	1.00	0.25	-
		<i>Total uranium^e</i>		2.64			90 ^d
SWSD010	5/15/2003	Radium-226		0.99 ± 0.51	1.00	0.06	5
	5/15/2003	Radium-228		0.91 ± 0.41	0.50	0.11	5
	5/15/2003	Thorium-230		2.04 ± 0.39	1.00	0.39	5
	5/15/2003	Thorium-232		1.35 ± 0.35	1.00	0.25	5
	5/15/2003	Uranium-234		1.12 ± 0.23	1.00	0.24	-
	5/15/2003	Uranium-235	U	0.14 ± 0.13	1.00	0.21	-
	5/15/2003	Uranium-238		1.42 ± 0.13	1.00	0.17	-
		<i>Total uranium^e</i>		2.68			90 ^d
SWSD022	5/15/2003	Radium-226		1.01 ± 0.20	1.00	0.54	5
	5/15/2003	Radium-228		1.25 ± 0.17	0.50	0.10	5
	5/15/2003	Thorium-230		2.44 ± 0.52	1.00	0.27	5
	5/15/2003	Thorium-232		0.86 ± 0.32	1.00	0.30	5
	5/15/2003	Uranium-234		1.49 ± 0.41	1.00	0.25	-
	5/15/2003	Uranium-235	U	0.15 ± 0.14	1.00	0.19	-
	5/15/2003	Uranium-238		1.04 ± 0.34	1.00	0.19	-
		<i>Total uranium^e</i>		2.68			90 ^d

Table 6
2003

Sediment Analytical Results - Radioactive Constituents
Niagara Falls Storage Site

Sampling Location	Date Collected	Analyte	Qualifier ^g	Result (pCi/g) ^a	Reporting Limit (pCi/g) ^a	MDA ^b (pCi/g) ^a	Cleanup Criteria ^c (pCi/g) ^a
SWSD011	5/15/2003	Radium-226		1.08 ± 0.24	1.00	0.07	5
	5/15/2003	Radium-228		1.09 ± 0.17	0.50	0.15	5
	5/15/2003	Thorium-230		1.02 ± 0.33	1.00	0.18	5
	5/15/2003	Thorium-232		0.60 ± 0.25	1.00	0.14	5
	5/15/2003	Uranium-234		1.30 ± 0.37	1.00	0.19	-
	5/15/2003	Uranium-235		0.39 ± 0.21	1.00	0.19	-
	5/15/2003	Uranium-238		1.15 ± 0.35	1.00	0.17	-
		<i>Total uranium^e</i>		<i>2.84</i>			<i>90^d</i>
Duplicate ^f SWSD1-SED SWSD011	5/15/2003	Radium-226		1.05 ± 0.21	1.00	0.07	5
	5/15/2003	Radium-228		1.02 ± 0.16	0.50	0.14	5
	5/15/2003	Thorium-230		1.57 ± 0.46	1.00	0.22	5
	5/15/2003	Thorium-232		1.08 ± 0.38	1.00	0.19	5
	5/15/2003	Uranium-234		1.18 ± 0.36	1.00	0.19	-
	5/15/2003	Uranium-235		0.27 ± 0.18	1.00	0.21	-
	5/15/2003	Uranium-238		0.92 ± 0.31	1.00	0.14	-
		<i>Total uranium^e</i>		<i>2.37</i>			<i>90^d</i>

a. pCi/g - picocuries per gram.

b. MDA - Minimum detectable activity.

c. DOE surface soil cleanup criteria, averaged over topmost 6 in. (15 cm) of soil. Because there are no standards for radioactive constituents in sediment, these soil values are used as a basis for comparison of sediment results.

d. NFSS site-specific cleanup criterion for total uranium.

e. Sum of uranium isotope concentrations.

f. A quality control duplicate is collected at the same time and location and is analyzed by the same method for evaluating precision in sampling and analysis.

g. Lab Qualifier: U - indicates that no analyte was detected above reporting limit (Non-Detect).

Table 7
2003 Field Parameter Summary
Niagara Falls Storage Site

Sampling Location	Date	Temperature (°F ^a)	pH	Spec. Cond. ^b (mS/cm ^c)	DO ^d (mg/L ^e)	Eh ^f (mV ^g)	Turbidity (NTU ^h)	Volume Purged (Liters ⁱ)	Discharge milliter PM ^j
GROUNDWATER									
A45	05/16/2003	50.5	6.68	1.855	22.62	56	2.62	17.10	380
A50	05/15/2003	55.8	6.87	1.725	2.14	331	3.61	9.36	130
OW04B	05/13/2003	53.7	7.40	1.810	1.33	183	4.34	17.60	160
OW06B	05/16/2003	53.2	7.11	1.781	19.88	241	2.85	2.80	100
OW07B	05/13/2003	51.6	7.28	2.187	8.29	259	7.51	3.10	100
OW13B	5/14/2003	52.7	6.19	2.130	2.84	371	2.40	5.20	100
OW15B	05/13/2003	51.2	7.16	1.169	7.04	240	3.21	9.75	130
OW17B	05/13/2003	54.6	7.42	1.391	4.19	320	10.90	8.63	115
B02W20S	05/14/2003	51.8	-	1.212	8.21	297	11.70	21.85	230
SURFACE WATER^l									
SWSD009									
SWSD010									
SWSD011									
SWSD021									
SWSD022									

- a. °F - Degrees Fahrenheit.
- b. Spec. Cond. - Specific conductance.
- c. mS/cm - milliSiemens/centimeter.
- d. DO - Dissolved oxygen.
- e. mg/L - milligrams per liter.
- f. Eh - Oxidation/reduction potential.
- g. mV - milliVolts.
- h. NTU - Nephelometric turbidity units.
- i. 1-Liter = 0.26 gallons
- j. Milliter PM = milliter per minute (1000ml = 1.0 liter)
- l. No results obtained due to malfunctioning of the meter

Table 8
2003 Groundwater Quality Results for Niagara Falls Storage Site

Sampling Location	Date Collected	Analyte	Qualifier ^f	Reporting		Related Regulations ^b	
				Result (mg/L) ^a	Limit (mg/L) ^a	Federal ^c (mg/L) ^a	State ^d (mg/L) ^a
B02W20S	05/16/03	Alkalinity, Total as CaCO ₃		455	2	NE	NE
Background	05/16/03	Bicarbonate alkalinity (CaCO ₃)		452	2	NE	NE
	05/15/03	Calcium		81.3	0.5	NE	NE
	05/16/03	Carbonate alkalinity (CaCO ₃)		2.34	2	NE	NE
	05/15/03	Chloride**		8.96	0.2	250	250
	05/15/03	Magnesium		123	0.05	NE	NE
	05/15/03	Nitrogen, Nitrate*		0.10	0.1	10	10
	05/15/03	Nitrogen, Nitrite*	U	0.05	0.1	1	1
	05/15/03	Ortho-phosphate	U	0.15	0.2	NE	NE
	05/15/03	Potassium		1.8	0.1	NE	NE
	05/15/03	Sodium***		56.7	0.1	20	20
	05/16/03	Solids, Total Dissolved**		895	10	500	500
	05/15/03	Sulfate***		305	8	250	250
A45	05/16/03	Alkalinity, Total as CaCO ₃		465	2	NE	NE
	05/16/03	Bicarbonate alkalinity (CaCO ₃)		464	2	NE	NE
	05/16/03	Calcium		293	0.5	NE	NE
	05/16/03	Carbonate alkalinity (CaCO ₃)	U	1.45	2	NE	NE
	05/16/03	Chloride**		48.7	1	250	250
	05/16/03	Magnesium		145	0.5	NE	NE
	05/16/03	Nitrogen, Nitrate*	U	0.03	0.1	10	10
	05/16/03	Nitrogen, Nitrite*	U	0.05	0.1	1	1
	05/16/03	Ortho-phosphate	U	0.15	0.2	NE	NE
	05/16/03	Potassium		4.81	0.1	NE	NE
	05/16/03	Sodium***		51.5	0.1	20	20
	05/16/03	Solids, Total Dissolved**		1800	10	500	500
	05/16/03	Sulfate***		777	20	250	250
Duplicate ^e (D1-GW) OW04B	05/15/03	Alkalinity, Total as CaCO ₃		293	2.00	NE	NE
	05/15/03	Bicarbonate alkalinity (CaCO ₃)		284	2.00	NE	NE
	05/15/03	Calcium		216	0.0416	NE	NE
	05/15/03	Carbonate alkalinity (CaCO ₃)	U	1.17	2.00	NE	NE
	05/15/03	Chloride**		89.1	2.00	250	250
	05/15/03	Magnesium		138	0.0149	NE	NE
	05/15/03	Nitrogen, Nitrate*	U	0.03	0.10	10	10
	05/15/03	Nitrogen, Nitrite*	U	0.05	0.10	1	1
	05/15/03	Ortho-phosphate	U	0.15	0.20	NE	NE
	05/15/03	Potassium		1.94	0.0242	NE	NE
	05/15/03	Sodium***		69.8	0.0215	20	20
	05/15/03	Solids, Total Dissolved**		1610	10.00	500	500
	05/15/03	Sulfate***		728	40.00	250	250

Table 8
2003 Groundwater Quality Results for Niagara Falls Storage Site

Sampling Location	Date Collected	Analyte	Qualifier ^f	Reporting		Related Regulations ^b	
				Result (mg/L) ^a	Limit (mg/L) ^a	Federal ^c (mg/L) ^a	State ^d (mg/L) ^a
A50	05/15/03	Alkalinity, Total as CaCO ₃		440	2	NE	NE
	05/15/03	Bicarbonate alkalinity (CaCO ₃)		438	2	NE	NE
	05/15/03	Calcium		133	0.5	NE	NE
	05/15/03	Carbonate alkalinity (CaCO ₃)	U	1.46	2	NE	NE
	05/15/03	Chloride**		19.6	0.4	250	250
	05/15/03	Magnesium		160	0.05	NE	NE
	05/15/03	Nitrogen, Nitrate*	U	0.03	0.1	10	10
	05/15/03	Nitrogen, Nitrite*	U	0.05	0.1	1	1
	05/15/03	Ortho-phosphate	U	0.15	0.2	NE	NE
	05/15/03	Potassium		1.63	0.1	NE	NE
	05/15/03	Sodium***		83.4	0.1	20	20
	05/15/03	Solids, Total Dissolved**		1350	10	500	500
	05/15/03	Sulfate***		577	20	250	250
OW04B	05/15/03	Alkalinity, Total as CaCO ₃		303	2	NE	NE
	05/15/03	Bicarbonate alkalinity (CaCO ₃)		302	2	NE	NE
	05/15/03	Calcium		218	0.5	NE	NE
	05/15/03	Carbonate alkalinity (CaCO ₃)	U	1.45	2	NE	NE
	05/15/03	Chloride**		90.4	2	250	250
	05/15/03	Magnesium		144	0.05	NE	NE
	05/15/03	Nitrogen, Nitrate*		0.16	0.1	10	10
	05/15/03	Nitrogen, Nitrite*	U	0.05	0.1	1	1
	05/15/03	Ortho-phosphate	U	0.15	0.2	NE	NE
	05/15/03	Potassium		1.95	0.1	NE	NE
	05/15/03	Sodium***		70.4	0.1	20	20
	05/15/03	Solids, Total Dissolved**		1630	10	500	500
	05/15/03	Sulfate***		725	40	250	250
OW06B	05/16/03	Alkalinity, Total as CaCO ₃		586	2	NE	NE
	05/16/03	Bicarbonate alkalinity (CaCO ₃)		585	2	NE	NE
	05/16/03	Calcium		134	0.1	NE	NE
	05/16/03	Carbonate alkalinity (CaCO ₃)	U	1.7	2	NE	NE
	05/16/03	Chloride**		27.3	1	250	250
	05/16/03	Magnesium		199	0.05	NE	NE
	05/16/03	Nitrogen, Nitrate*	U	0.03	0.1	10	10
	05/16/03	Nitrogen, Nitrite*	U	0.05	0.1	1	1
	05/16/03	Ortho-phosphate		0.24	0.2	NE	NE
	05/16/03	Potassium		3.24	0.1	NE	NE
	05/16/03	Sodium***		69.7	0.1	20	20
	05/16/03	Solids, Total Dissolved**		1490	10	500	500
	05/16/03	Sulfate***		571	20	500	250

Table 8
2003 Groundwater Quality Results for Niagara Falls Storage Site

Sampling Location	Date Collected	Analyte	Qualifier ^f	Reporting		Related Regulations ^b	
				Result (mg/L) ^a	Limit (mg/L) ^a	Federal ^c (mg/L) ^a	State ^d (mg/L) ^a
OW07B	05/19/03	Alkalinity, Total as CaCO ₃		364	2	NE	NE
	05/19/03	Bicarbonate alkalinity (CaCO ₃)		363	2	NE	NE
	05/14/03	Calcium		150	0.5	NE	NE
	05/19/03	Carbonate alkalinity (CaCO ₃)	U	1.45	2	NE	NE
	05/14/03	Chloride**		19.5	0.2	250	250
	05/13/03	Magnesium		209	0.05	NE	NE
	05/14/03	Nitrogen, Nitrate*		2.96	0.1	10	10
	05/14/03	Nitrogen, Nitrite*	U	0.05	0.1	1	1
	05/14/03	Ortho-phosphate	U	0.15	0.2	NE	NE
	05/13/03	Potassium		3.63	0.1	NE	NE
	05/13/03	Sodium***		75.3	0.1	20	20
	05/19/03	Solids, Total Dissolved**		1660	10	500	500
	05/14/03	Sulfate***		773	20	250	250
OW15B	05/14/03	Alkalinity, Total as CaCO ₃		332	2	NE	NE
	05/14/03	Bicarbonate alkalinity (CaCO ₃)		331	2	NE	NE
	05/14/03	Calcium		98	0.1	NE	NE
	05/14/03	Carbonate alkalinity (CaCO ₃)	U	1.49	2	NE	NE
	05/14/03	Chloride**		6.45	0.2	250	250
	05/14/03	Magnesium		88	0.05	NE	NE
	05/14/03	Nitrogen, Nitrate*		1.05	0.1	10	10
	05/14/03	Nitrogen, Nitrite*	U	0.05	0.1	1	1
	05/14/03	Ortho-phosphate	U	0.15	0.2	NE	NE
	05/14/03	Potassium		1.23	0.1	NE	NE
	05/14/03	Sodium***		39.9	0.1	20	20
	05/14/03	Solids, Total Dissolved**		840	10	500	500
	05/14/03	Sulfate***		317	20	250	250
OW17B	05/19/03	Alkalinity, Total as CaCO ₃		409	2	NE	NE
	05/19/03	Bicarbonate alkalinity (CaCO ₃)		407	2	NE	NE
	05/14/03	Calcium		91.7	0.5	NE	NE
	05/19/03	Carbonate alkalinity (CaCO ₃)	U	1.92	2	NE	NE
	05/14/03	Chloride**		11.3	0.2	250	250
	05/14/03	Magnesium		135	0.05	NE	NE
	05/14/03	Nitrogen, Nitrate*		0.10	0.1	10	10
	05/14/03	Nitrogen, Nitrite*	U	0.05	0.1	1	1
	05/14/03	Ortho-phosphate	U	0.15	0.2	NE	NE
	05/14/03	Potassium		1.97	0.1	NE	NE
	05/14/03	Sodium***		61.4	0.1	20	20
	05/19/03	Solids, Total Dissolved**		1090	10	500	500
	05/14/03	Sulfate**		410	20	250	250

a. mg/L - milligrams per liter.

b. Regulations presented pertain to drinking water quality and are listed for comparison only.

No drinking water supply is obtained from groundwater at NFSS. NE - Not established.

c. 2004 Edition of the Drinking Water Standards and Health Advisories (EPA 822-R-04-005)

*-Drinking Water Standards Maximum Contaminant Level: Nitrate and Nitrite

National Secondary Drinking Water Regulations (40CFR143.3). These regulations primarily control and affect the aesthetic qualities of drinking water.

***-Drinking Water Advisory Table (Health -based Value): Sodium

d. Water Quality Criteria (class GA) per 6 NYCRR, Part 703.

e. A quality control (QC) duplicate is collected at the same time and location and is analyzed by the same method for evaluating precision in sampling and analysis.

f. Lab Qualifier: U - indicates that no analyte was detected above reporting limit (Non-Detect).

Table 9
2003 Groundwater Analytical Results - Radioactive Constituents
Niagara Falls Storage Site

Page 1 of 3

Sampling Location	Date Collected	Analyte	Qualifier ^c	Result ^a (pCi/L) ^b	Reporting Limit (pCi/L) ^b	DCG ^d (pCi/L) ^b
B02W20S	05/15/03	Radium-226	U	0.08 ± 0.31	1.00	100 ^h
Background	05/15/03	Radium-228	U	0.01 ± 0.48	1.00	100 ^h
		<i>Total Radium^g</i>	Non-Detect			100 ^h
	05/15/03	Thorium-230		0.11 ± 0.09	0.50	300
	05/15/03	Thorium-232	U	0.00 ± 0.01	0.50	50
	05/15/03	Uranium-234		5.39 ± 0.92	0.50	500
	05/15/03	Uranium-235		1.24 ± 0.34	0.50	600
	05/15/03	Uranium-238		3.97 ± 0.73	0.50	600
		<i>Total Uranium^e</i>		10.60		600
A50	05/15/03	Radium-226	U	0.00 ± 0.29	1.00	100 ^h
	05/15/03	Radium-228		1.06 ± 0.52	1.00	100 ^h
		<i>Total Radium^g</i>		1.06		100 ^h
	05/15/03	Thorium-230	U	0.04 ± 0.04	0.50	300
	05/15/03	Thorium-232	U	-0.01 ± 0.01	0.50	50
	05/15/03	Uranium-234		10.80 ± 1.37	0.50	500
	05/15/03	Uranium-235		0.51 ± 0.17	0.50	600
	05/15/03	Uranium-238		8.53 ± 1.12	0.50	600
		<i>Total Uranium^e</i>		19.84		600
OW04B	05/14/03	Radium-226	U	0.04 ± 0.28	1.00	100 ^h
	05/14/03	Radium-228	U	0.41 ± 0.38	1.00	100 ^h
		<i>Total Radium^g</i>	Non-Detect			100 ^h
	05/14/03	Thorium-230	U	0.04 ± 0.05	0.50	300
	05/14/03	Thorium-232	U	0.00 ± 0.00	0.50	50
	05/14/03	Uranium-234		25.50 ± 3.46	0.50	500
	05/14/03	Uranium-235		1.56 ± 0.39	0.50	600
	05/14/03	Uranium-238		24.50 ± 3.33	0.50	600
		<i>Total Uranium^e</i>		51.56		600
Duplicate (D1-GW) ^f OW04B	05/14/03	Radium-226	U	0.33 ± 0.35	1.00	100 ^h
	05/14/03	Radium-228	U	0.01 ± 0.44	1.00	100 ^h
		<i>Total Radium^g</i>	Non-Detect			100 ^h
	05/14/03	Thorium-230	U	0.06 ± 0.06	0.50	300
	05/14/03	Thorium-232	U	0.00 ± 0.01	0.50	50
	05/14/03	Uranium-234		24.00 ± 3.37	0.50	500
	05/14/03	Uranium-235		1.84 ± 0.45	0.50	600
	05/14/03	Uranium-238		22.50 ± 3.18	0.50	600
		<i>Total Uranium^e</i>		48.34		600
OW04B Filtered	05/15/03	Radium-226	U	0.33 ± 0.33	1.00	100 ^h
	05/15/03	Radium-228		0.42 ± 0.29	1.00	100 ^h
		<i>Total Radium^g</i>		0.42		100 ^h
	05/15/03	Thorium-230	U	0.38 ± 0.22	0.50	300
	05/15/03	Thorium-232	U	0.00 ± 0.06	0.50	50
	05/15/03	Uranium-234		23.80 ± 3.48	0.50	500
	05/15/03	Uranium-235		1.78 ± 0.45	0.50	600
	05/15/03	Uranium-238		20.90 ± 3.09	0.50	600
		<i>Total Uranium^e</i>		46.48		600

