# Surveillance2019

## *Vermont Yankee Nuclear Power Station*

Report on Public Health Monitoring

VERMONT
DEPARTMENT OF HEALTH
Agency of Human Services

108 Cherry Street, PO Box 70
Burlington, VT 05402

**healthvermont.gov**

# *Table of Contents*

# *Executive Summary*

The Vermont Department of Health has been monitoring and reporting on radiation emissions and radiological effluents (discharges) from the Vermont Yankee Nuclear Power Station since 1971. The purpose of this environmental surveillance is to protect the public's health from excess amounts of radiation.

This *Surveillance 2019* report details over 1,400 separate measurements of nearly 700 samples of air, water, milk, vegetation, soil, sediment and fish taken during the year at the Vermont Yankee site boundary (property line), from the Connecticut River, and from the towns surrounding the station.

The Health Department enforces the state's Radiological Health Rule, which limits the amount of ionizing radiation to which any member of the public could be exposed if standing at the site boundary of the station. The Rule also limits the amount of gaseous, liquid, radioiodine and radioactive particulate effluents to which any member of the public could possibly be exposed because of activities at Vermont Yankee.

The Rule limits the annual direct gamma radiation from Vermont Yankee to a measured exposure value of 20 milliroentgen above background radiation at the site boundary on land. The Rule also limits specific emissions or discharges from Vermont Yankee to an effective dose of no more than 5 millirem from each pathway to any member of the public.

The Connecticut River site boundary around Vermont Yankee is regulated by the U.S. Nuclear Regulatory Commission, which limits the annual direct gamma radiation to any member of the public at this boundary to 100 millirem.

### 2019 Surveillance Results:

- Measurements in this report confirm no dose in excess of any limit established by the Vermont Department of Health's Radiological Health Rule.

- The numerous samples and measurements of the environment around Vermont Yankee in 2019 show no instances of non-compliance with the Radiological Health Rule from activities at Vermont Yankee.

- This report is the fourth since 2010 to not include Health Department analytical results from on-site groundwater monitoring wells. Entergy stopped splitting samples from the on-site wells with the Health Department at the end of 2015. The Health Department is thus no longer able to independently assess on-site

impacts of the tritium-contaminated plume of groundwater first detected in January 2010.

- Entergy provides annual effluent and environmental reports to the Nuclear Regulatory Commission. Those reports for the years 2005 through 2015 are available at VY Reports from Health . The 2016 through 2018 Radioactive Effluent reports may be found at VY Reports in NRC ADAMS .

- The Health Department's continuing analysis of cancer statistics for people who live in the communities surrounding Vermont Yankee shows that cancer incidence and mortality do not differ significantly from people in the rest of Windham County, elsewhere in Vermont, or in the United States.

**For questions or more information –** The information presented in this report is sometimes complex. We invite interested readers to contact the Health Department's Radiological Sciences program at 802-865-7730 with any questions.

# Introduction

This *Surveillance 2019* report describes the amount and types of radiation found near the Vermont Yankee Nuclear Power Station located in Vernon, Vermont. Until the reactor was shut down on December 29, 2014, Vermont Yankee was generating and emitting ionizing radiation in the form of direct gamma radiation, and discharging radioactive materials that emit alpha-, beta- and gamma-radiations. A person could be exposed to radiation released from Vermont Yankee in air or liquid discharges from the station, or from unmonitored releases or leaks. After reactor shutdown, there remain sources of radiation exposure and radioactive material release pathways that may contribute to public dose. The Health Department intends to continue this surveillance until Vermont Yankee is decontaminated and dismantled, and the site is released for unrestricted use.

The Vermont Department of Health enforces the state's Radiological Health Rule, which limits the amount of ionizing radiation to which a member of the public could be exposed if standing at the site boundary (property line) of the station. Specifically, the Rule limits the annual direct gamma radiation from Vermont Yankee to a measured exposure value of 20 milliroentgen above background radiation at the site boundary on land. The Rule also limits the amount of gaseous, liquid, radioiodine and radioactive particulate effluents to which a member of the public could possibly be exposed because of activities at Vermont Yankee. The Rule limits specific emissions or discharges from Vermont Yankee to an effective dose of no more than 5 millirem from each pathway to any member of the public.

The Health Department monitors radiation levels at and near Vermont Yankee. Because both naturally-occurring and human-made radiation is all around us in the environment, the Health Department also tests other areas of the state to provide background data on types and amounts of environmental radiation. Background measurements are compared to measurements of radiation found in areas near Vermont Yankee. The two sets of values are compared to determine if Vermont Yankee's activities are resulting in an increased radiation risk to the public.

This report presents over 1,400 measurements taken from nearly 700 samples that were obtained near Vermont Yankee and from background locations during 2019. Air, water, milk, vegetation, soil, fish and sediment samples were collected and tested. Maps of

locations where many samples or measurements were taken, as well as the testing procedures, are provided.

Most samples are tested by the Health Department Laboratory located in Colchester, Vermont. Measurements of direct gamma radiation exposures using thermoluminescent dosimeters (TLDs) are tested by a National Voluntary Laboratory Accreditation Program (NVLAP) vendor of dosimetry.

The primary human health concern with chronic low-level exposure to ionizing radiation is the potential to develop cancer. For this reason, the Health Department also presents cancer incidence and cancer mortality data for the area near Vermont Yankee and compares it to the same type of data for the state of Vermont as well as for the U.S. population.

## Tritium Contamination

Testing and evaluation of the tritium contamination described in the 2010 Surveillance Report continued in 2019. No tritium was found in any river water downstream from the station, or in samples collected from off-site wells near Vermont Yankee.

## Results Presented in this Report:

- Direct gamma radiation measured continuously from 70 sites
- Air samples collected by continuous air samplers and tested for radioactive particulates, gases, vapors and radioactive iodine
- Drinking water wells and Connecticut River water near Vermont Yankee tested for tritium, gamma-emitting materials, total alpha radioactivity and total beta radioactivity
- Milk, vegetation, soil, river sediments and fish tested for natural and human-made radioactive materials

These data show no radiation dose in excess of the Health Department's limits as a result of Vermont Yankee activities in 2019.

The *Surveillance 2019* report is published at the Vermont Department of Health web site: www.healthvermont.gov. For questions about the content, call the Health Department's Radiological Sciences program at 802-865-7730.

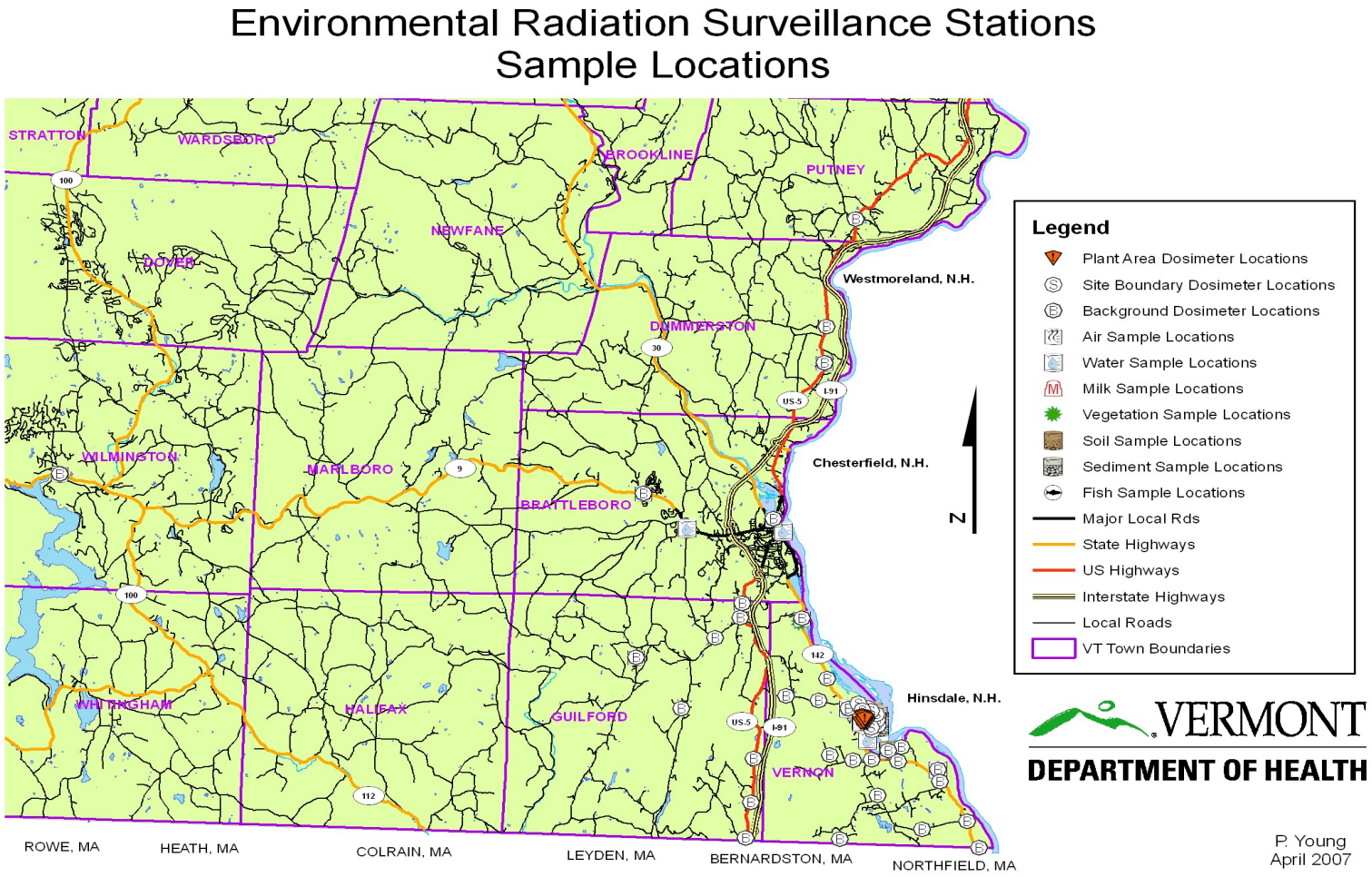
# Program Results Summary

An overview of the 2019 sample data is presented in this summary. Detailed descriptions of sample measurement techniques and analyses are presented in further sections of this report. The total numbers, types of sample collected, types of analysis performed, and summary results are reported in Table 1. Routine environmental sampling sites are shown in Maps 1 and 2. Map 1 shows the locations where routine samples were taken. Map 2 shows the sample locations in Vernon.

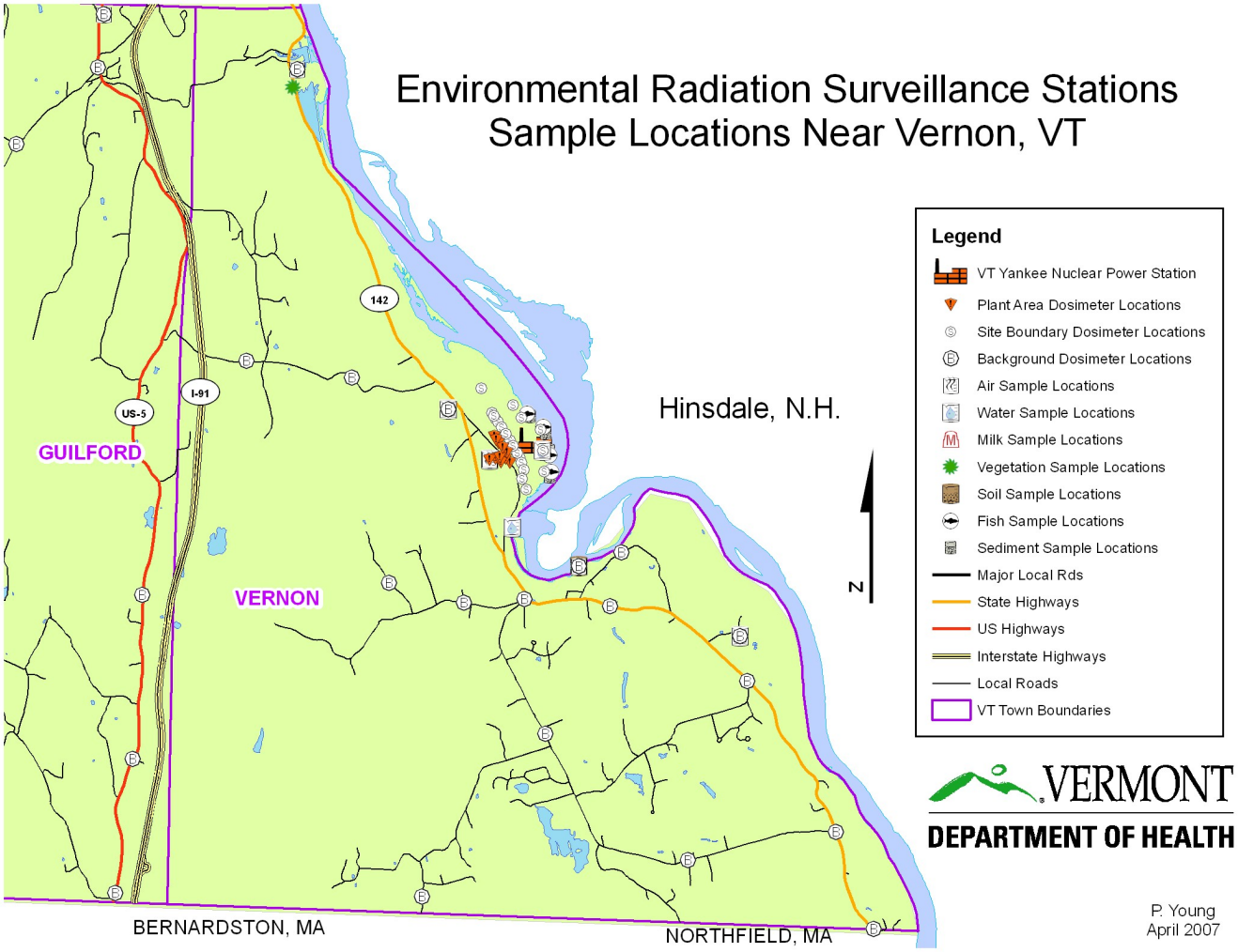
### Table 1. 2019 Summary of Samples, Tests and Results

| Sample Type | Sites | Number of Tests | Test Type | Results |
|---|---|---|---|---|
| **Direct Gamma Radiation** | 70 | 274 | Thermoluminescent dosimeters | Less than 20 milliroentgen per year at the land site boundary; no single quarter exceeded 10 milliroentgen. |
| **Air: Particulates, Gases and Vapors** | 10 | 109 | Total Alpha Radioactivity | Alpha radioactivity within the historical range. No increase observed as a result of operations at Vermont Yankee. |
| | | 109 | Total Beta Radioactivity | Beta radioactivity within the historical range. No increase observed as a result of operations at Vermont Yankee. |
| | | 110 | Iodine-131 | No iodine-131 was detected in air samples. |
| | | 110 | Gamma (gas/vapors) Radioactivity | Gamma radioactivity detected was of natural origin. |
| | | 4 (*quarterly composites)* | Gamma (particulates) Radioactivity | Gamma radioactivity detected was of natural origin. |
| **Water** | 12 | 99 | Total Alpha Radioactivity | Alpha radioactivity within the historical range. No increase observed as a result of operations at Vermont Yankee. |
| | | 99 | Total Beta Radioactivity | Beta radioactivity within the historical range. No increase observed as a result of operations at Vermont Yankee. |
| | 16 | 223 | Tritium | All samples less than the lower limit of detection. |
| | | 223 | Gamma Radioactivity | All detected gamma radioactivity of natural origin. |
| **Milk** | 2 | 20 | Iodine-131 | All samples less than the lower limit of detection. |
| | | 20 | Gamma Radioactivity | All gamma radioactivity detected was of natural origin. |
| **Vegetation** | 3 | 3 | Gamma Radioactivity | Gamma radioactivity detected attributable to natural, Chernobyl, Fukushima, or above-ground nuclear weapons testing origin. |
| **Soil** | 3 | 3 | Gamma Radioactivity | Gamma radioactivity detected attributable to natural, Chernobyl, Fukushima, or above-ground nuclear weapons testing origin. |
| **Sediments** | 18 | 36 | Gamma Radioactivity | Gamma radioactivity detected attributable to natural, Chernobyl, Fukushima, or above-ground nuclear weapons testing origin. |
| **Fish** | 2 | 4 | Gamma Radioactivity | Gamma radioactivity detected attributable to natural, Chernobyl, Fukushima, or above-ground nuclear weapons testing origin. |
| **Total number of tests** | | **1446** | | |

## Map 1


Environmental Radiation Surveillance Stations
Sample Locations
STRATTON
WARDSBORO
BROOKLINE
PUTNEY
NEWFANE
DOVER
Westmoreland, N.H.
DUMMERSTON
WILMINGTON
MARLBORO
Chesterfield, N.H.
BRATTLEBORO
N
WHITINGHAM
HALIFAX
GUILFORD
Hinsdale, N.H.
VERNON
ROWE, MA
HEATH, MA
COLRAIN, MA
LEYDEN, MA
BERNARDSTON, MA
NORTHFIELD, MA
Legend
Plant Area Dosimeter Locations
Site Boundary Dosimeter Locations
Background Dosimeter Locations
Air Sample Locations
Water Sample Locations
Milk Sample Locations
Vegetation Sample Locations
Soil Sample Locations
Sediment Sample Locations
Fish Sample Locations
Major Local Rds
State Highways
US Highways
Interstate Highways
Local Roads
VT Town Boundaries
VERMONT
DEPARTMENT OF HEALTH
P. Young
April 2007

## Map 2


Environmental Radiation Surveillance Stations
Sample Locations Near Vernon, VT
Hinsdale, N.H.
GUILFORD
VERNON
BERNARDSTON, MA
NORTHFIELD, MA
142
I-91
US-5
N
Legend
VT Yankee Nuclear Power Station
Plant Area Dosimeter Locations
Site Boundary Dosimeter Locations
Background Dosimeter Locations
Air Sample Locations
Water Sample Locations
Milk Sample Locations
Vegetation Sample Locations
Soil Sample Locations
Fish Sample Locations
Sediment Sample Locations
Major Local Rds
State Highways
US Highways
Interstate Highways
Local Roads
VT Town Boundaries
VERMONT
DEPARTMENT OF HEALTH
P. Young
April 2007

# Types of Ionizing Radiation

There are three main types of ionizing radiation that could be released from Vermont Yankee: alpha particles, beta particles and gamma rays. The risk of adverse health effects from ionizing radiation is linked to the type and energy of radiation, the length and method of exposure to the radiation, and the organ or organs of the body that are impacted. The Health Department tests for these forms of radiation in many sample types.

## Alpha and Beta (particle) Radiation

Alpha and beta radiation are particle forms of radiation energy. Alpha- and beta-charged particles can only travel a short distance and are completely blocked by simple materials.

Alpha radiation is the most biologically hazardous form of ionizing radiation, causing about 20 times more tissue damage than the same amount of beta or gamma radiation energy. It is also the type of radiation that people can most easily shield against. A sheet of paper can stop an alpha particle, and so can the dead layer of skin that covers the outer surface of our bodies. Alpha particles can only cause harm if alpha-emitting materials are inhaled, ingested or otherwise taken into the body. The most common alpha radiation exposure for people is from naturally-occurring radon gas in their homes.

### Table 2. Examples of Radioactive Elements that Produce Alpha-Radiations

| Naturally-occurring alpha emitters | |
|---|---|
| Uranium-238 | Radon-222 |
| Thorium-232 | Polonium-210 |
| Radium-226 | Bismuth-212 |
| **Human-made alpha emitters** | |
| Americium-241 | Plutonium-239 |
| Neptunium-237 | Curium-244 |

Beta radiation is easily stopped by simple materials like plastics, aluminum and wood, but may be able to go through the first few millimeters of human skin. Beta radiation

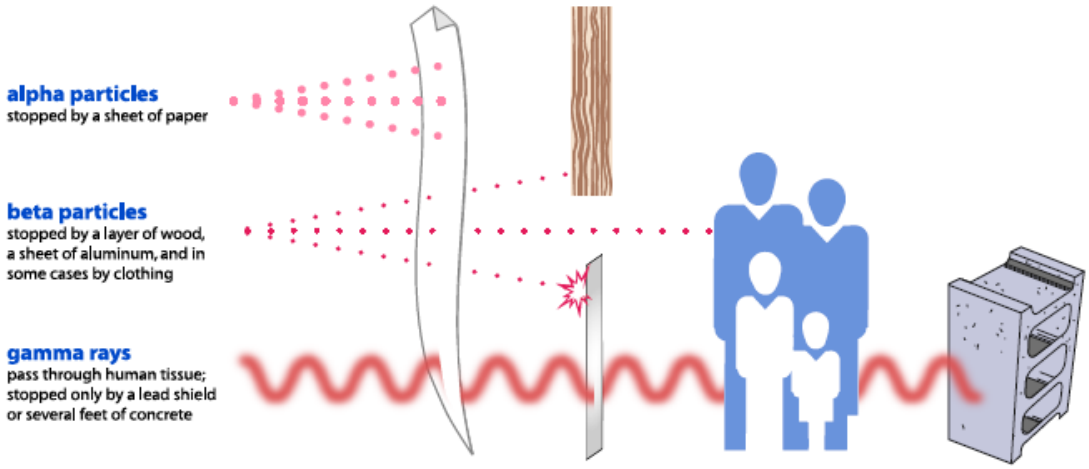
can cause damage to internal tissues and organs if a beta-emitting material is inhaled, ingested or otherwise taken into the body.

Alpha and beta-emitting materials are released from the station's air stack at Vermont Yankee. They may also be emitted in liquid discharges from contaminated reactor systems.

### Table 3. Examples of Radioactive Elements that Produce Beta-Radiations

| Naturally-occurring beta emitters | |
|---|---|
| Carbon-14 | Potassium-40 |
| Radium-228 | Hydrogen-3, "tritium" (also human-made) |
| **Human-made beta emitters** | |
| Iodine-131 | Technetium-99 |
| Strontium-90 | Hydrogen-3, "tritium" (also naturally-occurring) |
| Nickel-63 | Iron-59 |

### Figure 1. Relative Ability of Ionizing Radiations to go through Materials



## Gamma Radiation

Direct gamma radiation is an electromagnetic wave of energy similar to light, except that it passes through most materials. Like all radiation, gamma radiation can also scatter off materials. Direct gamma radiation loses strength as it travels away from the source. It is also reduced after large numbers of collisions with electrons in the atom.

Gamma radiation passes through the skin and may pass through the whole body. If gamma radiation passes through the body, it may damage tissues. People can be affected by gamma radiation if they are in an area where direct gamma radiation exists, or if they ingest a gamma-emitting material.

Direct gamma radiation is emitted from the reactor and turbine systems such as those at Vermont Yankee. Gamma-emitting materials may also be released as gases or particles from the station's air stack.

## Decommissioning Perspectives

While in SAFSTOR, the reactor systems are contaminated but drained of water. The water, about one million gallons, is stored in a very large doughnut-shaped tank-like structure under the reactor vessel. When the station is decontaminated and dismantled during DECON, the water will be disposed of as low-level radioactive waste along with the decontaminated and dismantled system components.

During DECON, the decontamination and dismantling of the structures, systems and components at Vermont Yankee will be monitored for human and environmental impacts. The Health Department intends to continue its monitoring of public radiation exposures and radioactive material release pathways at least until the NRC license is terminated and the site may be released for unrestricted use.

**Table 4. Examples of Radioactive Elements that Produce Gamma-Radiations**

| Naturally-occurring gamma emitters | | |
|---|---|---|
| Beryllium-7 | Potassium-40 | Thallium-208 |
| Bismuth-212 | Bismuth-214 | Lead-210 |
| Lead-212 | Lead-214 | Polonium-210 |
| Actinium-228 | Radium-224 | Radium-226 |
| Radium-228 | Thorium-228 | Thorium-229 |
| Thorium-230 | Thorium-231 | Thorium-232 |
| Thorium-234 | Uranium-233 | Uranium-234 |
| Uranium-235 | Uranium-238 | |
| **Human-made gamma emitters** | | |
| Antimony-124 | Antimony-126 | Barium-140/ Lanthanum-140 |
| Cerium-144/ Promethium-144 | Cesium-134 | Cesium-136 |
| Chromium-51 | Cobalt-56 | Cobalt-58 |
| Cobalt-60 | Iodine-131 | Iodine-132 |
| Iodine-133 | Iodine-135 | Krypton-85 |
| Krypton-88 | Manganese-54 | Neptunium-239 |
| Plutonium-239 | Plutonium-240 | Ruthenium-103 |
| Tellurium-132 | Strontium-85 | Strontium-89 |
| Zinc-65 | Xenon-133 | Xenon-133m |
| Xenon-135 | Zirconium-95/Niobium-95 | |

# *Ionizing Radiation Risks*

The radiations to which people may be exposed as a result of Vermont Yankee activities are ionizing radiations. According to the International Agency for Research on Cancer (IARC), ionizing radiation can cause cancer in humans. The energy released by ionizing radiation may directly or indirectly damage the DNA of human cells and over time cause cancer. It has been shown that people who are exposed to high doses of ionizing radiation, generally greater than 10,000 millirem, have a statistically higher risk of cancer. As with other cancer-causing agents, it is not possible to prove that low doses of ionizing radiation are without risk. The risk of developing cancer from chronic exposure to very low doses of radiation, such as the doses detailed in this report, is considered very low.

