Evaluation of Neonicotinoid Seed Treatments in the Environment

VERMONT
AGENCY OF AGRICULTURE, FOOD & MARKETS

Image 1. Foraging honey bee

Over the past years, there has been a lot of concern raised about the use of neonicotinoid pesticides, both as products and as a seed treatment. To evaluate neonicotinoids in Vermont, the Agency has been conducting research focused on the potential impacts of seed treatments in the environment. There is a significant amount of research related to pollinator health and its potential relationship to neonicotinoid pesticides in other areas of the country and internationally; however, the Agency recognizes that agricultural systems can differ significantly and needed to identify potential environmental pathways in the state. Pathways evaluated were pollen (as it enters the hive), surface waters, soil, vegetation, and tile drain outlet water. The results of the studies are summarized here, and additional data are provided in the Appendix.

The Agency thanks the W.H. Miner Institute researchers in Chazy, New York for collecting and transporting research water samples to the Agency.

Neonicotinoids in Vermont

In Vermont, neonicotinoid pesticides enter the state as treated agricultural seed, pesticide products (for treating turf, ornamentals, and fruit trees), and pet care treatments (eg, flea collars, spot-on treatments). The class of neonicotinoid pesticides is a relatively new class of insecticides and is generally seen as a replacement for the more toxic organophosphate insecticides. Neonicotinoids are less toxic to human and mammalian health but can pose different exposure concerns for pollinators. The focus of these studies was to assess the agricultural impacts on the Vermont environment from treated seeds.

Most corn and soybean seed grown in Vermont are treated with a neonicotinoid(s) insecticide to protect seeds and young seedlings from insect pests. As neonicotinoids are systemic, they are absorbed into the plant; this protects the plant from insects that are chewing on it but can result in insecticides in pollen and nectar of the plants. Neonicotinoids, like most insecticides, are classified as highly toxic to honey bees.

Estimated annual acreage of treated seed planted in Vermont (2018)

- 100,000–120,000 acres of corn
- 7,500-10,000 acres of soybeans

Some treatments may not be taken up by the plant and will enter the environment (soil, water, non-target plants). Conventional corn seeds are usually treated with thiamethoxam and clothianidin. Soybeans are usually treated with imidacloprid. Vermont farms plant significantly more corn than soybean.

Aquatic environmental benchmarks for these three neonicotinoid pesticides (thiamethoxam, clothianidin, and imidacloprid) are shown in Table 1. The invertebrate benchmark values are the most conservative (restrictive) and thus are used for comparison in the water results in this report. Of note, thiamethoxam in the environment degrades into clothianidin. Also, the invertebrate chronic level for imidacloprid (0.01 ppb) is lower than the Vermont Agricultural and Environmental Laboratory's (VAEL) detection limit of 0.05 ppb.

Table 1. Aquatic environmental benchmarks in parts per billion

Pesticide	Year updated	Fish		Invertebrates		Nonvascular plants	Vascular plants
		Acute	*Chronic*	*Acute*	*Chronic*	*Acute*	*Acute*
Imidacloprid	2017	114,500	9,000	0.385	0.01	>10,000	-
Thiamethoxam	2017	>50,000	20,000	17.5	-	>97,000	>90,000
Clothianidin	2016	>50,750	9,700	11.0	1.1	64,000	121,000

All units *are* ug/L or parts per billion (ppb)
Data extracted 1/2018 and 11/2018

Vermont pollen studies

In 2012 and 2013, the Agency conducted a pollen study, as this was the most likely exposure to honey bees. During the growing seasons, pollen was collected weekly from two managed honey bee hives in Addison County. Hive 1 was located next to a hay field and Hive 2 was located near conventional corn fields. The collected pollen was brought to the State laboratory for testing (Appendix, Tables A1 and A2). Pollen collected after planting (week 6/11/12–6/15/12) from Hive 2 had an imidacloprid detection level of 0.70 ppb. No other pollen samples tested positive for imidacloprid. In 2013, Hive 2 was relocated but was still proximate to corn fields. Thiamethoxam and clothianidin were detected in pollen during corn planting. The source of the pollen was never determined.