Table 9
2003 Groundwater Analytical Results - Radioactive Constituents
Niagara Falls Storage Site

Sampling Location	Date Collected	Analyte	Qualifier ^c	Result ^a (pCi/L) ^b	Reporting Limit (pCi/L) ^b	DCG ^d (pCi/L) ^b
OW07B	05/13/03	Radium-226	U	0.21 ± 0.28	1.00	100 ^h
	05/13/03	Radium-228	U	0.93 ± 0.63	1.00	100 ^h
		<i>Total Radium^g</i>	Non-Detect			100 ^h
	05/13/03	Thorium-230	U	-0.02 ± 0.03	0.50	300
	05/13/03	Thorium-232	U	-0.01 ± 0.01	0.50	50
	05/13/03	Uranium-234		9.62 ± 1.40	0.50	500
	05/13/03	Uranium-235		0.95 ± 0.28	0.50	600
	05/13/03	Uranium-238		7.93 ± 1.20	0.50	600
		<i>Total Uranium^e</i>		18.50		600
OW07B Filtered	05/13/03	Radium-226	U	0.23 ± 0.25	1.00	100 ^h
	05/13/03	Radium-228		1.87 ± 0.45	1.00	100 ^h
		<i>Total Radium^g</i>		0.23		100 ^h
	05/13/03	Thorium-230	U	0.11 ± 0.09	0.50	300
	05/13/03	Thorium-232	U	0.01 ± 0.03	0.50	50
	05/13/03	Uranium-234		11.40 ± 1.96	0.50	500
	05/13/03	Uranium-235		1.19 ± 0.38	0.50	600
	05/13/03	Uranium-238		8.72 ± 1.56	0.50	600
		<i>Total Uranium^e</i>		21.31		600
OW13B ^h	05/13/03	Radium-226	U	0.27 ± 0.33	1.00	100 ^h
	05/13/03	Radium-228	U	0.59 ± 0.43	1.00	100 ^h
		<i>Total Radium^h</i>	Non-Detect			100 ^h
	05/13/03	Thorium-230	U	0.04 ± 0.05	0.50	300
	05/13/03	Thorium-232	U	0.00 ± 0.01	0.50	50
	05/13/03	Uranium-234		0.88 ± 0.25	0.50	500
	05/13/03	Uranium-235		0.18 ± 0.11	0.50	600
	05/13/03	Uranium-238		0.53 ± 0.19	0.50	600
		<i>Total Uranium^e</i>		1.59		600
OW13B Filtered	05/13/03	Radium-226	U	0.21 ± 0.19	1.00	100 ^h
	05/13/03	Radium-228	U	0.59 ± 0.51	1.00	100 ^h
		<i>Total Radium^g</i>	Non-Detect			100 ^h
	05/13/03	Thorium-230	U	0.02 ± 0.03	0.50	300
	05/13/03	Thorium-232	U	-0.01 ± 0.01	0.50	50
	05/13/03	Uranium-234		10.20 ± 1.42	0.50	500
	05/13/03	Uranium-235		0.54 ± 0.20	0.50	600
	05/13/03	Uranium-238		8.38 ± 1.20	0.50	600
		<i>Total Uranium^e</i>		19.12		600
OW06B	05/16/03	Radium-226	U	-0.04 ± 0.21	1.00	100 ^h
	05/16/03	Radium-228	U	0.12 ± 0.46	1.00	100 ^h
		<i>Total Radium^g</i>	Non-Detect			100 ^h
	05/16/03	Thorium-230	U	0.04 ± 0.08	0.50	300
	05/16/03	Thorium-232	U	0.01 ± 0.07	0.50	50
	05/16/03	Uranium-234		9.38 ± 1.35	0.50	500
	05/16/03	Uranium-235		0.68 ± 0.23	0.50	600
	05/16/03	Uranium-238		7.55 ± 1.13	0.50	600
		<i>Total Uranium^e</i>		17.61		600

Table 9
2003 Groundwater Analytical Results - Radioactive Constituents
Niagara Falls Storage Site

Page 3 of 3

Sampling Location	Date Collected	Analyte	Qualifier ^c	Result ^a (pCi/L) ^b	Reporting Limit (pCi/L) ^b	DCG ^d (pCi/L) ^b
OW15B	05/14/03	Radium-226	U	0.36 ± 0.30	1.00	100 ^h
	05/14/03	Radium-228	U	0.38 ± 0.32	1.00	100 ^h
		<i>Total Radium^g</i>	Non-Detect			100 ^h
	05/14/03	Thorium-230		0.17 ± 0.12	0.50	300
	05/14/03	Thorium-232	U	0.01 ± 0.03	0.50	50
	05/14/03	Uranium-234		4.15 ± 0.82	0.50	500
	05/14/03	Uranium-235		0.82 ± 0.29	0.50	600
	05/14/03	Uranium-238		3.09 ± 0.67	0.50	600
		<i>Total Uranium^e</i>		8.06		600
OW17B	05/14/03	Radium-226	U	0.24 ± 0.36	1.00	100 ^h
	05/14/03	Radium-228	U	0.61 ± 0.45	1.00	100 ^h
		<i>Total Radium^g</i>	Non-Detect			100 ^h
	05/14/03	Thorium-230	U	0.17 ± 0.13	0.50	300
	05/14/03	Thorium-232	U	-0.01 ± 0.01	0.50	50
	05/14/03	Uranium-234		3.04 ± 0.63	0.50	500
	05/14/03	Uranium-235		0.14 ± 0.13	0.50	600
	05/14/03	Uranium-238		2.48 ± 0.55	0.50	600
		<i>Total Uranium^e</i>		5.66		600
A45	05/16/03	Radium-226	U	0.32 ± 0.29	1.00	100 ^h
	05/16/03	Radium-228	U	-0.02 ± 0.52	1.00	100 ^h
		<i>Total Radium^g</i>	Non-Detect			100 ^h
	05/16/03	Thorium-230	U	0.02 ± 0.04	0.50	300
	05/16/03	Thorium-232	U	-0.01 ± 0.01	0.50	50
	05/16/03	Uranium-234		16.40 ± 2.14	0.50	500
	05/16/03	Uranium-235		0.90 ± 0.26	0.50	600
	05/16/03	Uranium-238		11.80 ± 1.61	0.50	600
		<i>Total Uranium^e</i>		29.10		600
A45 Filtered	05/16/03	Radium-226	U	0.34 ± 0.26	1.00	100 ^h
	05/16/03	Radium-228	U	0.49 ± 0.35	1.00	100 ^h
		<i>Total Radium^g</i>	Non-Detect			100 ^h
	05/16/03	Thorium-230		0.20 ± 0.14	0.50	300
	05/16/03	Thorium-232	U	0.02 ± 0.03	0.50	50
	05/16/03	Uranium-234		19.10 ± 3.07	0.50	500
	05/16/03	Uranium-235		0.96 ± 0.33	0.50	600
	05/16/03	Uranium-238		13.80 ± 2.30	0.50	600
		<i>Total Uranium^e</i>		33.86		600

a. Results reported with (±) radiological error quoted at 2-sigma (95 percent confidence level).

b. pCi/L - picocuries per liter.

c. Lab Qualifier: U - indicates that no analyte was detected above reporting limit (Non-Detect).

d. DOE derived concentration guide for water.

e. Sum of uranium isotope concentrations.

f. A quality control duplicate is collected at the same time and location and is analyzed by the same method for evaluating precision of sampling and analysis.

g. Sum of radium isotope concentrations.

h. Not included in averages for Section 5.6.2.3

Table 10
2003 Groundwater Analytical Results - Metals
Niagara Falls Storage Site

Sampling Location	Date Collected	Detected Analyte	Qualifier ^a	Result (mg/L) ^a	Detection Limit (mg/L) ^a	Related Regulations ^c	
						Federal ^d	State ^e
B02W20S	05/15/03	Copper	U	1.64	1.64	1300	200
Background	05/15/03	Lead		0.40	0.003	15	25
	05/15/03	Vanadium	U	2.48	2.48	NE ^b	NE ^b
A45	05/16/03	Copper		10.8	1.64	1300	200
	05/16/03	Lead		0.234	0.003	15	25
	05/16/03	Vanadium	U	2.48	2.48	NE ^b	NE ^b
A45 Filtered	05/16/03	Copper	U	1.64	1.64	1300	200
	05/16/03	Lead	U	0.003	0.003	15	25
	05/16/03	Vanadium	U	2.48	2.48	NE ^b	NE ^b
Duplicate (D1-GW) OW04B	05/15/03	Copper		4.12	1.64	1300	200
	05/15/03	Lead		0.032	0.003	15	25
	05/15/03	Vanadium	U	2.48	2.48	NE ^b	NE ^b
OW04B	05/15/03	Copper		5.96	1.64	1300	200
	05/15/03	Lead		0.028	0.003	15	25
	05/15/03	Vanadium	U	2.48	2.48	NE ^b	NE ^b
OW04B Filtered	05/15/03	Copper		22.1	1.64	1300	200
	05/15/03	Lead	U	0.003	0.003	15	25
	05/15/03	Vanadium	U	2.50	2.48	NE ^b	NE ^b
Duplicate (D1-GW) OW04B Filtered	05/15/03	Copper		12.6	1.64	1300	200
	05/15/03	Lead	U	0.003	0.003	15	25
	05/15/03	Vanadium	U	2.48	2.48	NE ^b	NE ^b
OW06B	05/16/03	Copper		114	1.64	1300	200
	05/16/03	Lead		1.1	0.003	15	25
	05/16/03	Vanadium	U	2.48	2.48	NE ^b	NE ^b
OW07B	05/13/03	Copper		2.69	1.64	1300	200
	05/13/03	Lead		0.118	0.003	15	25
	05/13/03	Vanadium	U	2.48	2.48	NE ^b	NE ^b
OW07B Filtered	05/13/03	Copper		5.22	1.64	1300	200
	05/13/03	Lead		0.922	0.003	15	25
	05/13/03	Vanadium	U	2.48	2.48	NE ^b	NE ^b
OW13B	05/14/03	Copper		1.74	1.64	1300	200
	05/14/03	Lead		0.98	0.003	15	25
	05/14/03	Vanadium	U	2.48	2.48	NE ^b	NE ^b
OW13B Filtered	05/14/03	Copper	U	1.64	1.64	1300	200
	05/14/03	Lead		0.388	0.003	15	25
	05/14/03	Vanadium	U	2.48	2.48	NE ^b	NE ^b
OW15B	05/14/03	Copper		6.69	1.64	1300	200
	05/14/03	Lead		0.465	0.004	15	25
	05/14/03	Vanadium	U	2.48	2.48	NE ^b	NE ^b
OW17B	05/14/03	Copper		7.14	1.64	1300	200
	05/14/03	Lead		2.21	0.003	15	25
	05/14/03	Vanadium	U	2.48	2.48	NE ^b	NE ^b
A50	05/15/03	Copper		9.29	1.64	1300	200
	05/15/03	Lead		0.18	0.003	15	25
	05/15/03	Vanadium	U	2.48	2.48	NE ^b	NE ^b

a. mg/L - micrograms per liter.

b. NE - Not Established

c. Regulations presented pertain to drinking water quality and are listed for comparison only.

No drinking water supply is obtained from groundwater at NFSS.

d. Federal Safe Drinking Water Act maximum contaminant levels from EPA Drinking Water Regulations and Health Advisories (October 1996).

e. Water Quality Criteria (Class GA) per 6 NYCRR, Chapter X, Subchapter A.

f. A quality control duplicate is collected at the same time and location and is analyzed by the same method for evaluating precision in sampling and analysis.

g. Lab Qualifier: U - indicates that no analyte was detected above detection limit (Non-Detect).

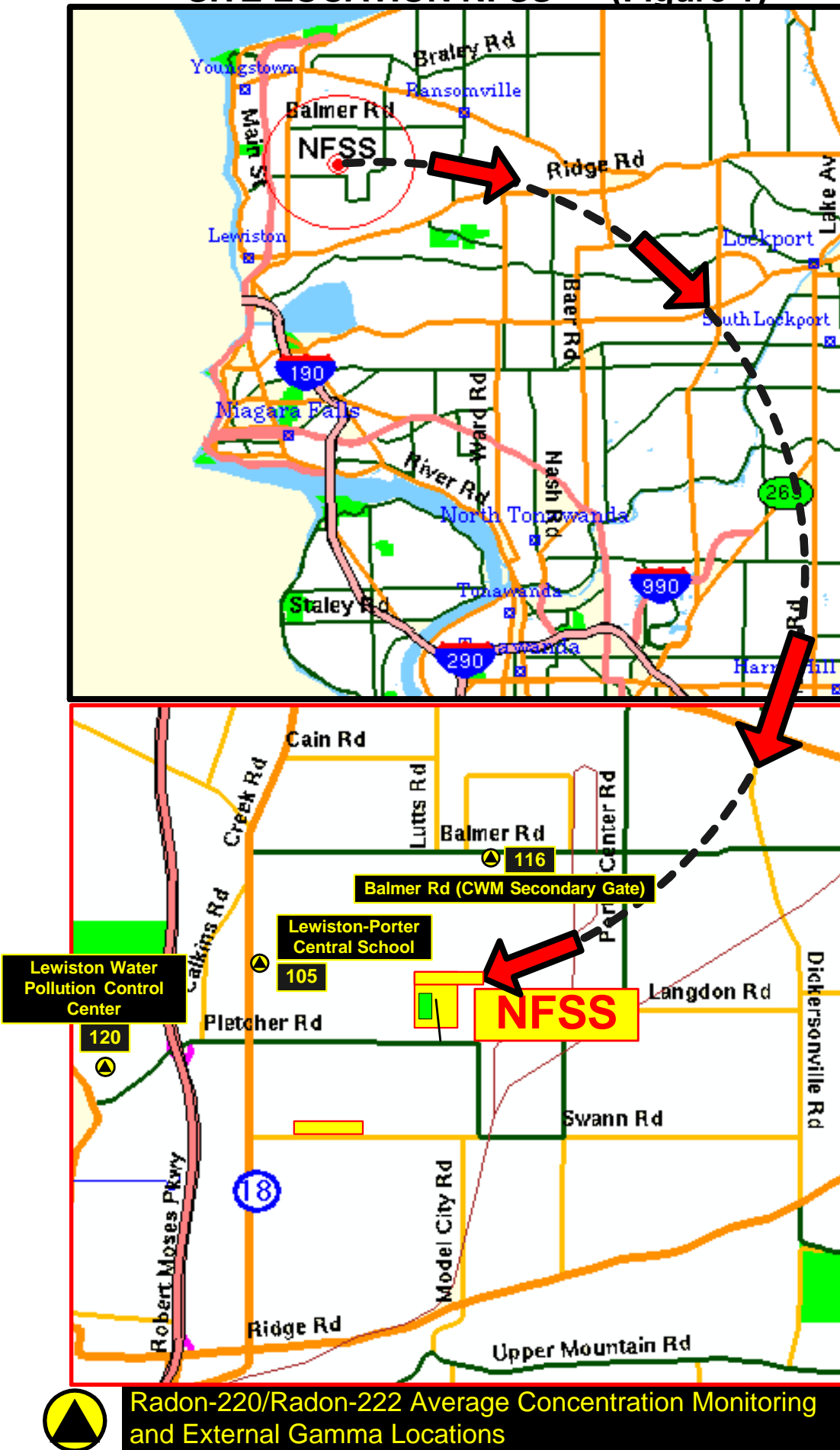
FUSRAP NIAGARA FALLS STORAGE SITE

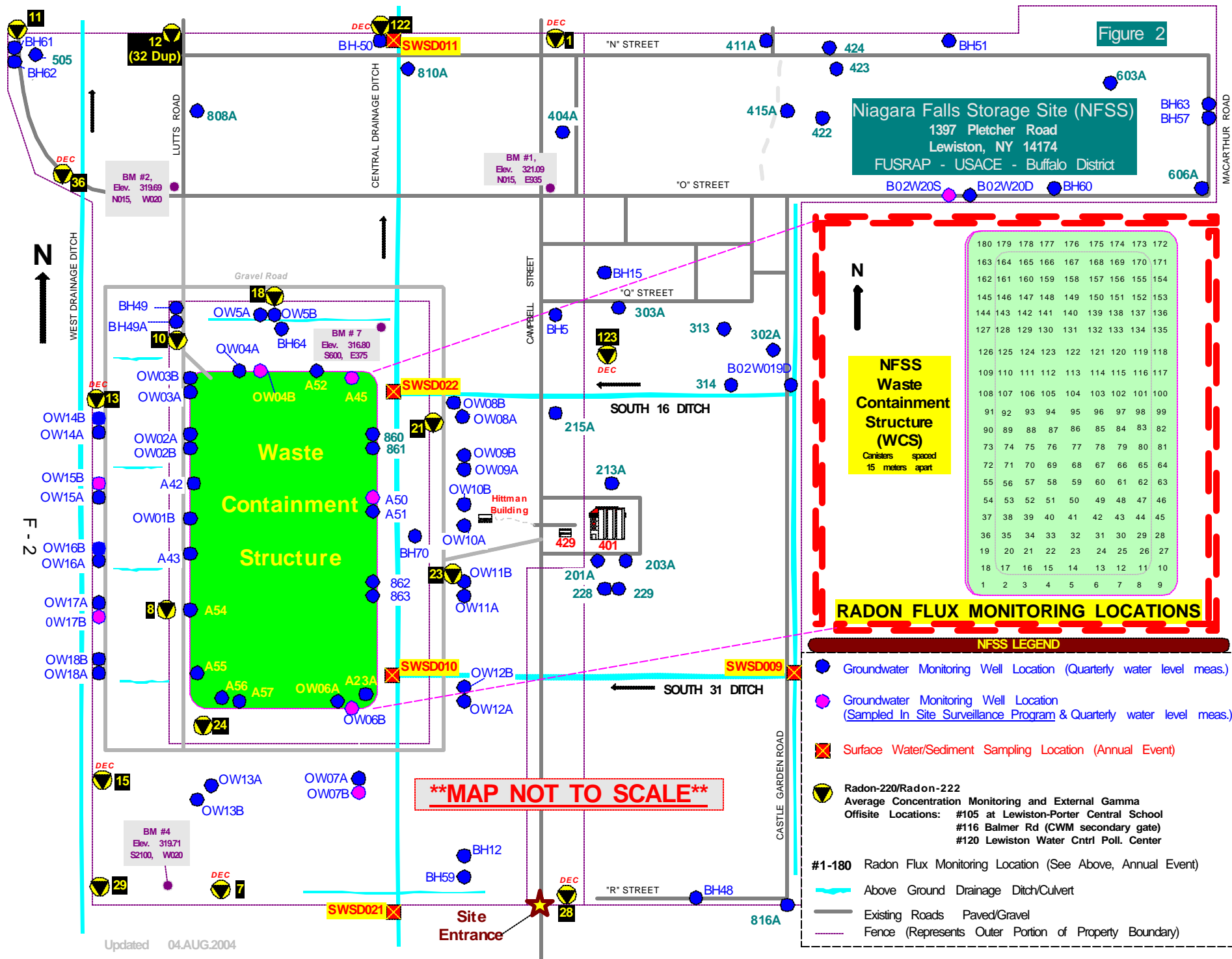
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FIGURES