The risk management approach used for public health protection with ionizing radiation is called the ALARA Principle. The ALARA Principle states that every reasonable effort must be made to maintain radiation exposures ***A****s* ***L****ow* ***A****s* ***R****easonably* ***A****chievable*. The Health Department's Radiological Health Rule not only requires that exposures to ionizing radiation be less than specific limits, but also that Vermont Yankee and all other radiation users in industry, medicine and education use the ALARA Principle.

For more information about ionizing radiation risk:

- The National Academies of Science

  National Research Council. *Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2*. Washington, DC: The National Academies Press, 2006.

- The Health Physics Society

  Health Physics Society, *Radiation Risk in Perspective*: *Position Statement of the Health Physics Society*. McLean, VA: The Health Physics Society, 2019

- The International Agency for Research on Cancer

  The International Agency for Research on Cancer, *Radiation, Volume 100D*. France: The World Health Organization, 2012

# Cancer Prevalence, Incidence & Mortality

The primary health concern with chronic low-level exposure to ionizing radiation is the potential to develop cancer. Starting in 2007, the Health Department began presenting cancer-related health outcome data for the population in the area of Vermont Yankee. The Health Department tabulates, analyzes and provides data for cancer incidence (new cancer cases diagnosed) and cancer mortality (people dying from cancer) for Windham County and for the six towns nearest Vermont Yankee that make up the Emergency Planning Zone. The Health Department evaluates trends in all cancer types (all ages, all sites) and evaluates thyroid cancers, leukemia and pediatric (childhood) cancers separately because these types of cancers can be associated with excess radiation exposure or radiation exposure during fetal development.

## Cancer Prevalence

Cancer is not one disease, but a group of more than 100 different diseases. Cancer is very common. Roughly four out of ten men and women in the U.S. will develop cancer in their lifetime. A cancer usually develops gradually as a result of a complex mix of factors related to personal behaviors, environment and genetics. Each type of cancer is caused by a different set of factors, some well-established, some uncertain, and some unknown.

Cancer *prevalence* means the number of people alive today who have ever been diagnosed with cancer. According to 2019 Behavioral Risk Factor Surveillance System (BRFSS) data, approximately 36,500 or seven percent of Vermonters age 18 and older have ever been told by a doctor they had cancer. This includes people who are newly diagnosed, in active treatment, or have completed active treatment, and people living with progressive symptoms of their disease.

As a population ages, the occurrence of new cancer cases can be expected to increase. With treatment advances, people are living longer with a cancer diagnosis. Between 2008 and 2017 the number of cancer survivors has increased by approximately a third (SEER Cancer Statistics Review 1975-2008 and 1975-2017).

## Cancer Incidence

Cancer *incidence* is the number of newly diagnosed cases during a specific time period. Incidence data in Table 5 were compiled from Vermont Cancer Registry data. Incidence rates are shown for all cancers, thyroid cancers, leukemia, and childhood (pediatric) cancers for the 10-year period 2008 to 2017.

The data in Table 5 indicate that:

- Incidence rates for all cancer types combined are not different in Vermont compared to the U.S.
- Incidence rates for leukemia in the Emergency Planning Zone are not different from Windham County, Vermont, or the U.S. population.
- Incidence rates for thyroid cancer in the Emergency Planning Zone are not different from Windham County and Vermont but is lower than the U.S. population.
- Incidence rates for pediatric cancers in the Emergency Planning Zone could not be calculated.
- The incidence of thyroid cancer in Windham County is significantly lower than Vermont and the U.S. rate.
- For all cancer types combined, the rate of cancer incidence in the six towns near Vermont Yankee (Brattleboro, Dummerston, Guilford, Halifax, Marlboro and Vernon) is not different from Vermont, Windham County, or the U.S. population.

The U.S. incidence rates and mortality rates are all races population rates. Analysis prior to the 2011 report compared only U.S. white population incidence and mortality rates to Vermont rates. This change is consistent with current Health Department publications that compare Vermont (all races) to U.S. (all races) rates.

## Table 5. Cancer Incidence Rates Near Vermont Yankee, in Vermont & U.S.

**Age Adjusted Vermont and U.S. Cancer Incidence, All Sites, Males and Females per 100,000 population, 2008-2017.**

| | Rate | Lower CL | Upper CL | Avg. cases per year |
|---|---|---|---|---|
| U.S. | 461.4 | 461.2 | 461.7 | 1,636,239 |
| Vermont | 462.2 | 457.3 | 467.1 | 3,680 |
| Windham County | 449.5 | 432.1 | 467.5 | 275 |
| Emergency Zone | 443.0 | 417.3 | 470.0 | 122 |

**Age Adjusted Vermont and U.S. Cancer Incidence, Thyroid, Males and Females per 100,000 population, 2008-2017.**

| | Rate | Lower CL | Upper CL | Avg. cases per year |
|---|---|---|---|---|
| U.S. | 14.1 | 14.0 | 14.1 | 46,256 |
| Vermont | 14.0 | 13.1 | 15.0 | 94 |
| Windham County | 7.9 | 5.5 | 11.1 | 4 |
| Emergency Zone | 8.5 | 5.0 | 13.6 | 2 |

**Age Adjusted Vermont and U.S. Cancer Incidence, Leukemia, Males and Females per 100,000 population, 2008-2017.**

| | Rate | Lower CL | Upper CL | Avg. cases per year |
|---|---|---|---|---|
| U.S. | 14.4 | 14.4 | 14.4 | 49,525 |
| Vermont | 12.9 | 12.1 | 13.7 | 98 |
| Windham County | 15.1 | 11.9 | 18.9 | 9 |
| Emergency Zone | 13.7 | 9.5 | 19.2 | 4 |

**Age Adjusted Vermont and U.S. Cancer Incidence, Pediatric Cancers (Ages 0-19), Males and Females per 100,000 population, 2008-2017.**

| | Rate | Lower CL | Upper CL | Avg. cases per year |
|---|---|---|---|---|
| U.S. | 18.7 | 18.6 | 18.7 | 15,478 |
| Vermont | 16.7 | 14.7 | 19.0 | 25 |
| Windham County | 14.4 | 7.8 | 24.3 | 1 |
| Emergency Zone | -- | -- | -- | -- |

-- Rates and incidence counts are only presented when the total number of cases is greater than 5.
**Data Sources:** Vermont Cancer Registry (VCR), Vermont Department of Health (1994-2018). NPCR and SEER Incidence - U.S. Cancer Statistics Public Use Database, 2020 Submission (2001-2018).
**Technical Notes:** Emergency Zone towns include: Brattleboro, Dummerston, Guilford, Halifax, Marlboro, and Vernon. All rates are age adjusted to the 2000 U.S. standard population and rates are per 100,000 population. Incidence rates are for invasive cancers and in situ urinary bladder cancers. Cancer diagnoses exclude basal cell and squamous cell skin cancers. A reporting delay by Department of Veterans Affairs (VA) has resulted in incomplete reporting of VA hospital cases in 2011-2014 and 2016-2018.

## Cancer Mortality

In Table 6, mortality rates from the U.S., Vermont, Windham County, and the Emergency Planning Zone towns are presented for the 10 years 2008 to 2017. The Vermont data are from the Vermont Department of Health's Vital Statistics System. Data for U.S. cancer mortality rates are from the Vital Statistics System of the United States. Cancer mortality data are presented for all cancers, thyroid cancers, leukemia and pediatric cancers.

The data in Table 6 indicate:

- Mortality rates for all cancers combined is higher in Vermont compared to the U.S.
- For the years 2008 to 2017, cancer mortality rates for all cancers combined and the leukemia mortality rates in the six towns of the Emergency Planning Zone around Vermont Yankee do not differ from those for Windham County, Vermont or the U.S.
- Similar results were seen in mortality rates in the prior report.
- Mortality rates for thyroid and pediatric cancers in Windham County and the six towns could not be calculated as there were too few deaths (fewer than six) over the time period studied (10 years).

## Table 6. Cancer Mortality Rates Near Vermont Yankee, in Vermont & U.S.

**Age Adjusted Vermont and U.S. Cancer Mortality, All Sites, Males and Females per 100,000 population, 2008-2017.**

| | Rate | Lower CL | Upper CL | Avg. deaths per year |
|---|---|---|---|---|
| U.S. | 164.4 | 164.3 | 164.6 | 583,671 |
| Vermont | 169.2 | 166.3 | 172.1 | 1,353 |
| Windham County | 170.0 | 159.7 | 181.0 | 106 |
| Emergency Zone | 164.2 | 149.2 | 180.6 | 47 |

**Age Adjusted Vermont and U.S. Cancer Mortality, Thyroid, Males and Females per 100,000 population, 2008-2017.**

| | Rate | Lower CL | Upper CL | Avg. deaths per year |
|---|---|---|---|---|
| U.S. | 0.5 | 0.5 | 0.5 | 1,799 |
| Vermont | 0.6 | 0.5 | 0.8 | 5 |
| Windham County | -- | -- | -- | <1 |
| Emergency Zone | -- | -- | -- | <1 |

**Age Adjusted Vermont and U.S. Cancer Mortality, Leukemia, Males and Females per 100,000 population, 2008-2017.**

| | Rate | Lower CL | Upper CL | Avg. deaths per year |
|---|---|---|---|---|
| U.S. | 6.7 | 6.6 | 6.7 | 23,107 |
| Vermont | 6.3 | 5.8 | 6.9 | 49 |
| Windham County | 8.3 | 6.1 | 11.1 | 5 |
| Emergency Zone | 6.7 | 4.0 | 10.9 | 2 |

**Age Adjusted Vermont and U.S. Cancer Mortality, Pediatric Cancers (Ages 0-19), Males and Females per 100,000 population, 2008-2017.**

| | Rate | Lower CL | Upper CL | Avg. deaths per year |
|---|---|---|---|---|
| U.S. | 2.3 | 2.3 | 2.3 | 1,917 |
| Vermont | 2.8 | 2.0 | 3.8 | 4 |
| Windham County | -- | -- | -- | <1 |
| Emergency Zone | -- | -- | -- | <1 |

-- Rates are only presented when the total number of deaths is greater than 5.
**Data Sources:** Vermont Vital Statistics System, Vermont Department of Health (1994-2018). SEER Program Mortality - Aggregated With State, Total U.S. (1990-2018).
**Technical Notes:** Emergency Zone towns include: Brattleboro, Dummerston, Guilford, Halifax, Marlboro, and Vernon. All rates are age adjusted to the 2000 U.S. standard population and rates are per 100,000 population.

## Cancer Surveillance Methodology

The rates in this report are calculated at a 95 percent confidence level. This means, for example, given a reported thyroid cancer incidence rate of 14.0 per 100,000 for Vermont in 2008-2017, that we are 95 percent confident (not due to chance alone) that the true 2008 to 2017 Vermont thyroid cancer rate is in the range of 13.1 to 15.0 per 100,000. In Windham County, the thyroid cancer incidence rate is 7.9 cases per 100,000 people. Statistically speaking, this means we are 95 percent confident that the actual rate is between 5.5 cases and 11.1 cases per 100,000 people. Because the *ranges* for these rates do not overlap, we conclude that there is a meaningful statistical difference between the two rates.

In Table 6, it may appear that the leukemia mortality rates are different for Windham County compared to the towns included in the Emergency Planning Zone around Vermont Yankee, Vermont, or the U.S. However, the confidence intervals (ranges) for these rates overlap, and the cancer mortality rates are *not* statistically different. In Windham County, the death rate from leukemia, males and females, was 8.3 deaths per 100,000 people, while the death rate in the six towns near Vermont Yankee was 6.7 deaths per 100,000 people. The same conclusion is drawn for Vermont and the U.S. where the leukemia mortality rates are not significantly different.

## Data Limitations

One limitation of these data is that the numbers of cancer cases and the number of cancer deaths in the six towns near Vermont Yankee are small. There are challenges associated with computing rates for small geographical areas, such as the Vermont Yankee Emergency Planning Zone, with an estimated population that is less than 20,000 people in 2017. When the rates are based on a small number of cases, it is almost impossible to distinguish random fluctuation from true changes in the underlying risk of disease. This is an issue in a state like Vermont, which has many communities with small populations. To improve rate stability, the cases have been combined for the 10-year period from 2008 through 2017. For more information about cancer and for resources to assist those living with cancer in Vermont: https://www.healthvermont.gov/wellness/cancer.

# Environmental Surveillance Methods

The types of surveys and analyses performed by the Vermont Department of Health are described here in relationship to their role in protecting the public from ionizing radiation resulting from activities at Vermont Yankee.

## Direct Gamma Radiation Monitoring

Direct gamma radiation in air is measured by the Health Department with thermoluminescent dosimeters (TLDs). Gamma radiation energy interacts with and changes the materials inside the TLDs. The more gamma energy, the more change occurs in the materials. The TLDs are then heated in a laboratory to reverse the physical changes. When this occurs, light is emitted, and the amount of light measured in the process is directly related to the amount of gamma radiation energy the TLD received in the environment. These instruments are calibrated to provide a measure of radiation exposure, reported in milliroentgen.

TLDs are placed in the environment to measure how much direct gamma radiation is being given off from Vermont Yankee and how much exists from natural or other human-made sources in background areas of Vermont. The Health Department's dosimeters are located on the site boundary (property line), in the area around the station and at background locations in Windham County. A total of 70 locations are monitored. Samples are tested quarterly by a National Voluntary Laboratory Accreditation Program vendor of dosimetry.

Vermont Yankee emits direct gamma radiation from components and nuclear reactor systems. Direct gamma radiation may also result when gases and particulates are released from the station's air stack, or from industrial activities, including spent fuel movement and building demolition. Measuring the amount emitted ensures that no member of the public is exposed to excessive increased levels of gamma radiation because of activities at Vermont Yankee.

## Continuous Flow Air Sampling

Continuous air samplers are located in Vernon, Guilford, Dummerston, Wilmington and Brattleboro. An additional air sampler exists in Burlington. These air samplers have a mechanical pump that pulls air through two types of sample media, and an in-line flow

meter that tracks the volume of air pulled through the sample. The air samplers run continuously.

The samplers collect alpha-, beta- and gamma-emitting materials in air. Each sampler has two collection media to capture these radioactive materials. The first medium is a glass fiber filter. As outdoor air is pulled through the sampler, particulates containing alpha-, beta- and gamma-emitting materials are collected on the glass fiber filter.

Located behind the glass fiber filter is the second medium, a charcoal cartridge. The cartridge is treated with triethylenediamine (TEDA), a compound that attracts radioactive iodine vapors. As air passes through, radioactive iodine as well as other gamma-emitting gases and vapors are collected.

The filter is sent to the Health Department Laboratory where the alpha- and beta-emitting materials are counted on a gas flow proportional counter. The charcoal cartridge is tested by the Health Department Laboratory on a gamma spectrometer. Samples are collected and tested monthly. In addition, every three months the filters are grouped together and tested by gamma spectroscopy. These grouped samples are called quarterly composites.

Measurements of total alpha and beta radiation, gamma radiation and specifically iodine-131 ensure that activities at—and discharges from—Vermont Yankee are within limits and do not result in an increased radiation exposure to the public.

## Water Monitoring

Water samples are collected at locations near Vermont Yankee. Off-site water samples include drinking water wells, a municipal water supply, and samples from the Connecticut River. These locations allow the Health Department to determine if radioactive materials have left the Vermont Yankee site and entered these waters. Water samples are also collected from four on-site locations.

Water samples can be tested for total alpha and beta radioactivity, and gamma-emitting materials. Alpha and beta radioactivity are tested with a gas proportional counter. Gamma-emitting materials are measured with a gamma spectrometer.

Water samples are also tested for tritium. Tritium is a radioactive form of hydrogen and is a weak beta-emitter. Tritium is created when water passes through the reactor core

and the hydrogen atoms in the water molecules and trace elements like boron absorb neutrons from the fission of the reactor fuel. Tritiated water can leave the power station in the same ways that non-radioactive water leaves the station: in the air, in groundwater, and through discharges into surface water. Tritium is also created by cosmic radiation in the atmosphere. The Health Department Laboratory measures tritium with a liquid scintillation counter.

## Monitoring Food Chain Inputs

The Health Department also routinely tests milk, sediment, soil, vegetation and fish in the Vernon and Brattleboro area.

*Milk Sampling*

Milk samples are collected from two farms located near Vermont Yankee. Raw cows' milk samples are taken monthly and tested for gamma-emitting materials and specifically for iodine-131 (I-131).

*Sediment Sampling*

Sediments from the bottom of the Connecticut River are collected twice a year. They are tested for gamma-emitting materials.

*Soil and Vegetation Sampling*

Soil and vegetation are collected in areas in Vermont and tested for gamma-emitting materials. A variety of natural plants are sampled to determine if radioactive materials are accumulating in the food chain.

*Fish Sampling*

Fish are collected at two sites in the Connecticut River by an environmental contractor and tested for gamma-emitting materials. One site is outside the Vermont Yankee discharge and the other site is about nine miles upstream from Vermont Yankee, where the Route 9 bridge crosses the Connecticut River. Fish are caught by a method known as electro-fishing. This involves putting a weak electric current in the water. Fish exposed to the current are temporarily stunned and float to the surface where they are collected. Sport and pan fish species are caught and tested, including large and small mouth bass, yellow perch and pumpkinseed.

# Laboratory Testing and Measurements

Laboratory instruments at the Health Department that are used to test samples can measure very small amounts of radioactivity. Each instrument has a limit as to how low it can measure or identify radioactivity. This limit is determined by the Health Department radiochemists and reported as the *Lower Limit of Detection* (LLD). Lower Limits of Detection are calculated for each sample, based on the specific instrument and sample characteristics such as type (e.g. water, soil, milk, air), length of time the sample is tested, and the amount of the sample tested. The Health Department's Lower Limits of Detection for routine gamma spectroscopy tests are presented in Table 8.

All of the Health Department's instruments meet strict quality control checks. Data reported by the Health Department is thoroughly reviewed by both the radiochemists and data review personnel.

## Units of Measurement

For most results in this report, radioactivity is reported in units of *picocuries per mass or volume* of sample. One picocurie is one trillionth of a curie. Curies and picocuries are units that measure the amount of radiation "activity" in the sample, or the rate at which a radioactive isotope decays.

Direct gamma exposure is measured and reported in milliroentgen. Milliroentgen is a unit of exposure to ionizing radiation. One milliroentgen is equal to one thousandth of a roentgen. An average dental x-ray provides a dose of around 100 milliroentgen.

**Table 7. Units of Measurement**

| Type | Unit | Abbreviation | Measures (amount of) | Equivalent to |
|---|---|---|---|---|
| Radiation units | curie | Ci | activity of a radioactive material | 1,000,000,000,000 picocuries (pCi) |
| | picocurie | pCi | activity of a radioactive material | 0.000000000001 curie (Ci) |
| | roentgen | R | *exposure* to ionizing radiation | 1000 milliroentgens (mR) |
| | milliroentgen | mR | *exposure* to ionizing radiation | 0.001 roentgen (R) |
| | **r**oentgen **e**quivalent **m**an | rem | *dose* equivalent of ionizing radiation | 1000 millirem (mrem) |
| | milli**rem** | mrem | *dose* equivalent of ionizing radiation | 0.001 roentgen equivalent man (rem) |
| Mass & Volume units | gram | g | mass | 0.001 kilogram (kg) |
| | kilogram | kg | mass | 1000 grams (g) |
| | liter | L | volume of liquid | 1000 milliliters (mL) |
| | milliliter | mL | volume of liquid | 0.001 liter (L) |
| | cubic meter | $m^3$ | volume of air | 1,000,000 centimeters$^3$ ($cm^3$) |

Roentgens are units of radiation exposure in air. To determine the effect that the exposure would have on a person, roentgens are converted to **rem** ("**r**oentgen **e**quivalent **m**an"). A rem accounts for both the amount of radiation energy absorbed by a person and the potential biological effects of that energy in the human body. The Health Department's Radiological Health Rule provides limits for gamma radiation emitted from Vermont Yankee in units of measured exposure and relates it to a *biological dose*. As the Vermont Yankee site boundary TLDs measure exposure in milliroentgen, the corresponding limit in milliroentgen applies. Personal TLDs, like those worn by workers in nuclear power, medical or research facilities, are calibrated to provide a measure of *biological dose* for the wearer and are reported in millirem.

## Uncertainty of Radiation Measurements

Measurements reported by a laboratory have an amount of *uncertainty* associated with them. Uncertainty, sometimes called error, results from variability in sampling and testing. The smaller the uncertainty associated with a measurement, the more accurate the number reported is likely to be. The uncertainty associated with a measurement is calculated by radiochemists and reported as a plus/minus (+/-) value. All of the measurements in this report are presented at the 95 percent confidence level. This means it is 95 percent certain (not due to chance alone) that the results are within the value and error range reported. Uncertainty can be minimized by increasing instrument efficiency, sample size and counting time.

*Uncertainty of Thermoluminescent Dosimeter (TLD) Measurements*
Dosimeter measurements over time are estimates and are also subject to uncertainty. The error for the sum of the quarterly results is the total propagated error at the 95 percent confidence level. The formula for the propagation of error is a root-mean-square formula:

$$[(\sigma_1^2) + (\sigma_2^2) + (\sigma_3^2) + (\sigma_4^2)]^{1/2}$$

Where $(\sigma_1^2)$ is the uncertainty for quarter 1, $(\sigma_2^2)$ is the uncertainty for quarter 2, $(\sigma_3^2)$ is the uncertainty for quarter 3 and $(\sigma_4^2)$ is the uncertainty for quarter 4. The Health Department regulates the direct gamma radiation exposure on the reported measurement.

## Table 8. Health Department Gamma Spectroscopy Calculated Lower Limits of Detection

| Radioactive element | Calculated Lower Limit of Detection: fish, water, vegetation & milk (pCi/L or pCi/kg) | Calculated Lower Limit of Detection: soil, sediment (pCi/kg) |
|---|---|---|
| Antimony-124 | 3 | 24 |
| Antimony-126 | 3 | 23 |
| Barium-133 | 4 | 30 |
| Beryllium-7 | 24 | 183 |
| Cadmium-109 | 48 | 349 |
| Cerium-139 | 3 | 18 |
| Cerium-141 | 4 | 29 |
| Cerium-144 | 16 | 115 |
| Cesium-134 | 4 | 25 |
| Cesium-136 | 3 | 23 |
| Cesium-137 | 4 | 24 |
| Chromium-51 | 24 | 182 |
| Cobalt-57 | 2 | 14 |
| Cobalt-58 | 3 | 23 |
| Cobalt-60 | 3 | 23 |
| Iodine-131 | 3 | 23 |
| Manganese-54 | 4 | 24 |
| Mercury-203 | 3 | 22 |
| Potassium-40 | 48 | 367 |
| Ruthenium-103 | 3 | 22 |
| Ruthenium-106 | 29 | 220 |
| Silver-110m | 3 | 23 |
| Strontium-85 | 4 | 26 |
| Tin-113 | 4 | 31 |
| Yttrium-88 | 4 | 26 |
| Zinc-65 | 6 | 46 |

# *Direct Gamma Radiation Results*

Thermoluminescent dosimeters (TLDs) are located along the Vermont Yankee site boundary (property line) and in public areas in Vernon and other Windham County towns. Thirteen TLDs placed at the Vermont Yankee site boundary are evaluated for compliance with the regulations detailed in the Health Department's Radiological Health Rule. The Health Department limits the measured exposure at the site boundary to no more than 20 milliroentgen per year above background radiation, and no more than 10 milliroentgen per calendar quarter above background radiation.

Site boundary TLDs:

- VY North Fence
- VY North Fence #2
- VY SW Fence
- VY SW Fence #2
- VY Parking Lot A
- VDH T07A
- Governor Hunt Road # 39
- VDH T07B
- VDH DR42
- VDH DR48
- VDH DR51A
- VDH DR52A
- VDH DR53A

Five additional TLDs—VDH DR43, DR44, DR45, DR46 and DR47—are located on the Connecticut River site boundary and are subject to the U.S. Nuclear Regulatory Commission limit of 100 millirem per year.

