VERMONT
DEPARTMENT OF HEALTH

Tritium – Laboratory Testing & Results

Investigation into Tritium Contamination at Vermont Yankee

Since January 7, 2010 the Vermont Department of Health has stepped up its environmental surveillance of Vermont Yankee by testing water samples taken from drinking water wells and ground water monitoring wells on site at the plant, and in the surrounding area. Water is being sampled at least weekly for independent testing. Other samples, such as soil, milk, river sediment, and vegetation (when available), are being taken for testing as needed.

Tritium & Gamma Spectroscopy Test Results

Independent test results for tritium and gamma spectroscopy. The Vermont Department of Health uses gamma spectroscopy analysis to determine if other radioisotopes - in addition to tritium - are present in samples collected from and around Vermont Yankee site.

Incorporated into our "Investigation Update," this is a list of test results from Vermont Yankee of on-site and off-site drinking water well samples, as well as water taken from the Connecticut River. Results continue to show no tritium in excess of the lower limit of detection (<LLD). No on-site or off-site wells show any other radioactive materials related to nuclear power plant operations.

Connecticut River Fish Tests and Results

As part of ongoing environmental surveillance around Vermont Yankee, the Health Department tests and reports on fish from two locations in the Connecticut River (9 miles upstream of the plant, and at a location outside the Vermont Yankee discharge).
Fish are tested either as a whole fish, or split into edible and inedible portions. The Health Department tests the fish for hard-to-detects and gamma-emitting materials.
Fish types tested were yellow perch, pumpkinseed, bluegill and large and small mouth bass.

Gamma Spectroscopy and Hard-to-Detects

2011 Test Results

2011 Connecticut River Fish Hard-to-Detect Results

Month Sample Collected	Location Sampled	Edible (flesh)				Inedible (bones, head, scales, guts)			
		Iron-55 +/- error (pCi/kg)	Nickel-63 +/- error (pCi/kg)	Strontium-89 +/- error (pCi/kg)	Strontium-90 +/- error (pCi/kg)	Iron-55 +/- error (pCi/kg)	Nickel-63 +/- error (pCi/kg)	Strontium-89 +/- error (pCi/kg)	Strontium-90 +/- error (pCi/kg)
April 2011	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD
	Upstream of VY	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	48 +/- 34
	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD
	Upstream of VY	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	85 +/-29
May 2011	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD
	Upstream of VY	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	69 +/-38
June 2011	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	53 +/-18
	Upstream of VY	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD
July 2011	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	54 +/-17
	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD
	Upstream of VY	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD
August 2011	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD
	Upstream of VY	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	63+/-32
September 2011	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD
	Upstream of VY	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	56+/-33
October 2011	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD
	Upstream of VY	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD
November 2011	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD
	Upstream of VY	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	60 +/- 19

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

2011 Connecticut River Fish Gamma Spectroscopy Results					
Month Sample Collected	Location Sampled	Edible (flesh)		Inedible (bones, head, scales, guts)	
		Potassium-40 +/- error (pCi/kg)	Cesium-137 +/- error (pCi/kg)	Potassium-40 +/- error (pCi/kg)	Cesium-137 +/- error (pCi/kg)
April 2011	Near VY Discharge	3,360 +/- 725	< LLD	3,220 +/- 439	< LLD
	Upstream of VY	2,830 +/- 626	< LLD	2,740 +/-451	< LLD
May 2011	Near VY Discharge	2,520 +/- 471	< LLD	2,660+/- 461	< LLD
	Upstream of VY	2,570 +/- 824	< LLD	2,370 +/- 398	< LLD
June 2011	Near VY Discharge	3,170 +/- 507	< LLD	2,130 +/- 348	< LLD
	Upstream of VY	2,650 +/- 640	< LLD	2,860 +/- 388	< LLD
July 2011	Near VY Discharge	3,930 +/- 1027	< LLD	2,560 +/- 889	< LLD
	Near VY Discharge	2,790 +/- 369	< LLD	2,280 +/- 310	14 +/- 7
	Upstream of VY	3,360 +/- 673	< LLD	2,290 +/- 320	< LLD
August 2011	Near VY Discharge	2,560 +/- 396	< LLD	2,290 +/- 434	< LLD
	Upstream of VY	2,710 +/- 358	< LLD	2,430 +/- 362	< LLD
September 2011	Near VY Discharge	3,160 +/- 428	< LLD	2,310 +/- 307	< LLD
	Upstream of VY	3,140 +/- 384	< LLD	2,780+/- 402	< LLD
October 2011	Near VY Discharge	3,890 +/- 469	25 +/- 9	2,610 +/- 387	< LLD
	Upstream of VY	3,530 +/- 457	17 +/- 9	2,320 +/- 404	< LLD
November 2011	Near VY Discharge	3,090 +/- 426	< LLD	2,050 +/- 299	< LLD
	Upstream of VY	3,480 +/- 426	< LLD	2,230 +/- 312	< LLD
< LLD means less than the Laboratory's Lower Limit of Detection					

