Knolls Laboratory and Kesselring Site

Environmental Monitoring Report

Calendar Year 2018

Prepared for the U. S. Department of Energy
by Fluor Marine Propulsion, LLC

FLUOR®

KNOLLS LABORATORY AND KESSELRING SITE

ENVIRONMENTAL MONITORING REPORT

CALENDAR YEAR 2018

Prepared for the U.S. Department of Energy by
Fluor Marine Propulsion, LLC
Knolls Laboratory
Niskayuna, New York
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LIST OF ACRONYMS

AE	Air Emission
AEA	Atomic Energy Act
AFR	Air Facility Registration
ALARA	As Low As Reasonably Achievable
ANSI	American National Standards Institute
AOC	Areas of Concern
ASFP	Air State Facility Permit
ASGTF	Advanced Steam Generator Test Facility
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BCSF	Bulk Chemical Storage Facility
BOD-5	Biochemical Oxygen Demand, 5-day test
BTU(s)	British Thermal Unit(s)
CAA	Clean Air Act
CBS	Chemical Bulk Storage
CEDR	Consolidated Energy Data Report
CERCLA	Comprehensive Environmental Response, Compensation, & Liability Act
CFR	Code of Federal Regulations
COD	Chemical Oxygen Demand
CWA	Clean Water Act
CX(s)	Categorical Exclusion(s)
D&D	Decontamination and Decommissioning
DCG	Derived Concentration Guide
DCS	Derived Concentration Standard
DGS	Distributed Generation Sources
DO	Dissolved Oxygen
DOE	U.S. Department of Energy
DOE-EM	U.S. Department of Energy – Office of Environmental Management
DOT	U.S. Department of Transportation
DOW	Department of Water
ECL	[New York State] Environmental Conservation Law
EHS	Extremely Hazardous Substance
ELAP	Environmental Laboratory Approval Program
EMS	ESH Management System
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ERA	Environmental Resource Associates
ESH	Environment(al), Safety, and Health

LIST OF ACRONYMS (continued)

FFCA	Federal Facility Compliance Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FMP	Fluor Marine Propulsion, LLC
HEPA	High Efficiency Particulate Air [filters]
HSWA	Hazardous and Solid Waste Amendments
KAPL	Knolls Atomic Power Laboratory
LDR	Land Disposal Restrictions
LEPC(s)	Local Emergency Planning Committee(s)
MBAS	Methylene Blue Active Substances
MCL	Maximum Contaminant Level
MLLW	Mixed Low Level Waste
MS4	Municipal Separate Storm Sewer System
MSDS(s)	Material Safety Data Sheet(s)
MTBE	Methyl Tertiary Butyl Ether
NA	Not Applicable
NC	No Criteria [Available]
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NNL	Naval Nuclear Laboratory
NNPP	Naval Nuclear Propulsion Program
NOI(s)	Notice(s) of Intent
NOx	Nitrogen Oxides
NRC	U.S. Nuclear Regulatory Commission
NRLFO	Naval Reactors Laboratory Field Office
NSPS	New Source Performance Standards
NYS	New York State
NYSCC	New York State Canal Corporation
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
PBS(F)	Petroleum Bulk Storage (Facility)
PCB(s)	Polychlorinated Biphenyl(s)
PCMMM	Post-Closure Monitoring and Maintenance Manual
POC	Principal Organic Contaminants
POTW	Publicly Owned Treatment Works
PVU(s)	Portable Ventilation Unit(s)
QAP	Quality Assurance Program
RAE	Radionuclide Air Emission
RCRA	Resource Conservation and Recovery Act

LIST OF ACRONYMS (continued)

RL	Reporting Limit
RQ(s)	Reportable Quantity(ies)
SBR	Sequencing Batch Reactors
SCF	Standard Cubic Feet
SDS(s)	Safety Data Sheet(s)
SERC	State Emergency Response Commission
SI (unit)	Standard International (unit)
SOx	Sulfur Oxides
SPDES	State Pollutant Discharge Elimination System
SPRU	Separations Process Research Unit
SPRU DP	Separations Process Research Unit Disposition Project
SSW	Site Service Water
STP	Site Treatment Plan
SWDA	Solid Waste Disposal Act
SWMP(s)	Stormwater Management Program(s)
SWMU	Solid Waste Management Unit
SWPPP	Stormwater Pollution Prevention Plan
SWTF	Sewage Waste Treatment Facility
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TLD(s)	Thermoluminescent Dosimeter(s)
TOC	Total Organic Carbon
TOGS	Technical and Operational Guidance Series
TON	Total Organic Nitrogen
TPQ	Threshold Planning Quantity
TRI	Toxic Release Inventory
TSCA	Toxic Substances Control Act
TSDF(s)	Treatment, Storage, and Disposal Facility(ies)
TSS	Total Suspended Solids
UIC	Underground Injection Control
URS	URS Corporation (formally United Research Service)
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
VOC(s)	Volatile Organic Compound(s)
WBSD	West Boundary Stream Ditch
WET	Whole Effluent Toxicity
WIPP	Waste Isolation Pilot Plant
WMP	Waste Management Plan

COMMON ABBREVIATIONS

Bq	becquerel
C	Celsius
CFU/100ml	colony-forming units per 100 milliliters
cfs	cubic feet per second
Ci	curie
F	Fahrenheit
hr(s)	hour(s)
GPD	gallons per day
µCi	microcurie = 1×10^{-6} curie
µCi/ml	microcuries per milliliter
µg	microgram = 1×10^{-6} gram
µg/l	micrograms per liter
µmho	micromho = 1×10^{-6}/ohm
µmho/cm	micromho per centimeter
mg	milligram = 1×10^{-3} gram
mg/l	milligrams per liter
MGD	million gallons per day
mrem	millirem = 1×10^{-3} rem
ml	milliliters = 1×10^{-3} liter
ml/l	milliliters per liter
mSv	millisieverts = 100 millirem
nCi	nanocurie = 1×10^{-9} curie
ntu	Nephelometric Turbidity Units
pCi	picocurie = 1×10^{-12} curie
pCi/g	picocuries per gram
pCi/l	picocuries per liter
SU	Standard [pH] Units

EXECUTIVE SUMMARY

The results of the effluent and environmental monitoring programs at the Knolls Laboratory and Kesselring Site are summarized and assessed in this report. Tables 1 - 4 summarize the major elements of the environmental monitoring programs at each site. Information regarding the U.S. Department of Energy – Office of Environmental Management (DOE-EM) Separations Process Research Unit (SPRU) Disposition Project (SPRU DP), is also included in this report. Operations at the Knolls Laboratory, SPRU, and the Kesselring Site continue to have no adverse effect on human health and the quality of the environment.

The effluent and environmental monitoring programs conducted by the Knolls Laboratory and the Kesselring Site are designed to determine the effectiveness of treatment and control methods, to provide measurement of the concentrations in effluents for comparison with applicable standards, and to assess resultant concentrations in the environment. The monitoring programs include analyses of samples of liquid and gaseous effluents for chemical constituents and radioactivity as well as environmental monitoring of air, water, sediment, and fish. Radiation measurements are also made around the perimeter of the Knolls Laboratory, the perimeter of the Kesselring Site, and at off-site background locations.

The Knolls Laboratory and the Kesselring Site environmental controls are subject to applicable Federal, State, and local regulations governing use, emission, treatment, storage, and/or disposal of solid, liquid, and gaseous materials. Some nonradiological water and air emissions are generated and treated on-site prior to discharge to the environment.

Nonradiological liquid effluents from the Knolls Laboratory (including SPRU) and the Kesselring Site are controlled and monitored in accordance with permits issued by the New York State Department of Environmental Conservation (NYSDEC). Radiological liquid effluents are controlled and monitored in accordance with U.S. Department of Energy (DOE) requirements. Liquid effluent monitoring data show that both the Knolls Laboratory and the Kesselring Site have maintained a high degree of compliance with the New York State and DOE requirements. At the Knolls Laboratory, sewage discharges are controlled and monitored in accordance with limitations imposed locally by the Town of Niskayuna in accordance with an Outside Users Agreement.

Nonradiological air emissions from the Knolls Laboratory (including SPRU) and the Kesselring Site are controlled and monitored in accordance with NYSDEC and U.S. Environmental Protection Agency (EPA) air regulations. Radionuclide air emissions are regulated by the EPA under the requirements of the National Emission Standards for Hazardous Air Pollutants ((NESHAPs) 40 CFR 61, Subpart H). For the purposes of the radionuclide NESHAPs regulations, operations at the Knolls Laboratory and at SPRU are considered one site. Nonradiological air emission sources are not required to have stack monitoring. The use and maintenance of air emissions control equipment, fuel usage and tracking, or air source limitations such as fuel oil sulfur concentration limits, are used to demonstrate compliance. All of the Knolls Laboratory and the Kesselring Site air emissions were within applicable Federal and State standards.

The Knolls Laboratory and the Kesselring Site operated their own landfills for facility-generated nonradiological wastes during their early histories. The Knolls Laboratory and the Kesselring Site landfill operations were terminated in 1993 and 1994, respectively. Nonhazardous solid wastes are disposed of off-site through local permitted facilities.

Chemicals are not manufactured at either the Knolls Laboratory or Kesselring Site but are used incidental to operations at both facilities. Those substances characterized as hazardous by Federal and State regulations are controlled through administrative procedures and personnel training. Small amounts of chemical wastes are generated and disposed of off-site by waste vendors operating under permits issued by the cognizant Federal and State regulatory agencies. Handling and storage incidental to shipment of wastes are controlled and monitored by trained personnel in compliance with applicable permits and regulations. The Knolls Laboratory and Kesselring Site strive to minimize the quantity of hazardous and solid waste that they produce. Waste avoidance, beneficial reuse, and recycling are practiced whenever practicable.

Accountability and radiation survey procedures are used at the Knolls Laboratory (including SPRU) and the Kesselring Site for the handling, packaging, and transportation of all radioactive materials. Shipments of radioactive materials are performed in accordance with detailed written procedures to ensure compliance with all applicable regulations of the U.S. Department of Transportation (DOT), the DOE, and the U.S. Nuclear Regulatory Commission (NRC). All Knolls Laboratory and Kesselring Site generated wastes that contain radioactive constituents are regulated under the Atomic Energy Act of 1954 and applicable DOE requirements. The volume of solid radioactive waste that requires disposal is minimized by using procedures that limit the amount of materials that become contaminated and by recycling. Radioactive wastes are shipped to government owned or licensed disposal sites. During 2018, approximately 24,408 cubic meters (31,925 cubic yards) of low-level radioactive waste were shipped from the Knolls Laboratory, SPRU, and the Kesselring Site for disposal. The majority of this volume was due to SPRU demolition debris and water.

The Knolls Laboratory (including SPRU) and the Kesselring Site are within the DOE and EPA standards governing the release of radioactivity to the environment. The annual average concentration of Knolls Laboratory and Kesselring Site radioactivity in liquid and gaseous effluents at the boundary of each Site corresponded to less than one percent of the permissible DOE radioactivity concentration standards. Radionuclide air emissions were also less than one percent of the EPA air emission standard. Radiation dose to the general public as a result of Knolls Laboratory and Kesselring Site operations was too small to be measured and, therefore, was estimated using conservative calculation techniques that provide an upper bound on the potential dose. The maximum potential annual dose to an individual off-site was less than 0.1 mrem per year. This is less than one percent of the numerical guide established by the NRC for commercial reactor sites to demonstrate that radioactive materials in effluents released to unrestricted areas are as low as reasonably achievable. The maximum potential annual dose is also less than ten percent of the total radiation a person aboard a commercial airplane would receive from cosmic sources during one coast-to-coast flight. The estimated annual collective dose to the entire population within 80 kilometers (50 miles) of either the Knolls Laboratory or the Kesselring Site was less than 0.1 person-rem, which corresponds to less than one thousandth of one percent of the dose received by that population from normal background radiation.

In summary, the operations and activities at the Knolls Laboratory (including SPRU) and the Kesselring Site continue to have no adverse effect on human health or the quality of the environment.

To improve clarity in this report, the following naming conventions are used:

- Knolls Laboratory refers to the Naval Nuclear Propulsion Program (NNPP) facility in Niskayuna, New York only.
- Kesselring Site refers to the NNPP facility in West Milton, New York only.
- SPRU refers to the overall DOE-EM SPRU project in Niskayuna, New York.
- SPRU DP refers to the SPRU Disposition Project, which is the portion of the SPRU project involved with the Buildings G2 and H2 Decontamination and Decommissioning (D&D) in Niskayuna, New York.

TABLE 1
KNOLLS LABORATORY RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Media Monitored	Analysis Frequency	Routine Analysis
Liquid Effluent		
• Outfall 002	Monthly – Continuous Composite Sample	Gross Alpha, Gross Beta, H-3, Sr-90, Cs-137
• Outfall 03A • Outfall 03D • Outfall 03E • Lower Level Parking Lot Seepage	Monthly – Grab Sample	Gross Alpha, Gross Beta, Sr-90
	Quarterly Composite Sample	Cs-137
• Outfall 004 (Lower Level Road Ditch)	Monthly – Grab Sample	Gross Alpha, Gross Beta, Sr-90, Cs-137
• Outfall 03B • West Landfill Stream	Monthly Grab Samples taken and combined into a Quarterly Composite for analysis	Gross Alpha, Gross Beta, Sr-90, Cs-137 if Gross Beta >10 pCi/l
• Upper West Boundary Stream (Background) • Mohawk River – Incoming river water to Lower Level Pumphouse (Outfall 001) (Background)	Monthly – Grab Sample	Gross Alpha, Gross Beta, H-3, Sr-90, Cs-137
• East Boundary Stream (Upper and Lower (Outfall 006)) • Midline Stream (Outfall 005)	Monthly Grab Samples taken and combined into a Quarterly Composite for analysis	Gross Alpha, Gross Beta, Sr-90, Cs-137
• Mohawk River Bank Seepage	At least annually	If sufficient sample volume: Gross Alpha, Gross Beta, Sr-90, Cs-137

TABLE 1 (continued)
KNOLLS LABORATORY RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Media Monitored	Analysis Frequency	Routine Analysis
Sanitary Effluent	Weekly – 24-hour composite sample	Gross Alpha, Gross Beta
	Quarterly Composite of weekly samples	H-3, Co-60, Sr-90, Cs-137, Uranium
Municipal Drinking Water Systems • Schenectady • Niskayuna • Latham/Colonie	Monthly Grab Samples taken and combined into a Quarterly Composite for analysis	Gross Alpha, Gross Beta; Sr-90, Cs-137 if Gross Beta >10 pCi/l
Knolls Laboratory Service Water	Monthly Grab Sample	Gross Alpha, Gross Beta, H-3, Sr-90, Cs-137
Mohawk River Water		
• 1000 feet upriver • 3000 feet downriver	Second, Third, and Fourth Quarters	Gross Alpha, Gross Beta; Sr-90, Cs-137 if Gross Beta >10 pCi/l
• 2000 feet upriver • 4500 feet downriver	Second, Third, and Fourth Quarters	Gross Alpha, Gross Beta, Sr-90, Cs-137
Mohawk River Sediment	Second, Third, and Fourth Quarters	Gross Beta, Cs-137, Uranium, Plutonium; Sr-90 on seven sediment samples in second quarter sample set only
Mohawk River Fish • Upriver above Lock 7 • Downriver below Outfall 002	Annually	Sr-90, Cs-137, Plutonium
Groundwater	Annually	Gross Alpha, Gross Beta, H-3, Sr-90, Cs-137 (Well points – H-3 only)
Stack Air Effluents		
• Particulate Radioactivity • Radioiodine	Weekly	Gross Alpha, Gross Beta on Filter Papers; Gamma Spectrometry on Charcoal Cartridges
• Krypton-85	Continuous	Noble Gas Monitor System
Environmental Air		
• Particulate Radioactivity	Weekly	Gross Alpha, Gross Beta on Filter Papers
• Radioiodine	Bi-monthly	Gamma Spectrometry on Charcoal Cartridges
Environmental Radiation	Quarterly	Gamma Radiation

TABLE 2
KNOLLS LABORATORY NONRADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Media Monitored	Analysis Frequency	Routine Analysis
Liquid Effluent		
• Outfall 002	Continuous	Flow, Temperature
	Weekly	pH, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Oil & Grease, Total & Net Total Copper (when Copper Ion Generator is in use)
	Quarterly (during calendar years ending in "1" or "6")	Whole Effluent Toxicity (WET) Testing
• Outfall 03B	Continuous	Flow, Temperature
	Weekly	pH, Total & Net Total Copper (when Copper Ion Generator is in use)
	Monthly	Net TSS, Oil & Grease
• Outfall 03D	Continuous	Flow, Temperature
	Weekly	pH, Total & Net Total Copper (when Copper Ion Generator is in use)
	Monthly	TSS, Oil & Grease
• Outfall 03A	Quarterly	Flow, pH, TSS, Thallium, Oil & Grease
• Outfall 03E	Quarterly	Flow, pH, TSS, Oil & Grease
• Outfall 004 • Outfall 005 • Outfall 006	Quarterly	Flow, pH, TSS, Oil & Grease, Chemical Oxygen Demand (COD), Chloride, Thallium [Outfall 004 only], Volatile Organic Compounds (VOCs) [Outfalls 004 & 005 only] (EPA 601)
• East Boundary Stream, Upstream • East Boundary Stream, Downstream (Outfall 006)	Annually concurrent with landfill well sampling	Flow, Temperature, pH, Dissolved Oxygen (DO), Specific Conductance, Chloride, VOCs (EPA 601)
• Mohawk River Upstream (Outfall 001)	Continuous	Flow, Temperature
	Weekly	pH, TSS, TDS, Total Copper (when Copper Ion Generator is in use)
• Mohawk River Upstream & Downstream	Quarterly	Chloride
• Sanitary Effluent	Daily	Flow, pH
	Weekly 24-hour composite	Biological Oxygen Demand, 5-day test (BOD-5), COD, TSS, Ammonia, Nitrate, Nitrite, Total Kjeldahl Nitrogen (TKN), Total Organic Nitrogen (TON), Total Nitrogen, Phosphate, Oil & Grease
	Monthly	Flow (Pump run-time based)

TABLE 2 (continued)
KNOLLS LABORATORY NONRADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Media Monitored	Analysis Frequency	Routine Analysis
Groundwater		
• Landfill Wells	Annually	Field Parameters, VOCs (EPA 601)
• Land Area Wells	Annually	Field Parameters, Filtered & Unfiltered Metals, Turbidity, VOCs (EPA 601 and 602)
• Hillside and Lower Level Wells	Annually	Field Parameters, VOCs (EPA 601 and 602)
• Hillside Remediation Wells	Annually	Acetone, Hexane (EPA 624), Field Parameters, VOCs (EPA 601 and 602)
• Former High Yard Area Wells	Quarterly	VOCs (EPA 8260), PCBs (EPA 8082)

TABLE 3
KESSELRING SITE RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Media Monitored	Analysis Frequency	Routine Analysis
Liquid Effluent		
• Retention Basins • Outfalls 001, 002	Monthly Composite Monthly Grab Sample	H-3, Co-60
• Glowegee Creek Water	Quarterly	Co-60
• Glowegee Creek Sediment	Quarterly	Co-60
• Glowegee Creek Fish	Annually	Co-60
• Groundwater (Hogback Road Landfill, Developed Area, and Perimeter Area Wells)	Annually	H-3, Co-60, Cs-137
Stack Air Effluents		
• Particulate Radioactivity	Bi-monthly	Co-60
• Radioiodine	Bi-weekly	I-131
• H-3/C-14	Weekly	H-3, C-14
Environmental Air		
• Particulate Radioactivity	Bi-monthly	Co-60
• Radioiodine	Bi-weekly	I-131
Environmental Radiation	Quarterly	Gamma Radiation

TABLE 4
KESSELRING SITE NONRADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Media Monitored	Analysis Frequency	Routine Analysis
Liquid Effluent		
• Outfall 001 • Outfall 002	Daily, when discharging from Outfalls 001 and 002	Flow, Temperature, Total Residual Chlorine
	Monthly	pH, Oil & Grease, TSS, Nitrite, Total Iron, Total Phosphorus, Total Zinc, Total Boron, Total Sulfite, Ammonia
• Outfall 003	Daily	Flow
	Week Days	Settleable Solids, pH, DO, Temperature
	Monthly	Nitrite, Available Cyanide, Ammonia, Total Surfactants (Methylene Blue Active Substances (MBAS)), Dissolved Copper, BOD-5, TSS, Total Phosphorus, Total Zinc, Total Copper, Total Iron, Total Boron, Total Aluminum, Butyl Benzyl Phthalate
• Outfall 02B	Monthly	Nitrite, Ammonia, Total Residual Chlorine
Glowegee Creek Water	Daily, when discharging from Outfalls 001 and 002	Temperature
Glowegee Creek Fish	Annually	Species Survey
Groundwater		
• Hogback Road Landfill	Annually	Field Parameters, Modified Routine List, VOCs (SW-8021B)
• Developed Area	Annually	Field Parameters, VOCs (EPA 601 and 602)
Drinking Water System		
• Head Tank 27B	Annually	Disinfection Byproducts (Trihalomethanes, Haloacetic Acids)
• Entry Point to the Distribution System	Daily	Free Chlorine Residual
	Annually	Nitrates
	Every 3 years	Group 1 and Group 2 Pesticides, Dioxin, and Polychlorinated Biphenyl(s) (PCBs), Arsenic, Barium, Cadmium, Chromium, Mercury, Selenium, Fluoride, Antimony, Beryllium, Nickel, Sulfate, Thallium, Cyanide
	Every 9 years	Asbestos
• Distribution System (various locations)	Minimum three times per month	Total Coliform, Free Chlorine Residual
	Every 3 years	Lead, Copper
• Treatment Locations	Every 3 years and Annually	Principal Organic Contaminants (POC), Vinyl Chloride, and Methyl Tertiary Butyl Ether (MTBE) (EPA 524.2)

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INTRODUCTION

The Knolls Laboratory and the Kesselring Site are operated by Fluor Marine Propulsion, LLC (FMP), under contract with the DOE and are both United States Government owned facilities. The principal function at the Knolls Laboratory is research and development in the design and operation of naval nuclear propulsion plants. The Kesselring Site is dedicated primarily to the training of personnel in the operation of these plants. Knolls Laboratory and Kesselring Site are two of four DOE sites that make up the Naval Nuclear Laboratory (NNL), which refers to the collective operations of these sites performing NNPP work and the personnel operating at these associated locations.

The Knolls Laboratory is located in the Town of Niskayuna, New York, approximately two miles (3.2 kilometers) east of the City of Schenectady (Figure 1). The Knolls Laboratory is situated on 170 acres of land on the south bank of the Mohawk River. Facilities at the Knolls Laboratory include administrative offices; machine shops; a sewage pumping station; a boiler house; oil storage facilities; cooling towers; waste storage facilities; and chemistry, physics, and metallurgical laboratories. The surrounding area is a mixture of open land, other light industry, small farms, a closed municipal landfill, a small municipal park, and suburban residential areas.

The Separations Process Research Unit (SPRU) was operated at the Knolls Laboratory from 1950 to 1953 as a pilot plant to research chemical processes to extract uranium and plutonium from irradiated uranium. The historical SPRU operations resulted in contamination of the facilities (Buildings G2 and H2, also known as the SPRU Disposition Project or SPRU DP) and land areas where waste handling operations occurred. The SPRU work is being performed by a separate contract under DOE-EM. URS Corporation (URS) is under contract for the Buildings G2 and H2 areas. Information on the SPRU project is provided in a later section of this report. Separate information can also be found at the DOE-EM website *http://www.spru.energy.gov*.

The Kesselring Site is located near West Milton, New York, approximately 17 miles (27.4 kilometers) north of the City of Schenectady, nine miles (14.5 kilometers) southwest of Saratoga Springs and 13 miles (21 kilometers) northeast of Amsterdam (Figure 1). The Kesselring Site consists of 3900 acres on which are presently located two operating pressurized-water naval nuclear propulsion plants and support facilities, including administrative offices, machine shops, training facilities, equipment service buildings, chemistry laboratories, a boiler house, oil storage facilities, cooling towers, waste storage facilities, and wastewater treatment facilities. Additionally, there have been two other nuclear propulsion plants operated at the Kesselring Site, the S3G plant (shut down in 1991) and the D1G plant (shut down in 1996). The dismantlement process began in 1998 after completion of the National Environmental Policy Act (NEPA) process. The dismantlement of the S3G plant was completed in 2006 and the dismantlement of the D1G plant is still in process. The surrounding area is a rural, sparsely populated region of wooded lands through which flow the Glowegee Creek and several small streams that empty into the Kayaderosseras Creek.

Liquid effluents are monitored at the Knolls Laboratory and the Kesselring Site for the chemical parameters listed in the applicable State Pollutant Discharge Elimination System (SPDES) permits and for radioactivity. At the Knolls Laboratory, the Outside Users Agreement with the

Town of Niskayuna specifies the chemical parameters and radioactivity required to be monitored in the sanitary sewage effluent. Analyses are also performed on effluent and receiving stream water samples for select chemical parameters, some of which have State water quality standards. Additionally, fish, water, and bottom sediment samples from the receiving streams are collected periodically and analyzed for radioactivity. Nonradiological industrial air emission sources do not require continuous monitoring under the terms of current New York State air regulations due to the combustion fuels used and the very low levels of emissions from overall operations at the Knolls Laboratory and the Kesselring Site. Airborne effluents from the main radiological emission points are continuously sampled for radioactivity. Other minor radiological emission points are evaluated for their potential for release, and a periodic measurement protocol is used to confirm the low radionuclide emissions. In addition, radiation levels around the perimeter of the Knolls Laboratory, the Kesselring Site, and at several off-site background locations are monitored with sensitive thermoluminescent dosimeters.

The quantities of radioactivity contained in liquid and gaseous effluents during operations in 2018 at the Knolls Laboratory and the Kesselring Site were too small to have a measurable effect on normal background radioactivity. Solid radioactive wastes are packaged and shipped from the sites in accordance with all applicable DOT, DOE, and NRC regulations.

The use of chemically hazardous substances at the Knolls Laboratory and the Kesselring Site is strictly limited to the types and quantities essential for operations. On-site handling of hazardous waste is performed by trained personnel in accordance with applicable regulations and permits. The transportation and disposal of hazardous waste is limited to vendors operating under permits issued by the cognizant Federal and State regulatory agencies. Additionally, all Knolls Laboratory and Kesselring Site personnel receive training on the hazards of chemical substances. Other types of solid waste produced on-site, such as cafeteria waste, are disposed of at off-site permitted facilities. Paper, cardboard, glass, wood, and plastic are also segregated for recycling whenever possible. Scrap metals are recycled through local vendors.

Effluent and environmental surveillance programs are conducted at both the Knolls Laboratory and the Kesselring Site in accordance with applicable DOE Orders to monitor conformance with applicable Federal and State standards and to confirm that operations have had no adverse impact on the environment or the public. Knolls Laboratory and Kesselring Site policy is to minimize releases to levels that are as low as reasonably achievable. A summary of the year’s routine monitoring data for each site is presented and assessed in this report.

Demonstration of compliance with environmental regulations is an integral part of the mission at both the Knolls Laboratory and the Kesselring Site and is necessary for each site’s operations. Federal, State, and local regulatory personnel periodically perform site visits and inspections of the Knolls Laboratory, SPRU, and the Kesselring Site. During 2018 a total of eleven of these visits and/or inspections were performed. Any questions or deficiencies identified during these visits and/or inspections were immediately addressed or promptly corrected.

Areas where historical petroleum or chemical spills have been identified were reported to appropriate regulatory authorities. These areas have been remediated or will be in the future to meet State requirements.

FIGURE 1

KNOLLS LABORATORY (INCLUDING SPRU) AND KESSELRING SITE LOCATIONS IN RELATION TO THE SURROUNDING COMMUNITIES

Numerous programs to reduce the potential for environmental effects from operations at the Knolls Laboratory and the Kesselring Site have been implemented over the years. Additionally, both sites work to minimize the amount of hazardous waste generated annually.

A later section of this report provides information on radiation and radioactivity for those who may not be familiar with radiological terms and concepts.

ENVIRONMENTAL PROGRAM & COMPLIANCE

ENVIRONMENTAL PROGRAM

Policy

The Knolls Laboratory and the Kesselring Site are committed to conducting operations and activities in a manner that provides and maintains safe and healthful working conditions, protects the environment and surrounding communities, and conserves natural resources. The Knolls Laboratory and the Kesselring Site are committed to environmental excellence through compliance with applicable Federal, State, and local regulations; proactive planning to integrate sound environmental, safety, and health (ESH) principles into every aspect of the work, including hazard identification and risk assessment; and a commitment to waste minimization and pollution prevention.

Objectives

The objectives of the environmental monitoring programs are to:

- Demonstrate compliance with regulatory requirements,
- Demonstrate that operations do not significantly impact the environment,
- Confirm the effectiveness of control methods in preventing increases in environmental radioactivity levels,
- Confirm that the potential radiation exposure received by a member of the public is insignificant compared to the dose received from natural background radioactivity,
- Provide accurate monitoring results to applicable Federal, State, and local officials and to the general public, and
- Maintain an accurate record of effluent releases to the environment from the Knolls Laboratory and the Kesselring Site.

Organization

The Knolls Laboratory and the Kesselring Site employ environmental staff professionals to ensure environmental responsibilities are met while also fulfilling the mission of each site. Although the Knolls Laboratory and Kesselring Site each have distinct ESH organizations, there is significant collaboration between the two sites' ESH organizations to optimize personnel expertise, establish uniform practices, and promote the sharing of best practices. These organizations are responsible to identify, interpret, and communicate ESH requirements to facility personnel for implementation, assist other Knolls Laboratory and Kesselring Site organizations in meeting their ESH responsibilities, monitor ESH activities for compliance, interface with regulatory agencies, and complete required regulatory reports.

ENVIRONMENTAL, SAFETY, AND HEALTH MANAGEMENT SYSTEM

The NNL Environmental, Safety, and Health Management System (EMS) documents the management processes and systems to perform work in a manner protective of employees, the public, and the environment, while ensuring regulatory compliance. Environmental performance objectives, performance targets, and deliverables are prepared and reviewed annually. The management processes and systems are used to identify, communicate, implement, assess, and update environmental programs.

ENVIRONMENTAL COMPLIANCE

Demonstration of compliance with environmental regulations is an integral part of the Knolls Laboratory and Kesselring Site missions and is necessary for successful site operations. Federal and State regulatory personnel periodically perform site visits and inspections of the Knolls Laboratory, SPRU, and Kesselring Site. Table 5 depicts a list of the visits and inspections that occurred in 2018.

TABLE 5
SUMMARY OF VISITS & INSPECTIONS BY REGULATORY AGENCIES

Knolls Laboratory		
Date	**Purpose**	**Regulatory Agency**
02/21/18	NYSDEC SPDES Permit Administrative Modification Site Visit	NYSDEC – Central DOW
05/07/18	NYSDEC Fish and Wildlife – Verification Monitoring Observation	NYSDEC – Central Office
05/08/18	EPA Multimedia Inspection	EPA – Region 2
05/09/18	Knolls Laboratory Landfill Inspection	NYSDEC – Central Office
06/20/18	Annual SPDES Inspection	NYSDEC – Region 4
07/18/18	RCRA Corrective Action Program Review	NYSDEC – Region 4
Kesselring Site		
Date	**Purpose**	**Regulatory Agency**
02/15/18	Annual SPDES Inspection	NYSDEC – Region 5
05/07/18	EPA Multimedia Inspection	EPA – Region 2
06/06/18	Drinking Water Sanitary Survey	NYSDOH
08/30/18	PBS/UST/CBS Inspection	NYSDEC – Region 5
SPRU		
Date	**Purpose**	**Regulatory Agency**
07/19/18	RCRA Corrective Action Program Review	NYSDEC – Region 4

Any questions or deficiencies identified during these visits and/or inspections were immediately addressed or promptly corrected. Over 90 periodic environmentally related reports were filed with Federal, State, and local agencies during 2018.

The Knolls Laboratory, SPRU, and Kesselring Site environmental permits, registrations, or agreements in effect during 2018 that were issued from regulatory agencies for specific facilities or operations are shown in Table 6. New York State General Permits for Stormwater Discharges implemented by the Knolls Laboratory or the Kesselring Site for construction projects one acre or greater or for work in wetlands or streams are not included in Table 6 if their duration was less than one year. However, the Knolls Laboratory and the Kesselring Site have included Municipal Separate Storm Sewer System (MS4) Permits that cover day-to-day operations with regard to stormwater management.

TABLE 6
KNOLLS LABORATORY, KESSELRING SITE, AND SPRU ENVIRONMENTAL PERMITS

Permit Number	Permit Type	Issuing Agency	In Compliance	Expiration Date	Other Information
KNOLLS LABORATORY					
NY0005851	SPDES	NYSDEC	Yes	06/30/20	Site Outfalls
4-4224-00024/00052	Water Withdrawal	NYSDEC	Yes	05/20/25	Initial Water Withdrawal Permit
94 3850	Sanitary	Town of Niskayuna	Yes	None	Outside Users Agreement for Sanitary Sewer Service
GP-0-15-003	SPDES	NYSDEC	Yes	04/30/17(1)	MS4 General Permit Knolls Laboratory ID# NYR20A026
GP-0-15-002	SPDES	NYSDEC	Yes	01/28/20	Construction General Permit - Clean Soil Management Areas II (ID# NYR10H590), III (ID# NYR10N657), IV (ID# NYR10T230); Building P9 (ID# NYR10Z507)(2)
4-4224-00024/00001	RCRA	NYSDEC	Yes	07/29/22	RCRA Waste (EPA ID NY6890008992)
4-4224-00024/00039 Mod 4	AE	NYSDEC	Yes	None	Heating Boilers and ASGTF
4-443417	PBSF	NYSDEC	Yes	08/23/23	Oil Storage
KAPL-2012-003	RAE	EPA Region 2	Yes	None	Bldg. D3 Ventilation Duct Removal
49-5-162	Canal	NYSCC	Yes	None	Land Easement Permit
C-OC-201800030	Use & Occupancy Permit	NYSCC	Yes	10/29/18	L4 Pump House Cooling Water Intake Screen
C-OC-201800134	Use & Occupancy Permit	NYSCC	Yes	None	L4 Pump House Cooling Water Intake Screen
C-WK-201800062	Canal Work	NYSCC	Yes	12/31/18(3)	Mohawk River Sampling

Notes for Table 6 are at the bottom of page 16

TABLE 6 (continued)
KNOLLS LABORATORY, KESSELRING SITE, AND SPRU ENVIRONMENTAL PERMITS

Permit Number	Permit Type	Issuing Agency	In Compliance	Expiration Date	Other Information
KESSELRING SITE					
NY0005843	SPDES	NYSDEC	Yes	08/31/23	Site Outfalls
GP-0-15-003	SPDES	NYSDEC	Yes	04/30/17[(1)]	MS4 General Permit Kesselring Site ID# NYR20A027
GP-0-15-002	SPDES	NYSDEC	Yes	01/28/20	Clean Soil Management Area (ID# NYR10F015), West Perimeter Upgrades (ID# NYR10Z523), Entrance Building 116 (ID# NYR11C247)
5-4142-00005/00049	RCRA	NYSDEC	Yes	12/12/23	RCRA Waste (EPA ID NY5890008993)
5-4142-00005/00073	AFR	NYSDEC	Yes	04/19/26	Air Facility Registration
5-000070	BCSF	NYSDEC	Yes	07/19/19	Chemical Storage
5-414506	PBSF	NYSDEC	Yes	08/17/22	Oil Storage
KAPL-788-01	RAE	EPA Region 2	Yes	None	Radiological Work Facility
A-05	Wastewater Sludge	Saratoga County Sewer District #1	Yes	09/23/21	Sewage Waste Treatment Facility (SWTF) Sludge Disposal
GR-042-4	Grease Trap Disposal	Saratoga County Sewer District #1	Yes	12/31/19	Cafeteria Grease Trap Disposal
5-4142-00005/00088	Water Quality Certification	NYSDEC	Yes	None	Security Upgrades Project
NAN-2012-00680-UDE	Nationwide	USACE	Yes	03/18/22	Security Upgrades Project
NAN-2014-01227-UDE	Nationwide	USACE	Yes	03/18/22	Parking Lot Ditch Cleanout Project
5-4142-00005/00089	Water Quality Certification	NYSDEC	Yes	None	Parking Lot Ditch Cleanout Project
SPRU					
4-4224-00024/00055	RCRA	NYSDEC	Yes	09/28/18	RCRA Waste (EPA ID NYR000096859)
GP-0-15-002	SPDES	NYSDEC	Yes	None	ID# NYR10R700
KAPL-SPRU-PVU-01	RAE	EPA Region 2	Yes	None	Portable Ventilation Units
UIC ID: 09399036	Surface Water	EPA Region 2	Yes	None	Underground Injection Control (UIC) using French Drain System

Notes:
1. NYSDEC has not issued the final MS4 permit to replace the current permit which expired on April 30, 2017. In the interim, the expired permit remains administratively in effect.
2. Notice of Termination submitted to NYSDEC on November 30, 2018.
3. Permit is obtained annually.

A description of the Knolls Laboratory and the Kesselring Site's compliance with key environmental regulations is provided in the proceeding pages. Information on SPRU compliance is also provided, where applicable.

Clean Water Act (CWA)

The Federal CWA and the New York State Environmental Conservation Law (ECL) regulate the chemical components and physical attributes of liquids discharged to the surface waters of the State of New York. Specifically, the Knolls Laboratory and the Kesselring Site effluent and environmental standards are established in site-specific SPDES Permits issued by NYSDEC. New York State water quality standards applicable to the Mohawk River and Glowegee Creek are given in Reference (1). NYSDEC renewed the Knolls Laboratory SPDES permit in 2015, which became effective on July 1, 2015. Subsequently, NYSDEC issued an administrative SPDES permit modification, dated March 30, 2018. NYSDEC renewed the Kesselring Site SPDES permit in 2018, which became effective on September 1, 2018. Renewed permits are generally in effect for five years.

The constituents of the Knolls Laboratory sewage are regulated by an Outside Users Agreement with the Town of Niskayuna as defined in Reference (2).

During 2018, the Knolls Laboratory experienced one SPDES noncompliance event as summarized in Table 7. The Kesselring Site experienced two SPDES noncompliance events as summarized in Table 8.

New York State implements the EPA Phase II Stormwater regulations under the SPDES program through two stormwater general permits applicable to the Knolls Laboratory and the Kesselring Site. The versions in effect during this reporting period were GP-0-15-002 (General Permit for Stormwater Discharges from Construction Activities) and GP-0-15-003 (Municipal Separate Storm Sewer System, or MS4). The Construction Stormwater permit requires the Knolls Laboratory, the Kesselring Site, and SPRU to process Notices of Intent (NOIs) to participate in the NYSDEC's Stormwater general permitting program for sites disturbing one acre or greater of soil. Participation in this general permit also requires preparation of project-specific Stormwater Pollution Prevention Plans (SWPPPs). The MS4 general permits were applicable to the Knolls Laboratory and Kesselring Site because they are Federal facilities and participation required preparation and management of Stormwater Management Programs (SWMPs) for both sites. SPRU was not required to obtain the MS4 permit coverage as they are embedded within the Knolls Laboratory boundaries. In addition to certain administrative documentation requirements listed in each permit, the SPDES general permit for construction activities requires an inspection of the project site at least once every seven days. Post-rainfall inspections are required for specific erosion and sediment control practices.

TABLE 7

KNOLLS LABORATORY SPDES NONCOMPLIANCES

Permit Type	Outfall	Parameter	# of Permit Exceedances	# of Samples Taken	# of Compliant Samples	Percent Compliance	Date(s) Exceeded	Description/ Solution
SPDES	002	TSS-Net	1	53	52	98%	02/27/18	See Note 1

Note:

1. The Total Suspended Solids (TSS) SPDES Permit effluent net limit (40 mg/l daily max) was exceeded, with a net value of 53 mg/l. The suspected cause of this non-compliance event is rapid melting of the snow banks from plowing/clearing parking lots and walkways, due to unseasonably warm temperatures (~60°F).

TABLE 8

KESSELRING SITE SPDES NONCOMPLIANCES

Permit Type	Outfall	Parameter	# of Permit Exceedances	# of Samples Taken	# of Compliant Samples	Percent Compliance	Date(s) Exceeded	Description/ Solution
SPDES	001/002	pH	2	28	26	93%	01/04/18	See Note 1
SPDES	North of Bldg. 1	Sanitary Bypass	1	0	0	NA	08/02/18	See Note 2

Notes:

1. The Kesselring Site had two pH permit exceedances in 2018. On January 4, 2018, Environmental Engineering noted high out-of-spec pH from Outfalls 001 and 002. The high pH stemmed from old pH probes not reading the correct values for the system.
2. The Kesselring Site had one sanitary bypass in 2018. On August 2, 2018, during routine sanitary line inspections, a crack North of Building 1 was identified. The sewage was lost into the surrounding ground.

Clean Air Act (CAA)

The Federal CAA and its amendments provide the regulatory basis for the protection of ambient air quality; control and reduction in the emissions of the pollutants carbon monoxide, particulate matter, and those compounds that contribute to the formation of ground-level ozone (i.e., volatile organic compounds (VOCs) and nitrogen oxides (NO_x)); control and reduction of pollutants likely to increase the risk of death or serious illness; control and prevention of accidental releases of regulated hazardous air pollutants or any other extremely hazardous substances; control of the principal contributors to acid rain and other forms of acid deposition (i.e., sulfur dioxide (SO_2) and NO_x); protection of stratospheric ozone; and a mandated Federal permitting program (Title V) for major air emission sources.

The regulatory authority for the majority of the CAA regulations that affect the Knolls Laboratory and the Kesselring Site in New York State has been delegated by the EPA to NYSDEC. Six Federal regulations which currently affect the Knolls Laboratory and the Kesselring Site that have not yet been implemented by the State, but require report submittals, recordkeeping, or operation and maintenance activity tracking are "Standards of Performance for Small Industrial-Commercial-Institutional Steam Generating Units" (40 CFR 60 – Subpart Dc), "National Emission

Standards for Hazardous Air Pollutants Area Sources: Industrial, Commercial, and Institutional Boilers" (40 CFR 63 – Subpart JJJJJJ), "National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities" (40 CFR 61 – Subpart H), "National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines at Area Sources" (40 CFR 63 – Subpart ZZZZ), "Standards of Performance for Stationary Compression Ignition Combustion Engines" (40 CFR Part 60 – Subpart IIII), and "General Compliance Provisions for Highway, Stationary, and Nonroad Programs" (40 CFR 1068). For these six regulations, the EPA retains regulatory authority.

In 2016, 6 NYCRR Part 225.1, "Fuel Combustion and Use – Sulfur Limitations," became effective and regulates the sulfur content of diesel fuels combusted in stationary sources to a maximum of 0.0015% sulfur. Both Knolls Laboratory and the Kesselring Site have stationary combustion sources (emergency power generators and site heating boilers) subject to this regulation. In December 2016, NYSDEC adopted 6 NYCRR Part 222, Distributed Generation Sources (DGS), which established emission standards, monitoring requirements and recordkeeping requirements for certain DGS in New York State. In March of 2017, this regulation was stayed due to a lawsuit filed by several New York based industries and has yet to be reinstated.