Additional Health Department TLDs are located in other areas of Vernon, and in Guilford, Brattleboro, Dummerston, and Putney. These provide the background measurements of direct gamma radiation from both natural and human-made sources unrelated to the operation of Vermont Yankee. All TLDs are collected and tested every three months (quarterly).

## Comparison to Background Levels

To determine the amount of direct gamma radiation exposure attributed to emissions from Vermont Yankee, the background gamma radiation is subtracted from the site boundary (property line) measurements. Background gamma radiation unrelated to

Vermont Yankee may be from naturally-occurring sources, other industrial applications, and global contaminants remaining from above-ground weapons testing during the 1940s, 50s and 60s and global nuclear incidents like Chernobyl and Fukushima.

To measure background gamma radiation an additional 32 TLDs are placed in locations beyond the immediate area of Vermont Yankee's activities. These locations are as far west as West Brattleboro, as far north as Putney, and as far south as the Massachusetts state line in Guilford and Vernon. Each quarter's average exposure to these 32 TLDs is calculated and used to estimate environmental background radiation. Background gamma radiation levels for the four quarters of 2019 are presented in Table 9.

The exposures reported in Tables 10 and 11 show the total (gross) dosimeter measurement and the net value. The net value is calculated by subtracting the background radiation measurement from the total radiation measurement. For regulatory purposes, the net values are compared to the quarterly and annual limits.

**Table 9. 2019 Average Direct Gamma Background Radiation Results**

| Calendar Quarter | Average Background Exposure Measurements (milliroentgen) |
|---|---|
| January 1 to March 31 | 12.8 ± 2.2 |
| April 1 to June 30 | 13.8 ± 2.3 |
| July 1 to September 30 | 13.9 ± 2.7 |
| October 1 to December 31 | 13.8 ± 2.5 |
| Total for Calendar Year 2019 | **54.3 ± 4.9** |
| Calendar Year 2018 | 53.3 ± 4.6 |
| Calendar Year 2017 | 58.2 ± 4.9 |
| Calendar Year 2016 | 57.3 ± 7.4 |
| Calendar Year 2015 | 55.7 ± 8.4 |
| Calendar Year 2014 | 57.7 ± 4.9 |
| Calendar Year 2013 | 56.8 ± 4.5 |
| Calendar Year 2012 | 57.0 ± 4.4 |
| Calendar Year 2011 | 56.1 ± 7.3 |
| Calendar Year 2010 | 59.2 ± 7.1 |
| Calendar Year 2009 | 57.9 ± 4.8 |
| Calendar Year 2008 | 56.4 ± 4.6 |
| Calendar Year 2007 | 56.2 ± 5.2 |

## 2019 Direct Gamma Radiation Exposure Results

The following tables show the results of the Health Department's TLD measurements of direct gamma radiation. Table 10 contains the results for the Vermont Yankee site boundary, and the dosimeters in the immediate area around the power station. Table 11 contains the results for the dosimeters placed in 32 locations beyond the immediate area of Vermont Yankee.

In 2019:

- 274 TLDs were tested for direct gamma radiation.
    - 126 of those provided background exposure measurements
    - 148 of those provided exposure measurements at the site boundary and in the immediate area of Vermont Yankee

Dosimeter locations on the site boundary bordered by land and used for direct gamma radiation compliance measurements reflect Vermont Yankee property purchases on or before August 1, 2008. The site boundary dosimeter location data are bolded in Table 10.

For 2019, the net site boundary results used for verifying compliance ranged from 0.0 to 7.9 milliroentgen.

Map 3 shows the locations of the site boundary and station area dosimeters. Maps 4 and 5 show the locations of the background dosimeters. The ID numbers on the maps can be matched to the locations in Tables 10 and 11.

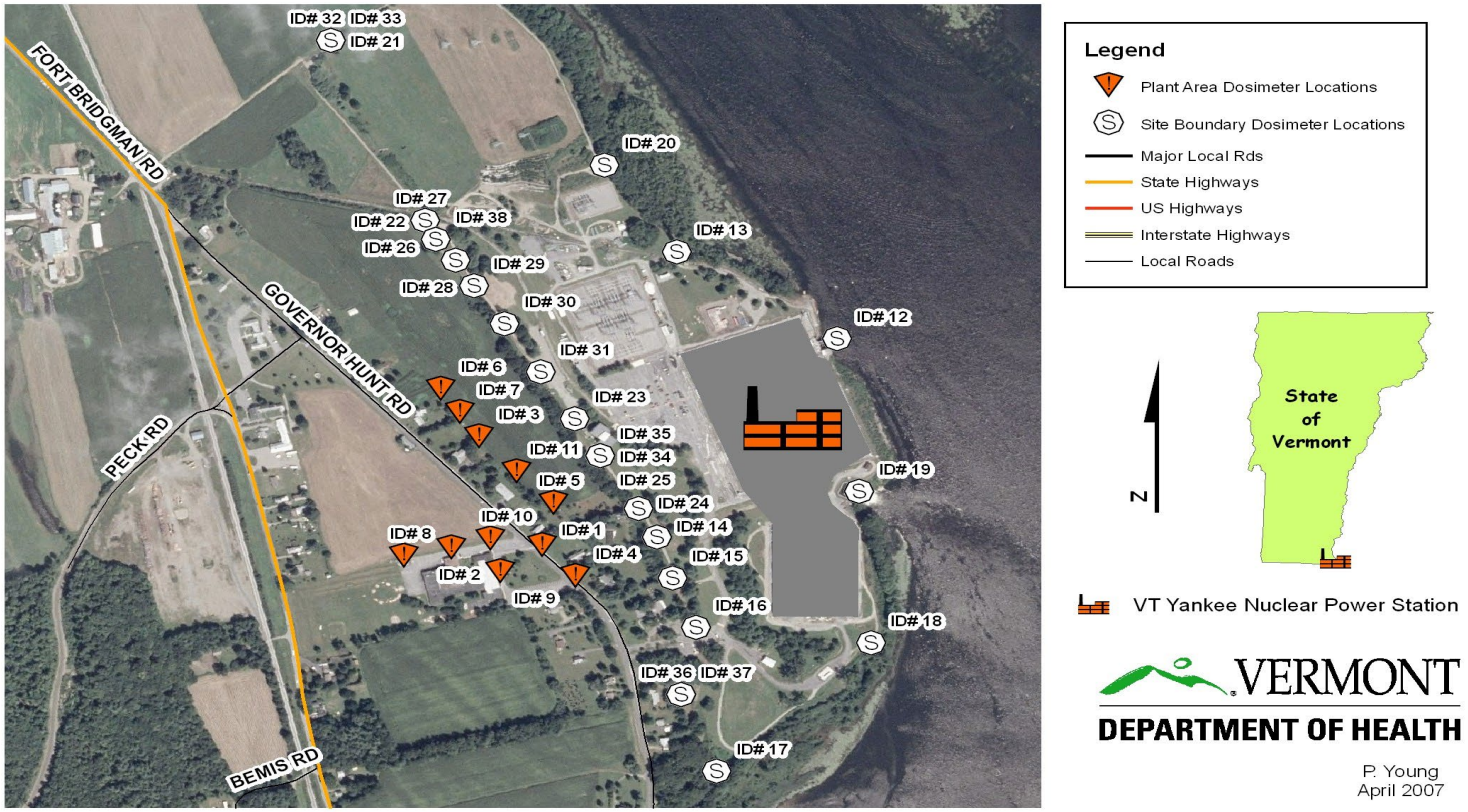
_____

For 2019, the quarterly limit of 10 milliroentgen and the annual limit of 20 milliroentgen were not exceeded.

_____

## Map 3

VT Yankee Nuclear Power Station
Site Boundary and Plant Area Dosimeter Locations



## Table 10. 2019 Thermoluminescent Dosimeter Exposure Measurements and Net Gamma Radiation: Station Area & Site Boundary Locations

2019 **Site Boundary and Station Area** Dosimeter Exposure (milliroentgen)

| Location | Map ID # | Qtr1 Gross | 1SD Error | Avg Bkgrd | Qtr1 Net | Net Q1 >=0 | 2SD Error | Qrtr2 Gross | 1SD Error | Avg Bkgrd | Qtr2 Net | Net Q2 >=0 | 2SD Error | Qrtr3 Gross | 1SD Error | Avg Bkgrd | Qtr3 Net | Net Q3 >=0 | 2SD Error | Qrtr4 Gross | 1SD Error | Avg Bkgrd | Qtr4 Net | Net Q4 >=0 | 2SD Error | Annual Net | 2SD Error |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gov Hunt Road #39** | **1** | **13.77** | **0.59** | **12.8** | **0.9** | **0.9** | **1.2** | **15.22** | **0.63** | **13.8** | **1.4** | **1.4** | **1.2** | | | **13.9** | **-13.9** | **0.0** | **0.0** | **14.35** | **0.80** | **13.8** | **0.6** | **0.6** | **1.6** | **3.0** | **2.3** |
| VDH DR06 | 2 | 11.94 | 0.54 | **12.8** | -0.9 | 0.0 | 1.1 | 14.23 | 0.66 | **13.8** | 0.5 | 0.5 | 1.3 | 14.21 | 0.77 | **13.9** | 0.3 | 0.3 | 1.5 | 13.55 | 0.76 | **13.8** | -0.2 | 0.0 | 1.5 | 0.8 | 2.7 |
| **VDH DR51A** | **3** | **12.46** | **0.75** | **12.8** | **-0.4** | **0.0** | **1.5** | **14.72** | **0.59** | **13.8** | **0.9** | **0.9** | **1.2** | **14.60** | **0.82** | **13.9** | **0.7** | **0.7** | **1.6** | **14.28** | **1.08** | **13.8** | **0.5** | **0.5** | **2.1** | **2.2** | **3.2** |
| **VDH DR52A** | **4** | **13.83** | **0.64** | **12.8** | **1.0** | **1.0** | **1.3** | **15.46** | **0.67** | **13.8** | **1.7** | **1.7** | **1.3** | **15.83** | **0.97** | **13.9** | **1.9** | **1.9** | **1.9** | **15.23** | **1.10** | **13.8** | **1.5** | **1.5** | **2.2** | **6.1** | **3.4** |
| **VDH DR53A** | **5** | **13.16** | **0.58** | **12.8** | **0.3** | **0.3** | **1.1** | **16.18** | **0.80** | **13.8** | **2.4** | **2.4** | **1.6** | **16.97** | **0.88** | **13.9** | **3.1** | **3.1** | **1.7** | **15.91** | **0.98** | **13.8** | **2.1** | **2.1** | **1.9** | **7.9** | **3.2** |
| **VDH T07A** | **6** | **12.81** | **0.64** | **12.8** | **0.0** | **0.0** | **1.3** | **14.89** | **0.68** | **13.8** | **1.1** | **1.1** | **1.3** | **14.43** | **1.03** | **13.9** | **0.5** | **0.5** | **2.0** | **13.97** | **1.32** | **13.8** | **0.2** | **0.2** | **2.6** | **1.9** | **3.8** |
| **VDH T07B** | **7** | **13.28** | **0.88** | **12.8** | **0.4** | **0.4** | **1.7** | **15.34** | **0.60** | **13.8** | **1.6** | **1.6** | **1.2** | **14.69** | **0.93** | **13.9** | **0.8** | **0.8** | **1.8** | **15.75** | **1.07** | **13.8** | **2.0** | **2.0** | **2.1** | **4.8** | **3.5** |
| Vernon School (air sampler) | 8 | 12.96 | 0.55 | **12.8** | 0.1 | 0.1 | 1.1 | 14.49 | 0.63 | **13.8** | 0.7 | 0.7 | 1.2 | 14.07 | 0.89 | **13.9** | 0.2 | 0.2 | 1.7 | 13.73 | 0.74 | **13.8** | 0.0 | 0.0 | 1.5 | 1.0 | 2.8 |
| Vernon School Nurse | 9 | 16.07 | 0.76 | **12.8** | 3.2 | 3.2 | 1.5 | 16.55 | 0.87 | **13.8** | 2.8 | 2.8 | 1.7 | 16.47 | 1.03 | **13.9** | 2.6 | 2.6 | 2.0 | 17.38 | 1.07 | **13.8** | 3.6 | 3.6 | 2.1 | 12.2 | 3.7 |
| Vernon School Pole | 10 | 12.34 | 0.74 | **12.8** | -0.5 | 0.0 | 1.5 | 13.95 | 0.82 | **13.8** | 0.2 | 0.2 | 1.6 | 13.62 | 1.27 | **13.9** | -0.3 | 0.0 | 2.5 | 14.81 | 1.00 | **13.8** | 1.0 | 1.0 | 2.0 | 1.2 | 3.8 |
| **VY Parking Lot A** | **11** | **12.72** | **0.74** | **12.8** | **-0.1** | **0.0** | **1.5** | **16.57** | **0.88** | **13.8** | **2.8** | **2.8** | **1.7** | **16.17** | **1.06** | **13.9** | **2.3** | **2.3** | **2.1** | | | **13.8** | **-13.8** | **0.0** | **0.0** | **5.1** | **3.1** |
| VDH DR45 | 12 | 25.56 | 1.71 | **12.8** | 12.7 | 12.7 | 3.4 | 26.02 | 1.26 | **13.8** | 12.2 | 12.2 | 2.5 | 29.16 | 1.23 | **13.9** | 15.3 | 15.3 | 2.4 | 22.78 | 1.06 | **13.8** | 9.0 | 9.0 | 2.1 | 49.2 | 5.2 |
| VDH DR46 | 13 | 14.78 | 0.61 | **12.8** | 1.9 | 1.9 | 1.2 | 15.19 | 0.58 | **13.8** | 1.4 | 1.4 | 1.1 | 15.64 | 1.39 | **13.9** | 1.7 | 1.7 | 2.7 | 15.24 | 0.82 | **13.8** | 1.5 | 1.5 | 1.6 | 6.6 | 3.6 |
| VDH DR08 | 15 | 14.84 | 0.73 | **12.8** | 2.0 | 2.0 | 1.4 | 16.84 | 0.74 | **13.8** | 3.1 | 3.1 | 1.5 | 15.29 | 1.30 | **13.9** | 1.4 | 1.4 | 2.5 | 14.56 | 0.81 | **13.8** | 0.8 | 0.8 | 1.6 | 7.3 | 3.6 |
| VDH DR41 | 16 | 13.69 | 0.60 | **12.8** | 0.9 | 0.9 | 1.2 | 14.32 | 0.72 | **13.8** | 0.5 | 0.5 | 1.4 | 13.90 | 1.19 | **13.9** | 0.0 | 0.0 | 2.3 | 15.40 | 0.89 | **13.8** | 1.6 | 1.6 | 1.7 | 3.0 | 3.4 |
| **VDH DR42** | **17** | **12.51** | **0.69** | **12.8** | **-0.3** | **0.0** | **1.4** | **14.40** | **0.77** | **13.8** | **0.6** | **0.6** | **1.5** | **14.51** | **0.88** | **13.9** | **0.6** | **0.6** | **1.7** | **13.81** | **1.07** | **13.8** | **0.0** | **0.0** | **2.1** | **1.3** | **3.4** |
| VDH DR43 | 18 | 12.89 | 0.57 | **12.8** | 0.1 | 0.1 | 1.1 | 14.42 | 0.79 | **13.8** | 0.6 | 0.6 | 1.5 | 14.35 | 1.11 | **13.9** | 0.5 | 0.5 | 2.2 | 16.40 | 1.02 | **13.8** | 2.6 | 2.6 | 2.0 | 3.8 | 3.5 |
| VDH DR44 | 19 | 17.04 | 0.69 | **12.8** | 4.2 | 4.2 | 1.4 | 18.00 | 0.63 | **13.8** | 4.2 | 4.2 | 1.2 | 17.92 | 1.59 | **13.9** | 4.0 | 4.0 | 3.1 | 14.67 | 0.88 | **13.8** | 0.9 | 0.9 | 1.7 | 13.4 | 4.0 |
| VDH DR47 | 20 | 15.31 | 0.58 | **12.8** | 2.5 | 2.5 | 1.1 | 16.17 | 0.71 | **13.8** | 2.4 | 2.4 | 1.4 | 16.36 | 1.29 | **13.9** | 2.5 | 2.5 | 2.5 | 13.92 | 0.90 | **13.8** | 0.2 | 0.2 | 1.8 | 7.5 | 3.6 |
| **VDH DR48** | **21** | **12.77** | **0.57** | **12.8** | **-0.1** | **0.0** | **1.1** | **13.03** | **0.71** | **13.8** | **-0.7** | **0.0** | **1.4** | **14.92** | **1.08** | **13.9** | **1.0** | **1.0** | **2.1** | **12.27** | **1.04** | **13.8** | **-1.5** | **0.0** | **2.0** | **1.0** | **3.4** |
| VDH T01 | 22 | 13.08 | 0.65 | **12.8** | 0.2 | 0.2 | 1.3 | 14.87 | 0.75 | **13.8** | 1.1 | 1.1 | 1.5 | 14.34 | 1.20 | **13.9** | 0.4 | 0.4 | 2.4 | 14.08 | 0.73 | **13.8** | 0.3 | 0.3 | 1.4 | 2.1 | 3.4 |
| VDH DR49 | 22 | 12.25 | 0.60 | **12.8** | -0.6 | 0.0 | 1.2 | 14.35 | 0.67 | **13.8** | 0.6 | 0.6 | 1.3 | 14.22 | 1.13 | **13.9** | 0.3 | 0.3 | 2.2 | 14.56 | 0.98 | **13.8** | 0.8 | 0.8 | 1.9 | 1.7 | 3.4 |
| VDH DR51 | 23 | 13.69 | 0.55 | **12.8** | 0.9 | 0.9 | 1.1 | 16.43 | 0.63 | **13.8** | 2.7 | 2.7 | 1.2 | 15.91 | 1.07 | **13.9** | 2.0 | 2.0 | 2.1 | 14.54 | 0.86 | **13.8** | 0.8 | 0.8 | 1.7 | 6.3 | 3.2 |
| VDH DR52 | 24 | 15.94 | 0.61 | **12.8** | 3.1 | 3.1 | 1.2 | 17.76 | 0.75 | **13.8** | 4.0 | 4.0 | 1.5 | 18.22 | 1.30 | **13.9** | 4.3 | 4.3 | 2.5 | | | **13.8** | -13.8 | 0.0 | 0.0 | 11.4 | 3.2 |
| VDH DR53 | 25 | 15.55 | 0.79 | **12.8** | 2.7 | 2.7 | 1.5 | 18.13 | 0.62 | **13.8** | 4.4 | 4.4 | 1.2 | 16.75 | 0.96 | **13.9** | 2.9 | 2.9 | 1.9 | 15.67 | 0.90 | **13.8** | 1.9 | 1.9 | 1.8 | 11.8 | 3.2 |
| VDH T03 | 26 | 12.28 | 0.90 | **12.8** | -0.6 | 0.0 | 1.8 | 14.58 | 0.62 | **13.8** | 0.8 | 0.8 | 1.2 | 13.87 | 0.86 | **13.9** | 0.0 | 0.0 | 1.7 | 14.03 | 1.18 | **13.8** | 0.3 | 0.3 | 2.3 | 1.1 | 3.6 |

Site boundary dosimeter measurements are bolded.

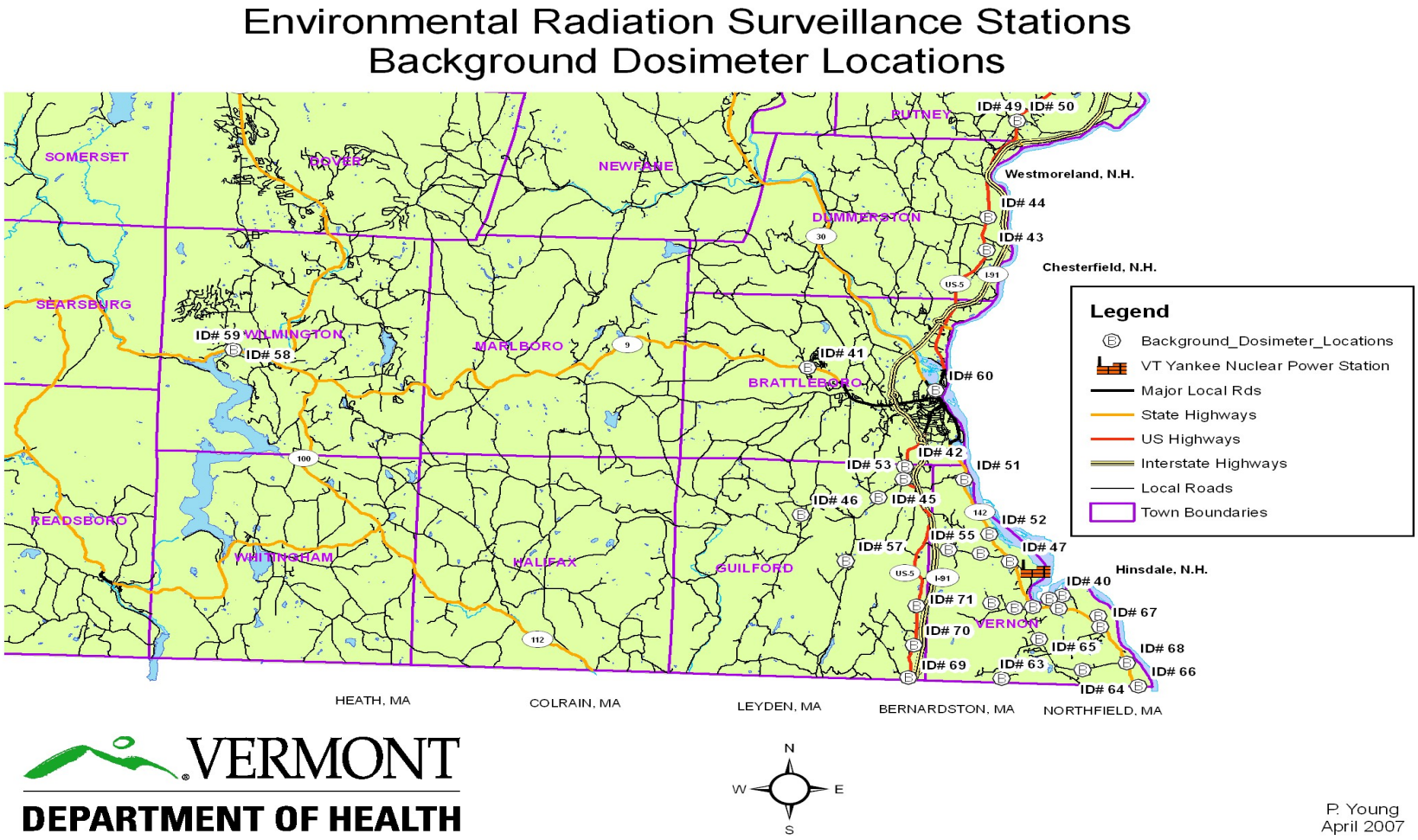
## Table 10 (continued). 2019 Thermoluminescent Dosimeter Exposure Measurements and Net Gamma Radiation: Station Area & Site Boundary Locations

2019 **Site Boundary and Station Area** Dosimeter Exposure (milliroentgen)