ENVIRONMENTAL SURVEILLANCE TECHNICAL MEMORANDUM

SITE LOCATION NFSS (Figure 1)





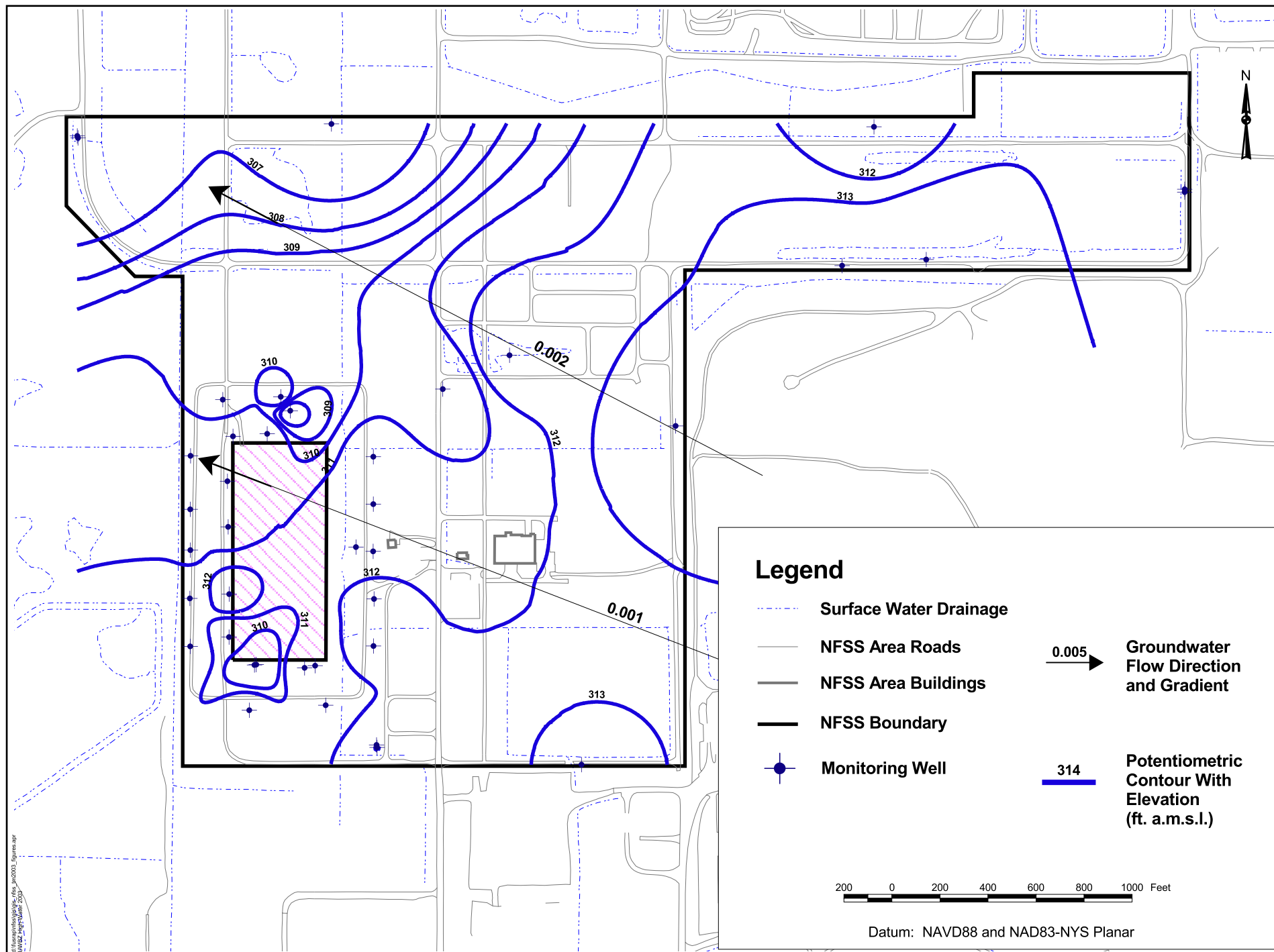


Figure 3
Seasonal High Potentiometric Surface Map (June 23, 2003)
Lower Groundwater System

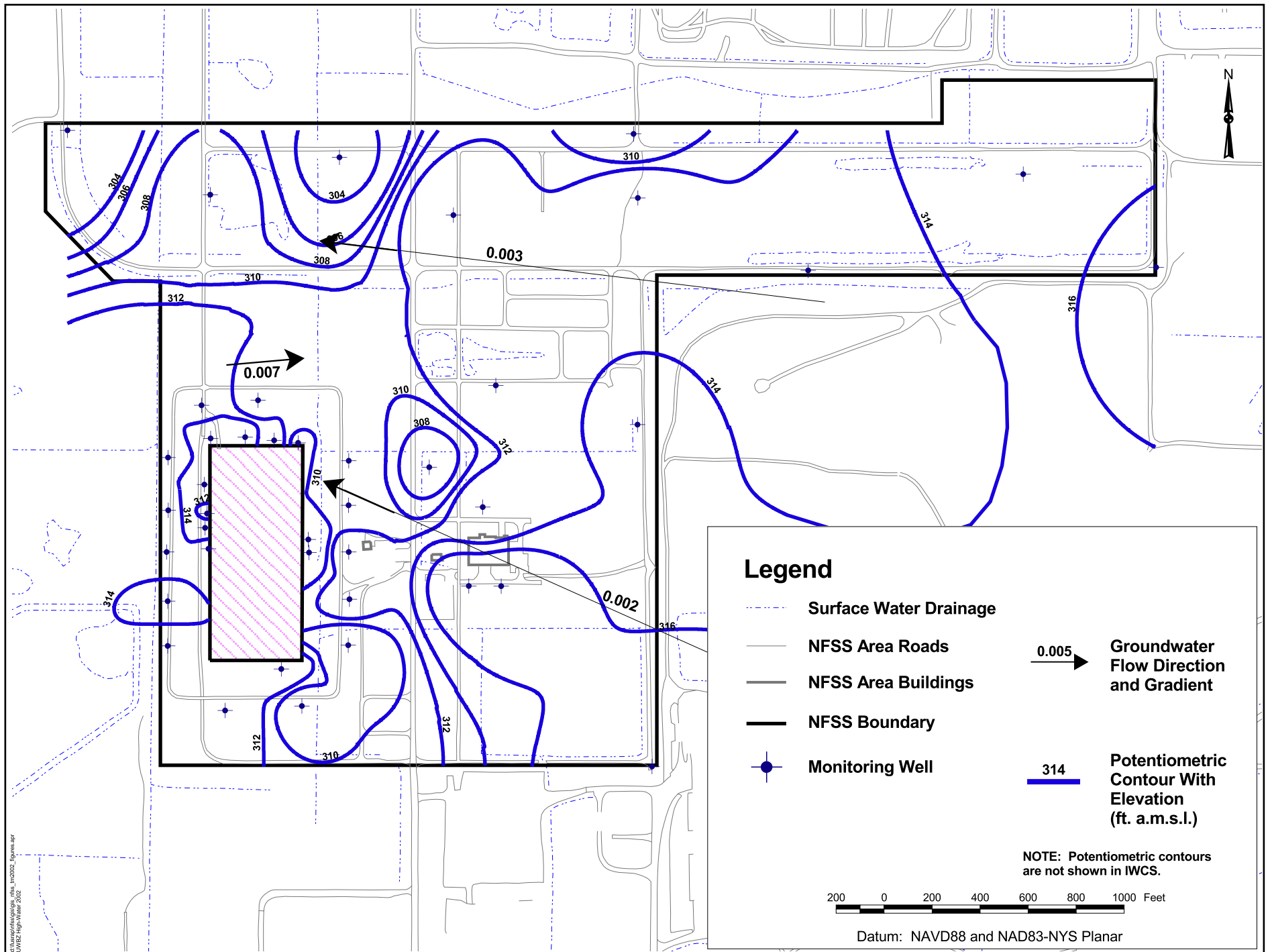


Figure 4
Seasonal High Potentiometric Surface Map (June 23, 2003)
Upper Groundwater System

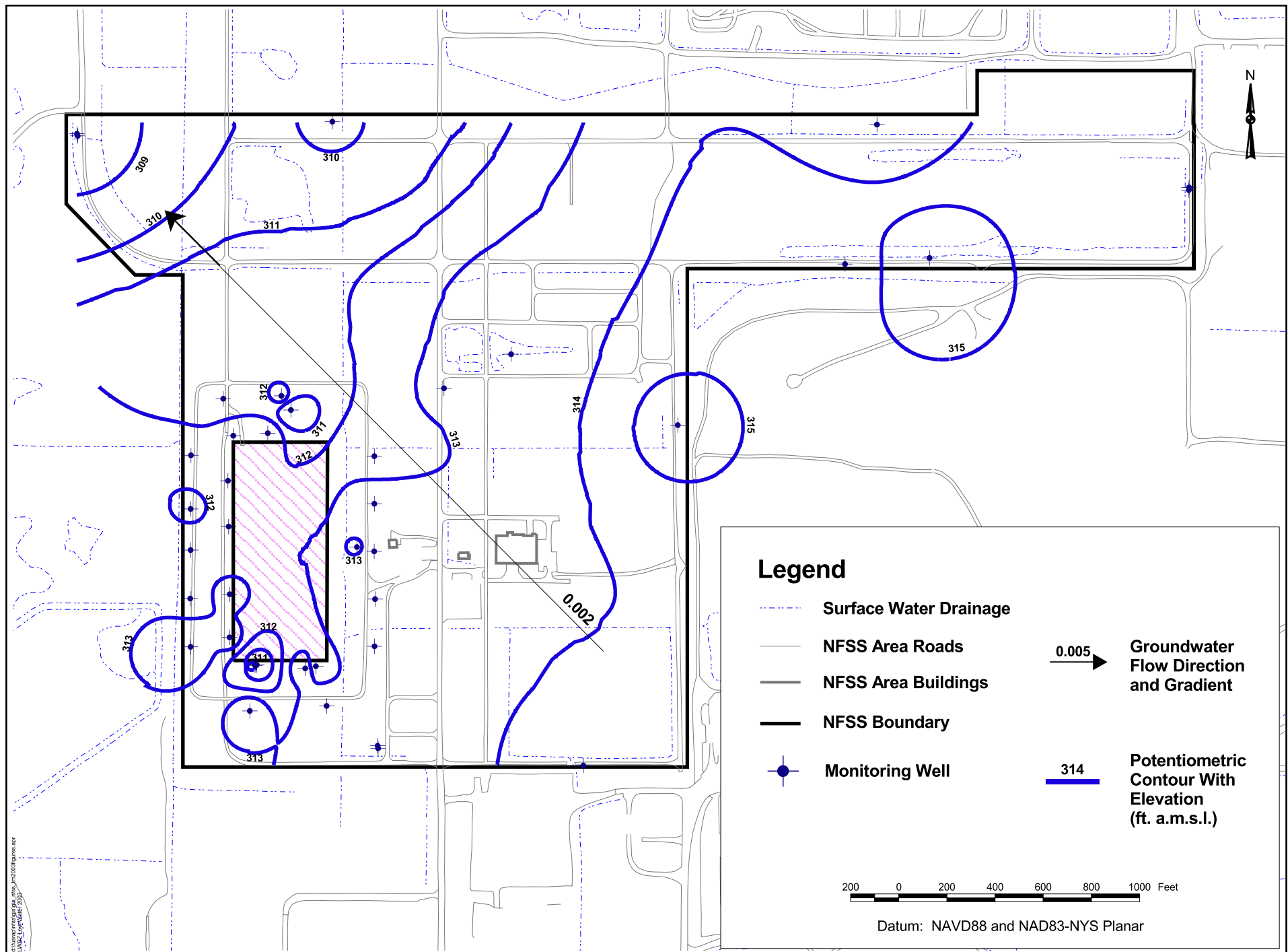


Figure 5
Seasonal Low Potentiometric Surface Map (September 15, 2003)
Lower Groundwater System

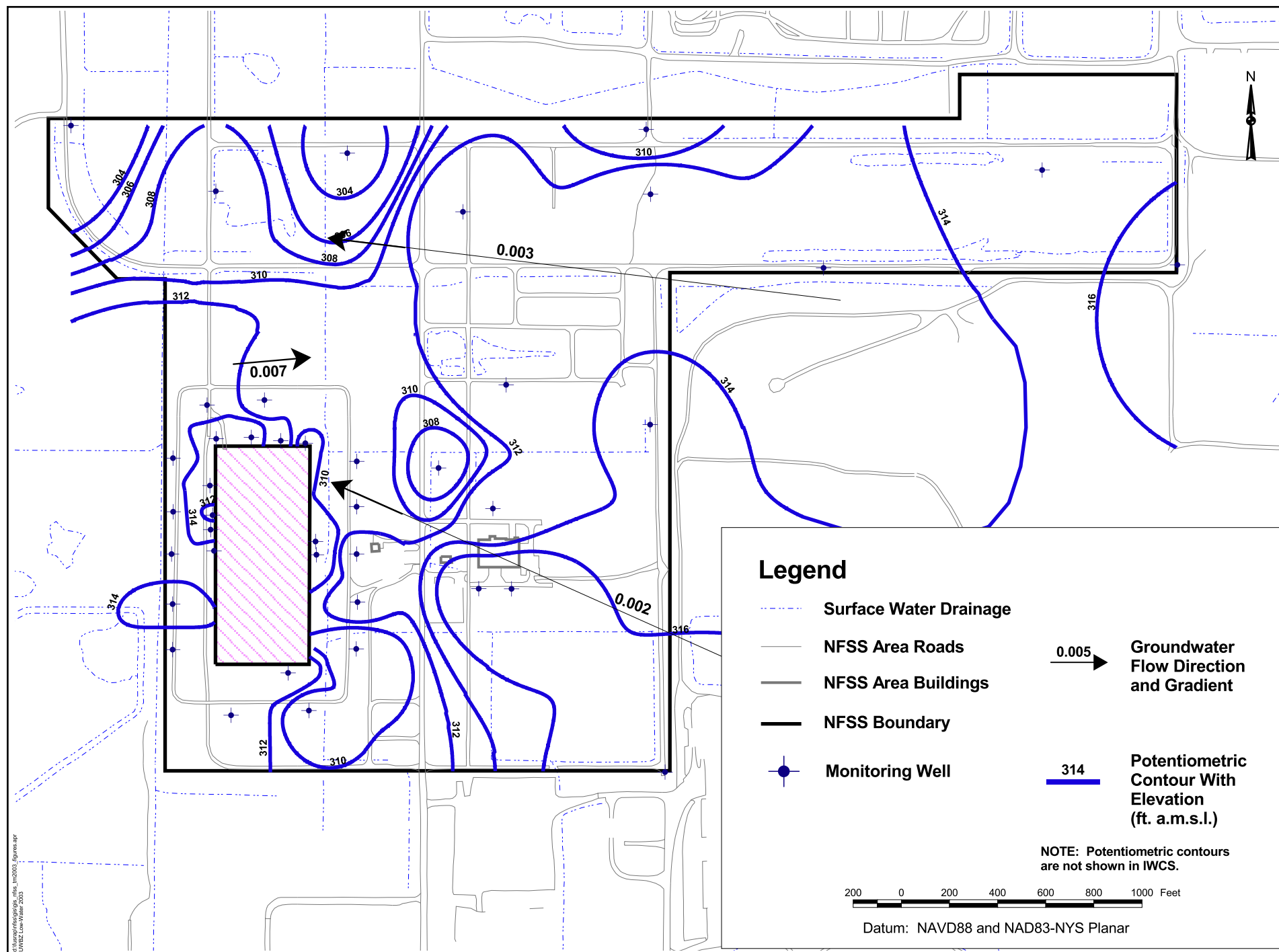
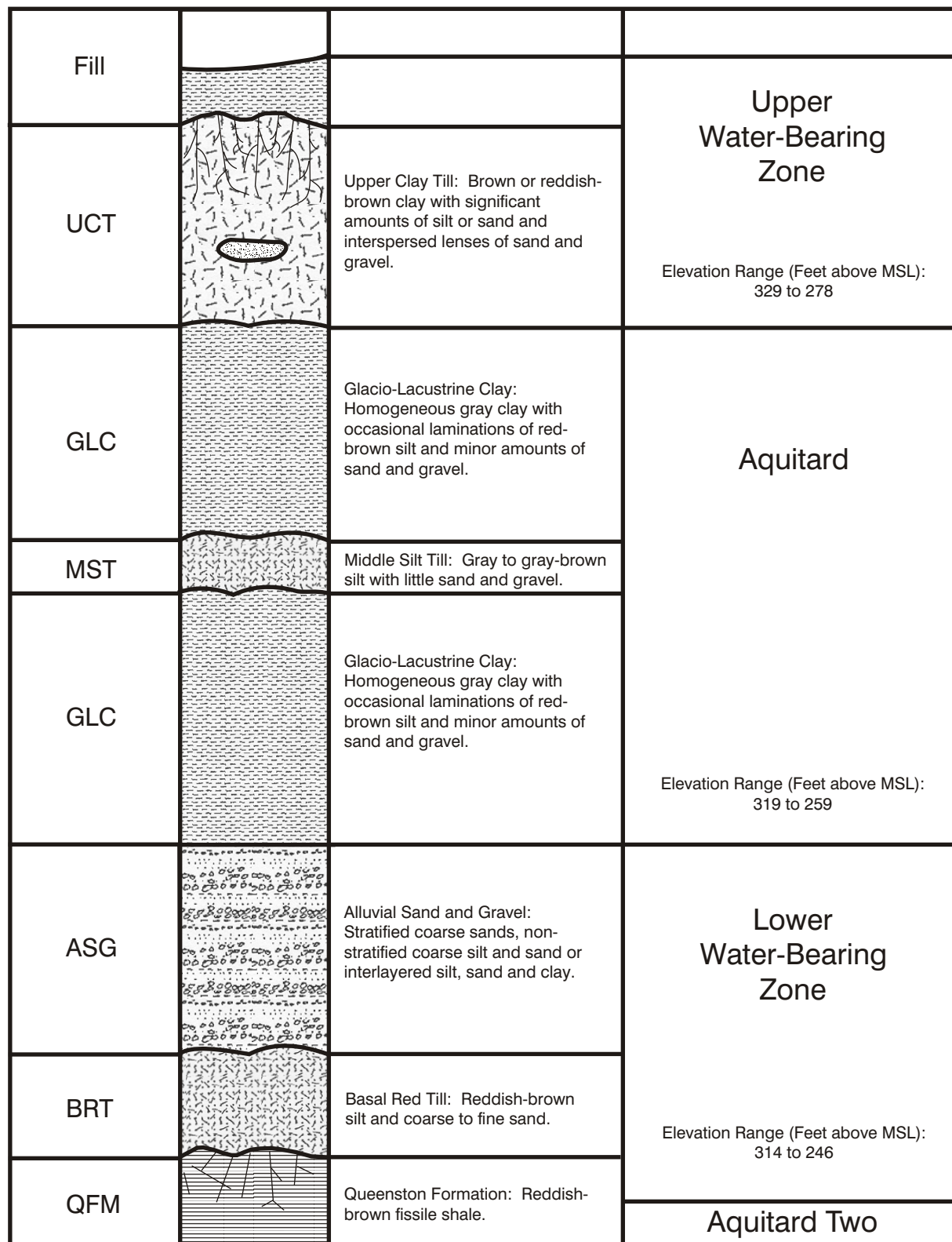