A number of air emission sources at both the Knolls Laboratory and the Kesselring Site, such as site heating boilers, are regulated under the NYSDEC Air Permitting/Registration Program (see Table 6). In addition to the site heating boilers at the Knolls Laboratory, one of the two Advanced Steam Generator Test Facility (ASGTF) water heaters is also regulated by the EPA under 40 CFR 60 – Subpart Dc. Both the Knolls Laboratory heating boilers and the ASGTF water heaters are permitted under a NYSDEC Air State Facility Permit, which was renewed in January 2010 and is still in effect.

The Air State Facility permit for the Knolls Laboratory heating boilers has federally enforceable capping provisions that allow the heating boilers to be classified as synthetic minor sources. As such, the Knolls Laboratory does not require a Title V facility permit, which normally applies to major sources under the CAA.

During the renewal process for the Kesselring Site's NYSDEC Air Facility Registration for its two boiler house stacks, which exhausts the Kesselring Site's two heating boilers, NYSDEC stated that the Kesselring Site no longer had the potential to emit contaminants above the Title V thresholds. Therefore, the Kesselring Site no longer had to comply with the State's cap-by-rule provisions, and this requirement was removed from the Site's new Air Facility Registration requirements in 2016. The Kesselring Site heating boilers are considered an area source and do not require a Title V or a State Facility Permit.

The air emission sources listed in Table 6 have been operated in accordance with their permit or facility registration conditions.

Other nonradioactive air emission sources that do not require State permits or registrations at the Knolls Laboratory and Kesselring Site either come under an exemption for ventilating and exhausts from laboratory operations, NESHAPs minor source exemptions presently in effect, or are considered as exempt or trivial activities under New York State regulations.

The EPA, under 40 CFR 61 Subpart H, regulates radionuclide air emission sources at the Knolls Laboratory (including SPRU) and the Kesselring Site. During 2018, the maximally exposed individual effective dose equivalent, calculated using the EPA computer code CAP88-PC, was less than 0.1 mrem for the Knolls Laboratory, including SPRU, and the Kesselring Site, which is less than 1% of the 10 mrem/year EPA standard. Annual radionuclide air emission reports are provided to the EPA, as required by the regulations, and also to NYSDEC.

Resource Conservation and Recovery Act (RCRA)

The Federal RCRA and the New York State ECL were enacted to address the safe disposal of municipal and industrial solid and hazardous waste. RCRA, like most environmental legislation, encourages States to develop their own hazardous waste programs as an alternative to direct implementation of the Federal program. To this end, the EPA has delegated its authority to NYSDEC for all aspects of RCRA, with the exception of a few specific portions associated with the 1984 Hazardous and Solid Waste Amendments (HSWA) to RCRA.

During 2018, the Knolls Laboratory and the Kesselring Site continued to operate as both hazardous waste generators and permitted storage facilities. In this latter instance, the Knolls Laboratory and the Kesselring Site received their original NYSDEC, 6 NYCRR Part 373, hazardous waste storage permits in July 1998 and June 1995, respectively. As such, both the Knolls Laboratory and the Kesselring Site must follow specific requirements for handling and accumulation of hazardous waste under applicable New York State regulations as well as the conditions for storage of such waste under their respective State-issued hazardous waste management permits. Hazardous waste management permits are generally in effect for ten years. The Knolls Laboratory permit was renewed on July 30, 2012. The Kesselring Site permit was renewed on December 13, 2013. Representatives from the EPA inspect both the Knolls Laboratory and the Kesselring Site annually for compliance.

SPRU personnel and contractors manage universal/hazardous/mixed waste in accordance with 6 NYCRR Parts 370-373, Part 376, and Part 374-3 regulations, as applicable, and ship waste to permitted Treatment, Storage, and Disposal Facilities (TSDFs). Storage of mixed TRU waste at SPRU is managed under a NYSDEC issued consent order pending issuance of a 6 NYCRR Part 373 Hazardous Waste Management Permit. In 2018, SPRU operated as a small quantity generator.

RCRA Corrective Action Program

The 1984 HSWA to RCRA expanded EPA's authority to require TSDFs to conduct corrective action for releases from a facility. Under this section of RCRA, the EPA or an authorized State must require corrective action for all releases of hazardous waste or constituents from any solid waste management unit at a TSDF seeking a permit under RCRA, regardless of the time at which the waste was placed in such units. The regulations implementing this section of RCRA define the term "solid waste management unit (SWMU)" to include: any discernible unit at which solid wastes have been placed at any time, irrespective of whether the unit was intended for the management of solid or hazardous waste. Such units include any area at a facility at which solid wastes have been routinely and systematically released.

NYSDEC has been granted authority by the EPA to manage their own RCRA 3004(u) corrective action program via the New York State ECL. The Knolls Laboratory and the Kesselring Site 6 NYCRR Part 373 hazardous waste permits require each site to pursue facility characterization and corrective action, if necessary. In addition to the SWMUs included in each of the permits, New York State has also established "areas of concern" or AOCs. An AOC is an area that is not at this time known to be a SWMU, where hazardous waste and/or hazardous constituents are present, or are suspected to be present as a result of a release from the facility. The term includes areas of potential or suspected contamination as well as actual contamination. Such area(s) may require study and a determination of what, if any, corrective action may be necessary.

The Knolls Laboratory and the Kesselring Site are performing RCRA corrective action efforts under the oversight of NYSDEC. Each site has several areas where historical releases of hazardous chemicals require sampling and potential remedial action. Reports of sample analytical results and actions taken are submitted for NYSDEC approval as they are accomplished, in accordance with established schedules.

SPRU performs RCRA corrective actions in accordance with DOE-EM 6 NYCRR Part 373 Permit No. 4-4224-00024/00055 (issued as #4-4224-00024/00042) under NYSDEC's authority. This permit is a Corrective Action Only permit, meaning that there are no treatment, storage, or disposal provisions included therein. During 2018, the SPRU site completed the remediation of the G2 AOC and Upper Level SWMUs; and received NYSDEC concurrence for backfilling the corresponding excavations. Close out of those areas is dependent on NYSDEC approval of the closure reports, with completion of site restoration expected in 2019.

Federal Facility Compliance Act (FFCA)

The FFCA was signed into law in October 1992 as an amendment to the Solid Waste Disposal Act (SWDA). The FFCA applied certain requirements and sanctions of RCRA to Federal facilities. In short, the FFCA waives sovereign immunity for Federal facilities from all civil and administrative penalties and fines; this includes waivers for both coercive and punitive sanctions for violations of the SWDA. Relative to mixed waste, the FFCA mandated the development and Federal/State approval of Site Treatment Plans (STPs), that contain schedules for developing treatment capabilities and for treating mixed wastes subject to the Land Disposal Restrictions (LDR) of 40 CFR 268 and 6 NYCRR 376.

The DOE Naval Reactors Laboratory Field Office (NRLFO) and the NYSDEC signed Administrative Consent Orders in October 1995 to establish commitments regarding compliance with the approved STPs for mixed wastes stored and generated at the Knolls Laboratory and the Kesselring Site. NRLFO and NYSDEC terminated the Kesselring Site's Administrative Consent Order in August 2009, because the requirements and milestones established in the Kesselring Site STP had all been completed. In compliance with the Knolls Laboratory's Order, the STP is updated annually and issued to NYSDEC by June 30 each year, as needed. The Knolls Laboratory STP has met all of its milestones with the exception of the mixed transuranic remote handled waste stream, which has yet to be generated. The SPRU RCRA Permit authorizes transfer of small amounts of mixed waste to the Knolls Laboratory permitted area until shipped off-site by SPRU in accordance with DOE-EM's STP.

Waste Minimization, Pollution Prevention, and Recycling Programs

The Knolls Laboratory and Kesselring Site waste minimization and pollution prevention programs promote pollution prevention and waste minimization by encouraging employees to reduce the initial use of hazardous materials, energy, water, and other resources while protecting existing resources through conservation and more efficient use. The program focuses mainly on process efficiency improvements; source reduction; inventory control; preventive maintenance; improved housekeeping; recycling; and increasing employee awareness of, and participation in, pollution prevention.

The goal of the Pollution Prevention Program is to minimize the quantity and toxicity of waste generated at its source and, if waste is generated, to ensure that the treatment and disposal method used minimizes the present and future threat to people and the environment. The program consists of the following elements:

- Control of chemical acquisitions, including type and quantity;
- Maximized use of on-hand chemicals;
- Minimized production of process wastes (Source Reduction); and
- Process evaluation and modification.

The Knolls Laboratory and the Kesselring Site ensure that pollution prevention strategies are met by reviewing chemical purchases and major construction projects to incorporate source reduction strategies for environmentally hazardous substances.

Consistent with the EMS, which serves as the foundation of both the Knolls Laboratory and the Kesselring Site environmental management programs, both facilities established and implemented a sustainable acquisition program.

Progress in sustainable acquisition is reported annually to the DOE via the DOE Sustainability Dashboard, formerly the Consolidated Energy Data Report (CEDR). Sustainable acquisition maximizes the amounts of material procured that contain recycled material. Environmentally preferable items reported in the Knolls Laboratory and Kesselring Site programs include but are not limited to: paper and paper products, vehicular products (e.g., engine coolants, oils), construction (e.g., insulation, carpet, concrete, paint) and transportation products (e.g., traffic barricades, traffic cones), park and recreation products, landscaping products, non-paper office products (e.g., binders, toner cartridges, office furniture), and miscellaneous products (e.g., pallets, sorbents, and industrial drums).

The Knolls Laboratory and the Kesselring Site facilities both maintain an extensive recycling program which includes office paper, cardboard, newspapers, telephone books, printer cartridges, scrap metal, batteries, scrap lead, cooking oil, aluminum cans, asphalt, concrete, tires, oil, light bulbs, circuit boards, computer equipment, magnetic media, precious metals, and wood. The facilities recycled approximately 53% of their waste streams in 2018.

SPRU complied with DOE Order 450.1, "Environmental Protection Program" that contains DOE Sustainable Environmental Stewardship goals, which include the goals to reduce or eliminate the acquisition, use, and release of toxic and hazardous chemicals and materials and to maximize the acquisition and use of environmentally preferable products in the conduct of operations.

Toxic Substances Control Act (TSCA)

The U.S. Congress enacted TSCA in 1976. TSCA authorizes EPA to secure information on all new and existing chemical substances and to control any of these substances determined to cause an unreasonable risk to public health or the environment. Unlike many other environmental laws, which generally govern discharge of substances, TSCA requires that the health and environmental effects be reviewed prior to a new chemical substance being manufactured for commercial use. TSCA, therefore, closes the gap in environmental regulations by allowing the EPA to prevent toxic problems rather than simply reacting to them after discharge. However, because the Knolls Laboratory and the Kesselring Site do not manufacture chemicals or materials for commercial use, a majority of the implementing TSCA regulations do not apply.

Polychlorinated biphenyls (PCBs) are regulated as a toxic substance under TSCA by means of 40 CFR Part 761. PCBs were used prior to 1979 mainly as a dielectric fluid in electrical equipment such as transformers and capacitors. PCBs were also added to certain surface coatings and other non-liquid materials due to their heat and chemical resistance. The Knolls Laboratory and the Kesselring Site have identified PCBs in materials such as small electrical transformers, fluorescent light ballasts, applied dried paints, lubricants/machine oils, and electrical cable insulation. The Knolls Laboratory and the Kesselring Site have removed all large PCB transformers from their sites and continue to remove and replace suspected PCB fluorescent light ballasts, where practical. Additionally, both the Knolls Laboratory and the Kesselring Site employ strict controls for removal, storage, and disposal of remaining PCB containing items. Similarly, SPRU manages PCBs in accordance with the requirements of TSCA under 40 CFR Part 761.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

The Federal CERCLA, or Superfund, was designed to respond to situations involving the past disposal of hazardous substances. As such, it complements RCRA, which regulates on-going hazardous waste handling and disposal.

The National Priorities List is an important facet of CERCLA's response procedures and is updated annually to list sites warranting evaluation and/or cleanup under CERCLA. EPA Region 2, in May 1994, designated both the Knolls Laboratory and the Kesselring Site as Site Evaluation Accomplished following a series of studies and correspondence related to a Preliminary Assessment and Site Inspection Report prepared in accordance with CERCLA Section 120. As a result, neither the Knolls Laboratory nor the Kesselring Site warranted inclusion on the National Priorities List.

Emergency Planning and Community Right-to-Know Act (EPCRA)

The Federal EPCRA establishes authorities for emergency planning and preparedness, emergency release notification reporting, community right-to-know reporting, and toxic chemical release reporting. Under the provisions of this Act, covered facilities must provide the following information to State and local entities: the name of the individual who will function as a Facility Emergency Coordinator, notice that certain applicable substances (e.g., extremely hazardous substances on-site above certain threshold planning quantities) are present at that facility and, when required, report releases of those substances and other listed hazardous substances in excess of certain reportable quantities (RQs). Additionally, EPCRA requires that facilities prepare and submit, or retain on file, the information listed in the following EPCRA Sections below which are codified under 40 CFR Parts 370 and 372:

§ 302-303 Provide initial notification to State Emergency Response Commission (SERC), Local Emergency Planning Committees (LEPCs), and local fire departments that the facility is subject to the emergency planning requirements under EPCRA.

§ 304 Facilities must immediately notify the LEPC and the SERC if there is a release to the environment of a hazardous substance that is equal to or exceeds the minimum reportable quantity set in the regulations.

§ 311 The submission of Material Safety Data Sheets or Safety Data Sheets (MSDS/SDS) for extremely hazardous substances (EHS) stored on-site in quantities greater than the threshold planning quantity (TPQ) or any substance on-site greater than 10,000 pounds for which a potential exposure to an employee exists. Updated SDS are to be submitted within three months of discovery of significant new information about the hazardous chemicals/substances.

§ 312 Complete an annual Tier Two Emergency and Hazardous Chemical Inventory Report for EHS and hazardous chemicals/substances present at each site in excess of specified quantities during the previous calendar year. The information is submitted to the SERC, LEPCs, and local fire departments for emergency planning purposes.

§ 313 Complete an annual evaluation of activities associated with the manufacturing, processing, or otherwise use of any of the listed toxic chemicals above the designated activity thresholds and where necessary prepare a Toxic Release Inventory (TRI) report for submittal to EPA.

The status summary of Knolls Laboratory, Kesselring Site, and SPRU EPCRA Reporting is shown in Tables 9 and 10. There were no EPCRA reportable releases from any of the sites in 2018 and none of the sites were required to submit TRI reports under Section 313 for the 2017 reporting year. Reports are filed in the year following the reporting year's activities (e.g., 2017 activities are reported in 2018).

TABLE 9
KNOLLS LABORATORY & KESSELRING SITE EPCRA REPORTING

EPCRA Section	Description of Reporting	Status
EPCRA § 302-303	Planning Notification	No Notifications required during calendar year 2018
EPCRA § 304	Emergency Release Notification	No Reportable Releases
EPCRA § 311-312	SDS Submittal / Tier Two Emergency and Hazardous Chemical Inventory Reporting	New SDS notifications were made during calendar year 2018
		The Chemical Inventory (Tier Two) Reports for calendar year 2017 filed
EPCRA § 313	TRI Reporting	Not Required

TABLE 10
SPRU EPCRA REPORTING

EPCRA Section	Description of Reporting	Status
EPCRA § 302-303	Planning Notification	No Notifications required during calendar year 2018
EPCRA § 304	Emergency Release Notification	No Reportable Releases
EPCRA § 311-312	SDS Submittal / Tier Two Emergency and Hazardous Chemical Inventory Reporting	No Notifications required for calendar year 2018
EPCRA § 313	TRI Reporting	Not Required

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

The FIFRA gives EPA authority to regulate the field use of pesticides, which EPA implements through a State-administered certification program. Authorized Knolls Laboratory and Kesselring Site personnel applying pesticides, such as cooling tower addition chemicals, keep a daily use log for every application of a general use pesticide. Annual reports are filed and provided to NYSDEC by the certified applicator/technician for all pesticides applied during the previous year. Any such chemical applied by a subcontractor licensed commercial application business or under their guidance is recorded and reported by the subcontractor directly.

National Environmental Policy Act (NEPA)

Significant construction, renovation, demolition, decommissioning, decontamination, and remediation activities are reviewed for their impact on the environment under the NEPA requirements as provided by the DOE. Other projects or capital equipment expenditures that have the potential for creating new emissions to the environment or effect any condition of a permitted or otherwise regulated operation also receive a NEPA evaluation. Summary forms for determinations made for the applicability of the use of Categorical Exclusions (CXs) for NEPA Compliance and all NEPA documentation for the NNPP Sites including the Knolls Laboratory and the Kesselring Site in New York are posted online at the U.S. DOE website located at *www.energy.gov/nepa/office-nepa-policy-and-compliance*.

ENVIRONMENTAL MONITORING

KNOLLS LABORATORY

SITE DESCRIPTION

The Knolls Laboratory is located in the Town of Niskayuna, New York, approximately two miles (3.2 kilometers) east of the City of Schenectady. The Knolls Laboratory is situated on 170 acres of land on the south bank of the Mohawk River. Facilities at the Knolls Laboratory include administrative offices; machine shops; a sewage pumping station; a boiler house; oil storage facilities; cooling towers; waste storage facilities; and chemistry, physics, and metallurgical laboratories. The surrounding area is a mixture of open land, other light industry, small farms, a closed municipal landfill, a small municipal park, and suburban residential areas.

The climate in the region of the Knolls Laboratory is primarily continental in character but is subject to some modification from the maritime climate that prevails in the extreme southeastern portion of New York State. Winters are usually cold and occasionally severe. Maximum temperatures during the colder winter months often are below freezing and nighttime low temperatures frequently drop to 10° Fahrenheit or lower. Sub-zero temperatures occur rather infrequently, about a dozen times a year. Snowfall in the area is quite variable, averaging approximately 65 inches per year. The mean annual precipitation for the region is approximately 44 inches per year. Westerly winds (W to NW) predominate, and a secondary maximum occurs about the south-southeast direction.

The Knolls Laboratory is located in the Mohawk River Valley at an elevation of approximately 330 feet above mean sea level. Monitoring wells and soil/bedrock borings in the vicinity of the Knolls Laboratory show that unconsolidated materials, consisting mainly of glacial deposits, overlie bedrock. The depth of bedrock beneath the site generally ranges between 10 and 70 feet. Rock outcrops are visible on both banks of the Mohawk River between the Rexford Bridge, approximately two miles upstream, and a point about three quarters of a mile downstream from the Knolls Laboratory. The outcrops are shales and sandstones of the Ordovician-age Schenectady Formation. These rocks are characteristically non-porous and impermeable and form poor aquifers. The bedrock structure is relatively simple. Over 90 percent of Schenectady County is underlain by the Schenectady Formation, a series of alternating beds of shale, sandstone, and grit about 2,000 feet thick, which dip gently west and southwest. The Snake Hill formation is exposed along both sides of the Mohawk River near the dam at Lock 7, downstream from the Knolls Laboratory. This formation consists of a considerable thickness of dark gray to black, bluish, and greenish-gray shale. It is the only formation in Schenectady County that is strongly folded, having been thrust westward against and over the Schenectady Formation.

The glacial deposits consist almost entirely of glacial till. The glacial till at the Knolls Laboratory is clay rich, dense, compact, and is known locally as hardpan. The depth of the till beneath the site ranges from 0 to 70 feet. The till appears a grayish-blue color but in the upper 12-foot portion, it has been weathered to a yellowish brown color. Within the till, occasional lenses of graded material, usually fine sand, exist. The till is almost entirely impermeable except for a few lenses of sand, which are capable of transmitting water. These lenses are small in size and isolated from one another based on drilling records and on-site monitoring well performance. Overlying the till in the eastern portion of the site are glacial lake sequences (silts and clays) and thin, discontinuous ice-contact deposits (sands and gravels). The ice-contact deposits are capable of transmitting water, but their limited extent diminishes the potential for yielding useable water volumes.

The Knolls Laboratory is located adjacent to the Mohawk River that serves as the main watercourse for the Mohawk River Drainage Basin, covering an area of 3,450 square miles. The river flows eastward to where it joins the Hudson River in Cohoes, N.Y. The average flow rate (1926–2018) of the Mohawk River is 5,924 cubic feet per second (cfs) and the lowest recorded seven-day minimum flow is 458.1 cfs during August 1995. Three small streams that receive drainage from the Knolls Laboratory are tributaries to the Mohawk River. The East Boundary Stream is located between the Knolls Laboratory closed landfill and the closed Town of Niskayuna landfill. The East Boundary Stream also receives runoff from a nearby housing development and roadway. The Midline Stream originates on-site and drains the central portion of the site. The West Boundary Stream is located adjacent to the Knolls Laboratory on General Electric Global Research Center property. This stream receives some surface water runoff from a tributary ditch from the site. A fourth surface water drainage-way, located on the west side of the closed Knolls Laboratory landfill, is referred to as the West Landfill Stream. This drainage-way does not directly discharge to the Mohawk River and rarely has an observable flow. The flow in all of these streams becomes extremely low to nonexistent during the late summer/early fall. These streams are not accessible to the public, except at the point where they each meet the Mohawk River, nor are they suitable for fishing or swimming.

The groundwater within the immediate vicinity of the Knolls Laboratory is very limited due to both low porosity and permeability of the till which prohibits the development of the groundwater as a potable water supply. As such, there are no drinking water wells on-site. There are no underlying principal or primary bedrock or overburden aquifers. Water for site operations involving potable and noncontact cooling use is obtained from the Schenectady and Niskayuna Municipal Water Systems. The majority of water for noncontact cooling at the Knolls Laboratory is obtained from the Mohawk River.

The Mohawk River is classified by NYSDEC as a Class A stream. The best usages of Class A waters are considered to be: a source of water for drinking, culinary or food processing purposes, primary and secondary contact recreation, and fishing. The waters shall be suitable for fish propagation and survival. The Knolls Laboratory discharges water from its various operations within the concentration, mass loading, and flow limits set by the SPDES Permit, Reference (3).

LIQUID EFFLUENT MONITORING

Sources

Nonradiological: The principal sources of effluent water are:

1. *Sewage Pumping Station* - Knolls Laboratory sewage is pumped to the Town of Niskayuna Publicly Owned Treatment Works (POTW). The untreated sewage consists primarily of wastewater from restrooms, cafeteria services, and janitorial sinks. A small portion may also consist of dilute nonhazardous laboratory rinse water, dilute nonhazardous analytical waste, environmental samples, and ammoniated or phosphated process water.

2. *Cooling Towers* - Cooling water, used mainly for central air conditioning, is treated to maintain a pH range of 7.0 to 7.5, to minimize scale buildup, to prevent corrosion of system materials, and to inhibit the growth of algae and slime. The towers are periodically blown down to control chemistry and some are drained to prevent freezing in the winter. The water drained from the towers is discharged to the Mohawk River.

3. *Site Boiler Plant* - Site boiler water is chemically treated, softened, and de-alkalized. Operations that result in releases are (1) periodic blowdowns to control boiler chemistry and (2) ion exchange resin regeneration effluent from the softener and the de-alkalizer systems. Water generated by the blowdown and de-alkalizer regeneration operations are neutralized and allowed to cool before being discharged to the Mohawk River.

4. *Noncontact Cooling Water* - Mohawk River water and Site Service Water ((SSW) municipal water supply) are used as noncontact cooling media for several heat exchangers and are discharged to the Mohawk River.

5. *Process Water* - Treated/untreated wastewater, primarily from the river water system, is generated on-site. Process water treatment typically consists of one or more of the following processes: sedimentation, filtration, ion exchange, activated carbon adsorption, or neutralization before being discharged to the Mohawk River.

6. *Site Drainage Water* - Stormwater and groundwater also make up a portion of the liquid effluent to the Mohawk River.

Approximate flows and chemical characteristics of the discharges to the Mohawk River (Items 2-6) were incorporated into the SPDES Permit application and Permit, Reference (3).

Radiological: Historically, the concentrations of radioactivity in liquids released from the Knolls Laboratory have always been below all applicable limits. The small volume of liquids generated from current laboratory operations that may contain radioactivity are collected for shipment off-site in an absorbed form to an approved disposal facility. This minimizes the quantities of radioactivity released from the Knolls Laboratory.

The small amounts of groundwater and stormwater that runoff from SPRU contain low level residual radioactivity from operations conducted during the 1950s and 1960s and are released in the site drainage water. The principal radioactive constituents released to the Mohawk River from all sources are the longer-lived fission products strontium-90 and cesium-137.

Effluent Monitoring

Nonradiological: The Knolls Laboratory sanitary sewage is pumped to the Town of Niskayuna POTW in accordance with an Outside Users Agreement, Reference (2). The Agreement specifies the parameters and sampling frequency for the untreated sewage. The minimum sampling frequency is monthly for chemical constituents, while flow and pH measurements are required daily. Typically, a twenty-four hour flow-adjusted composite sample for chemical constituents is collected weekly. All monitoring data are averaged, with the exception of pH for which the maximum and minimum values for the month are reported, and then provided in a monthly report to the Town. The sewage pumping station is equipped with a pH alarm that shuts off the main pumps when the alarm set points are exceeded. Sewage flow is then allowed to passively overflow into a holding tank.

The Knolls Laboratory water discharged to the Mohawk River is regulated by a SPDES Permit, Reference (3). The SPDES Permit specifies the required sampling locations, parameters, and minimum sampling frequencies. The SPDES Permit was renewed in June 2015 with an effective date of July 1, 2015. An administrative change to the SPDES permit was approved by NYSDEC on March 30, 2018. The change adjusted the sample location of Outfall 001 and modified the copper sampling at Outfalls 001 and 002. The term of the permit is five years, with an expiration date of June 30, 2020.

Liquid effluent from the Knolls Laboratory enters the Mohawk River through a submerged outfall (Outfall 002), four small surface outfalls (Outfalls 03A, 03B, 03D, and 03E), and three natural stormwater streams (Outfalls 004, 005, and 006) as shown in Figure 2.

Outfall 002 discharges noncontact cooling water, process water, stormwater, and groundwater through a submerged drain line directly to the Mohawk River. The Outfall 002 monitoring station consists of a continuous temperature monitor and a Parshall flume, which provides for the continuous measurement and recording of effluent flow rate and total flow. In addition, weekly grab and composite samples are taken at Outfall 002 and analyzed for the constituents specified in the SPDES Permit, including copper when the Copper Ion Generator is operating.

Outfalls 03B and 03D discharge Mohawk River water used for once-through noncontact cooling, municipal water, stormwater, and groundwater. The Outfalls 03B and 03D monitoring stations consist of continuous temperature and flow monitoring which provides for the continuous measurement and recording of effluent flow rates and total flows. In addition, weekly grab samples are taken at Outfalls 03B and 03D and analyzed for the constituents specified in the SPDES Permit, including copper when the Copper Ion Generator is operating. A Copper Ion Generator is used to inhibit zebra mussel attachment to noncontact cooling water system piping when the river water temperature is in excess of 50^{o} Fahrenheit.

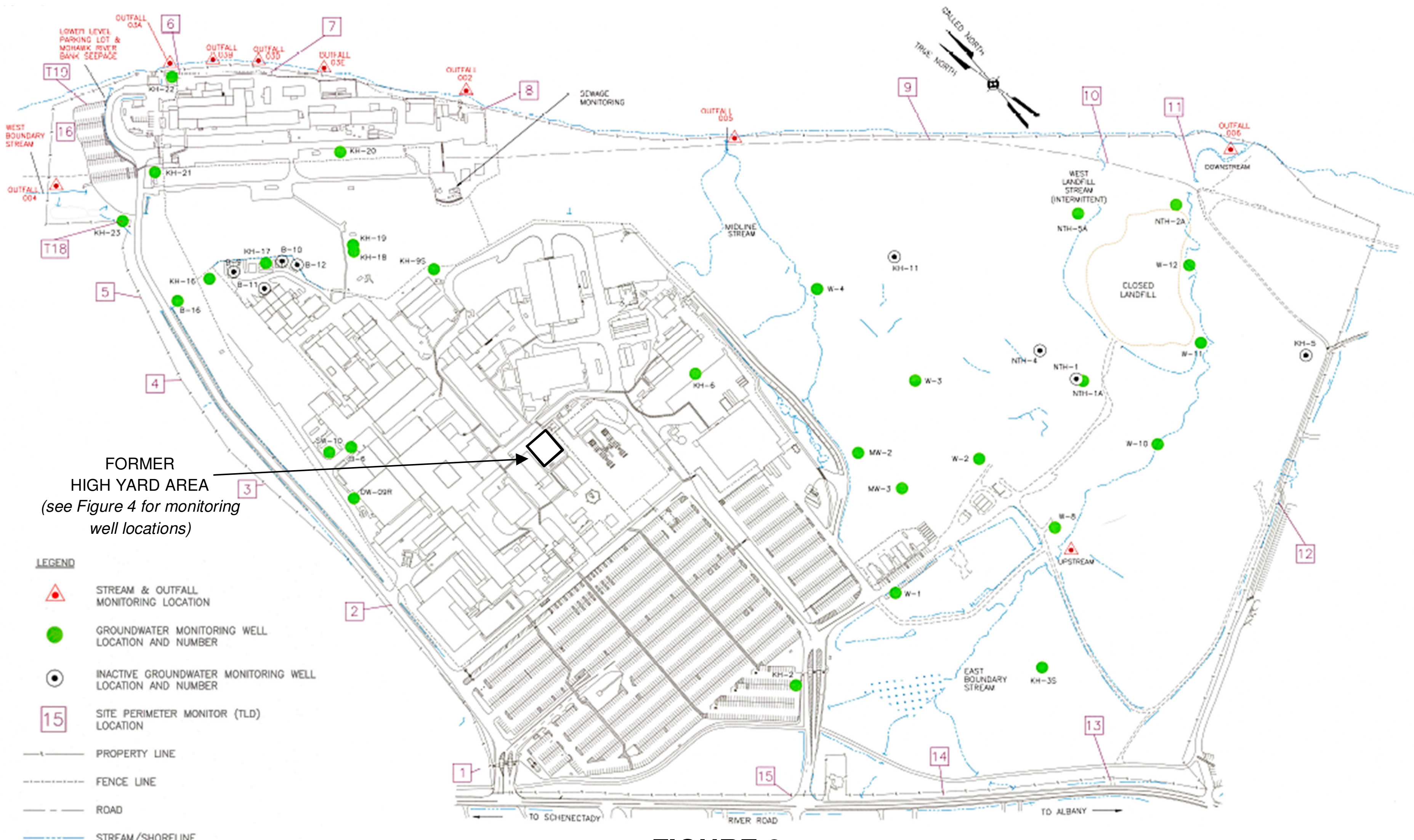

FIGURE 2

KNOLLS LABORATORY, NISKAYUNA, NEW YORK

STREAM AND OUTFALL, GROUNDWATER, AND PERIMETER TLD MONITORING LOCATIONS

The river water used for noncontact cooling must be strained to remove particles and biological life to prevent clogging of the Knolls Laboratory heat exchangers and instrumentation lines. In 2017, the Knolls Laboratory installed an inline screen (aka, Johnson screen) with a 0.79 mm screen in the Mohawk River. The Johnson screen filters the river water prior to entering the pump house galley. The settling tank, which removed sediment from the river water pump strainer backwash effluent, was in use up through October 2017. The settling tank is currently not in use; however, it is still installed inline for future use, if needed. The discharge from the settling tank is directed to Outfall 03B. After installation of the Johnson screen in the Mohawk River, verification monitoring to determine the efficiency of the Johnson screen was performed in 2018 per the SPDES permit. An entrainment reduction of 98.3% was calculated, well in excess of the 90% required by the facility's SPDES permit.

Outfalls 03A and 03E discharge only groundwater and stormwater as allowed by the SPDES Permit. These outfalls are monitored quarterly utilizing flow estimates and grab samples for pH and chemical constituent analyses. All monitoring is in accordance with the SPDES Permit.

Three Knolls Laboratory stormwater outfalls, designated as 004, 005, and 006, are commonly referred to as the West Boundary Stream Ditch, Midline Stream, and East Boundary Stream, respectively. The flows in these surface water streams are intermittent, and the streams are sampled quarterly for SPDES parameters, when possible. Additionally, the East Boundary Stream is sampled annually in accordance with the Knolls Laboratory Landfill Post-Closure Monitoring Program. The sampling location for Outfall 004 is a ditch on Knolls Laboratory property that drains to the West Boundary Stream.

The West Landfill Stream is not part of the SPDES program and was removed from the Knolls Laboratory Landfill Post-Closure Monitoring Program in September 2018.

The current SPDES permit requires Whole Effluent Toxicity (WET) testing for Outfall 002 every five years, specifically in the years ending with a "1" or a "6." The next required round of WET Testing will occur in 2021.

Radiological: The Outfall 002 Monitoring station includes a system for the collection of samples that are proportional to effluent flow. A monthly composite sample is prepared from the proportional samples and analyzed monthly for radioactivity. Monthly grab samples are taken at Outfalls 03A, 03B, 03D, 03E, 004, 005, 006, Upper East Boundary Stream, and West Landfill Stream. Background grab samples are also taken monthly at the Upper West Boundary Stream, Site Service Water, and Mohawk River Cooling Water Intake. Seepage samples are also collected from the Mohawk River Bank and near the Lower Level Parking Lot. Beginning in May of 2011, monthly split samples of Outfall 002 and 004 were provided to the New York State Department of Health (NYSDOH). The monitoring by the NYSDOH was secured in July 2018.

The sanitary sewage pumped to the Town of Niskayuna POTW is required to be sampled a minimum of quarterly for radioactivity in accordance with the Outside Users Agreement. However, typically, weekly 24-hour composite samples are obtained and then composited into quarterly samples and analyzed for radioactivity.

Effluent Analyses

Nonradiological: Periodic grab and composite samples collected from Outfalls 002, 03A, 03B, 03D, 03E, 004, 005, and 006 are analyzed for the chemical constituents listed in Reference (3). Samples from various outfalls may be analyzed for additional parameters for informational purposes only and are presented in the appropriate data tables. A twenty-four hour flow adjusted composite sample of the sewage pumped to the Town of Niskayuna POTW is collected and analyzed as required by Reference (2).

Radiological: The monthly composite sample collected at the Outfall 002 is analyzed for (1) strontium-90 by radiochemical separation and subsequent beta counting, (2) cesium-137 and other gamma-emitting radionuclides by gamma spectrometry, (3) tritium by liquid scintillation counting, and (4) gross alpha and gross beta radioactivity by direct sample evaporation and subsequent alpha and beta counting. Samples from the remaining outfalls are analyzed for gross alpha and gross beta radioactivity. Analyses for strontium-90 and cesium-137 are routinely performed for Outfalls 03A, 03D, 03E, 004, 005, 006, Lower Level Parking Lot Seepage, and Mohawk River Bank Seepage. For Outfall 03B and the West Landfill Stream, analysis for strontium-90, cesium-137, and other gamma-emitting radionuclides are performed if the gross beta radioactivity exceeds 10 pCi/l.

The quarterly composite sample of the sanitary sewage effluent to the Town of Niskayuna POTW is analyzed for strontium-90, cesium-137, cobalt-60, tritium, and uranium. Weekly samples are analyzed for gross alpha and beta radioactivity.

Assessment

Nonradiological: The analytical results for the chemical constituents, flow, and pH monitored in the Knolls Laboratory sewage effluent during 2018 are summarized in Table 11. The Knolls Laboratory average effluent results show that the Knolls Laboratory has operated within all parameters specified in the Outside Users Agreement, Reference (2).

The analytical results for the chemical constituents, flow, and temperature monitored in the Knolls Laboratory liquid effluent during 2018 are summarized in Table 12. The annual average values of all parameters were within the appropriate effluent permit limits or standards where standards exist for Outfalls 002, 03A, 03B, 03D, and 03E. This data was reported to NYSDEC as appropriate in the monthly SPDES Discharge Monitoring Reports.

The Knolls Laboratory SPDES Permit designates the Mohawk River intake as Outfall 001 and requires it to be monitored for flow, pH, total suspended solids, and copper (when the Copper Ion Generator is operating). The designated Outfall 001 sampling location, per the 2018 SPDES permit modification, is located in the L4 Pump House downstream of the Johnson Screen. The Knolls Laboratory SPDES permit requires composite sampling for total suspended solids at Outfalls 001 and 002 and composite sampling for total dissolved solids at Outfall 002. The 2018 SPDES permit modification requires composite sampling for total copper at Outfalls 001 and 002. The intake data is used to determine both the net limits and appropriate pH ranges for the outfalls or for information. Data is summarized in Table 12. The Mohawk River is voluntarily monitored for chloride at two locations and total dissolved solids at Outfall 001. The data for the upstream and downstream locations are presented in Table 13.

The Knolls Laboratory SPDES Permit requires the surface water streams, West Boundary Stream Ditch, Midline Stream, and East Boundary Stream, to be monitored quarterly for five parameters, when flow exists in these streams. The analytical results for required chemical constituents, flow, and pH were within the specified limits. Additional parameters are monitored voluntarily. These results are summarized in Tables 14 and 15.

Nonradioactive liquid effluent monitoring data are reported monthly as required in Reference (3). The monthly SPDES Discharge Monitoring Reports are available for public viewing at the Niskayuna Branch of the Schenectady County Public Library.

TABLE 11
CHEMICAL CONSTITUENTS IN KNOLLS LABORATORY SANITARY SEWAGE EFFLUENT DISCHARGED TO THE TOWN OF NISKAYUNA PUBLICLY OWNED TREATMENT WORKS

Knolls Laboratory Sewage Lift Station						
Parameter (Units)	**Number of Samples**	**Value[1]**				**Percent of Limit[4]**
		Minimum	**Maximum**	**Average[2]**	**Limit[3]**	
Outside Users Agreement #94 3850 Requirements (Reference (2))						
Flow (GPD)	365	3,040	38,685	18,933[5]	45,000	42
pH (SU)	721	6.8	8.9	----	6.0-9.5[6]	----
Biochemical Oxygen Demand (mg/l)	56[7]	207	937[8]	381	700	54
Chemical Oxygen Demand (mg/l)	56[7]	491	1,360	844	1,800	47
Total Suspended Solids (mg/l)	56[7]	172	1,410	449	1,600	28
Ammonia (as N, mg/l)	56[7]	79	152	114	200	57
Nitrate (as N, mg/l)	56[7]	<0.04	0.27	<0.07	4	<2
Nitrite (as N, mg/l)	56[7]	<0.01	0.49	<0.10	4	<2
Total Kjeldahl Nitrogen (as N, mg/l)	56[7]	106	192	143	250	57
Total Organic Nitrogen (as N, mg/l)	56[7]	<1	113	<28	175	<16
Total Nitrogen[9] (as N, mg/l)	56[7]	<106	193	<143	250	<57
Phosphate (as P, mg/l)	56[7]	10	18	14	30	45
Additional Parameters Monitored						
Oil & Grease[10] (mg/l)	56[7]	10	46	20	100	20

Notes:

1. A value preceded by "<" is less than the reporting limit (RL)
2. Average values preceded by "<" contain at least one "less than reporting limit value" in the average calculation.
3. Limit based on Outside Users Agreement (Reference (2)). Outside Users Agreement allows for monthly averaging of data unless noted.
4. Percent of limit for the average value, unless otherwise noted.
5. The average of the monthly flows reported to the Town of Niskayuna is used for this value.
6. pH values are not averaged and are required to be in this range.
7. Additional samples were collected in August 2018 for all parameters as part of quality assurance/quality control (QA/QC) for an internal investigation involving elevated Biochemical Oxygen Demand results.
8. Biochemical Oxygen Demand is reported to the Town as a monthly average. The monthly average never exceeded the 700 mg/l limit.
9. Daily average limit; calculated as the sum of Nitrate + Nitrite + Total Kjeldahl Nitrogen concentrations.
10. This parameter is not limited by the Outside Users Agreement; however, the Town of Niskayuna sanitary code prohibits fats, waxes, grease or oils in excess of 100 mg/l.

TABLE 12
CHEMICAL CONSTITUENTS AND TEMPERATURE IN KNOLLS LABORATORY LIQUID EFFLUENT

Parameter (Units)	Number of Samples	Value[1]				
		Minimum	Maximum	Average	Permit Limit[2]	Percent of Limit[3]
Discharge Permit Requirements (Reference (3))						
Intake Point 001						
Flow (MGD)	Continuous[4]	0	1.7	1.5	Monitor	----
pH (SU)	52	6.6	7.9	----	Monitor	----
Total Suspended Solids (mg/l)	52	<1.0	59	<8.6	Monitor	----
Total Copper (mg/l)	27	0.004	0.045	0.02	Monitor	----
Discharge Point 002						
Flow (MGD)	Continuous[4]	0.10	2.5	1.7	Monitor	----
pH (SU)	52	6.7	7.9	----	6.5-8.5[5]	----
Temperature (°F)	Continuous[4]	33	80	54	90	----
Total Suspended Solids (mg/l)	53	<1.0	110	<14	Monitor	----
Total Suspended Solids, Net (mg/l)	53	0	53	6.8	40	17
Total Dissolved Solids (mg/l)	52	130	4,100	400	Monitor	----
Oil & Grease (mg/l)	52	<5.0	<5.1	<5.1	15	<34
Total Copper (mg/l)	27	0.011	0.044	0.019	Monitor	----
Copper, Net (lbs/day)	27	0	0.62	0.1	Monitor	----
Discharge Point 03A						
Flow (MGD)	14	0.0014	0.022	0.0061	Monitor	----
pH (SU)	4	7.2	7.5	----	6.5-8.5	----
Oil & Grease (mg/l)	4	<5.0	<5.1	<5.1	15	<34
Total Suspended Solids (mg/l)	4	2.5	6.2	4.9	Monitor	----
Thallium (μg/l)	4	<10	17	<12	25[6]	<48
Discharge Point 03B						
Flow (MGD)	Continuous[4]	0.0037	0.59	0.29	Monitor	----
pH (SU)	52	6.6	8.0	----	6.5-8.5[5]	----
Temperature (°F)	Continuous[4]	34	81	56	90	----
Oil & Grease (mg/l)	12	<5.0	<5.1	<5.1	15	<34
Total Suspended Solids, Net (mg/l)	16	0	31	5.6	40	14
Total Copper (mg/l)	27	0.005	0.014	0.01	Monitor	----
Copper, Net (lbs/day)	27	0	0.02	0.002	Monitor	----
Discharge Point 03D						
Flow (MGD)	Continuous[4]	0	0.043	0.014	Monitor	----
pH (SU)	52	6.6	8.0	----	6.5-8.5[5]	----
Temperature (°F)	Continuous[4]	44	69	57	90	----
Oil & Grease (mg/l)	12	<5.0	<5.1	<5.1	15	<34
Total Suspended Solids (mg/l)	12	<1.0	8.6	<2.9	Monitor	----
Total Copper (mg/l)	27	<0.003	0.028	<0.007	Monitor	----
Copper, Net (lbs/day)	27	0	0.003	0	Monitor	----

Notes for Table 12 are on page 36.