2010 Test Results

2010 Connecticut River Fish Gamma Spectroscopy Results							
Month Sample Collected	Location Sampled	Edible (flesh) [1]		Inedible (bones, head, scales, guts) [1]		Whole fish [2]	
		Potassium-40 +/- error (pCi/kg)	Cesium-137 +/- error (pCi/kg)	Potassium-40 +/- error (pCi/kg)	Cesium-137 +/- error (pCi/kg)	Potassium-40 +/- error (pCi/kg)	Cesium-137 +/- error (pCi/kg)
February 2010	Near VY Discharge					2,500 +/- 460	< LLD
	Upstream of VY					2,260 +/- 420	< LLD
Apr/May 2010	Near VY Discharge					2,090 +/- 400	< LLD
	Upstream of VY					2,640 +/- 520	< LLD
July 2010	Near VY Discharge	2,630 +/- 298	11 +/- 7	2,980 +/- 361	15 +/- 10		
	Upstream of VY	2,150+/- 510	< LLD	2,680 +/- 408	< LLD		
September 2010	Near VY Discharge	3,610 +/- 428	18 +/- 12	2,730 +/- 365	< LLD		
	Upstream of VY	3,490 +/- 434	21 +/- 9	3,100 +/- 403	< LLD		
October 2010	Near VY Discharge					2,610 +/- 470	< LLD
	Upstream of VY					2,880 +/- 510	< LLD
November 2010	Near VY Discharge	2,990 +/- 744	< LLD	2,850 +/- 528	< LLD		
	Upstream of VY	3,700 +/- 708	< LLD	2,410 +/- 403	< LLD		
< LLD means less than the Laboratory's Lower Limit of Detection							
[1] Edible and Inedible fish portions were tested by contract laboratory							
[2] Whole fish were tested by the Health Department Laboratory							

2010 Connecticut River Fish Hard-to-Detect Results										
Month Sample Collected	Location Sampled	Edible (flesh)				Inedible (bones, head, scales, guts)				
		Iron-55 +/- error (pCi/kg)	Nickel-63 +/- error (pCi/kg)	Strontium-89 +/- error (pCi/kg)	Strontium-90 +/- error (pCi/kg)	Iron-55 +/- error (pCi/kg)	Nickel-63 +/- error (pCi/kg)	Strontium-89 +/- error (pCi/kg)	Strontium-90 +/- error (pCi/kg)	
February 2010	Near VY Discharge	N/A	N/A	N/A	< LLD	N/A	N/A	N/A	47 +/- 16	
	Upstream of VY	N/A	N/A	N/A	< LLD	N/A	N/A	N/A	30 +/- 17	
Apr/May 2010	Near VY Discharge	N/A	N/A	N/A	< LLD	N/A	N/A	N/A	50 +/- 18	
	Upstream of VY	N/A	N/A	N/A	< LLD	N/A	N/A	N/A	77 +/- 16	
June 2010	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	84 +/- 34	
	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	
	Upstream of VY	< LLD	< LLD	< LLD	58 +/- 35	< LLD	< LLD	< LLD	255 +/- 48	
July 2010	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	
	Upstream of VY	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	65 +/- 37	
August 2010	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	
	Upstream of VY	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	28 +/- 19	
September 2010	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	
	Upstream of VY	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	51 +/- 35	
October 2010	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	
	Upstream of VY	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	101 +/- 31	
November 2010	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	
	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	
	Upstream of VY	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	
	Upstream of VY	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	79 +/- 32	
< LLD means less than the Laboratory's Lower Limit of Detection N/A = samples were not analyzed for Fe-55, Ni-63, Sr-89										