Figure 6
Seasonal Low Potentiometric Surface Map (September 15, 2003)
Upper Groundwater System

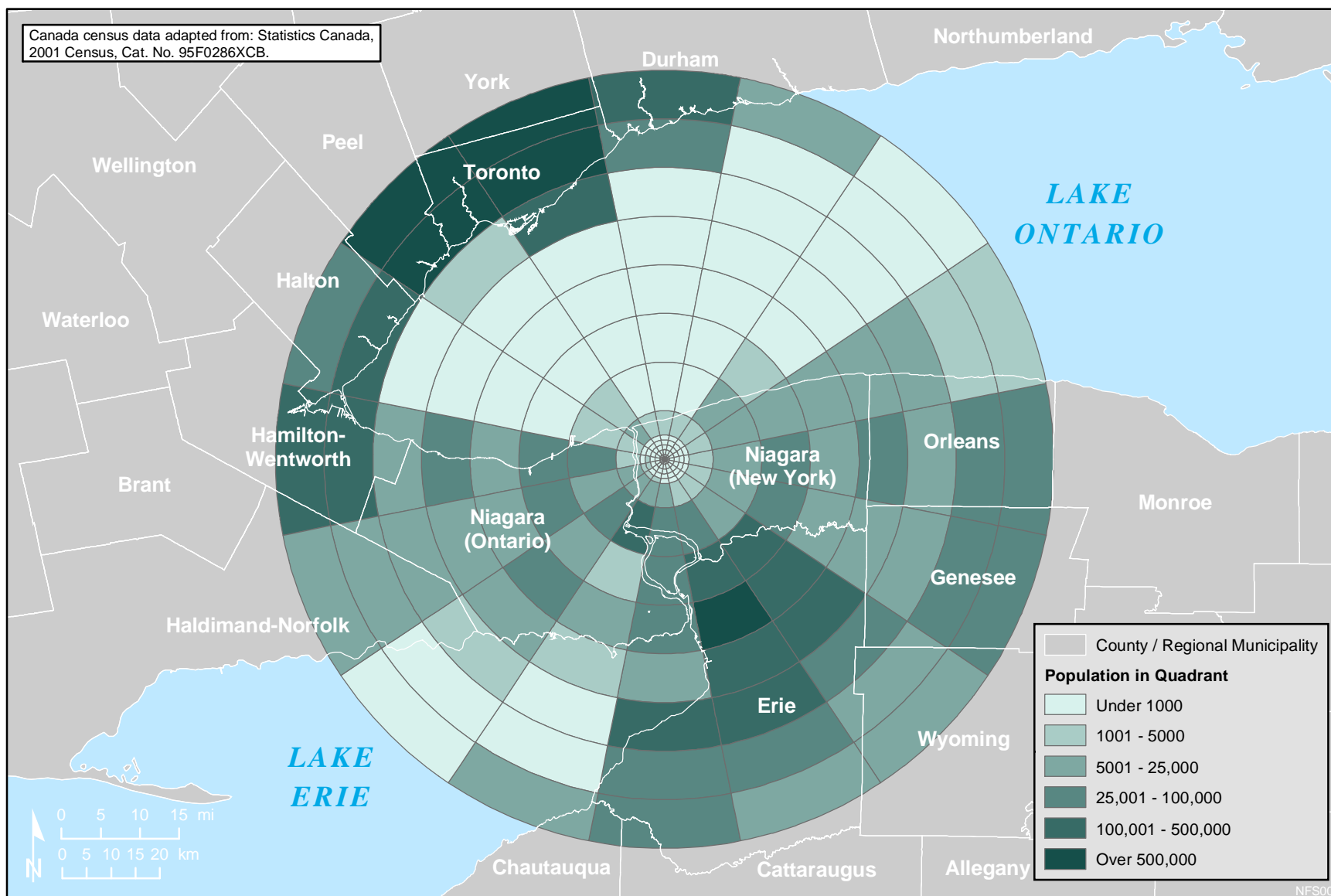


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Revised: 04/17/02 asp
Source: HydroGeoLogic, Inc., 2002



Figure 7
Schematic of Conceptualized
Hydrostratigraphy

Figure 8. 2001 Census Data



APPENDIX B: NFSS CY2003 ENVIRONMENTAL SURVEILLANCE TECHNICAL MEMORANDUM

CY2003 CALCULATION OF EXTERNAL GAMMA RADIATION DOSE RATES FOR NIAGARA FALLS STORAGE SITE (NFSS)

LEWISTON, NEW YORK

APRIL 2004



**U.S. Army Corps of Engineers
Buffalo District Office
Formerly Utilized Sites Remedial Action Program**

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LIST OF ATTACHMENTS

Attachment 1B: CY2003 External Gamma Radiation Dose Rates Niagara Falls Storage Site

1.0 PURPOSE

This calculation estimates the external gamma radiation dose rates at the Niagara Falls Storage Site (NFSS), Lewiston, New York (see Figure 1, Appendix A), during calendar year 2003 (CY2003). Dose rates from external gamma radiation to hypothetical members of the public are calculated from dose measurements taken by thermoluminescent dosimeters (TLDs) located at the perimeter of the NFSS facility and the waste containment structure (WCS) (see Figure 2, Appendix A).

2.0 ASSUMPTIONS

Calculations for the external gamma radiation dose rate to residence-based and off-site worker-based receptors are incorporated using the following assumptions:

- Distance from each TLD above the source (the ground) is 3 feet (ft),
- Distance from the TLDs to the nearest resident is 3,600 ft,
- Distance from the TLDs to the nearest off-site worker is 1,020 ft,
- Length of the western TLD monitoring line (perimeter fence) is 2,766 ft,
- Length of the eastern TLD monitoring line (East of Campbell Street) is 2,700 ft.

3.0 TLD DATA

The TLD measures gamma radiation from gamma-emitting site contaminants and from sources of background radiation. The relevant sources of background radiation can be divided into three categories including cosmic radiation, terrestrial radiation and, to an insignificant extent, man-made sources. NCRP Report 93 states that average levels of cosmic and terrestrial radiation in the United States are 27 millirem per year (mrem/yr) and 28 mrem/yr, respectively. These background doses can be measured by the TLD and are subtracted to estimate the net dose from site-related contaminants, if any.

Gamma radiation was measured at the NFSS during CY2003 using TLDs located at the facility perimeter boundaries and the perimeter of the WCS. The TLDs were placed at the monitoring locations approximately 3 ft [1.6 meters (m)] above the ground surface. The TLDs were collected semi-annually and sent to an off-site vendor for analysis.

Gamma radiation monitoring was performed at NFSS during CY2003 at eleven locations around the perimeter of the site and six locations around the WCS (see Figure 2, Appendix A). In addition to these locations, three background locations (Figure 1, Appendix A) were monitored to compare on-site and background exposures. In January 2003, two environmental TLDs were placed at each monitoring location. The program utilizes two TLDs at each monitoring location (for each monitoring period) to provide additional quality control of monitoring data.

TLD monitoring data for CY2003 are presented in Table 1. The TLD data reported from the vendor for each period are shown as "Gross TLD Data" in Table 1. The gross TLD data were normalized to a daily dose rate for each period, averaged, and then normalized to a one-year exposure. Net monitoring results (average normalized location reading minus average normalized background reading) that are less than zero are retained as negative values for calculational purposes. A more detailed description of CY2003 TLD results is presented in Attachment 1B.

Table 1. External Gamma Radiation at NFSS

Monitoring Location	Monitoring Station	Gross TLD Data ^a (mrem) (First period)	Gross TLD Data ^a (mrem) (Second period)	Normalized Gross TLD Data ^b (mrem/yr)	CY2003 Net TLD Data ^c (mrem/yr)
NFSS Perimeter	1	19.9	22.5	42.6	2.9
	1	21.2	21.3	42.7	2.9
	7	18.4	15.3	33.7	-6.1
	7	15.0	18.8	34.1	-5.7
	11	17.2	17.5	34.8	-4.9
	11	20.0	18.9	39.0	-0.8
	12	18.7	16.7	35.5	-4.3
	12	24.0	19.7	43.7	3.9
	13	27.5	22.0	49.5	9.7
	13	22.2	22.6	45.0	5.2
	15	19.8	18.5	38.4	-1.4
	15	15.0	18.9	34.2	-5.6
	28	23.1	26.7	50.1	10.3
	28	22.1	26.2	48.6	8.8
	29	20.2	21.0	41.4	1.6
	29	23.1	21.9	45.1	5.3
	36	18.7	16.4	35.2	-4.6
	36	20.3	22.5	43.0	3.2
	122	22.1	19.5	41.7	1.9
	122	18.1	20.9	39.2	-0.5
WCS Perimeter	123	19.4	22.3	42.0	2.2
	123	19.6	22.8	42.7	2.9
	8	15.8	22.5	38.7	-1.1
	8	19.8	21.6	41.6	1.8
	10	19.5	21.8	41.5	1.7
	10	13.9	18.1	32.3	-7.5
	18	16.7	18.3	35.2	-4.6
	18	18.3	21.4	40.0	0.2
	21	19.9	25.9	46.2	6.4
	21	18.9	24.4	43.6	3.9
Background	23	24.5	20.2	44.7	4.9
	23	24.9	18.8	43.7	3.9
	24	19.2	25.4	45.0	5.2
	24	17.3	28.0	45.8	6.0
	105	17.1	24.4	41.9	---
	105	19.6	19.7	39.5	---
Background	116	15.5	18.7	34.4	---
	116	14.0	24.5	39.0	---
	120	16.2	22.8	39.4	---
	120	Not found upon retrieval	21.5	44.6	---
Average Background	---	16.5	21.9	39.8	---

^a All data reported from the vendor were gross results in mrem per monitoring period.

^b Gross data for each period are normalized to a daily dose rate, averaged, and then normalized for the length of the year (365 days).

^c Net data are corrected by subtracting the average normalized background value.

4.0 ASSESSMENT METHODOLOGY AND RESULTS

Gamma radiation exposure measured at the perimeter fence line represents doses to a hypothetical receptor that would be at the same locations 24 hours/day, 365 days/year. Off-site dose to the nearest member of the public is significantly affected based on their proximity to the gamma source and amount of time spent at the affected site. A more realistic approach to project dose is to evaluate members of the public as either residence-based or off-site worker-based receptors. A residence-based off-site exposure assumes a 100 percent occupancy rate at a given location. An off-site worker exposure assumes that a worker's occupancy rate is 23 percent, based on an 8 hour/day, 5 day/week, and 50 weeks/year. Thus, a realistic assessment of dose can be performed using conservative assumptions of occupancy rate and distance from the source.

4.1 NEAREST RESIDENT

For the dose calculation to the nearest resident, the line of TLDs along the western perimeter fence is used. The TLDs along this side of the facility include NFSS perimeter fence monitoring locations 11, 13, 15, 29, and 36, and WCS perimeter fence monitoring locations 8 and 10. The two WCS locations are added due to their close proximity to the western NFSS perimeter fence. These TLD locations are shown in Figure 2, Appendix A. Net dose rates (corrected for background) for these TLDs are summed and divided by the total number of observations (14 for CY2003). This value represents the dose at the site perimeter ($D_1 = 0.19$ mrem/yr for CY2003). The site perimeter dose is then used in the following equation for a line source:

$$D_2 = D_1 * h_1/h_2 * (\text{ArcTan}(L/h_2)/\text{ArcTan}(L/h_1))$$

where:

- D_2 = dose calculated at the residence from the line source (the site)
- D_1 = dose at the site perimeter as described above
- h_1 = the distance of the TLDs from the source (3 ft for CY2003)
- h_2 = the distance of the resident from the fence line (3,600 ft for CY2003)
- L = half the length of line of TLDs measuring the line source (1,383 ft for CY2003)

This yields a dose of $3.7\text{E-}05$ mrem/yr at the residence.

4.2 NEAREST OFF-SITE WORKER

For the dose to the nearest off-site worker, the TLDs in a line closest to the eastern perimeter fence (Castle Garden Road) are used. The TLDs used include monitoring locations 1, 28, and 123. These TLDs are located along an interior fence (east of Campbell Street). Their locations are shown in Figure 2, Appendix A. There are no WCS perimeter fence monitoring locations in close proximity to those along the line east of Campbell Street; therefore, none are included in the dose calculations. Net dose rates (corrected for background) for TLD monitoring locations 1, 28, and 123 are summed and divided by the total number observations (6 for CY2003). This represents the dose at the site perimeter ($D_1 = 4.99$ mrem/yr for CY2003).

Using the equation above (with the assumptions given in Attachment 1B) and a correction factor for off-site worker occupancy of 2000 hours/8760 hours, i.e., 23 percent, the dose to the nearest off-site worker is $2.0\text{E-}03$ mrem/yr.

5.0 REFERENCES

Bechtel National, Inc. (BNI), 1997. "1996 Public External Gamma Dose," 14501-158-CV-031, Rev. 0, Oak Ridge, TN.

ATTACHMENT 1B

**CY2003 EXTERNAL GAMMA RADIATION DOSE RATES
NIAGARA FALLS STORAGE SITE**

Attachment 1B
CY2003 External Gamma Radiation Dose Rates – Niagara Falls Storage Site

TLD ^a Dose Rate				
Monitoring Location ^b	Total ^c First ^j (mrem) ^f	Total ^c Second ^k (mrem) ^f	Normalized ^d (mrem/yr) ^g	Above Background ^e (mrem/yr) ^g
NFSS Perimeter				
1	19.9	22.5	42.6	2.9
1	21.2	21.3	42.7	2.9
7	18.4	15.3	33.7	-6.1
7	15.0	18.8	34.1	-5.7
11	17.2	17.5	34.8	-4.9
11	20.0	18.9	39.0	-0.8
12	18.7	16.7	35.5	-4.3
12	24.0	19.7	43.7	3.9
13	27.5	22.0	49.5	9.7
13	22.2	22.6	45.0	5.2
15	19.8	18.5	38.4	-1.4
15	15.0	18.9	34.2	-5.6
28	23.1	26.7	50.1	10.3
28	22.1	26.2	48.6	8.8
29	20.2	21.0	41.4	1.6
29	23.1	21.9	45.1	5.3
36	18.7	16.4	35.2	-4.6
36	20.3	22.5	43.0	3.2
122	22.1	19.5	41.7	1.9
122	18.1	20.9	39.2	-0.5
123	19.4	22.3	42.0	2.2
123	19.6	22.8	42.7	2.9

TLD ^a Dose Rate				
Monitoring Location ^b	Total ^c First (mrem) ^f	Total ^c Second (mrem) ^f	Normalized ^d (mrem/yr) ^g	Above Background ^e (mrem/yr) ^g
WCS ^h Perimeter				
8	15.8	22.5	38.7	-1.1
8	19.8	21.6	41.6	1.8
10	19.5	21.8	41.5	1.7
10	13.9	18.1	32.3	-7.5
18	16.7	18.3	35.2	-4.6
18	18.3	21.4	40.0	0.2
21	19.9	25.9	46.2	6.4
21	18.9	24.4	43.6	3.9
23	24.5	20.2	44.7	4.9
23	24.9	18.8	43.7	3.9
24	19.2	25.4	45.0	5.2
24	17.3	28.0	45.8	6.0
TLD ^a Dose Rate				
Background:				
105	17.1	24.4	41.9	---
105	19.6	19.7	39.5	---
116	15.5	18.7	34.4	---
116	14.0	24.5	39.0	---
120	16.2	22.8	39.4	---
120	N/A ^l	21.5	44.6	---
Average Background	16.5	21.9	39.8	

a. TLD = Thermoluminescent dosimeter. There are two TLDs per monitoring location.

b. Monitoring locations are shown in Figure 2, Appendix A.

c. Reported values are the average reading per TLD. There are two detection units per each device.

d. TLD readings are normalized to a one-year exposure.

Annual exposure = (first TLD reading/exposure duration + second TLD reading/exposure duration)/2 * 365 days per year.

Example for Location 1: (19.9 mrem/188 days + 22.5 mrem/176 days)/2 * 365 days per year = 42.6 mrem/year

e. Average background (normalized) is subtracted from annual exposure. Negative values are retained for calculational purposes.

f. mrem – millirem.

g. mrem/yr – millirem per year.

h. Monitoring locations along the perimeter of the waste containment structure (WCS).

i. The average dose rate was calculated by summing the TLD measurements and dividing by the total number of TLD measurements.

j. First monitoring period.

k. Second monitoring period.

l. Data not found in retrieval.

Nearest Resident Dose Calculations (3,600 feet Southwest of NFSS)

- NFSS Perimeter Monitoring Locations 11, 13, 15, 29, and 36
- WCS Perimeter Monitoring Locations 8 and 10

h1	3 feet	distance of TLD from the source
h2	3,600 feet	distance of resident from the TLDs
L	1,383 feet	half the length of the line source (West perimeter fence)
D1	0.19 mrem/yr	average dose rate at the TLD monitoring locations ⁱ
D2	0.00037 mrem/yr	resident dose rate at 3,600 feet from the TLD

Nearest Off-Site Worker Dose Calculations (150 ft East of Castle Garden Road)

- NFSS Perimeter Monitoring Locations 1, 28, 123
- Off-Site Worker Receives 8-Hour Dose per Day

h1	3 feet	distance of TLD from the source
h2	1,020 feet	distance of off-site worker from the TLDs
L	1,350 feet	half the length of the line source (Campbell Street)
D1	4.99 mrem/yr	average dose rate at the TLD monitoring locations ⁱ
D2	0.0020 mrem/yr	off-site worker dose rate at 1,020 feet from the TLD (8-hour day)

APPENDIX C: NFSS CY2003 ENVIRONMENTAL SURVEILLANCE TECHNICAL MEMORANDUM

FUSRAP CY2003 NESHAP ANNUAL REPORT FOR NIAGARA FALLS STORAGE SITE (NFSS)

LEWISTON, NEW YORK

APRIL 2004



**U.S. Army Corps of Engineers
Buffalo District Office
Formerly Utilized Sites Remedial Action Program**

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Attachment B: Source Term Calculations and Annual Air Releases
Attachment C: CAP88-PC Reports – Individual
Attachment D: CAP88-PC Reports – Population
Attachment E: CY2003 Radon-222 Flux Measurements
Attachment F: National Climatic Data Center, Niagara Falls, New York

ACRONYMS AND ABBREVIATIONS

BNI	Bechtel National, Inc.
°C	degree Celsius
CAP88-PC	Clean Air Act Assessment Package-1988, Version 2.0
cm	centimeter
Ci	curie(s)
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
E_w	annual wind erosion emission
EPA	Environmental Protection Agency
FUSRAP	Formerly Utilized Sites Remedial Action Program
g	gram(s)
ha	hectare(s)
hr	hour(s)
ICRP	International Commission on Radiological Protection
km	kilometer(s)
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MEI	maximally exposed individual
mph	miles per hour
mrem	millirem
NOAA	National Oceanic and Atmospheric Administration
NESHAP	National Emission Standards for Hazardous Air Pollutants
NFSS	Niagara Falls Storage Site
s	second
TLD	thermoluminescent dosimeters
USACE	United States Army Corps of Engineers
WCS	Waste Containment Structure
yr	year(s)

1.0 INTRODUCTION

In 1974, the Atomic Energy Commission, a predecessor to the Department of Energy (DOE), instituted the Formerly Utilized Sites Remedial Action Program (FUSRAP). This program is now managed by United States Army Corps of Engineers (USACE) to identify and clean up, or otherwise control sites where residual radioactivity remains from the early years of the nation's atomic energy program or from commercial operations causing conditions that Congress has authorized USACE to remedy under FUSRAP. The Niagara Falls Storage Site (NFSS) is a federally-owned storage site managed under FUSRAP. In October 1997, Congress transferred the responsibility for FUSRAP from DOE to USACE.