TABLE 12 (continued)
CHEMICAL CONSTITUENTS AND TEMPERATURE IN KNOLLS LABORATORY LIQUID EFFLUENT

Parameter (Units)	Number of Samples	Value[1]				Percent of Limit[3]
		Minimum	Maximum	Average	Permit Limit[2]	
Discharge Permit Requirements (Reference (3))						
Discharge Point 03E						
Flow (MGD)	12	0.00014	0.017	0.0022	Monitor	----
pH (SU)	4	7.2	7.7	----	6.5-8.5	----
Oil & Grease (mg/l)	4	<5.0	<5.1	<5.1	15	<34
Total Suspended Solids (mg/l)	4	3.3	33	18	Monitor	----
Discharge Point 001, 002, 03B and 03D						
Copper, Net Loading (lbs/day)	27	0	0.62	0.1	1.1	9

Notes:
1. A value preceded by "<" is less than the RL. Average values preceded by "<" contain at least one value in the average that is less than the RL.
2. NYSDEC SPDES Permit (Reference (3)).
3. Percent of limit is for the average value, unless otherwise noted.
4. The number of continuous monitoring days may differ slightly due to shutdown during maintenance activities.
5. If intake pH (Outfall 001) is greater than or equal to 8.2, the upper pH limit is increased to 9.0 but in no case can the effluent pH exceed intake pH by more than 0.5 SU.
6. NYSDEC SPDES Permit Action Level.

TABLE 13
CHEMICAL CONSTITUENTS IN MOHAWK RIVER WATER

Parameter (Units)	Number of Samples Upstream/ Downstream	Value							Standard[(1)]
		Mohawk River Upstream (Outfall 001)				Mohawk River Downstream			
		Minimum	Maximum	Average		Minimum	Maximum	Average	
Total Dissolved Solids (mg/l)[(2)]	52/0	80	320	180		----	----	----	500
Chloride (mg/l)[(2)]	4/4	31.8	33.3	32.8		31.0	1,040	289	250

Notes:

1. New York State Quality Standards (Reference (1)) for Class A Waters: source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. The waters shall be suitable for fish propagation and survival.
2. Voluntary parameter.

TABLE 14
CHEMICAL CONSTITUENTS IN WEST BOUNDARY STREAM DITCH AND MIDLINE STREAM

Parameter (Units)	Number of Samples West Boundary Stream Ditch (WBSD) / Midline Stream	Value[1]						Standard / Guidance Value[2]
		West Boundary Stream Ditch (Outfall 004)			Midline Stream (Outfall 005)			
		Minimum	Maximum	Average	Minimum	Maximum	Average	
Flow (Estimated (GPD))[3]	4/4	27,000	240,000	92,000	43,000	97,000	69,000	Monitor[4]
pH (SU)	4/4	6.8	7.5	----	6.6	8.1	----	6.5-8.5[4]
Total Suspended Solids (mg/l)	4/4	3.2	9.2	6.1	<1.0	10	<4.6	Monitor[4]
Oil & Grease (mg/l)	4/4	<5.0	<5.2	<5.1	<5.0	<5.3	<5.1	15[4]
Chemical Oxygen Demand (mg/l)	4/4	14	26	20	11	26	19	Monitor[4]
Chloride (mg/l)[5]	4/4	557	3,690	2,057	712	1,630	1,087	250
Thallium (µg/l)	4/0	<10	19	<14	----	----	----	25[4]
Volatile Organic Compounds (µg/l)[5][6]	4/4	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	Note (7)

Notes:

1. A value preceded by "<" is less than the RL. Average values preceded by "<" contain at least one value in the average that is less than the RL.
2. New York State Quality Standards and Guidance Values (Reference (4)) for Class A Waters: source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. The waters shall be suitable for fish propagation and survival. The West Boundary and Midline Streams are tributaries to the Mohawk River, which is a Class A water.
3. Flow is estimated by measuring stream depth, width, and velocity. Flow is intermittent and is measured only when samples are collected.
4. Permit limits as required by NYSDEC SPDES permit (Reference (3)).
5. Voluntary parameter.
6. EPA method 601 was utilized to analyze for volatile organic compounds listed in Table 25. All results were less than the RL of 1 µg/l.
7. Water quality standards and guidance values differ depending upon the specific parameter. The standards/guidance values range from 0.07 to 50 µg/l.

TABLE 15
CHEMICAL CONSTITUENTS AND TEMPERATURE IN EAST BOUNDARY STREAM

Parameter (Units)	Number of Samples Upstream / Downstream	Value[1]							Standard / Guidance Value[2]
		East Boundary Stream Upstream				East Boundary Stream Downstream (Outfall 006)			
		Minimum	Maximum	Average		Minimum	Maximum	Average	
Flow (Estimated (GPD))[3]	1/4	27,000	27,000	27,000		46,000	180,000	92,000	Monitor[4]
pH (SU)	1/4	7.7	7.7	----		6.6	7.9	----	6.5-8.5[4]
Temperature (°F)	1/1	62	62	62		58	58	58	No Standard
Dissolved Oxygen (DO) (mg/l)	1/1	8.4	8.4	8.4		7.4	7.4	7.4	Note (5)
Specific Conductance (µmhos/cm)	1/1	2,570	2,570	2,570		2,421	2,421	2,421	No Standard
Volatile Organic Compounds (µg/l)[6]	1/1	<1.0	<1.0	<1.0		<1.0	<1.0	<1.0	Note (7)
Oil & Grease (mg/l)	0/4	----	----	----		<5.0	<5.2	<5.1	15[4]
Total Suspended Solids (mg/l)	0/4	----	----	----		<1.0	130	<33	Monitor[4]
Chemical Oxygen Demand (mg/l)	0/4	----	----	----		11	27	17	Monitor[4]
Chloride (mg/l)[8]	1/4	613	613	613		395	1,030	665	250

Notes:

1. A value preceded by "<" is less than the RL. Average values preceded by "<" contain at least one value in the average that is less than the RL.
2. New York State Quality Standards and Guidance Values (Reference (4)) for Class A Waters: source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. The waters shall be suitable for fish propagation and survival. The East Boundary Stream is tributary to the Mohawk River, which is a Class A water.
3. Flow is intermittent and is estimated by measuring stream depth, width, and velocity or by volume collected over a time period. Flow is measured only when samples are collected.
4. Permit limit as required by NYSDEC SPDES permit (Reference (3)) for the downstream location.
5. For non-trout waters, the minimum daily average shall not be less than 5.0 mg/l, and at no time shall the DO concentration be less than 4.0 mg/l.
6. EPA method 601 was used to analyze for volatile organic compounds listed in Table 25. All results were less than the RL of 1 µg/l.
7. Water quality standards and guidance values differ depending upon the specific parameter. The standards/guidance values range between 0.07 and 50 µg/l.
8. Voluntary parameter.

Radiological: The average radioactivity concentrations in the sanitary sewage effluent to the Town of Niskayuna POTW are shown in Table 16. Only strontium-90 and naturally occurring uranium were detected in the quarterly effluent composite samples. The concentration of strontium-90 is at levels typically found in surface water from historical atmospheric weapons testing. The radioactivity concentrations in the sanitary sewage effluent quarterly composite samples were less than one percent of the DOE derived concentration guide (DCG) for effluent released to unrestricted areas (Reference (5)) as required by the Outside Users Agreement (Reference (2)).

TABLE 16
KNOLLS LABORATORY SANITARY SEWAGE EFFLUENT DISCHARGED TO THE TOWN OF NISKAYUNA PUBLICLY OWNED TREATMENT WORKS: QUARTERLY COMPOSITE SAMPLE RADIOACTIVITY RESULTS

Radionuclide	Quarterly Composite Sample Average Radioactivity Concentration (pCi/liter)(1)	DOE Order 5400.5 Derived Concentration Guide (DCG) (pCi/liter)	Percent of DCG
Cs-137	<0.36 ± 0.02	3,000	<0.01
Sr-90	<0.15 ± 0.13	1,000	<0.02
Co-60	<0.37 ± 0.03	5,000	<0.01
H-3	<82.01 ± 29.45	2,000,000	<0.01
Total Uranium	<0.47 ± 0.15	500(2)	<0.07
		Total Percentage(3)	<0.12

Notes:
1. Average values preceded by "<" contain at least one less than decision level concentration value in the average. The (±) value provides the 95% confidence interval for the average value.
2. The derived concentration guide for total uranium is based on U-234.
3. The radioactivity standard for the Town of Niskayuna Sanitary Sewer System corresponds to one percent of the derived concentration guide in DOE Order 5400.5 for the mixture of radionuclides present (Reference (2)).

The radioactivity concentrations in Knolls Laboratory liquid effluent are shown in Table 17. The average concentrations are all well below the DOE Derived Concentration Standard (DCS). The amount of each radionuclide released from the Knolls Laboratory (including SPRU) in liquid effluent is shown in Table 18.

The total radioactivity released from each outfall/source is as follows: Outfall 002, 492.0 μCi; Outfall 03A, 55.3 μCi; Outfall 03D, 66.2 μCi; Outfall 03E, 0.2 μCi; Outfall 004, 74.7 μCi, and Lower Level Parking Lot / River Bank Seepage, 0.8 μCi for a total of 689.2 μCi (or 6.89×10^{-4} Ci). The radioactivity was contained in approximately 2.36×10^{9} liters of water released from the Knolls Laboratory. The annual average radioactivity concentration in that effluent, prior to entering the Mohawk River water, corresponded to less than 0.1 percent of the DOE DCS for effluent released to unrestricted areas (Reference (6)) for the mixture of radionuclides present.

TABLE 17
RADIOACTIVITY CONCENTRATIONS IN KNOLLS LABORATORY LIQUID EFFLUENT

Sample Point / Parameter	Number of Samples	Radioactivity Concentration (pCi/l)(1)				Percent of DCS
		Minimum	Maximum	Average	DOE-STD-1196-2011 DCS(2)	
Outfall 002						
Gross Alpha	12	<0.57	3.79 ± 3.64	<1.47 ± 0.56	140	<1.05
Gross Beta	12	1.37 ± 1.13	5.07 ± 1.62	<3.38 ± 0.78	1,100	<0.31
Sr-90	12	<0.07	0.38 ± 0.14	<0.16 ± 0.06	1,100	<0.01
Cs-137	12	<0.11	<0.24	<0.14 ± 0.03	3,000	<0.01
H-3	12	<68.59	<105.77	<92.05 ± 8.95	1,900,000	<0.01
Outfall 03A						
Gross Alpha	12	<4.26	26.71 ± 22.58	<12.41 ± 4.20	140	<8.87
Gross Beta	12	6.05 ± 7.48	34.72 ± 12.09	<18.38 ± 6.29	1,100	<1.67
Sr-90	12	2.12 ± 0.29	9.18 ± 0.70	4.67 ± 1.15	1,100	0.42
Cs-137(3)	4	<0.11	<0.13	<0.12 ± 0.01	3,000	<0.01
Outfall 03B						
Gross Alpha(3)	4	<0.40	2.64 ± 3.25	<1.10 ± 1.66	140	<0.79
Gross Beta(3)	4	1.32 ± 1.11	4.28 ± 1.62	2.48 ± 2.19	1,100	0.23
Outfall 03D						
Gross Alpha	12	<3.26	<15.56	<8.17 ± 1.98	140	<5.84
Gross Beta	12	<4.50	29.78 ± 10.23	<13.12 ± 4.46	1,100	<1.19
Sr-90	12	1.05 ± 0.19	3.41 ± 0.39	1.82 ± 0.40	1,100	0.17
Cs-137(3)	4	<0.11	<0.25	<0.15 ± 0.10	3,000	<0.01
Outfall 03E						
Gross Alpha(4)	12	<1.76	<14.68	<5.94 ± 2.76	140	<4.24
Gross Beta(4)	12	2.06 ± 1.21	11.83 ± 7.87	<6.17 ± 2.14	1,100	<0.56
Sr-90(4)	12	<0.08	1.06 ± 0.23	<0.25 ± 0.17	1,100	<0.02
Cs-137(3)(4)	4	<0.11	<0.12	<0.12 ± 0.01	3,000	<0.01
Outfall 004						
Gross Alpha(4)	12	<3.54	21.26 ± 17.96	<9.14 ± 3.34	140	<6.53
Gross Beta(4)	12	4.68 ± 4.37	22.36 ± 9.82	<8.76 ± 3.28	1,100	<0.80
Sr-90(4)	12	0.45 ± 0.17	1.44 ± 0.22	0.89 ± 0.22	1,100	0.08
Cs-137(4)	12	0.11 ± 0.13	0.59 ± 0.13	<0.21 ± 0.09	3,000	<0.01
Outfall 005						
Gross Alpha(3)(4)	4	<4.04	<15.69	<7.71 ± 8.66	140	<5.50
Gross Beta(3)(4)	4	<5.80	11.47 ± 7.87	<8.38 ± 3.74	1,100	<0.76
Sr-90(3)(4)	4	<0.09	0.37 ± 0.15	<0.23 ± 0.19	1,100	<0.02
Cs-137(3)(4)	4	<0.08	<0.25	<0.14 ± 0.12	3,000	<0.01
Outfall 006						
Gross Alpha(3)(4)	4	<1.83	<9.63	<4.67 ± 5.44	140	<3.34
Gross Beta(3)(4)	4	<2.47	7.68 ± 7.23	<4.47 ± 3.95	1,100	<0.41
Sr-90(3)(4)	4	<0.08	0.22 ± 0.12	<0.15 ± 0.10	1,100	<0.01
Cs-137(3)(4)	4	<0.12	<0.12	<0.12 ± 0.01	3,000	<0.01

Notes for Table 17 are on shown on page 42.

TABLE 17 (continued)
RADIOACTIVITY CONCENTRATIONS IN KNOLLS LABORATORY LIQUID EFFLUENT

Sample Point / Parameter	Number of Samples	Radioactivity Concentration (pCi/l)(1)				Percent of DCS
		Minimum	Maximum	Average	DOE–STD-1196-2011 DCS(2)	
Seepage from Parking Lot						
Gross Alpha(4)	0	NA	NA	NA	140	NA
Gross Beta(4)	0	NA	NA	NA	1,100	NA
Sr-90(4)	0	NA	NA	NA	1,100	NA
Cs-137(3)(4)	0	NA	NA	NA	3,000	NA
River Bank Seepage						
Gross Alpha(4)	1	<2.32	<2.32	<2.32	140	<1.66
Gross Beta(4)	1	<2.70	<2.70	<2.70	1,100	<0.25
Sr-90(4)	1	0.21 ± 0.12	0.21 ± 0.12	0.21 ± 0.12	1,100	0.02
Cs-137(4)	1	<0.29	<0.29	<0.29	3,000	<0.01
West Landfill Stream						
Gross Alpha(3)(4)	4	<0.42	<1.98	<0.87 ± 1.18	140	<0.62
Gross Beta(3)(4)	4	<1.05	3.80 ± 1.30	<2.53 ± 1.82	1,100	<0.23
Upper East Boundary Stream						
Gross Alpha(3)(4)	4	<2.37	<15.83	<6.38 ± 10.08	140	<4.56
Gross Beta(3)(4)	4	3.24 ± 2.19	8.46 ± 9.70	<5.13 ± 3.86	1,100	<0.47
Sr-90(3)(4)	4	0.11 ± 0.11	0.27 ± 0.14	0.20 ± 0.11	1,100	0.02
Cs-137(3)(4)	4	<0.11	<0.24	<0.15 ± 0.10	3,000	<0.01
Upper West Boundary Stream (background for comparison)						
Gross Alpha	12	<1.33	<3.69	<2.14 ± 0.43	140	<1.53
Gross Beta	12	1.43 ± 1.42	10.05 ± 4.07	<3.56 ± 1.47	1,100	<0.32
Sr-90	12	<0.07	0.33 ± 0.18	<0.15 ± 0.06	1,100	<0.01
Cs-137	12	<0.12	<0.24	<0.15 ± 0.03	3,000	<0.01
H-3	12	<68.40	<105.52	<92.23 ± 9.03	1,900,000	<0.01
Site Service Water (background for comparison)						
Gross Alpha	12	<0.52	<2.65	<1.38 ± 0.38	140	<0.99
Gross Beta	12	<0.93	6.85 ± 2.36	<2.39 ± 1.01	1,100	<0.22
Sr-90	12	<0.07	0.23 ± 0.11	<0.11 ± 0.04	1,100	<0.01
Cs-137	12	<0.12	<0.25	<0.16 ± 0.04	3,000	<0.01
H-3	12	<68.32	<104.50	<90.62 ± 8.57	1,900,000	<0.01
Mohawk River Cooling water (background for comparison)						
Gross Alpha	12	<0.34	3.20 ± 2.08	<1.11 ± 0.50	140	<0.79
Gross Beta	12	0.94 ± 1.10	7.91 ± 1.92	2.63 ± 1.30	1,100	0.24
Sr-90	12	<0.07	0.23 ± 0.11	<0.11 ± 0.03	1,100	<0.01
Cs-137	12	<0.11	<0.26	<0.17 ± 0.04	3,000	<0.01
H-3	12	<68.55	<105.23	<89.2 ± 9.5	1,900,000	<0.01

Notes:
1. A value preceded by "<" is less than the decision level concentration. Average values preceded by "<" contain at least one value that is less than the decision level concentration. The (±) value provides the 95% confidence interval for the value.
2. The DCS for gross alpha and gross beta radioactivity is based on the most restrictive radionuclide possibly present in measurable quantities as a result of Knolls Laboratory operations.
3. Monthly samples are composited and analyzed quarterly.
4. Samples may not be obtained every month due to dry or frozen conditions.

TABLE 18
KNOLLS LABORATORY RADIOACTIVITY RELEASED IN LIQUID EFFLUENT

Radionuclide	Release (Ci)[1]	Half-life
Sr-90	2.52E-04	28.78 years
Y-90	2.52E-04	2.67 days
Cs-137	1.85E-04	30.07 years
Fission and Activation Products ($T_{1/2}$ > 3 hr)	6.89E-04	
U-234	5.85E-07	2.46E05 years
U-235	3.30E-08	7.04E08 years
U-238	4.50E-07	4.47E09 years
Total Uranium	1.07E-06	
Pu-238	3.97E-09	87.7 years
Pu-239/Pu-240	3.55E-09	2.41E04 years/6.56E03 years
Total Plutonium	7.52E-09	

Note:
1. The totals include results that were less than or equal to the decision level concentration.

AIRBORNE EFFLUENT MONITORING

Sources

Nonradiological: The principal source of industrial air emissions is the Knolls Laboratory steam-generating heating boiler system. The Knolls Laboratory heating boilers are comprised of three stationary combustion units that primarily combust natural gas with ultra-low sulfur distillate fuel oil used as a backup fuel. The combustion products from this source are released through individual elevated stacks. Another stationary combustion source is the Advanced Steam Generator Test Facility (ASGTF) that is comprised of two natural gas-fired water heaters that exhaust through a common stack. Both gas-fired water heaters are in layup and have not been operated since 2010 and 2002, respectively.

Other operations at the Knolls Laboratory that can result in air emissions include the carpenter shop, metalwork operations, belt grinders, welding, nonradiological laboratory hoods, and emergency power generating stationary internal combustion engines. These sources of air emissions at the Knolls Laboratory meet the criteria for exempt and trivial sources under the NYSDEC air regulations and are not required to have air permits or registrations.

Radiological: Laboratory operations capable of generating airborne radioactivity are serviced by controlled exhaust systems that discharge through stacks. To minimize radioactivity content, the exhaust air is passed through appropriate air cleaning devices, such as high efficiency particulate air (HEPA) filters and activated carbon adsorbers, prior to release. Potential diffuse sources are also evaluated and may include emissions from resuspension of contaminated soil, D&D activities, and fugitive building emissions.

Effluent Monitoring

Nonradiological: The Knolls Laboratory originally had two nonradiological air emission permits, one for the heating boilers and one for the ASGTF. Effective December 7, 2009, the permits for these two air emission sources were consolidated under an Air State Facility Permit (Mod 2). This permit limits carbon monoxide and sulfur dioxide emissions from the heating boilers based on fuel usage. The New York State emission standards for stationary combustion installations are listed in Reference (7). Under the terms of the permit for these emission sources, direct emission monitoring is not required. The quantities of pollutants released are estimated based on the quantity and type of fuel burned multiplied by the appropriate EPA approved emission factors. In January 2010, the Knolls Laboratory was granted a modification to the Air State Facility Permit (Mod 4), listed in Table 6, to consolidate the reporting dates for certain regulatory submittals listed in the permit.

The NYSDEC regulations do not require air emission permits for exempt and trivial activities. In general, exempt and trivial activities do not require emissions monitoring; although some activities may require monitoring of run times, installation and maintenance of air quality control equipment, or limiting source material usage to maintain their exempt status.

Radiological: Airborne effluents from the main radiological emission points are continuously sampled for particulate radioactivity with particulate filter samplers and with activated charcoal cartridge samplers where iodine or antimony may be present. Exhaust systems servicing major facilities are also continuously monitored for particulate, iodine, and noble gas radioactivity. The monitors continuously record radioactivity levels in the effluents and are equipped with alarm functions to provide an alert should an abnormal level occur. Other minor radiological emission points are evaluated for the potential for release and monitored on a periodic basis, as necessary, to confirm the low emissions.

Effluent Analyses

Radiological: Particulate filters and activated charcoal cartridges are changed and analyzed on a routine basis. Particulate filters are analyzed by direct counting for gross alpha and beta radioactivity using a sensitive low-background gas proportional counting system. The system provides decision level concentrations for alpha and beta radioactivity of approximately 1×10^{-15} μCi/ml and 5×10^{-15} μCi/ml, respectively. The activated charcoal cartridges are analyzed for iodine-131 and antimony-125 by gamma spectrometry, which provides decision level concentrations of approximately 2×10^{-14} μCi/ml and 1×10^{-13} μCi/ml, respectively. Noble gas radioactivity released is calculated based on integration of recorded data from a continuous noble gas monitor.

Assessment

Nonradiological: The heating boiler operations at the Knolls Laboratory are "capped," or limited, to the following conditions under the Air State Facility Permit (Mod 4) issued by NYSDEC:

1. A maximum heat input of 162.4 billion British Thermal Units (BTUs) during any 12-month period;

2. The quantity of fuel used during any 12-month period shall not exceed 159.2 million standard cubic feet (SCF) of natural gas or 1.16 million gallons of distillate fuel oil or any combination of the two, not to exceed condition 1 above;

3. Annual emissions of the following contaminants are capped as follows:
   Carbon monoxide (CO) – 13,370 pounds per year
   Sulfur dioxide (SO_2) – 82,360 pounds per year;

4. The sulfur content of any fuel oil burned shall not exceed 0.5 percent by weight, and the fuel oil must conform to the specifications for distillate fuel oil per American Society for Testing and Materials (ASTM) D396-78, as amended; and

5. The annual capping period will run from the first working day in September to the first working day in September of the following year with the Annual Capping Certification due by September 30 each year.

The ASGTF hot water heater operations are not capped under the Air State Facility Permit (Mod 4) (ASFP). Fuel oil supplier certification statements and/or applicable fuel oil analyses for distillate fuel oil are maintained to confirm that the fuel oil burned in the Knolls Laboratory heating boilers contained less than 0.5 percent sulfur by weight and conforms to the ASTM Standards for distillate fuel oil. Semi-annual reports demonstrating compliance with the fuel oil sulfur limitation are sent to both the EPA and NYSDEC. Under current NYSDEC regulations, the sulfur content of fuel oil is limited to 0.0015 percent sulfur by weight. Although the EPA and the ASFP require the combustion of fuel oil with a sulfur content of less than 0.5 perent sulfur, the Knolls Laboratory complies with the more stringent NYSDEC regulatory requirement that fuel oils contain no more than 0.0015 percent sulfur by weight.

Compliance with the capping requirements is determined by calculations using fuel usage records each year, and an annual capping certification statement is sent to NYSDEC. Although the emissions from the operation of Air Emission Point EP-00030, ASTGF, are not capped, the emissions from this facility are included in the capping certification for information.

The Knolls Laboratory heating boilers continue to operate within the capped operating and emission limits established by NYSDEC in the Knolls Laboratory's ASFP for the boilers.

In May 2011, the Knolls Laboratory opted to operate their heating boilers as gas-fired boilers under 40 CFR 63 Subpart JJJJJJ – National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers located at Area Sources of Hazardous Air

Pollutants. For gas-fired boilers, the combustion of fuel oil is limited to periods of gas curtailment, gas supply emergencies, or periodic testing on fuel oil. Periodic testing on fuel oil under this regulation, which includes boiler tune-ups and boiler operator training, is limited to 48 hours of fuel oil combustion per boiler during any calendar year.

Radiological: The radioactivity released in airborne effluent during 2018 is shown in Table 19. The point source airborne radioactivity was contained in a total air exhaust volume of 1.41×10^{12} liters. The average radioactivity concentration in the exhaust air was well below the applicable standards listed in Reference (6). The diffuse source emissions are calculated using EPA approved methods and represent a small fraction of the point source emissions. The radioactivity concentration for 2018 at the nearest Knolls Laboratory boundary, based on the annual diffusion parameters, averaged less than 0.01 percent of the DOE DCS for effluent released to unrestricted areas (Reference (6)) for the mixture of radionuclides present. Airborne effluent monitoring data are reported as required by EPA regulations in Reference (8).

TABLE 19
KNOLLS LABORATORY RADIOACTIVITY RELEASED IN AIRBORNE EFFLUENT

Radionuclide	Point Source Release Ci(1)	Diffuse Source Release Ci	Total Release Ci	Half-life
H-3	1.61E-07	0.00E+00	1.61E-07	12.32 years
Kr-85	3.23E-01	0.00E+00	3.23E-01	10.76 years
Sr-90	2.47E-06	1.09E-07	2.58E-06	28.8 years
Y-90	2.47E-06	1.09E-07	2.58E-06	2.67 days
Cs-137	2.47E-06	2.75E-07	2.74E-06	30.07 years
Co-60	5.50E-08	6.64E-08	1.21E-07	5.271 years
Total Fission and Activation Products ($T_{1/2}$ >3 hr)	3.23E-01	5.59E-07	3.23E-01	
U-234	4.18E-07	1.20E-09	4.19E-07	2.46E05 years
U-235	7.02E-09	3.86E-11	7.06E-09	7.04E08 years
U-236	1.30E-09	4.96E-12	1.30E-09	2.34E07 years
U-238	8.30E-12	3.52E-13	8.65E-12	4.47E09 years
Total Uranium	4.26E-07	1.24E-09	4.27E-07	
Pu-238	1.12E-07	1.33E-09	1.14E-07	87.7 years
Pu-239	0.00E+00	8.12E-11	8.12E-11	2.41E04 years
Pu-240	0.00E+00	2.02E-11	2.02E-11	6.56E03 years
Pu-242	0.00E+00	2.02E-15	2.02E-15	3.75E05 years
Total Plutonium (Alpha)	1.12E-07	1.43E-09	1.14E-07	
Am-241	0.00E+00	2.02E-11	2.02E-11	432.7 years
Pu-241	0.00E+00	4.09E-11	4.09E-11	14.29 years

Note:

1. With the exception of Kr-85, the totals include results that were less than or equal to the decision level concentration.

ENVIRONMENTAL MONITORING

Scope

Nonradiological: The Knolls Laboratory nonradiological environmental monitoring program consists of routine surface water and groundwater sampling. Surface water is sampled for water quality at the following locations: Mohawk River upstream and downstream from the Knolls Laboratory outfalls, the Midline Stream near the point of entry to the Mohawk River, the West Boundary Stream Ditch, and the East Boundary Stream upstream and downstream of the closed landfill. The West Boundary Stream Ditch sample point is on Knolls Laboratory property, prior to where the ditch enters the West Boundary Stream on the General Electric Global Research Center property. The West Boundary Stream Ditch enters the Mohawk River upstream from the Knolls Laboratory. Required analytical surface water parameters are discussed later in this report. Stream sample points are shown in Figure 2.

The Knolls Laboratory contains a permanently capped landfill that covers an area of approximately 3.7 acres on the east side of the site. The landfill was officially closed in October 1993. The groundwater and surface water surrounding the closed landfill is routinely monitored and the results are reported to NYSDEC in compliance with Reference (9). A revised Post-Closure Monitoring and Maintenance Manual (PCMMM) requesting a reduction in sampling and monitoring frequency was approved by NYSDEC in September 2018. Quarterly landfill inspections were conducted up through the third quarter 2018, and no degradation in the cap was identified. Routine landfill maintenance was performed to ensure continued integrity of the landfill cap and associated cover. In accordance with a NYSDEC-approved RCRA Corrective Action groundwater monitoring plan, quarterly groundwater monitoring is performed at the former electrical High Yard Area to assess the effectiveness of a soil remediation project. The results of the groundwater monitoring are reported to NYSDEC annually. Groundwater is also monitored by other groundwater monitoring wells located throughout the Knolls Laboratory. Knolls Laboratory groundwater data are discussed separately later in this report.

Radiological: The Knolls Laboratory radiological environmental monitoring program includes: a) the routine collection and analysis of samples of Mohawk River water, sediment, and fish; surface water streams; groundwater; and local municipal waters; and b) the continuous sampling of air at stations located in the predominant upwind and downwind directions from the Knolls Laboratory.

Mohawk River water and bottom sediment samples are collected for radioactivity analyses at locations upstream and downstream from the main Knolls Laboratory outfall as shown in Figure 3. Samples are collected during each of three (3) calendar quarters; ice coverage and/or winter weather prevents sampling during the first calendar quarter. A Birge-Ekman dredge, which samples an area of approximately 15 cm x 15 cm to an average depth of 2.5 cm, is used for the collection of sediment samples. In addition, bottom feeding fish and recreational sport fish are collected from the Mohawk River upstream and downstream from the main Knolls Laboratory outfall for gamma spectrometry and radiochemical analyses.

Surface water is also sampled monthly for radioactivity at the Midline Stream near the point of entry to the Mohawk River, the West Boundary Stream Ditch, and the East Boundary Stream upstream and downstream of the closed landfill, and the West Landfill Stream. Perimeter radiation levels are continuously monitored with thermoluminescent dosimeters (TLDs) and are discussed separately, later in this report in the Radiation Monitoring section. Groundwater wells are sampled annually for radioactivity and are discussed separately in the Groundwater Monitoring section of this report.

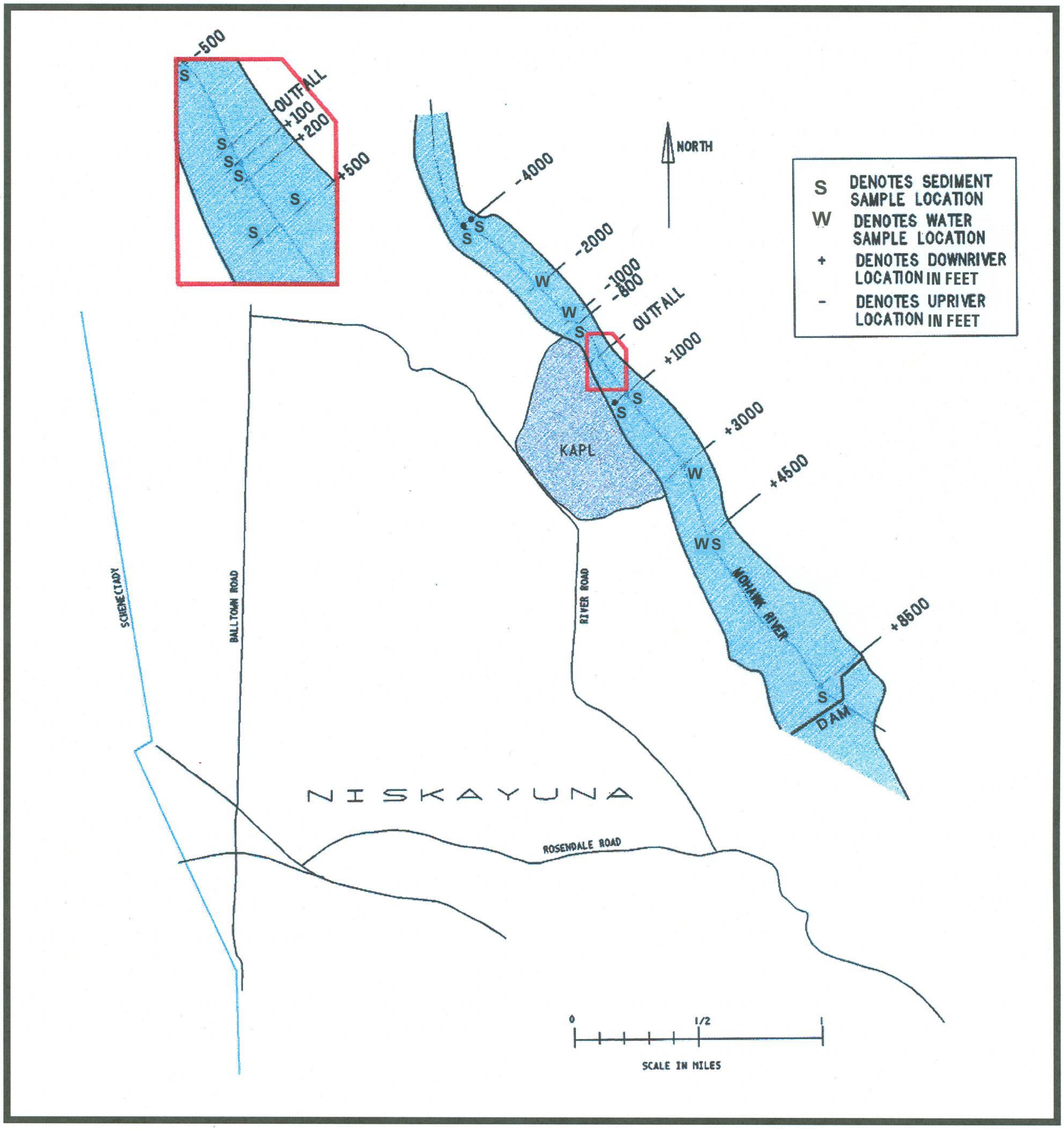

FIGURE 3
KNOLLS LABORATORY, NISKAYUNA, NEW YORK
MOHAWK RIVER SAMPLING LOCATIONS

The municipal water systems servicing the area surrounding the Knolls Laboratory are those of Schenectady, Niskayuna, and Latham/Colonie, New York. Supply wells for the Schenectady and Niskayuna systems are located upstream and downstream, respectively, from the Knolls Laboratory. Although there is no direct mechanism for Knolls Laboratory effluent to enter the water supplies, samples are collected monthly from the Schenectady and Niskayuna municipal water systems. A monthly sample is also collected from the Latham/Colonie municipal water system that obtains a portion of its water from the Mohawk River. Monthly samples are composited quarterly and analyzed for radioactivity.

Environmental air samplers are operated in the predominant upwind and ten downwind locations around the entire perimeter of the Knolls Laboratory to measure normal background airborne radioactivity, and to confirm that Knolls Laboratory (including SPRU) effluents have no measurable effect on normal background airborne radioactivity levels.

Analyses

Nonradiological: The water samples collected from the Mohawk River and the three main surface water streams are analyzed for the constituents listed in Tables 13, 14, and 15. The analyses were performed in accordance with 40 CFR Part 136 utilizing the procedures provided in Standard Methods, Reference (10), or other EPA approved methods.

Radiological: The individual quarterly samples of Mohawk River water and quarterly composite samples of Schenectady, Niskayuna, and Latham/Colonie municipal waters are analyzed for gross alpha and gross beta radioactivity. The stream samples are analyzed for gross alpha and gross beta radioactivity, and for other radionuclides as appropriate. The methods used are described in the Effluent Analyses portion of the Liquid Effluent Monitoring section of this report.

The Mohawk River sediment samples are analyzed for uranium and plutonium alpha radioactivity by chemical extraction with subsequent direct counting on an alpha spectrometry system, for gross beta radioactivity by direct counting of a dried sample, and for cesium-137 and other gamma emitting radionuclides by gamma spectrometry. Seven samples from the second quarter sample set collected at locations upstream, opposite, and downstream from the main Knolls Laboratory outfall (i.e., Outfall 002) are also analyzed for strontium-90 by chemical extraction and gross beta counting. The downstream samples for strontium-90 analyses are selected from locations that previous monitoring had indicated would be locations of highest concentrations.

Edible portions of the fish collected from the Mohawk River are analyzed for gamma emitting radionuclides with a high purity germanium spectrometer system, for strontium-90 by chemical extraction and beta counting, and for plutonium by chemical separation followed by alpha spectrometry.

The environmental air sample filters are changed on a routine basis and analyzed by direct counting for gross alpha and gross beta radioactivity using the method described in the Effluent Analyses of the Airborne Effluent Monitoring section of this report. An environmental air sampler was installed in May 2011 near Outfall 002 that is owned and operated by NYSDOH as a result of the

September 29, 2010 SPRU radiological contamination event during Building H2 demolition and was removed by NYSDOH in July 2018.

Assessment

Nonradiological: The results of the analyses of Mohawk River water for chemical quality are summarized in Table 13. Results of routine analyses in the West Boundary Stream Ditch and Midline Stream are summarized in Table 14, and results for the East Boundary Stream are summarized in Table 15. Analyzed parameters were generally below the New York State standards for Class A waters for the section of the Mohawk River that borders the Knolls Laboratory. The surface water database shows that there is no water quality degradation attributable to the Knolls Laboratory.

Current Knolls Laboratory Operations

The Midline Stream has the potential to be influenced by runoff from the east side of the Knolls Laboratory. The West Boundary Stream Ditch captures runoff from an on-site road. Therefore, the Knolls Laboratory SPDES Permit requires the stormwater for these areas to be monitored. Additional voluntary monitoring is also performed and is presented in Tables 13, 14, and 15. The State water quality standard for chloride was exceeded in West Boundary Stream Ditch, Midline Stream, and East Boundary Stream. The high chloride results for all streams were attributed to winter road salting and snow/ice removal operations.

Voluntary surface water monitoring is also performed for other parameters at these locations to supplement the regulatory required SPDES and landfill post-closure monitoring activities. The data from samples analyzed during 2018 continued to indicate there is no adverse impact from current Knolls Laboratory operations on the Mohawk River or the closed landfill on the surrounding surface water streams. Instances where surface water standards or guidance values have been exceeded are discussed below.

Surface Water near the Closed Landfill

The former Knolls Laboratory landfill (permanently closed and capped in 1993) is bordered by the East Boundary Stream, the West Landfill Stream (which is frequently dry), and the Mohawk River to the north. Sample data for the East Boundary Stream is presented in Table 15. The East Boundary Stream upstream and downstream locations were sampled concurrently with landfill post-closure monitoring activities.

Sufficient water was not present in the West Landfill Stream during the second quarter 2018 sampling event, and the requirement to sample the West Landfill Stream was removed from the Landfill Post-Closure Monitoring Program in September 2018.

The Mohawk River and East Boundary Stream data, as previously discussed, do not indicate any measurable impact from the former landfill.

Radiological: Results of the radioactivity analyses performed on samples of Mohawk River and municipal waters are summarized in Table 20. The results for the gross alpha and gross beta radioactivity concentrations show no significant difference between river water samples upstream and downstream from the Knolls Laboratory or in Schenectady, Niskayuna, and Latham/Colonie municipal waters.

The results of radioactivity measurements for gross beta, strontium-90, cesium-137, plutonium, and uranium in Mohawk River bottom sediment samples are summarized in Table 21. The 2018 data shows no significant differences between upstream and downstream radioactivity concentrations for gross beta, strontium-90, cesium-137, plutonium, and uranium. Historically, slightly higher concentrations of radioactivity have occasionally been measured in samples collected from locations within one thousand feet downstream from the main Knolls Laboratory outfall. This localized concentration of radioactivity is attributed to operations conducted prior to 1964, when the facility was subject to applicable Federal regulations and State and local agreements through the Mohawk River Advisory Committee that permitted limited amounts of radioactivity to be released to the Mohawk River. These low levels of radioactivity in the river sediment do not present a health risk since the radioactivity is deposited as bottom sediment, which is not subject to becoming airborne and is unlikely to interact with the aquatic environment. Additional detail regarding the low level of radioactivity in the Mohawk River is discussed in the Special Mohawk River Surveys section, later in this report.

The results of the detailed gamma spectrum analyses performed on Mohawk River bottom sediment samples also indicated the expected low levels of potassium-40 and daughters of uranium and thorium. The potassium-40 and daughters of uranium and thorium are naturally-occurring radionuclides. No detectable cobalt-60 was found in any of the samples. However, localized low levels of cobalt-60, attributable to operations prior to 1964, have been observed occasionally in past river sediment samples.

The analytical results for the fish collected from the Mohawk River are summarized in Tables 22 and 23. The results indicate the presence of naturally occurring potassium-40. The results of sensitive analyses for strontium-90 and plutonium indicate essentially no detectable strontium-90 or plutonium in either upstream or downstream fish. The measured concentrations of radioactivity indicate no effect from Knolls Laboratory operations. In addition, the results of a detailed biological survey (Reference (11)) confirm that the low levels of radioactivity in the Mohawk River bottom sediment near the main Knolls Laboratory outfall (Outfall 002) are not taken up and propagated through the food chain.

The analytical results for the environmental air samples for 2018 indicate that there were no significant differences between the average upwind and downwind radioactivity concentrations. The average upwind gross alpha and gross beta radioactivity concentrations were 8.7×10^{-16} μCi/ml and 1.5×10^{-14} μCi/ml, respectively. The average downwind gross alpha and gross beta radioactivity concentrations were 8.9×10^{-16} μCi/ml and 1.6×10^{-14} μCi/ml, respectively. Gamma spectrometry analyses performed on the environmental air samples indicated only background quantities of naturally occurring radionuclides with the exception for the third quarter of 2018. The gamma spectroscopy of the composite of all the third quarter 2018 downwind perimeter weekly air filters together showed a positive indication of 1.6 pCi of Cs-137 from occasional small releases due to the ongoing DOE-SPRU D&D work. This value is only detectable by very sensitive gamma spectroscopy of the composite of the entire quarter's air filters and is so small that it is not detectable via the associated gross beta and gamma spectroscopy analysis of any individual weekly air filter. Additionally, there were no significant differences between the NYSDOH environmental air sampling results and the Knolls Laboratory results.

TABLE 20
RESULTS OF MONITORING MOHAWK RIVER WATER AND MUNICIPAL WATER

Location and Source of Water Sample	Number of Samples	Radioactivity Concentration (pCi/l)(1,2,3)					
		Gross Alpha Values			Gross Beta Values		
		Minimum	Maximum	Average	Minimum	Maximum	Average
Mohawk River							
Upstream	6	<0.37	<2.52	<0.93 ± 0.83	<1.08	<4.65	<2.29 ± 1.40
Downstream	6	<0.22	1.22 ± 0.95	<0.59 ± 0.38	0.87 ± 0.53	2.60 ± 0.66	1.68 ± 0.68
Municipal Water							
Schenectady Municipal Water(4)	4	<0.49	<0.98	<0.71 ± 0.35	<0.71	2.30 ± 1.18	<1.29 ± 1.13
Niskayuna Municipal Water(4)	4	<0.60	<1.27	<0.84 ± 0.48	<0.72	2.84 ± 1.30	<1.90 ± 1.44
Latham/Colonie Municipal Water(4)	4	<0.44	<0.84	<0.64 ± 0.36	<0.72	2.38 ± 1.17	<1.62 ± 1.31

Notes:

1. The (±) value for average values provides the 95% confidence interval for the average value. The lowest possible value for any parameter is zero.
2. A value preceded by "<" is less than the decision level concentration for that sample and parameter.
3. Average values preceded by "<" contain at least one value that is less than the decision level concentration.
4. Monthly samples are composited and analyzed quarterly.