Results Summary:

- Potassium-40, cesium-137 and strontium-90 were measured in the fish in 2010 and 2011.
- Potassium-40, a naturally occurring radionuclide, was detected in all fish tested by gamma spectroscopy with a range between 2000-4000 pCi/kg (picocuries per kilogram).
- Cesium-137 was measured in both edible and inedible portions of fish in the range of 11-25 pCi/kg. The cesium-137 results are within the historical range of less than the lower limit of detection to 100 pCi/kg.
- No historical range has been established for strontium-90 in Vermont fish. The levels measured in the inedible fractions range from less than lower limit of detection to 255 pCi/kg. The average detected result of strontium-90 was 71 pCi/kg; the median value was 58 pCi/kg.
- To date, only one sample, collected in June 2010 and reported in August 2011 has had a detectable amount of strontium-90 in the edible portion.

Strontium-90

- On July 26, 2011, we received results from our contract laboratory for nine additional samples of fish samples taken since June 2010. No iron-55 or nickel-63 was detected in these samples. Similar to earlier results from the Wadsworth Laboratory, strontium-90 (Sr-90) was detected in most of the nine new samples. One finding of Sr-90 just above the lower limit of detection in one fish sample was notable because it was the first time Sr-90 had been detected in the edible portion of any of our fish samples.

Results of Hard-to-detect Analyses on Fish Collected in 2010-2011 from Connecticut River (Brattleboro/Vernon, VT)									
Date Sample Collected	Location Sampled	Edible (flesh)				Inedible (bones, head, scales, guts)			
		Iron-55 (pCi/kg)	Nickel-63 (pCi/kg)	Strontium-89 (pCi/kg)	Strontium-90 (pCi/kg)	Iron-55 (pCi/kg)	Nickel-63 (pCi/kg)	Strontium-89 (pCi/kg)	Strontium-90 (pCi/kg)
February 2010	Near VY Discharge	N/A	N/A	N/A	< LLD	N/A	N/A	N/A	47 +/- 16
	Upstream of VY	N/A	N/A	N/A	< LLD	N/A	N/A	N/A	30 +/- 17
Apr/May 2010	Near VY Discharge	N/A	N/A	N/A	< LLD	N/A	N/A	N/A	50 +/- 18
	Upstream of VY	N/A	N/A	N/A	< LLD	N/A	N/A	N/A	77 +/- 16
June 2010	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	84 +/- 34
	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD
	Upstream of VY	< LLD	< LLD	< LLD	58 +/- 35	< LLD	< LLD	< LLD	255 +/- 48
August 2010	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD
	Upstream of VY	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	28 +/- 19
October 2010	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD
	Upstream of VY	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	101 +/- 31
April 2011	Near VY Discharge	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD
	Upstream of VY	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	85 +/- 29

<LLD = less than lower limit of detection

N/A = samples were not analyzed for Iron-55, Nickel-63, Strontium-89

- Independent analysis results for Strontium-90 for two sets of fish. For each collection, one set of fish was collected several miles upstream of Vermont Yankee and one set of fish was collected just outside of Vermont Yankee

Fish Data Comparison: Strontium-90				
Collection Information			VDH-Contracted: Concentration (pCi/kg)	VY-contract: Concentration (pCi/kg)
Early February	Edible	Upstream from VY	< LLD	< LLD
		Near VY	< LLD	< LLD
	Inedible	Upstream from VY	30	58.8
		Near VY	47	< LLD
Early Spring	Edible	Upstream from VY	< LLD	< LLD
		Near VY	< LLD	< LLD
	Inedible	Upstream from VY	77	109, 103 (spl tested twice)
		Near VY	50	62.4, 69.5 (spl tested twice)

<LLD = less than lower limt of detection

Lake Carmi - Connecticut River Fish Data Comparison

Results of fish collected from Lake Carmi in 2011 show the levels of radioactive materials, both naturally-occurring and human-made were similar to those in fish collected from the Connecticut River in 2010 and 2011. Low levels of cesium-137 and naturally-occurring potassium-40 were found in all the fish tested, in both edible and inedible (bone, guts) portions. Low levels of strontium-90 were found only in the inedible portion of the fish.