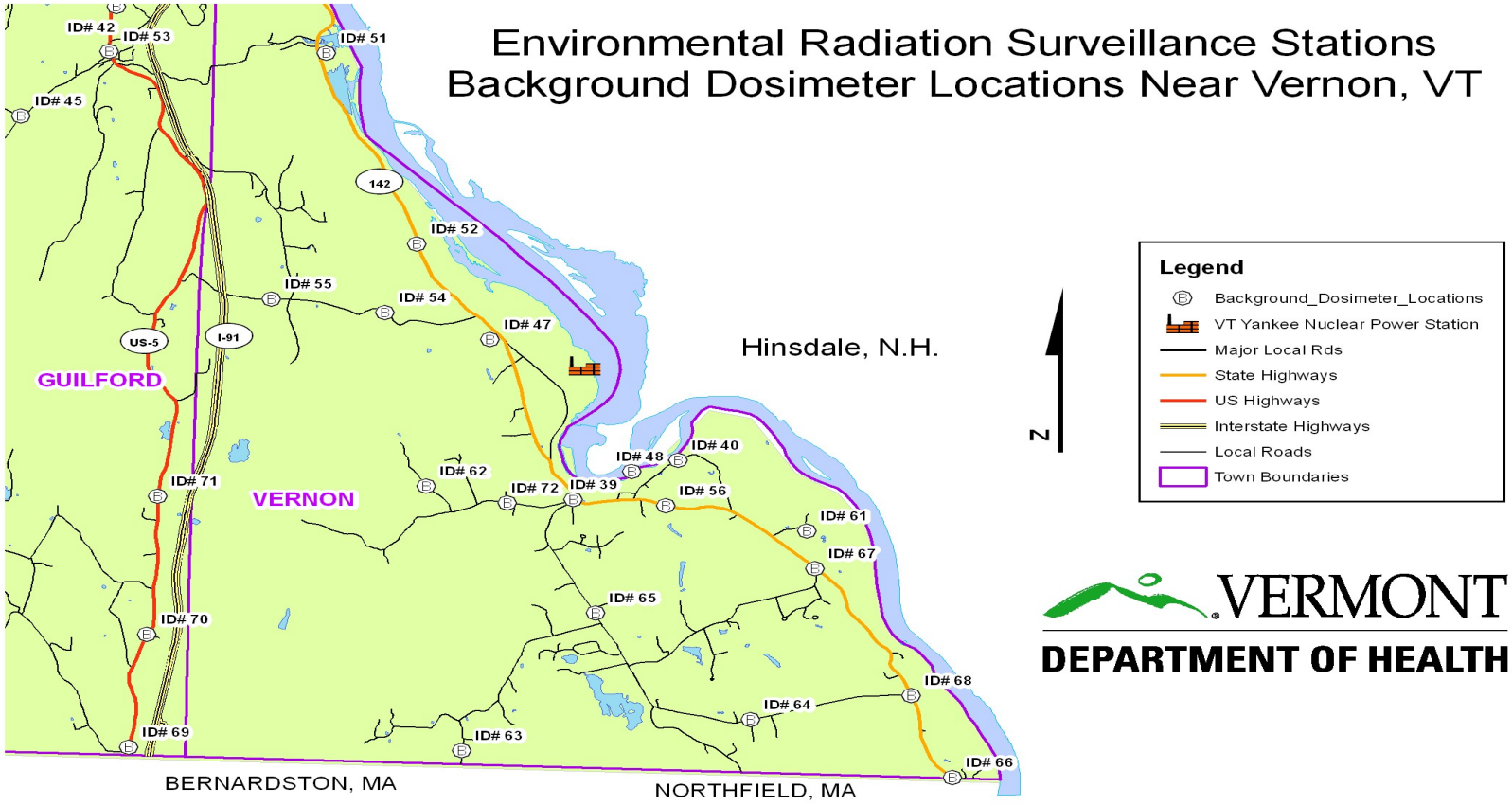
| Location | Map ID # | Qtr1 Gross | 1SD Error | Avg Bkgrd | Qtr1 Net | Net Q1 >=0 | 2SD Error | Qrtr2 Gross | 1SD Error | Avg Bkgrd | Qtr2 Net | Net Q2 >=0 | 2SD Error | Qrtr3 Gross | 1SD Error | Avg Bkgrd | Qtr3 Net | Net Q3 >=0 | 2SD Error | Qrtr4 Gross | 1SD Error | Avg Bkgrd | Qtr4 Net | Net Q4 >=0 | 2SD Error | Annual Net | 2SD Error |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VDH T05 | 28 | 12.98 | 0.80 | **12.8** | 0.1 | 0.1 | 1.6 | 15.22 | 0.76 | **13.8** | 1.4 | 1.4 | 1.5 | 14.50 | 0.95 | **13.9** | 0.6 | 0.6 | 1.9 | 14.23 | 1.15 | **13.8** | 0.5 | 0.5 | 2.3 | 2.7 | 3.6 |
| VDH T04 | 29 | 12.59 | 0.61 | **12.8** | -0.2 | 0.0 | 1.2 | 14.04 | 0.89 | **13.8** | 0.3 | 0.3 | 1.7 | 14.22 | 0.85 | **13.9** | 0.3 | 0.3 | 1.7 | 14.12 | 0.73 | **13.8** | 0.4 | 0.4 | 1.4 | 0.9 | 3.0 |
| VDH T06 | 30 | 0.00 | 0.00 | **12.8** | -12.8 | 0.0 | 0.0 | | | **13.8** | -13.8 | 0.0 | 0.0 | 14.68 | 1.11 | **13.9** | 0.8 | 0.8 | 2.2 | 14.32 | 0.84 | **13.8** | 0.6 | 0.6 | 1.6 | 1.3 | 2.7 |
| VDH DR07 | 31 | 13.25 | 1.08 | **12.8** | 0.4 | 0.4 | 2.1 | 15.48 | 0.64 | **13.8** | 1.7 | 1.7 | 1.3 | 15.37 | 1.08 | **13.9** | 1.5 | 1.5 | 2.1 | 14.21 | 0.75 | **13.8** | 0.4 | 0.4 | 1.5 | 4.0 | 3.6 |
| **VY North Fence** | **32** | **12.75** | **0.84** | **12.8** | **-0.1** | **0.0** | **1.6** | **14.10** | **0.87** | **13.8** | **0.3** | **0.3** | **1.7** | **13.00** | **0.95** | **13.9** | **-0.9** | **0.0** | **1.9** | **12.11** | **0.88** | **13.8** | **-1.7** | **0.0** | **1.7** | **0.3** | **3.5** |
| **VY North Fence #2** | **33** | **12.77** | **0.74** | **12.8** | **-0.1** | **0.0** | **1.5** | **13.76** | **0.78** | **13.8** | **0.0** | **0.0** | **1.5** | **12.92** | **1.15** | **13.9** | **-1.0** | **0.0** | **2.3** | **11.76** | **0.83** | **13.8** | **-2.0** | **0.0** | **1.6** | **0.0** | **3.5** |
| VY Parking Lot #2 | 34 | 15.81 | 0.90 | **12.8** | 3.0 | 3.0 | 1.8 | 17.17 | 0.64 | **13.8** | 3.4 | 3.4 | 1.3 | 16.64 | 0.90 | **13.9** | 2.7 | 2.7 | 1.8 | 15.40 | 1.02 | **13.8** | 1.6 | 1.6 | 2.0 | 10.7 | 3.4 |
| VY Parking Lot, ID | 35 | 15.49 | 1.06 | **12.8** | 2.7 | 2.7 | 2.1 | 17.40 | 0.73 | **13.8** | 3.6 | 3.6 | 1.4 | 15.97 | 1.12 | **13.9** | 2.1 | 2.1 | 2.2 | 15.30 | 0.96 | **13.8** | 1.5 | 1.5 | 1.9 | 9.9 | 3.8 |
| **VY SW Fence** | **36** | **13.36** | **0.55** | **12.8** | **0.5** | **0.5** | **1.1** | **13.84** | **0.53** | **13.8** | **0.1** | **0.1** | **1.0** | **13.58** | **0.81** | **13.9** | **-0.3** | **0.0** | **1.6** | **13.65** | **1.00** | **13.8** | **-0.1** | **0.0** | **2.0** | **0.6** | **2.9** |
| **VY SW Fence #2** | **37** | **13.65** | **0.56** | **12.8** | **0.8** | **0.8** | **1.1** | **13.41** | **0.58** | **13.8** | **-0.4** | **0.0** | **1.1** | **13.01** | **1.02** | **13.9** | **-0.9** | **0.0** | **2.0** | **13.06** | **0.76** | **13.8** | **-0.7** | **0.0** | **1.5** | **0.8** | **3.0** |
| VDH T02 | 38 | 12.66 | 0.60 | **12.8** | -0.2 | 0.0 | 1.2 | 14.59 | 0.63 | **13.8** | 0.8 | 0.8 | 1.2 | 14.25 | 1.14 | **13.9** | 0.4 | 0.4 | 2.2 | 13.87 | 0.94 | **13.8** | 0.1 | 0.1 | 1.8 | 1.3 | 3.4 |
| Meteorology Tower | n/a | 12.44 | 0.96 | **12.8** | -0.4 | 0.0 | 1.9 | 14.46 | 0.64 | **13.8** | 0.7 | 0.7 | 1.3 | 13.97 | 0.88 | **13.9** | 0.1 | 0.1 | 1.7 | 15.08 | 1.51 | **13.8** | 1.3 | 1.3 | 3.0 | 2.1 | 4.1 |

Site boundary dosimeter measurements are bolded.

## Map 4


Environmental Radiation Surveillance Stations
Background Dosimeter Locations
SOMERSET
ROYER
NEWFANE
PUTNEY
DUMMERSTON
SEARSBURG
WILMINGTON
MARLBORO
BRATTLEBORO
READSBORO
WHITINGHAM
HALIFAX
GUILFORD
VERNON
Westmoreland, N.H.
Chesterfield, N.H.
Hinsdale, N.H.
ID# 49
ID# 50
ID# 44
ID# 43
ID# 59
ID# 58
ID# 41
ID# 60
ID# 53
ID# 42
ID# 51
ID# 46
ID# 45
ID# 52
ID# 57
ID# 55
ID# 47
ID# 40
ID# 71
ID# 67
ID# 70
ID# 65
ID# 68
ID# 69
ID# 63
ID# 66
ID# 64
HEATH, MA
COLRAIN, MA
LEYDEN, MA
BERNARDSTON, MA
NORTHFIELD, MA
Legend
Background_Dosimeter_Locations
VT Yankee Nuclear Power Station
Major Local Rds
State Highways
US Highways
Interstate Highways
Local Roads
Town Boundaries
VERMONT
DEPARTMENT OF HEALTH
N
W
E
S
P. Young
April 2007

## Map 5


Environmental Radiation Surveillance Stations
Background Dosimeter Locations Near Vernon, VT
ID# 42
ID# 53
ID# 51
ID# 45
142
ID# 52
ID# 55
ID# 54
ID# 47
US-5
I-91
GUILFORD
Hinsdale, N.H.
ID# 48
ID# 40
ID# 62
ID# 72
ID# 39
ID# 56
ID# 71
VERNON
ID# 61
ID# 67
ID# 65
ID# 70
ID# 68
ID# 64
ID# 69
ID# 63
ID# 66
BERNARDSTON, MA
NORTHFIELD, MA
N
Legend
Background_Dosimeter_Locations
VT Yankee Nuclear Power Station
Major Local Rds
State Highways
US Highways
Interstate Highways
Local Roads
Town Boundaries
VERMONT
DEPARTMENT OF HEALTH
P. Young
April 2007

## Table 11. 2019 Thermoluminescent Dosimeter Exposure Measurements and Net Gamma Radiation: Background Locations

2019 **Background** Dosimeter Exposure (milliroentgen)

| Location | Map ID # | Qtr1 Gross | 1SD Error | Avg Bkgrd | Qtr1 Net | Net >=0 | 2SD Error | Qrtr2 Gross | 1SD Error | Avg Bkgrd | Qtr2 Net | Net >=0 | 2SD Error | Qrtr3 Gross | 1SD Error | Avg Bkgrd | Qtr3 Net | Net >=0 | 2SD Error | Qrtr4 Gross | 1SD Error | Avg Bkgrd | Qtr4 Net | Net >=0 | 2SD Error | Annual Net | 2SD Error |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 142/Pond Road (N) | 39 | 12.75 | 0.94 | **12.8** | -0.1 | 0.0 | 1.8 | 13.98 | 0.74 | **13.8** | 0.2 | 0.2 | 1.5 | 14.07 | 1.02 | **13.9** | 0.2 | 0.2 | 2.0 | 13.65 | 0.82 | **13.8** | -0.1 | 0.0 | 1.6 | 0.4 | 3.5 |
| A&M Auto/Smead Rd | 40 | 11.45 | 0.64 | **12.8** | -1.4 | 0.0 | 1.3 | 13.98 | 0.64 | **13.8** | 0.2 | 0.2 | 1.3 | 13.41 | 0.85 | **13.9** | -0.5 | 0.0 | 1.7 | 12.37 | 0.93 | **13.8** | -1.4 | 0.0 | 1.8 | 0.2 | 3.0 |
| West Brattleboro State Police | 41 | 11.31 | 0.76 | **12.8** | -1.5 | 0.0 | 1.5 | 12.06 | 0.66 | **13.8** | -1.7 | 0.0 | 1.3 | 12.00 | 0.86 | **13.9** | -1.9 | 0.0 | 1.7 | 11.99 | 0.80 | **13.8** | -1.8 | 0.0 | 1.6 | 0.0 | 3.0 |
| D&E Tree, Rt 5, Guilford | 42 | 14.46 | 0.63 | **12.8** | 1.6 | 1.6 | 1.2 | 15.48 | 0.54 | **13.8** | 1.7 | 1.7 | 1.1 | 13.06 | 0.75 | **13.9** | -0.8 | 0.0 | 1.5 | 15.90 | 0.91 | **13.8** | 2.1 | 2.1 | 1.8 | 5.5 | 2.8 |
| Dummerston AOT | 43 | 13.54 | 0.88 | **12.8** | 0.7 | 0.7 | 1.7 | 13.93 | 0.63 | **13.8** | 0.2 | 0.2 | 1.2 | 14.21 | 1.02 | **13.9** | 0.3 | 0.3 | 2.0 | 14.49 | 0.76 | **13.8** | 0.7 | 0.7 | 1.5 | 1.9 | 3.3 |
| Dummerston School | 44 | 12.74 | 0.65 | **12.8** | -0.1 | 0.0 | 1.3 | 13.97 | 0.57 | **13.8** | 0.2 | 0.2 | 1.1 | 13.46 | 1.07 | **13.9** | -0.4 | 0.0 | 2.1 | 13.26 | 0.87 | **13.8** | -0.5 | 0.0 | 1.7 | 0.2 | 3.2 |
| Guilford Center Rd/Tater Rd | 45 | 11.93 | 0.75 | **12.8** | -0.9 | 0.0 | 1.5 | 13.40 | 0.72 | **13.8** | -0.4 | 0.0 | 1.4 | 13.53 | 0.98 | **13.9** | -0.4 | 0.0 | 1.9 | 13.01 | 0.72 | **13.8** | -0.8 | 0.0 | 1.4 | 0.0 | 3.1 |
| Guilford Town Garage | 46 | 14.25 | 0.58 | **12.8** | 1.4 | 1.4 | 1.1 | 14.10 | 0.67 | **13.8** | 0.3 | 0.3 | 1.3 | 14.35 | 0.79 | **13.9** | 0.5 | 0.5 | 1.5 | 14.75 | 1.21 | **13.8** | 1.0 | 1.0 | 2.4 | 3.2 | 3.3 |
| Miller Farm | 47 | 12.59 | 1.06 | **12.8** | -0.2 | 0.0 | 2.1 | 14.00 | 0.56 | **13.8** | 0.2 | 0.2 | 1.1 | 11.37 | 0.72 | **13.9** | -2.5 | 0.0 | 1.4 | 14.38 | 0.91 | **13.8** | 0.6 | 0.6 | 1.8 | 0.8 | 3.3 |
| Power Line River Crossing | 48 | 12.56 | 0.71 | **12.8** | -0.3 | 0.0 | 1.4 | 13.77 | 0.66 | **13.8** | 0.0 | 0.0 | 1.3 | 13.55 | 1.03 | **13.9** | -0.3 | 0.0 | 2.0 | 14.07 | 0.95 | **13.8** | 0.3 | 0.3 | 1.9 | 0.3 | 3.3 |
| Putney Pole | 49 | 13.21 | 0.72 | **12.8** | 0.4 | 0.4 | 1.4 | 14.55 | 0.99 | **13.8** | 0.8 | 0.8 | 1.9 | 14.51 | 0.79 | **13.9** | 0.6 | 0.6 | 1.5 | 14.68 | 1.04 | **13.8** | 0.9 | 0.9 | 2.0 | 2.7 | 3.5 |
| Putney Town Clerk | 50 | 12.55 | 0.61 | **12.8** | -0.3 | 0.0 | 1.2 | 12.51 | 0.69 | **13.8** | -1.3 | 0.0 | 1.4 | | | **13.9** | -13.9 | 0.0 | 0.0 | 16.72 | 0.90 | **13.8** | 3.0 | 3.0 | 1.8 | 3.0 | 2.5 |
| Renaud Brothers | 51 | 14.02 | 0.63 | **12.8** | 1.2 | 1.2 | 1.2 | 14.68 | 0.57 | **13.8** | 0.9 | 0.9 | 1.1 | 16.01 | 0.94 | **13.9** | 2.1 | 2.1 | 1.8 | | | **13.8** | -13.8 | 0.0 | 0.0 | 4.2 | 2.5 |
| Rt 5/Guilford Ctr Rd | 53 | 12.59 | 0.56 | **12.8** | -0.2 | 0.0 | 1.1 | 13.25 | 0.50 | **13.8** | -0.5 | 0.0 | 1.0 | 16.07 | 1.06 | **13.9** | 2.2 | 2.2 | 2.1 | 12.84 | 0.89 | **13.8** | -0.9 | 0.0 | 1.7 | 2.2 | 3.1 |
| Tyler Hill Road | 54 | 13.00 | 0.71 | **12.8** | 0.2 | 0.2 | 1.4 | 14.64 | 0.63 | **13.8** | 0.9 | 0.9 | 1.2 | 14.24 | 1.28 | **13.9** | 0.3 | 0.3 | 2.5 | 14.24 | 0.84 | **13.8** | 0.5 | 0.5 | 1.6 | 1.8 | 3.5 |
| Tyler Rd/Franklin Rd | 55 | 13.53 | 0.97 | **12.8** | 0.7 | 0.7 | 1.9 | 13.82 | 0.66 | **13.8** | 0.0 | 0.0 | 1.3 | 15.49 | 1.05 | **13.9** | 1.6 | 1.6 | 2.1 | 14.46 | 0.76 | **13.8** | 0.7 | 0.7 | 1.5 | 3.0 | 3.4 |
| Vernon Fire Station | 56 | 12.12 | 0.58 | **12.8** | -0.7 | 0.0 | 1.1 | 13.33 | 0.61 | **13.8** | -0.4 | 0.0 | 1.2 | 12.63 | 1.18 | **13.9** | -1.3 | 0.0 | 2.3 | 12.53 | 0.76 | **13.8** | -1.2 | 0.0 | 1.5 | 0.0 | 3.2 |
| Weatherhead Hollow Rd | 57 | 10.98 | 0.64 | **12.8** | -1.9 | 0.0 | 1.3 | 11.81 | 0.67 | **13.8** | -2.0 | 0.0 | 1.3 | 11.61 | 0.72 | **13.9** | -2.3 | 0.0 | 1.4 | 12.00 | 0.66 | **13.8** | -1.8 | 0.0 | 1.3 | 0.0 | 2.6 |
| Windham County Court | 60 | 15.80 | 0.73 | **12.8** | 3.0 | 3.0 | 1.4 | 15.85 | 0.88 | **13.8** | 2.1 | 2.1 | 1.7 | 15.80 | 1.19 | **13.9** | 1.9 | 1.9 | 2.3 | 16.50 | 0.90 | **13.8** | 2.7 | 2.7 | 1.8 | 9.7 | 3.7 |
| Blodgett Farm | 61 | 14.24 | 1.06 | **12.8** | 1.4 | 1.4 | 2.1 | 11.51 | 0.71 | **13.8** | -2.3 | 0.0 | 1.4 | 13.34 | 0.97 | **13.9** | -0.6 | 0.0 | 1.9 | 12.20 | 1.02 | **13.8** | -1.6 | 0.0 | 2.0 | 1.4 | 3.7 |
| Fairman Road | 62 | 11.92 | 0.73 | **12.8** | -0.9 | 0.0 | 1.4 | 12.87 | 0.57 | **13.8** | -0.9 | 0.0 | 1.1 | 12.99 | 1.08 | **13.9** | -0.9 | 0.0 | 2.1 | 13.10 | 0.92 | **13.8** | -0.7 | 0.0 | 1.8 | 0.0 | 3.3 |
| Huckle Hill Rd VT | 63 | 14.57 | 0.59 | **12.8** | 1.7 | 1.7 | 1.2 | 16.65 | 0.74 | **13.8** | 2.9 | 2.9 | 1.5 | 16.83 | 1.45 | **13.9** | 2.9 | 2.9 | 2.8 | 15.87 | 0.91 | **13.8** | 2.1 | 2.1 | 1.8 | 9.6 | 3.8 |

## Table 11. 2019 Thermoluminescent Dosimeter Exposure Measurements and Net Gamma Radiation: Background Locations (continued)

2019 **Background** Dosimeter Exposure (milliroentgen)

| Location | Map ID # | Qtr1 Gross | 1SD Error | Avg Bkgrd | Qtr1 Net | Net >=0 | 2SD Error | Qrtr2 Gross | 1SD Error | Avg Bkgrd | Qtr2 Net | Net >=0 | 2SD Error | Qrtr3 Gross | 1SD Error | Avg Bkgrd | Qtr3 Net | Net >=0 | 2SD Error | Qrtr4 Gross | 1SD Error | Avg Bkgrd | Qtr4 Net | Net >=0 | 2SD Error | Annual Net | 2SD Error |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pond Rd & Houghton | 64 | 11.99 | 0.74 | **12.8** | -0.8 | 0.0 | 1.5 | 13.92 | 0.68 | **13.8** | 0.1 | 0.1 | 1.3 | 13.77 | 0.96 | **13.9** | -0.1 | 0.0 | 1.9 | 13.65 | 0.84 | **13.8** | -0.1 | 0.0 | 1.6 | 0.1 | 3.2 |
| Pond Rd/Vernon Rec | 65 | 11.75 | 0.54 | **12.8** | -1.1 | 0.0 | 1.1 | 12.35 | 0.68 | **13.8** | -1.4 | 0.0 | 1.3 | 11.82 | 0.92 | **13.9** | -2.1 | 0.0 | 1.8 | 12.30 | 0.79 | **13.8** | -1.5 | 0.0 | 1.5 | 0.0 | 2.9 |
| Rt 142 & Depot St | 66 | 12.99 | 0.83 | **12.8** | 0.2 | 0.2 | 1.6 | 14.15 | 0.69 | **13.8** | 0.4 | 0.4 | 1.4 | 14.34 | 0.84 | **13.9** | 0.4 | 0.4 | 1.6 | 13.72 | 0.99 | **13.8** | 0.0 | 0.0 | 1.9 | 1.0 | 3.3 |
| Rt 142 & Newton Rd | 67 | 11.67 | 0.52 | **12.8** | -1.2 | 0.0 | 1.0 | 12.52 | 0.88 | **13.8** | -1.3 | 0.0 | 1.7 | 12.19 | 0.82 | **13.9** | -1.7 | 0.0 | 1.6 | 12.26 | 0.90 | **13.8** | -1.5 | 0.0 | 1.8 | 0.0 | 3.1 |
| Rt 142 & Pond Rd (S) | 68 | 12.75 | 0.94 | **12.8** | -0.1 | 0.0 | 1.8 | 13.98 | 0.74 | **13.8** | 0.2 | 0.2 | 1.5 | 14.07 | 1.02 | **13.9** | 0.2 | 0.2 | 2.0 | 13.65 | 0.82 | **13.8** | -0.1 | 0.0 | 1.6 | 0.4 | 3.5 |
| Route 5/Wolosko Rd | 69 | 14.24 | 1.08 | **12.8** | 1.4 | 1.4 | 2.1 | 14.00 | 0.65 | **13.8** | 0.2 | 0.2 | 1.3 | 15.76 | 1.30 | **13.9** | 1.9 | 1.9 | 2.5 | 14.48 | 0.79 | **13.8** | 0.7 | 0.7 | 1.5 | 4.2 | 3.9 |
| Rt 5/Andrews Cmtry | 70 | 12.35 | 0.77 | **12.8** | -0.5 | 0.0 | 1.5 | 13.55 | 0.71 | **13.8** | -0.2 | 0.0 | 1.4 | 14.36 | 1.00 | **13.9** | 0.5 | 0.5 | 2.0 | 13.23 | 0.93 | **13.8** | -0.5 | 0.0 | 1.8 | 0.5 | 3.4 |
| Rt 5/Tkaczyk Frm Rd | 71 | 12.93 | 0.62 | **12.8** | 0.1 | 0.1 | 1.2 | 15.53 | 0.69 | **13.8** | 1.8 | 1.8 | 1.4 | 14.30 | 0.89 | **13.9** | 0.4 | 0.4 | 1.7 | 13.62 | 0.99 | **13.8** | -0.1 | 0.0 | 1.9 | 2.3 | 3.2 |
| West Rd/Edgewood | 72 | 11.19 | 0.44 | **12.8** | -1.6 | 0.0 | 0.9 | 12.91 | 0.70 | **13.8** | -0.9 | 0.0 | 1.4 | 13.74 | 0.89 | **13.9** | -0.2 | 0.0 | 1.7 | 13.31 | 1.06 | **13.8** | -0.5 | 0.0 | 2.1 | 0.0 | 3.2 |
| Average Background (Avg) | | **12.8** | | | | | | **13.8** | | | | | | **13.9** | | | | | | **13.8** | | | | | | **54.3** | |

# Continuous Flow Air Sampling Results

The Health Department uses continuously operating air samplers to monitor the air near Vermont Yankee. They are located in Vernon, Guilford, Brattleboro, Dummerston and Wilmington. The locations of the air samplers are shown on Map 6. In 2011, to provide comparison, another air sampler was sited in Burlington at the Health Department.