TABLE 21
RESULTS OF ANALYSES OF MOHAWK RIVER SEDIMENT FOR RADIOACTIVITY

Number of Samples and Type of Results	Radioactivity Concentration (pCi/g, dry weight)(1)		
	Area Sampled Relative to Effluent Point		
	Upstream	Opposite	Downstream
Gross Beta Concentration			
Number of samples	12	3	24
Average Concentration	35.20 ± 4.31	36.00 ± 6.92	33.01 ± 2.10
Minimum Concentration	24.12 ± 5.41	33.82 ± 6.35	25.35 ± 5.59
Maximum Concentration	45.65 ± 7.35	39.14 ± 6.81	42.40 ± 7.22
Sr-90 Concentration			
Number of samples	4	1	2
Average Concentration	<0.01 ± 0.01	0.01 ± 0.01	<0.03 ± 0.29
Minimum Concentration	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01
Maximum Concentration	0.02 ± 0.01	0.01 ± 0.01	<0.06
Cs-137 Concentration			
Number of samples	12	3	24
Average Concentration	<0.05 ± 0.02	<0.05 ± 0.05	<0.04 ± 0.01
Minimum Concentration	<0.01	<0.02	0.02 ± 0.02
Maximum Concentration	0.08 ± 0.03	0.06 ± 0.03	0.12 ± 0.04
Plutonium Concentration(2)			
Number of samples	12	3	24
Average Concentration	<0.01 ± 0.01	<0.01 ± 0.01	<0.01 ± 0.01
Minimum Concentration	<0.01	<0.01	<0.01
Maximum Concentration	0.01 ± 0.01	<0.01	<0.02
Uranium Concentration(3)			
Number of samples	12	3	24
Average Concentration	<0.86 ± 0.12	0.91 ± 0.43	<0.86 ± 0.08
Minimum Concentration	0.56 ± 0.08	0.73 ± 0.09	0.61 ± 0.07
Maximum Concentration	1.10 ± 0.11	1.08 ± 0.11	1.29 ± 0.16

Notes:
1. The sediment is sampled to a depth of approximately 2.5 cm. The (±) values for minimum and maximum concentrations represent the statistical uncertainty at two standard deviations. The (±) values for average concentrations provide the 95% confidence interval for the average value. A value preceded by "<" is less than the decision level concentration. Average values preceded by "<" contain at least one value that is less than the decision level concentration.
2. Plutonium concentration values are the sum of results for Pu-238, Pu-239, and Pu-240. Minimum and maximum concentrations preceded by "<" include at least one radionuclide concentration that is less than the decision level concentration in the sum of the radionuclides.
3. Uranium concentration values are the sum of results for U-234, U-235, and U-238. Minimum and maximum concentrations preceded by "<" include at least one radionuclide concentration that is less than the decision level concentration in the sum of the radionuclides.

TABLE 22
GAMMA SPECTROMETRY RESULTS FOR MOHAWK RIVER FISH

Sample Location(2)	Fish Type	Number of Samples	Radioactivity Concentrations (pCi/g, wet weight)(1)				
			K-40			Cs-137	
			Maximum	Average		Maximum	Average
Upstream	Carp Shorthead Redhorse Sucker	3	4.35 ± 0.45	3.38 ± 2.15		<0.01	<0.01 ± 0.01
Upstream	Smallmouth Bass Northern Pike	2	3.53 ± 0.36	3.27 ± 3.24		<0.01	<0.01 ± 0.01
Downstream	Carp Brown Bullhead	4	3.77 ± 0.48	2.98 ± 0.85		<0.01	<0.01 ± 0.01
Downstream	Walleye Smallmouth Bass	2	3.51 ± 0.35	3.40 ± 1.51		<0.01	<0.01 ± 0.01

Notes:
1. A value preceded by "<" is less than the decision level concentration for that sample and parameter. Average values preceded by "<" contain at least one value that is less than the decision level concentration. The (±) value provides the statistical uncertainty at the 95% confidence interval.
2. Upstream samples were obtained above Lock 8 and below Lock 9. (Lock 8 and Lock 9 are located approximately 9 miles and 14 miles, upstream respectively, from the Knolls Laboratory Outfall 002). Downstream samples were obtained between the Knolls Laboratory Outfall 002 and Lock 7.

TABLE 23
RADIOCHEMICAL ANALYSIS RESULTS FOR MOHAWK RIVER FISH

Sample Location(2)	Fish Type	Radioactivity Concentration (pCi/g wet weight)(1)	
		Sr-90	Plutonium(3)
Upstream	Carp	0.005 ± 0.004	<0.001
Upstream	Shorthead Redhorse	0.002 ± 0.003	<0.001
Upstream	Northern Pike	0.003 ± 0.004	<0.001
Downstream	Smallmouth Bass	<0.003	<0.001
Downstream	Walleye	<0.003	<0.001
Downstream	Carp	<0.003	<0.001

Notes:
1. A value preceded by "<" is less than the decision level concentration for that sample and parameter. The (±) value provides the statistical uncertainty at the 95% confidence interval.
2. Upstream samples were obtained above Lock 8 and below Lock 9. (Lock 8 and Lock 9 are located approximately 9 miles and 14 miles, upstream respectively, from the Knolls Laboratory Outfall 002.) Downstream samples were obtained between the Knolls Laboratory Outfall 002 and Lock 7.
3. Plutonium concentration values are the sum of results for Pu-238, Pu-239, and Pu-240.

Special Mohawk River Surveys

The Knolls Laboratory conducted an extensive sediment and biological sampling program of the Mohawk River during the summer of 1992 and again during the summer of 2002. These sampling programs were performed to update information on the quantity and distribution of radioactivity in the river sediment attributable to Knolls Laboratory operations prior to 1964 and to demonstrate that the residual radioactivity has no adverse effect on human health or the environment. Samples included numerous sediment core samples and various samples of fish, macrophyton, periphyton, plankton, benthic macroinvertebrates, and water. NYSDEC participated in the 2002 survey by observing the Knolls Laboratory sampling on the Mohawk River and splitting select core samples for independent analysis. The Knolls Laboratory also conducted a special sampling program consisting of only sediment core samples in 1981.

The results of the 1992 and 2002 sampling programs, as discussed in References (12) and (13), respectively, show that the distribution of residual radioactivity in the Mohawk River sediment in the vicinity of the Knolls Laboratory is well understood. The majority of radioactivity present is confined to an area along the south side of the Mohawk River, which extends from the Knolls Laboratory Outfall 002 to 1,000 feet downstream. The radioactivity generally is located at least 8 inches below the top of the sediment surface. Radioactivity concentrations above background levels are also detectable further downstream; however, the concentrations are lower, and the radioactivity is located even deeper in the sediment. Comparison of the 2002 sediment sampling results with those from 1992 and to those obtained from the similar survey done in 1981 shows that the 2002 results are similar to the 1992 results, though generally are lower than the 1981 results. The residual radioactivity remains deeper in the sediment than when surveyed in 1981, due to deposition of new sediment in the outfall area. Additionally, the NYSDEC split sample results for the 2002 survey were in very good agreement with the Knolls Laboratory sample results.

A comparison was made between the total amount of residual radioactivity of Knolls Laboratory origin estimated to be present in the sediment above the Lock 7 dam for the 1981, 1992, and 2002 surveys. Though below the results from 1981 (with correction for radioactive decay), the 2002 survey results are not significantly different than the results obtained in 1992. The total radioactivity of Knolls Laboratory origin present in the sediment above the Lock 7 dam is considered to be the same as estimated from the 1992 study: less than 0.65 Ci, of which 90% is attributable to cesium-137 and strontium-90 (and its short-lived daughter product yttrium-90). For perspective, the total radioactivity of Knolls Laboratory origin present in the sediment is less than 10% of the naturally occurring radioactivity found in the sediment in the same region.

The results of the fish and other biological sampling conducted show no detectable radioactivity of Knolls Laboratory origin above weapons testing fallout levels in any biological sample. These results continue to demonstrate that the residual radioactivity in the sediment is not being taken up in the food chain.

A radiological assessment of the residual radioactivity in the sediment concludes that, even using very conservative assumptions and hypothetical scenarios, no measurable dose to a member of the public would result, even if all of the radioactivity in the sediment were released back into the river water. The major conclusion of the radiological assessment is that the radioactivity of Knolls Laboratory origin continues to have no adverse effect on human health or the environment.

RADIATION MONITORING

The purpose of the environmental radiation monitoring program is to measure the ambient radiation levels around the Knolls Laboratory to confirm that operations have not altered the natural radiation background levels at the Knolls Laboratory perimeter. The sources of radiation at the Knolls Laboratory are from small specimens of irradiated and non-irradiated materials and from residual radioactivity remaining in facilities from historical operations.

TABLE 24
PERIMETER AND OFF-SITE RADIATION MONITORING RESULTS, KNOLLS LABORATORY (INCLUDING SPRU)

Monitoring Location(1)	Total Annual Exposure(2) (millirem)
1	73 ± 4
2	68 ± 2
3	72 ± 3
4	81 ± 3
5	82 ± 3
6	72 ± 3
7	80 ± 2
8	75 ± 2
9	68 ± 2
10	67 ± 2
11	75 ± 3
12	70 ± 2
13	65 ± 2
14	70 ± 4
15	76 ± 3
16	71 ± 2
Off-Site Locations	67 ± 24(3)

Notes:
1. See Figure 2 for perimeter monitoring locations.
2. The (±) values for individual locations provide the 95% confidence interval for the exposure due to random uncertainty.
3. Approximately 95% of off-site natural background measurements are expected to be within this range.

Scope

Environmental radiation levels were monitored at the perimeter of the Knolls Laboratory with a network of standard DT-702/PD lithium fluoride TLDs. The sixteen locations of the Knolls Laboratory perimeter TLD monitors are shown in Figure 2. Two new temporary perimeter TLD locations were added to monitor the relocation of the SPRU project TRU waste temporary storage at the end of 2018. Locations T18 and T19 were installed on November 27, 2018 at the start of the first quarter 2019 monitoring period. These results will be reported in the 2019 Environmental Monitoring Report.

Control TLD monitors were also posted at remote off-site locations to measure the natural background levels typical of the surrounding area. All TLD monitors were posted for quarterly exposure periods.

Analyses

The environmental TLDs were calibrated to a cesium-137 standard source. The TLD radiation exposures were measured quarterly utilizing an automated TLD readout system, which was calibrated prior to the processing of the TLDs.

Assessment

The results for the Knolls Laboratory perimeter and off-site radiation monitoring locations are summarized in Table 24. The average of the total annual exposures for each perimeter location is within the expected distribution of the off-site measurements at the 95% confidence interval. This shows that Knolls Laboratory operations in 2018 had no significant effect on natural background radiation levels at the Knolls Laboratory perimeter.

GROUNDWATER MONITORING

Scope

The Knolls Laboratory groundwater monitoring program includes routine monitoring of the closed Knolls Laboratory landfill, monitoring of localized areas as part of the RCRA Corrective Action program, and voluntary monitoring across the site.

Groundwater from 32 monitoring wells was sampled and analyzed for chemical quality and/or radioactivity in 2018. Sampling and analysis of fifteen groundwater monitoring wells is required by State regulations or agreements. Five wells (NTH-1A, NTH-2A, NTH-5A, W-11, and W-12) are associated with post-closure landfill groundwater monitoring. Three wells (SW-10, DW-09R, and B-6) are remediation assessment wells associated with evaluating the effectiveness of a soil remediation project in the former D3/D4 Yard area. Seven wells (MW-6R, MW-7, MW-8, MW-9, MW-10, MW-11, and MW-12) are remediation assessment wells associated with evaluating the effectiveness of a soil remediation project in the former electrical High Yard Area. The remaining groundwater monitoring wells were voluntarily monitored by the Knolls Laboratory. Figure 2 is a map showing the locations of the Knolls Laboratory monitoring wells and the location of the former High Yard Area. The locations of the former High Yard Area groundwater monitoring wells are shown on Figure 4.

Sources

Nonradiological: Generally, groundwater underlying the Knolls Laboratory is contained in highly impermeable and nonporous soil and bedrock. As a consequence, there is only slight movement of the water, generally believed to be toward the northeast, to the Mohawk River. Due to the impermeable and nonporous nature of the soil and bedrock, there is no commercial or public development of the groundwater in the vicinity of the Knolls Laboratory. Groundwater contaminants can be introduced through two possible routes. The first route, surface recharging, carries atmospheric contaminants such as acid rain and airborne radioactivity from natural and manmade sources (such as past nuclear weapons testing), and surface contaminants from operational and historical land use (such as de-icing compounds, fertilizers, and pesticides). The second route is leaching of shallow nonradioactive buried wastes in the closed Knolls Laboratory landfill and other burial areas in the vicinity of the landfill where small amounts of waste chemicals from laboratory operations were buried many years ago, consistent with common industrial practices at the time.

Radiological: In some areas of the Knolls Laboratory, the soil contains low levels of radioactivity from operations over 55 years ago that is detectable above background levels. This has resulted in low levels of radioactivity in some of the on-site groundwater wells.

Analyses

Nonradiological: During 2018, the landfill wells and the D3/D4 Yard remediation assessment wells were sampled once, in accordance with regulatory agency (NYSDEC) agreements. The remaining wells were also sampled once during 2018. The former High Yard Area wells were sampled quarterly in 2018, in accordance with a NYSDEC-approved RCRA Corrective Action groundwater monitoring plan.

Table 25 lists the specific analyses for each chemical parameter group (field parameters, metals, and VOCs) for the landfill, D3/D4 Yard, and voluntary groundwater monitoring programs. For the voluntary program, the selection of wells and parameter groups is based on the historical groundwater monitoring program results, site operational history, well locations, and subsurface hydrogeological information.

As part of the NYSDEC-approved Knolls Laboratory Landfill Post-Closure Monitoring Program, Reference (9), the Knolls Laboratory monitors five overburden wells; one upgradient (NTH-1A) and four downgradient wells (NTH-2A, NTH-5A, W-11, and W-12). The parameters monitored under the revised monitoring plan (approved by NYSDEC in 2018) allow for adequate groundwater quality assessment based on the large historical database. Under a 1997 remediation agreement with NYSDEC, five wells (SW-10, DW-09R, B-5, B-6, and B-7) were monitored annually as part of the voluntary groundwater monitoring program to assess the effectiveness of a soil remediation project in the former D3/D4 yard area. The soil remediation project entailed removal of soils containing VOCs and was driven by the need to construct a building at the Knolls Laboratory and not by an environmental concern. The agreement to monitor these wells under the voluntary groundwater monitoring program is included in the Knolls Laboratory RCRA Permit and addresses the RCRA Corrective Action monitoring requirement until such time that a separate RCRA Corrective Action groundwater monitoring plan is developed and approved by NYSDEC. Well DW-09R was damaged in 2013 during a utility relocation. The requirement to monitor well B-7 was removed under NYSDEC agreement in April 2008 to allow for a road modification project. Monitoring well B-7 was decommissioned during 2008, and monitoring well B-5 was decommissioned in 2017 during the NYSDEC-approved G1-D4 Alleyway remediation project to remove VOCs from soil and groundwater. A new groundwater monitoring plan under the RCRA

Corrective Action program will be developed for this area of the site as part of the G1-D4 Alleyway remediation report. Until that time, monitoring of B-6 and SW-10 will continue.

In accordance with a NYSDEC-approved RCRA Corrective Action groundwater monitoring plan, seven wells (MW-6R, MW-7, MW-8, MW-9, MW-10, MW-11, and MW-12) were monitored quarterly to assess the effectiveness of a soil remediation project in the former High Yard Area. The soil remediation project was performed in accordance with State and Federal regulatory agency approved plans and entailed the removal of soil and debris containing VOCs and PCBs. Post-remediation groundwater monitoring of the former High Yard Area is a requirement of the Knolls Laboratory RCRA Permit as part of the RCRA Corrective Action program and is separate from the voluntary groundwater monitoring program. An annual groundwater monitoring report for the former High Yard Area is provided to NYSDEC.

TABLE 25
GROUNDWATER MONITORING PARAMETERS

MONITORING PARAMETER GROUPS		
FIELD	**METALS[(1)]**	**VOLATILE ORGANIC COMPOUNDS**
Static Water Level	Aluminum	EPA 601:
Specific Conductance	Antimony	Chloromethane
Temperature	Arsenic	Bromomethane
pH	Barium	Dichlorodifluoromethane
Turbidity[(2)]	Beryllium	Vinyl Chloride
	Boron	Chloroethane
	Cadmium	Methylene Chloride
	Calcium	Trichlorofluoromethane
	Chromium (total and hexavalent)	1,1-Dichloroethane
	Copper	1,1-Dichloroethylene
	Iron	trans-1,2-Dichloroethylene
	Lead	cis-1,2-Dichloroethylene
	Magnesium	Chloroform
	Manganese	1,2-Dichloroethane
	Mercury	1,1,1-Trichloroethane
	Nickel	Carbon Tetrachloride
	Potassium	Bromodichloromethane
	Selenium	1,2-Dichloropropane
	Silver	trans-1,3-Dichloropropene
	Sodium	Trichloroethylene
	Thallium	Dibromochloromethane
	Zinc	1,1,2-Trichloroethane
		cis-1,3-Dichloropropene
		Bromoform
		1,1,2,2-Tetrachloroethane
		Tetrachloroethylene
		Chlorobenzene
		p-Dichlorobenzene
		m-Dichlorobenzene
		o-Dichlorobenzene
		EPA 602:[(3)]
		Benzene
		Toluene
		Ethylbenzene
		Xylenes
		EPA 8260(C):[(4)]
		Acetone
		Hexane

Notes:
1. Analysis of metals (unfiltered and filtered) is performed voluntarily and only in the Land Area Wells.
2. Measured in the laboratory and only for the Land Area Wells.
3. EPA 602 parameters not required at the Landfill Wells.
4. Acetone and Hexane analysis for B-6, DW-09R, and SW-10 groundwater samples is required per NYSDEC agreement.

All field parameters except for turbidity are measured in the field using procedures provided in Standard Methods, Reference (10), or other EPA approved methods for analyzing chemical parameters. The vendor analytical laboratory is New York State (NYS) Environmental Laboratory Approval Program (ELAP) certified in potable water analyses and wastewater chemical analyses.

Radiological: The groundwater well samples are analyzed by the Knolls Laboratory for radiological parameters using the methods described in the Effluent Analyses section of this report.

Assessment

Nonradiological: Tables 26, 27, and 28 summarize the 2018 groundwater monitoring nonradiological results. Generally, the majority of analytical results are indicative of natural groundwater quality. Most variations in the data are attributable to natural water quality, variability in laboratory results at or near the RL, or interference associated with groundwater turbidity. The turbidity is the result of natural particulate materials entering the well from the surrounding clay and silt-rich geologic materials. Turbid water samples commonly show elevated metal results that are caused by particle mineralogy and are not indicative of dissolved, mobile metals. Table 29 summarizes the 2018 quarterly groundwater monitoring of the former High Yard Area.

All monitoring results are compared to the NYS groundwater standards provided in 6 NYCRR Part 703 for class GA groundwater (Reference (1)). If no standard is provided, then the results are compared to the Guidance Values provided in the NYS Technical and Operational Guidance Series (1.1.1) Water Quality Standards and Guidance Values.

Landfill

The Knolls Laboratory Landfill well results are presented in Table 26. Specific conductance and pH were consistent with past monitoring results. Overall results of field parameters for the landfill wells are within representative ranges typical of the landfill area per Reference (14). VOCs were not detected at or above the RL in any of the monitored Landfill wells except for the detection of trichloroethene on June 7, 2018, in monitoring well W-12. Trichloroethene was detected at 1.4 µg/l, which is below the NYS water quality standard of 5.0 µg/l. Trichloroethene has not been detected in any of the landfill monitoring well locations since initiation of the Post-Closure Landfill Monitoring Plan. In accordance with the Post-Closure Landfill Monitoring Plan, the Knolls Laboratory attempted to resample this well on numerous occasions; however, due to low groundwater levels, monitoring well W-12 had insufficient recharge to collect a sample. Monitoring well W-12 will be sampled in the second quarter 2019.

Land Area

The Land Area data (Table 27) show natural water quality variations, the turbidity/elevated metal relationship, and road salting effects. Toxic metal results from all wells are less than the corresponding groundwater standard and are attributable to natural water quality. VOCs were not detected at or above the RL at any Land Area well locations.

Hillside

The Hillside groundwater monitoring consists of field parameters and VOC analysis. The field parameter data is consistent with the effects of natural groundwater compositional variations (Table 28). VOCs were not detected at or above the RL at any Hillside well locations. An investigation of the Hillside revealed that the VOCs are mostly restricted to porous backfill associated with building foundations and utility lines, and are not migrating through indigenous soils.

Lower Level

The Lower Level wells are installed in bedrock and are sampled for field parameters and VOCs. Field analysis data is shown in Table 28. The field data shows the effects of natural groundwater compositional variations. The data is generally consistent with that reported previously. VOCs were not detected at or above the RL at any Lower Level well locations.

Former High Yard Area

The former High Yard Area groundwater monitoring wells are installed adjacent to and within the former High Yard Area (Figure 4). The former High Yard Area groundwater monitoring consists of VOC and PCB analyses. VOCs were detected in samples collected from four of the seven monitoring wells. The results are below applicable groundwater standards. PCBs were not detected in any of the seven wells during 2018 quarterly monitoring. A summary of detected VOCs is provided in Table 29. The trace detections of VOCs indicate the residual effects of contamination removed during the former High Yard Area remediation.

Radiological: Results of the groundwater monitoring for radioactivity are summarized in Table 30. Due to SPRU work, wells KH-16, and KH-17 were not accessible and were not sampled in 2018. Some wells had slightly higher gross beta and/or gross alpha radioactivity than the background wells. This is attributed to slightly higher levels of dissolved naturally occurring uranium, thorium, and their respective daughter products. Naturally occurring potassium-40 would also contribute to the gross beta radioactivity. Strontium-90 was detected above background levels in several wells. Strontium-90 and its daughter product, yttrium-90, also contribute to the gross beta radioactivity. All gross alpha, gross beta, and strontium-90 results were generally within the range of previously reported values. The maximum concentration of strontium-90, which has the most restrictive DCS of any radionuclide measured in any well, was detected in well KH-21. The KH-21 strontium-90 concentration was less than one percent of the DOE DCS (Reference (6)).

Conclusion

The overall conclusion of the groundwater monitoring program is that previous operations and waste disposal practices have resulted in some small, measurable effects on the groundwater quality in localized areas of the Knolls Laboratory. Based on upstream and downstream monitoring of the Mohawk River, there is no detectable effect on river water quality as a result of past or current Knolls Laboratory operations. The groundwater is limited in quantity and is not used as a drinking water supply. In addition, the Knolls Laboratory is not located over any principal or primary bedrock or overburden aquifers. Therefore, the groundwater associated with the Knolls Laboratory does not pose any threat to public health.

TABLE 26
RESULTS OF KNOLLS LABORATORY GROUNDWATER MONITORING OF LANDFILL WELLS

Well	Sample Date	Parameter				
		Water Level Elevation (feet)[1]	Temperature (°C)	pH (SU)	Specific Conductance (µmhos/cm)	VOCs[2] (µg/l)
NTH-1A[3]	06/04/18	317.46	9.4	6.9	753	<1.0
NTH-2A	06/04/18	232.68	8.4	6.6	948	<1.0
NTH-5A	06/04/18	267.67	9.6	6.3	410	<1.0
NTH-5A QA Duplicate	06/04/18	NM	NM	NM	NM	<1.0
W-11	06/04/18	257.49	10.6	7.0	1,063	<1.0
W-12	06/04/18	239.21	Note (4)	Note (4)	Note (4)	Note (4)
	06/07/18	238.63	11.4	6.9	1,013	1.4 Trichloroethene
FIELD BLANK (NTH-5A)	06/04/18	NM	NM	NM	NM	<1.0
STANDARD/GUIDANCE VALUE[5]		Note (6)	Note (6)	6.0 – 9.0[7]	Note (6)	Note (8)

Notes:

NM Not Measured

1. The latest site-wide topological mapping project results were used for the groundwater elevation calculations.
2. See Table 25 for a listing of the Volatile Organic Compounds (VOCs). Landfill wells are analyzed for VOCs only using EPA Method 601. A value preceded by "<" is less than the RL.
3. Up-gradient well
4. Inadequate recharge to produce a sample to determine field parameters or VOCs.
5. New York State Quality Standards and Guidance Values (Reference (4)).
6. No standard or guidance value available.
7. Per the NYSDEC-approved Post-Closure Landfill Monitoring Plan, the acceptable pH range is 6.0 – 9.0.
8. Standards/Guidance Values vary between 0.4 µg/l and 50 µg/l.

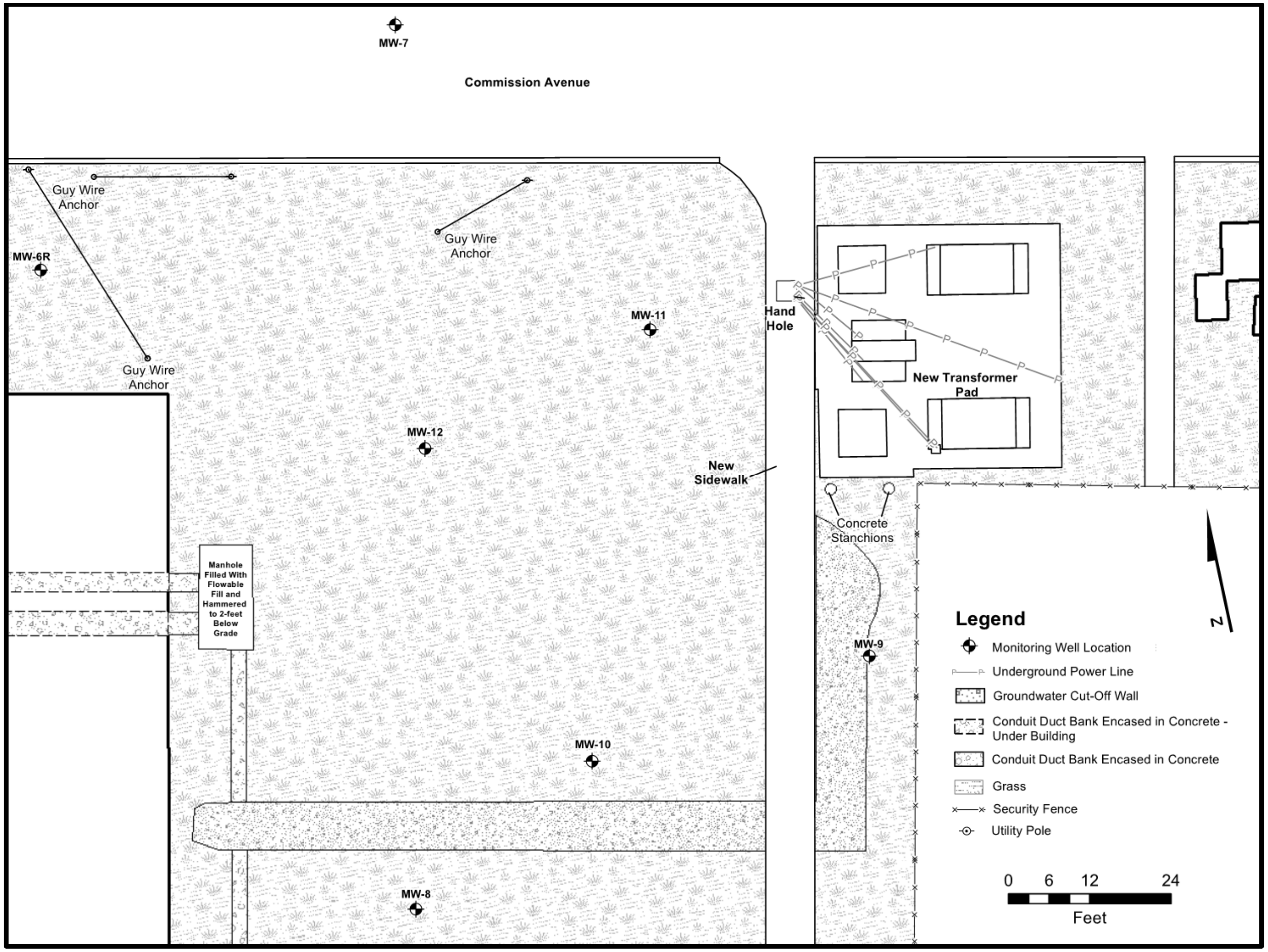

FIGURE 4

KNOLLS LABORATORY, NISKAYUNA, NEW YORK

FORMER HIGH YARD AREA GROUNDWATER MONITORING LOCATIONS

TABLE 27
RESULTS OF KNOLLS LABORATORY GROUNDWATER MONITORING OF LAND AREA WELLS

Well	Sample Date	Parameter(1)									
		Field Parameters					Metals(2)				
		Water Level Elevation (ft)	Temperature (°C)	pH (SU)	Specific Conductance (µmhos/cm)	Turbidity (ntu)	Aluminum (mg/l)	Antimony (mg/l)	Arsenic (mg/l)	Barium (mg/l)	Beryllium (mg/l)
KH-2	06/04/18	324.26	17.1	7.0	2,742	58	0.638 / <0.100	<0.060 / <0.060	<0.005 / <0.005	0. 077 / 0.065	<0.005 / <0.005
MW-3	06/04/18	319.77	11.0	6.7	2,302	3.2	<0.100 / <0.100	<0.060 / <0.060	<0.005 / <0.005	0.079 / 0.084	<0.005 / <0.005
W-1	06/04/18	316.12	12.2	7.2	6,071	16	0.235 / <0.100	<0.060 / <0.060	<0.005 / <0.005	0.307 / 0.346	<0.005 / <0.005
W-2	06/04/18	305.90	13.1	7.2	1,535	120	0.821 / <0.100	<0.060 / <0.060	<0.005 / <0.005	0.052 / 0.042	<0.005 / <0.005
W-3	06/04/18	282.17	11.8	7.4	1,688	58	0.665 / <0.100	<0.060 / <0.060	<0.005 / <0.005	0.045 / 0.040	<0.005 / <0.005
W-4	06/04/18	283.70	10.3	7.0	1,867	1,200	1.40 / 0.610	<0.060 / <0.060	<0.005 / <0.005	0.101 / 0.087	<0.005 / <0.005
W-4, Duplicate	06/04/18	NA	NA	NA	NA	1,500	1.86 / 0.400	<0.060 / <0.060	<0.005 / <0.005	0.134 / 0.082	<0.005 / <0.005
W-8	06/04/18	301.89	12.1	7.5	490	42	0.355 / <0.100	<0.060 / <0.060	<0.005 / <0.005	0.107 / 0.118	<0.005 / <0.005
W-10	06/04/18	286.03	10.0	6.9	884	3.7	0.151 / <0.100	<0.060 / <0.060	<0.005 / <0.005	0.026 / 0.024	<0.005 / <0.005
FIELD BLANKS (W-4)	06/04/18	NA	NA	NA	NA	0.17	<0.100 / <0.100	<0.060 / <0.060	<0.005 / <0.005	<0.010 / <0.010	<0.005 / <0.005
STANDARD/GUIDANCE VALUE(3)		Note (4)	Note (4)	6.5 - 8.5	Note (4)	5	Note (4)	0.003	0.025	1	0.003(5)

Notes for Table 27 are on page 67.

TABLE 27 (continued)
RESULTS OF KNOLLS LABORATORY GROUNDWATER MONITORING OF LAND AREA WELLS

Well	Sample Date	Metals[1,2]									
		Boron (mg/l)	Cadmium (mg/l)	Calcium (mg/l)	Chromium (mg/l)	Chromium, VI (mg/l)[6]	Copper (mg/l)	Iron (mg/l)	Lead (mg/l)	Magnesium (mg/l)	Manganese (mg/l)
KH-2	06/04/18	<0.050 / <0.050	<0.005 / <0.005	72.2 / 78.8	<0.005 / <0.005	<0.02	0.016 / 0.012	0.504 / 0.079	<0.005 / <0.005	12.6 / 14.4	0.106 / <0.020
MW-3	06/04/18	<0.050 / 0.058	<0.005 / <0.005	155 / 180	<0.005 / <0.005	<0.02	0.006 / 0.005	0.156 / <0.050	<0.005 / <0.005	33.7 / 41.2	0.121 / 0.077
W-1	06/04/18	0.056 / 0.052	<0.005 / <0.005	336 / 389	<0.005 / <0.005	<0.02	0.009 / 0.008	0.545 / 0.175	<0.005 / <0.005	77.6 / 106	0.171 / 0.147
W-2	06/04/18	0.291 / 0.291	<0.005 / <0.005	136 / 118	<0.005 / <0.005	<0.02	0.012 / 0.008	1.22 / 0.333	<0.005 / <0.005	38.0 / 41.8	0.479 / 0.370
W-3	06/04/18	0. 507 / 0.490	<0.005 / <0.005	80.0 / 86.1	<0.005 / 0.005	<0.02	0.007 / <0.005	0.823 / <0.050	<0.005 / <0.005	21.6 / 23.9	0.169 / 0.124
W-4	06/04/18	0.081 / 0.088	<0.005 / <0.005	204 / 185	<0.005 / 0.008	<0.02	0.016 / 0.007	2.54 / 2.15	0.010 / <0.005	52.3 / 59.9	0.418 / 0.309
W-4, Duplicate	06/04/18	0.090 / 0.081	<0.005 / <0.005	211 / 175	<0.005 / <0.005	<0.02	0.027/ 0.009	5.00 / 1.44	0.014 / <0.005	56.3 / 56.2	0.755 / 0.225
W-8	06/04/18	0.245 / 0.265	<0.005 / <0.005	37.1 / 42.5	<0.005 / <0.005	<0.02	0.008 / 0.006	0.479 / 0.145	<0.005 / <0.005	11.1 / 13.0	0.075 / 0.039
W-10	06/04/18	<0.050 / <0.050	<0.005 / <0.005	109 / 106	<0.005 / <0.005	<0.02	0.007 / <0.005	0.166 / <0.050	<0.005 / <0.005	29.6 / 33.2	0.101 / 0.033
FIELD BLANKS (W-4)	06/04/18	<0.050 / <0.050	<0.005 / <0.005	<0.050 / 0.052	<0.005 / <0.005	<0.02	0.006 / <0.005	<0.050 / <0.050	<0.005 / <0.005	<0.050 / <0.050	<0.020 / <0.020
STANDARDS/GUIDANCE VALUES[3]		1	0.005	Note (4)	0.05	0.05	0.2	0.3[7]	0.025	35[5]	0.3[7]

Notes for Table 27 are on page 67.

TABLE 27 (continued)
RESULTS OF KNOLLS LABORATORY GROUNDWATER MONITORING OF LAND AREA WELLS

Well	Sample Date	Metals[1,2]								Organics
		Mercury (mg/l)	Nickel (mg/l)	Potassium (mg/l)	Selenium (mg/l)	Silver (mg/l)	Sodium (mg/l)	Thallium (mg/l)	Zinc (mg/l)	VOCs (µg/l)
KH-2	06/04/18	<0.0002 / <0.0002	<0.020 / <0.020	4.90 / 7.20	<0.005 / <0.005	<0.010 / <0.010	359 / 471	<0.010 / <0.010	0.098 / 0.047	<1.0
MW-3	06/04/18	<0.0002 / <0.0002	<0.020 / <0.020	0.810 / 2.36	<0.005 / <0.005	<0.010 / <0.010	176 / 226	<0.010 / <0.010	<0.010 / <0.010	<1.0
W-1	06/04/18	<0.0002 / <0.0002	<0.020 / <0.020	11.3 / 12.9	<0.005 / <0.005	<0.010 / <0.010	565 / 698	<0.010 / <0.010	0.011 / <0.010	<1.0
W-2	06/04/18	<0.0002 / <0.0002	<0.020 / <0.020	9.56 / 8.90	<0.005 / <0.005	<0.010 / <0.010	127 / 129	<0.010 / <0.010	0.013 / <0.010	<1.0
W-3	06/04/18	<0.0002 / <0.0002	<0.020 / <0.020	18.1 / 18.2	<0.005 / <0.005	<0.010 / <0.010	194 / 252	<0.010 / <0.010	0.010 / <0.010	<1.0
W-4	06/04/18	<0.0002 / <0.0002	<0.020 / <0.020	4.52 / 7.48	<0.005 / <0.005	<0.010 / <0.010	79.0 / 114.0	<0.010 / <0.010	0.017 / <0.010	<1.0
W-4, Duplicate	06/04/18	<0.0002 / <0.0002	<0.020 / <0.020	4.84 / 4.54	<0.005 / <0.005	<0.010 / <0.010	83.5 / 133	<0.010 / <0.010	0.030 / 0.023	<1.0
W-8	06/04/18	<0.0002 / <0.0002	<0.020 / <0.020	3.49 / 5.05	<0.005 / <0.005	<0.010 / <0.010	39.7 / 48.0	<0.010 / <0.010	0.010 / <0.010	<1.0
W-10	06/04/18	<0.0002 / <0.0002	<0.020 / <0.020	3.22 / 4.05	<0.005 / <0.005	<0.010 / <0.010	25.1 / 32.6	<0.010 / <0.010	0.041 / 0.011	<1.0
FIELD BLANKS (W-4)	06/04/18	<0.0002 / <0.0002	<0.020 / <0.020	<0.050 / 0.352	<0.005 / <0.005	<0.010 / <0.010	0.716 / 0.689	<0.010 / <0.010	<0.010 / <0.010	2.7 Methylene chloride 2.8 Chloroform
STANDARD/GUIDANCE VALUE[3]		0.0007	0.10	Note (4)	0.010	0.05	20	0.0005[5]	2.0[5]	Note (8)

Notes:

NA Not Applicable.

1. A value preceded by "<" is less than the RL.
2. Unfiltered / Filtered results.
3. Water Quality Standards, 6 NYCRR 703.5 (Reference (1)).
4. No groundwater standard or guidance value available.
5. Technical and Operational Guidance Series (TOGS) 1.1.1, Guidance Values (Reference (4)).
6. Hexavalent chromium results are unfiltered, per Standard Method 3500Cr-D.
7. Combined concentration of iron and manganese shall not exceed 0.5 mg/l per 6 NYCRR 703.
8. See Table 25 for the complete list of VOCs that were analyzed. Standards/Guidance values vary between 0.4 µg/l and 50 µg/l.

TABLE 28
RESULTS OF KNOLLS LABORATORY GROUNDWATER MONITORING OF HILLSIDE AREA AND LOWER LEVEL WELLS

Locations	Sample Date	Water Level Elevation (ft)	Temperature (°C)	pH (SU)	Specific Conductance (µmhos/cm)	Volatile Organic Compounds (µg/l)[(1)]
Hillside Area						
B-6	06/06/18	322.88	16.9	7.4	3,107	<1.0
SW-10	06/06/18	328.33	15.1	7.6	1,546	<1.0
SW-10 (Duplicate)	06/06/18	NA	NA	NA	NA	<1.0
B-16	06/06/18	268.86	12.3	6.8	4,471	<1.0
KH-6	06/06/18	314.98	11.6	6.8	814	<1.0
KH-9S	06/06/18	324.22	11.3	7.0	4,879	<1.0
KH-18	06/06/18	280.09	11.7	6.5	1,521	<1.0
Lower Level						
KH-19	06/06/18	237.85	12.7	8.9	1,170	<1.0
KH-21	06/06/18	242.12	13.1	6.8	7,769	<1.0
KH-22	06/06/18	227.33	15.4	7.0	1,110	<1.0
KH-23	06/06/18	242.23	12.5	7.3	3,673	<1.0
KH-23 (Duplicate)	06/06/18	NA	NA	NA	NA	<1.0
Field Blanks						
KH-23	06/06/18	NA	NA	NA	NA	<1.0
SW-10	06/06/18	NA	NA	NA	NA	<1.0

Notes:

NA – Not Applicable.

1. See Table 25 for the complete list of VOCs that were analyzed. A value preceded by "<" is less than the RL. The results for those parameters not listed in this table were all less than the RL.

TABLE 29
RESULTS OF KNOLLS LABORATORY GROUNDWATER MONITORING OF FORMER HIGH YARD AREA, DETECTED VOLATILE ORGANIC COMPOUNDS

Well	Sample Date	Volatile Organic Compounds (1,2)				
		Vinyl Chloride (µg/L)	trans-1,2-Dichloroethene (µg/L)	cis-1,2-Dichloroethene (µg/L)	Trichloroethene (µg/L)	1,3-Dichlorobenzene (µg/L)
MW-6R	03/26/18	1.2	0.76 J	1.2	1.2	<1.0
	06/19/18	0.53 J	0.39 J	0.66 J	0.53 J	<1.0
	09/12/18	0.91 J	0.70 J	1.4	1.2	<1.0
	12/04/18	0.66 J	0.52 J	0.75 J	0.55 J	<1.0
MW-7	03/26/18	<1.0	0.20 J	0.62 J	<1.0	0.58 J
	06/19/18	<1.0	<1.0	0.66 J	<1.0	<1.0
	09/12/18	<1.0	0.26 J	1.2	<1.0	0.51 J
	12/04/18	<1.0	<1.0	0.74 J	<1.0	0.53 J
MW-8	06/19/18	<1.0	<1.0	0.37 J	<1.0	<1.0
	09/12/18	<1.0	<1.0	0.36 J	<1.0	<1.0
	12/04/18	<1.0	<1.0	0.47 J	<1.0	<1.0
MW-9	09/12/18	<1.0	<1.0	0.60 J	<1.0	<1.0
Standards (3)		2	5	5	5	3

Notes:

J = The associated result is less than the RL but greater than or equal to the method detection limit and the concentration is an approximate value.

1. A value preceded by "<" is less than the RL.
2. Samples were analyzed for 51 volatile organic compounds. Carbon disulfide was detected in the December 4, 2018 sample collected from MW-6R at a concentration of 0.38 J µg/L, which is less than the standard of 60 µg/L. Carbon disulfide can be naturally occurring and its detection is attributed to natural organic material in the soil.
3. Water Quality Standards, 6 NYCRR 703.5 (Reference (1)).