1.1 SITE DESCRIPTION

Niagara Falls Storage Site (NFSS) is located in the Town of Lewiston in northwestern New York State, northeast of Niagara Falls and south of Lake Ontario (Figure 1-Appendix A). NFSS is a 190 acre site which includes: one former process building (Building 401), one office building (Building 429), an equipment shed, and a 9.9 acre waste containment structure (WCS). The property is fenced, and public access is restricted.

Land use in the region is primarily rural; however, the site is bordered by a chemical waste disposal facility (ChemWaste Management Chemical Services, Inc.) on the north, a solid waste disposal facility (Modern Disposal, Inc.) on the east and south, and a Niagara Mohawk Power Corporation right-of-way on the west. The nearest residential areas are approximately 1.1 km southwest of the site; the residences are primarily single-family dwellings.

1.2 SOURCE DESCRIPTION

Beginning in 1944, NFSS was used as a storage facility for low-level radioactive residues and wastes. The residues and wastes are the process by-products of uranium extraction from pitchblende (uranium ore). Waste was also generated from remediation of buildings and process equipment used in the uranium extraction process. The residues originated at other sites and were transferred to NFSS for storage in buildings, on-site pits, and surface piles. Table 1 includes a brief history and description of the major radioactive residues and wastes transferred to NFSS. From 1953 to 1959 and 1965 to 1971, Building 401 was used as a boron-10 isotope separation plant.

Table 1. History and Description of Wastes Transferred to NFSS

Material	Description	Transferred to NFSS
L-50	Low-level, low-activity radioactive residues from the processing of low-grade uranium ores at Linde Air Products, Tonawanda, New York.	1944
R-10	Low-level, low-activity radioactive residues from the processing of low-grade uranium ores at Linde Air Products, Tonawanda, New York.	1944
F-32	Low-level, low-activity radioactive residues from the processing of high-grade uranium ores at Middlesex, New Jersey.	1944 to early 1950
L-30	Low-level, low-activity radioactive residues from the processing of low-grade uranium ores at Linde Air Products, Tonawanda, New York.	1945
K-65	Low-level, high-activity radioactive residues from the processing of low-grade uranium ores at Mallinckrodt Chemical Works, St. Louis, Missouri.	1949
Middlesex Sands	Sand and abraded material from the sandblasting of buildings and process equipment where the F-32 residue was generated at Middlesex Metal Refinement Plant, Middlesex, New Jersey.	1950

Since 1971, activities at NFSS have been confined to residue and waste storage and remediation. All on-site and off-site areas with residual radioactivity exceeding DOE guidelines were remediated between 1955 and 1992. The materials generated during remedial actions (approximately 195,000 m³) are encapsulated in the WCS (See Appendix A, Figure 2), which is specifically designed to provide long-term storage of the materials. Remedial investigation began at the end of 1999 to see if any areas of elevated activity were missed during the DOE cleanup. Initial results show that isolated areas of elevated activity were missed. This investigation is currently ongoing.

2.0 REGULATORY STANDARDS

The Environmental Protection Agency's (EPA) National Emission Standards for Hazardous Air Pollutants (NESHAP) are compliance standards that require annual reporting of emissions of radionuclides and radon gas from operations at nuclear facilities.

2.1 40 CFR 61, SUBPART H

40 CFR 61, Subpart H provides standards for reporting emissions of radionuclides (excluding radon-222 and radon-220) into the air from DOE facilities. Although control and maintenance of the site currently rests with USACE, responsibility for NFSS will return to DOE following completion of remedial actions. Hence, this regulation is felt to provide the most appropriate standards for NFSS. Compliance with Subpart H is verified by applying the EPA approved CAP88-PC version 2.0 (CAP88-PC) model (EPA 1997). 40 CFR 61.92 states that emissions "shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr."

2.2 40 CFR 61, SUBPART Q

40 CFR 61, Subpart Q applies to storage and disposal facilities for radium-containing material that emits radon-222 into air. NFSS is specifically identified as one such facility in this subpart (in 40 CFR 61.190). Compliance with Subpart Q is verified by annual monitoring of the WCS for radon-222 flux. Subpart Q states "no source shall emit more than 20 pCi/m²/s of radon-222."

3.0 AIR EMISSION DATA

Table 2 summarizes the sources of air emissions. Attachment A contains the annual wind erosion emission (E_w) calculation. Attachment B contains the source term calculations and annual air releases.

The area of the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) Class 1 units designated in planning the activities for the Phase II remedial investigation was used to determine the *in situ* emission rates for each radionuclide. The WCS was identified as a Class 1 MARSSIM unit, but was not used in the source term development because it is covered with vegetation and at least 3 to 4 feet of clean clay and topsoil (Attachment B). Although the total area of each Class 1 unit is not contaminated with elevated levels of radionuclides, it was used to provide a conservative estimate for *in situ* emission rates.

Table 2. Air Emission Data - NFSS

Point Sources	Type Control	Efficiency	Distance to Hypothetical Maximally Exposed Individual
none	not applicable	not applicable	not applicable
Non-Point Sources	Type Control	Efficiency	Distance to Hypothetical Maximally Exposed Individual
<i>in situ</i> soil	vegetative cover	75 percent ^a	1,475 m southwest (resident) ^b 275 m east (off-site worker) 3,050 m west-northwest (school) 595 m south (farm)
Group Sources	Type Control	Efficiency	Distance to Hypothetical Maximally Exposed Individual
None	not applicable	not applicable	not applicable

^a This efficiency is the reduction factor used to correct emissions for vegetative cover (Attachment A,B).

^b Distance from center of non-point source to nearest resident and worker were defined previously (BNI 1997).

4.0 DOSE ASSESSMENTS

4.1 MODEL SOURCE DESCRIPTION

To determine the dose from airborne particulates potentially released from NFSS during CY2003, the annual wind erosion emission, E_w (Attachment A) is first calculated using local climatological data (Attachment F) from the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center. The E_w factor combines the frequency at which a defined velocity occurs with the resuspension rate to provide the annual dust lost per unit area. The E_w factor is then applied to the source term and applicable area to calculate annual radionuclide emissions for each radionuclide. The source term was developed from sample data compiled during the CY2000 Phase I remedial investigation for site soil contamination (Attachment B). Contributions from radon gas, per regulatory guidance, are not considered in this calculation. The total annual radionuclide emissions for each radionuclide are then entered into the EPA's CAP88-PC computer model.

The model estimates resultant doses from airborne particulates to hypothetical individuals at the distances to the nearest residence, commercial/industrial facility, school, and farm as measured from a central location on-site. Hypothetical doses are then corrected for residential home and farm occupancy (conservatively assumed to be 24 hr/day, 365 days/yr) and commercial/industrial facility and school occupancy (40 hr/week, 50 weeks/yr). The hypothetical individual receiving the higher of these calculated doses is then identified as the hypothetical maximally exposed individual (MEI) for airborne particulate dose.

4.2 DESCRIPTION OF DOSE MODEL

4.2.1 CAP88-PC Computer Program

The CAP88-PC model is a set of computer programs, databases, and associated utility programs that estimate the dose and risk from airborne radioactivity emissions. The EPA NESHAP compliance procedures for airborne radioactivity emissions at DOE facilities (40 CFR 61.93(a)) require the use of the CAP88-PC model, or other approved procedures to calculate effective dose equivalents to members of the public.

CAP88-PC uses a modified Gaussian plume equation to estimate the average dispersion of radionuclides released from a site. Assessments are performed for a circular grid of distances and directions for a radius of 80 km (50 miles) around the facility. Agricultural arrays of milk cattle, beef cattle and agricultural crop area are generated automatically, requiring the user to supply only the State name or agricultural productivity values. Organs and weighting factors are modified to follow the International Commission on Radiological Protection (ICRP) 26/30 effective dose equivalent calculations. The calculation of deposition velocity and the default scavenging coefficient is also modified to incorporate current EPA policy. The default scavenging coefficient is calculated as a function of annual precipitation. The program calculates the effective dose equivalents by combining the inhalation and ingestion intake rates and the air and ground surface concentrations with dose conversion factors.

4.2.2 CAP88-PC Input

Input parameters for CAPP88-PC include:

- Radionuclide emissions (Attachment B),
- Weather data (average annual temperature, total annual precipitation) (Attachment F),
- Emission source height and area (Section 4.3), and
- Distances to nearest resident, off-site worker, school, and farm (Section 4.3).

4.2.3 CAP88-PC Output

The "Dose and Risk Equivalent Summaries" from CAP88-PC contains the resulting effective dose equivalents for each modeled scenario. The effective dose equivalent summary contains results for the 16 directions around the facility. The effective dose equivalent for the nearest resident, off-site worker, school, and farm is the value for the appropriate distance and direction. CY2003 CAP88-PC individual receptor and population output summaries are located in Attachment C and D, respectively.

4.3 Compliance Assessment

The released activity data from Attachment B is entered into the CAP88-PC modeling program to derive the hypothetical dose to the defined receptors. To derive the dose to the MEI, the CAP88-PC model must have weather data for the appropriate year, information on the emission source, and the distances and directions to the nearest residence, off-site worker, school, and farm. The following CY2003 meteorological data for the Niagara Falls area was entered into CAP88-PC (see Attachment F):

- Average temperature, CY2003 8.06 °C,
- Precipitation, CY2003 81.4 cm, and
- Mixing height, CY2003 1,000 m.

The following emission source and nearest receptor distances and direction information were also entered into the program:

Source height	0 m,
Source area	26,045 m ² ,
Resident	1,475 m (southwest),
Off-site worker	275 m (east),
School	3,050 m (west-northwest), and
Farm	595 m (south).

The CAP88-PC annual hypothetical dose to the nearest resident, off-site worker, school, and farm at the corresponding directions and distances taken from page six of the "Dose and Risk Equivalent Summaries" document for individual modeling (Attachment C) are:

Resident	3.9E-03 mrem/yr,
Off-site worker	7.9E-02 mrem/yr,
School	2.3E-03 mrem/yr, and
Farm	1.4E-02 mrem/yr.

The nearest off-site worker and school doses are corrected to 2,000 hr out of 8,760 possible hours per year. The adjusted hypothetical doses are:

Off-site worker	1.8E-02 mrem/yr and
School	5.2E-04 mrem/yr.

5.0 SUPPLEMENTAL INFORMATION

5.1 POPULATION DOSE

The CAP88-PC model was used to estimate the hypothetical airborne particulate collective dose to the population within 80 km of the site. A population file (generated from census data, see Figure 8-Appendix A, main text) to determine the number of people in circular grid sections fanning out to 80 km from the center of site. The effective dose equivalent for the collective population is the total collective population (person-rem/yr) result from any of the summaries in the "Dose and Risk Equivalent Summaries" report from the population assessment.

The population data for the area around the facility was taken from year 2000 census data for New York State and Ontario, Canada. This population data was entered into a text file that the program could read and incorporate into the model for the population dose.

The CAP88-PC annual effective dose for the population within 80 km of the facility taken from page two of the "Dose and Risk Equivalent Summaries" document for the population modeling run (Attachment D) is:

Population:	1.5E-01 person-rem/yr.
-------------	------------------------

5.2 RADON-222 FLUX

Measurement of radon-222 flux provides an indication of the rate of radon-222 emission from a surface. Radon-222 flux is measured with activated charcoal canisters placed at 15-m intervals across the surface of the WCS for a 24-hr exposure period. Measurements for CY2003 are presented in Attachment E; measurement locations are shown in Appendix A, Figure 2.

Measured results for CY2003 ranged from -0.046 to 1.419 pCi/m²/s, with an average value of 0.080 pCi/m²/s. As in previous years, these results are well below the 20 pCi/m²/s standard specified in 40 CFR Part 61, Subpart Q, and demonstrate the effectiveness of the containment cell design and construction in mitigating radon-222 migration.

5.3 NON-APPLICABILITY

Requirements from section 61.93(b) of 40 CFR for continuous monitoring from point sources (stacks or vents) are not applicable to NFSS.

6.0 REFERENCES

ANL 2003. CAP88-PC Population Files for NFSS, Argonne National Laboratory, Chicago, Illinois.

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EPA 1997. CAP88PC Version 2.0 Computer Code, U.S. Environmental Protection Agency.

NRC 1987. Regulatory Guide 3.59, *Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations*, U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, March.

40 CFR 61, Subpart H. *National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities.*

40 CFR 61, Subpart Q. *National Emission Standards for Radon Emissions From Department of Energy Facilities.*

ATTACHMENT A

ANNUAL WIND EROSION EMISSION CALCULATION

A.1 CALCULATED *IN SITU* WINDBLOWN PARTICLE EMISSIONS

The windblown particle emissions for the NFSS is based on local climatological data collected from the Niagara Falls International Airport in CY2003 by the NOAA, National Climatic Data Center (Appendix F).

Wind speed frequency data was obtained from the CY2003 average daily wind velocity (see Table A-1).

Table A-1. Niagara Falls Storage Site Wind Speed Frequency

Wind Speed Group, knots*	Frequency
0 – 3	0.18
4 – 6	0.17
7 – 10	0.24
11 – 16	0.31
17 – 21	0.06
21+	0.03

*knot = 1.151 mph

Wind direction frequency was obtained from the CAP-88 wind file, IAG0905.WND (see Table A-2).

Table A-2. Niagara Falls Storage Site Wind Rose Frequency

Wind Direction		Wind Frequency	Wind Direction		Wind Frequency
Towards	From		Towards	From	
N	S	0.062	S	N	0.049
NNW	SSE	0.020	SSE	NNW	0.050
NW	SE	0.029	SE	NW	0.077
WNW	ESE	0.032	ESE	WNW	0.077
W	E	0.063	E	W	0.087
WSW	ENE	0.043	ENE	WSW	0.100
SW	NE	0.045	NE	SW	0.141
SSW	NNE	0.032	NNE	SSW	0.092

Windblown particle emissions per unit area are estimated using Equation 2 from NRC 1987. The equation is:

$$E_w = \frac{3.156E7}{0.5} \times \sum R_s F_s$$

where:

- E_w = annual dust loss per unit area ($\text{g/m}^2\text{yr}$),
- F_s = annual average wind speed frequency for Niagara Falls (Table A-1),
- R_s = resuspension rate at the average wind speed for particles $<20 \mu\text{m}$

3.156E07 = (g/m²s), reported in Table A-3, from NRC 1987,
0.5 = number of seconds per year, and
= fraction of dust loss by particles <20 µm.

Table A-3. *In situ* Windblown Dust Emission Calculation

Wind Speed Group, knots	Frequency F_s	Resuspension Rate R_s (g/m ² s)	Product $R_s F_s$
0 – 3	0.18	0	0
4 – 6	0.17	0	0
7 – 10	0.24	3.92E-07	9.22E-08
11 – 16	0.31	9.68E-06	3.02E-06
17 – 21	0.06	5.71E-05	3.65E-06
21+	0.03	2.08E-04	6.15E-06
	$\Sigma = 1.00$		$\Sigma = 1.29E-05$

The annual dust loss per unit area is calculated to be **815 g/m²yr**.

The total annual wind blown *in situ* emission rate, by radionuclide, is calculated using Equation 3 from NRC 1987.

$$S_{Ci/yr} = E_w \times A \times C_{pCi/g} \times \frac{Ci}{10^{12} pCi} \times (1 - RF)$$

where:

E_w = annual dust loss per unit area (= 815 g/m²y),
A = surface area (= 26,045 m²),
C = soil concentration (Tables B-3 through B-5, Appendix B), and
RF = unitless factor for effective reduction in emission for vegetative cover from NRC 1987 (= 0.75)

Wind blown *in situ* emission rates for each radionuclide are calculated and illustrated in Appendix B.

A.2 REFERENCES

NRC 1987. Regulatory Guide 3.59, *Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations*, U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, March 1987.

ATTACHMENT B

SOURCE TERM CALCULATIONS AND ANNUAL AIR RELEASES

B.1 SOURCE TERM DEVELOPMENT

The source term for NFSS NESHAPS calculations was developed considering the radionuclides in the uranium, thorium, and actinium decay series as shown in Table B-1. Concentration data for these radioisotopes were taken from the 2000 Phase I remedial investigation and is listed in Table B-2. The same data set was used in 2002. Phase I sampling performed at the end of 1999 and beginning of 2000 focused on identifying areas with elevated activity in surface soil, if any, and would still be conservative, but would be more realistic than using the historical data set.

The WCS, completed in 1986 and added to in 1991, is surrounded by sufficient topsoil and compacted clay to consider radionuclide emissions negligible. In 1986, the entire WCS was covered with 3 feet of low-permeability, compacted clay, a 12 inch-thick layer of loosely compacted soil, 6 inches of topsoil and covered with shallow-rooted grass. A clay cutoff wall and dike measuring 11 to 29 feet in thickness formed the perimeter. In 1991, additional soil with residual radioactivity from a vicinity property, along with 60 drums containing radioactive material, were placed over the existing WCS. Six inches of clay was placed over the waste material and two feet of compacted clay was added on top along with 1.5 feet of topsoil material.

Radium-226 was detected at an elevated concentration of 1,140 pCi/g in one area during the Phase I remedial investigation. This was analyzed and determined to come from a stone in the sample. Since release rates are based on dust erosion and not buried stones, this detection was not used in the source term calculation.

The area over which the annual dust loss was applied included all areas receiving a Class 1 designation (designated as part of the planning of the Phase II RI, are strictly for planning purposes) as part of the current remedial investigation. This is a conservative assumption since many of the Class 1 areas reported elevated radionuclide concentrations over only a portion of the defined area.

Concentration data are not available for all the radionuclides in Table B-1. If explicit results for a radionuclide were not available, it was assumed that the radionuclide was present in equilibrium with (i.e., at the same concentration as) the nearest long-lived parent. Branching ratios were also used, as appropriate, to more accurately estimate source term concentrations. Tables B-3 through B-5 list source term values used in the CAP-88PC modeled scenarios.

Table B-1. Radionuclides Considered in NESHAPS Evaluation

Uranium Series	Thorium Series	Actinium Series
U-238	Th-232	U-235
Th-234	Ra-228	Th-231
Pa-234m	Ac-228	Pa-231
Pa-234 (0.13%)	Th-228	Ac-227
U-234	Ra-224	Th-227 (98.62%)
Th-230	*Rn-220 (thoron)	Fr-223 (1.38%)
Ra-226	Po-216	Ra-223
*Rn-222 (radon)	Pb-212	*Rn-219 (actinon)
Po-218	Bi-212	Po-215
Pb-214 (99.98%)	Po-212 (64.07%)	Pb-211 ($\approx 100\%$)
*At-218 (0.02%)	Tl-208 (35.93%)	*At-215 (0.00023%)
Bi-214	*Pb-208 (stable)	Bi-211
Po-214 (99.979%)		Po-211 (0.273%)
*Tl-210 (0.021%)		Tl-207 (99.73%)
Pb-210		*Pb-207 (stable)
Bi-210		
Po-210 ($\approx 100\%$)		
*Tl-206 (0.00013%)		
*Pb-206 (stable)		
Nuclides with asterisks (*) were excluded from dose calculations for the following reasons: 1) Radon isotopes including thoron and actinon are specifically excluded per the regulation, 2) nuclides of insignificant abundance, and 3) stable nuclides do not contribute to radiological dose.		
Nuclides are presented from top to bottom in order of decay starting from the parent radionuclides. Branching fractions are shown, as appropriate, for consideration in source term development. Fractions taken from (Shleien, 1992).		