Vermont Department of Health
-- Fish Results --
February 9, 2012

Edible Portion Average Result (pCi/kg)

Radionuclide	Lake Carmi	(number of positive results, number of tests)	2010-2011 Connecticut River	(number of positive results, number of tests)	2010-2011 Connecticut River Range
Potassium-40	2,630	(2,2)	3,080	(21, 21)	2,153 - 3,933
Cesium-137	52.8	(2,2)	18.5	(5, 21)	less than detection limit -25.2
Strontium-90	none detected	(0,2)	57.6	(1, 36)	less than detection limit - 58

Inedible Portion Average Result (pCi/kg)

Radionuclide	Lake Carmi	(number of positive results, number of tests)	2010-2011 Connecticut River	(number of positive results, number of tests)	2010-2011 Connecticut River Range
Potassium-40	2,310	(2,2)	2,600	(21, 21)	2,126 - 3,218
Cesium-137	33.6	(2,2)	14.5	(2, 21)	less than detection limit - 15.2
Strontium-90	54.6	(2,2)	68.7	(20, 36)	less than detection limit - 255

pCi/kg: picocuries per kilogram
Results reported on wet weight
Cesium-137 detection limit is 10 pCi/kg (approximate)
Strontium-90 detection limit is 50 pCi/kg (approximate)

Updated 02/09/2012

Updated Feb. 10, 2012: replaced preliminary data comparison with final.

Lake Carmi was selected as a collection site because the Department of Fish and Wildlife was already sampling the lake at a time when we needed samples from water unaffected by nuclear power plants.

The Lake Carmi fish provide a baseline measure of radioactive materials that are expected as a result of historical above-ground weapons testing and global nuclear incidents. The levels of radioactive materials are similar to what has been documented in the U.S. diet and do not pose a health risk.

Tritium Concentration Graphs

These graphs present Vermont Yankee laboratory measurements of tritium concentrations in samples collected from certain groundwater monitoring wells on site at the plant that have shown the highest measurements of tritium, expressed in picocuries per liter (pCi/l).

Well GZ-10 is close to the site of the major leak that was identified and stopped on February 14, 2010. All evidence points to this site as the major pathway for tritium entering the groundwater.
Results from groundwater samples may change over time, depending on the initial concentration of tritium, the volume of water, and the movement of the groundwater. Groundwater in this area generally flows east to the Connecticut River. Once a tritium leak is stopped, we can expect changes in the test results. Tritium test results from a well that is mid-way between the leak and the river would increase, peak and then decline as the groundwater moves to the river.
The graphs are updated periodically.

Gamma Spectroscopy

Gamma Spectroscopy is an analytical method used by the Department of Health Laboratory to identify specific radioisotopes in a sample. Gamma spectroscopy measures energies and intensities of gamma radiation emitted from samples to identify specific radioisotopes. Each gamma radiation-emitting radioisotope has unique gamma radiation energies and intensities, like a fingerprint, allowing comparison of sample results to a library of known radioisotopes in the identification process.

Common Natural Gamma Radiation Emitters		
Actinium-228	Americium-241	Beryllium-7
Bismuth-212	Bismuth-214	Lead-210
Lead-212	Lead-214	Polonium-210
Potassium-40	Protactinium-234m	Radium-224
Radium-226	Radium-228	Radon-222
Technetium-99	Thallium-208	Thorium-228
Thorium-229	Thorium-230	Thorium-231
Thorium-232	Thorium-234	Uranium-233
Uranium-234	Uranium-235	Uranium-238

Nuclear Facility Gamma Radiation Emitters		
Antimony-124	Antimony-126	Barium-140/ Lanthanum-140
Cerium-144/ Promethium-144	Cobalt-56	Cobalt-60
Chromium-51	Cesium-134	Cesium-136

Cesium-137	Iodine-131	Iodine-132
Iodine-133	Iodine-135	Krypton-85
Krypton-88	Manganese-54	Plutonium-239
Plutonium-240	Ruthenium-103	Strontium-85
Strontium-89	Tellurium-132	Xenon-133
Xenon-133m	Xenon-135	Zinc-65
Zirconium-95/Niobium-95		

Testing Your Drinking Water

Once every week, the Vermont Department of Health Laboratory is testing private drinking water supplies of selected residences near the Vermont Yankee site boundary.

To date, none of these wells have shown evidence of contamination with tritium or other radionuclides that would be associated with a nuclear reactor.