Air filters are tested monthly for alpha- and beta-emitting materials and are then grouped quarterly to test for gamma-emitting materials. Air cartridges are tested monthly for iodine-131 (I-131) and other gamma-emitting materials at the Health Department Laboratory. Data associated with the air filters are provided in Appendix A.

For 2019:

- 110 air cartridges were tested for iodine-131 and gamma-emitting materials.
- 109 air filters were tested for total alpha and beta radioactivity.
- 4 sets of air filters were grouped and tested for gamma-emitting materials.

## Air Filter Total Alpha and Beta Radioactivity Results

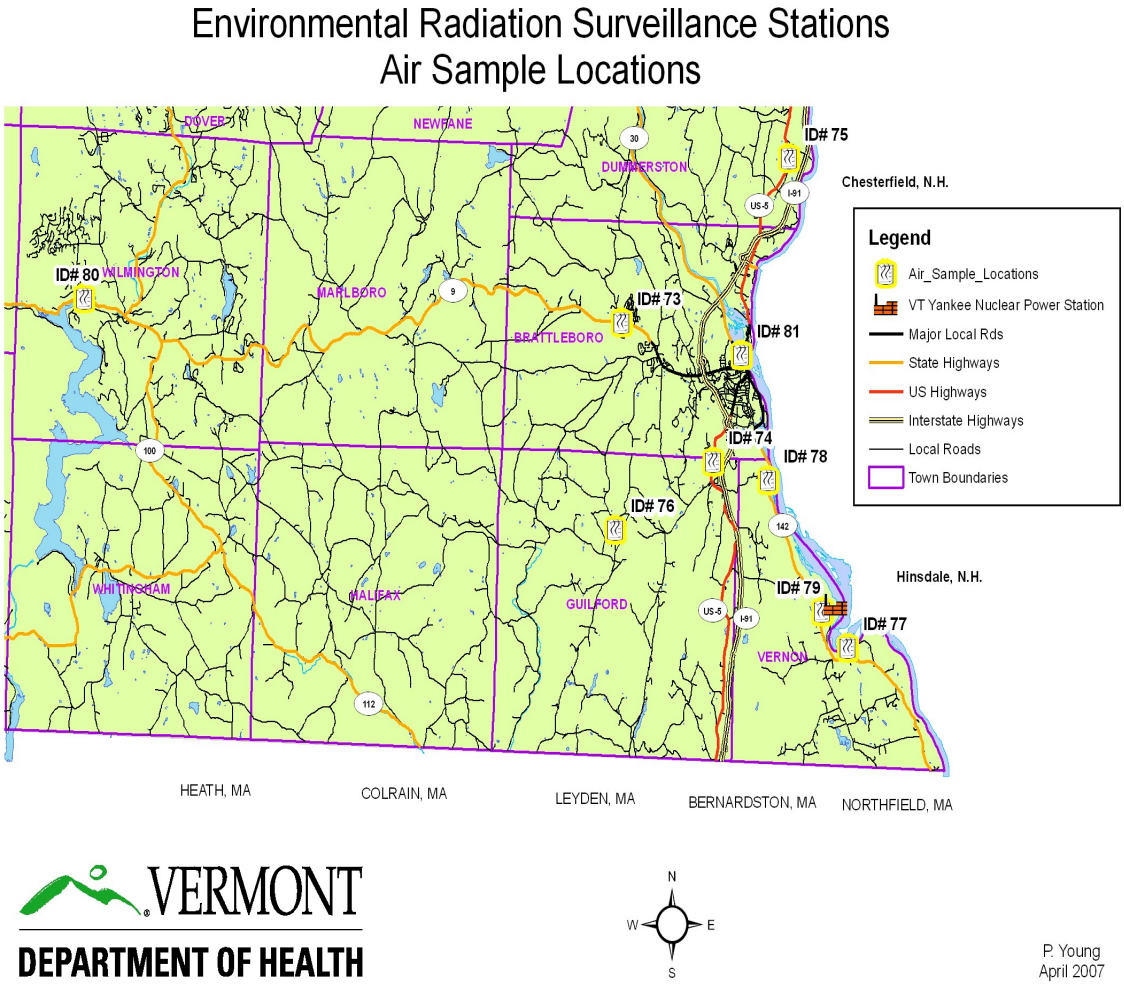
In 2019, the average result for total alpha radioactivity was 0.001269 picocuries per cubic meter ($pCi/m^3$). The 2019 average result for total beta radioactivity was 0.01536 $pCi/m^3$. The 2019 total alpha and beta radioactivity air filter results are presented in Appendix A.

Figures 2 and 3 show the average total alpha and beta radioactivity for the sample locations compared to the 2015, 2016, 2017 and 2018 results. Results that were uncertain because of noted collection problems were removed prior to calculating the average result. This is a conservative approach and results in an increased average.

## Air Cartridge and Air Filter Gamma-Emitting Materials Results

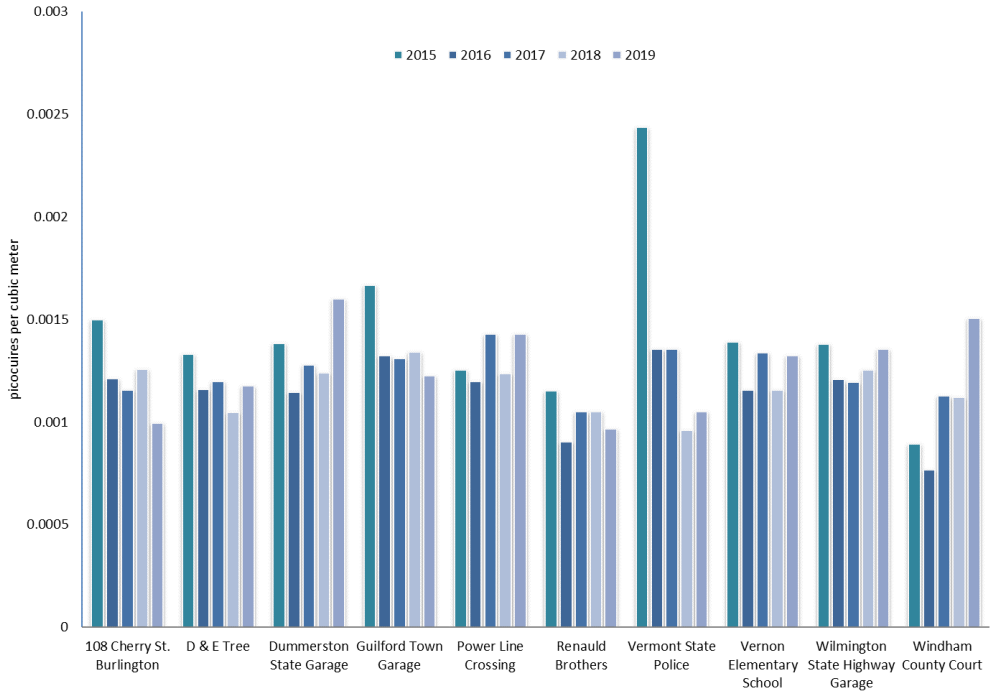
No iodine-131 was detected in any air cartridge in 2019. Only naturally-occurring gamma-emitting materials were detected, specifically beryllium-7.

## Map 6




| Sample Location | Map ID | Sample Location | Map ID |
|---|---|---|---|
| D & E Tree | 74 | Vermont State Police-Brattleboro | 73 |
| Dummerston State Garage | 75 | Vernon Elementary School | 79 |
| Guilford Town Garage | 76 | Wilmington State Highway Garage | 80 |
| Power Line River Crossing | 77 | Windham County Courthouse | 81 |
| Renaud Brothers | 78 | 108 Cherry St. Burlington | n/a |

## Figure 2. 2015-2019 Average Alpha Radioactivity in Air




## Figure 3. 2015-2019 Average Beta Radioactivity in Air

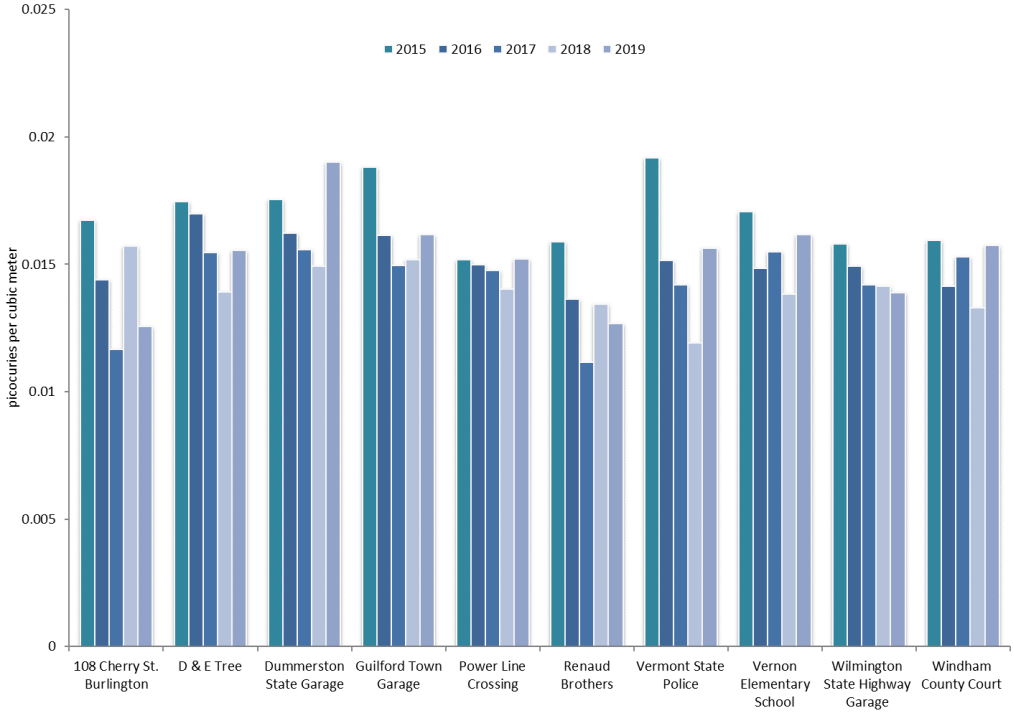


**Table 12. 2019 Air Filter Composite Results (Gamma Spectroscopy)**

| Quarter | Last Date of Quarter | Element | Concentration +/- error (pCi) |
|---|---|---|---|
| 1st Quarter | 3/31/2019 | Beryllium-7 | 9,680 +/- 1,120 |
| 2nd Quarter | 6/30/2019 | Beryllium-7 | 11,100 +/- 1,100 |
| 3rd Quarter | 9/30/2019 | Beryllium-7 | 9,930 +/- 600 |
| 4th Quarter | 12/31/2019 | Beryllium-7 | 10,200 +/- 600 |
| Historical Range | 2010-2018 | Beryllium-7 | 1,690-17,500 |

In 2019, no alpha, beta or gamma radioactivity related to the activities of Vermont Yankee was identified in the continuous flow air samples. Results were consistent with historical ranges.

# *Water Sampling Results*

The Health Department has routinely collected off-site monthly water samples from six locations around Vermont Yankee. Samples are collected from drinking water wells (3), a public water supply (1) and the Connecticut River (2). These sample locations are shown on Map 7. Additional off-site samples are collected at a private residence and a nursing home.

In addition, Vermont Yankee routinely collects at two Connecticut River sites monthly: Stations 3-3 and 3-8. These sample locations are shown on Map 8. Vermont Yankee also collects at four on-site monitoring wells quarterly: WVN0201, WVN0202, WVN0203 and WVN0204. Other on-site monitoring wells are also sampled by Vermont Yankee. The samples Vermont Yankee takes from the Connecticut River and the four on-site monitoring wells are split so the Health Department Laboratory can analyze them for comparison.

Routine off-site water samples are tested by the Health Department Laboratory for total alpha and beta radioactivity, gamma radioactivity and tritium. The Connecticut River on-site monitoring wells are tested for tritium and gamma radioactivity.

For 2019:

- 99 water samples were tested for total alpha and beta radioactivity
- 223 water samples were tested for tritium
- 223 water samples were tested for gamma-emitting materials

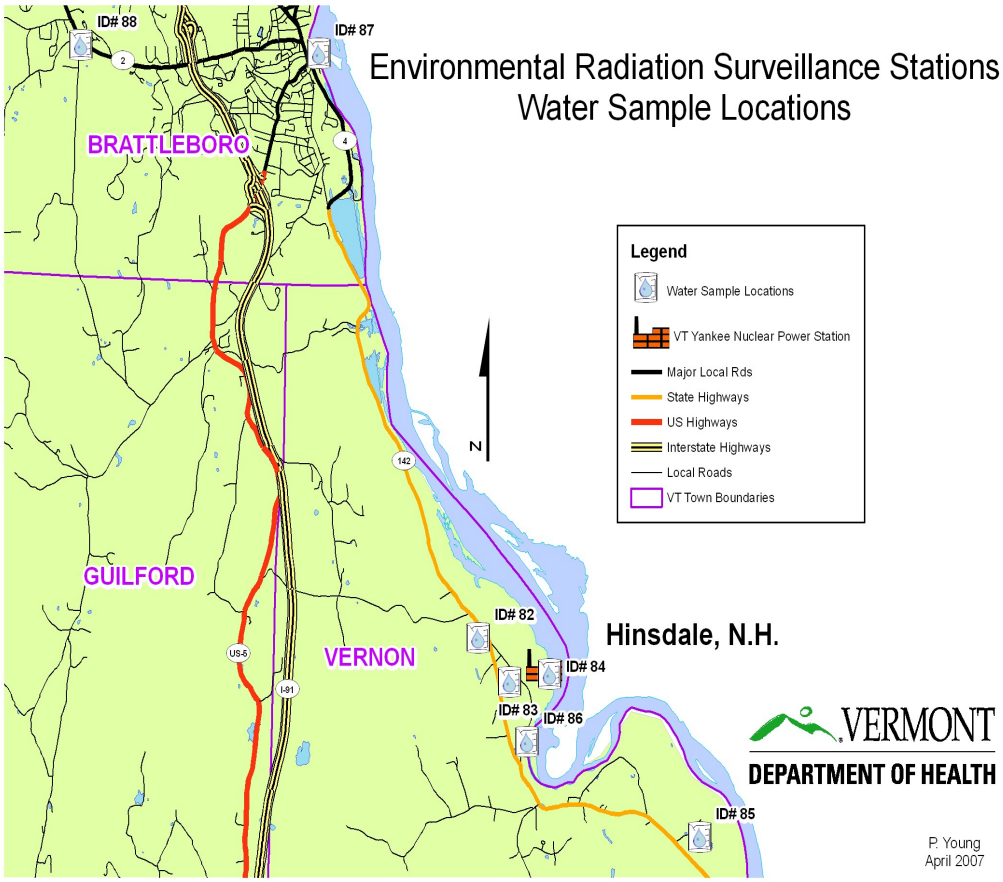
Due to the large number of results associated with tritium and gamma spectroscopy, the individual data for these tests are presented in Appendices B and C.

## Water Total Alpha and Beta Radioactivity Results

The alpha and beta radioactivity measured in the water samples is within the historical range for both types of radioactivity. Water alpha and beta radioactivity measurements around Vermont Yankee have both historically ranged from below the lower limit of detection to 15 picocuries per liter (pCi/L). The U.S. Environmental Protection Agency has established maximum contaminant levels (MCLs) of 15 pCi/L for alpha radioactivity and 50 pCi/L for beta radioactivity. In 2019, the range for alpha radioactivity was -0.28 to 10.50 pCi/L. The 2019 range for beta radioactivity was -0.84 to 12.90 pCi/L. Results

from 2019 are presented in Table 13. Comparisons of 2015-2019 data are presented in Figures 4 and 5. Trends for both alpha and beta results are similar to past years: Vernon Elementary School and Blodgett Farm have historically had higher levels of natural radioactivity in the water, principally isotopes of uranium and radium and their daughter products.

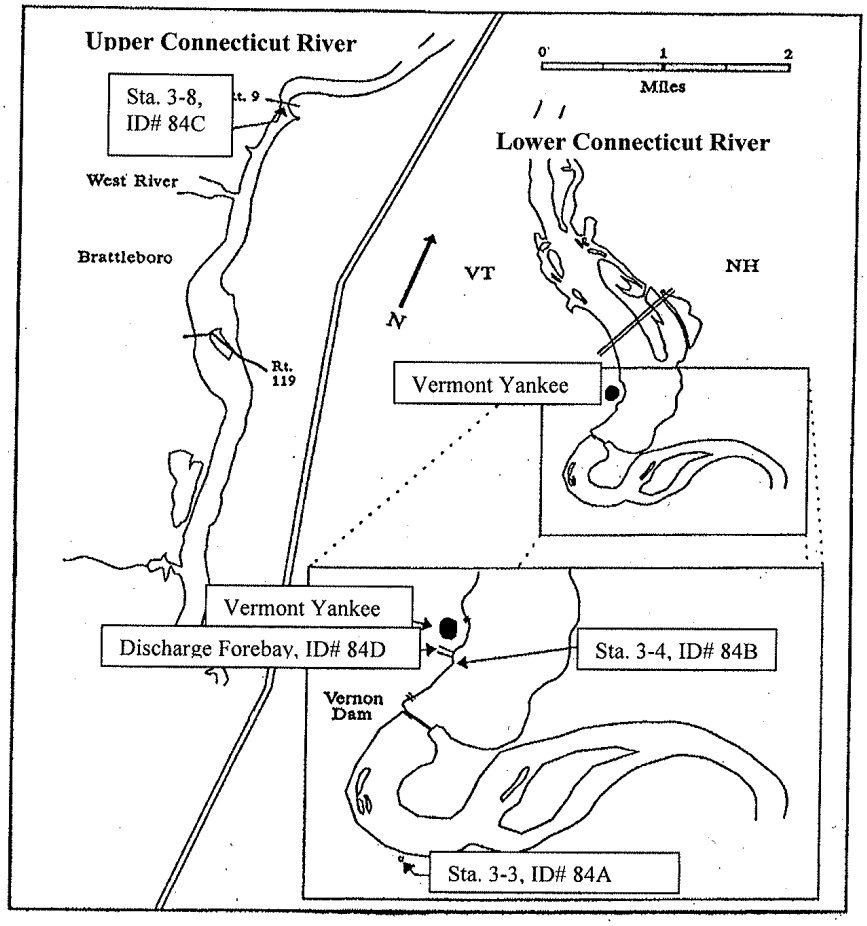
## Map 7




| Sample Location | Map ID |
|---|---|
| Miller Farm | 82 |
| Vernon Elementary School | 83 |
| Blodgett Farm | 85 |
| Connecticut River, Downstream | 86 |
| Connecticut River, Upstream | 87 |
| Brattleboro Fire Dept., West Station | 88 |

## Map 8

**Routine Connecticut River Water Sample Locations**




| Sample Location | Map ID |
|---|---|
| 3-3 Connecticut River Station | 84A |
| 3-4 Connecticut River Station | 84B |
| 3-8 Connecticut River Station | 84C |
| Discharge Forebay | 84D |

## Table 13. 2019 Total Alpha and Beta Radioactivity Water Results

| Sample Location | Date of Sample | Total Alpha Radioactivity +/- error (pCi/L) | Total Beta Radioactivity +/- error (pCi/L) |
|---|---|---|---|
| 3-3 Connecticut River Station | 1/14/2019 | 0.27 +/- 0.41 | 2.91 +/- 1.02 |
| | 2/16/2019 | 0.84 +/- 0.55 | 1.01 +/- 1.01 |
| | 3/13/2019 | 7.92 +/- 1.53 | 9.62 +/- 1.33 |
| | 4/16/2019 | 0.16 +/- 0.44 | 0.50 +/- 1.16 |
| | 5/16/2019 | 1.06 +/- 0.57 | 1.79 +/- 1.02 |
| | 6/13/2019 | -0.25 +/- 0.48 | 0.22 +/- 0.99 |
| | 7/16/2019 | 0.27 +/- 0.53 | 1.25 +/- 1.09 |
| | 8/14/2019 | 0.88 +/- 0.57 | 1.35 +/- 1.01 |
| | 9/16/2019 | 0.00 +/- 0.51 | 1.57 +/- 1.03 |
| | 10/14/2019 | 0.66 +/- 0.71 | 1.02 +/- 1.05 |
| | 11/13/2019 | 0.13 +/- 0.42 | 1.34 +/- 1.01 |
| | 12/16/2019 | 0.26 +/- 0.52 | 1.11 +/- 0.97 |
| 3-8 Connecticut River Station | 1/14/2019 | 0.22 +/- 0.19 | 0.63 +/- 0.38 |
| | 2/16/2019 | 0.22 +/- 0.19 | 0.63 +/- 0.41 |
| | 3/13/2019 | 0.12 +/- 0.23 | 0.76 +/- 0.42 |
| | 4/16/2019 | 0.93 +/- 0.29 | 1.59 +/- 0.51 |
| | 5/16/2019 | 0.52 +/- 0.45 | 0.45 +/- 0.96 |
| | 6/13/2019 | 0.25 +/- 0.58 | 0.78 +/- 1.01 |
| | 7/16/2019 | 0.28 +/- 0.56 | 1.53 +/- 1.08 |
| | 8/14/2019 | 1.21 +/- 0.65 | 1.69 +/- 1.03 |
| | 9/16/2019 | 0.58 +/- 0.63 | 1.46 +/- 1.03 |
| | 10/14/2019 | 2.32 +/- 0.88 | 3.82 +/- 1.15 |
| | 11/13/2019 | 0.05 +/- 0.18 | 0.76 +/- 0.41 |
| | 12/16/2019 | 1.52 +/- 0.70 | 2.76 +/- 1.04 |
| Blodgett Farm | 1/8/2019 | 3.56 +/- 0.93 | 4.87 +/- 1.11 |
| | 2/5/2019 | 5.11 +/- 1.18 | 3.96 +/- 1.14 |
| | 3/5/2019 | 4.14 +/- 0.93 | 3.28 +/- 1.10 |
| | 4/9/2019 | 4.11 +/- 0.89 | 3.40 +/- 1.27 |
| | 5/7/2019 | 4.95 +/- 1.20 | 5.99 +/- 1.19 |
| | 6/4/2019 | 3.83 +/- 0.89 | 4.50 +/- 1.17 |
| | 7/2/2019 | 3.58 +/- 0.92 | 9.06 +/- 1.31 |
| | 8/6/2019 | 4.13 +/- 0.86 | 3.74 +/- 1.12 |
| | 9/4/2019 | 4.04 +/- 0.87 | 3.17 +/- 1.11 |
| | 10/8/2019 | 5.03 +/- 1.00 | 2.72 +/- 1.11 |
| | 11/5/2019 | 4.27 +/- 0.91 | 3.95 +/- 1.12 |
| | 12/3/2019 | 3.47 +/- 0.84 | 3.69 +/- 1.09 |