Table B-2. Summary of CY2000 Phase I Characterization Data Used in NESHAP Dose Calculations

Analyte	Units	Results > Detection Limit	Minimum Detect	Maximum Detect	Average Result	95% UCL of the Mean	Exposure Concentration
Radium-226 ^a	(pCi/g)	198/ 202	0	1140	7.11	16.4	16.4
Radium-226 ^b	(pCi/g)	197/ 201	0	16	1.48	1.67	1.67
Thorium-228	(pCi/g)	201/ 201	0	24	1.24	1.5	1.5
Thorium-230	(pCi/g)	200/ 201	0	16	1.74	1.99	1.99
Thorium-232	(pCi/g)	195/ 196	0	21	1.17	1.39	1.39
Uranium-234	(pCi/g)	176/ 176	0	119	1.88	2.99	2.99
Uranium-235	(pCi/g)	33/ 112	0	6	0.0536	0.142	0.142
Uranium-238	(pCi/g)	176/ 176	0	120	1.9	3.02	3.02

^a Including 1,140 pCi/g outlier NiagAir1 on 25JUL00 at 15:36 using dataset allradnq

^b Excluding 1,140 pCi/g outlier NiagAir1 on 26JUL00 at 08:00 using dataset allradnq

Except where noted, all values generated by program NiagAir1 and NiagAir2 using dataset allradnq. Values used in the uranium series source term estimate bolded for ease of reference.

Table B-3. Uranium Series Release Estimates

Analyte	(C _m) Measured Activity (pCi/g)	(F) Activity Fraction ^a	(C) Source Unit Activity (pCi/g) ^b	(S) Released Activity (Ci/yr) ^c
U-238	3.02	1.0	3.02	1.60E-05
Th-234	3.02	1.0	3.02	1.60E-05
Pa-234m	3.02	1.0	3.02	1.60E-05
Pa-234	3.02	1.3E-03	3.93E-03	2.08E-08
U-234	2.99	1.0	2.99	1.59E-05
Th-230	1.99	1.0	1.99	1.06E-05
Ra-226	1.67	1.0	1.67	8.86E-06
Rn-222 (radon)	1.67	0	0	0.00E+00
Po-218	1.67	1.0	1.67	8.86E-06
Pb-214	1.67	1.0	1.67	8.86E-06
At-218	1.67	2.0E-04	3.34E-04	1.77E-09
Bi-214	1.67	1.0	1.67	8.86E-06
Po-214	1.67	1.0	1.67	8.86E-06
Tl-210	1.67	2.1E-04	3.51E-04	1.86E-09
Pb-210	1.67	1.0	1.67	8.86E-06
Bi-210	1.67	1.0	1.67	8.86E-06
Po-210	1.67	1.0	1.67	8.86E-06
Tl-206	1.67	0	0	0.00E+00
Pb-206 (stable)	1.67	0	0	0.00E+00

Erosion Rate (E_w)^d 815 grams/m²year

Area (A) 26,045 m²

Constant (Fc) 1.00E-12 Ci/pCi

Reduction (RF)^e 0.75 unitless

^a F = 0.0 for radon and stable isotopes, and isotopes with activity fractions << 0.01. F applied to nearest long-lived isotope with measured result.

^b C = C_m x F

^c S = E_w x A x C x Fc x (1 - RF)

^d From Appendix A

^e Reduction factor for vegetative cover from NRC 1987

Table B-4. Thorium Series Release Estimates

Analyte	(C _m) Measured Activity (pCi/g)	(F) Activity Fraction ^a	(C) Source Unit Activity (pCi/g) ^b	(S) Released Activity (Ci/yr) ^c
Th-232	1.39	1.0	1.39	7.38E-06
Ra-228	1.39	1.0	1.39	7.38E-06
Ac-228	1.39	1.0	1.39	7.38E-06
Th-228	1.50	1.0	1.50	7.96E-06
Ra-224	1.50	1.0	1.50	7.96E-06
Rn-220 (thoron)	1.50	0	0	0.00E+00
Po-216	1.50	1.0	1.50	7.96E-06
Pb-212	1.50	1.0	1.50	7.96E-06
Bi-212	1.50	1.0	1.50	7.96E-06
Po-212	1.50	0.67	1.01	5.33E-06
Tl-208	1.50	0.36	0.539	2.87E-06
Pb-208 (stable)	1.50	0	0	0.00E+00

Erosion Rate (E_w)^d 815 grams/m²/year

Area (A) 26,045 m²

Constant (Fc) 1.00E-12 Ci/pCi

Reduction (RF)^e 0.75 unitless

^a F = 0.0 for radon and stable isotopes, and isotopes with activity fractions << 0.01. F applied to nearest long-lived isotope with measured result.

^b C = C_m x F

^c S = E_w x A x C x Fc x (1-RF)

^d From Appendix A

^e Reduction factor for vegetative cover from NRC 1987

Table B-5. Actinium Series Release Estimates

Analyte	(C _m) Measured Activity (pCi/g)	(F) Activity Fraction ^a	(C) Source Unit Activity (pCi/g) ^b	(S) Released Activity (Ci/yr) ^c
U-235	0.142	1.0	0.142	7.54E-07
Th-231	0.142	1.0	0.142	7.54E-07
Pa-231	0.142	1.0	0.142	7.54E-07
Ac-227	0.142	1.0	0.142	7.54E-07
Th-227	0.142	0.99	0.140	7.46E-07
Fr-223	0.142	0.014	1.96E-03	1.06E-08
Ra-223	0.142	1.0	0.142	7.54E-07
Rn-219 (actinon)	0.142	0	0	0.00E+00
Po-215	0.142	1.0	0.142	7.54E-07
Pb-211	0.142	1.0	0.142	7.54E-07
At-215	0.142	0	0	0.00E+00
Bi-211	0.142	1.0	0.142	7.54E-07
Po-211	0.142	2.7E-03	3.88E-04	2.03E-09
Tl-207	0.142	1.0	0.142	7.54E-07
Pb-207 (stable)	0.142	0	0	0.00E+00

Erosion Rate (E_w)^d 815 grams/m²/year

Area (A) 26,045 m²

Constant (Fc) 1.00E-12 Ci/pCi

Reduction (RF)^e 0.75 unitless

^a F = 0.0 for radon and stable isotopes, and isotopes with activity fractions << 0.01. F applied to nearest long-lived isotope with measured result.

^b C = C_m x F

^c S = E_w x A x C x Fc x (1 - RF)

^d From Appendix A

^e Reduction factor for vegetative cover from NRC 1987

B.2 REFERENCES

Shleien, 1992. *The Health Physics and Radiological Health Handbook*, Scinta, Inc., Silver Spring, MD.

NRC 1987. Regulatory Guide 3.59, *Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations*, U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, March.

ATTACHMENT C

CAPP88-PC REPORTS – INDIVIDUAL

Nfss03in

C A P 8 8 - P C

Version 2.00

Clean Air Act Assessment Package - 1988

D O S E A N D R I S K E Q U I V A L E N T S U M M A R I E S

Non-Radon Individual Assessment
May 11, 2004 10:50 am

Facility: Niagara Falls Storage Site
Address: 1397 Pletcher Road
City: Lewiston
State: NY Zip: 14174

Source Category: Area
Source Type: Area
Emission Year: 2003

Comments: NFSS 2003 Individual

Dataset Name: NFSS 2003 Ind
Dataset Date: May 11, 2004 10:50 am
Wind File: C:\CAP88PC2\WINDFILES\IAG0905.WND

May 11, 2004 10:50 am

SUMMARY
Page 1

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
GONADS	9.38E-04
BREAST	6.71E-04
R MAR	4.50E-02
LUNGS	6.38E-01
THYROID	6.42E-04
ENDOST	5.63E-01
RMNDR	6.36E-03
EFFEC	1.01E-01

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Selected

Page 1

Pathway	Nfss03i n Indi vi dual (mrem/y)
INGESTION	2. 27E- 03
INHALATION	9. 88E- 02
AIR IMMERSION	1. 61E- 07
GROUND SURFACE	3. 40E- 05
INTERNAL	1. 01E- 01
EXTERNAL	3. 41E- 05
TOTAL	1. 01E- 01

May 11, 2004 10:50 am

SUMMARY
Page 2

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nucl i de	Selected Indi vi dual (mrem/y)
U- 238	1. 50E- 02
TH- 234	6. 23E- 06
PA- 234M	5. 47E- 10
U- 234	1. 67E- 02
TH- 230	2. 09E- 02
RA- 226	8. 28E- 04
PO- 218	2. 41E- 09
PB- 214	7. 33E- 08
BI- 214	9. 27E- 08
PO- 214	0. 00E+00
PB- 210	1. 82E- 03
BI- 210	1. 36E- 05
PO- 210	8. 45E- 04
TH- 232	2. 10E- 02
RA- 228	2. 29E- 04
AC- 228	5. 04E- 06
TH- 228	1. 59E- 02
RA- 224	2. 21E- 04
PO- 216	0. 00E+00
PB- 212	1. 06E- 05
BI- 212	2. 10E- 06
TL- 208	3. 57E- 08
U- 235	7. 50E- 04
TH- 231	5. 99E- 09
PA- 231	2. 92E- 03
AC- 227	3. 83E- 03
FR- 223	2. 16E- 10
RA- 223	5. 12E- 05
PO- 215	0. 00E+00
PB- 211	5. 49E- 08
BI- 211	3. 70E- 09
PO- 211	0. 00E+00
TL- 207	4. 34E- 11
PA- 234	5. 13E- 10
PO- 212	0. 00E+00
TH- 227	6. 91E- 05
TOTAL	1. 01E- 01

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
LEUKEMIA	3.93E-08
BONE	2.57E-08
THYROID	1.13E-10
BREAST	1.04E-09
LUNG	1.06E-06
STOMACH	7.64E-10
BOWEL	6.52E-10
LIVER	1.36E-08
PANCREAS	5.49E-10
URINARY	4.43E-09
OTHER	6.72E-10
TOTAL	1.14E-06

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	1.32E-08
INHALATION	1.13E-06
AIR IMMERSION	3.88E-12
GROUND SURFACE	7.79E-10
INTERNAL	1.14E-06
EXTERNAL	7.82E-10
TOTAL	1.14E-06

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
U-238	1.99E-07
TH-234	2.81E-10
PA-234M	1.39E-14
U-234	2.20E-07
TH-230	1.73E-07
RA-226	1.50E-08

	Nfss03i n
PO- 218	1. 71E- 12
PB- 214	1. 25E- 11
BI - 214	1. 07E- 11
PO- 214	0. 00E+00
PB- 210	1. 30E- 08
BI - 210	3. 67E- 10
PO- 210	1. 30E- 08
TH- 232	1. 19E- 07
RA- 228	2. 99E- 09
AC- 228	1. 02E- 10
TH- 228	3. 19E- 07
RA- 224	5. 01E- 09
PO- 216	0. 00E+00
PB- 212	1. 81E- 10
BI - 212	2. 70E- 11
TL- 208	8. 74E- 13
U- 235	1. 01E- 08
TH- 231	1. 75E- 13
PA- 231	1. 63E- 08
AC- 227	3. 32E- 08
FR- 223	2. 28E- 15
RA- 223	1. 24E- 09
PO- 215	0. 00E+00
PB- 211	1. 06E- 12
BI - 211	4. 39E- 14
PO- 211	0. 00E+00
TL- 207	1. 42E- 15
PA- 234	1. 32E- 14
PO- 212	0. 00E+00
TH- 227	1. 90E- 09
TOTAL	1. 14E- 06

May 11, 2004 10: 50 am

SUMMARY
Page 5

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

Direction	Distance (m)			
	275	595	1475	3050
N	6. 2E- 02	1. 7E- 02	4. 7E- 03	2. 5E- 03
NNW	3. 3E- 02	6. 4E- 03	2. 6E- 03	1. 9E- 03
NW	3. 8E- 02	1. 0E- 02	3. 3E- 03	2. 1E- 03
WNW	5. 5E- 02	1. 3E- 02	3. 8E- 03	2. 3E- 03
W	7. 5E- 02	2. 1E- 02	5. 4E- 03	2. 7E- 03
WSW	5. 7E- 02	1. 3E- 02	3. 9E- 03	2. 3E- 03
SW	4. 8E- 02	1. 3E- 02	3. 9E- 03	2. 3E- 03
SSW	4. 0E- 02	9. 1E- 03	3. 1E- 03	2. 1E- 03
S	5. 1E- 02	1. 4E- 02	4. 0E- 03	2. 3E- 03
SSE	5. 4E- 02	1. 2E- 02	3. 7E- 03	2. 2E- 03
SE	7. 0E- 02	1. 9E- 02	5. 0E- 03	2. 6E- 03
ESE	7. 2E- 02	1. 7E- 02	4. 7E- 03	2. 5E- 03
E	7. 9E- 02	2. 0E- 02	5. 3E- 03	2. 7E- 03
ENE	8. 4E- 02	1. 9E- 02	5. 1E- 03	2. 6E- 03
NE	1. 0E- 01	2. 8E- 02	6. 7E- 03	3. 1E- 03
NNE	8. 0E- 02	1. 9E- 02	5. 0E- 03	2. 6E- 03

May 11, 2004 10:50 am

SUMMARY
Page 6INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

Direction	Distance (m)			
	275	595	1475	3050
N	7.0E-07	1.9E-07	4.4E-08	2.0E-08
NNW	3.7E-07	6.4E-08	2.0E-08	1.3E-08
NW	4.3E-07	1.1E-07	2.9E-08	1.5E-08
WNW	6.2E-07	1.4E-07	3.4E-08	1.7E-08
W	8.5E-07	2.3E-07	5.3E-08	2.2E-08
WSW	6.4E-07	1.4E-07	3.5E-08	1.7E-08
SW	5.4E-07	1.4E-07	3.5E-08	1.7E-08
SSW	4.5E-07	9.4E-08	2.6E-08	1.4E-08
S	5.7E-07	1.5E-07	3.7E-08	1.7E-08
SSE	6.1E-07	1.3E-07	3.4E-08	1.6E-08
SE	7.9E-07	2.1E-07	4.8E-08	2.1E-08
ESE	8.1E-07	1.9E-07	4.4E-08	2.0E-08
E	8.9E-07	2.2E-07	5.1E-08	2.2E-08
ENE	9.5E-07	2.1E-07	4.9E-08	2.1E-08
NE	1.1E-06	3.1E-07	6.8E-08	2.6E-08
NNE	9.1E-07	2.0E-07	4.7E-08	2.1E-08

ATTACHMENT D

CAP88-PC REPORTS – POPULATION

Nfss03po

C A P 8 8 - P C

Version 2.00

Clean Air Act Assessment Package - 1988

D O S E A N D R I S K E Q U I V A L E N T S U M M A R I E S

Non-Radon Population Assessment
May 11, 2004 10:45 am

Facility: Niagara Falls Storage Site
Address: 1397 Pletcher Road
City: Lewiston
State: NY Zip: 14174

Source Category: Area
Source Type: Area
Emission Year: 2003

Comments: NFSS 2003 Population

Dataset Name: NFSS 2003 Pop
Dataset Date: May 11, 2004 10:44 am
Wind File: C:\CAP88PC2\WINDFILES\IAG0905.WND
Population File: C:\CAP88PC2\POPFILES\NFSS2003.POP

May 11, 2004 10:45 am

SUMMARY
Page 1

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)	Collective Population (person-rem/y)
GONADS	8.23E-04	1.57E-03
BREAST	5.24E-04	1.20E-03
R MAR	4.99E-02	6.79E-02
LUNGS	7.47E-01	9.40E-01
THYROID	4.91E-04	1.13E-03
ENDOST	6.22E-01	8.50E-01
RMNDR	4.33E-03	1.11E-02
EFFEC	1.16E-01	1.50E-01

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)	Collective Population (person- rem/y)
INGESTION	1. 18E- 04	4. 74E- 03
INHALATION	1. 16E- 01	1. 46E- 01
AIR IMMERSION	1. 90E- 07	7. 62E- 08
GROUND SURFACE	3. 96E- 05	8. 57E- 05
INTERNAL	1. 16E- 01	1. 50E- 01
EXTERNAL	3. 98E- 05	8. 58E- 05
TOTAL	1. 16E- 01	1. 50E- 01

May 11, 2004 10: 45 am

SUMMARY
Page 2

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nucl i des	Selected Individual (mrem/y)	Collective Population (person- rem/y)
U- 238	1. 72E- 02	2. 23E- 02
TH- 234	5. 41E- 06	9. 81E- 06
PA- 234M	6. 82E- 10	6. 04E- 11
U- 234	1. 92E- 02	2. 49E- 02
TH- 230	2. 44E- 02	3. 09E- 02
RA- 226	7. 43E- 04	1. 37E- 03
PO- 218	2. 92E- 09	3. 37E- 10
PB- 214	8. 63E- 08	2. 40E- 08
BI- 214	1. 09E- 07	2. 62E- 08
PO- 214	0. 00E+00	0. 00E+00
PB- 210	1. 17E- 03	3. 15E- 03
BI- 210	1. 59E- 05	1. 96E- 05
PO- 210	7. 19E- 04	1. 38E- 03
TH- 232	2. 45E- 02	3. 09E- 02
RA- 228	1. 70E- 04	3. 98E- 04
AC- 228	5. 91E- 06	5. 17E- 06
TH- 228	1. 86E- 02	2. 34E- 02
RA- 224	2. 58E- 04	3. 16E- 04
PO- 216	0. 00E+00	0. 00E+00
PB- 212	1. 24E- 05	1. 23E- 05
BI- 212	2. 46E- 06	1. 05E- 06
TL- 208	4. 33E- 08	5. 00E- 09
U- 235	8. 63E- 04	1. 13E- 03
TH- 231	7. 02E- 09	8. 08E- 09
PA- 231	3. 35E- 03	4. 33E- 03
AC- 227	4. 42E- 03	5. 66E- 03
FR- 223	2. 54E- 10	6. 34E- 11
RA- 223	5. 77E- 05	7. 57E- 05
PO- 215	0. 00E+00	0. 00E+00
PB- 211	6. 45E- 08	2. 10E- 08
BI- 211	4. 53E- 09	4. 72E- 10
PO- 211	6. 84E- 38	0. 00E+00
TL- 207	5. 22E- 11	6. 90E- 12
PA- 234	6. 00E- 10	6. 30E- 10
PO- 212	0. 00E+00	0. 00E+00

TH- 227	Nfss03po 8. 07E- 05	1. 01E- 04
TOTAL	1. 16E- 01	1. 50E- 01

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CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk	Total Collective Population Fatal Cancer Risk (Deaths/y)
LEUKEMIA	4. 30E- 08	8. 43E- 07
BONE	2. 82E- 08	5. 51E- 07
THYROID	8. 98E- 11	2. 93E- 09
BREAST	8. 63E- 10	2. 81E- 08
LUNG	1. 24E- 06	2. 20E- 05
STOMACH	5. 94E- 10	1. 94E- 08
BOWEL	4. 74E- 10	1. 63E- 08
LIVER	1. 14E- 08	3. 16E- 07
PANCREAS	4. 23E- 10	1. 39E- 08
URINARY	1. 89E- 09	1. 22E- 07
OTHER	5. 17E- 10	1. 70E- 08
TOTAL	1. 32E- 06	2. 39E- 05