TABLE 30
RESULTS OF KNOLLS LABORATORY GROUNDWATER MONITORING FOR RADIOACTIVITY

Location Month Sampled		Radioactivity Concentrations(1,2)					
		Gross Alpha	Gross Beta	Sr-90	Cs-137		H-3
		pCi/l					x10^2 pCi/l
Landfill Area							
June	NTH-1A	<2.10	4.33 ± 2.79	0.40 ± 0.20	<0.28		<0.67
	NTH-2A	<3.69	11.73 ± 5.76	0.49 ± 0.23	<0.17		<0.67
	NTH-5A	<2.23	6.54 ± 3.28	0.25 ± 0.21	<0.52		<0.67
	W-11	<3.29	10.40 ± 4.65	<0.18	<0.24		<0.67
	W-12	<2.90	12.69 ± 4.23	0.42 ± 0.18	<2.35		<0.67
Land Area							
June	W-2	<3.81	16.96 ± 6.76	<0.10	<0.48		<0.67
	W-3	<0.86	6.96 ± 1.70	<0.12	<0.25		<0.67
	W-4	<4.34	11.61 ± 6.37	<0.09	<0.41		<0.67
	W-8	<1.93	12.48 ± 3.65	0.20 ± 0.22	<0.53		<0.67
	W-10	<1.97	9.23 ± 2.70	<0.14	<0.49		<0.67
	MW-3	<4.00	8.30 ± 5.90	0.30 ± 0.15	<0.17		<0.67
Hillside Area							
June	B-6	<7.23	17.92 ± 9.18	<0.11	<0.54		<0.67
	B-16	<8.81	23.17 ± 10.17	0.37 ± 0.18	<0.28		<0.68
	KH-6	<2.80	9.66 ± 4.65	<0.21	<0.28		<0.71
	KH-9S	<6.00	17.30 ± 8.02	<0.12	<0.56		<0.68
	KH-18	<4.17	13.21 ± 6.49	0.14 ± 0.11	<0.56		<0.68
	SW-10	<3.28	11.59 ± 5.00	<0.09	<0.25		<0.67
Lower Level							
June	KH-19	<2.07	6.56 ± 2.93	<0.12	<0.29		<0.68
	KH-20	<3.12	12.62 ± 4.82	<0.11	<0.27		<0.68
	KH-21	10.80 ± 13.94	21.97 ± 10.79	5.52 ± 0.48	<0.28		<0.69
	KH-22	<2.55	64.13 ± 7.95	0.34 ± 0.16	<0.23		<0.68
	KH-23	<7.73	15.10 ± 10.04	<0.59	<0.38		<0.68
Background Wells – for comparison							
June	W-1	<11.40	19.02 ± 13.06	0.14 ± 0.14	<0.41		<0.68
	KH-2	<7.04	16.80 ± 9.01	0.19 ± 0.20	<0.58		<0.68
	KH-3S	<2.09	9.02 ± 3.49	<0.10	<0.28		<0.68

Notes:
1. A value preceded by "<" is less than the decision level concentration for that sample and parameter. The (±) value represents the statistical uncertainty at the 95% confidence interval.
2. The lowest possible value for any parameter is zero.

CONTROL OF CHEMICALLY HAZARDOUS SUBSTANCES AND SOLID WASTE

Sources

Chemicals are not manufactured at the Knolls Laboratory. Minimal quantities of hazardous wastes do result from the necessary use of chemicals in Knolls Laboratory operations. To ensure the safe use of chemicals and disposal of the resulting wastes, the Knolls Laboratory maintains a hazardous waste control program. Hazardous wastes are disposed of through permitted off-site treatment and disposal facilities.

Chemical Control Program

The control program minimizes the quantity of waste material generated, ensures safe usage and storage of the materials at the Knolls Laboratory, and provides for proper disposal of the wastes by vendors that operate under permits issued by Federal and State agencies.

A principal part of the waste minimization program is the control of the acquisition of hazardous substances for use at the Knolls Laboratory. Purchase requests for chemicals are reviewed to ensure that the materials are actually necessary for Knolls Laboratory operations, the amount ordered is not excessive, and that methods for proper disposal are in place before the material is ordered. Hazardous substance storage controls include as a minimum: labeling, providing revetments as appropriate, segregation based on compatibility, limited storage volumes, and weather protection as appropriate. When required, large volumes of chemicals and petroleum products are stored in accordance with the New York State Chemical Bulk Storage regulations (Reference (15)) and the Petroleum Bulk Storage regulations (Reference (16)). The Knolls Laboratory did not store any chemicals in quantities that are subject to the Chemical Bulk Storage regulations during 2018.

Additionally, many hazardous substances have been replaced by non-hazardous substitutes. The Knolls Laboratory stresses the "Know-Before-Do" principle. To this end, facility personnel must identify ways to minimize waste prior to performing a waste generating process. The Knolls Laboratory also evaluates the hazardous waste that is generated and determines if additional waste minimization can be achieved.

All personnel working at the Knolls Laboratory are provided with general information on the Knolls Laboratory policies for the procurement, use, and disposal of hazardous substances. For individuals who use hazardous substances in operations, specific training is provided to ensure that they are knowledgeable of safe handling techniques and emergency response procedures. After chemicals are used and no longer needed, they are accumulated in designated staging and storage areas where they are segregated and packaged for shipment. Waste is temporarily stored only as necessary to accumulate sufficient volumes for shipment to a waste disposal vendor. Hazardous and mixed (radioactive and hazardous) waste storage facilities are operated at the Knolls Laboratory under a permit obtained from NYSDEC. The Knolls Laboratory has an inspection program to verify routinely that hazardous substances are properly stored and controlled in accordance with approved procedures.

In addition, the Knolls Laboratory hazardous waste control program is subject to an annual on-site inspection. The EPA conducted a hazardous waste management inspection during 2018.

Chemical Disposal

Hazardous waste is managed in compliance with RCRA. Generated waste is transported by vendors to treatment, storage, and disposal facilities for final disposition. The transportation vendors and the treatment, storage, and disposal facilities operate under permits issued by the cognizant Federal and State regulatory agencies. The Knolls Laboratory requires the disposal facilities to provide itemized written verification that the waste was actually received. During 2018, the Knolls Laboratory shipped approximately 8.3 tons of RCRA and New York State hazardous waste off-site for disposal. This included approximately 1.6 tons of mixed waste. The Knolls Laboratory reduces the potential environmental impact of the waste by selecting the ultimate disposal methods that minimize or eliminate future environmental intrusion.

Non-hazardous chemical waste is also sent off-site for disposal. The transportation vendors and the treatment, storage, and disposal facilities are typically the same as those used for hazardous waste disposal. These facilities also operate under permits issued by the cognizant Federal and State regulatory agencies. The Knolls Laboratory requires the disposal facility to provide itemized written verification that the waste was actually received. During 2018, approximately 640 tons of non-hazardous chemical waste was sent for off-site disposal via incineration, wastewater treatment, chemical treatment, or land disposal from the Knolls Laboratory.

Solid Waste Disposal/Recycling

During 2018, approximately 968 tons of non-hazardous solid waste were generated from such waste streams as office and cafeteria trash, construction and demolition debris, and classified scrap paper. From these waste streams, the Knolls Laboratory recycles materials such as office paper, except classified items, glass, tin, aluminum, newspapers, magazines, plastic, cardboard, wood, asphalt, lead/lead acid batteries, concrete, precious metals, computers, metal and plastic drums, cafeteria grease, used oil, and universal waste (e.g., light bulbs, batteries, thermostats). In 2018, approximately 652 tons of these materials were recycled from the Knolls Laboratory.

CONTROL OF RADIOACTIVE MATERIALS AND RADIOACTIVE WASTE

Sources

Operation of the Knolls Laboratory results in the generation of various types of radioactive materials and wastes. Low level radioactive solid waste materials that require disposal include filters, metal scrap, rags, resin, paper, and plastic materials.

Control Program

Detailed procedures are used for handling, packaging, transportation, and disposal of radioactive waste at a government operated or licensed disposal site. Internal reviews are made prior to the shipment of any radioactive material from the Knolls Laboratory to ensure that the material is properly identified, surveyed, and packaged in accordance with Federal requirements.

The volume of radioactive waste is minimized through the use of special work procedures that limit the amount of materials that become contaminated during work on radioactive systems and components. Radioactive liquid waste is collected in an absorbed form prior to shipment to an approved disposal facility. All radioactive wastes are prepared and shipped in accordance with written procedures to meet the applicable DOT regulations given in Reference (17). The waste packages also comply with all applicable requirements of the NRC, the DOE, and the disposal sites.

Disposal/Recycling

The shipments of low level radioactive solid wastes were made by authorized common carriers to disposal sites located outside New York State. During 2018, approximately 4,543.061 cubic meters (5,942.1 cubic yards) of low level radioactive waste containing approximately 2.59×10^{-3} Ci were shipped from the Knolls Laboratory for disposal.

CONTROL OF MIXED WASTES

Sources

Waste that is both radioactive and chemically hazardous is regulated under both the Atomic Energy Act (AEA) and RCRA as "mixed waste." Also, per NYSDEC, certain TSCA regulated PCB waste is also considered a hazardous waste. Operations at the Knolls Laboratory, in support of research and development for the design and operation of naval nuclear propulsion plants, resulted in the generation of a small quantity of mixed wastes. These wastes included laboratory chemicals, oils, equipment, and debris.

Control Program

Mixed wastes were managed in accordance with the Knolls Laboratory RCRA permit, the Knolls Laboratory Mixed Waste Site Treatment Plan, which is updated as required and provided to NYSDEC, and the Federal Facility Compliance Act of 1992. The Knolls Laboratory takes aggressive action to minimize the creation of mixed waste by reducing the commingling of radioactive and hazardous materials and avoiding the use of hazardous substances where technically acceptable. The amount of generated mixed waste was also minimized through the use of detailed work procedures and worker training.

Storage and Disposal

Mixed wastes were accumulated in designated regulated and permitted storage areas. The wastes were packaged for storage and shipment to off-site treatment facilities in accordance with the Knolls Laboratory Mixed Waste Site Treatment Plan. In 2018, there were four shipments totaling approximately 1.6 tons of various mixed wastes to treatment and disposal facilities.

RADIATION DOSE ASSESSMENT

The effluent and environmental monitoring results show that radioactivity present in liquid and gaseous effluents from 2018 operations at the Knolls Laboratory and SPRU had no measurable effect on normal background radioactivity levels. Therefore, any radiation doses from the Knolls Laboratory and SPRU operations to off-site individuals were too small to be measured and must be calculated using conservative methods. Estimates of the radiation dose to the maximally exposed individual in the vicinity of the Knolls Laboratory, including SPRU and the collective dose to the population residing in the 80 kilometer (50 mile) radius assessment area are summarized later in this report in the Radiation Dose Assessment and Methodology section.

The results show that the estimated doses were less than 0.1 percent of that permitted by the radiation protection standards of the DOE listed in Reference (18) and that the estimated dose to the population residing within 80 kilometers (50 miles) of the Knolls Laboratory was less than 0.001 percent of the natural background radiation dose to the population. In addition, the estimated doses were less than one percent of that permitted by the NRC numerical guide listed in Reference (19) for whole-body dose, demonstrating that doses are as low as is reasonably achievable. The dose attributed to radioactive air emissions from both the Knolls Laboratory and SPRU was less than one percent of the EPA standard in Reference (8).

The collective radiation dose to the public along the travel route from outgoing Knolls Laboratory shipments of radioactive materials during 2018 was calculated using data given by the NRC in Reference (20). The collective radiation dose to the public from all NNPP shipments of radioactive materials is included in Reference (21).

Based on the type and number of shipments made, the collective annual radiation dose to the public along the transportation routes, including transportation workers, was less than one person-rem. (See the SPRU Radiation Dose Assessment section of this report for the collective radiation dose from SPRU shipments). This is less than 0.001 percent of the dose received by the same population from natural background radiation.

KESSELRING SITE

SITE DESCRIPTION

The Kesselring Site consists of 3,900 acres on which two operating pressurized-water naval nuclear propulsion plants and support facilities are located, including administrative offices, machine shops, waste storage facilities, oil storage facilities, training facilities, equipment service buildings, chemistry laboratories, a boiler house, cooling towers, and wastewater treatment facilities. Two other nuclear propulsion plants were permanently shut down during the 1990s; one has been dismantled, the other is undergoing dismantlement. Kesselring Site is located near West Milton, New York, approximately 17 miles (27.4 kilometers) north of the City of Schenectady, 9 miles (14.5 kilometers) southwest of Saratoga Springs, and 13 miles (21 kilometers) northeast of Amsterdam (see Figure 1). The surrounding area is a rural, sparsely populated region of wooded lands through which flow the Glowegee Creek and several small streams that empty into the Kayaderosseras Creek.

As a result of the end of the Cold War and the downsizing of the Navy, the S3G and D1G Prototype reactor plants were shut down in May 1991 and March 1996, respectively. All spent nuclear fuel was removed from the S3G Prototype reactor and shipped off-site in July 1994. All spent nuclear fuel was removed from the D1G Prototype reactor and shipped off-site in February 1997. After completion of the public National Environmental Policy Act process in 1998, a record of decision was issued for prompt dismantlement of the defueled S3G and D1G reactor plants. Dismantlement operations began, starting on the S3G plant, shortly after this decision was made. Dismantlement of the S3G plant was completed during 2006 and dismantlement of the D1G plant is continuing. The project is planned to be completed as soon as practicable subject to available appropriated funding.

The climate in the region of the Kesselring Site is primarily continental in character, but is subjected to some modification from the maritime climate, which prevails in the extreme southeastern portion of New York State. Winters are usually cold and occasionally fairly severe. Maximum temperatures during the colder winter months often are below freezing and nighttime low temperatures frequently drop to 10° F or lower. Sub-zero temperatures occur rather infrequently, about a dozen times a year. Snowfall in the area is quite variable, averaging approximately 69 inches per year. Over some of the higher elevation areas nearby, snowfall ranges up to 75 inches or more for a season. The mean annual precipitation for the area is approximately 45 inches per year. The prevailing winds are from the west.

The area surrounding the Kesselring Site has a complex geological history due to the processes of erosion, glaciation, folding, and faulting. The geological formations of the West Milton area are comprised of two major types: bedrock, which ranges in age from Precambrian to Ordovician, and unconsolidated deposits of Pleistocene and Recent age. Bedrock underlying the area crops out only on some steep hillsides and in some stream valleys. It is covered by the unconsolidated deposits in the remainder of the area. These unconsolidated deposits range in thickness from zero to 200 feet with an average thickness of 50 feet. Bedrock underlying the West Milton area may be divided into two groups: (1) metamorphosed rocks of Precambrian age and (2) sedimentary rocks of Paleozoic age. The older metamorphosed rocks consist of gneiss, schist, quartzite, and limestone (marble) of sedimentary origin and syenite and granite of igneous origin. These rocks are referred to as crystalline rocks. The Paleozoic rocks likewise consist of several types of rocks including sandstone, dolomite, limestone, and shale. The unconsolidated deposits can be subdivided into four groups: (1) till - an unstratified, dense heterogeneous mixture of glacially deposited rock particles ranging in size from clay to gravel; (2) ice-contact deposits - kames and eskers composed of stratified sand and gravel; (3) glaciolacustrine deposits - a homogeneous stratified layer of sand, silt, and clay; and (4) recent fluvial deposits consisting of sand and gravel.

Generally, the coarser-grained and stratified unconsolidated deposits form better aquifers than the fine-grained and unstratified unconsolidated deposits or bedrock foundations. Only small areas are underlain by these coarse-grained deposits. Percolating water from rainfall and snowmelt recharge the shallow, unconfined aquifers beneath the Kesselring Site, and in turn, streams are recharged by shallow groundwater. The Kayaderosseras Creek is underlain by coarse-grained glacial and fluvial valley-fill deposits from which all Site Service (drinking) Water is produced. Kesselring Site drinking water well field is located near the eastern boundary of the Kesselring Site within the Creek's floodplain. The Kesselring Site obtains all water for its operation from on-site production wells that are hydrogeologically separate from current and historical operational areas.

The Kesselring Site is located in the transition zone between the Adirondack Mountains and the Hudson-Mohawk Valley lowland. The Kayaderosseras Creek forms the main drainage system in the vicinity of the Kesselring Site. The average flow (1927–1994) in the Kayaderosseras Creek is 137.8 cubic feet per second (cfs) and the lowest recorded seven-day minimum flow is 12.4 cfs during August 1964. The Kayaderosseras gauging station was taken out of service in 1995.

The Glowegee Creek, Crook Brook, and Hogback Brook drain the Kesselring Site. Crook Brook directly joins the Kayaderosseras. Hogback Brook is a tributary to the Glowegee, which is the receiving water for Kesselring Site drainage. The average flow (1948–2018) in the Glowegee is 38.6 cfs and the lowest recorded seven-day minimum flow is 0.51 cfs during August 1949. The Glowegee Creek joins with the Kayaderosseras Creek approximately one mile east of West Milton.

The Glowegee and Kayaderosseras Creeks are classified under New York State Codes, Rules and Regulations as Class C - Trout Streams. Under this classification, the waters are suitable for fishing and fish propagation. Additionally, the water quality shall be suitable for primary and secondary contact recreation, even though other factors may limit the use for that purpose. The NYSDEC has permitted the Kesselring Site to discharge effluent from various Kesselring Site operations to the Glowegee Creek as specified in the Kesselring Site’s SPDES Permit (Reference (22)). Environmental monitoring has shown no measurable water quality degradation in the Glowegee Creek due to Kesselring Site operations.

LIQUID EFFLUENT MONITORING

Sources

Nonradiological: The primary sources of the effluent water at the Kesselring Site are:

1. *Site Boiler House Discharges* - Site boiler water is treated demineralized water. Operations that result in discharges are (1) annual boiler draining and periodic blowdowns to control the concentration of solids and (2) wastewater from a reverse osmosis water treatment system.

2. *Sanitary Wastewater Treatment Facility* - The sanitary wastewater treatment facility consists of influent wastewater grinding, a biological treatment process consisting of pre-equalization, sequencing batch reactors (SBR), post-equalization, aeration, and filtration. Waste sludge is stored in a holding tank and removed periodically by a licensed subcontractor for disposal at a State-approved facility.

3. *Cooling Tower Water* - Cooling tower water is treated to minimize scale formation, to prevent corrosion of system materials, and to inhibit the growth of algae and slime. The pH is normally maintained in the range of 7.1 to 8.2.

4. *Retention Basin Liquids* - The retention basins receive wastewater from prototype plant facilities including blowdown water from steam generators and drainage water from the engine rooms.

5. *Site Drainage Water* - Stormwater and groundwater (treated and untreated) also make up a portion of the liquid effluent. A portion of the groundwater on site is treated with sodium hypochlorite due to elevated levels of ammonia in the groundwater.

6. *Site Service Water* - Site Service Water is used for drinking water and non-contact cooling purposes. Sodium hypochlorite is added to the Site Service Water system as a drinking water disinfectant.

With the exception of the Sanitary Wastewater Treatment Facility effluent and some stormwater, all of the above sources of effluent water are discharged into the Kesselring Site Lagoon and through a wastewater treatment system before ultimate off-site discharge into the Glowegee Creek. The Kesselring Site lagoon is a five-million gallon holding basin that was designed to accumulate effluent water for the purposes of pH control, thermal equalization, chlorine dissipation, and settling of solid particles.

Radiological: Some of the liquid effluent discharged from the retention basins contains low levels of radioactivity. The source of this radioactivity is small quantities of activation products. The activation products may include tritium and radionuclides of corrosion and wear products.

Tritium is present in the reactor coolant as the result of neutron interaction with naturally occurring deuterium present in the water. Tritium produced in the reactor exists in the oxide form and is chemically indistinguishable from water. Corrosion and wear products, in the form of small insoluble metal oxide particles, become radioactive as they pass through the reactor, with cobalt-60 being the predominant radionuclide. Operation of the prototype plant requires processing reactor coolant using radioactive liquid waste collection systems.

To minimize releases of radioactivity in liquid effluent to the environment, a water reuse system and evaporators are employed. The reactor coolant water that is discharged from the prototype plant to the radioactive liquid waste collection system is processed through a series of filters and demineralizers. The processing system removes nearly all of the radioactivity with the exception of tritium. After purification, the water is either reused as reactor coolant makeup and in other radioactive systems, or evaporated to reduce the amount of radioactivity that could be released as liquid effluent.

The low concentrations of radioactivity in the liquids released from the Kesselring Site have always been below all applicable Federal and State limits and have not resulted in any detectable radioactivity in the Glowegee Creek from Kesselring Site operations.

Effluent Monitoring

Nonradiological: Liquid effluents from the Kesselring Site enter the Glowegee Creek through two surface channels (Outfalls 001 and 002) and a submerged drain line from the Sanitary Wastewater Treatment Facility (Outfall 003) shown in Figure 5. A series of gates are located in the main discharge channel upstream of the lagoon to provide a means to contain effluent if concentrations should ever exceed applicable discharge limits. An internal outfall (Outfall 02B) discharges groundwater treated with sodium hypochlorite to the main discharge channel upstream of the lagoon.

Since 1998, the Kesselring Site has operated a wastewater treatment system at the outlet of the lagoon. This treatment system is designed primarily to minimize total suspended solids and residual chlorine levels, and adjust pH. This is necessary in order to maintain Kesselring Site operations and to ensure continued compliance with the SPDES Permit limits. The system also removes residual chlorine from the lagoon effluent using an automated sodium bisulfite system. Treatment is also provided for pH using carbon dioxide, and temperature using Site Service Water.

Effluent samples from the lagoon wastewater treatment system (Outfalls 001 and 002) and the Sanitary Wastewater Treatment Facility (Outfall 003) are collected and analyzed as required by the SPDES Permit.

Stormwater from the Kesselring Site enters the Glowegee Creek from stormwater Outfalls 01A, 02A, 004, 005, and 006 (Figure 5). Outfalls 01A and 02A were used for Kesselring Site discharge prior to the construction of the lagoon. These outfalls currently collect only stormwater.

Outfall 004, which discharges into the Glowegee Creek just below the main access road bridge, collects drainage from the parking lot and the southern part of the Kesselring Site. Discharges through this outfall are controlled locally or remotely by a sluice gate. This gate provides control for contaminants (i.e., oils and chemicals) which could reach this drainage way in the event of a spill, fire, or other emergency. Stormwater also collects in Outfall 005 from Hogback Road and enters the Glowegee Creek. Outfall 006 collects stormwater runoff from the landfill that was closed and capped in 1993. Currently, no routine sampling or monitoring is required for stormwater Outfalls 01A, 02A, 004, 005, and 006.

In June 2007, NYSDEC's Stream Biomonitoring Unit performed an assessment of the Glowegee Creek. The report was published April 17, 2009, and a copy has been provided in the Saratoga Library. The results and conclusions were that the water quality in Glowegee Creek was very good at all locations, and there appeared to be no impacts from the Kesselring Site discharges.

Radiological: Liquid discharges that might contain tritium are either sampled and analyzed individually or sampled and combined into a monthly composite that is then analyzed for tritium. Monthly grab samples are also taken at Outfalls 001 and 002.

Effluent Analyses

Nonradiological: The analyses performed for chemical constituents on effluent samples from each discharge point and the sanitary wastewater treatment facility are listed in Tables 31, 32, and 33. Analyses for chemical constituents are performed using procedures described in Standard Methods, Reference (10), or other EPA approved procedures. Flow, temperature, and total residual chlorine are measured at Outfalls 001 and 002 during every day on which there is a discharge from the lagoon, except when the flume is flooded with Glowegee Creek water. Outfall 001 is flooded more often than Outfall 002 because its elevation is lower.

Radiological: Each liquid discharge that might contain tritium is sampled. The samples are combined into a monthly composite for each frequently used release point. Samples from other tritium release points are analyzed individually. The monthly grab samples are analyzed for tritium and by gamma spectrometry. Tritium analyses are performed by liquid scintillation counting.

Assessment

Nonradiological: The analytical results for the measurements of chemical constituents summarized in Tables 31, 32, and 33 show that average values are within the applicable effluent standards. Liquid effluent monitoring data is reported as required in Reference (22).

Radiological: The radioactivity released in Kesselring Site liquid effluent during 2018 totaled 9.37×10^{-4} Ci of tritium as shown in Table 34. The activity was contained in approximately 5.89×10^{6} liters of water. Tritium and gamma emitting radionuclides attributable to Kesselring Site operations were not detected in the monthly grab samples of the outfalls. The resulting annual average radioactivity concentration in the effluent corresponded to less than 0.1 percent of the DOE DCS for effluent released to unrestricted areas, (Reference (6)) for the mixture of radionuclides present.

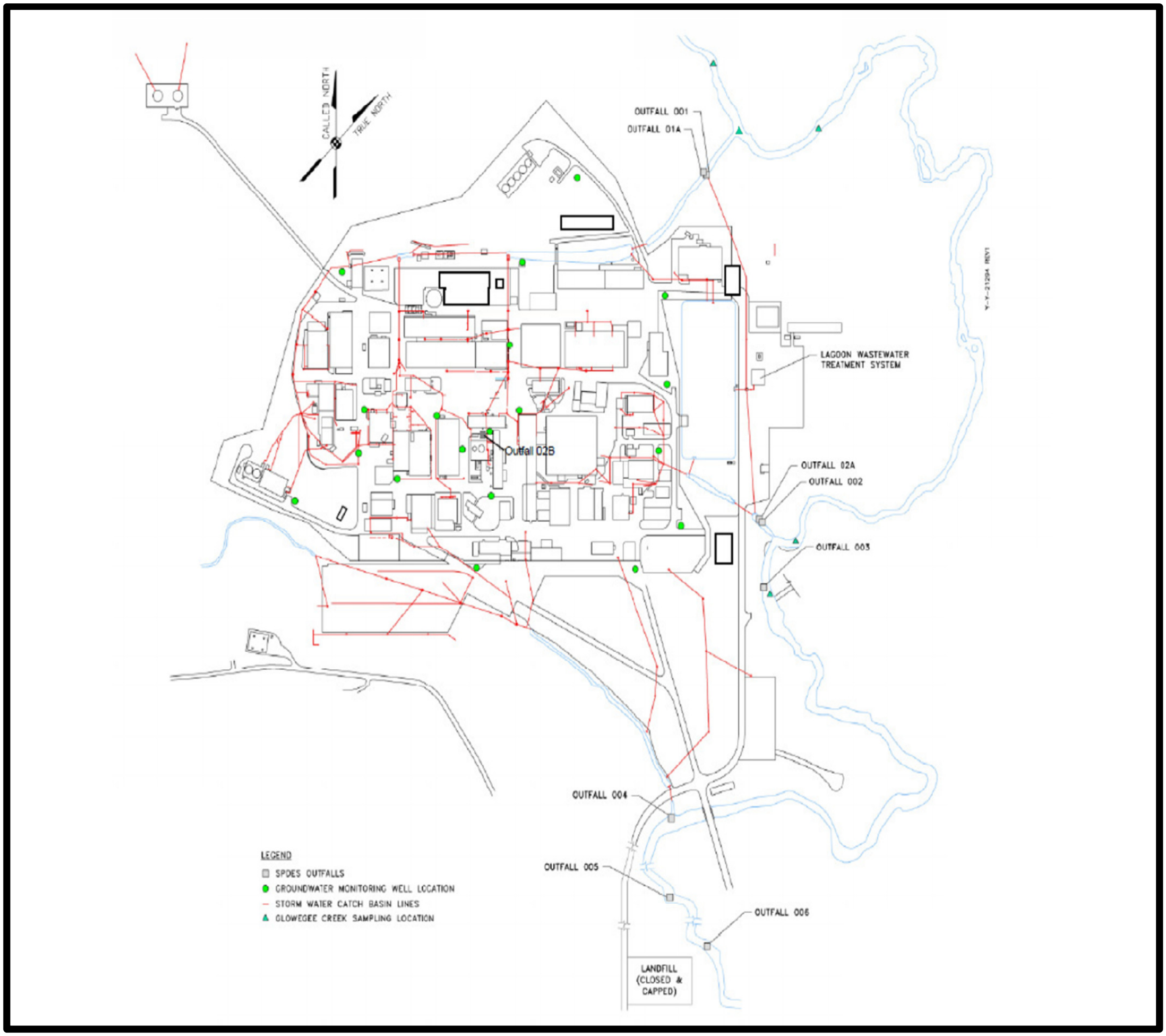

FIGURE 5

KESSELRING SITE, NEAR WEST MILTON, NEW YORK

GLOWEGEE CREEK SAMPLING LOCATIONS AND OUTFALL LOCATIONS

TABLE 31
CHEMICAL CONSTITUENTS AND TEMPERATURE IN KESSELRING SITE LIQUID EFFLUENT, OUTFALL 001

Parameter (units)	Number of Samples	Value			SPDES Permit Limit	Percent of Limit[3]
		Minimum[1]	Maximum[1]	Average[2]		
Discharge Requirements (Reference (22))						
Flow (MGD)	146	0.05	0.89	0.39	Monitor[4]	----
Temperature (°F)	146	33	74	54	Note (5)	----
Residual Chlorine (mg/l)	146	<0.02	<0.02	<0.02	0.04	<50
pH (SU)	15	7.3	9.1	----	6.0 – 9.0[6]	----
Oil and Grease (mg/l)	12	<5.0	5.9	<5.3	15	<35
Total Suspended Solids (mg/l)	12	1.6	11.8	8.0	45	18
Nitrite as N (mg/l)	12	<0.01	0.02	<0.01	0.04	<25
Iron						
(mg/l)	12	0.153	0.362	0.261	Monitor[4]	----
(lbs/day)	12	0.115	1.122	0.482	Note (7)	----
Total Phosphorus						
(mg/l)	12	0.08	0.21	0.12	Monitor[4]	----
(kg/month)	12	0.62	3.90	2.29	Note (8)	----
Zinc						
(mg/l)	12	0.006	0.021	0.012	Monitor[4]	----
(lbs/day)	12	0.006	0.049	0.022	Note (9)	----
Boron (mg/l)	12	<0.050	0.070	<0.052	0.5	<10
Sulfite (mg/l)	12	<2.0	<2.0	<2.0	2.0	<100
Nitrogen, Ammonia (as N, mg/l)	12	<0.1	0.1	<0.1	Monitor[4]	----
Additional Parameters Monitored (Not Required by Permit – Reference (22))						
Surfactants (MBAS, mg/l)	12	<0.02	0.03	<0.02	N/A	N/A

Notes for Table 31 are on page 83.

TABLE 32
CHEMICAL CONSTITUENTS AND TEMPERATURE IN KESSELRING SITE LIQUID EFFLUENT, OUTFALL 002 AND 02B

Parameter (units)	Number of Samples	Value			SPDES Permit Limit	Percent of Limit (3)
		Minimum(1)	Maximum(1)	Average(2)		
Discharge Requirements (Reference (22))						
Flow (MGD)	159	0.06	1.19	0.53	Monitor(4)	----
Temperature (°F)	159	33	74	54	Note (5)	----
Residual Chlorine (mg/l)	159	<0.02	<0.02	<0.02	0.04	<50
pH (SU)	15	7.3	9.1	----	6.0 – 9.0(6)	----
Oil and Grease (mg/l)	12	<5.0	10.7	<5.7	15	<38
Total Suspended Solids (mg/l)	12	2.3	18.2	9.3	45	21
Nitrite (as N, mg/l)	12	<0.01	0.02	<0.01	0.04	<25
Iron						
(mg/l)	12	0.158	0.363	0.259	Monitor(4)	----
(lbs/day)	12	0.150	1.633	0.648	Note (7)	----
Total Phosphorus						
(mg/l)	12	0.07	0.22	0.12	Monitor(4)	----
(kg/month)	12	1.71	6.05	3.32	Note (8)	----
Zinc						
(mg/l)	12	0.006	0.019	0.012	Monitor(4)	----
(lbs/day)	12	0.008	0.065	0.028	Note (9)	----
Boron (mg/l)	12	<0.050	0.097	<0.055	0.5	<11
Sulfite (mg/l)	12	<2.0	<2.0	<2.0	2.0	<100
Nitrogen, Ammonia (as N, mg/l)	12	<0.1	0.1	<0.1	Monitor(4)	----
Additional Parameters Monitored (Not Required by Permit – Reference (22))						
Surfactants (MBAS, mg/l)	12	<0.020	0.030	<0.021	N/A	N/A
OUTFALL 02B						
Residual Chlorine (mg/l)	12	5.0	70.0	13.3	Monitor(4)	----
Nitrite (as N, mg/l)	12	<0.01	<0.01	<0.01	Monitor(4)	----
Nitrogen, Ammonia (as N, mg/l)	12	<0.1	<0.1	<0.1	2.0	<5

Notes for Table 32 are on page 83.

NOTES FOR TABLES 31 AND 32

1. A value preceded by "<" is less than the RL for that sample and parameter.

2. Average values preceded by "<" contain at least one value less than the RL value in the average.

3. Percent of limit for the average value, unless otherwise noted.

4. The Reference (22) permit requires the data to be reported but does not specify a limit for this discharge parameter.

5. During the period from May through October, the temperature of heated water discharges from Kesselring Site operations shall not exceed 75˚ F, except that if the ambient stream temperature exceeds 75° F, the temperature of the discharge can be equal to the stream temperature, up to a maximum of 78˚ F. During the period from November through April, the temperature of the heated water discharges from Kesselring Site operations shall not exceed 75˚ F. In addition, no discharges will occur which will raise the temperature of the stream by more than 5˚ F, or to a maximum of 55˚ F, whichever temperature is less, except that if the upstream temperature is > 55˚ F, the discharge to the stream shall be such that the downstream temperature is less than or equal to the upstream temperature. If the upstream creek temperature is > 55˚ F, the heated water discharges shall not exceed the upstream temperature of the creek.

6. The pH values are not averaged and are required to be in this range.

7. Total Kesselring Site mass discharge limit of 4.0 lbs/day for Outfalls 001, 002, and 003 combined.

8. An action level of 50 kg/month has been assigned for the total mass discharged from Outfalls 001, 002, and 003 combined. An action level is not a limit, but a specified effluent level that requires additional short term monitoring upon exceedance.

9. Total Kesselring Site mass discharge limit of 0.5 lbs/day for Outfalls 001, 002, and 003 combined.

N/A = Not Applicable

TABLE 33
CHEMICAL CONSTITUENTS AND TEMPERATURE IN KESSELRING SITE SANITARY WASTEWATER TREATMENT FACILITY EFFLUENT, OUTFALL 003

Parameter (units)	Number of Samples	Value			SPDES Permit Limit	Percent of Limit(3)
		Minimum(1)	Maximum(1)	Average(2)		
Discharge Requirements (Reference (22))						
Flow (MGD)	360	0.0002	0.027	0.012	0.09(4)	13
pH (SU)	360	7.4	8.5	----	6.0 - 9.0(5)	----
Settleable Solids (ml/l)	360	<0.1	<0.1	<0.1	0.1	<100
Dissolved Oxygen (mg/l)	360	7.7	13.0	10.0	≥ 5.0	Note (6)
Nitrite (as N, mg/l)	12	0.01	0.29	0.06	0.6	10
Cyanide, Available (mg/l)	12	<0.006	<0.006	<0.006	0.09	<7
Ammonia (as N, mg/l)	12	<0.1	<0.1	<0.1	25	<1
Surfactants (MBAS) (mg/l)	12	<0.02	0.06	<0.03	0.7	<4
Boron (mg/l)	12	<0.050	0.146	<0.074	1.2(7)	<6
Dissolved Copper (mg/l)	12	0.009	0.019	0.014	Monitor(8)	----
Biological Oxygen Demand-5 (mg/l)	12	<2	<4	<4	30(9)	<13
Total Suspended Solids (mg/l)	12	1.2	3.7	2.4	30(9)	8
Total Phosphorus						
(mg/l)	12	0.24	2.75	1.37	Monitor(8)	----
(kg/month)	12	0.22	4.52	1.99	Note (10)	----
Zinc						
(mg/l)	12	<0.005	0.106	<0.016	Monitor(8)	----
(lbs/day)	12	<0.0001	0.015	<0.002	Note (11)	----
Total Copper (lbs/day)	12	0.0001	0.003	0.0016	0.06	3
Iron						
(mg/l)	12	<0.050	0.092	<0.054	Monitor(8)	----
(lbs/day)	12	<0.001	0.013	<0.007	Note (12)	----
Aluminum (mg/l)	12	<0.100	0.140	<0.103	2.0(7)	<5
Butyl Benzyl Phthalate (mg/l)	12	<0.0050	<0.0051	<0.0050	0.1(7)	<5
Additional Parameters Monitored (Not Required by Permit – Reference (22))						
Temperature (°F)	360	58	76	66	N/A	N/A

Notes:
1. A value preceded by "<" is less than the RL for that sample and parameter.
2. Average values preceded by "<" contain at least one value less than the RL value in the average.
3. Percent of limit for the average value, unless otherwise noted.
4. 30-day average.
5. The pH values are not averaged and are required to be in this range.
6. The average value is well above the limit, which is a minimum value.
7. Values are action levels which are not a limit but a specified effluent level which requires additional short term monitoring upon exceedance.
8. The Reference (22) permit requires the data to be reported but does not specify a limit for this discharge parameter.
9. The maximum limit for the 30-day arithmetic mean is 30 mg/l; the maximum limit for the 7-day arithmetic mean is 45 mg/l.
10. An action level of 50 kg/month has been assigned for the total mass discharged from Outfalls 001, 002 and 003 combined. An action level is not a limit but a specified effluent level that requires additional short term monitoring upon exceedance.
11. Total Site mass discharge limit of 0.5 lbs/day for Outfalls 001, 002, and 003 combined.
12. Total Site mass discharge limit of 4.0 lbs/day for Outfalls 001, 002, and 003 combined.

N/A = Not Applicable

TABLE 34
KESSELRING SITE RADIOACTIVITY RELEASE IN LIQUID EFFLUENT

Radionuclide	Release Ci(1)	Half-life
H-3	9.37E-04	12.32 years

Note:
1. The total includes results that were less than or equal to the decision level concentration.

AIRBORNE EFFLUENT MONITORING

Sources

Nonradiological: The principal sources of industrial gaseous effluents are two 21 million BTU/hr steam generating boilers. The Number 2 distillate fuel oil that is used to fire these boilers contains less than 0.0015 weight percent sulfur. Combustion gases from the boilers are released through two elevated exhaust stacks, installed in 2016 that replaced the previously combined exhaust stack. Other operations such as carpenter shops, welding hoods, abrasive cleaning, and spray painting constitute point sources of airborne effluents.

Kesselring Site emergency generators operated less than 100 hours during 2018. An emergency generator would have to operate 500 hours or greater to trigger a permitting requirement.

Radiological: Small quantities of particulate radioactivity, principally cobalt-60, are processed through controlled exhaust systems during reactor coolant sampling, draining, and venting operations. Gaseous radioactivity contained in the exhaust air consists principally of carbon-14, short-lived isotopes of xenon and krypton, argon-41, and tritium. Carbon-14 and argon-41 are the result of neutron interaction with isotopes of dissolved oxygen, nitrogen, and argon in the coolant. Other radioactive gases such as xenon and krypton are produced by neutron interaction with trace quantities of uranium impurities in structural members within the reactor. Prior to release from the exhaust stacks, the exhaust air is passed through HEPA filter systems to minimize particulate radioactivity content. Additionally, some processed water is evaporated to minimize releases of radioactivity in liquid effluent. The evaporator air effluent contains gaseous tritium. Potential diffuse sources are also evaluated and include emissions from D&D activities such as building demolition.

Effluent Monitoring

Nonradiological: Previously, the emissions of NO_x from the Kesselring Site's steam boilers were controlled by a NYSDEC Air Facility Registration that limited total fuel usage to no more than 1,250,000 gallons in any 12-month period. With the decommissioning of one of the Kesselring Site's boilers in 2014, the Kesselring Site was no longer limited by its NYSDEC Air Facility Registration to an allowable total fuel usage quantity because its potential to emit air contaminants could not exceed Federal or State permitting requirements. For the Kesselring Site boilers, monthly usage records are still tracked and tabulated to ensure compliance with regulatory requirements. Fuel oil supplier certification certificates for purchased distillate fuel oil are maintained by the Kesselring Site to confirm that the fuel oil burned in the Kesselring Site boilers contains less than 0.0015 percent sulfur by weight and conforms to the ASTM Standards for distillate fuel oil. Semiannual reports demonstrating compliance with the fuel oil sulfur limitation are sent to the EPA as required by EPA's New Source Performance Standards (NSPS) for these stationary combustion installations. All other industrial emission points at the Kesselring Site do not require permits due to very low emission levels.

Radiological: The air exhausted from the reactor plants is continuously monitored for particulate radioactivity with monitors that are equipped with alarm functions to provide an alert should an out-of-specification release occur. The air exhausted from all radiological work facilities is continuously sampled for particulate radioactivity. Reactor plant air emissions are also continuously sampled for radioiodine with activated charcoal cartridges. Sampling is performed for tritium and carbon-14 using appropriate absorbers.

Effluent Analyses

Radiological: The air particulate sample filters from the radiological emission points are changed routinely and analyzed by gamma spectrometry. A decision level concentration of approximately 5×10^{-15} µCi/ml is achieved for cobalt-60. The activated charcoal cartridges are analyzed for radioiodine by gamma spectrometry to a decision level concentration of approximately 5×10^{-15} µCi/ml for iodine-131. The tritium and carbon-14 absorbers are analyzed by liquid scintillation spectrometry. The decision level concentrations of tritium and carbon-14 in air are approximately 5×10^{-11} µCi/ml for typical sampling parameters. The quantity of gaseous radioactivity released is calculated based on reactor plant operating parameters.

Assessment

Nonradiological: Emissions of NO_x continue to be well within the limits established by NYSDEC in the registration associated with the Kesselring Site boiler units. Emissions of sulfur oxides (SO_x) from the Kesselring Site boiler units are also well within the EPA's NSPS emission standards for stationary combustion installations.

All other point source emissions also conform to the applicable Federal and State clean air standards.

Radiological: The radioactivity released in airborne effluent during 2018 is shown in Table 35. The radioactivity was contained in a total volume of 6.80×10^{11} liters of air. The average radioactivity concentration in the effluent air was well below the applicable standards listed in Reference (6). The average annual radioactivity concentration at the nearest Kesselring Site boundary, based on average annual diffusion parameters, was less than 0.01 percent of the DOE DCS for effluent release to unrestricted areas (Reference (6)) for the mixture of radionuclides present. Diffuse source emissions are calculated using EPA approved methods. Airborne effluent monitoring data is reported as required in Reference (8).

TABLE 35
KESSELRING SITE RADIOACTIVITY RELEASED IN AIRBORNE EFFLUENT

Radionuclide	Point Source Release Ci[1]	Diffuse Source Release Ci	Total Release Ci	Half-life
Fission & Activation Products[2]				
Ag-110m	5.71E-09	1.17E-11	5.72E-09	249.85 days
Ba-137m	3.81E-09	7.77E-12	3.82E-09	11.23 years
C-14	5.90E-02	2.92E-11	5.90E-02	5715 years
Co-58	1.81E-07	3.70E-10	1.81E-07	70.80 days
Co-60	8.87E-06	1.94E-09	8.87E-06	5.27 years
Cr-51	1.80E-06	0.00E+00	1.80E-06	27.70 days
Cs-134	3.81E-10	7.77E-13	3.82E-10	2.06 years
Cs-137	3.81E-09	7.77E-12	3.82E-09	30.07 years
Fe-55	9.51E-07	1.94E-09	9.53E-07	2.70 years
H-3	3.06E-01	0.00E+00	3.06E-01	12.32 years
I-129	1.90E-13	3.89E-16	1.90E-13	1.57E07 years
I-131	4.26E-07	0.00E+00	4.26E-07	8.04 days
K-40	1.50E-07	0.00E+00	1.50E-07	1.25E09 years
K-42	1.10E-06	0.00E+00	1.10E-06	12.36 hours
Kr-85	1.67E-06	0.00E+00	1.67E-06	10.76 years
Mn-54	7.61E-08	1.55E-10	7.63E-08	312.70 days
Mn-56	3.97E-09	0.00E+00	3.97E-09	2.58 hours
Na-24	7.19E-08	0.00E+00	7.19E-08	14.95 hours
Nb-94	1.90E-10	3.89E-13	1.90E-10	2.03E04 years
Ni-59	7.61E-10	1.55E-12	7.63E-10	7.50E04 years
Ni-63	7.61E-08	1.55E-10	7.63E-08	100.10 years
Sb-125	4.76E-09	9.72E-12	4.77E-09	2.77 years
Sr-90	1.90E-10	3.89E-13	1.90E-10	28.78 years
Tc-99	3.81E-10	7.77E-13	3.82E-10	2.13E05 years
Y-90	1.90E-10	3.89E-13	1.90E-10	2.67 days
Zn-65	1.35E-08	1.55E-11	1.35E-08	244.40 days
Total Fission & Activation Products ($T_{1/2}$ >3hr)	3.65E-01	4.65E-09	3.65E-01	
Noble Gases				
Ar-41	9.39E-01	0.00E+00	9.39E-01	1.83 hours
Kr-83m	4.71E-04	0.00E+00	4.71E-04	1.86 hours
Kr-85m	1.20E-03	0.00E+00	1.20E-03	4.48 hours
Kr-87	1.33E-03	0.00E+00	1.33E-03	1.27 hours
Kr-88	2.40E-03	0.00E+00	2.40E-03	2.84 hours
Xe-131m	1.14E-04	0.00E+00	1.14E-04	11.90 days
Xe-133m	8.03E-04	0.00E+00	8.03E-04	2.19 days
Xe-133	2.18E-02	0.00E+00	2.18E-02	5.24 days
Xe-135	1.86E-02	0.00E+00	1.86E-02	9.10 hours
Total Noble Gases ($T_{1/2}$ <40 days)	9.86E-01	0.00E+00	9.86E-01	

Notes:
1. The H-3, C-14, Co-60, and I-131 totals include results that were less than or equal to the decision level concentration.
2. The number of radionuclides listed varies year-to-year based on the Kesselring Site's potential to emit evaluations for area or point releases from D&D type work. Those that are listed were detected in radiochemistry analysis of samples.