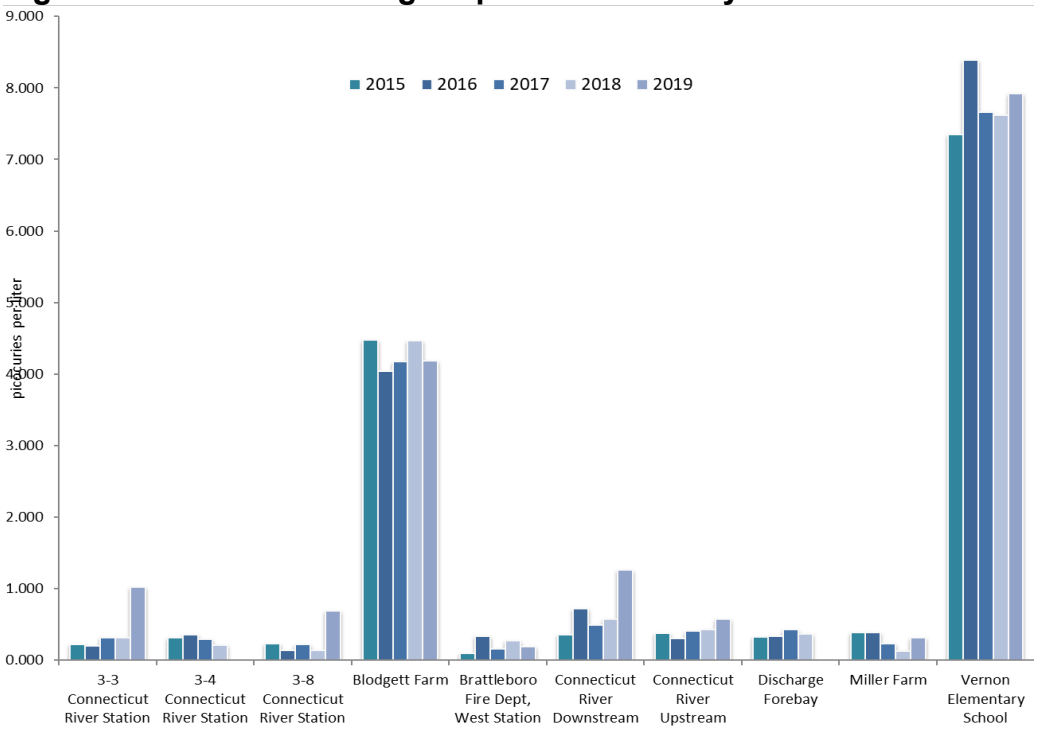
**Table 13. 2019 Total Alpha and Beta Radioactivity Water Results (continued)**

| Sample Location | Date of Sample | Total Alpha Radioactivity +/- error (pCi/L) | Total Beta Radioactivity +/- error (pCi/L) |
|---|---|---|---|
| Brattleboro Fire Dept, West Station | 1/8/2019 | 0.53 +/- 0.47 | 1.90 +/- 0.98 |
| | 2/5/2019 | 0.53 +/- 0.46 | 0.56 +/- 0.99 |
| | 3/5/2019 | -0.26 +/- 0.40 | 1.12 +/- 1.00 |
| | 4/9/2019 | -0.06 +/- 0.36 | -0.84 +/- 1.00 |
| | 5/7/2019 | 0.26 +/- 0.40 | 1.34 +/- 1.00 |
| | 6/4/2019 | -0.24 +/- 0.47 | 0.78 +/- 1.01 |
| | 7/2/2019 | -0.26 +/- 0.40 | 1.83 +/- 1.09 |
| | 8/6/2019 | 0.55 +/- 0.49 | 1.12 +/- 1.00 |
| | 9/4/2019 | 0.00 +/- 0.48 | 1.34 +/- 1.02 |
| | 10/8/2019 | 0.53 +/- 0.56 | 0.67 +/- 1.02 |
| | 11/5/2019 | 0.38 +/- 0.47 | 1.23 +/- 1.00 |
| | 12/3/2019 | 0.26 +/- 0.50 | 1.33 +/- 0.98 |
| Connecticut River Downstream | 1/8/2019 | 1.04 +/- 0.56 | 1.79 +/- 0.97 |
| | 2/5/2019 | 0.00 +/- 0.33 | 0.78 +/- 1.00 |
| | 3/5/2019 | 0.00 +/- 0.48 | 0.67 +/- 0.98 |
| | 4/9/2019 | 0.42 +/- 0.48 | -0.31 +/- 1.14 |
| | 5/7/2019 | 6.88 +/- 1.38 | 7.13 +/- 1.23 |
| | 6/4/2019 | 0.25 +/- 0.57 | 0.67 +/- 1.01 |
| | 7/2/2019 | 0.27 +/- 0.53 | 1.09 +/- 1.03 |
| | 8/6/2019 | 4.37 +/- 1.14 | 4.87 +/- 1.16 |
| | 9/4/2019 | 0.89 +/- 0.68 | 1.12 +/- 1.02 |
| | 10/8/2019 | 0.29 +/- 0.57 | 0.45 +/- 1.01 |
| | 11/5/2019 | 0.38 +/- 0.47 | 1.67 +/- 1.02 |
| | 12/3/2019 | 0.26 +/- 0.51 | 1.00 +/- 0.97 |
| Connecticut River Upstream | 1/8/2019 | 0.32 +/- 0.48 | 1.81 +/- 0.98 |
| | 3/5/2019 | 0.51 +/- 0.51 | 0.46 +/- 0.99 |
| | 4/9/2019 | -0.21 +/- 0.38 | -0.75 +/- 1.07 |
| | 5/7/2019 | 1.51 +/- 0.70 | 1.58 +/- 1.02 |
| | 6/4/2019 | 0.27 +/- 0.63 | 1.23 +/- 1.03 |
| | 7/2/2019 | 0.00 +/- 0.49 | 2.13 +/- 1.10 |
| | 8/6/2019 | 1.22 +/- 0.65 | 1.46 +/- 1.02 |
| | 9/4/2019 | 0.31 +/- 0.60 | 1.47 +/- 1.03 |
| | 10/8/2019 | 0.32 +/- 0.62 | 0.90 +/- 1.04 |
| | 11/5/2019 | 1.82 +/- 0.75 | 3.48 +/- 1.10 |
| | 12/3/2019 | 0.26 +/- 0.51 | 1.55 +/- 0.99 |

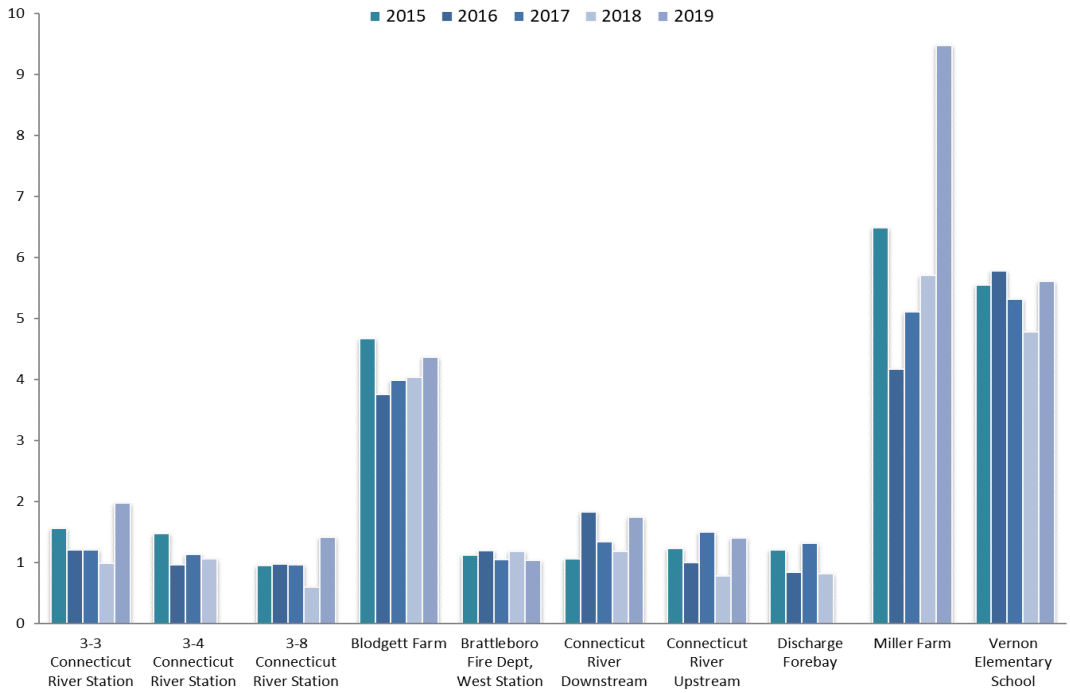
**Table 13. 2019 Total Alpha and Beta Radioactivity Water Results (continued)**

| Sample Location | Date of Sample | Total Alpha Radioactivity +/- error (pCi/L) | Total Beta Radioactivity +/- error (pCi/L) |
|---|---|---|---|
| Miller Farm | 1/8/2019 | -0.09 +/- 0.50 | 6.77 +/- 1.18 |
| | 2/5/2019 | 0.58 +/- 0.62 | 9.60 +/- 1.33 |
| | 3/5/2019 | 0.09 +/- 0.43 | 8.91 +/- 1.30 |
| | 4/9/2019 | 0.20 +/- 0.42 | 8.82 +/- 1.43 |
| | 5/7/2019 | 0.12 +/- 0.59 | 9.48 +/- 1.31 |
| | 6/4/2019 | 0.20 +/- 0.44 | 8.88 +/- 1.32 |
| | 7/2/2019 | -0.04 +/- 0.49 | 10.20 +/- 1.30 |
| | 8/6/2019 | 0.70 +/- 0.46 | 12.90 +/- 1.40 |
| | 9/4/2019 | 0.53 +/- 0.41 | 9.27 +/- 1.32 |
| | 10/8/2019 | 0.67 +/- 0.52 | 10.50 +/- 1.40 |
| | 11/5/2019 | 0.25 +/- 0.45 | 9.45 +/- 1.32 |
| | 12/3/2019 | 0.56 +/- 0.43 | 8.91 +/- 1.27 |
| Vernon Elementary School | 1/8/2019 | 7.69 +/- 1.28 | 6.09 +/- 1.15 |
| | 2/5/2019 | 8.59 +/- 1.47 | 5.64 +/- 1.20 |
| | 3/5/2019 | 7.08 +/- 1.16 | 5.41 +/- 1.18 |
| | 4/9/2019 | 7.60 +/- 1.17 | 3.70 +/- 1.20 |
| | 5/7/2019 | 7.54 +/- 1.42 | 5.97 +/- 1.19 |
| | 6/4/2019 | 7.89 +/- 1.21 | 5.39 +/- 1.20 |
| | 7/2/2019 | 6.47 +/- 1.12 | 7.83 +/- 1.31 |
| | 8/6/2019 | 5.82 +/- 1.04 | 5.21 +/- 1.17 |
| | 9/4/2019 | 10.50 +/- 1.30 | 5.87 +/- 1.20 |
| | 10/8/2019 | 9.10 +/- 1.32 | 4.97 +/- 1.20 |
| | 11/5/2019 | 8.07 +/- 1.25 | 6.42 +/- 1.21 |
| | 12/3/2019 | 8.68 +/- 1.52 | 4.80 +/- 1.13 |
| GZ-11S | 11/7/2019 | 0.32 +/- 0.28 | 2.22 +/- 0.47 |
| GZ-12S | 11/7/2019 | 0.67 +/- 0.49 | 2.67 +/- 1.15 |
| GZ-13D | 11/7/2019 | 8.73 +/- 1.28 | 11.10 +/- 1.50 |
| GZ-13S | 11/7/2019 | 1.65 +/- 0.65 | 3.37 +/- 1.16 |

## Figure 4. 2015-2019 Average Alpha Radioactivity in Water




## Figure 5. 2015-2019 Average Beta Radioactivity in Water



## Water Tritium Results

In 2019, the Health Department Laboratory tested 223 drinking, ground and surface (Connecticut River) water samples from off-site and on-site locations for tritium. No tritium was detected from any off-site water sample, including Connecticut River samples, in 2019. The Health Department Laboratory's lower limit of detection for tritium is 500 picocuries per liter. All tritium data are presented in Appendix B.

### Table 14. 2019 Water Sample Locations, Number of Tritium Tests

| | |
|---|---|
| **Wells near Vermont Yankee** | |
| Blodgett Farm | 24 |
| Brattleboro Fire Department, West Station | 21 |
| Miller Farm | 24 |
| Residence - 1 | 21 |
| Vernon Elementary School | 24 |
| Vernon Green Nursing Home | 24 |
| **Connecticut River Sample Sites** | |
| 3-3 Connecticut River Station | 12 |
| 3-4 Connecticut River Station | 10 |
| 3-8 Connecticut River Station | 12 |
| Discharge Forebay | 10 |
| Connecticut River Downstream | 24 |
| Connecticut River Upstream | 21 |
| **On-Site Wells** | |
| WVN0201 | 3 |
| WVN0202 | 3 |
| WVN0203 | 3 |
| WVN0204 | 3 |
| Total number of samples tested for tritium | 239 |

## Water Gamma Spectroscopy Results

A total of 223 drinking, ground and surface (Connecticut River) water samples were collected from both off-site and on-site locations in 2019 for gamma-emitting materials. No radioactive materials other than naturally-occurring were identified in any water sample collected in 2019. The Health Department calculated limits of detection for gamma-emitting materials are listed in Table 8. All results are presented in Appendix C.

In 2019, all off-site water sample locations showed no significant dose impact from activities at Vermont Yankee for total alpha, total beta, tritium and gamma spectroscopy, and VDH dose limits were not exceeded. No human-made radioactive elements were measured in water samples in 2019.

# Food Chain Sampling Results

Monitoring the food chain involves direct monitoring of some foods such as milk and fish. It also involves testing the soil and sediment that supports land and aquatic species, as well as natural vegetation.

For 2019:

- 20 milk samples were tested for iodine-131 and gamma-emitting materials
- 3 soil samples were tested for gamma-emitting materials
- 3 vegetation samples were tested for gamma-emitting materials
- 36 Connecticut River sediment samples were tested for gamma-emitting materials
- 4 fish samples collected in the Connecticut River were tested for gamma-emitting materials

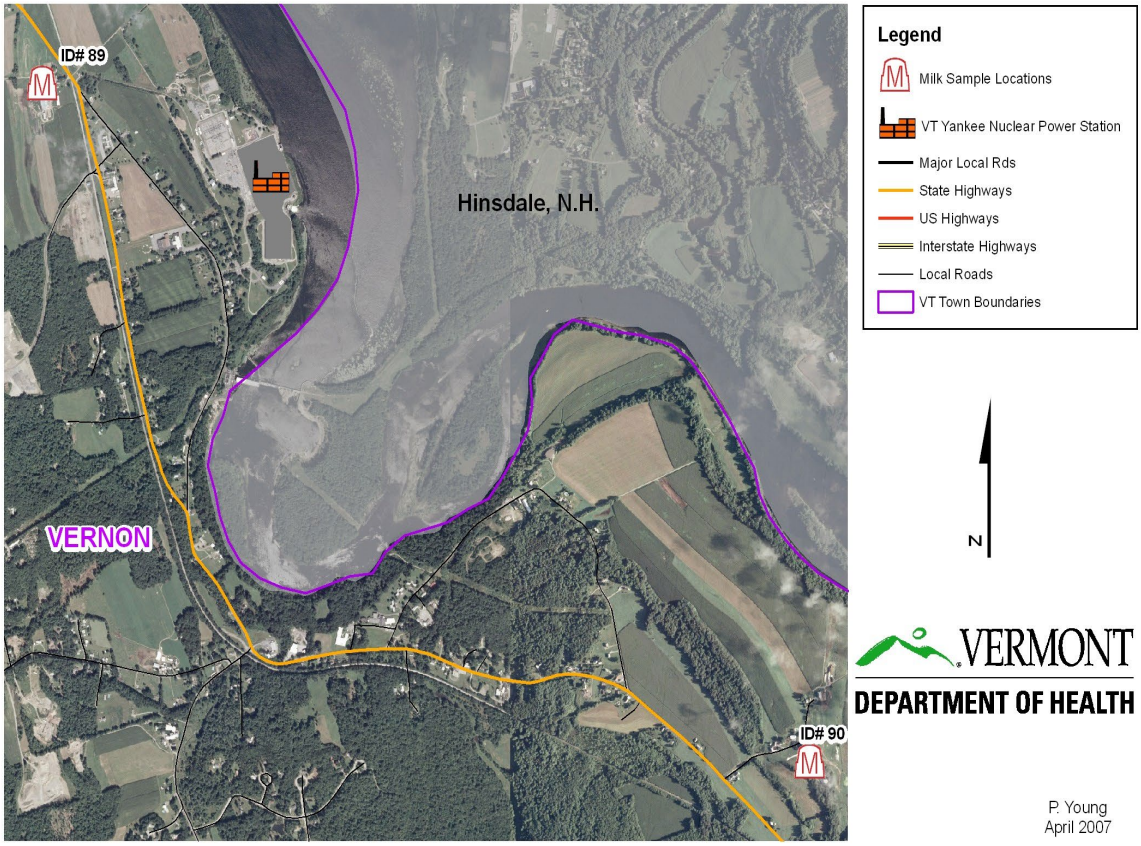
## Milk Sample Results

Cows' raw milk is sampled monthly from two farms in Vernon. One farm is about one-half mile north of Vermont Yankee and the other is about three miles south of Vermont Yankee. Map 9 shows the locations of these two dairy farms.

Potassium-40 (K-40) was the only radioactive material found in milk samples. Potassium-40 is a primordial radioactive material with a half-life of 1.28 billion years. Primordial radioactive materials are those created with the formation of the earth. In 2019 potassium-40 was detected in all milk samples. Results are shown in Table 15. The potassium-40 results for all milk samples range from 1,180 to 1,600 picocuries per liter (pCi/L), and fall within the historical range of 1,200 to 2,000 pCi/L. The average potassium-40 result in 2019 was 1,349 pCi/L. No iodine-131 (I-131) was found in any milk sample in 2019.

## Map 9

Environmental Radiation Surveillance Stations
Milk Sample Locations




| Sample Location | Map ID |
|---|---|
| Miller Farm | 89 |
| Blodgett Farm | 90 |

### Table 15. 2019 Milk Iodine-131 and Gamma Spectroscopy Results

| Sample Location | Date of Sample | Iodine-131 Result | Gamma Spectrometry Result | Potassium-40 Result +/- error (pCi/L) |
|---|---|---|---|---|
| Blodgett Farm | 1/8/2019 | < LLD | Natural | 1340 +/- 310 |
| | 2/5/2019 | < LLD | Natural | 1280 +/- 290 |
| | 3/5/2019 | < LLD | Natural | 1230 +/- 280 |
| | 5/7/2019 | < LLD | Natural | 1180 +/- 270 |
| | 6/4/2019 | < LLD | Natural | 1360 +/- 300 |
| | 7/2/2019 | < LLD | Natural | 1380 +/- 300 |
| | 9/4/2019 | < LLD | Natural | 1380 +/- 300 |
| | 10/8/2019 | < LLD | Natural | 1310 +/- 210 |
| | 11/5/2019 | < LLD | Natural | 1420 +/- 220 |
| | 12/3/2019 | < LLD | Natural | 1250 +/- 200 |
| Miller Farm | 2/5/2019 | < LLD | Natural | 1380 +/- 320 |
| | 3/5/2019 | < LLD | Natural | 1340 +/- 310 |
| | 4/9/2019 | < LLD | Natural | 1390 +/- 320 |
| | 5/7/2019 | < LLD | Natural | 1310 +/- 300 |
| | 6/4/2019 | < LLD | Natural | 1320 +/- 300 |
| | 7/2/2019 | < LLD | Natural | 1340 +/- 310 |
| | 9/4/2019 | < LLD | Natural | 1290 +/- 300 |
| | 10/8/2019 | < LLD | Natural | 1460 +/- 230 |
| | 11/5/2019 | <LLD | Natural | 1420 +/- 240 |
| | 12/3/2019 | < LLD | Natural | 1600 +/- 250 |

< LLD = Less than the laboratory's Lower Limit of Detection

Natural = gamma-emitting materials measured are not related to nuclear reactions

## Soil and Vegetation Sample Results

Three soil samples were collected in the state. The results are shown in Table 16. The soil contained measurable amounts of beryllium-7, potassium-40 and cesium-137, at levels similar to historical values for Vermont and the area around Vermont Yankee. Beryllium-7 and potassium-40 are naturally-occurring, while cesium-137 is related to fallout from above-ground weapons testing and global nuclear incidents like Chernobyl.

### Table 16. 2019 Soil Gamma Spectroscopy Results

| Sample Location | Date of Sample | Beryllium-7 +/- error (pCi/kg) | Potassium-40 +/- error (pCi/kg) | Cesium-137 +/- error (pCi/kg) |
|---|---|---|---|---|
| Waterbury Soil Sample 1 | 10/23/2019 | < LLD | 11900 +/- 2100 | 98.5 +/- 16.8 |
| Waterbury Soil Sample 2 | 10/23/2019 | 649 +/- 151 | 14600 +/- 2500 | 49.7 +/- 13.9 |
| Waterbury Soil Sample 3 | 10/23/2019 | 614 +/- 140 | 9050 +/- 1610 | < LLD |
| Windham County Historical Range | 2009-2018 | < LLD-512 | 7660-17400 | < LLD-1090 |
| < LLD = Less than the laboratory's Lower Limit of Detection | | | | |

Three vegetation samples were taken in October 2019. Results are presented in Table 17. Potassium-40 and beryllium-7 were detected in the vegetation samples. Both are naturally-occurring. No other gamma-emitting materials were detected.

### Table 17. 2019 Vegetation Gamma Spectroscopy Results

| Sample Location | Date of Sample | Beryllium-7 +/- error (pCi/kg) | Potassium-40 +/- error (pCi/kg) |
|---|---|---|---|
| Waterbury Vegetation Sample 1 | 10/23/2019 | 3540 +/- 490 | 8670 +/- 1570 |
| Waterbury Vegetation Sample 2 | 10/23/2019 | 3180 +/- 650 | 4430 +/- 1270 |
| Waterbury Vegetation Sample 3 | 10/23/2019 | 3810 +/- 610 | 7200 +/- 1400 |
| Windham County Historical Range | 2009-2018 | < LLD-11900 | < LLD-7740 |
| < LLD = Less than the laboratory's Lower Limit of Detection | | | |

## Sediment Sample Results

Sediment samples were collected from the bottom of the Connecticut River. The sediment samples were taken from four areas of the Connecticut River: Station 3-3 (south of Vernon Dam), Station 3-4 (near Vermont Yankee discharge), Station 3-8 (upstream near the Route 9 Bridge) and the North Storm Drain area. In 1997, the North Storm Drain area was identified as having been contaminated with cobalt-60 from Vermont Yankee operations. The North Storm Drain area is sampled at 15 distinct locations: S-1, S-2, T-1, T-2, T-3, U-1, U-2, U-3, U-4, V-3, V-4, V-5, W-4, W-5 and X-5. These sample locations are shown in Map 10. Prior to 2016, cobalt-60 was last detected in a sediment sample obtained and tested in 2005. Cobalt-60 (Co-60) was detected in three samples collected in October 2016 and in two samples collected in May 2019.

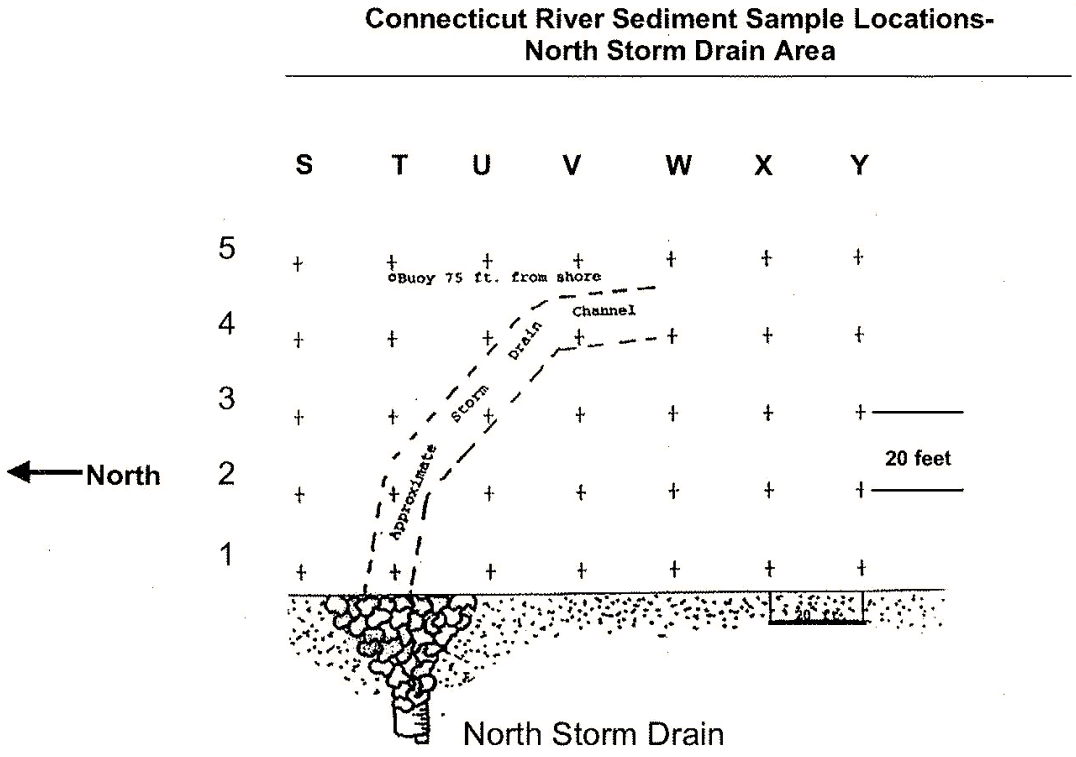
All sediment locations are sampled each spring and fall. A sediment sample is taken with a mass ranging from 0.2 to 0.5 kilograms. Sediment samples are dried and tested by

gamma spectroscopy. Tested sediments contained naturally-occurring beryllium-7 (Be-7) and potassium-40 (K-40) as well as cesium-137 (Cs-137), which is related mostly to fallout from above-ground weapons testing and global nuclear incidents like Chernobyl and Fukushima. The results are presented in Table 19. Concentrations of beryllium-7, potassium-40, cesium-137 and cobalt-60 were within historical ranges for Vermont. Comparisons to previous years' data are presented in Figures 6 and 7.