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk	Total Collective Population Fatal Cancer Risk (Deaths/y)
INGESTION	6. 86E- 10	3. 90E- 07
INHALATION	1. 32E- 06	2. 35E- 05
AIR IMMERSION	4. 60E- 12	2. 58E- 11
GROUND SURFACE	9. 08E- 10	2. 78E- 08
INTERNAL	1. 32E- 06	2. 39E- 05
EXTERNAL	9. 13E- 10	2. 78E- 08
TOTAL	1. 32E- 06	2. 39E- 05

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PATHWAY GENETIC RISK SUMMARY (Collective Population)

Pathway	Genetic Risk (person-rem/y)
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Nfss03po

INGESTION	5. 78E- 05
INHALATION	7. 78E- 05
AIR IMMERSION	7. 41E- 08
GROUND SURFACE	7. 31E- 05
INTERNAL	1. 36E- 04
EXTERNAL	7. 32E- 05
TOTAL	2. 09E- 04

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NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk	Total Collective Population Fatal Cancer Risk (Deaths/y)
U- 238	2. 31E- 07	4. 16E- 06
TH- 234	3. 07E- 10	5. 93E- 09
PA- 234M	1. 74E- 14	2. 17E- 14
U- 234	2. 57E- 07	4. 61E- 06
TH- 230	2. 02E- 07	3. 60E- 06
RA- 226	1. 64E- 08	3. 25E- 07
PO- 218	2. 07E- 12	3. 38E- 12
PB- 214	1. 48E- 11	5. 80E- 11
BI- 214	1. 27E- 11	4. 27E- 11
PO- 214	0. 00E+00	0. 00E+00
PB- 210	8. 37E- 09	3. 17E- 07
BI- 210	4. 29E- 10	7. 46E- 09
PO- 210	1. 38E- 08	2. 81E- 07
TH- 232	1. 39E- 07	2. 47E- 06
RA- 228	2. 80E- 09	6. 83E- 08
AC- 228	1. 19E- 10	1. 47E- 09
TH- 228	3. 73E- 07	6. 64E- 06
RA- 224	5. 86E- 09	1. 01E- 07
PO- 216	0. 00E+00	0. 00E+00
PB- 212	2. 12E- 10	2. 99E- 09
BI- 212	3. 17E- 11	1. 91E- 10
TL- 208	1. 06E- 12	1. 73E- 12
U- 235	1. 17E- 08	2. 16E- 07
TH- 231	2. 05E- 13	3. 32E- 12
PA- 231	1. 89E- 08	3. 41E- 07
AC- 227	3. 85E- 08	6. 93E- 07
FR- 223	2. 68E- 15	9. 46E- 15
RA- 223	1. 44E- 09	2. 56E- 08
PO- 215	0. 00E+00	0. 00E+00
PB- 211	1. 24E- 12	5. 72E- 12
BI- 211	5. 38E- 14	7. 91E- 14
PO- 211	1. 64E- 42	1. 23E- 42
TL- 207	1. 71E- 15	3. 19E- 15
PA- 234	1. 54E- 14	2. 26E- 13
PO- 212	0. 00E+00	0. 00E+00
TH- 227	2. 22E- 09	3. 93E- 08
TOTAL	1. 32E- 06	2. 39E- 05

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INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

Direction	Distance (m)						
	250	750	1500	2500	3500	4500	7500
N	7. 1E- 02	1. 0E- 02	2. 9E- 03	1. 2E- 03	7. 1E- 04	4. 8E- 04	2. 2E- 04
NNW	4. 0E- 02	3. 1E- 03	9. 0E- 04	3. 8E- 04	2. 2E- 04	1. 5E- 04	6. 6E- 05
NW	4. 4E- 02	5. 6E- 03	1. 6E- 03	6. 8E- 04	3. 9E- 04	2. 6E- 04	1. 2E- 04
WNW	6. 4E- 02	7. 2E- 03	2. 1E- 03	8. 7E- 04	5. 0E- 04	3. 4E- 04	1. 5E- 04
W	8. 5E- 02	1. 3E- 02	3. 7E- 03	1. 5E- 03	8. 9E- 04	6. 0E- 04	2. 7E- 04
WSW	6. 7E- 02	7. 3E- 03	2. 1E- 03	9. 0E- 04	5. 2E- 04	3. 5E- 04	1. 6E- 04
SW	5. 5E- 02	7. 4E- 03	2. 1E- 03	9. 0E- 04	5. 2E- 04	3. 5E- 04	1. 6E- 04
SSW	4. 7E- 02	4. 8E- 03	1. 4E- 03	5. 9E- 04	3. 4E- 04	2. 3E- 04	1. 0E- 04
S	5. 7E- 02	7. 9E- 03	2. 3E- 03	9. 6E- 04	5. 5E- 04	3. 8E- 04	1. 7E- 04
SSE	6. 4E- 02	7. 0E- 03	2. 0E- 03	8. 5E- 04	4. 9E- 04	3. 3E- 04	1. 5E- 04
SE	8. 1E- 02	1. 1E- 02	3. 2E- 03	1. 4E- 03	7. 8E- 04	5. 3E- 04	2. 4E- 04
ESE	8. 5E- 02	1. 0E- 02	2. 9E- 03	1. 2E- 03	7. 1E- 04	4. 8E- 04	2. 2E- 04
E	9. 2E- 02	1. 2E- 02	3. 5E- 03	1. 5E- 03	8. 6E- 04	5. 9E- 04	2. 7E- 04
ENE	1. 0E- 01	1. 1E- 02	3. 3E- 03	1. 4E- 03	8. 1E- 04	5. 5E- 04	2. 5E- 04
NE	1. 2E- 01	1. 7E- 02	4. 9E- 03	2. 1E- 03	1. 2E- 03	8. 2E- 04	3. 7E- 04
NNE	9. 5E- 02	1. 1E- 02	3. 2E- 03	1. 4E- 03	7. 8E- 04	5. 3E- 04	2. 4E- 04

Direction	Distance (m)						
	15000	25000	35000	45000	55000	65000	75000
N	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	7. 2E- 06	5. 7E- 06
NNW	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	3. 4E- 06	2. 5E- 06	2. 0E- 06
NW	4. 2E- 05	0. 0E+00	0. 0E+00	0. 0E+00	5. 4E- 06	3. 7E- 06	3. 0E- 06
WNW	5. 5E- 05	0. 0E+00	0. 0E+00	0. 0E+00	6. 7E- 06	4. 5E- 06	3. 5E- 06
W	9. 8E- 05	4. 4E- 05	2. 7E- 05	1. 8E- 05	1. 2E- 05	8. 1E- 06	6. 3E- 06
WSW	5. 8E- 05	2. 6E- 05	1. 6E- 05	1. 1E- 05	7. 6E- 06	5. 3E- 06	4. 2E- 06
SW	5. 8E- 05	2. 6E- 05	1. 6E- 05	1. 1E- 05	7. 6E- 06	5. 3E- 06	0. 0E+00
SSW	3. 7E- 05	1. 7E- 05	1. 0E- 05	7. 1E- 06	0. 0E+00	3. 6E- 06	2. 9E- 06
S	6. 1E- 05	2. 8E- 05	1. 7E- 05	1. 1E- 05	8. 0E- 06	5. 5E- 06	4. 4E- 06
SSE	5. 4E- 05	2. 5E- 05	1. 5E- 05	1. 0E- 05	7. 3E- 06	5. 2E- 06	4. 1E- 06
SE	8. 6E- 05	3. 9E- 05	2. 4E- 05	1. 6E- 05	1. 1E- 05	7. 9E- 06	6. 2E- 06
ESE	7. 9E- 05	3. 6E- 05	2. 2E- 05	1. 5E- 05	1. 1E- 05	7. 5E- 06	5. 9E- 06
E	9. 7E- 05	4. 4E- 05	2. 7E- 05	1. 8E- 05	1. 3E- 05	9. 0E- 06	7. 1E- 06
ENE	9. 2E- 05	4. 2E- 05	2. 6E- 05	1. 8E- 05	1. 3E- 05	9. 0E- 06	7. 1E- 06
NE	1. 4E- 04	6. 3E- 05	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00
NNE	8. 9E- 05	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	6. 8E- 06

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COLLECTIVE EFFECTIVE DOSE EQUIVALENT (person rem/y)
(All Radionuclides and Pathways)

Nfss03po
Distance (m)

Direction	250	750	1500	2500	3500	4500	7500
N	6.4E-04	2.8E-04	2.8E-04	1.6E-04	1.3E-04	1.1E-04	3.0E-04
NNW	3.6E-04	8.6E-05	9.1E-05	5.0E-05	4.1E-05	3.3E-05	1.0E-04
NW	3.9E-04	1.6E-04	1.8E-04	1.0E-04	7.3E-05	6.8E-05	9.7E-04
WNW	5.8E-04	2.0E-04	2.3E-04	1.6E-04	1.2E-04	2.0E-04	5.7E-04
W	7.7E-04	3.5E-04	4.1E-04	2.8E-04	1.4E-03	2.0E-04	3.1E-04
WSW	6.1E-04	2.0E-04	2.4E-04	1.7E-04	7.9E-04	6.9E-04	1.1E-03
SW	4.9E-04	2.1E-04	2.4E-04	1.7E-04	1.7E-04	7.4E-04	1.9E-03
SSW	4.3E-04	1.3E-04	1.6E-04	1.1E-04	9.8E-05	3.5E-04	1.1E-03
S	5.2E-04	2.2E-04	2.6E-04	1.8E-04	1.2E-04	1.1E-04	1.8E-03
SSE	5.8E-04	2.0E-04	2.3E-04	1.6E-04	1.1E-04	9.4E-05	6.9E-04
SE	7.3E-04	3.1E-04	3.6E-04	2.5E-04	1.9E-04	1.5E-04	7.4E-04
ESE	7.7E-04	2.8E-04	3.3E-04	2.3E-04	1.8E-04	1.6E-04	5.5E-04
E	8.3E-04	3.4E-04	3.9E-04	2.8E-04	2.2E-04	1.9E-04	6.4E-04
ENE	9.0E-04	3.2E-04	3.7E-04	2.5E-04	1.6E-04	1.2E-04	8.0E-04
NE	1.0E-03	4.7E-04	5.4E-04	2.5E-04	1.4E-04	1.2E-04	1.0E-03
NNE	8.6E-04	3.1E-04	3.2E-04	1.8E-04	1.4E-04	1.1E-04	3.6E-04

Distance (m)

Direction	15000	25000	35000	45000	55000	65000	75000
N	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.5E-04	1.6E-03
NNW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.2E-04	2.7E-03	1.4E-03
NW	4.3E-05	0.0E+00	0.0E+00	0.0E+00	2.7E-05	3.1E-03	1.6E-03
WNW	1.9E-04	0.0E+00	0.0E+00	0.0E+00	6.7E-09	1.1E-03	3.1E-04
W	2.6E-03	2.8E-03	2.5E-04	5.0E-04	2.5E-04	1.3E-03	1.6E-03
WSW	8.5E-04	1.2E-03	1.3E-04	7.4E-05	4.1E-05	5.1E-05	2.4E-05
SW	4.1E-03	1.5E-04	9.2E-04	1.5E-04	1.4E-05	3.6E-06	0.0E+00
SSW	4.3E-03	3.9E-05	8.0E-05	3.1E-05	0.0E+00	5.1E-07	4.3E-05
S	5.5E-03	1.5E-03	1.6E-03	6.6E-05	8.5E-04	3.4E-04	1.6E-04
SSE	4.2E-03	1.2E-02	1.3E-02	4.9E-03	1.2E-03	2.2E-04	1.0E-04
SE	1.5E-03	4.7E-03	4.5E-03	1.7E-03	5.3E-04	1.9E-04	1.4E-04
ESE	8.9E-04	3.0E-03	3.5E-04	3.7E-04	2.4E-04	5.1E-04	1.9E-04
E	9.3E-04	2.3E-03	4.3E-04	6.9E-04	2.0E-04	3.5E-04	2.8E-04
ENE	5.3E-04	9.2E-04	2.5E-04	1.2E-04	7.3E-05	3.0E-05	1.4E-05
NE	1.1E-03	7.2E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NNE	4.6E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.4E-04

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AVERAGE COLLECTIVE GENETIC DOSE EQUIVALENT
(person rem)
(All Radionuclides and Pathways)

Distance (m)							
Direction	250	750	1500	2500	3500	4500	7500

Nfss03po

N	8. 1E- 05	3. 6E- 05	3. 6E- 05	2. 2E- 05	1. 8E- 05	1. 5E- 05	4. 1E- 05
NNW	4. 6E- 05	1. 1E- 05	1. 2E- 05	6. 8E- 06	5. 6E- 06	4. 6E- 06	1. 6E- 05
NW	5. 0E- 05	2. 0E- 05	2. 4E- 05	1. 3E- 05	9. 9E- 06	9. 3E- 06	1. 4E- 04
WNW	7. 4E- 05	2. 6E- 05	3. 0E- 05	2. 1E- 05	1. 6E- 05	2. 7E- 05	8. 1E- 05
W	9. 8E- 05	4. 6E- 05	5. 3E- 05	3. 7E- 05	1. 9E- 04	2. 7E- 05	4. 2E- 05
WSW	7. 8E- 05	2. 6E- 05	3. 1E- 05	2. 2E- 05	1. 1E- 04	9. 3E- 05	1. 5E- 04
SW	6. 3E- 05	2. 7E- 05	3. 1E- 05	2. 2E- 05	2. 2E- 05	1. 0E- 04	2. 7E- 04
SSW	5. 5E- 05	1. 7E- 05	2. 0E- 05	1. 4E- 05	1. 3E- 05	4. 9E- 05	1. 7E- 04
S	6. 6E- 05	2. 9E- 05	3. 3E- 05	2. 4E- 05	1. 7E- 05	1. 5E- 05	2. 5E- 04
SSE	7. 4E- 05	2. 5E- 05	3. 0E- 05	2. 1E- 05	1. 5E- 05	1. 3E- 05	9. 8E- 05
SE	9. 3E- 05	4. 0E- 05	4. 7E- 05	3. 3E- 05	2. 5E- 05	2. 0E- 05	1. 0E- 04
ESE	9. 8E- 05	3. 6E- 05	4. 3E- 05	3. 0E- 05	2. 5E- 05	2. 1E- 05	7. 7E- 05
E	1. 1E- 04	4. 4E- 05	5. 1E- 05	3. 6E- 05	3. 0E- 05	2. 6E- 05	8. 8E- 05
ENE	1. 1E- 04	4. 1E- 05	4. 8E- 05	3. 3E- 05	2. 1E- 05	1. 6E- 05	1. 1E- 04
NE	1. 3E- 04	6. 0E- 05	7. 0E- 05	3. 4E- 05	1. 8E- 05	1. 6E- 05	1. 4E- 04
NNE	1. 1E- 04	4. 0E- 05	4. 1E- 05	2. 4E- 05	1. 9E- 05	1. 5E- 05	5. 0E- 05

Distance (m)

Direction	15000	25000	35000	45000	55000	65000	75000
N	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	1. 8E- 04	6. 0E- 04
NNW	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	3. 7E- 04	1. 8E- 03	1. 1E- 03
NW	7. 1E- 06	0. 0E+00	0. 0E+00	0. 0E+00	1. 0E- 05	1. 5E- 03	9. 1E- 04
WNW	3. 0E- 05	0. 0E+00	0. 0E+00	0. 0E+00	2. 2E- 09	4. 8E- 04	1. 6E- 04
W	3. 8E- 04	4. 6E- 04	4. 7E- 05	1. 0E- 04	6. 1E- 05	4. 0E- 04	5. 4E- 04
WSW	1. 3E- 04	2. 3E- 04	2. 8E- 05	1. 9E- 05	1. 3E- 05	2. 0E- 05	1. 1E- 05
SW	6. 4E- 04	2. 7E- 05	2. 0E- 04	3. 9E- 05	4. 5E- 06	1. 4E- 06	0. 0E+00
SSW	7. 3E- 04	8. 3E- 06	2. 1E- 05	9. 9E- 06	0. 0E+00	2. 5E- 07	2. 5E- 05
S	8. 6E- 04	2. 7E- 04	3. 4E- 04	1. 7E- 05	2. 6E- 04	1. 3E- 04	7. 0E- 05
SSE	6. 8E- 04	2. 2E- 03	3. 0E- 03	1. 3E- 03	3. 7E- 04	8. 7E- 05	4. 6E- 05
SE	2. 3E- 04	7. 9E- 04	8. 6E- 04	3. 8E- 04	1. 3E- 04	5. 7E- 05	4. 8E- 05
ESE	1. 4E- 04	5. 1E- 04	6. 8E- 05	8. 3E- 05	6. 2E- 05	1. 6E- 04	6. 9E- 05
E	1. 4E- 04	3. 9E- 04	7. 9E- 05	1. 4E- 04	4. 7E- 05	9. 8E- 05	8. 9E- 05
ENE	7. 9E- 05	1. 5E- 04	4. 7E- 05	2. 5E- 05	1. 8E- 05	8. 5E- 06	4. 4E- 06
NE	1. 6E- 04	1. 1E- 05	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00
NNE	7. 0E- 06	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	4. 7E- 05

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INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

Distance (m)

Direction	250	750	1500	2500	3500	4500	7500
N	8. 1E- 07	1. 1E- 07	3. 3E- 08	1. 4E- 08	8. 1E- 09	5. 5E- 09	2. 5E- 09
NNW	4. 5E- 07	3. 5E- 08	1. 0E- 08	4. 3E- 09	2. 5E- 09	1. 7E- 09	7. 6E- 10
NW	5. 0E- 07	6. 4E- 08	1. 9E- 08	7. 7E- 09	4. 4E- 09	3. 0E- 09	1. 3E- 09
WNW	7. 4E- 07	8. 2E- 08	2. 4E- 08	9. 9E- 09	5. 7E- 09	3. 9E- 09	1. 7E- 09
W	9. 7E- 07	1. 4E- 07	4. 2E- 08	1. 8E- 08	1. 0E- 08	6. 9E- 09	3. 1E- 09

	Nfss03po						
WSW	7. 7E- 07	8. 4E- 08	2. 4E- 08	1. 0E- 08	5. 9E- 09	4. 0E- 09	1. 8E- 09
SW	6. 3E- 07	8. 4E- 08	2. 5E- 08	1. 0E- 08	5. 9E- 09	4. 0E- 09	1. 8E- 09
SSW	5. 4E- 07	5. 5E- 08	1. 6E- 08	6. 7E- 09	3. 9E- 09	2. 6E- 09	1. 2E- 09
S	6. 6E- 07	9. 1E- 08	2. 6E- 08	1. 1E- 08	6. 3E- 09	4. 3E- 09	1. 9E- 09
SSE	7. 3E- 07	8. 0E- 08	2. 3E- 08	9. 7E- 09	5. 6E- 09	3. 8E- 09	1. 7E- 09
SE	9. 2E- 07	1. 3E- 07	3. 7E- 08	1. 5E- 08	8. 9E- 09	6. 0E- 09	2. 7E- 09
ESE	9. 7E- 07	1. 1E- 07	3. 4E- 08	1. 4E- 08	8. 1E- 09	5. 5E- 09	2. 5E- 09
E	1. 0E- 06	1. 4E- 07	4. 0E- 08	1. 7E- 08	9. 8E- 09	6. 7E- 09	3. 0E- 09
ENE	1. 1E- 06	1. 3E- 07	3. 8E- 08	1. 6E- 08	9. 3E- 09	6. 3E- 09	2. 9E- 09
NE	1. 3E- 06	1. 9E- 07	5. 6E- 08	2. 4E- 08	1. 4E- 08	9. 3E- 09	4. 2E- 09
NNE	1. 1E- 06	1. 3E- 07	3. 7E- 08	1. 5E- 08	8. 9E- 09	6. 1E- 09	2. 8E- 09