ENVIRONMENTAL MONITORING

Scope

Nonradiological: The nonradiological environmental monitoring program at the Kesselring Site during 2018 included monitoring and recording of the Glowegee Creek temperature conducted upstream of the Kesselring Site, between the discharge channels, and downstream of the Kesselring Site discharge locations each day the Kesselring Site discharged water through Outfalls 001 and 002 (See Figure 5). Flow measuring equipment is installed in the Kesselring Site's three non-stormwater discharge channels. In addition, Glowegee Creek flow is monitored by the U.S. Geological Survey (USGS) one-half mile downstream of the Kesselring Site at the West Milton Road gauging station (USGS No. 01330000).

A voluntary aquatic life sampling and evaluation program is conducted in the Glowegee Creek upstream, near the discharge channels, and downstream in the Glowegee Creek. Backpack electro-fishing techniques are used to collect the fish, which are identified, measured, and returned to the creek unharmed.

The Kesselring Site operated its own sanitary landfill for the disposal of non-radioactive and non-hazardous solid wastes until October 1993, when landfill operations permanently ceased. NYSDEC approved the final Landfill Closure Plan, and landfill closure construction was completed in October 1994. The closed landfill is maintained in accordance with a Post Closure Monitoring and Maintenance Operations Manual, which has been approved by NYSDEC. Groundwater monitoring of the landfill is performed in accordance with this manual.

Radiological: The radiological environmental monitoring program at the Kesselring Site during 2018 included: (1) the collection of fish upstream and downstream of discharge locations to the Glowegee Creek, (2) the collection of quarterly samples of Glowegee Creek water and sediment at five locations, and (3) the operation of continuous air samplers at stations located in the primary upwind and downwind directions from the Kesselring Site.

Three samples of sediment and one composite water sample are collected quarterly for radioanalysis across the creek at the five locations shown in Figure 5.

Environmental air samplers are operated in the primary upwind and downwind directions from the Kesselring Site to measure normal background airborne radioactivity and to confirm that Kesselring Site effluents have no measurable effect on normal background levels.

Analyses

Radiological: The routine quarterly samples of Glowegee Creek water and bottom sediment samples are analyzed with a high-purity germanium gamma spectrometer system. In addition, a more sensitive gamma spectrometry analyses is performed annually on the fish and some of the water and sediment samples collected from the Glowegee Creek. The more sensitive analysis is intended to fully characterize the low levels of naturally and non-naturally occurring gamma-emitting radionuclides. The environmental air particulate sample filters are changed and analyzed routinely by high-purity germanium gamma spectrum analysis.

Assessment

Nonradiological: The Glowegee Creek fish survey results from 2018 are summarized in Table 36. The concentrations of chemical constituents in liquid effluent from the Kesselring Site resulted in no adverse effect on the quality of the Glowegee Creek. This conclusion is substantiated by results of the fish surveys that confirmed the existence of a diverse and healthy aquatic community in the creek water. The 2018 survey data is consistent with historical fish survey data. The different relative abundance of fish species at each sampling location reflects their different preferred habitats.

Radiological: The gamma spectrum analysis results for fish collected from the Glowegee Creek are shown in Table 37. The results show no radioactivity attributable to Kesselring Site operations. The only radionuclide observed in both fish samples was potassium-40. This naturally occurring radionuclide is frequently observed in fish.

Results of the gamma analysis of sediment and water samples are shown in Table 38. The data shows that there is no significant difference between radioactivity concentrations measured upstream and downstream. Only naturally occurring radionuclides were detected in the Glowegee Creek water samples. Results of the detailed gamma spectrum analyses performed on sediment samples also indicate low concentrations of potassium-40, cesium-137, and daughters of uranium and thorium. Potassium-40 and the daughters of uranium and thorium are naturally occurring radionuclides and are not associated with Kesselring Site operations. The EPA has attributed similar low levels of cesium-137 to fallout from low yield atmospheric nuclear weapon tests. Since the beginning of prototype operations more than 60 years ago, the release of radioactivity into the Glowegee Creek has been small and has had no adverse effect on the natural background radioactivity levels in the sediment.

The results for the environmental air samples show that there was no significant difference between the average upwind and downwind radioactivity concentrations. The average upwind radioactivity concentration was 2.80×10^{-15} μCi/ml and the average downwind radioactivity concentration was 5.54×10^{-15} μCi/ml. Gamma spectrum analyses indicated the presence of only background quantities of naturally occurring radionuclides.

RADIATION MONITORING

The purpose of the environmental radiation monitoring program is to measure the ambient radiation levels around the Kesselring Site to confirm that operations have not altered the natural radiation background levels at the Kesselring Site perimeter. The sources of radiation at the Kesselring Site are the operation and maintenance of the prototype reactor plants.

Scope

Environmental radiation levels were monitored at the perimeter of the Kesselring Site with a network of DT-702/PD lithium fluoride TLDs. The eight locations of the Kesselring Site perimeter TLDs are shown in Figure 6. Control TLDs were posted at four remote off-site locations to measure the natural background levels typical of the surrounding area. All TLDs were posted for quarterly exposure periods.

Analyses

The DT-702/PD lithium-fluoride environmental TLDs are calibrated to a cesium-137 standard source. The TLD radiation exposures were measured quarterly utilizing an automated TLD readout system that was calibrated prior to the processing of the TLDs.

Assessment

The total annual radiation exposures measured with TLDs at the boundary of the Kesselring Site and at remote, off-site monitoring locations are summarized in Table 39. There is no statistically significant difference between the perimeter and the off-site measurements. This shows that Kesselring Site operations in 2018 had no measurable effect on natural background radiation levels at the Kesselring Site perimeter.

TABLE 36
GLOWEGEE CREEK FISH SURVEY

Location	Species	Number Collected	Length (mm)
400 Feet Upstream of 001	Blacknose Dace	35	52 - 73
	Bluegill	-	-
U-2	Bluntnose Minnow	-	-
	Brook Stickleback	-	-
	Brook Trout	-	-
	Brown Bullhead	-	-
	Brown Trout	-	-
	Common Shiner	4	71 - 102
	Creek Chub	75	34 - 142
	Cutlips Minnow	27	64 - 121
	Fallfish	-	-
	Fathead Minnow	-	-
	Golden Shiner	-	-
	Largemouth Bass	2	52 - 82
	Longnose Dace	-	-
	Northern Redbelly Dace	-	-
	Pearl Dace	-	-
	Pumpkinseed	6	69 - 100
	Rainbow Trout	-	-
	Tessellated Darter	6	40 - 67
	White Sucker	89	47 - 155
	Yellow Bullhead	1	170
	Yellow Perch	-	-
50 Feet Upstream of 001	Blacknose Dace	54	24 - 77
	Bluegill	-	-
U-1	Bluntnose Minnow	-	-
	Brook Stickleback	-	-
	Brook Trout	-	-
	Brown Bullhead	-	-
	Brown Trout	-	-
	Common Shiner	-	-
	Creek Chub	36	24 - 132
	Cutlips Minnow	22	72 - 97
	Fallfish	-	-
	Fathead Minnow	2	49 - 53
	Golden Shiner	-	-
	Largemouth Bass	-	-
	Longnose Dace	1	45
	Northern Redbelly Dace	-	-
	Pearl Dace	-	-
	Pumpkinseed	-	-
	Rainbow Trout	-	-
	Tessellated Darter	3	68 - 73
	White Sucker	37	48 - 76
	Yellow Bullhead	-	-
	Yellow Perch	-	-
360 Feet Downstream of 001	Blacknose Dace	55	41 - 76
	Bluegill	-	-
M-1	Bluntnose Minnow	2	71 - 78
	Brook Stickleback	-	-
	Brook Trout	-	-
	Brown Bullhead	-	-
	Brown Trout	-	-
	Common Shiner	25	37 - 118
	Creek Chub	48	21 - 148
	Cutlips Minnow	17	71 - 123
	Fallfish	-	-
	Fathead Minnow	1	63
	Golden Shiner	-	-
	Largemouth Bass	-	-
	Longnose Dace	2	44 - 51
	Northern Redbelly Dace	-	-
	Pearl Dace	-	-
	Pumpkinseed	-	-
	Rainbow Trout	-	-
	Tessellated Darter	8	44 - 63
	White Sucker	114	51 - 74
	Yellow Bullhead	1	124
	Yellow Perch	-	-

TABLE 36 (continued)
GLOWEGEE CREEK FISH SURVEY

Location	Species	Number Collected	Length (mm)
2350 Feet Downstream of 001	Blacknose Dace	49	27 - 72
	Bluegill	-	-
D-2	Bluntnose Minnow	-	-
	Brook Stickleback	-	-
	Brook Trout	-	-
	Brown Bullhead	-	-
	Brown Trout	-	-
	Common Shiner	23	40 - 113
	Creek Chub	103	33 - 103
	Cutlips Minnow	11	68 - 97
	Fallfish	-	-
	Fathead Minnow	1	54
	Golden Shiner	-	-
	Largemouth Bass	-	-
	Longnose Dace	2	39 - 47
	Northern Redbelly Dace	-	-
	Pearl Dace	-	-
	Pumpkinseed	-	-
	Rainbow Trout	-	-
	Tessellated Darter	19	29 - 65
	White Sucker	157	61 - 84
	Yellow Bullhead	1	129
	Yellow Perch	-	-
2700 Feet Downstream of 001	Blacknose Dace	44	26 - 67
	Bluegill	-	-
D-1	Bluntnose Minnow	-	-
	Brook Stickleback	-	-
	Brook Trout	-	-
	Brown Bullhead	-	-
	Brown Trout	-	-
	Common Shiner	9	37 - 57
	Creek Chub	118	29 - 108
	Cutlips Minnow	8	40 - 93
	Fallfish	-	-
	Fathead Minnow	-	-
	Golden Shiner	-	-
	Largemouth Bass	-	-
	Longnose Dace	3	44 - 46
	Northern Redbelly Dace	-	-
	Pearl Dace	-	-
	Pumpkinseed	-	-
	Rainbow Trout	-	-
	Tessellated Darter	14	42 - 79
	White Sucker	20	60 - 92
	Yellow Bullhead	-	-
	Yellow Perch	-	-
5000 Feet Downstream of 001	Blacknose Dace	19	37 - 72
	Bluegill	-	-
D-3	Bluntnose Minnow	2	68 - 83
	Brook Stickleback	-	-
	Brook Trout	-	-
	Brown Bullhead	-	-
	Brown Trout	-	-
	Common Shiner	1	89
	Creek Chub	40	30 - 132
	Cutlips Minnow	10	36 - 113
	Fallfish	-	-
	Fathead Minnow	1	47
	Golden Shiner	-	-
	Largemouth Bass	-	-
	Longnose Dace	9	40 - 99
	Northern Redbelly Dace	-	-
	Pearl Dace	-	-
	Pumpkinseed	-	-
	Rainbow Trout	-	-
	Tessellated Darter	-	-
	White Sucker	6	59 - 85
	Yellow Bullhead	-	-
	Yellow Perch	-	-

TABLE 37
RESULTS OF ANALYSES OF GLOWEGEE CREEK FISH FOR RADIOACTIVITY

Sample Location	Radioactivity Concentration(1) (pCi/g wet wt)		
	K-40	**Cs-137**	**Co-60**
Upstream of Discharge			
Channel 001	2. 700 ± 0.271	<0.006	<0.006
Downstream of Discharge			
Channel 002	2.727 ± 0.271	<0.006	<0.006

Note:
1. A value preceded by "<" is less than the decision level concentration for that sample and parameter. The (±) value represents the statistical uncertainty at two standard deviations.

TABLE 38
RESULTS OF ANALYSES OF GLOWEGEE CREEK SEDIMENT AND WATER FOR RADIOACTIVITY

Sample Location	No. of Samples	Co-60 Radioactivity Concentration					
		Sediment (pCi/g, dry wt)(1,2)			Water (pCi/l)(2)		
	Sediment / Water	Minimum	Maximum	Average	Minimum	Maximum	Average
Upstream of Discharge							
Channel 001	12 / 4	<0.01	<0.02	<0.01	<7.28	<11.90	<10.22
Opposite Discharge							
Channel 001	12 / 4	<0.01	<0.02	<0.02	<7.80	<9.54	<8.58
Between Discharge							
Channels 001 & 002	24 / 8	<0.01	<0.02	<0.01	<7.83	<11.20	<9.58
Opposite Discharge							
Channel 002	12 / 4	<0.01	<0.02	<0.01	<7.86	<11.49	<9.25
Downstream of Discharge							
Channel 003	24 / 8	<0.01	<0.02	<0.01	<9.21	<10.98	<10.18

Notes:
1. Dry weight is based on sample weight with free water removed.
2. A value preceded by "<" is less than the decision level concentration for that sample and parameter.

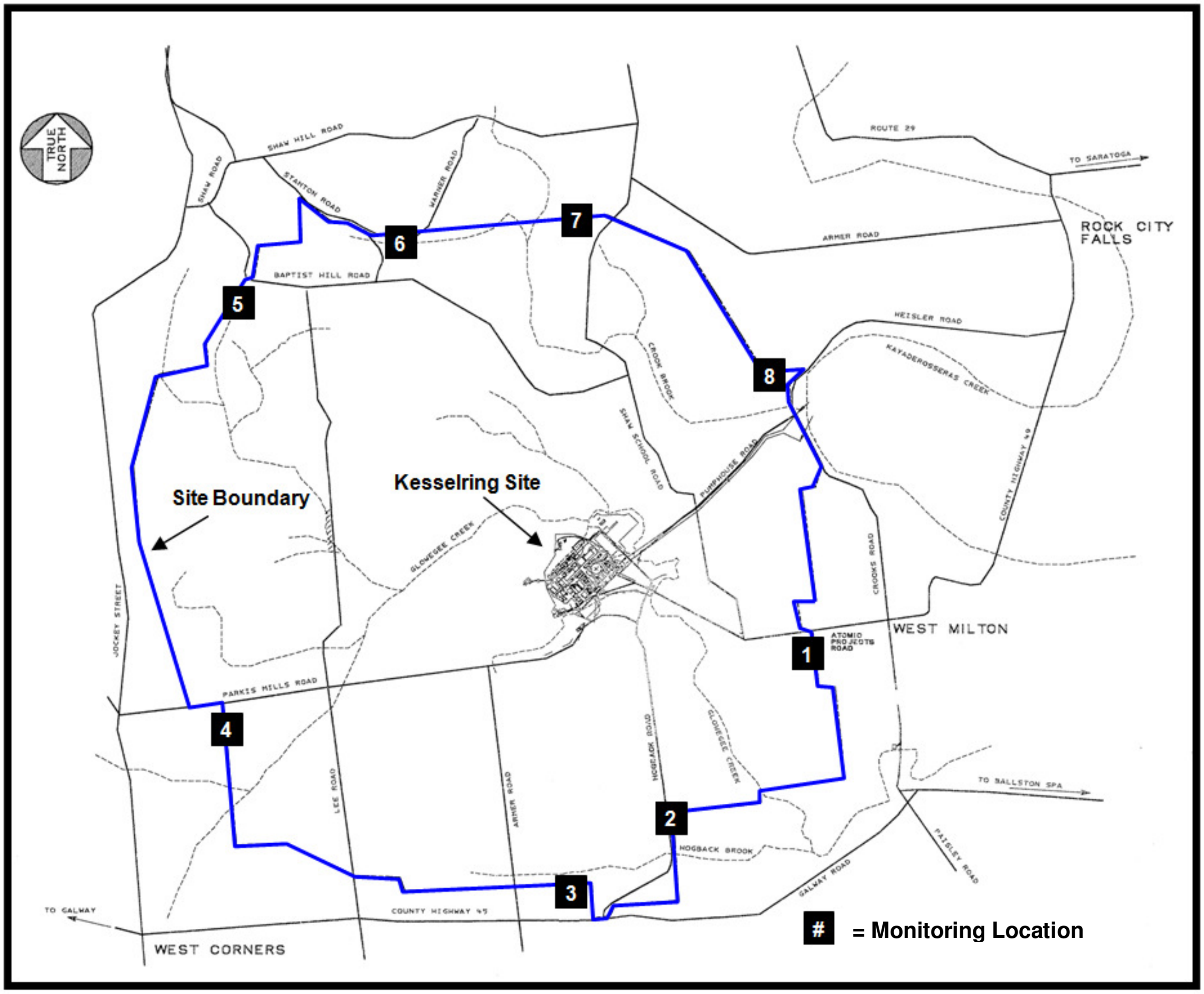

FIGURE 6
KESSELRING SITE, NEAR WEST MILTON, NEW YORK
PERIMETER MONITORING LOCATIONS

TABLE 39
PERIMETER AND OFF-SITE RADIATION MONITORING RESULTS, KESSELRING SITE

Perimeter Location No.[1]	Total Annual Exposure (millirem)[2]
1	57 ± 2
2	50 ± 1
3	52 ± 2
4	52 ± 2
5	56 ± 2
6	56 ± 2
7	55 ± 2
8	56 ± 2
Off-site locations	56 ± 18[3]

Notes:
1. See Figure 6 for monitoring locations.
2. The (±) values for individual locations are expressed at the 2 sigma confidence level based on the calculated measurement uncertainty.
3. Approximately 95% of natural background radiation measurements are expected to be within this range.

GROUNDWATER MONITORING

Scope

The Kesselring Site groundwater program includes environmental (nonradiological) monitoring of the closed Hogback Road Landfill in accordance with NYSDEC regulations and the voluntary monitoring of wells within the developed area of the Kesselring Site. Voluntary radiological monitoring of groundwater is also performed concurrently at the above locations and at several outlying areas of the Kesselring Site. The groundwater monitoring program is summarized in Table 40.

In 1993, the Hogback Road Landfill was closed, and in 1994 it was capped in accordance with a closure plan approved by New York State. Landfill capping minimizes the amount of precipitation moving through the fill material and serves to stabilize and lessen the generation of landfill leachate that would migrate into groundwater. The Hogback Road Landfill Post-Closure Monitoring and Maintenance Operations Manual documents all of the required measures the Kesselring Site takes to ensure the integrity of the landfill cap, and any associated impacts to the environment are tracked and understood.

The Landfill regulatory-required monitoring program consists of annually sampling six groundwater monitoring wells during the late summer to fall timeframe when groundwater tables are typically lowest. Five shallow overburden wells (HB-1A, LMW-4, HB-5A2, LMW-6, and HB-11A) and one deep bedrock well (HB-5B) are sampled for a focused list of analytical parameters approved by NYSDEC. The locations of all existing landfill groundwater monitoring wells are shown in Figure 7. In addition to annual groundwater monitoring, the Kesselring Site performs quarterly inspections of landfill integrity and an annual survey for explosive gases at the landfill gas vents.

The groundwater monitoring program for the developed area (Figure 8) typically consists of annual sampling of 18 monitoring wells. This sampling is performed as a best management practice to track known constituents and to provide early detection of unexpected releases.

The groundwater monitoring program for the former disposal areas consists of annual sampling of 13 monitoring wells (Figure 9) for radiological analyses. In 1999, the Kesselring Site evaluated each of the former disposal sites with regard to the nature of the disposal source material, hydrogeology, and historic analytical database, and concluded that no groundwater threat exists. These wells are monitored to maintain a record of negative radiological data.

Sources

Nonradiological: Elevated parameters in the landfill wells are associated with past disposal practices. The landfill, operated since 1951 and closed in 1993, was used predominantly for the disposal of sanitary wastes. Prior to enactment of Federal and State regulations for solid waste disposal activities that banned disposal of certain wastes in such facilities, asbestos scraps, scrap metal including lead, some oil and oily water, solvents, paint, and chemicals were disposed of in the landfill.

Elevated parameters in and adjacent to the developed area of the Kesselring Site are predominantly the result of operational activities, such as: historical material handling practices and construction activities, on-going use of roadway de-icing materials (e.g., sodium chloride, calcium chloride, etc.), cooling tower operations, and routine operations of Site Service Water systems containing chlorine. In 2007, elevated ammonia levels were detected in groundwater collected from the drainage system underlying the newly constructed Building 102. Investigation of the elevated ammonia levels indicated some potential sources, including leaking sanitary sewage lines and historic farming operations. Results of the investigation did not reveal a definitive source; however, any identified issues with sewage lines in the vicinity have since been fixed.

The five former disposal sites at the Kesselring Site were used for construction and demolition waste, limited amounts of acid waste, and some waste burning. These disposal practices were conducted prior to enactment of Federal and State regulations governing the disposal of these materials.

Analyses

Nonradiological: All groundwater samples are analyzed by a New York State Department of Health certified laboratory for chemical parameters in accordance with Reference (10) or other EPA approved methods. Field parameters, which include static water level, temperature, and pH, are measured on site at the time of environmental sampling. Specific conductance and turbidity are sampled on site at the time of sampling for some monitoring events and are analyzed at a certified laboratory for others.

TABLE 40
KESSELRING SITE GROUNDWATER MONITORING PROGRAM

Program Area	Monitoring Wells	Field Parameters & Modified Routine List & Halogenated Volatile Organic Compounds[1,2]	Field Parameters & Volatile Organic Compounds	Radioactivity
Landfill	HB-1A, HB-5A2, HB-5B, HB-11A, LMW-4, LMW-6	A, R		A, V
Developed Area	MW-1 to MW-20[3]		A, V[4]	A, V
Land Disposal Area	KBH-1 to KBH-4, KBH-6 to KBH-13, and T-3[5]			A, V

Notes:

A = Annual
R = Regulatory Required Monitoring
V = Voluntary Monitoring

1. Parameters are discussed in the following sections.
2. Filtered metals analysis is performed as necessary for verification of elevated metals which are attributable to sample turbidity (suspended clay/silt particles).
3. Except MW-5 and MW-20, which have been decommissioned. MW-20 was decommissioned on October 9, 2018, after the 2018 sampling was completed.
4. In 2007, the scope of the developed area well sampling was expanded to include additional sampling events and additional parameters (chemical and metal) in support of investigation activities related to elevated ammonia levels detected in developed area groundwater.
5. KBH-5 was decommissioned in 2008.

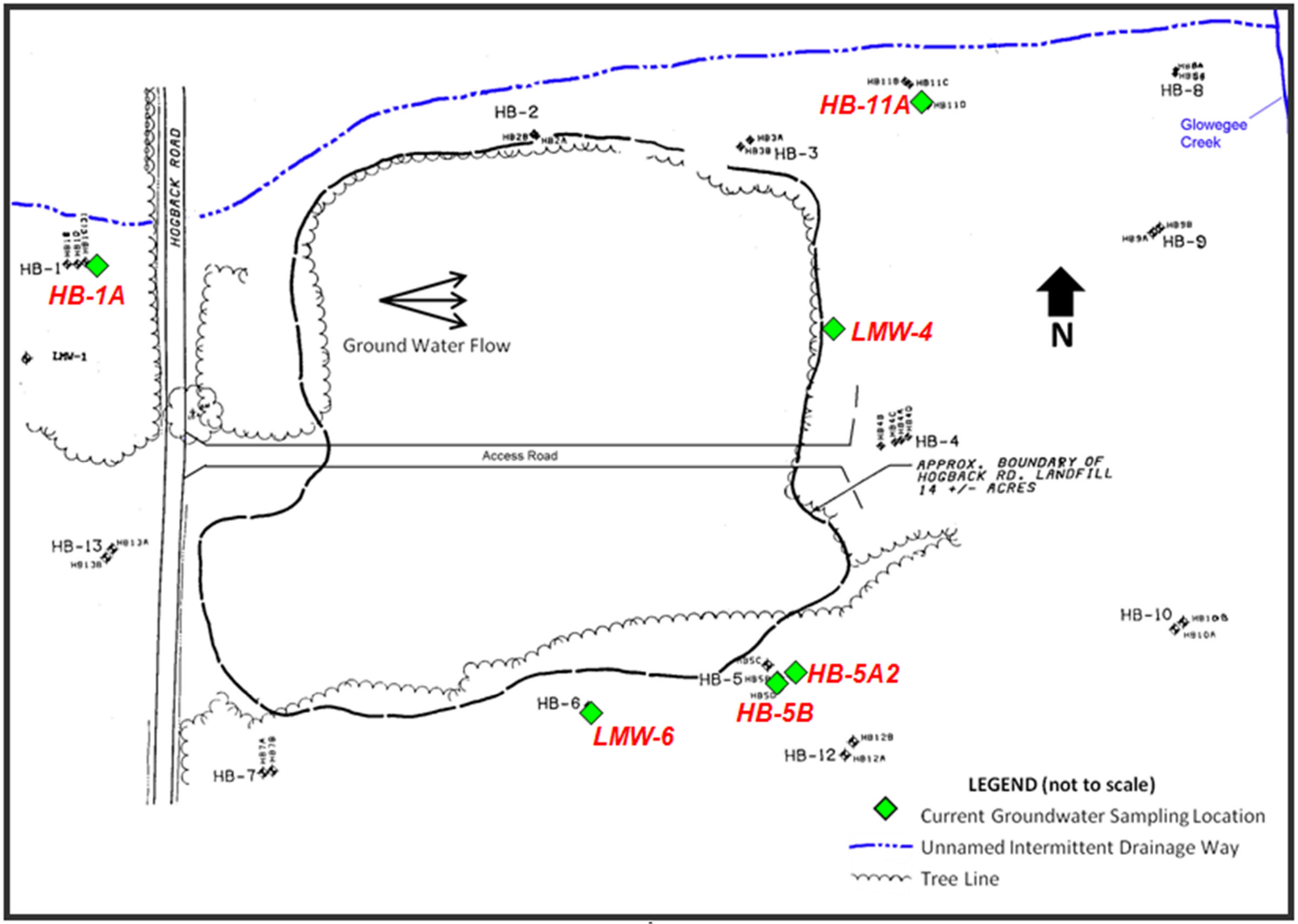

FIGURE 7

KESSELRING SITE, NEAR WEST MILTON, NEW YORK

LANDFILL GROUNDWATER MONITORING WELLS

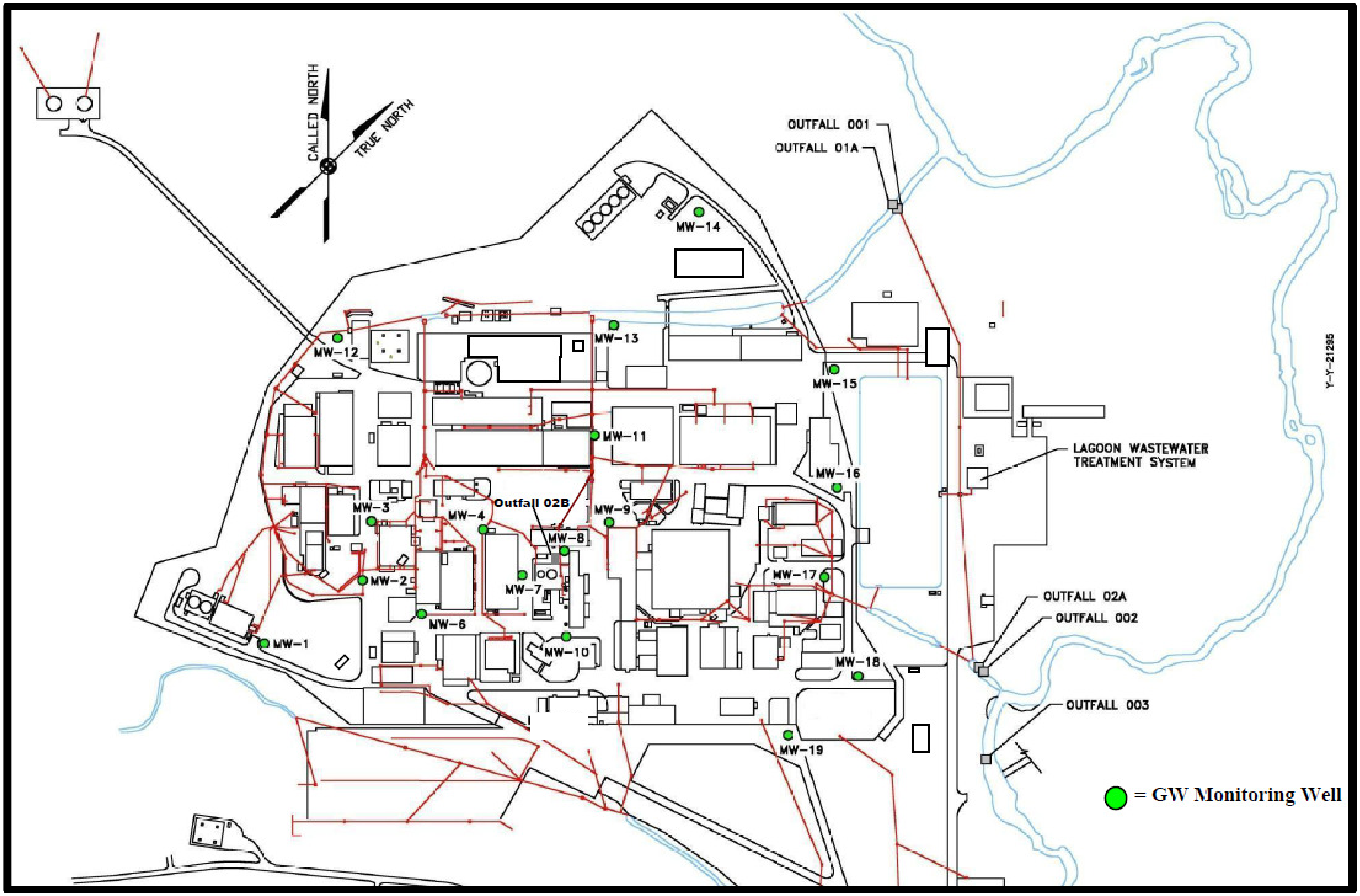

FIGURE 8

KESSELRING SITE, NEAR WEST MILTON, NEW YORK
DEVELOPED AREA GROUNDWATER MONITORING WELLS

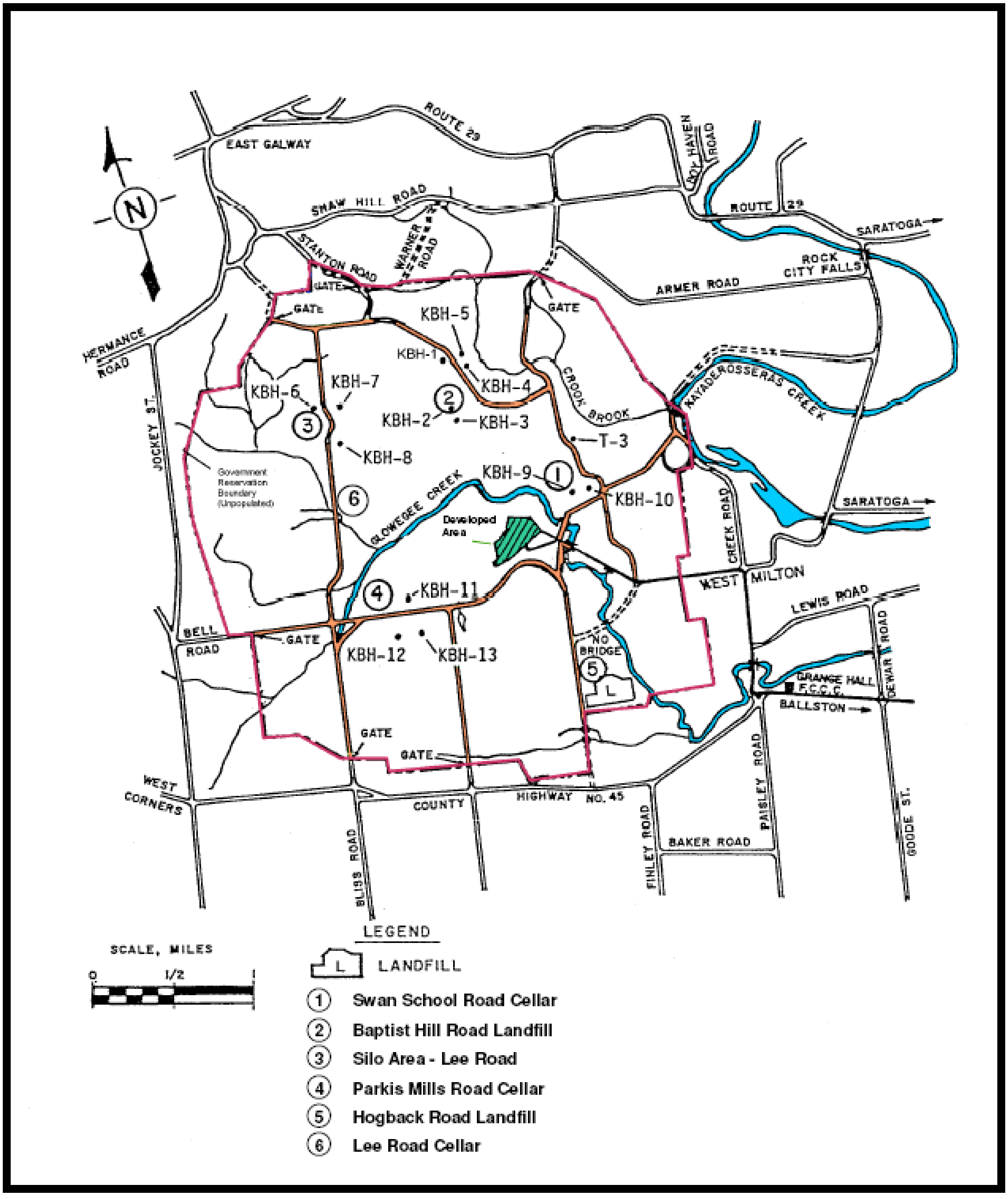

FIGURE 9

KESSELRING SITE, NEAR WEST MILTON, NEW YORK
DISPOSAL AREAS – GROUNDWATER MONITORING WELLS

Landfill samples are analyzed for a modified list of routine chemical and leachate-indicator parameters approved by NYSDEC in 2002. The modified routine parameter list includes alkalinity, ammonia, chemical oxygen demand (COD), chloride, hardness, nitrate, sulfate, total dissolved solids (TDS), total organic carbon (TOC), calcium, iron, manganese, magnesium, potassium, and sodium. The samples are also analyzed for halogenated and aromatic volatile organic compounds (VOCs). All samples were collected in accordance with the procedures and requirements of the Post-Closure Monitoring and Maintenance Operations Manual. All routine parameter results are shown in Table 41. Gas monitoring was performed at the landfill in accordance with the post-closure monitoring requirements using an oxygen/explosive gas detector calibrated to the manufacturer's specifications.

Within the developed area, the 18 monitoring wells are sampled for both halogenated and aromatic VOCs. The VOC analysis suite consists of 29 halogenated and 5 aromatic compounds of which only a few have been detected above the practical quantitation limit in the past. VOC results are shown in Table 42. In addition, laboratory analyses are performed for chloride, nitrate, ammonia, and nitrite for the developed area monitoring wells.

Groundwater from three production wells located along the Kesselring Site's eastern property boundary is used to supply the drinking water system at the Kesselring Site. The drinking water is sampled in accordance with New York State drinking water regulations defined in Reference (23). The sample results are shown in Table 43.

Radiological: The Kesselring Site conducts voluntary radiological monitoring on the groundwater wells at the landfill area, the developed area, and four former disposal sites. The well locations are shown in Figures 7, 8, and 9. The well samples are analyzed by gamma spectrometry for cesium-137 and cobalt-60 and by liquid scintillation spectrometry for tritium. The results of the analyses are shown in Table 44.

Assessment

Nonradiological:

Landfill

Groundwater wells were sampled both upgradient and downgradient of the Hogback Road Landfill to monitor groundwater quality impacts from the landfill and for any indications of a breach in the integrity of the landfill cap. Analytical results obtained during 2018 remain consistent overall with historical data trends.

The 2018 analytical results continue to show that while certain routine parameters remain elevated in most of the downgradient wells when compared to the upgradient well (HB-1A) (Table 41), these parameters are either stable or decreasing over time, and that there remains no indication of a breach in landfill cap integrity. The individual parameters that are typically elevated include: specific conductance, alkalinity, hardness, TDS, chloride, sulfate, magnesium, manganese, potassium, sodium, calcium, and VOCs. A number of other parameters exhibit variability and are generally elevated in only a few downgradient wells. These parameters routinely include turbidity, COD, TOC, ammonia, nitrate, and iron.

While a number of parameters continue to exceed groundwater quality standards per Reference (1) or guidance values per Reference (24), inorganic parameters detected in downgradient well samples are within, or below, representative ranges for inorganic parameters typical of leachate from sanitary landfills per Reference (14). VOC analytical results obtained during 2018 remain consistent with historical data trends and were all reported below the detection limit.

Ambient air gas monitoring was performed at the landfill gas vents. No detectable concentrations of explosive gases were observed. Quarterly landfill inspections were conducted and no degradation or breaches in the cap were identified. Routine landfill maintenance was performed to ensure continued integrity of the landfill cap.

TABLE 41
RESULTS OF KESSELRING SITE GROUNDWATER MONITORING, HOGBACK ROAD LANDFILL(1)

ROUTINE PARAMETERS (2002 MODIFIED LIST)

Sample Location	HB-1A	LMW-4	HB-11A	HB-5A2	HB-5B Duplicate	HB-5B	LMW-6	Standard/ Criteria(2)
Sample Date	09/13/18	09/13/18	09/13/18	09/13/18	09/13/18	09/13/18	09/13/18	
Field Parameters								
Groundwater Elevation (ft)	484.21	Dry	460.03	451.04	----	452.83	460.69	NC
Temperature (°C)	17.5	----	13.7	11.1	----	11.8	12.1	NC
pH (SU)	6.5	----	7.0	6.5	----	6.7	6.7	6.5 - 8.5
Specific Conductance (µmhos/cm)	96	----	864	1123	----	1,209	1,780	NC
Turbidity (NTU)	16	----	465	15	----	6	4	5
Indicator (mg/l, or as indicated)								
Alkalinity, as $CaCO_3$	40	----	310	550	590	560	470	NC
Ammonia (as N, mg/l)	<0.1	----	<0.1	<0.1	0.3	0.3	<0.1	2
COD	7	----	9	<5	<5	<5	<5	NC
Chloride	<2.00	----	44.2	<2.00	42.5	42.4	276	250
Hardness, as $CaCO_3$	39	----	374	467	495	494	432	NC
Nitrate (as N, mg/l)	<0.04	----	<0.04	0.07	<0.04	<0.04	0.11	10
Sulfate	2.53	----	7.09	4.50	8.75	8.78	17.5	250
TDS	125	----	420	575	570	675	920	500
TOC	1.8	----	2.3	1.6	<1.0	1.4	2.4	NC
Metals (mg/l)(3)								
Calcium	12.2/11.7	----	129/106	218/186	186/140	173/141	159/131	NC
Iron	0.373/0.062	----	1.84/0.057	7.21/6.64	6.21/5.05	5.44/5.35	0.691/<0.050	0.3
Magnesium	2.05/1.99	----	23.8/23.7	12.6/12.6	31.2/30.6	31.4/30.9	24.4/24.4	35.0(g)(4)
Manganese	0.045/<0.0200	----	0.446/0.080	3.88/3.86	0.629/0.604	0.631/0.610	0.797/0.298	0.3
Potassium	0.590/0.580	----	1.45/1.29	3.80/3.84	2.77/2.74	2.78/2.78	2.74/2.79	NC
Sodium	7.23/8.43	----	36.9/37.8	12.2/11.4	82.2/66.1	74.9/64.0	297/249	20
Volatiles (µg/l)(5)(6)								
1,1 – Dichloroethane	<1.0	----	<1.0	<1.0	<1.0	<1.0	<1.0	5
Chloroethane	<1.0	----	<1.0	<1.0	<1.0	<1.0	<1.0	5
Chloromethane	<1.0	----	<1.0	<1.0	<1.0	<1.0	<1.0	5

Notes for Table 41 are on page 103.

NOTES for TABLE 41

NC No Criteria Available (no standards or guidance values per 6NYCRR Part 703 or TOGS 1.1.1)

1. Compounds that are not detected at or above the RL are reported in the table as less than (<) the RL.
2. Groundwater standards taken from 6NYCRR Part 703.3, dated September 1991 (applicable regulations at time of Landfill closure) and from Part 703.5 dated April 1999. Additional water standards and guidance values taken from Technical and Operational Guidance Series (TOGS) 1.1.1, Ambient Water Quality Standards and Guidance Values, Revised; June 1998.
3. Total metal sample analysis data is shown preceding the dissolved metal result, i.e., total/dissolved. In some cases, the dissolved data is shown to be slightly higher than the total data. The laboratory has stated that this data is correct, and that the total and dissolved results are within the margin of error for the analytical procedures.
4. (g) = Groundwater Guidance Value
5. VOCs analyzed but not detected at or above the RL in any of the presented sampling rounds are not listed in the table.
6. VOCs analyzed using method EPA SW-846 Method 8260/8021. EPA Method 601 had been used prior to 2006.

TABLE 42
RESULTS OF KESSELRING SITE GROUNDWATER MONITORING, DEVELOPED AREA WELLS(1,2,3)

Well	Sample Date	Chloroform (µg/l)	Trichloroethene (µg/l)	Bromodichloro-methane (µg/l)	cis-1,2-Dichloroethene (µg/l)
MW-1(4)	09/12/18	<1.0	<1.0	<1.0	<1.0
MW-4	09/11/18	<1.0	<1.0	<1.0	<1.0
Standard(5)		7	5	50	5
RL		1.0	1.0	1.0	1.0

Notes:
1. All samples were analyzed by EPA methods 601 and 602.
2. 2018 VOCs analyzed were below the RL of less than 1 ppb. In 2017, the listed VOCs in the table had detectable values above the RL.
3. Compounds that are not detected at or above the RL are reported in the table as less than (<) the RL.
4. Upgradient well
5. Groundwater standards taken from 6NYCRR Part 703.5 and Division of Water, TOGS (1.1.1) Ambient Water Quality Standards and Guidance Values.