**Table 18. 2019 Sediment Gamma Spectroscopy Ranges as Compared to Historical Ranges**

| Radioactive Element | 2019 Sediment Concentration Range (pCi/kg) | Historical Sediment Concentration Range (pci/kg) |
|---|---|---|
| Beryllium-7 | < LLD-884 | < LLD-3,000 |
| Potassium-40 | 9,880-27,300 | 6,000-30,400 |
| Cesium-137 | < LLD-123 | < LLD-500 |
| Cobalt-60 | < LLD-117 | < LLD-335* |
| < LLD = Less than the Laboratory's Lower Limit of Detection | | |
| *Range of Cobalt-60 concentration in samples collected in 2005 | | |

## Map 10

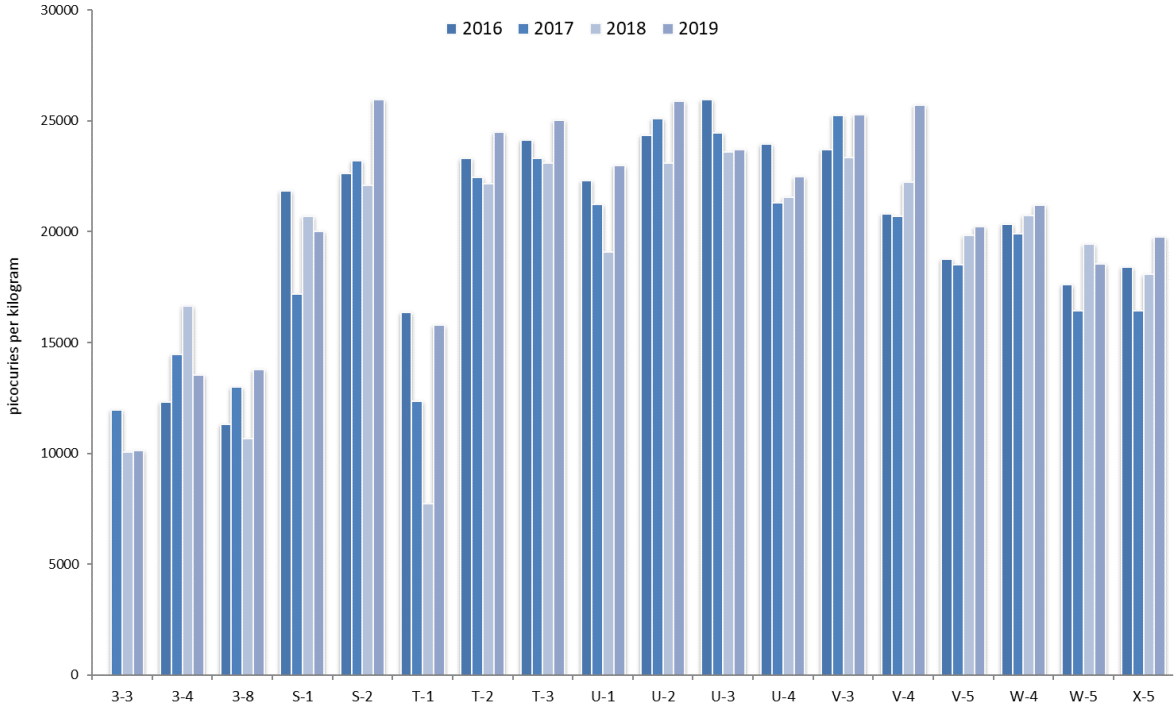

Connecticut River Sediment Sample Locations-
North Storm Drain Area
S
T
U
V
W
X
Y
5
4
3
2
1
North
Buoy 75 ft. from shore
Channel
Storm Drain
Approximate
20 feet
North Storm Drain

## Table 19. 2019 Sediment Gamma Spectroscopy Results

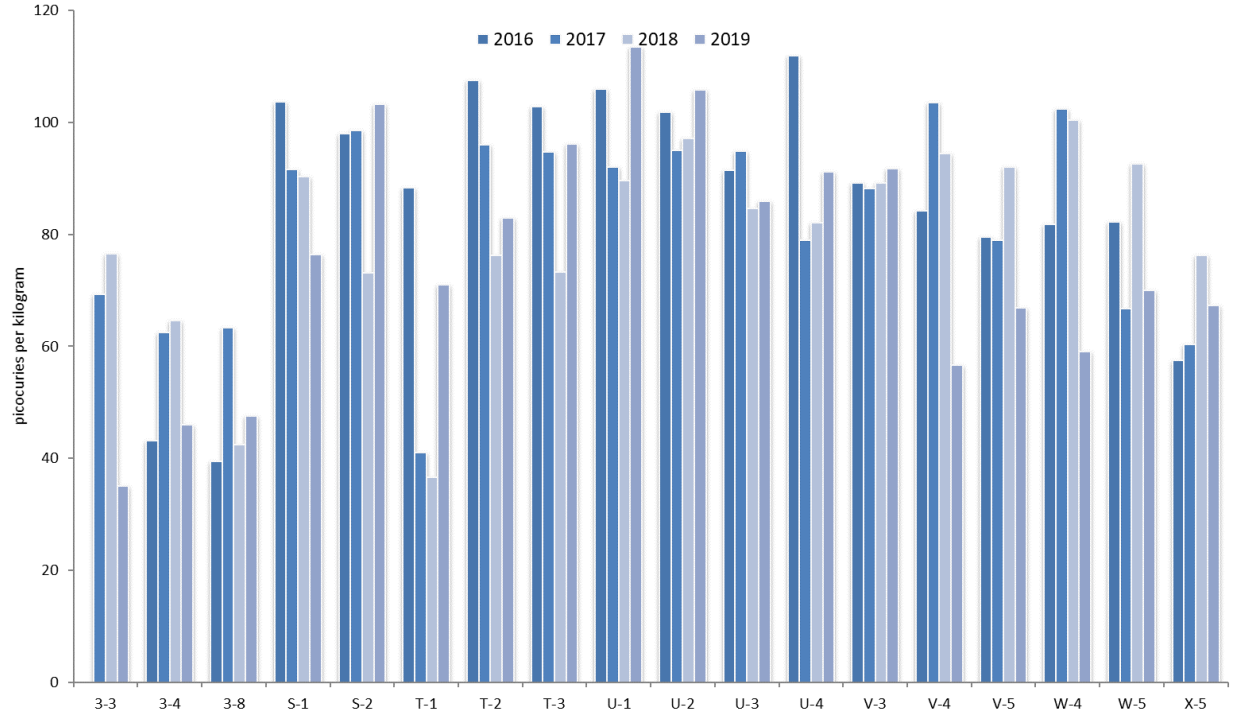
| Sample Location | Date of Sample | Beryllium-7 Result +/- error (pCi/kg) | Potassium-40 Result +/- error (pCi/kg) | Cesium-137 Result +/- error (pCi/kg) | Cobalt-60 Result +/- error (pCi/kg) |
|---|---|---|---|---|---|
| 3-3 | 5/14/2019 | < LLD | 10,400 +/- 1,900 | 35.0 +/- 13.7 | < LLD |
| 3-4 | 5/14/2019 | 427 +/- 132 | 13,400 +/- 2,300 | 44.5 +/- 14.0 | < LLD |
| 3-8 | 5/6/2019 | < LLD | 13,700 +/- 2,400 | 38.1 +/- 14.2 | < LLD |
| S-1 | 5/14/2019 | < LLD | 15,300 +/- 2,700 | 50.9 +/- 14.2 | < LLD |
| S-2 | 5/14/2019 | < LLD | 27,200 +/- 4,700 | 112 +/- 27.0 | < LLD |
| T-1 | 5/14/2019 | < LLD | 15,800 +/- 2,800 | 63.9 +/- 18.6 | 73.2 +/- 16.9 |
| T-2 | 5/14/2019 | < LLD | 25,300 +/- 4,400 | 83.4 +/- 25.2 | < LLD |
| T-3 | 5/14/2019 | < LLD | 27,000 +/- 4,700 | 109 +/- 27.0 | < LLD |
| U-1 | 5/14/2019 | < LLD | 23,600 +/- 4,100 | 123 +/- 26.0 | 117 +/- 24.0 |
| U-2 | 5/14/2019 | < LLD | 24,900 +/- 4,300 | 89.5 +/- 25.4 | < LLD |
| U-3 | 5/14/2019 | < LLD | 23,900 +/- 4,200 | 91.7 +/- 25.0 | < LLD |
| U-4 | 5/14/2019 | < LLD | 23,300 +/- 4,100 | 85.1 +/- 26.3 | < LLD |
| V-3 | 5/14/2019 | < LLD | 25,400 +/- 4,500 | 106 +/- 29.0 | < LLD |
| V-4 | 5/14/2019 | < LLD | 24,100 +/- 4,200 | 56.6 +/- 20.8 | < LLD |
| V-5 | 5/14/2019 | 433 +/- 189 | 19,100 +/- 3,300 | 83.0 +/- 20.6 | < LLD |
| W-4 | 5/14/2019 | < LLD | 23,100 +/- 4,000 | 66.6 +/- 21.7 | < LLD |
| W-5 | 5/14/2019 | < LLD | 18,300 +/- 3,200 | 67.9 +/- 19.8 | < LLD |
| X-5 | 5/14/2019 | < LLD | 19,700 +/- 3,400 | 62.1 +/- 18.8 | < LLD |
| 3-3 | 9/24/2019 | < LLD | 9,880 +/- 1,730 | < LLD | < LLD |
| 3-4 | 9/23/2019 | < LLD | 13,700 +/- 2,400 | 47.5 +/- 12.9 | < LLD |
| 3-8 | 9/23/2019 | < LLD | 13,900 +/- 2,400 | 56.9 +/- 16.0 | < LLD |
| S-1 | 9/23/2019 | < LLD | 24,700 +/- 4,300 | 102 +/- 24.0 | < LLD |
| S-2 | 9/23/2019 | < LLD | 24,700 +/- 4,300 | 94.4 +/- 23.9 | < LLD |
| T-1 | 9/23/2019 | < LLD | 15,800 +/- 2,800 | 78.0 +/- 18.4 | < LLD |
| T-2 | 9/23/2019 | < LLD | 23,700 +/- 4,100 | 82.4 +/- 24.3 | < LLD |
| T-3 | 9/23/2019 | < LLD | 23,100 +/- 4,000 | 83.4 +/- 21.3 | < LLD |
| U-1 | 9/23/2019 | < LLD | 22,400 +/- 3,900 | 104 +/- 27.0 | < LLD |
| U-2 | 9/23/2019 | < LLD | 26,900 +/- 4,700 | 122 +/- 31.0 | < LLD |
| U-3 | 9/23/2019 | < LLD | 23,500 +/- 4,100 | 80.1 +/- 24.5 | < LLD |
| U-4 | 9/23/2019 | 884 +/- 330 | 21,700 +/- 3,800 | 97.2 +/- 22.4 | < LLD |
| V-3 | 9/23/2019 | < LLD | 25,200 +/- 4,400 | 77.4 +/- 24.2 | < LLD |
| V-4 | 9/23/2019 | < LLD | 27,300 +/- 4,800 | < LLD | < LLD |
| V-5 | 9/23/2019 | < LLD | 21,400 +/- 3,700 | 50.8 +/- 19.0 | < LLD |
| W-4 | 9/23/2019 | < LLD | 19,300 +/- 3,400 | 51.6 +/- 17.6 | < LLD |
| W-5 | 9/23/2019 | < LLD | 18,800 +/- 3,300 | 72.0 +/- 18.6 | < LLD |
| X-5 | 9/23/2019 | < LLD | 19,800 +/- 3,500 | 72.4 +/- 21.0 | < LLD |

< LLD = Less than the laboratory's Lower Limit of Detection

## Figure 6. 2016-2019 Average Potassium-40 Levels in Sediment




## Figure 7. 2016-2019 Average Cesium-137 Levels in Sediment



## Fish Sample Results

Each year, fish are collected at two sites in the Connecticut River by an environmental contractor. One site is near the Vermont Yankee discharge and the other site is about nine miles upstream from Vermont Yankee, where the Route 9 Bridge crosses the Connecticut River.

The Health Department Laboratory tests fish samples for gamma-emitting materials. Fish gamma spectroscopy results are presented in Table 20.

Potassium-40, a naturally-occurring radioactive material was measured in all Connecticut River fish sampled in 2019. Samples of fish taken in 2011 from Lake Carmi and in 2012 from Lakes Bomoseen and Hortonia contained levels of cesium-137 between 23.3 and 73.9 pCi/kg, indicating that the radionuclide is related to fallout from weapons testing and global incidents. Cesium-137 was not found in any Connecticut River fish sampled in 2019.

### Table 20. 2019 Connecticut River Fish Gamma Spectroscopy Results

| Month Sample Collected | Sample Location | Potassium-40 +/- error (pCi/kg) | Cesium-137 +/- error (pCi/kg) |
|---|---|---|---|
| May 2019 | Near VY Discharge | 686 ± 157 | < LLD |
| | Upstream of VY | 1,040 ± 240 | < LLD |
| September 2019 | Near VY Discharge | 3,940 ± 620 | < LLD |
| | Upstream of VY | 3,620 ± 570 | < LLD |
| < LLD means less than the Laboratory's Lower Limit of Detection | | | |

---

In 2019, no radioactivity in food chain inputs was measured above historical and background ranges. Radioactivity measured in the food chain inputs can be attributed to either natural sources or human-made sources released in above-ground weapons testing or global nuclear incidents.

---

# List of Tables

# List of Figures

# List of Maps

# *Appendix A*

## 2019 Air Filter Data for Total Alpha & Beta Radioactivity

Alpha and beta radioactivity results for all air filter samples tested by the Health Department in 2019 are provided in this appendix. Results are presented in order by sampling date.

| Sample Location | Date of Sample | Total Alpha Radioactivity +/- error (pCi/$m^3$) | Total Beta Radioactivity +/- error (pCi/$m^3$) |
|---|---|---|---|
| 108 Cherry St Burlington | 1/8/2019 | 0.000936 +/- 0.000154 | 0.011 +/- 0.0004 |
| D & E Tree | 1/8/2019 | 0.00136 +/- 0.00021 | 0.0182 +/- 0.0006 |
| Dummerston IFO | 1/8/2019 | 0.00106 +/- 0.0002 | 0.0194 +/- 0.0006 |
| Guilford Town Garage | 1/8/2019 | 0.00146 +/- 0.00021 | 0.0183 +/- 0.0005 |
| Power Line Crossing | 1/8/2019 | 0.00166 +/- 0.0002 | 0.0166 +/- 0.0005 |
| Renaud/Puffer | 1/8/2019 | 0.00104 +/- 0.00019 | 0.0153 +/- 0.0005 |
| Vermont Courthouse | 1/8/2019 | 0.000998 +/- 0.00021 | 0.0142 +/- 0.0006 |
| Vermont State Police | 1/8/2019 | 0.000814 +/- 0.000154 | 0.0157 +/- 0.0005 |
| Vernon Elementary School | 1/8/2019 | 0.00168 +/- 0.00021 | 0.0186 +/- 0.0005 |
| Wilmington State Highway Garage | 1/8/2019 | 0.00118 +/- 0.00023 | 0.0122 +/- 0.0006 |
| 108 Cherry St Burlington | 2/6/2019 | 0.00129 +/- 0.00016 | 0.0119 +/- 0.0004 |
| D & E Tree | 2/5/2019 | 0.0012 +/- 0.00023 | 0.0128 +/- 0.0006 |
| Dummerston IFO | 2/5/2019 | 0.00124 +/- 0.00025 | 0.0165 +/- 0.0007 |
| Guilford Town Garage | 2/5/2019 | 0.00202 +/- 0.00027 | 0.02 +/- 0.0007 |
| Power Line Crossing | 2/5/2019 | 0.00146 +/- 0.00021 | 0.0161 +/- 0.0005 |
| Renaud/Puffer | 2/5/2019 | 0.00121 +/- 0.00022 | 0.0148 +/- 0.0006 |
| Vermont Courthouse | 2/5/2019 | 0.00133 +/- 0.00026 | 0.0136 +/- 0.0006 |
| Vermont State Police | 2/5/2019 | 0.00104 +/- 0.00019 | 0.0165 +/- 0.0006 |
| Vernon Elementary School | 2/5/2019 | 0.00146 +/- 0.00021 | 0.0185 +/- 0.0006 |
| Wilmington State Highway Garage | 2/5/2019 | 0.00111 +/- 0.00025 | 0.0123 +/- 0.0006 |
| 108 Cherry St Burlington | 3/5/2019 | 0.0000648 +/- 0.00006 | 0.000795 +/- 0.000143 |
| D & E Tree | 3/5/2019 | 0.00147 +/- 0.00026 | 0.0166 +/- 0.0007 |
| Dummerston IFO | 3/5/2019 | 0.00195 +/- 0.00035 | 0.0223 +/- 0.0009 |
| Guilford Town Garage | 3/5/2019 | 0.00203 +/- 0.00026 | 0.0204 +/- 0.0006 |
| Power Line Crossing | 3/5/2019 | 0.00177 +/- 0.00022 | 0.0179 +/- 0.0005 |
| Renaud/Puffer | 3/5/2019 | 0.000988 +/- 0.00021 | 0.0136 +/- 0.0006 |
| Vermont Courthouse | 3/5/2019 | 0.00121 +/- 0.00025 | 0.0161 +/- 0.0007 |
| Vermont State Police | 3/5/2019 | 0.000905 +/- 0.000179 | 0.0183 +/- 0.0006 |
| Vernon Elementary School | 3/5/2019 | 0.00162 +/- 0.00023 | 0.0199 +/- 0.0006 |
| Wilmington State Highway Garage | 3/5/2019 | 0.00196 +/- 0.00034 | 0.0163 +/- 0.0007 |
| 108 Cherry St Burlington | 4/2/2019 | 0.001 +/- 0.00016 | 0.0122 +/- 0.0004 |
| D & E Tree | 4/9/2019 | 0.0015 +/- 0.00024 | 0.0171 +/- 0.0006 |
| Dummerston IFO | 4/9/2019 | 0.00187 +/- 0.00027 | 0.0205 +/- 0.0007 |
| Guilford Town Garage | 4/9/2019 | 0.000797 +/- 0.000152 | 0.0158 +/- 0.0005 |
| Power Line Crossing | 4/9/2019 | 0.00161 +/- 0.0002 | 0.0151 +/- 0.0005 |
| Renaud/Puffer | 4/9/2019 | 0.00121 +/- 0.00021 | 0.0143 +/- 0.0005 |
| Vermont Courthouse | 4/9/2019 | 0.000994 +/- 0.00021 | 0.0142 +/- 0.0006 |
| Vermont State Police | 4/9/2019 | 0.00118 +/- 0.00018 | 0.0153 +/- 0.0005 |
| Vernon Elementary School | 4/9/2019 | 0.00166 +/- 0.00021 | 0.0171 +/- 0.0005 |
| Wilmington State Highway Garage | 4/9/2019 | 0.00136 +/- 0.00025 | 0.0145 +/- 0.0006 |

| Sample Location | Date of Sample | Total Alpha Radioactivity +/- error (pCi/$m^3$) | Total Beta Radioactivity +/- error (pCi/$m^3$) |
|---|---|---|---|
| 108 Cherry St Burlington | 5/7/2019 | 0.001 +/- 0.00015 | 0.0112 +/- 0.0004 |
| D & E Tree | 5/7/2019 | 0.00127 +/- 0.00025 | 0.011 +/- 0.0006 |
| Dummerston IFO | 5/7/2019 | 0.00127 +/- 0.00026 | 0.0141 +/- 0.0007 |
| Guilford Town Garage | 5/7/2019 | 0.000993 +/- 0.000186 | 0.0106 +/- 0.0005 |
| Power Line Crossing | 5/7/2019 | 0.00103 +/- 0.00018 | 0.00944 +/- 0.00043 |
| Renaud/Puffer | 5/7/2019 | 0.000888 +/- 0.000204 | 0.00944 +/- 0.00052 |
| Vermont Courthouse | 5/7/2019 | 0.000795 +/- 0.000218 | 0.00975 +/- 0.00059 |
| Vermont State Police | 5/7/2019 | 0.00086 +/- 0.000176 | 0.0115 +/- 0.0005 |
| Vernon Elementary School | 5/7/2019 | 0.000924 +/- 0.000183 | 0.0102 +/- 0.0005 |
| Wilmington State Highway Garage | 5/7/2019 | 0.001 +/- 0.00025 | 0.00913 +/- 0.00059 |
| 108 Cherry St Burlington | 6/4/2019 | 0.000659 +/- 0.000136 | 0.00967 +/- 0.00039 |
| D & E Tree | 6/4/2019 | 0.000354 +/- 0.00015 | 0.0111 +/- 0.0006 |
| Dummerston IFO | 6/4/2019 | 0.00107 +/- 0.00025 | 0.013 +/- 0.0006 |
| Guilford Town Garage | 6/4/2019 | 0.000523 +/- 0.000144 | 0.0108 +/- 0.0005 |
| Renaud/Puffer | 6/4/2019 | 0.000633 +/- 0.00018 | 0.00988 +/- 0.00052 |
| Vermont Courthouse | 6/4/2019 | 0.000482 +/- 0.00019 | 0.011 +/- 0.0006 |
| Vermont State Police | 6/4/2019 | 0.000604 +/- 0.000159 | 0.0117 +/- 0.0005 |
| Vernon Elementary School | 6/4/2019 | 0.000579 +/- 0.000151 | 0.0105 +/- 0.0005 |
| Wilmington State Highway Garage | 6/4/2019 | 0.000999 +/- 0.000252 | 0.0103 +/- 0.0006 |
| 108 Cherry St Burlington | 7/2/2019 | 0.000624 +/- 0.000136 | 0.0126 +/- 0.0005 |
| D & E Tree | 7/2/2019 | 0.000852 +/- 0.000211 | 0.0125 +/- 0.0006 |
| Dummerston IFO | 7/2/2019 | 0.0013 +/- 0.00027 | 0.0169 +/- 0.0007 |
| Guilford Town Garage | 7/2/2019 | 0.000761 +/- 0.000172 | 0.0122 +/- 0.0005 |
| Renaud/Puffer | 7/2/2019 | 0.000798 +/- 0.000195 | 0.0113 +/- 0.0005 |
| Vermont Courthouse | 7/2/2019 | 0.00128 +/- 0.00027 | 0.0131 +/- 0.0007 |
| Vermont State Police | 7/2/2019 | 0.000677 +/- 0.000166 | 0.0133 +/- 0.0005 |
| Vernon Elementary School | 7/2/2019 | 0.000854 +/- 0.000177 | 0.0132 +/- 0.0005 |
| Wilmington State Highway Garage | 7/2/2019 | 0.00122 +/- 0.00027 | 0.0121 +/- 0.0007 |
| 108 Cherry St Burlington | 8/6/2019 | 0.000938 +/- 0.000141 | 0.0142 +/- 0.0004 |
| D & E Tree | 8/6/2019 | 0.000426 +/- 0.000135 | 0.0174 +/- 0.0006 |
| Dummerston IFO | 8/6/2019 | 0.00174 +/- 0.00027 | 0.0221 +/- 0.0007 |
| Vermont Courthouse | 8/6/2019 | 0.00112 +/- 0.00022 | 0.0141 +/- 0.0006 |
| Vermont State Police | 8/6/2019 | 0.0013 +/- 0.00019 | 0.0189 +/- 0.0005 |
| Vernon Elementary School | 8/6/2019 | 0.0012 +/- 0.00018 | 0.0182 +/- 0.0005 |
| Wilmington State Highway Garage | 8/6/2019 | 0.00166 +/- 0.00027 | 0.0178 +/- 0.0007 |