Distance (m)							
Direction	15000	25000	35000	45000	55000	65000	75000
N	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	8. 0E- 11	6. 2E- 11
NNW	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	3. 6E- 11	2. 5E- 11	2. 0E- 11
NW	4. 8E- 10	0. 0E+00	0. 0E+00	0. 0E+00	5. 8E- 11	4. 0E- 11	3. 1E- 11
WNW	6. 2E- 10	0. 0E+00	0. 0E+00	0. 0E+00	7. 3E- 11	4. 8E- 11	3. 7E- 11
W	1. 1E- 09	5. 0E- 10	3. 0E- 10	2. 0E- 10	1. 4E- 10	9. 0E- 11	6. 9E- 11
WSW	6. 6E- 10	3. 0E- 10	1. 8E- 10	1. 2E- 10	8. 4E- 11	5. 7E- 11	4. 5E- 11
SW	6. 6E- 10	3. 0E- 10	1. 8E- 10	1. 2E- 10	8. 3E- 11	5. 7E- 11	0. 0E+00
SSW	4. 2E- 10	1. 9E- 10	1. 2E- 10	7. 8E- 11	0. 0E+00	3. 8E- 11	3. 0E- 11
S	7. 0E- 10	3. 1E- 10	1. 9E- 10	1. 3E- 10	8. 8E- 11	6. 0E- 11	4. 7E- 11
SSE	6. 2E- 10	2. 8E- 10	1. 7E- 10	1. 2E- 10	8. 0E- 11	5. 6E- 11	4. 4E- 11
SE	9. 8E- 10	4. 4E- 10	2. 7E- 10	1. 8E- 10	1. 3E- 10	8. 8E- 11	6. 8E- 11
ESE	9. 0E- 10	4. 1E- 10	2. 5E- 10	1. 7E- 10	1. 2E- 10	8. 2E- 11	6. 4E- 11
E	1. 1E- 09	5. 0E- 10	3. 1E- 10	2. 1E- 10	1. 4E- 10	1. 0E- 10	7. 8E- 11
ENE	1. 0E- 09	4. 8E- 10	3. 0E- 10	2. 0E- 10	1. 4E- 10	1. 0E- 10	7. 9E- 11
NE	1. 5E- 09	7. 1E- 10	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00
NNE	1. 0E- 09	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	7. 5E- 11

May 11, 2004 10:45 am

SUMMARY
Page 10

COLLECTIVE FATAL CANCER RATE (deaths/y)
(All Radionuclides and Pathways)

Distance (m)							
Direction	250	750	1500	2500	3500	4500	7500
N	1. 0E- 07	4. 5E- 08	4. 5E- 08	2. 6E- 08	2. 1E- 08	1. 8E- 08	4. 8E- 08
NNW	5. 8E- 08	1. 4E- 08	1. 5E- 08	8. 1E- 09	6. 6E- 09	5. 3E- 09	1. 6E- 08
NW	6. 4E- 08	2. 5E- 08	2. 9E- 08	1. 6E- 08	1. 2E- 08	1. 1E- 08	1. 6E- 07
WNW	9. 4E- 08	3. 2E- 08	3. 7E- 08	2. 6E- 08	2. 0E- 08	3. 2E- 08	9. 3E- 08
W	1. 2E- 07	5. 7E- 08	6. 6E- 08	4. 6E- 08	2. 3E- 07	3. 2E- 08	4. 9E- 08
WSW	9. 8E- 08	3. 3E- 08	3. 8E- 08	2. 7E- 08	1. 3E- 07	1. 1E- 07	1. 7E- 07
SW	8. 0E- 08	3. 3E- 08	3. 9E- 08	2. 7E- 08	2. 7E- 08	1. 2E- 07	3. 1E- 07
SSW	6. 9E- 08	2. 2E- 08	2. 5E- 08	1. 8E- 08	1. 6E- 08	5. 7E- 08	1. 8E- 07
S	8. 3E- 08	3. 6E- 08	4. 1E- 08	2. 9E- 08	2. 0E- 08	1. 8E- 08	2. 8E- 07
SSE	9. 3E- 08	3. 1E- 08	3. 6E- 08	2. 5E- 08	1. 8E- 08	1. 5E- 08	1. 1E- 07
SE	1. 2E- 07	5. 0E- 08	5. 8E- 08	4. 1E- 08	3. 0E- 08	2. 4E- 08	1. 2E- 07

	Nfss03po						
ESE	1. 2E- 07	4. 5E- 08	5. 3E- 08	3. 7E- 08	3. 0E- 08	2. 6E- 08	8. 9E- 08
E	1. 3E- 07	5. 5E- 08	6. 3E- 08	4. 4E- 08	3. 6E- 08	3. 1E- 08	1. 0E- 07
ENE	1. 4E- 07	5. 1E- 08	6. 0E- 08	4. 1E- 08	2. 6E- 08	1. 9E- 08	1. 3E- 07
NE	1. 7E- 07	7. 6E- 08	8. 7E- 08	4. 1E- 08	2. 2E- 08	1. 9E- 08	1. 6E- 07
NNE	1. 4E- 07	4. 9E- 08	5. 1E- 08	2. 9E- 08	2. 3E- 08	1. 8E- 08	5. 9E- 08

	Distance (m)						
Direction	15000	25000	35000	45000	55000	65000	75000
N	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	8. 6E- 08	2. 5E- 07
NNW	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	1. 1E- 07	3. 9E- 07	2. 0E- 07
NW	6. 8E- 09	0. 0E+00	0. 0E+00	0. 0E+00	4. 1E- 09	4. 6E- 07	2. 3E- 07
WNW	3. 1E- 08	0. 0E+00	0. 0E+00	0. 0E+00	1. 0E- 12	1. 7E- 07	4. 6E- 08
W	4. 2E- 07	4. 5E- 07	4. 0E- 08	7. 9E- 08	4. 0E- 08	2. 1E- 07	2. 4E- 07
WSW	1. 4E- 07	2. 0E- 07	2. 1E- 08	1. 2E- 08	6. 5E- 09	7. 9E- 09	3. 6E- 09
SW	6. 5E- 07	2. 3E- 08	1. 5E- 07	2. 4E- 08	2. 2E- 09	5. 6E- 10	0. 0E+00
SSW	6. 9E- 07	6. 2E- 09	1. 3E- 08	4. 8E- 09	0. 0E+00	7. 7E- 11	6. 3E- 09
S	8. 9E- 07	2. 4E- 07	2. 6E- 07	1. 0E- 08	1. 3E- 07	5. 3E- 08	2. 4E- 08
SSE	6. 8E- 07	1. 8E- 06	2. 1E- 06	7. 6E- 07	1. 8E- 07	3. 4E- 08	1. 5E- 08
SE	2. 5E- 07	7. 5E- 07	7. 1E- 07	2. 8E- 07	8. 3E- 08	2. 9E- 08	2. 1E- 08
ESE	1. 4E- 07	4. 7E- 07	5. 6E- 08	5. 8E- 08	3. 7E- 08	8. 0E- 08	2. 9E- 08
E	1. 5E- 07	3. 7E- 07	6. 9E- 08	1. 1E- 07	3. 1E- 08	5. 4E- 08	4. 3E- 08
ENE	8. 5E- 08	1. 5E- 07	4. 0E- 08	1. 9E- 08	1. 2E- 08	4. 7E- 09	2. 1E- 09
NE	1. 8E- 07	1. 2E- 08	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00
NNE	7. 5E- 09	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	0. 0E+00	2. 2E- 08

ATTACHMENT E

CY2003 RADON-222 FLUX MEASUREMENTS

2003 Radon Flux Monitoring Results^a
Niagara Falls Storage Site

NFSS Radon Flux											
Sample ID	(pCi/m ² /s)			Sample ID	(pCi/m ² /s)			Sample ID	(pCi/m ² /s)		
1	0.147	±	0.068	41	0.070	±	0.026	81	0.066	±	0.053
2	0.159	±	0.095	42	0.030	±	0.045	82	0.113	±	0.071
3	0.102	±	0.076	43	0.819	±	0.043	83	0.077	±	0.053
4	0.010	±	0.032	44	0.016	±	0.046	84	0.006	±	0.033
5	0.042	±	0.042	45	0.227	±	0.032	85	0.054	±	0.040
6	0.038	±	0.041	46	0.091	±	0.047	86	0.039	±	0.059
7	0.079	±	0.050	47	0.124	±	0.057	87	0.114	±	0.051
8	0.131	±	0.071	48	0.111	±	0.066	88	0.055	±	0.055
9	0.044	±	0.056	49	0.072	±	0.048	89	0.066	±	0.056
10	0.108	±	0.071	50	0.044	±	0.043	90	0.148	±	0.047
10 DUP	0.100	±	0.053	50 DUP	0.046	±	0.063	90 DUP	0.112	±	0.074
11	0.158	±	0.089	51	0.060	±	0.037	91	0.157	±	0.064
12	0.142	±	0.078	52	0.054	±	0.048	92	0.062	±	0.036
13	0.069	±	0.046	53	0.061	±	0.034	93	0.104	±	0.097
14	0.136	±	0.055	54	0.145	±	0.085	94	0.061	±	0.040
15	0.063	±	0.049	55	0.166	±	0.040	95	0.035	±	0.048
16	0.106	±	0.089	56	0.007	±	0.042	96	0.517	±	0.040
17	0.033	±	0.039	57	0.112	±	0.057	97	0.016	±	0.047
18	-0.007	±	0.042	58	0.073	±	0.051	98	0.036	±	0.037
19	0.110	±	0.066	59	0.082	±	0.049	99	0.002	±	0.040
20	0.084	±	0.048	60	0.003	±	0.054	100	0.032	±	0.047
20 DUP	0.056	±	0.033	60 DUP	0.082	±	0.058	100 DUP	0.036	±	0.049
21	0.093	±	0.067	61	0.164	±	0.042	101	0.051	±	0.055
22	0.047	±	0.040	62	0.045	±	0.057	102	0.095	±	0.058
23	0.044	±	0.050	63	0.053	±	0.038	103	0.033	±	0.055
24	0.126	±	0.040	64	0.080	±	0.054	104	-0.004	±	0.028
25	0.100	±	0.057	65	1.419	±	0.118	105	0.019	±	0.063
26	0.084	±	0.049	66	0.075	±	0.047	106	0.106	±	0.072
27	0.050	±	0.064	67	0.008	±	0.041	107	0.017	±	0.049
28	0.089	±	0.044	68	0.100	±	0.051	108	0.182	±	0.054
29	0.062	±	0.051	69	0.041	±	0.038	109	0.116	±	0.086
30	0.087	±	0.052	70	0.451	±	0.040	110	0.086	±	0.050
30 DUP	0.164	±	0.066	70 DUP	0.040	±	0.042	110 DUP	0.052	±	0.056
31	0.094	±	0.064	71	0.035	±	0.047	111	0.027	±	0.045
32	0.133	±	0.075	72	0.002	±	0.040	112	0.016	±	0.040
33	0.094	±	0.061	73	0.120	±	0.053	113	0.072	±	0.057
34	0.049	±	0.052	74	-0.007	±	0.044	114	0.104	±	0.062
35	0.064	±	0.045	75	0.018	±	0.024	115	0.070	±	0.052
36	0.098	±	0.054	76	0.007	±	0.043	116	0.043	±	0.059
37	0.106	±	0.051	77	0.023	±	0.037	117	-0.002	±	0.036
38	0.054	±	0.054	78	0.115	±	0.059	118	0.022	±	0.051
39	0.018	±	0.023	79	-0.024	±	0.045	119	0.063	±	0.048
40	0.043	±	0.043	80	0.016	±	0.047	120	0.007	±	0.045
40 DUP	-0.006	±	0.051	80 DUP	0.017	±	0.054	120 DUP	-0.022	±	0.048

2003 Radon Flux Monitoring Results^a
Niagara Falls Storage Site

NFSS Radon Flux											
Sample ID		(pCi/m ² /s)		Sample ID		(pCi/m ² /s)		Sample ID		(pCi/m ² /s)	
121	0.028	±	0.060	151	0.019	±	0.033	181 ^c	0.065	±	0.054
122	0.060	±	0.048	152	0.086	±	0.044	182 ^c	0.122	±	0.083
123	0.004	±	0.064	153	0.009	±	0.063	183 ^c	0.061	±	0.049
124	0.005	±	0.032	154	0.054	±	0.040	Average background	0.082		
125	0.086	±	0.078	155	0.029	±	0.048				
126	0.055	±	0.040	156	0.004	±	0.040				
127	0.048	±	0.054	157	0.095	±	0.053				
128	0.002	±	0.047	158	0.090	±	0.056				
129	0.035	±	0.068	159	0.051	±	0.070				
130	0.087	±	0.067	160	0.077	±	0.044				
130 DUP	0.125	±	0.058	160 DUP	-0.010	±	0.133				
131	0.018	±	0.057	161	0.057	±	0.054	Average:	0.080	(pCi/m ² /s)	
132	0.023	±	0.039	162	0.169	±	0.091	High:	1.419	(pCi/m ² /s)	
133	0.110	±	0.062	163	0.046	±	0.037	Low:	-0.046	(pCi/m ² /s)	
134	0.051	±	0.031	164	0.025	±	0.062				
135	0.126	±	0.065	165	0.030	±	0.048				
136	0.019	±	0.032	166	0.007	±	0.048				
137	0.017	±	0.049	167	0.002	±	0.050				
138	0.074	±	0.061	168	0.090	±	0.074				
139	-0.046	±	0.053	169	0.086	±	0.049				
140	0.004	±	0.038	170	0.039	±	0.045				
140 DUP	0.054	±	0.046	170 DUP	-0.009	±	0.040				
141	0.038	±	0.052	171	0.072	±	0.050				
142	0.033	±	0.049	172	0.206	±	0.114				
143	0.011	±	0.064	173	0.087	±	0.047				
144	0.081	±	0.067	174	0.138	±	0.080				
145	-0.002	±	0.059	175	0.122	±	0.074				
146	0.049	±	0.057	176	0.128	±	0.091				
147	0.072	±	0.056	177	0.007	±	0.060				
148	0.103	±	0.073	178	0.011	±	0.110				
149	0.005	±	0.034	179	0.067	±	0.027				
150	0.049	±	0.049	180	0.245	±	0.011				
150 DUP	0.007	±	0.047	180 DUP	0.233	±	0.064				

NOTE: The EPA Standard for Radon-222 Flux is 20 pCi/m²/sec

a. Radon-222 flux was performed in Jul. 29-30, 2003

b. Every 10th canister is counted twice as a quality control (QC) duplicate to evaluate analytical precision

c. Background

ATTACHMENT F

NATIONAL CLIMATIC DATA CENTER, NIAGARA FALLS, NEW YORK

ANNUAL CLIMATOLOGICAL SUMMARY (2003)

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801

Station: **305840/99999, NIAGARA FALLS INT'L AP, New York**

Elev. 519 ft. above sea level

Lat. 43°06'N, Lon. 78°57'W

Date	Temperature (° F)												Precipitation (inches)											
Elem->	MMXT	MMNT	MNTM	DPNT	HTDD	CLDD	EMXT		EMNP		DT90	DX32	DT32	DT00	TPCP	DPNP	EMXP		TSNW	MXSD		DP01	DP05	DP10
2003 Month	Mean Max.	Mean Min.	Mean	Depart. from Normal	Heating Degree Days	Cooling Degree Days	Highest	High Date	Lowest	Low Date	Number of Days				Total	Depart. from Normal	Greatest Observed		Snow, Sleet			Number of Days		
											Max >=90°	Max <=32°	Min <=32°	Min <=0°			Day	Date	Total Fall	Max Depth	Max Date	>=.10	>=.50	>=1.0
1	25.7	11.7	18.7	-5.5	1429	0	40	9	-13	27	0	26	31	3	1.56	-0.99	0.34	26	26.2	8	27	6	0	0
2	26.9	12.5	19.7	-5.6	1261	0	45	4	-7	26	0	20	28	3	1.72	-0.60	0.65	22	14.5	6	18	6	1	0
3	42.0	22.8	32.4	-1.4	1001	0	72	28	-2	3	0	5	22	1	2.34	-0.29	0.54	20	3.4	2	4	8	1	0
4	52.6	32.2	42.4	-2.7	673	0	79	20	20	6	0	4	18	0	2.01	-0.45	0.77	4	3.2X	2	8	5	2	0
5	64.4	45.4	54.9	-2.2	304	0	78	19	34	4	0	0	0	0	5.79	2.85	0.75	31	0.0	0		13	6	0
6	73.4	54.7	64.1	-1.7	86	66	88	26	44	3	0	0	0	0	1.76	-1.50	0.63	8	0.0	0		5	2	0
7	78.8	60.3	69.6	-1.8	3	151	87	4	51	17	0	0	0	0	2.82	0.13	0.62	10	0.0	0		8	1	0
8	79.8	61.3	70.6	1.0	12	192	86	21	48	31	0	0	0	0	2.51	-0.52	1.02	5	0.0	0		8	1	1
9	72.3	52.6	62.5	0.8	99	33	83	14	40	30	0	0	0	0	3.10	-0.42	0.84	27	0.0	0		9	2	0
10	57.8	38.6	48.2	-1.9	515	2	78	10	31	6	0	0	6	0	2.44	-0.23	0.58	14	0.0T	0T	24	7	1	0
11	50.4	34.0	42.2	2.3	678	0	69	23	19	9	0	0	13	0	3.49	0.51	0.95	2	1.6	0T	29	9	2	0
12	39.1	26.3	32.7	3.0	993	0	54	29	14	13	0	9	27	0	2.49	-0.39	0.63	10	8.3	4	15	7	1	0
Annual	55.3	37.7	46.5	-1.3	7054	444	88	Jun	-13	Jan	0	64	145	7	32.03	-1.90	1.02	Aug	57.2X	8	Jan	91	20	1

Notes

(blank) Not reported.

+ Occurred on one or more previous dates during the month.
The date in the Date field is the last day of occurrence. Used
through December 1983 only.

A Accumulated amount. This value is a total that may include
data from a previous month or months or year (for annual
value).

B Adjusted Total. Monthly value totals based on proportional
available data across the entire month.

E An estimated monthly or annual total.

X Monthly means or totals based on incomplete time series. 1 to 9
days are missing. Annual means or totals include one or more
months which had 1 to 9 days that were missing.

M Used to indicate data element missing.

T Trace of precipitation, snowfall, or snowdepth. The precipitation
data value will = zero.

Elem- Element Types are included to provide cross-reference for users
> of the NCDC CDO System.

Station Station is identified by: CoopID/WBAN, Station Name, State.

S Precipitation amount is continuing to
be accumulated. Total will be
included in a subsequent monthly or
yearly value. Example: Days 1-20
had 1.35 inches of precipitation, then
a period of accumulation began. The
element TPCP would then be
00135S and the total accumulated
amount value appears in a
subsequent monthly value. If TPCP
= "M" there was no precipitation
measured during the month. Flag is
set to "S" and the total accumulated
amount appears in a subsequent
monthly value.

Dynamically generated Thu Apr 15 14:26:14 EDT 2004 via <http://hurricane.ncdc.noaa.gov/ancsum/ACS>

Data provided from the NCDC CDO System

Additional documentation can be found at <http://www5.ncdc.noaa.gov/cdo/3220doc.txt>