Developed Area

The routine annual groundwater program for the developed area includes field parameters and VOC analyses. Field parameters include groundwater elevation, temperature, pH, specific conductance, and turbidity. Analyses for chloride, nitrate, ammonia, nitrite, and VOCs were performed at an off-site laboratory.

Samples are analyzed for VOCs utilizing EPA methods 601 and 602. Results for all the wells were below the RL of less than 1 ppb.

Due to high levels of ammonia detected in groundwater during the construction of Building 102, groundwater discharged from the Building 102 drainage system is treated for ammonia and nitrite in a facility that was completed and opened for use in 2011. From 2007 to 2011, ammonia concentration ranged between 2.4 and 3.8 mg/l. The source of the ammonia was investigated but has not been specifically identified. Groundwater ammonia ranged between <0.1 mg/l to 14.2 mg/l in 2018.

Elevated chloride and turbidity levels are attributed to the on-going use of roadway de-icing materials and snow/ice removal operations. In 2018, groundwater chloride results ranged between 49.9 mg/l to 7,890 mg/l, and turbidity ranged from 2 ntu to >999 ntu, consistent with elevated chloride levels. The 2018 pH results were all within the acceptable range for groundwater standards.

Site Service (Drinking) Water

The drinking water supply is part of the Site Service Water (SSW) system and is supplied from a deep (confined) groundwater aquifer. The drinking water system is sampled and monitored to ensure its quality meets New York State Department of Health drinking water regulations (Reference (23)). The sample results are shown in Table 43. The SSW well field is hydrogeologically separate from the Kesselring Site landfill and former disposal sites and is consequently not affected by materials at those locations.

Radiological: The groundwater sample results for radioactivity are summarized in Table 44. The levels of cesium-137, cobalt-60, and tritium were below decision level concentrations in all wells. The concentrations for these radionuclides were less than 0.1 percent of the respective Reference (6) DCS values.

TABLE 43
CHEMICAL CONSTITUENTS IN KESSELRING SITE DRINKING WATER

Parameter / Units[1] (Units are mg/l unless otherwise noted)	Number of Samples	Value[2]			Standard[4]	Percent of Standard[5]
		Minimum	Maximum	Average[3]		
Drinking Water Standards (Reference (23))						
Nitrates (mg/l as N)	1	0.633	0.633	0.633	10	6
Total Coliform[6,7] (CFU/100ml)	36	<1	<1	<1	None Detectable	N/A
Free Chlorine Residual	365	0.60	2.6	1.48	Note (8)	N/A
Free Chlorine Residual[7]	36	0.05	2.03	1.29	Note (8)	N/A
Benzene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
Bromobenzene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
Bromochloromethane[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
Bromomethane[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
n-Butylbenzene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
sec-Butylbenzene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
tert-Butylbenzene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
Carbon Tetrachloride[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
Chlorobenzene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
Chloroethane[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
Chloromethane[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
2-Chlorotoluene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
4-Chlorotoluene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
Dibromomethane[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
1,2-Dichlorobenzene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
1,3-Dichlorobenzene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
1,4-Dichlorobenzene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
Dichlorodifluoromethane[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
1,1-Dichloroethane[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
1,2-Dichloroethane[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
1,1-Dichloroethene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
cis-1,2-Dichloroethene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
trans-1,2-Dichloroethene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
1,2-Dichloropropane[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
1,3-Dichloropropane[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
2,2-Dichloropropane[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
1,1-Dichloropropene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
cis-1,3-Dichloropropene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
trans-1,3-Dichloropropene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
Ethylbenzene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
Hexachlorobutadiene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
Isopropylbenzene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
4-Isopropyltoluene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
Methylene Chloride[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
Methyl Tertiary-Butyl Ether[9]	1	<0.002	<0.002	<0.002	0.010	<20

Notes for Table 43 are on page 107.

TABLE 43 (continued)
CHEMICAL CONSTITUENTS IN KESSELRING SITE DRINKING WATER

Parameter / Units[1] (Units are mg/l unless otherwise noted)	Number of Samples	Value[2]			Standard[4]	Percent of Standard[5]
		Minimum	Maximum	Average[3]		
n-Propylbenzene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
Styrene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
1,1,1,2-Tetrachloroethane[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
1,1,2,2-Tetrachloroethane[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
Tetrachloroethene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
Toluene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
1,1,1-Trichloroethane[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
1,1,2-Trichloroethane[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
Trichloroethene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
Trichlorofluoromethane[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
1,2,3-Trichloropropane[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
1,2,3-Trichlorobenzene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
1,2,4-Trichlorobenzene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
1,2,4-Trimethylbenzene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
1,3,5-Trimethylbenzene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
Vinyl Chloride[9]	1	<0.0005	<0.0005	<0.0005	0.002	<25
m, p-Xylene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
o-Xylene[9]	1	<0.0005	<0.0005	<0.0005	0.005	<10
2,4,5-TP (Silvex)	1	<0.0001	<0.0001	<0.0001	0.01	<1
2,4-D	1	<0.0001	<0.0001	<0.0001	0.05	<0.2
3-Hydroxycarbofuran	1	<0.0005	<0.0005	<0.0005	N/A[10]	N/A
Alachlor	1	<0.0001	<0.0001	<0.0001	0.002	<5
Aldicarb	1	<0.0005	<0.0005	<0.0005	0.003	<17
Aldicarb Sulfone	1	<0.0007	<0.0007	<0.0007	0.002	<35
Aldicarb Sulfoxide	1	<0.0005	<0.0005	<0.0005	0.004	<13
Aldrin	1	<0.00005	<0.00005	<0.00005	N/A[10]	N/A
Atrazine	1	<0.0001	<0.0001	<0.0001	0.003	<3
Benzo(a)pyrene	1	<0.00002	<0.00002	<0.00002	0.0002	<10
Butachlor	1	<0.0001	<0.0001	<0.0001	N/A[10]	N/A
Carbaryl	1	<0.0005	<0.0005	<0.0005	N/A[10]	N/A
Carbofuran	1	<0.0009	<0.0009	<0.0009	0.04	<2
Chlordane	1	<0.0002	<0.0002	<0.0002	0.002	<10
Dalapon	1	<0.001	<0.001	<0.001	N/A[10]	N/A
Di(2-ethylhexyl)adipate	1	<0.0006	<0.0006	<0.0006	N/A[10]	N/A
Di(2-ethylhexyl)phthalate	1	<0.0006	<0.0006	<0.0006	0.006	<10
Dibromochloropropane	1	<0.00001	<0.00001	<0.00001	0.002	<5
Dicamba	1	<0.0001	<0.0001	<0.0001	N/A[10]	N/A
Dieldrin	1	<0.0001	<0.0001	<0.0001	N/A[10]	N/A
Dinoseb	1	<0.0001	<0.0001	<0.0001	0.007	<1
Endrin	1	<0.00001	<0.00001	<0.00001	0.002	<1
Ethylene Dibromide	1	<0.00001	<0.00001	<0.00001	0.00005	<20
Heptachlor	1	<0.0004	<0.0004	<0.0004	0.0004	<100
Heptachlor Epoxide	1	<0.00002	<0.00002	<0.00002	0.0002	<10

Notes for Table 43 are on page 107.

TABLE 43 (continued)
CHEMICAL CONSTITUENTS IN KESSELRING SITE DRINKING WATER

Parameter / Units[1] (Units are mg/l unless otherwise noted)	Number of Samples	Value[2]			Standard[4]	Percent of Standard[5]
		Minimum	Maximum	Average[3]		
Hexachlorobenzene	1	<0.0001	<0.0001	<0.0001	0.001	<10
Hexachlorocyclopentadiene	1	<0.0001	<0.0001	<0.0001	N/A[10]	N/A
Lindane	1	<0.00002	<0.00002	<0.00002	0.0002	<10
Methomyl	1	<0.0005	<0.0005	<0.0005	N/A[10]	N/A
Methoxychlor	1	<0.0001	<0.0001	<0.0001	0.04	<0.3
Metolachlor	1	<0.0001	<0.0001	<0.0001	N/A[10]	N/A
Metribuzin	1	<0.0001	<0.0001	<0.0001	N/A[10]	N/A
Oxamyl (Vydate)	1	<0.001	<0.001	<0.001	N/A[10]	N/A
Pentachlorophenol	1	<0.00004	<0.00004	<0.00004	0.001	<4
Total PCBs	1	<0.000065	<0.000065	<0.000065	0.0005	<13
Aroclor 1016 (PCB)	1	<0.000065	<0.000065	<0.000065	N/A[10]	N/A
Aroclor 1221 (PCB)	1	<0.000065	<0.000065	<0.000065	N/A[10]	N/A
Aroclor 1232 (PCB)	1	<0.000065	<0.000065	<0.000065	N/A[10]	N/A
Aroclor 1242 (PCB)	1	<0.000065	<0.000065	<0.000065	N/A[10]	N/A
Aroclor 1248 (PCB)	1	<0.000065	<0.000065	<0.000065	N/A[10]	N/A
Aroclor 1254 (PCB)	1	<0.000065	<0.000065	<0.000065	N/A[10]	N/A
Aroclor 1260 (PCB)	1	<0.000065	<0.000065	<0.000065	N/A[10]	N/A
Picloram	1	<0.0001	<0.0001	<0.0001	N/A[10]	N/A
Propachlor	1	<0.0001	<0.0001	<0.0001	N/A[10]	N/A
Simazine	1	<0.00007	<0.00007	<0.00007	0.004	<2
Toxaphene	1	<0.001	<0.001	<0.001	0.003	<33
Lead[11]	10	<0.0010	0.0133	<0.0024	0.015	<16
Copper[11]	10	0.0314	0.284	0.102	1.3	8
Haloacetic Acids[12]	1	0.0080	0.0080	0.0080	0.06	13
Total Trihalomethanes[12]	1	0.0164	0.0164	0.0164	0.08	21

Notes:
1. All samples were collected at the entry point to the distribution system unless otherwise noted.
2. A value preceded by “<” is less than the RL for that sample and parameter.
3. Average values preceded by “<” contain at least one value less than the RL value in the average.
4. Maximum Contaminant Level (MCL) per 10 NYCRR Subpart 5-1 Public Water Systems.
5. Percent of standard for the average value.
6. The minimum detectable concentration by the membrane filter method is one colony per 100 ml (N/100 ml).
7. These samples are taken at various locations in the site distribution system when routine total coliform samples are collected.
8. The minimum specification is that the free chlorine residual is 0.2 mg/l at the entry point and detectable in the distribution system. The maximum average level is 4 mg/l as calculated by taking the annual average, computed quarterly, of the samples collected in the distribution system.
9. These samples were taken from Well #8 in the Site Drinking Water System.
10. No standard for this parameter.
11. These samples are collected at 10 buildings throughout the distribution system.
12. These samples are collected from the Head Tank 27B (Storage Tank B).

TABLE 44
RESULTS OF KESSELRING SITE GROUNDWATER MONITORING FOR RADIOACTIVITY[1]

LOCATION		Cs-137	Co-60		Tritium pCi/liter x 10^2
		pCi/liter			
LANDFILL AREA					
HB-1A[2]		<0.95	<0.82		<1.46
HB-1B[2]	Well Dry, Not Sampled	----	----		----
HB-5A2		<0.95	<0.85		<1.46
HB-5B		<0.95	<0.82		<1.46
HB-11A		<0.93	<0.79		<1.54
HB-11B	Well Dry, Not Sampled	----	----		----
LMW-4		<2.30	<2.00		<1.54
LMW-6		<0.96	<0.86		<1.46
DEVELOPED AREA					
MW-1[2]		<0.93	<0.78		<1.47
MW-2		<0.94	<0.81		<1.47
MW-3		<0.94	<0.83		<1.47
MW-4		<0.93	<0.78		<1.48
MW-6		<0.94	<0.80		<1.47
MW-7		<0.95	<0.81		<1.47
MW-8		<1.00	<0.89		<1.47
MW-9		<0.96	<0.82		<1.47
MW-10		<0.93	<0.80		<1.47
MW-11		<0.93	<0.81		<1.47
MW-12		<0.96	<0.84		<1.48
MW-13		<0.94	<0.81		<1.48
MW-14		<1.00	<0.90		<1.48
MW-15		<0.93	<0.84		<1.48
MW-16		<0.94	<0.86		<1.48
MW-17		<2.34	<2.00		<1.48
MW-18		<0.96	<0.80		<1.48
MW-19		<0.93	<0.81		<1.48
MW-20	Well Dry, Not Sampled	----	----		----
BAPTIST HILL ROAD LANDFILL					
KBH-1[2]		<0.94	<0.81		<1.51
KBH-2		<0.93	<0.79		<1.51
KBH-3		<0.94	<0.79		<1.47
KBH-4		<0.91	<0.78		<1.51
SILO AREA					
KBH-6[2]		<2.40	<2.10		<1.47
KBH-7		<0.92	<0.78		<1.54
KBH-8	Well Dry, Not Sampled	----	----		----
SWANN SCHOOL ROAD CELLAR					
KBH-9	Well Dry, Not Sampled	----	----		----
KBH-10		<0.96	<0.84		<1.50
T-3		<2.40	<2.03		<1.51
PARKIS MILLS ROAD CELLAR					
KBH-11	Well Dry, Not Sampled	----	----		----
KBH-12	Well Dry, Not Sampled	----	----		----
KBH-13		<0.93	<0.81		<1.44

Notes:
1. A value preceded by “<” is less than the decision level concentration for that sample and parameter.
2. Background well for comparison purposes.

Conclusion

The 2018 groundwater data demonstrates no adverse changes from historical monitoring results. Past waste disposal practices at the landfill have resulted in observable effects on groundwater quality downgradient of the landfill. However, data trends show that groundwater quality has improved since the landfill was closed and that there is no indication of a breach in landfill cap integrity.

Within the industrial facility, groundwater results were obtained for chlorides, pH, and turbidity. These results are predominantly attributed to normal facility operations including the continued use of chlorinated Site Service Water for drinking, fire protection, and system cooling needs; the operation of the Kesselring Site cooling towers; the on-going use of roadway de-icing materials during winter months; and limited effects from past operational practices. Results from 2018 are consistent with historical monitoring trends. Previously sampled downstream surface water analysis has consistently shown no adverse effects from developed area Kesselring Site operations.

CONTROL OF CHEMICALLY HAZARDOUS SUBSTANCES AND SOLID WASTE

Chemical Control Program

Chemicals are not manufactured or disposed of at the Kesselring Site. To ensure the safe use of chemicals and disposal of the resulting wastes, the Kesselring Site maintains hazardous substance control and waste minimization programs similar to those at the Knolls Laboratory. Since 1990, significant reductions in hazardous waste streams have been accomplished at the Kesselring Site. Some hazardous waste streams have been eliminated through the use of non-hazardous substitutes. Most notably, a corrosive waste stream was eliminated by a process change, to make demineralized water by reverse osmosis rather than ion exchange. Hazardous substance storage controls include as a minimum: labeling, secondary containment as appropriate, segregation based on compatibility, limited storage volumes, and weather protection, as appropriate. When required, large volumes of chemicals and petroleum products are stored in accordance with the New York State Chemical Bulk Storage regulations as specified in Reference (15) and the Petroleum Bulk Storage regulations in Reference (16). Minimal quantities of hazardous wastes do result from the necessary use of chemicals in Site operations. Larger quantities of hazardous wastes result from one-time facility decommissioning and dismantlement activities. Hazardous and mixed (radioactive and hazardous) waste storage facilities are operated at the Kesselring Site under provisions of the New York State regulation implementing RCRA and the Federal Facility Compliance Act. The Kesselring Site operates these facilities under a Part 373 permit issued by NYSDEC. During 2018, the Kesselring Site shipped approximately 147 tons of RCRA and New York State hazardous waste off-site for treatment and disposal. This includes approximately 16 tons of mixed waste, predominantly from facility decommissioning and dismantlement activities. Waste that is both radioactive and chemically hazardous is regulated under both the AEA and RCRA as "mixed waste." Additionally, per the NYSDEC, certain TSCA regulated PCB waste is also considered a hazardous waste.

Elementary neutralization of small volume laboratory waste also occurs on-site. This process is exempt from regulation as a RCRA treatment process. The neutralized discharge is controlled under the Kesselring Site SPDES permit.

Nonhazardous chemical waste is also sent off-site for disposal. The transportation vendors and the treatment, storage, and disposal facilities are typically the same as those used for hazardous waste disposal. These facilities also operate under permits issued by the cognizant Federal and State regulatory agencies. The Kesselring Site also requires the disposal facility to provide itemized written verification that the waste was actually received. In 2018, approximately 349 tons of nonhazardous chemical waste was sent for off-site treatment and disposal via incineration, wastewater treatment, chemical treatment and/or land disposal. A significant fraction of these wastes was the result of either dismantlement and/or renovation activities at the Kesselring Site.

In addition, the Kesselring Site hazardous waste control program is subject to periodic on-site inspections by NYSDEC and the EPA.

Solid Waste Disposal/Recycling

During 2018, approximately 2,187 tons of nonhazardous, solid wastes were generated from such waste streams as construction and demolition debris, office and cafeteria trash, and classified paper. From these waste streams, the Kesselring Site recycles materials such as office paper, except classified items, glass, plastic, aluminum, newspapers, magazines, scrap metal, corrugated cardboard, computers, precious metals, lead, oil, fluorescent light bulbs, wood, asphalt, printer cartridges, and batteries. Approximately 1,026 tons of materials were recycled.

CONTROL OF RADIOACTIVE MATERIALS AND RADIOACTIVE WASTE

Sources

Operations at the Kesselring Site result in the generation of various types of radioactive materials and wastes. Low level radioactive solid waste material that requires disposal includes filters, metal scrap, resin, rags, paper, and plastic materials.

Control Program

Detailed procedures are used for handling, packaging, and transportation of radioactive materials and disposal of radioactive waste at a government operated or licensed disposal site. Internal reviews are made prior to the shipment of any radioactive material from the Kesselring Site to ensure that the material is properly identified, surveyed, and packaged in accordance with Federal, State, and local requirements.

The volume of radioactive waste is minimized through recycling and the use of special work procedures that limit the amount of material that becomes contaminated during work on radioactive systems and reactor components. Radioactive liquid waste is processed into an absorbed form prior to shipment to an approved disposal facility. All radioactive wastes are prepared and shipped to meet applicable regulations of the DOT given in Reference (17). The waste packages also comply with all applicable requirements of the NRC, the DOE, and the disposal sites.

Disposal/Recycling

The shipments of low level radioactive solid wastes were made by authorized common carriers to disposal sites located outside of New York State.

During 2018, approximately 41.0 cubic meters (53.6 cubic yards) of low level radioactive waste containing 0.0274 curies was shipped from the Kesselring Site for disposal. The Kesselring Site did not ship radioactive metal for radioactive material recycling.

CONTROL OF MIXED WASTES

Sources

Waste that is both radioactive and chemically hazardous is regulated under both the AEA and RCRA as "mixed waste." Ongoing operations at the Kesselring Site resulted in the generation of a very small proportion of the mixed waste generated at Kesselring. The majority of the mixed waste is generated as a result of dismantlement or refurbishment activities.

Control Program

Since mixed wastes are both RCRA hazardous and radioactive, the controls for hazardous wastes are applied to the hazardous constituents and the controls for radioactive wastes are applied to the radioactive constituents.

Mixed wastes are managed on-site in accordance with the Kesselring Site RCRA permit. The amount of mixed waste generated was minimized through the use of detailed work procedures and worker training. Mixed wastes were collected in designated regulated and permitted storage areas for the sole purpose of accumulating sufficient quantities to facilitate shipment to an off-site facility for proper treatment and disposal.

Disposal

Mixed wastes shipped off-site were packaged in compliance with DOT requirements for transport to and receipt at RCRA-permitted treatment and disposal facilities. In 2018, there were five shipments totaling 16.2 tons of various mixed wastes sent to treatment and disposal facilities.

RADIATION DOSE ASSESSMENT

The effluent and environmental monitoring results show that the radioactivity in liquid and gaseous effluents from 2018 operations at the Kesselring Site had no measurable effect on background radioactivity levels. Therefore, any radiation doses from Kesselring Site operations to off-site individuals were too small to be measured and must be calculated using conservative methods. Estimates of the radiation dose to the maximally exposed off-site individual in the vicinity of the Kesselring Site and the collective dose to the population residing in the 80 kilometer (50 mile) radius assessment area are summarized later in this report in the Radiation Dose Assessment and Methodology section.

The results show that the estimated doses were less than 0.1 percent of that permitted by the DOE radiation protection standards listed in Reference (18) and that the estimated dose to the population residing within 80 kilometers (50 miles) of the Kesselring Site was less than 0.001 percent of the natural background radiation dose to the population. In addition, the estimated doses were less than one percent of that permitted by the NRC numerical guide listed in Reference (19) for whole body dose demonstrating that doses are as low as reasonably achievable. The dose attributed to radioactive air emissions was less than one percent of the EPA standard in Reference (8).

The collective radiation dose to the public along travel routes from outgoing Kesselring Site shipments of radioactive materials during 2018 was calculated using data given by the NRC in Reference (20). The collective radiation dose to the public from all NNPP shipments of radioactive materials is included in Reference (21).

Based on the type and number of shipments made, the collective annual radiation dose to the public along the transportation routes, including transportation workers, was less than one person-rem. This is less than 0.001 percent of the dose received by the same population from natural background radiation.

SEPARATIONS PROCESS RESEARCH UNIT

BACKGROUND

A Cold War era facility known as the Separations Process Research Unit (SPRU) operated between 1950–1953 at the Knolls Laboratory as a pilot plant to research chemical processes to extract uranium and plutonium from irradiated uranium. The SPRU work was conducted under the direction of the Atomic Energy Commission. The work was done on a limited scale; SPRU was never a production plant. The SPRU processes were developed for use at the Atomic Energy Commission's Hanford Site in Washington State and the Savannah River Plant in South Carolina.

Following cessation of SPRU operations in 1953, partial cleaning of equipment and systems was performed, and the facility was placed in a stable long-term storage condition by the Atomic Energy Commission. The Knolls Laboratory maintained an environmental monitoring program to confirm that the inactivated SPRU facility posed no threat to the health of Laboratory workers, the public, or the environment.

Consistent with its objective to clean up legacy sites that are no longer needed, the U.S. Department of Energy-Office of Environmental Management (DOE-EM) dedicated funding to support SPRU dismantlement and remediation. The remediation of the SPRU facility and waste management areas will result in the removal of hazardous equipment, building materials, and impacted soil and the restoration of the land for Knolls Laboratory use. The Knolls Laboratory turned over the SPRU facilities (Buildings G2 and H2) and land areas to DOE-EM as necessary to support the objectives of the cleanup work. DOE-EM is responsible for the remediation of the SPRU areas, which are shown on Figure 10.

The nature of the work performed during 2018 in the Building G2/H2 area consisted of operating radioactive water collection systems, maintenance of the facility, removal of legacy radioactive materials, remediation of hazardous materials, and D&D of Buildings G2 and H2. In 2018, the work scope also included maintenance of contamination controls and shipments of waste. This work culminated in the completion of the building demolition and site remediation activities. Site restoration began in October 2018.

LIQUID EFFLUENT MONITORING

Sources

Nonradiological: The principal source of nonradiological effluent water from SPRU is stormwater to the Mohawk River.

Radiological: The main sources of radiological water are water collected around the foundation of Building H2 and water collected from the open excavation of the G2 Building and H2 Building demolition footprints. The excavation water included that used for dust suppression during demolition of the buildings and precipitation that fell on the footprint. Backfill of the building excavations began in October 2018. Water from the SPRU facilities was shipped off-site to approved disposal facilities. In 2018, a total of 284,120 gallons of water were shipped off-site for treatment and disposal.

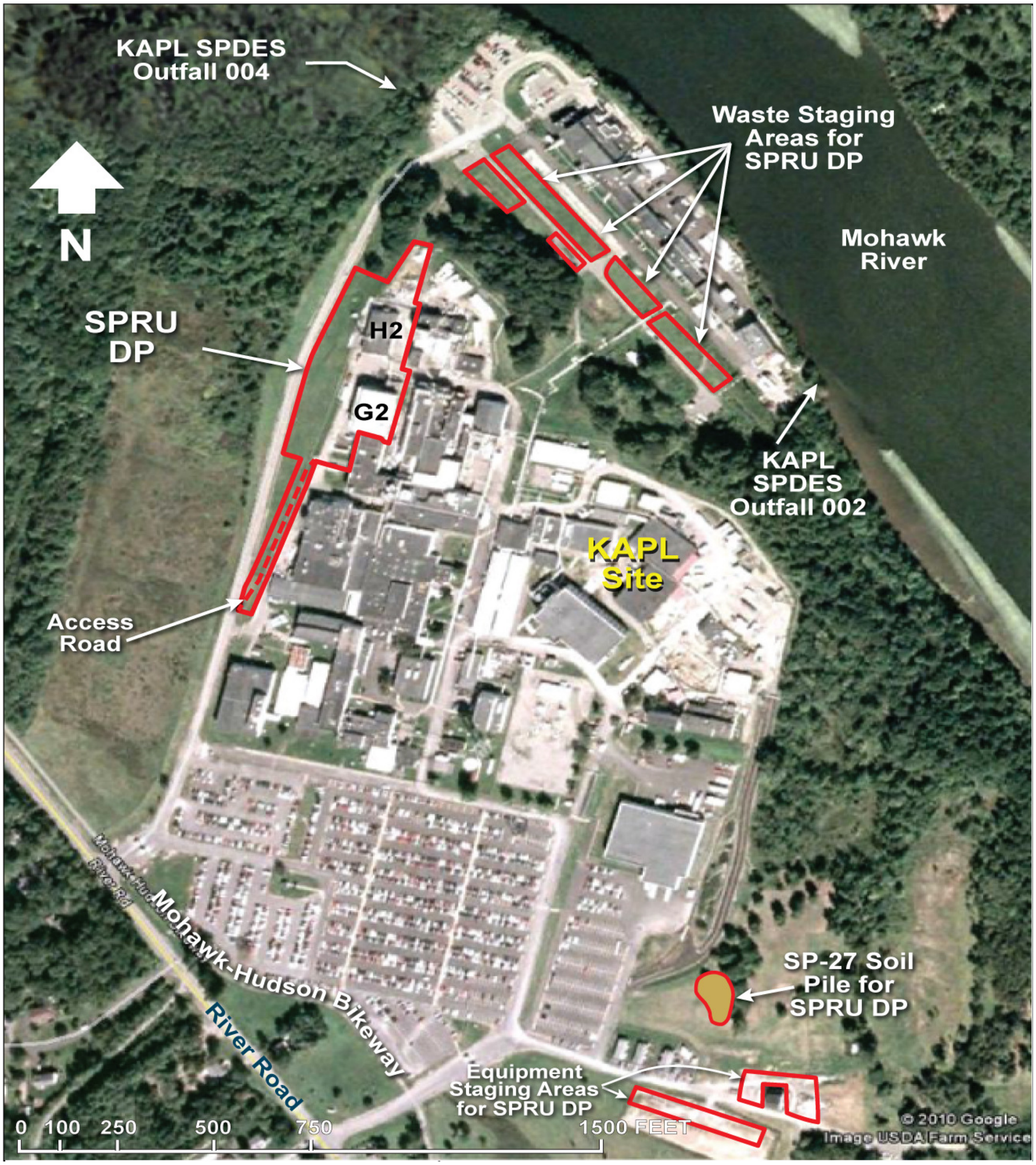

FIGURE 10
SPRU AREAS AT THE KNOLLS LABORATORY

Effluent Monitoring

Effluent monitoring is performed by the Knolls Laboratory and is described in the Knolls Laboratory section of this report.

Effluent Analyses

Effluent analyses are performed by the Knolls Laboratory and are described in the Knolls Laboratory section of this report.

Assessment

See the Knolls Laboratory section on this subject.

AIRBORNE EFFLUENT MONITORING

Sources

Nonradiological: The principal sources of nonradiological air emissions at SPRU are emergency and non-emergency diesel generators. This source of air emissions at SPRU meets the criteria for exempt and trivial sources under NYSDEC regulations and is not required to have air permits or registrations.

Radiological: The SPRU operations capable of generating airborne radioactivity include the operation of water collection systems, D&D activities associated with Portable Ventilation Units (PVUs), demolition of the G2 and H2 Buildings, and soil excavation. The PVUs are permitted point sources. PVUs were used intermittently at SPRU during 2018 to monitor decontamination of the E1 and G1 tunnels and during decontamination of fractionation tanks used to collect and store contaminated water. Building demolition, water collection, and soil excavation are sources of fugitive emissions.

Effluent Monitoring

Nonradiological: In general, exempt and trivial activities do not require emissions monitoring, although some activities such as operation of the diesel generators may require monitoring of run times to maintain their exempt status.

Radiological: Airborne effluents from PVUs are continuously sampled for particulate activity when the PVUs are in use. Emissions from diffuse sources were estimated using EPA methods.

Effluent Analyses

Radiological: Particulate filter papers from the PVUs were analyzed using a sensitive low-background gas proportional counting system. Follow-on analyses for specific radionuclides were performed quarterly.

Assessment

Radiological: The radioactivity released in SPRU monitored PVU airborne effluent during 2018 is shown in Table 45. Diffuse source emissions are summarized in Table 46. The releases from PVUs and diffuse sources are totaled in Table 47.

For Tables 45 - 47, **Bold** indicates radionuclide of interest in combined analyte.

TABLE 45
SPRU RADIOACTIVITY RELEASED IN AIRBORNE EFFLUENT FROM PORTABLE VENTILATION UNITS

Radionuclide	Release (Ci/yr)	Half-life
Sr-90	2.79E-10	28.78 years
Cs-137 Fission and Activation Products ($T_{1/2}$ >3 hr)	1.05E-09 1.33E-09	30.07 years
U-**233**/234 U-235 U-238 Total Uranium	3.33E-10 7.21E-11 1.81E-10 5.86E-10	1.59E05 years/2.46E05 years 7.04E08 years 4.47E09 years
Pu-238 Pu-**239**/240 Total Plutonium (alpha)	4.12E-11 1.34E-10 1.75E-10	87.7 years 2.41E04 years/6.56E03 years
Th-228 Th-230 Th-232 Total Thorium	1.14E-10 3.93E-10 3.24E-10 8.31E-10	1.91 years 7.34E04 years 1.40E10 years
Am-241	3.06E-11	432.7 years

TABLE 46
SPRU RADIOACTIVITY RELEASED FROM DIFFUSE SOURCES

Radionuclide	Water Storage (Ci/yr)	G2 and H2 Open Air Demolition (Ci/yr)	Soil Disturbance (Ci/yr)	Diffuse Total (Ci/yr)
Sr-90	3.77E-06	2.57E-04	1.33E-08	2.61E-04
C-14	3.31E-09	0.00E+00	0.00E+00	3.31E-09
Ni-63	1.63E-09	1.44E-09	0.00E+00	3.07E-09
Tc-99	1.04E-09	1.69E-09	0.00E+00	2.73E-09
Cs-137	2.57E-06	2.91E-04	3.42E-07	2.94E-04
Fission and Activation Products ($T_{1/2}$ >3 hr)				5.55E-04
U-**233**/234	1.25E-08	5.16E-07	1.38E-10	5.28E-07
U-235	7.44E-10	1.56E-07	1.06E-10	1.57E-07
U-236	0.00E-00	6.81E-09	0.00E-00	6.81E-09
U-238	7.33E-09	3.66E-08	1.41E-09	4.54E-08
Total Uranium	2.06E-08	7.15E-07	1.65E-09	7.37E-07
Pu-238	4.46E-10	2.32E-08	7.17E-11	2.37E-08
Pu-**239**/240	3.51E-08	5.52E-06	3.47E-09	5.56E-06
Total Plutonium (alpha)	3.55E-08	5.54E-06	3.54E-09	5.58E-06
Th-228	1.43E-09	1.13E-09	1.36E-10	2.70E-09
Th-230	9.99E-11	1.25E-10	1.60E-10	3.85E-10
Th-232	0.00E+00	1.19E-09	1.23E-09	2.42E-09
Th-234	0.00E+00	0.00E+00	1.23E-09	1.23E-09
Total Thorium	1.53E-09	2.45E-09	2.76E-09	6.74E.09
Am-241	2.50E-08	3.90E-07	3.41E-10	4.15E-07
Pu-241	1.70E-08	5.55E-07	0.00E+00	5.72E-07
Cm-242	1.47E-10	0.00E+00	0.00E+00	1.47E-10

TABLE 47
SPRU AIRBORNE RADIOACTIVITY RELEASED

Radionuclide	PVU (Ci/yr)	Diffuse Total (Ci/yr)	Total Emissions (Ci/yr)
Sr-90	2.79E-10	2.61E-04	2.61E-04
C-14	0.00E+00	3.31E-09	3.31E-09
Ni-63	0.00E+00	3.07E-09	3.07E-09
Tc-99	0.00E+00	2.73E-09	2.73E-09
Cs-137	1.05E-09	2.94E-04	2.94E-04
Fission and Activation Products ($T_{1/2}$ >3 hr)			5.55E-04
U-**233**/234	3.33E-10	5.28E-07	5.28E-07
U-235	7.21E-11	1.57E-07	1.57E-07
U-236	0.00E-00	6.81E-09	6.81E-09
U-238	1.81E-10	4.54E-08	4.56E-08
Total Uranium	5.86E-10	7.37E-07	7.38E-07
Pu-238	4.12E-11	2.37E-08	2.37E-08
Pu-**239**/240	1.34E-10	5.56E-06	5.56E-06
Total Plutonium (alpha)	1.75E-10	5.58E-06	5.58E-06
Th-228	1.14E-10	2.70E-09	2.81E-09
Th-230	3.93E-10	3.85E-10	7.78E-10
Th-232	3.24E-10	2.42E-09	2.74E-09
Th-234	0.00E-00	1.23E-09	1.23E-09
Total Thorium	8.31E-10	6.74E-09	7.57E-09
Am-241	3.06E-11	4.15E-07	4.15E-07
Pu-241	0.00E+00	5.72E-07	5.72E-07
Cm-242	0.00E+00	1.47E-10	1.47E-10

ENVIRONMENTAL MONITORING

Scope

Environmental air samplers are operated by the Knolls Laboratory and are described in that section on this subject. Air samplers are operated within the SPRU work area and on the boundary between SPRU and the Knolls Laboratory to confirm that SPRU work conforms to DOE regulations for exposure to workers and visitors.

RADIATION MONITORING

The environmental radiation monitoring program is performed by the Knolls Laboratory and is described in the Knolls Laboratory section of this report.

GROUNDWATER MONITORING

The groundwater monitoring program is performed by the Knolls Laboratory and is described in the Knolls Laboratory section of this report.

CONTROL OF CHEMICALLY HAZARDOUS SUBSTANCES

Sources

Chemicals are not manufactured at SPRU. To ensure the safe use of chemicals and disposal of the resulting wastes, SPRU maintains a hazardous waste control program. Hazardous wastes are disposed through permitted off-site treatment and disposal facilities.

Chemical Control Program

The control program minimizes the quantity of waste material generated, ensures safe usage and storage of the materials at SPRU, and provides for proper disposal of the wastes through vendors that operate under permits issued by Federal and State agencies.

The control of hazardous substances for use at SPRU includes a review of waste minimization impact. Purchase orders for chemicals are reviewed to ensure that the materials are actually necessary for operations, the amount ordered is not excessive, and that methods for proper disposal are in place before the material is ordered. Hazardous substance storage controls include as a minimum: labeling, providing revetments as appropriate, segregation based on compatibility, limited storage volumes, and weather protection as appropriate. When required, large volumes of chemicals and petroleum products would be stored in accordance with the New York State Chemical Bulk Storage regulations (Reference (15)) and the Petroleum Bulk Storage regulations (Reference (16)). SPRU currently does not store any chemicals or petroleum products in quantities that are subject to the Chemical Bulk Storage regulations or the Petroleum Bulk Storage regulations.

All personnel are provided with general information on the policies for the procurement, use, and disposal of hazardous substances. For individuals who use hazardous substances in operations, specific training is provided to ensure that they are knowledgeable of safe handling techniques and emergency response procedures. After chemicals are used and no longer needed, they are accumulated in designated staging and storage areas where they are segregated and packaged for shipment. Waste is temporarily stored only as necessary to accumulate sufficient volumes for shipment to a waste disposal vendor with the exception of mixed transuranic waste, which is stored under NYSDEC-approved storage extension to the regulatory time requirements. SPRU has an inspection program to routinely verify that hazardous substances are properly stored and controlled in accordance with approved procedures.

Chemical Disposal

Hazardous waste is managed in compliance with RCRA. Generated waste is transported by vendors to treatment, storage, and disposal facilities for final disposition. The transportation vendors and the treatment, storage, and disposal facilities operate under permits issued by the cognizant Federal and State regulatory agencies. The disposal facilities provide itemized written verification that the waste was actually received. During 2018, SPRU shipped 1,468 pounds (approximately 0.73 tons) of RCRA and New York State hazardous waste off-site for disposal, including 397 lbs (0.20 tons) of universal waste. Approximately 2.39 cubic meters (3.13 cubic yards) of mixed low level waste (MLLW) was shipped off-site during 2018.

The SPRU hazardous waste program is governed by the Waste Management Plan (WMP-001) and implementing procedures. Prior to performing any waste generating activity at SPRU, the work package is evaluated for safety, minimization, and compliance. Applicable process knowledge and existing conditions are evaluated and documented. This information, along with any additional sampling and analysis required, is used to make a hazardous waste determination for the waste stream, as well as to establish the initial categorization of the waste type. The waste determination process also includes consideration of the final disposition of the waste. This "cradle to grave" review plan ensures that the waste can be certified to TSDF acceptance criteria and that a generating activity will not generate a waste without a path forward.

Hazardous wastes that are not radioactive are packaged, treated, staged, transported, and disposed of consistent with the applicable (RCRA, NYS, TSCA, DOT) regulations. These wastes are disposed either by direct contract mechanism, by utilizing DOE's broad spectrum contract mechanism, or through a qualified hazardous waste broker.

No non-hazardous chemical waste was sent off-site for disposal during 2018.

CONTROL OF RADIOACTIVE MATERIALS AND RADIOACTIVE WASTE

Sources

Operations at SPRU result in the generation of various types of radioactive materials and wastes. Low level radioactive solid waste materials that require disposal include debris, soil, filters, metal scrap, rags, resin, paper, and plastic materials. Prior to 2018, remediation activities at SPRU generated waste that contained greater than 100 nCi of alpha-emitting transuranic isotopes per gram of waste with half-lives greater than 20 years, which is referred to as TRU waste. TRU waste (>100 nCi/g) is managed separately from low level radioactive waste and must be disposed of at the DOE Waste Isolation Pilot Plant (WIPP).

Control Program

Detailed procedures are used for handling, packaging, transportation, and disposal of radioactive waste at a government operated or licensed disposal site. Internal reviews are made prior to the shipment of any radioactive material from SPRU to ensure that the material is properly identified, surveyed, and packaged in accordance with Federal requirements.

The volume of radioactive waste that results from radiological control activities is minimized through the use of work procedures that limit the amount of materials that become contaminated during work on radioactive systems and components. All radioactive wastes are prepared and shipped in accordance with written procedures to meet the applicable DOT regulations given in Reference (17). The waste packages also comply with all applicable requirements of the DOE and the disposal sites.

Disposal/Recycling

In 2018, 1872 shipments of low level radioactive wastes were made by authorized common carriers to disposal sites located outside New York State. These shipments consisted of either water or solid form wastes as described in the next paragraph. No radioactive materials were recycled.

During 2018, 1,076 cubic meters (1,407 cubic yards) of water containing approximately 0.0046 Ci was shipped from SPRU for disposal. In addition, 1810 shipments totaling approximately 19,824 cubic meters (25,929 cubic yards) of solid low level radioactive waste containing approximately 5.38 Ci were shipped from SPRU for disposal.

CONTROL OF MIXED WASTE

Sources

Remediation activities at SPRU generate mixed waste, some of which, includes radioactive TSCA regulated PCB waste that NYSDEC considers to also be hazardous waste. Mixed waste generated from SPRU activities is packaged, treated, staged, transported and disposed of consistent with the applicable (RCRA, NYS, TSCA, DOT) regulations. WMP-001 directs that these wastes be disposed of either by direct contract mechanisms or by utilizing DOE's broad spectrum contract mechanism.

Control Program

SPRU cleanup operations take aggressive action to minimize the creation of mixed waste by reducing the commingling of radioactive and hazardous materials and avoiding the use of hazardous substances where practicable. The amount of generated mixed waste was also minimized through the use of detailed work procedures and worker training.

Storage and Disposal

All mixed wastes are accumulated in designated staging areas. Mixed wastes are packaged for storage and eventual shipment to off-site treatment facilities. In 2018, six shipments of mixed wastes totaling 2,087 pounds were made to treatment and disposal facilities. Mixed TRU waste from SPRU is being managed under a consent order with NYSDEC that covers the storage of mixed TRU until a hazardous waste storage permit is obtained by SPRU DP.

RADIATION DOSE ASSESSMENT

The effluent and environmental monitoring results show that radioactivity present in liquid and gaseous effluents from 2018 operations at the Knolls Laboratory (including SPRU) had no measurable effect on normal background radioactivity levels. Therefore, any radiation doses from the Knolls Laboratory (including SPRU) operations to off-site individuals were too small to be measured and must be calculated using conservative methods. Estimates of the radiation dose to the maximally exposed individual in the vicinity of the Knolls Laboratory (including SPRU) and the collective dose to the population residing in the 80 kilometer (50 mile) radius assessment area are summarized in the Radiation Dose Assessment and Methodology section later in this report.

The results show that the estimated doses were less than 0.1 percent of that permitted by the radiation protection standards of the DOE listed in Reference (18) and that the estimated dose to the population residing within 80 kilometers (50 miles) of the Knolls Laboratory (including SPRU), was less than 0.001 percent of the natural background radiation dose to the population. In addition, the estimated doses were less than one percent of that permitted by the NRC numerical guide listed in Reference (19) for whole-body dose, demonstrating that doses are as low as is reasonably achievable. The dose attributed to radioactive air emissions from the Knolls Laboratory (including SPRU) was less than one percent of the EPA standard in Reference (8).

The collective radiation dose to the public along the travel route from SPRU shipments of radioactive materials during 2018 was calculated using data and methods given by the NRC in Reference (20). Based on the type and number of shipments made, the collective annual radiation dose to the public along the transportation routes, including transportation workers, was less than ten person-rem. This is less than 0.01 percent of the dose received by the same population from natural background radiation.

RADIATION DOSE ASSESSMENT AND METHODOLOGY

Measurements for radioactivity in environmental media representing an exposure pathway to man indicated no radioactivity attributable to operations at the Knolls Laboratory (including SPRU) and Kesselring Site. Therefore, potential doses to the general public from liquid and airborne effluents were too small to be measured and are estimated using conservative calculational techniques based on assumed pathways to man.

The exposure pathways via air and water considered for estimating radiation exposures were:

1. *Air Pathways*

   a. External exposure from airborne radioactivity and radioactivity deposited on the ground,
   b. Ingestion of food products, and
   c. Inhalation of airborne radioactivity.

2. *Water Pathways*

   a. Ingestion of water and fish,
   b. Ingestion of food products grown on irrigated land,
   c. External exposure from irrigated land, and
   d. Boating, swimming, and shoreline recreation.