| Sample Location | Date of Sample | Total Alpha Radioactivity +/- error (pCi/$m^3$) | Total Beta Radioactivity +/- error (pCi/$m^3$) |
|---|---|---|---|
| 108 Cherry St Burlington | 9/3/2019 | 0.00108 +/- 0.00017 | 0.0167 +/- 0.0005 |
| D & E Tree | 9/4/2019 | 0.000944 +/- 0.000222 | 0.0186 +/- 0.0007 |
| Dummerston IFO | 9/4/2019 | 0.00192 +/- 0.00033 | 0.0196 +/- 0.0008 |
| Guilford Town Garage | 9/4/2019 | 0.00135 +/- 0.00021 | 0.0173 +/- 0.0006 |
| Vermont Courthouse | 9/4/2019 | 0.00559 +/- 0.00211 | 0.036 +/- 0.0043 |
| Vermont State Police | 9/4/2019 | 0.00109 +/- 0.00021 | 0.0169 +/- 0.0006 |
| Vernon Elementary School | 9/4/2019 | 0.00116 +/- 0.0002 | 0.0182 +/- 0.0006 |
| Wilmington State Highway Garage | 9/4/2019 | 0.00125 +/- 0.00027 | 0.0166 +/- 0.0007 |
| 108 Cherry St Burlington | 10/1/2019 | 0.00194 +/- 0.00023 | 0.0183 +/- 0.0005 |
| D & E Tree | 10/8/2019 | 0.00167 +/- 0.00027 | 0.0191 +/- 0.0007 |
| Dummerston IFO | 10/8/2019 | 0.00248 +/- 0.00035 | 0.0229 +/- 0.0008 |
| Guilford Town Garage | 10/8/2019 | 0.00119 +/- 0.00019 | 0.0186 +/- 0.0006 |
| Vermont Courthouse | 10/8/2019 | 0.00188 +/- 0.0003 | 0.0165 +/- 0.0007 |
| Vermont State Police | 10/8/2019 | 0.00162 +/- 0.00023 | 0.017 +/- 0.0006 |
| Vernon Elementary School | 10/8/2019 | 0.00204 +/- 0.00024 | 0.0174 +/- 0.0005 |
| Wilmington State Highway Garage | 10/8/2019 | 0.00187 +/- 0.0003 | 0.0157 +/- 0.0007 |
| 108 Cherry St Burlington | 11/5/2019 | 0.00112 +/- 0.00016 | 0.0144 +/- 0.0004 |
| D & E Tree | 11/5/2019 | 0.00131 +/- 0.00027 | 0.0144 +/- 0.0007 |
| Dummerston IFO | 11/5/2019 | 0.00142 +/- 0.00031 | 0.019 +/- 0.0008 |
| Guilford Town Garage | 11/5/2019 | 0.00119 +/- 0.00021 | 0.0156 +/- 0.0006 |
| Power Line Crossing | 11/5/2019 | 0.00107 +/- 0.00019 | 0.015 +/- 0.0005 |
| Vermont Courthouse | 11/5/2019 | 0.00106 +/- 0.00025 | 0.0143 +/- 0.0007 |
| Vermont State Police | 11/5/2019 | 0.00115 +/- 0.00021 | 0.0157 +/- 0.0006 |
| Vernon Elementary School | 11/5/2019 | 0.00118 +/- 0.0002 | 0.0151 +/- 0.0005 |
| Wilmington State Highway Garage | 11/5/2019 | 0.00125 +/- 0.00028 | 0.0136 +/- 0.0007 |
| 108 Cherry St Burlington | 12/3/2019 | 0.00129 +/- 0.00017 | 0.0177 +/- 0.0005 |
| D & E Tree | 12/3/2019 | 0.00174 +/- 0.00031 | 0.0178 +/- 0.0008 |
| Dummerston IFO | 12/3/2019 | 0.00186 +/- 0.00034 | 0.0217 +/- 0.0009 |
| Guilford Town Garage | 12/3/2019 | 0.00117 +/- 0.00021 | 0.0183 +/- 0.0006 |
| Power Line Crossing | 12/3/2019 | 0.00139 +/- 0.00021 | 0.0163 +/- 0.0006 |
| Vermont Courthouse | 12/3/2019 | 0.00134 +/- 0.00026 | 0.0159 +/- 0.0007 |
| Vermont State Police | 12/3/2019 | 0.00138 +/- 0.00023 | 0.0166 +/- 0.0006 |
| Vernon Elementary School | 12/3/2019 | 0.00154 +/- 0.00023 | 0.0169 +/- 0.0006 |
| Wilmington State Highway Garage | 12/3/2019 | 0.00141 +/- 0.00027 | 0.016 +/- 0.0007 |

pCi/m3 is picocurie per cubic meter of air volume

*Data in italics were qualified due to sampling issues.*

# Appendix B

## 2019 Tritium Water Data

Tritium results for all water samples tested by the Health Department in 2019 are provided in this appendix. Results are presented in order by sample location and by sampling date.

The Health Department's Lower Limit of Detection for tritium is 500 picocuries per liter (pCi/L).

| Sample Location | Date of Sample | Tritium Result +/- error (pCi/L) |
|---|---|---|
| 3-3 Connecticut River Station | 1/14/2019 | < 500 |
| | 2/16/2019 | < 500 |
| | 3/13/2019 | < 500 |
| | 4/16/2019 | < 500 |
| | 5/16/2019 | < 500 |
| | 6/13/2019 | < 500 |
| | 7/16/2019 | < 500 |
| | 8/14/2019 | < 500 |
| | 9/16/2019 | < 500 |
| | 10/14/2019 | < 500 |
| | 11/13/2019 | < 500 |
| | 12/16/2019 | < 500 |
| 3-8 Connecticut River Station | 1/14/2019 | < 500 |
| | 2/16/2019 | < 500 |
| | 3/13/2019 | < 500 |
| | 4/16/2019 | < 500 |
| | 5/16/2019 | < 500 |
| | 6/13/2019 | < 500 |
| | 7/16/2019 | < 500 |
| | 8/14/2019 | < 500 |
| | 9/16/2019 | < 500 |
| | 11/13/2019 | < 500 |
| | 12/16/2019 | < 500 |
| Connecticut River, Downstream | 1/8/2019 | < 500 |
| | 1/22/2019 | < 500 |
| | 2/5/2019 | < 500 |
| | 2/19/2019 | < 500 |
| | 3/5/2019 | < 500 |
| | 3/19/2019 | < 500 |
| | 4/9/2019 | < 500 |
| | 4/23/2019 | < 500 |
| | 5/7/2019 | < 500 |
| | 5/20/2019 | < 500 |
| | 6/4/2019 | < 500 |
| | 6/18/2019 | < 500 |
| | 7/2/2019 | < 500 |
| | 7/23/2019 | < 500 |
| | 8/6/2019 | < 500 |
| | 8/20/2019 | < 500 |

| Sample Location | Date of Sample | Tritium Result +/- error (pCi/L) |
|---|---|---|
| Connecticut River, Downstream (continued) | 9/4/2019 | < 500 |
| | 9/17/2019 | < 500 |
| | 10/8/2019 | < 500 |
| | 10/22/2019 | < 500 |
| | 11/5/2019 | < 500 |
| | 11/18/2019 | < 500 |
| | 12/3/2019 | < 500 |
| | 12/16/2019 | < 500 |
| Connecticut River, Upstream | 1/8/2019 | < 500 |
| | 1/22/2019 | < 500 |
| | 2/19/2019 | < 500 |
| | 3/5/2019 | < 500 |
| | 3/19/2019 | < 500 |
| | 4/9/2019 | < 500 |
| | 4/23/2019 | < 500 |
| | 5/7/2019 | < 500 |
| | 5/20/2019 | < 500 |
| | 6/4/2019 | < 500 |
| | 6/18/2019 | < 500 |
| | 7/2/2019 | < 500 |
| | 7/23/2019 | < 500 |
| | 8/6/2019 | < 500 |
| | 8/20/2019 | < 500 |
| | 9/4/2019 | < 500 |
| | 9/17/2019 | < 500 |
| | 10/8/2019 | < 500 |
| | 10/22/2019 | < 500 |
| | 11/5/2019 | < 500 |
| | 11/18/2019 | < 500 |
| | 12/3/2019 | < 500 |
| | 12/16/2019 | < 500 |
| GZ-11S | 11/7/2019 | < 500 |
| GZ-12S | 11/7/2019 | < 500 |
| GZ-12D | 11/7/2019 | < 500 |
| GZ-13S | 11/7/2019 | < 500 |
| WVN0201 | 4/17/2019 | < 500 |
| | 8/13/2019 | < 500 |
| | 11/4/2019 | < 500 |

| Sample Location | Date of Sample | Tritium Result +/- error (pCi/L) |
|---|---|---|
| WVN0202 | 4/17/2019 | < 500 |
| | 8/13/2019 | < 500 |
| | 11/4/2019 | < 500 |
| WVN0203 | 4/17/2019 | < 500 |
| | 8/13/2019 | < 500 |
| | 11/4/2019 | < 500 |
| WVN0204 | 4/17/2019 | < 500 |
| | 8/13/2019 | < 500 |
| | 11/4/2019 | < 500 |
| Blodgett Farm | 1/8/2019 | < 500 |
| | 1/22/2019 | < 500 |
| | 2/5/2019 | < 500 |
| | 2/19/2019 | < 500 |
| | 3/5/2019 | < 500 |
| | 3/19/2019 | < 500 |
| | 4/9/2019 | < 500 |
| | 4/23/2019 | < 500 |
| | 5/7/2019 | < 500 |
| | 5/20/2019 | < 500 |
| | 6/4/2019 | < 500 |
| | 6/18/2019 | < 500 |
| | 7/2/2019 | < 500 |
| | 7/23/2019 | < 500 |
| | 8/6/2019 | < 500 |
| | 8/20/2019 | < 500 |
| | 9/4/2019 | < 500 |
| | 9/17/2019 | < 500 |
| | 10/8/2019 | < 500 |
| | 10/22/2019 | < 500 |
| | 11/5/2019 | < 500 |
| | 11/18/2019 | < 500 |
| | 12/3/2019 | < 500 |
| | 12/16/2019 | < 500 |
| Brattleboro Fire Dept, West Station | 1/8/2019 | < 500 |
| | 2/5/2019 | < 500 |
| | 2/19/2019 | < 500 |
| | 3/5/2019 | < 500 |
| | 3/19/2019 | < 500 |

| Sample Location | Date of Sample | Tritium Result +/- error (pCi/L) |
|---|---|---|
| Brattleboro Fire Dept, West Station (continued) | 4/9/2019 | < 500 |
| | 4/23/2019 | < 500 |
| | 5/7/2019 | < 500 |
| | 5/20/2019 | < 500 |
| | 6/4/2019 | < 500 |
| | 6/18/2019 | < 500 |
| | 7/2/2019 | < 500 |
| | 7/23/2019 | < 500 |
| | 8/6/2019 | < 500 |
| | 9/4/2019 | < 500 |
| | 10/8/2019 | < 500 |
| | 10/22/2019 | < 500 |
| | 11/5/2019 | < 500 |
| | 11/18/2019 | < 500 |
| | 12/3/2019 | < 500 |
| | 12/16/2019 | < 500 |
| Miller Farm | 1/8/2019 | < 500 |
| | 1/22/2019 | < 500 |
| | 2/5/2019 | < 500 |
| | 2/19/2019 | < 500 |
| | 3/5/2019 | < 500 |
| | 3/19/2019 | < 500 |
| | 4/9/2019 | < 500 |
| | 4/23/2019 | < 500 |
| | 5/7/2019 | < 500 |
| | 5/20/2019 | < 500 |
| | 6/4/2019 | < 500 |
| | 6/18/2019 | < 500 |
| | 7/2/2019 | < 500 |
| | 7/23/2019 | < 500 |
| | 8/6/2019 | < 500 |
| | 8/20/2019 | < 500 |
| | 9/4/2019 | < 500 |
| | 9/17/2019 | < 500 |
| | 10/8/2019 | < 500 |
| | 10/22/2019 | < 500 |
| | 11/5/2019 | < 500 |
| | 11/18/2019 | < 500 |
| | 12/3/2019 | < 500 |
| | 12/16/2019 | < 500 |

| Sample Location | Date of Sample | Tritium Result +/- error (pCi/L) |
|---|---|---|
| Residence - 1 | 1/8/2019 | < 500 |
| | 1/22/2019 | < 500 |
| | 2/5/2019 | < 500 |
| | 3/5/2019 | < 500 |
| | 4/9/2019 | < 500 |
| | 4/23/2019 | < 500 |
| | 5/7/2019 | < 500 |
| | 5/20/2019 | < 500 |
| | 6/4/2019 | < 500 |
| | 6/18/2019 | < 500 |
| | 7/2/2019 | < 500 |
| | 7/23/2019 | < 500 |
| | 8/6/2019 | < 500 |
| | 8/20/2019 | < 500 |
| | 9/4/2019 | < 500 |
| | 9/17/2019 | < 500 |
| | 10/8/2019 | < 500 |
| | 10/22/2019 | < 500 |
| | 11/5/2019 | < 500 |
| | 12/16/2019 | < 500 |
| Vernon Elementary School | 1/8/2019 | < 500 |
| | 1/22/2019 | < 500 |
| | 2/5/2019 | < 500 |
| | 3/5/2019 | < 500 |
| | 3/19/2019 | < 500 |
| | 4/9/2019 | < 500 |
| | 4/23/2019 | < 500 |
| | 5/7/2019 | < 500 |
| | 5/20/2019 | < 500 |
| | 6/4/2019 | < 500 |
| | 6/18/2019 | < 500 |
| | 7/2/2019 | < 500 |
| | 7/23/2019 | < 500 |
| | 8/6/2019 | < 500 |
| | 8/20/2019 | < 500 |
| | 9/4/2019 | < 500 |
| | 9/17/2019 | < 500 |

| Sample Location | Date of Sample | Tritium Result +/- error (pCi/L) |
|---|---|---|
| Vernon Elementary School (continued) | 10/8/2019 | < 500 |
| | 10/22/2019 | < 500 |
| | 11/5/2019 | < 500 |
| | 11/18/2019 | < 500 |
| | 12/3/2019 | < 500 |
| | 12/16/2019 | < 500 |
| Vernon Green Nursing Home | 1/8/2019 | < 500 |
| | 1/22/2019 | < 500 |
| | 2/5/2019 | < 500 |
| | 2/19/2019 | < 500 |
| | 3/5/2019 | < 500 |
| | 3/19/2019 | < 500 |
| | 4/9/2019 | < 500 |
| | 4/23/2019 | < 500 |
| | 5/7/2019 | < 500 |
| | 5/20/2019 | < 500 |
| | 6/4/2019 | < 500 |
| | 6/18/2019 | < 500 |
| | 7/2/2019 | < 500 |
| | 7/23/2019 | < 500 |
| | 8/6/2019 | < 500 |
| | 8/20/2019 | < 500 |
| | 9/4/2019 | < 500 |
| | 9/17/2019 | < 500 |
| | 10/8/2019 | < 500 |
| | 10/22/2019 | < 500 |
| | 11/5/2019 | < 500 |
| | 11/18/2019 | < 500 |
| | 12/3/2019 | < 500 |
| | 12/16/2019 | < 500 |
| pCi/L = picocuries per liter | | |

# *Appendix C*

## 2019 Gamma Spectroscopy Water Data

Gamma spectroscopy data for all water samples tested by the Health Department in 2019 are provided in this appendix. Results are presented in order by sample location and by sampling date.

"Natural" means that gamma-emitting materials detected are not related to nuclear power stations or above-grounds weapons testing.

< LLD means less than the Laboratory's Lower Limit of Detection.

| Sample Location | Date of Sample | Gamma Spectroscopy Result |
|---|---|---|
| 3-3 Connecticut River Station | 1/14/2019 | <LLD |
| | 2/16/2019 | <LLD |
| | 3/13/2019 | <LLD |
| | 4/16/2019 | <LLD |
| | 5/16/2019 | <LLD |
| | 6/13/2019 | <LLD |
| | 7/16/2019 | <LLD |
| | 8/14/2019 | <LLD |
| | 9/16/2019 | <LLD |
| | 10/14/2019 | <LLD |
| | 11/13/2019 | <LLD |
| | 12/16/2019 | <LLD |
| 3-8 Connecticut River Station | 1/14/2019 | <LLD |
| | 2/16/2019 | <LLD |
| | 3/13/2019 | <LLD |
| | 4/16/2019 | <LLD |
| | 5/16/2019 | <LLD |
| | 6/13/2019 | <LLD |
| | 7/16/2019 | <LLD |
| | 8/14/2019 | <LLD |
| | 9/16/2019 | <LLD |
| | 10/14/2019 | Natural |
| | 11/13/2019 | <LLD |
| | 12/16/2019 | <LLD |
| Connecticut River, Downstream | 1/8/2019 | <LLD |
| | 1/22/2019 | <LLD |
| | 2/5/2019 | <LLD |
| | 2/19/2019 | <LLD |
| | 3/5/2019 | <LLD |
| | 3/19/2019 | <LLD |
| | 4/9/2019 | <LLD |
| | 4/23/2019 | <LLD |
| | 5/7/2019 | <LLD |
| | 5/20/2019 | <LLD |
| | 6/4/2019 | <LLD |
| | 6/18/2019 | <LLD |
| | 7/2/2019 | <LLD |
| | 7/23/2019 | <LLD |
| | 8/6/2019 | <LLD |

| Sample Location | Date of Sample | Gamma Spectroscopy Result |
|---|---|---|
| Connecticut River, Downstream (continued) | 8/20/2019 | <LLD |
| | 9/4/2019 | <LLD |
| | 9/17/2019 | <LLD |
| | 10/8/2019 | <LLD |
| | 10/22/2019 | <LLD |
| | 11/5/2019 | <LLD |
| | 11/18/2019 | <LLD |
| | 12/3/2019 | <LLD |
| | 12/16/2019 | <LLD |
| Connecticut River, Upstream | 1/8/2019 | <LLD |
| | 1/22/2019 | <LLD |
| | 2/19/2019 | <LLD |
| | 3/5/2019 | <LLD |
| | 3/19/2019 | <LLD |
| | 4/9/2019 | <LLD |
| | 4/23/2019 | <LLD |
| | 5/7/2019 | <LLD |
| | 5/20/2019 | <LLD |
| | 6/4/2019 | <LLD |
| | 6/18/2019 | <LLD |
| | 7/2/2019 | <LLD |
| | 7/23/2019 | <LLD |
| | 8/6/2019 | <LLD |
| | 8/20/2019 | <LLD |
| | 9/4/2019 | <LLD |
| | 9/17/2019 | <LLD |
| | 10/8/2019 | <LLD |
| | 10/22/2019 | <LLD |
| | 11/5/2019 | <LLD |
| | 11/18/2019 | <LLD |
| | 12/3/2019 | <LLD |
| | 12/16/2019 | <LLD |
| GZ-11S | 11/7/2019 | <LLD |
| GZ-12S | 11/7/2019 | <LLD |
| GZ-13D | 11/7/2019 | <LLD |
| GZ-13S | 11/7/2019 | <LLD |
| WVN0201 | 4/17/2019 | Natural |
| | 8/13/2019 | Natural |
| | 11/4/2019 | Natural |

| Sample Location | Date of Sample | Gamma Spectroscopy Result |
|---|---|---|
| WVN0202 | 4/17/2019 | Natural |
| | 8/13/2019 | Natural |
| | 11/4/2019 | Natural |
| WVN0203 | 4/17/2019 | Natural |
| | 8/13/2019 | Natural |
| | 11/4/2019 | Natural |
| WVN0204 | 4/17/2019 | Natural |
| | 8/13/2019 | Natural |
| | 11/4/2019 | Natural |
| Blodgett Farm | 1/8/2019 | Natural |
| | 1/22/2019 | Natural |
| | 2/5/2019 | Natural |
| | 2/19/2019 | Natural |
| | 3/5/2019 | Natural |
| | 3/19/2019 | Natural |
| | 4/9/2019 | Natural |
| | 4/23/2019 | Natural |
| | 5/7/2019 | Natural |
| | 5/20/2019 | Natural |
| | 6/4/2019 | Natural |
| | 6/18/2019 | Natural |
| | 7/2/2019 | Natural |
| | 7/23/2019 | Natural |
| | 8/6/2019 | Natural |
| | 8/20/2019 | Natural |
| | 9/4/2019 | Natural |
| | 9/17/2019 | Natural |
| | 10/8/2019 | Natural |
| | 10/22/2019 | Natural |
| | 11/5/2019 | Natural |
| | 11/18/2019 | Natural |
| | 12/3/2019 | Natural |
| | 12/16/2019 | Natural |
| Brattleboro Fire Dept, West Station | 1/8/2019 | <LLD |
| | 2/5/2019 | <LLD |
| | 2/19/2019 | <LLD |
| | 3/5/2019 | <LLD |
| | 3/19/2019 | <LLD |
| | 4/9/2019 | <LLD |

| Sample Location | Date of Sample | Gamma Spectroscopy Result |
|---|---|---|
| Brattleboro Fire Dept, West Station (continued) | 4/23/2019 | <LLD |
| | 5/7/2019 | <LLD |
| | 5/20/2019 | <LLD |
| | 6/4/2019 | <LLD |
| | 6/18/2019 | <LLD |
| | 7/2/2019 | <LLD |
| | 7/23/2019 | <LLD |
| | 8/6/2019 | <LLD |
| | 9/4/2019 | <LLD |
| | 10/8/2019 | <LLD |
| | 10/22/2019 | <LLD |
| | 11/5/2019 | <LLD |
| | 11/18/2019 | <LLD |
| | 12/3/2019 | <LLD |
| | 12/16/2019 | <LLD |
| Miller Farm | 1/8/2019 | Natural |
| | 1/22/2019 | Natural |
| | 2/5/2019 | Natural |
| | 2/19/2019 | Natural |
| | 3/5/2019 | Natural |
| | 3/19/2019 | Natural |
| | 4/9/2019 | Natural |
| | 4/23/2019 | Natural |
| | 5/7/2019 | Natural |
| | 5/20/2019 | Natural |
| | 6/4/2019 | Natural |
| | 6/18/2019 | Natural |
| | 7/2/2019 | Natural |
| | 7/23/2019 | Natural |
| | 8/6/2019 | Natural |
| | 8/20/2019 | Natural |
| | 9/4/2019 | Natural |
| | 9/17/2019 | Natural |
| | 10/8/2019 | Natural |
| | 10/22/2019 | Natural |
| | 11/5/2019 | Natural |
| | 11/18/2019 | Natural |
| | 12/3/2019 | Natural |
| | 12/16/2019 | Natural |

| Sample Location | Date of Sample | Gamma Spectroscopy Result |
|---|---|---|
| Residence - 1 | 1/8/2019 | Natural |
| | 1/22/2019 | Natural |
| | 2/5/2019 | <LLD |
| | 3/5/2019 | Natural |
| | 4/9/2019 | <LLD |
| | 4/23/2019 | Natural |
| | 5/7/2019 | Natural |
| | 5/20/2019 | Natural |
| | 6/4/2019 | Natural |
| | 6/18/2019 | Natural |
| | 7/2/2019 | Natural |
| | 7/23/2019 | Natural |
| | 8/6/2019 | Natural |
| | 8/20/2019 | Natural |
| | 9/4/2019 | Natural |
| | 9/17/2019 | Natural |
| | 10/8/2019 | Natural |
| | 10/22/2019 | Natural |
| | 11/5/2019 | Natural |
| | 12/16/2019 | <LLD |
| Vernon Elementary School | 1/8/2019 | Natural |
| | 1/22/2019 | Natural |
| | 2/5/2019 | Natural |
| | 3/5/2019 | Natural |
| | 3/19/2019 | Natural |
| | 4/9/2019 | Natural |
| | 4/23/2019 | Natural |
| | 5/7/2019 | Natural |
| | 5/20/2019 | Natural |
| | 6/4/2019 | Natural |
| | 6/18/2019 | Natural |
| | 7/2/2019 | <LLD |
| | 7/23/2019 | Natural |
| | 8/6/2019 | <LLD |
| | 8/20/2019 | Natural |
| | 9/4/2019 | Natural |
| | 9/17/2019 | Natural |

| Sample Location | Date of Sample | Gamma Spectroscopy Result |
|---|---|---|
| Vernon Elementary School (continued) | 10/8/2019 | Natural |
| | 10/22/2019 | Natural |
| | 11/5/2019 | Natural |
| | 11/18/2019 | Natural |
| | 12/3/2019 | Natural |
| | 12/16/2019 | Natural |
| Vernon Green Nursing Home | 1/8/2019 | Natural |
| | 1/22/2019 | Natural |
| | 2/5/2019 | Natural |
| | 2/19/2019 | Natural |
| | 3/5/2019 | Natural |
| | 3/19/2019 | Natural |
| | 4/9/2019 | Natural |
| | 4/23/2019 | Natural |
| | 5/7/2019 | Natural |
| | 5/20/2019 | Natural |
| | 6/4/2019 | Natural |
| | 6/18/2019 | Natural |
| | 7/2/2019 | Natural |
| | 7/23/2019 | Natural |
| | 8/6/2019 | Natural |
| | 8/20/2019 | Natural |
| | 9/4/2019 | Natural |
| | 9/17/2019 | Natural |
| | 10/8/2019 | Natural |
| | 10/22/2019 | Natural |
| | 11/5/2019 | Natural |
| | 11/18/2019 | Natural |
| | 12/3/2019 | Natural |
| < LLD means less than the Laboratory's Lower Limit of Detection | | |