For the Knolls Laboratory (including SPRU) and Kesselring Site, calculations were made to estimate: (1) the radiation dose to the maximally exposed individual in the vicinity of the two Sites, and (2) the collective dose to the population residing in the 80 kilometer (50 mile) radius assessment area. See Figure 11 for a map of the 80 kilometer (50 mile) assessment areas surrounding the two Sites.

The fundamental equation for calculation of the annual dose from a single radionuclide is:

$$D = XUK$$

where:

D = annual dose
X = the concentration of the radionuclide in the media of the exposure pathway of interest
U = the annual exposure time (hours) or intake (ml or kg) associated with the exposure pathway of interest
K = the annual dose factor for external exposure to a radionuclide or the dose commitment for a 50 year period from the current year's intake of a radionuclide

In estimating potential doses via the water pathway, the contribution from each radionuclide present in the liquid effluents to the effective dose equivalent was calculated using DOE dose conversion factors from Reference (25), Reference (18), and the Reference (26) liquid pathway model for both the Knolls Laboratory (including SPRU) and the Kesselring Site.

Estimates of potential doses via air pathways were calculated using CAP88-PC, Version 4.0, the EPA computer code package approved for use in Reference (27). The code package was prepared to implement the dose assessment required to demonstrate compliance with Reference (8). It includes the computer code AIRDOS2 and a file of the 50-year committed effective dose equivalent conversion factors calculated by the computer code DARTAB, which uses the dose factor database RADRISK using weighting factors from ICRP-72. CAP88-PC Version 4.0 is an updated version of CAP88-PC. It incorporates Federal Guidance Report 13 dose and risk factors.

In CAP88-PC Version 4.0, the area surrounding the site is divided into a circular grid defined by 16 pie-shaped segments, which are subdivided into sectors by annular rings out to 80 kilometers (50 miles). The computer code calculates the air concentration and surface deposition in each sector for each radionuclide released from each Site using site specific average atmospheric dispersion parameters. Dispersion parameters for each Site are based on on-site meteorological data summarized in accordance with Reference (28). Next, the radionuclide concentrations in meat, milk, and fresh vegetables produced in each sector are estimated using terrestrial food chain models. In CAP88-PC Version 4.0 the environmental radionuclide transfer factors were updated to the values from the National Council on Radiation Protection and Management Report 123. The code then calculates the effective dose equivalent to persons (adults) residing in each sector through the following exposure modes: (1) immersion in air containing radionuclides, (2) exposure to radionuclides deposited on ground surfaces, (3) inhalation of radionuclides in air, and (4) ingestion of food produced in the sector. The collective (population) effective dose equivalent is obtained by summing the product of the dose and population for each sector. The population residing within 80 kilometers (50 miles) of each site is based on the 2010 census data as reported in Reference (29).

The air pathway calculated doses are summarized in Tables 48 and 49. Ingestion was the calculated principal exposure pathway for the hypothetical maximally exposed individual at the Knolls Laboratory (including SPRU). At the Kesselring Site, the calculated principal exposure pathway for this hypothetical person was the ingestion pathway.

A comparison of the estimated (calculated) radiation dose to the maximally exposed individual from Knolls Laboratory (including SPRU) and Kesselring Site operations with the average radiation dose received from other sources is shown in Figure 12. Data in Figure 12 show that the maximum radiation dose that may have been received as a result of Knolls Laboratory and Kesselring Site operations is much lower than the DOE radiation protection standard and the drinking water and air emission standards established by the EPA, and considerably lower than the average dose received from other sources (natural and man-made) of radiation.

TABLE 48
ESTIMATED ANNUAL DOSE TO THE MAXIMALLY EXPOSED INDIVIDUAL AND ASSESSMENT AREA POPULATION FROM KNOLLS LABORATORY (INCLUDING SPRU)

Pathway	Dose to Maximally Exposed Individual[1] (mrem)	(mSv)	% of DOE 100 mrem/yr Limit	Estimated Population Dose (person-rem)	(person-Sv)	Population within 80 km	Estimated Background Radiation Population Dose (person-rem)
Air	3.0E-02[2]	3.0E-04	3.0E-02	5.9E-02	5.9E-04	1.36E06[3]	9.1E04[4]
Water	2.6E-04	2.6E-06	2.6E-04	4.3E-03	4.3E-05		
Other Pathways	None		None	None			
All Pathways	3.0E-02	3.0E-04	3.0E-02	6.3E-02	6.3E-04		

TABLE 49
ESTIMATED ANNUAL DOSE TO THE MAXIMALLY EXPOSED INDIVIDUAL AND ASSESSMENT AREA POPULATION FROM KESSELRING SITE OPERATONS

Pathway	Dose to Maximally Exposed Individual[1] (mrem)	(mSv)	% of DOE 100 mrem/yr Limit	Estimated Population Dose (person-rem)	(person-Sv)	Population within 80 km	Estimated Background Radiation Population Dose (person-rem)
Air	2.7E-03[2]	2.7E-05	2.7E-03	1.6E-02	1.6E-04	1.23E06[3]	6.9E04[4]
Water	4.1E-06	4.1E-08	4.1E-06	9.0E-07	9.0E-09		
Other Pathways	None		None	None			
All Pathways	2.7E-03	2.7E-05	2.7E-03	1.6E-02	1.6E-04		

Notes for Tables 48 and 49:

1. The Maximally Exposed Individual for the Water Pathway case is in a different location than the Maximally Exposed Individual for the Air Pathway and All Pathways cases.
2. The EPA Radionuclide NESHAPs standard is 10 mrem/year.
3. Total population residing within 80 kilometers (50 miles) is based on 2010 census data as reported in Reference (29).
4. Dose based on average off-site background radiation level determined for the Knolls Laboratory and Kesselring Site with TLDs as reported in Tables 24 and 39, respectively. It does not include the estimated average annual effective dose equivalent of 29 mrem that a member of the population receives from naturally occurring radionuclides in the human body or the 228 mrem received from exposure to radon and its decay products as reported in Reference (30).

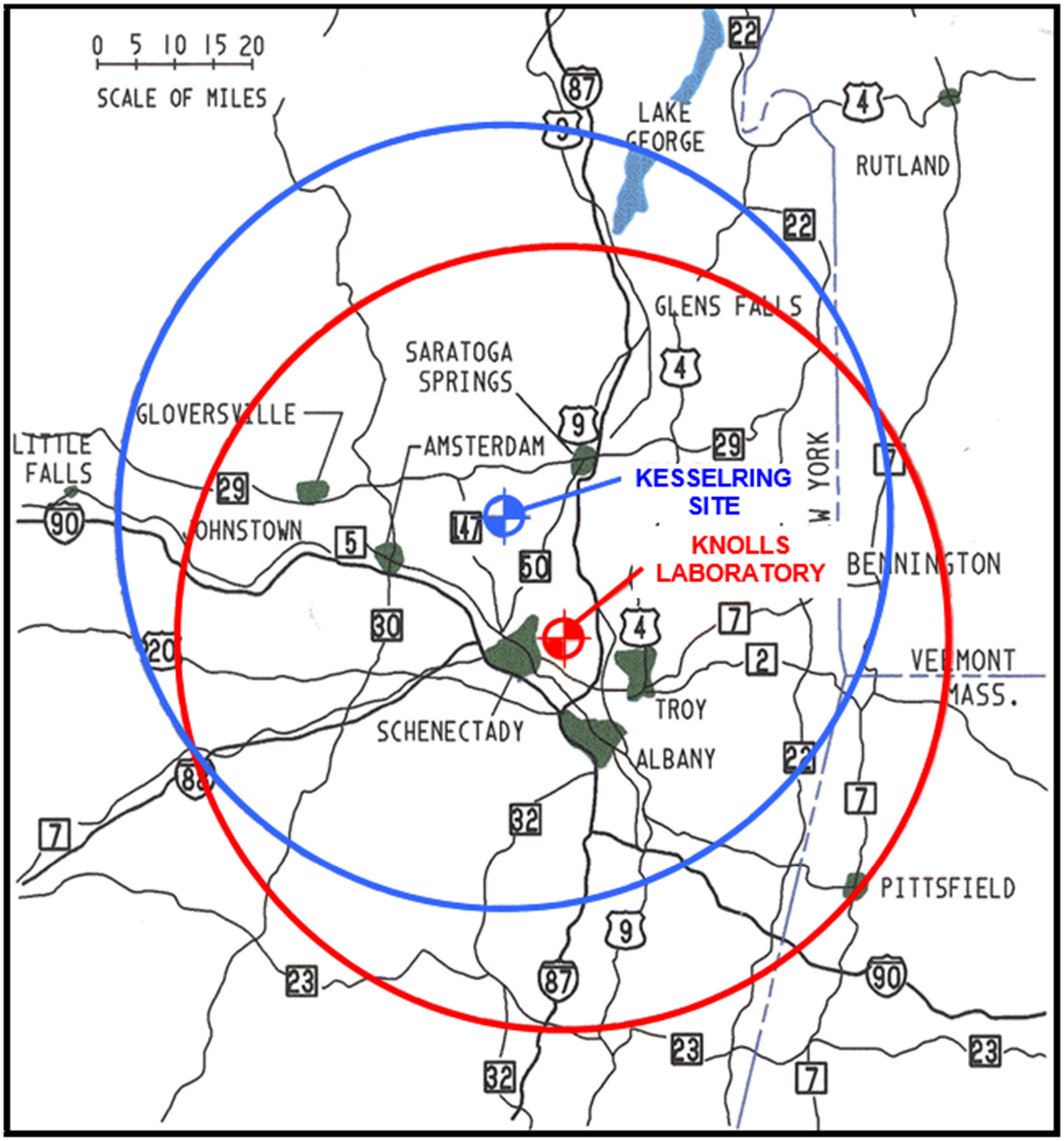

FIGURE 11
EIGHTY KILOMETER (50 MILE) ASSESSMENT AREA MAP FOR KNOLLS LABORATORY (INCLUDING SPRU) AND KESSELRING SITE

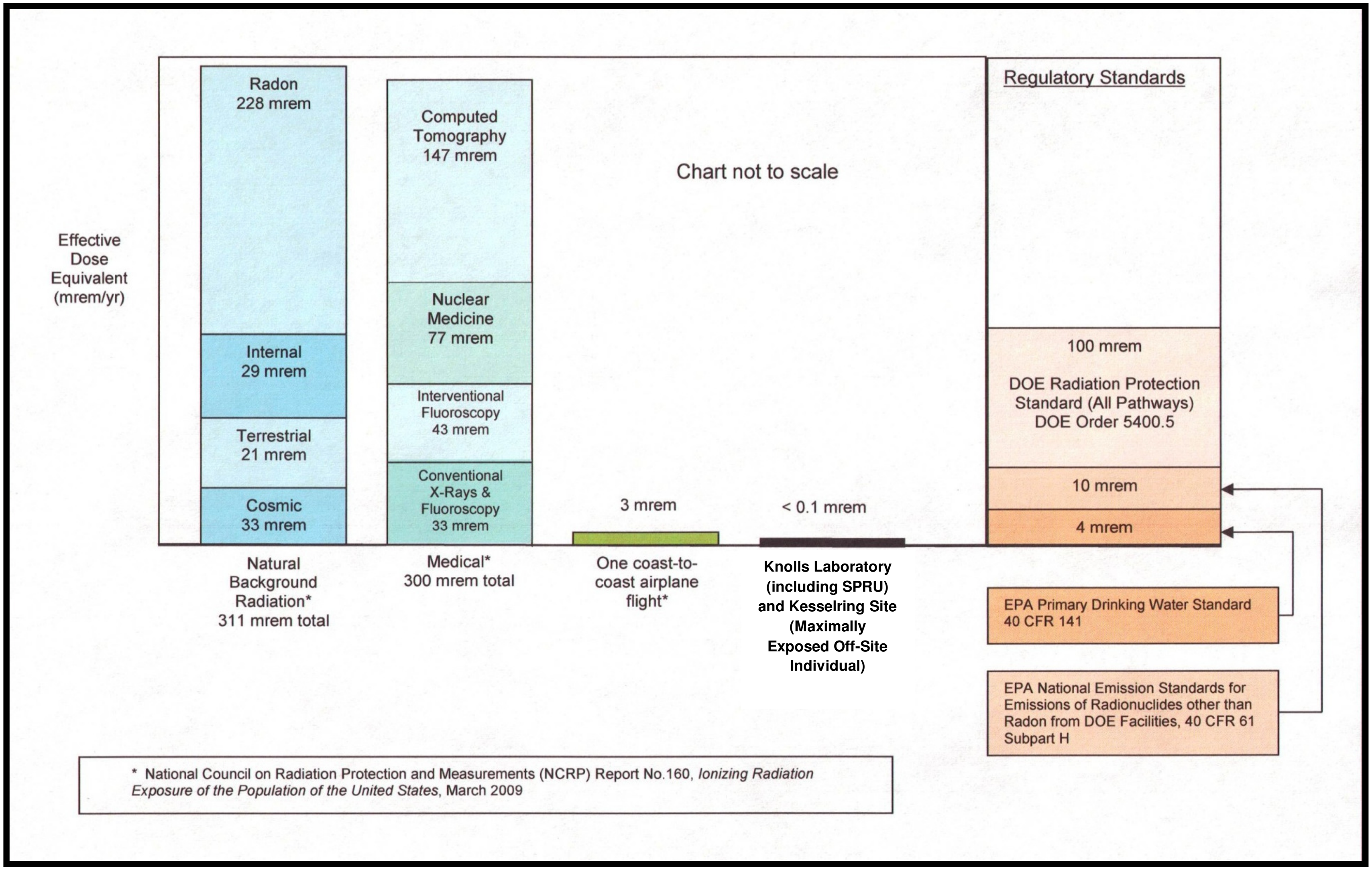

FIGURE 12

COMPARISON OF THE ESTIMATED RADIATION DOSE FROM KNOLLS LABORATORY (INCLUDING SPRU) AND KESSELRING SITE WITH DOSES FROM OTHER SOURCES

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QUALITY ASSURANCE PROGRAM

The Knolls Laboratory and Kesselring Site Quality Assurance Program is conducted to ensure the accuracy and precision of effluent and environmental sampling, analysis, and reporting. The program is based on the guidance contained in several DOE, EPA, and NRC documents on the subject (References 31, 32, and 33, respectively).

The program for 2018 consisted of the following elements:

1. Internal quality assurance procedures

    a. Personnel training and qualification
    b. Written procedures for sampling, sample analysis, and computational methods
    c. Calibration of sampling and sample analysis equipment
    d. Internal quality assurance sample analyses
    e. Data review and computation check

2. Participation in a Quality Assurance Program (QAP) administered by a commercial laboratory, Environmental Resource Associates (ERA)

3. Subcontractor quality assurance procedures

4. Program audits

The internal quality assurance procedures start with the training of all personnel involved in the collection and analysis of samples, in accordance with established Knolls Laboratory and Kesselring Site policies. Personnel are not permitted to perform sampling and sample analysis until they are trained and have demonstrated the ability to properly perform their duties. Written procedures, based on the methods recommended in References (31) and (33), cover collection and analysis of samples, the computation of results, and the calibration of sampling and analytical equipment, as required. Radioactivity counting equipment is, whenever possible, calibrated using standards that are traceable to the National Institute of Standards and Technology. Internal quality assurance procedures also provide for a system of duplicate (or replicate) analyses of the same sample and the analyses of spiked samples to demonstrate precision and accuracy. All measurement data are assessed to detect anomalies, unusual results, and trends.

The Knolls Laboratory and the Kesselring Site participate in a QAP administered by a commercial laboratory, ERA. The QAP provides an independent verification of the accuracy and precision of Knolls Laboratory and Kesselring Site analyses of effluent and environmental monitoring samples. The results of Knolls Laboratory and Kesselring Site participation in the ERA QAP are summarized in Table 50. The data demonstrate satisfactory Knolls Laboratory and Kesselring Site performance.

Vendor subcontractor laboratories perform non-radioactive effluent and environmental sample analyses. The Knolls Laboratory and the Kesselring Site maintain a quality assurance program to ensure the accuracy and precision of the subcontractor analytical results. This includes submitting blanks and replicate samples along with routine samples for analysis. If unsatisfactory results are obtained, follow-up investigations are performed to correct the problems. The Knolls Laboratory and the Kesselring Site also require vendor laboratories that perform analyses for the sites be certified by the New York State Department of Health under the Environmental Laboratory Approval Program (ELAP).

Periodic audits are conducted that examine the effluent and environmental monitoring programs to ensure compliance with all Knolls Laboratory and Kesselring Site procedures and applicable Federal and State regulations.

TABLE 50
KNOLLS LABORATORY AND KESSELRING SITE PERFORMANCE IN THE ENVIRONMENTAL RESOURCE ASSOCIATES (ERA) QUALITY ASSURANCE PROGRAM

Study & Study Dates(1)	Sample Type	Analysis	Knolls Laboratory/ Kesselring Site Result(2)	ERA Assigned Value(2)	Acceptance Limits(3)
MRAD-28 03/19/18 - 05/18/18	Soil	Potassium-40	10,600	10,600	7,300 – 12,700
		Cobalt-60	8,170	8,060	6,350 – 9,950
		Strontium-90	4,520	4,500	1,400 – 7,010
		Cesium-137	4,290	4,210	3,180 – 5,320
		Plutonium-238	1,330	1,470	733 – 2,230
		Plutonium-239	1,190	1,330	725 – 1,910
MRAD-28 03/19/18 - 05/18/18	Water	Tritium	21,400	21,700	16,400 – 26,400
		Cobalt-60	1,410	1,480	1,280 – 1,700
		Strontium-90	807	781	562 – 965
		Cesium-137	308	328	281 – 373
		Plutonium-238	53.9	66.1	39.7 – 85.6
		Plutonium-239	78.7	91.8	56.8 – 113
		Uranium-234	131	132	100 – 151
		Uranium-238	136	131	102 – 154
		Gross Alpha	22.0	29.0	10.6 – 40.0
		Gross Beta	67.7	73.1	36.6 – 101
MRAD-28 03/19/18 - 05/18/18	Air Filter	Gross Alpha	42.8	43.4	22.7 – 71.5
		Gross Beta	57.2	52.0	31.5 – 78.6
		Cobalt-60	732	665	565 – 845
		Cesium-137	964	865	710 – 1,130
MRAD-29 09/17/18 - 11/16/18	Soil	Potassium-40	26,100	24,300	17,300 – 31,400
		Cobalt-60	4,950	4,890	3,410 – 6,370
		Cesium-137	3,900	3,910	2,340 – 5,480
MRAD-29 09/17/18 - 11/16/18	Water	Tritium	3,770(4)	3,020	2,280 – 3,680
		Cobalt-60	1,550	1,510	1,300 – 1,730
		Cesium-137	909	898	769 – 1,020
		Gross Alpha	176	183	66.8 – 252
		Gross Beta	114	99.4	49.7 – 137
MRAD-29 09/17/18 - 11/16/18	Air Filter	Gross Alpha	43.3	55.3	28.9 – 91.1
		Gross Beta	73.0	86.5	52.4 – 131
		Cobalt-60	1,240	1,130	960 – 1,440
		Cesium-137	404	373	306 – 489

Notes:
1. The study dates are assigned by ERA.
2. The results are expressed in pCi/L for water, pCi/kg for soil, and pCi/Filter for air filters.
3. The Acceptance Limits range is provided by ERA.
4. The result was outside of the ERA's acceptance limit. The high (conservative) value was determined to be the result of two issues. First, the accepted count rates for Tritium were much lower than previous years, causing background count rates to have a larger impact on the final rates. Second, the calibration standards were degraded. A replacement counting equipment calibration standard was obtained and the equipment was recalibrated with satisfactory results.

SPRU Quality Assurance Program

The DOE-EM Quality Assurance Program described in Revision 0 EM-QA-001 establishes DOE-EM expectations for quality assurance programs and the implementation of quality assurance requirements DOE-EM complex-wide in the context of DOE Order 414.1C and Title 10 of the Code of Federal Regulations (CFR), Part 830, Subpart A. The DOE-EM QAP further adopts the use of the 2004 Edition of the American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME) NQA-1, "Quality Assurance Requirements for Nuclear Facility Applications," Part I and the applicable subparts of Part II with Addenda through 2007 as a national consensus standard for quality assurance requirements that apply to work accomplished by DOE-EM and work accomplished by private organizations under contract with the DOE-EM. Together, EM-QA-001, DOE Order 414.1C, 10 CFR 830 Subpart A and ANSI/ASME NQA-1-2004 Part I and the applicable subparts of Part II form the basis for the SPRU quality assurance programs.

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RADIATION AND RADIOACTIVITY

This section provides general information on radiation and radioactivity for those who may not be familiar with the terms and concepts.

Man has always lived in an environment where natural background radiation is present. This background radiation is as much a part of the earth's environment as is light and heat from the sun's rays. There are three principal sources of natural background radiation: cosmic radiation from the sun and outer space, radiation from the natural radioactivity in soil and rocks (called "terrestrial radiation"), and internal radiation from natural radioactive chemical elements that are part of our bodies. A basic knowledge of the concepts of radiation and radioactivity is important in understanding how effective control programs are in reducing radiation exposures and minimizing radioactivity releases to levels that are "as low as is reasonably achievable" (ALARA).

RADIATION

In simple terms, radiation is a form of energy. Microwaves, radio waves, X-rays, light, and heat are all common forms of radiation. The radiation from radioactive materials (radionuclides) is in the form of particles or rays. During the decay of radionuclides, alpha, beta, and gamma radiation can be emitted.

Alpha radiation consists of small, positively charged particles of low penetrating power that can be stopped by a sheet of paper. Radionuclides that emit alpha particles include radium, uranium, and thorium.

Beta radiation consists of positively or negatively charged particles that are smaller than alpha particles but generally have more penetrating power and may require up to an inch of wood or other light material to be stopped. Examples of beta emitters include strontium-90, cesium-137, and cobalt-60.

Gamma radiation is an energy emission similar to an X-ray. Gamma rays have great penetrating power but can potentially be stopped by several feet of concrete or several inches of lead. The actual thickness required of a particular shielding material depends on the quantity and energy of the gamma rays to be stopped. Most radionuclides emit gamma rays along with beta or alpha particles.

Each radionuclide emits a unique combination of radiations that is like a "finger print" of that radionuclide. Alpha or beta particles and/or gamma rays are emitted in various combinations and energies. Radionuclides may be identified by measuring the type, relative amounts, and energy of the radiations emitted. Measurement of half-life and chemical properties may also be used to help identify radionuclides.

Radiation Dose Assessment

Body tissue can be damaged if enough energy from radiation is absorbed. The amount of energy absorbed by body tissue during radiation exposure is called an "absorbed dose." The potential biological effect resulting from a particular dose is based on a technically defined quantity called a "dose equivalent." The unit of dose equivalent is called the Roentgen equivalent man or “rem.” Another quantity called "effective dose equivalent" is a dose summation that is used to estimate the risk of health-effects when the radiation dose is received from sources that are external to the body and from radioactive materials that are within the various body tissues. The traditional unit of effective dose equivalent, which is used in the United States is the rem, while the standard international (SI) unit is the Sievert (One Sievert is equal to 100 rem). The rem is a unit that is relatively large compared with the level of radiation doses received from natural background radiation or projected as a result of releases of radioactivity to the environment. The millirem (mrem, or one thousandth of a rem), is frequently used instead of the rem. The rem and mrem are better understood by relating to concepts that are more familiar.

Radiation comes from both natural and man-made sources. Natural background radiation includes cosmic radiation from the sun and outer space, terrestrial radiation from radioactivity in soil, radioactivity in the body, and inhaled radioactivity.

The National Council on Radiation Protection and Measurements estimates that the average member of the population of the United States receives an annual effective dose equivalent of approximately 311 mrem from natural background radiation. This is composed of approximately 33 mrem from cosmic radiation, 21 mrem from terrestrial radiation, 29 mrem from radioactivity within the body and 228 mrem from inhaled radon and its decay products. The cosmic radiation component in the United States varies from 22 mrem in Honolulu, Hawaii to 65 mrem in Colorado Springs, Colorado. The terrestrial component varies from about 10 mrem in the Atlantic and Gulf Coastal Plain to about 40 mrem in the mountainous regions of the west. The dose from inhaled radon and its decay products is the most variable because of fluctuations in radon concentrations within houses due to changes in weather patterns and other factors such as changes in living habits.

The average natural background radiation level measured in the vicinity of the KAPL Sites is approximately 70 mrem per year. Individual locations vary depending on soil composition, soil moisture content and snow cover.

In addition to natural background radiation, people are also exposed to man-made sources of radiation, such as medical and dental X-rays and conventional fluoroscopy, computed tomography, nuclear medicine, and interventional fluoroscopy. The average radiation dose from these sources is about 300 mrem per year. Other sources include consumer products such as building products (brick and concrete), lawn and garden fertilizer, loose leaf spinach, and bananas. Additionally, an airplane trip typically results in a radiation exposure. A round-trip flight between the east and the west coast results in a dose of about 6 mrem.

RADIOACTIVITY

All materials are made up of atoms. In the case of a radioactive material, these atoms are unstable and give off energy in the form of rays or tiny particles as they attempt to reach a stable state. Each type of radioactive atom is called a radionuclide. Each radionuclide emits a characteristic form of radiation as it gives off energy. Radionuclides change as radiation occurs, and this transition is called radioactive decay. The rate at which a particular radionuclide decays is measured by its half-life. A half-life is the time required for one-half the radioactive atoms in a given amount of material to decay. For example, the half-life of the man-made radionuclide cobalt-60 is 5.3 years. This means that after a 5.3 year period, half of the original cobalt-60 atoms present will have decayed. The following 5.3 year period will result in half of the remaining cobalt-60 atoms to decay, and so on.

The half-lives of radionuclides vary greatly. For instance, the half-life of naturally occurring radon-220 is only 55 seconds, but the half-live of uranium-238, another naturally occurring radionuclide, is 4.5 billion years.

Through the decay process, each radionuclide changes into a different nuclide or atom - often becoming a different chemical element. For example, naturally occurring radioactive thorium-232, after emitting its radiation, transforms to a second radionuclide, which transforms to a third, and so on. Thus, a chain of eleven radionuclides is formed including radon-220, before non-radioactive lead-208 is formed. Each of the radionuclides in the series has its own characteristic half-life and type of radiation. The chain finally ends when the newest nuclide is stable. The uranium chain starts with uranium-238 and proceeds through 13 radionuclides, ending with stable lead-206. All of these naturally occurring radionuclides are present in trace amounts in the soil in your backyard as well as in many other environmental media.

Measuring Radioactivity

The curie (Ci) is the traditional unit used for expressing the magnitude of radioactive decay in a sample containing radioactive material. The analogous SI unit to the Ci is the becquerel (Bq). Specifically, the Ci is the amount of radioactivity equal to 3.7×10^{10} (37 billion) disintegrations per second and a Bq is equal to one disintegration per second. For environmental monitoring purposes, the Ci is usually too large a unit to work with conveniently and is broken down into smaller values such as the microcurie (µCi, one millionth of a curie or 10^{-6} Ci) and the picocurie (pCi, one trillionth of a Ci or 10^{-12} Ci). Older wristwatches that were painted with radium to allow the numbers or segments to "glow in the dark" contained about one (1) µCi of radium. The average person has about one tenth (0.1) of a µCi of naturally occurring potassium-40 in his body. Typical soil and sediment samples contain about one (1) pCi of natural uranium per gram.

Sources of Radioactivity

Some of the radioactive atoms that exist in nature have always existed and natural processes are continually forming others. For example, uranium has always existed, it is radioactive, and it occurs in small but variable concentrations throughout the earth. Radioactive carbon and tritium, on the other hand, are formed by cosmic radiation striking atoms in the atmosphere. Radionuclides can also be created by man. For example, they are created in nuclear reactors and consist of fission products and activation products. Fission products are residues of the uranium fission process that produces the energy within the reactor. The fission process also produces neutrons that interact with structural and other materials in the reactor to form activation products. Because of the nature of the fission process, many fission products are radioactive. Most fission products have short half-lives and are retained within the nuclear fuel itself; however, trace natural uranium impurities in reactor structural materials release small quantities of fission products to the reactor coolant.

It should be noted that a certain level of background fission-product radioactivity also exists in the environment, primarily due to past atmospheric nuclear weapons testing. Although the level is very low, these fission products are routinely detected in air, food, and water when analyzed with extremely sensitive instruments and techniques.

CONTROL OF RADIATION AND RADIOACTIVITY

To reduce the exposure of persons to ionizing radiation to "as low as is reasonably achievable," controlling the use and disposal of radioactive materials and comprehensive monitoring programs to measure the effectiveness of these controls is required. Effluent streams that may contain radioactive materials must be treated by appropriate methods to remove the radioactive materials and the effluent monitored to ensure that these materials have been reduced to concentrations that are "as low as is reasonably achievable" and are well within all applicable guidelines and requirements prior to discharge.

GLOSSARY

Activation Products - As cooling water circulates through the reactor, certain impurities present in the water and even components of the water itself can be converted to radioactive nuclides (they become "activated"). Important activation products present in reactor coolant water include radionuclides of corrosion and wear products (Co-60, Fe-59, Co-58, Cr-51), of impurities dissolved in the water (Ar-41, Na-24, C-14) and of atoms present in the water molecules (tritium). Of these, the predominant radionuclide and also the one with the most restrictive limits is Co-60.

Algae - Simple rootless plants that grow in bodies of water in relative proportion to the amount of nutrients available. Algae blooms, or sudden growth spurts can affect water quality adversely.

Alkalinity - The measurable ability of solutions or aqueous suspensions to neutralize an acid.

Alpha Radioactivity - A form of radioactivity exhibited by certain radionuclides characterized by emission of an alpha particle. Many naturally occurring radionuclides including radium, uranium, and thorium decay in this manner.

Benthic Macroinvertebrates - Small organisms inhabiting the bottom of lakes and streams or attached to stones or other submersed objects. The study of macroinvertebrate communities gives an indication of the overall quality of the body of water from which they are taken.

Beta-Gamma Radioactivity - A form of radioactivity characterized by emission of a beta particle and/or gamma rays. Many naturally occurring radionuclides such as Pb-212, Bi-212, and Bi-214 decay in this manner.

Biochemical Oxygen Demand (BOD) - The BOD test is used to measure the content of organic material in both wastewater and natural waters. BOD is an important parameter for stream and industrial waste studies and control of waste treatment plants because it measures the amount of oxygen consumed in the biological process of breaking down organic materials in the water.

Birge-Ekman Dredge - A device used for sampling the bottom sediment in rivers, streams, lakes, etc. The Birge-Ekman dredge is lowered to the bottom on a line and its spring-loaded "jaws" are remotely tripped from the surface. It samples an area of approximately 230 cm^2 to an average depth of 2.5 cm.

British Thermal Unit (BTU) - A unit commonly used to quantify the heat output of boilers, furnaces, etc. Specifically, the amount of heat necessary to raise 1 lb. of water one degree Fahrenheit.

Chain Electro-Fishing Techniques - A technique of collecting samples of fish from a body of water whereby the fish are stunned with an electric current, categorized, and returned to the water unharmed.

Chemical Oxygen Demand (COD) - A measure of the oxygen required to oxidize all compounds in water, organic and inorganic.

Collective Dose Equivalent and Collective Effective Dose Equivalent - The sums of the dose equivalents or effective dose equivalents of all individuals in an exposed population within an 80-km radius and they are expressed in units of person-rem.

Committed Dose Equivalent (CDE) - The predicted total dose equivalent to a tissue or organ over a 50-year period after a known intake of a radionuclide into the body. It does not include contributions from external dose. Committed dose equivalent is expressed in units of rem.

Committed Effective Dose Equivalent (CEDE) - The sum of the committed dose equivalents to various tissues in the body, each multiplied by the appropriate weighting factor. Committed effective dose equivalent is expressed in units of rem.

Composite Sample - A sample that is comprised of a number of grab samples over the compositing period. In some cases the composite sample obtained may be proportional to effluent flow and is called a proportional sample or flow-composited sample.

Conductivity - A measure of water's capacity to convey an electric current. This property is related to the total concentration of the ionized substances in water and the temperature at which the measurement is made.

Confidence Interval - Statistical terminology for the error interval (±) assigned to numerical data. A two sigma (2σ) confidence interval means there is 95% confidence that the true value (as opposed to the measured one) lies within the (±) interval. The 95% is the confidence level (See (±) value, Standard Deviation of the Average).

Corrosion and Wear Products - Piping and components used in construction of a nuclear reactor are fabricated from extremely durable, corrosion and wear resistant materials. Even under the best circumstances, however, small amounts of these materials enter the reactor coolant due to wear of moving parts and corrosion of the water contact surfaces of reactor plant components. While in no way affecting operational characteristics or reactor plant integrity, some of these corrosion and wear products may become activated as they pass through the reactor core. This necessitates that the reactor coolant be processed by filtration or other methods of purification before it is discharged or reused (See Activation Products).

Curie (Ci) - The common unit used for expressing the magnitude of radioactive decay in a sample containing radioactive material. Specifically, the curie is that amount of radioactivity equal to 3.7×10^{10} (37 billion) disintegrations per second. For environmental monitoring purposes, the curie is usually too large a unit to conveniently work with and is broken down to smaller values (See microcurie and picocurie).

Decision Level Concentration - The quantity of radioactivity above which a decision is made that a net amount of radioactivity is present with a five percent probability of erroneously reporting net radioactivity when none is present (i.e., false positive).

Derived Concentration Guide (DCG) or Derived Concentration Standard (DCS) - The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in an effective dose equivalent of 100 mrem (0.1 rem).

Dose Equivalent - The quantity that expresses the biological effects of radiation doses from all types (alpha, beta-gamma) of radiation on a common scale. The unit of dose equivalent is the rem.

Dosimeter - See Thermoluminescent Dosimeters

Duplicate Sample - A sample that is created by splitting existing samples before analysis and treating each split sample as a separate sample. The samples are then analyzed as a quality assurance method to assess the precision in the analytical process.

Ecosystem - The integrated, interdependent system of plant and animal life existing in an environmental framework. Understanding of an entire ecosystem is important because changes or damage to one component of the system may have effects on others.

Effective Dose Equivalent - The sum of the dose equivalent to the whole body from external sources plus the dose equivalents to specific organs times a weighting factor appropriate for each organ. The weighting factor relates the effect of individual organ exposure relative to the effect of exposure to the whole body. The unit of effective dose equivalent is the rem.

Eh - A measure of the oxidation-reduction potential of water expressed in units of millivolts. The oxidation-reduction potential affects the behavior of many chemical constituents present in water in the environment.

Field Blank - A sample of laboratory distilled water that is put into a sample container at the field collection site and is processed from that point as a routine sample. Field blanks are used as a quality assurance method to detect contamination introduced by the sampling procedure.

Fission Products - During operation of a nuclear reactor, heat is produced by the fission (splitting) of "heavy" atoms, such as uranium, plutonium or thorium. The residue left after the splitting of these "heavy" atoms is a series of intermediate weight atoms generally termed "fission products." Because of the nature of the fission process, many fission products are unstable and, hence, radioactive. Most fission products have short lives and are retained within the nuclear fuel itself; however, trace natural uranium impurities in reactor structural materials release small quantities of fission products to the reactor coolant.

It should be noted that a certain level of background fission product radioactivity exists in the environment, primarily due to atmospheric nuclear weapons testing. The level is very low, but may be detectable when environmental samples are analyzed with extremely sensitive instruments and techniques such as those used by the Knolls Atomic Power Laboratory.

Grab Sample - A single sample that is collected and is representative of the stream or effluent.

Half-life - A value assigned to a radionuclide that specifies how long it takes for one half of a given quantity of radioactivity to decay away. Half-lives may range from fractions of a second to millions of years.

High Purity Germanium Gamma Spectrometry - A gamma ray measuring system designed for qualitative and quantitative determination of radionuclides present in a sample. Gamma spectrometry systems make use of the fact that during the decay of most radionuclides, one or more gamma rays are emitted at energy levels characteristic of the individual radionuclide. For example, during the decay of Co-60, two gamma rays of 1.17 and 1.33 million electron volts (MeV) are emitted while the decay of Ar-41 produces one gamma ray of 1.29 MeV. The high purity germanium detectors used in these systems are capable of detecting and very precisely resolving differences in gamma ray energy levels.

Long-Lived Gamma Radioactivity - Two very important characteristics of radionuclides are the length of time it takes for a given amount to decay away and the type of radiation emitted during decay. From an environmental standpoint, some of the most significant radionuclides are those whose half-lives are relatively long and that also emit penetrating gamma radiation during decay. Two radionuclides of concern in these respects are cobalt-60 (a corrosion and wear activation product) and Cs-137 (a fission product). (See Half-life, Beta-Gamma Radioactivity)

Macrophyton - Macroscopic plants in an aquatic environment.

Method Detection Limit - The lowest value at which a nonradiological sample result shows a statistically positive difference from a sample in which no constituent is present.

microcurie (µCi) - One millionth of a curie (10^{-6} curie). A typical smoke detector contains 1 µCi of Am-241 radioactive material (See curie and picocurie).

micrograms per liter (µg/l) - A unit of concentration commonly used to express the levels of impurities present in a water sample. A microgram is one millionth of a gram. One microgram per liter is equal to one part per billion.

milligrams per liter (mg/l) - A unit of concentration commonly used to express the levels of impurities present in a water sample. A milligram is one thousandth of a gram. One milligram per liter is equal to one part per million.

millirem (mrem) - One thousandth of a rem (10^{-3} rem).

Mixed waste - Waste that contains both hazardous (regulated by EPA/NYSDEC) and radioactive material (regulated by DOE)),

Outfall - A point of discharge (e.g., drain or pipe) of liquid effluent into a stream, river, ditch, or other water body.

Parshall Flume - A specially constructed channel designed such that discharge water flow rate can be accurately measured. The Parshall Flume may also be instrumented to record the total volume of flow over long periods of time.

Pasquill Stability Class - A classification that defines the relative stability and dispersive capability of the atmosphere. Classification is highly dependent upon the change in temperature with height.

Periphyton - Communities of microorganisms growing on stones, sticks, and other submerged surfaces. The quantities and types of periphyton present are very useful in assessing the effects of pollutants on lakes and streams.

Person-Rem - The sum of the individual dose equivalents or effective dose equivalents received by each member of a certain group or population. It is calculated by multiplying the average dose per person by the number of persons within a specific geographic area. For example, a thousand people each exposed to 0.001 rem would have a collective dose of one person-rem.

pH - A measure of the acidity or alkalinity of a solution on a scale of 0 to 14 (low is acidic, high is alkaline or caustic, 7 is neutral).

picocurie (pCi) - One trillionth of a curie (10^{-12} curie). Typical soil and sediment samples contain about 1 pCi of natural uranium per gram. (See curie and microcurie.)

Plankton - Tiny plants and animals that live in water.

± Value (plus or minus value) - An expression of the uncertainty in sample results. The magnitude of the (±) value depends on the number of samples, the size of the sample, intrinsic analytical uncertainties and the degree of confidence required. The (±) value assigned to data in this report is for the 95% confidence level (See Confidence Interval).

Polychlorinated Biphenyls (PCBs) - Halogenated aromatic hydrocarbons formed by the chlorination of biphenyl molecules. PCB's were commonly used in transformers as a dielectric fluid because of their stability.

Practical Quantitation Limit - The lowest concentration that can be reliably achieved in nonradiological samples within specified limits of precision and accuracy during routine laboratory operating conditions.

Radionuclides - Atoms that exhibit radioactive properties. Standard practice for naming radionuclides is to use the name or atomic symbol of an element followed by its atomic weight (e.g., cobalt-60 or Co-60, a radionuclide of cobalt). There are several hundred known radionuclides, some of which are man-made and some of which are naturally occurring. Radionuclides can be differentiated by the types of radiation they emit, the energy of the radiation and the rate at which a known amount of the radionuclide decays away (See Half-life).

Rem - The unit of dose equivalent and effective dose equivalent.

Reporting Limit - The lowest concentration of an analyte that can be reliably reported in nonradiological samples within specified limits of precision and accuracy during routine laboratory operating conditions.

Resource Conservation and Recovery Act (RCRA) - A Federal law that established a structure to track and regulate hazardous wastes from the time of generation to disposal. The law requires safe and secure procedures to be used in treating, transporting, storing, and disposing of hazardous substances. RCRA is designed to prevent new, uncontrolled hazardous waste sites.

Reverse Osmosis - Also known as hyper-filtration, it is a process that allows the separation of solutes (i.e., dissolved substances) from a solution by forcing the solvent through a semi-permeable membrane by applying a pressure greater than the osmotic pressure associated with the solutes. A semi-permeable membrane is a membrane that allows diffusion of solvent molecules through it, while retarding the diffusion of solute molecules.

Settleable Solids - A measurement of the amount of solids that will settle out of a sample of water in a certain interval of time. This parameter commonly applies to water being processed in sewage treatment plants and is used to control the operation and evaluate the performance of these plants.

Short-Lived Gamma Radioactivity - Radioactive material of relatively short life that decays with the emission of gamma rays. It is generally not important with respect to environmental discharges because of the short life span. Some examples of short-lived gamma emitting radionuclides are Ar-41 (an activation product gas), Kr-88 (a fission product gas), and Xe-138 (a fission product gas).

Spiked Sample - A sample to which a known quantity of the material that is being analyzed for has been added for quality assurance testing.

Standard Deviation of the Average - A term used to characterize the uncertainty assigned to the mean of a set of analyzed data (See Confidence Interval, (±) Value).

Surber Bottom Sampler - A device for collecting samples of benthic macroinvertebrates from the bottom of relatively shallow, fast moving streams.

Suspended Solids - Particulate matter, both organic and inorganic suspended in water. High levels of suspended solids not only affect the aesthetic quality of water by reducing clarity, but may also indirectly indicate other undesirable conditions present. The analysis for suspended solids is performed by passing a sample of water through a filter and weighing the residue.

Thermoluminescent Dosimeters (TLDs) - Sensitive monitoring devices that absorb and store energy from radiation. The TLDs used by the Knolls Laboratory and the Kesselring Site for environmental monitoring consist of small chips of lithium fluoride (LiF) encased in appropriate materials and strategically located at site perimeter and off-site locations. Thermoluminescent Dosimeters derive their name from a property that certain crystals exhibit when exposed to radiation and subsequently heated-that of emitting light proportional to the amount of radiation exposure received (thermoluminescence). The emitted light can then be read out on special instrumentation and correlated to the amount of radiation dose accumulated.

Turbidity - A cloudy condition in water due to suspended silt or organic matter. Turbidity is measured in nephelometric turbidity units (ntu).

Upgradient - Referring to the flow of groundwater, upgradient is analogous to upstream and is a point that is "before" an area of study that is used as a baseline for comparison with downgradient or downstream data.

Volatile Organic Compound (VOC) - An organic (carbon-containing) compound that evaporates (volatilizes) readily at room temperature.

Weight Percent - A term commonly used to describe the amount of a substance in a material. For example, oil containing 0.5 lb. sulfur per 100 lb. oil would contain 0.5 percent by weight sulfur.

Weighting Factor - Tissue-specific representation of the fraction of the total health risk resulting from uniform, whole-body irradiation that could be contributed to that particular tissue.

Whole Effluent Toxicity (WET) - The aggregate toxic effect to aquatic organisms from all pollutants contained in a facility's wastewater. WET tests measure wastewater's effects on specific test organisms' (plants, vertebrates and invertebrates) ability to survive, grow, and reproduce.

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