Vermont surface water

The Agency has also tested surface water samples for neonicotinoids. As of this report, the Agency has tested 252 surface water samples for neonicotinoids from 2014 through 2018. Samples were taken from areas of expected high agricultural use (Appendix, Table A3). Three of 252 samples tested positive for imidacloprid. All detections were below the acute invertebrate benchmark level of 0.385 ppb. There were more detections of thiamethoxam and clothianidin, usually at the time of planting; the levels were also below their respective benchmark levels (Table 2).

Image 2. A surface water sampling site

Table 2. Summary of neonicotinoid results from surface water samples (n = 252)

Neonicotinoid	Positive detection	Detection range	Acute benchmark*	Chronic benchmark*	Results ≥ acute benchmark*
	#	ppb	ppb	ppb	#
Thiamethoxam	26	0.05–1.73	17.50	-	0
Clothianidin	25	0.05–1.37	11.00	1.10	0
Imidacloprid	3	0.05–0.20	0.385	0.01	0

*Aquatic invertebrates

Vermont tile drain outlet water

Image 3. Tile drain sampling location

The Agency also tested water samples from tile drains on the edge of cropped agricultural fields (Appendix, Tables A4 and A5). These samples are obtained from water draining from a tiled field. Of the seventy-eight tile drain water samples analyzed, 4 had levels of imidacloprid above the acute invertebrate benchmark; these were all found in fields next to soybeans (Table 3). In general, the highest levels were found during planting and decreased over the growing season.

Table 3. Summary of neonicotinoid results from tile drain water samples (n = 78)

Neonicotinoid	Positive detection	Detection range	Acute benchmark*	Chronic benchmark*	Results ≥ acute benchmark*
	#	ppb	ppb	ppb	#
Thiamethoxam	29	0.05–1.31	17.50	-	0
Clothianidin	61	0.05–4.17	11.00	1.10	0
Imidacloprid	12	0.09–1.12	0.385	0.01	4

*Aquatic invertebrates

Vermont soil

In 2016, as part of a research project looking at the environmental fate of pesticides in an area of high agricultural use, the Agency took soil samples near tile drain outlets where the water samples were taken (Appendix, Table A6). Soil cores were taken at three depths: 0–12 inches, 12 – 24 inches, and 24 –36 inches. There were several positive detections for neonicotinoids in the corn field soil samples, most during planting or early seedling growth, and all but one were in the 0–12-inch depth. The soybean field soil samples had imidacloprid detections.

Vermont vegetation

To determine whether any residual neonicotinoid pesticides were being taken up by plants in the surrounding area, vegetation samples were taken from vegetation at the surface water and tile drain outlet sampling sites in Franklin County, Vermont, 2015–2016 (Appendix, Table A7). A sample of corn leaves from treated seed was also taken as a positive control. Samples were brought to VAEL to be analyzed. There were no neonicotinoids detected in any of the offsite vegetation samples. The corn leaves tested positive for clothianidin (2.91 ppb), as expected.

Image 4. A vegetation sample taken from water sampling areas

New York subsurface and surface water

The Agency, with assistance from the William H. Miner Institute in Chazy, New York, used samples from an edge-of-field research project testing paired subsurface tile water and surface water samples for neonicotinoids. The study site was planted in corn and had been for the 5 years preceding the start of sampling. Thiamethoxam-treated corn seeds were planted and water samples were collected weekly when possible, based on the precipitation variability in 2017–2018 (Appendix, Table A8). Combined, there were 128 water samples collected and analyzed, 27 of which tested positive for neonicotinoids (Table 4). All 27 water samples had detections less than the acute benchmark levels for aquatic invertebrates. The highest levels of thiamethoxam (6.48 ppb) and clothianidin (0.40 ppb) were detected in surface water sampled during planting (6/6/17) after an extreme rain event. In general, the highest neonicotinoid levels were detected during planting and decreased over the growing season.

Table 4. Summary results from the subsurface and surface water samples analyzed for neonicotinoids, Chazy, NY (2017 and 2018). (n=128)

Neonicotinoid	Positive detection	Detection range	Acute benchmark*	Chronic benchmark*	Results ≥ Acute benchmark*
	#	ppb	ppb	ppb	#
Thiamethoxam	25	0.06 6.48	17.50	-	0
Clothianidin	13	0.08–0.40	11.00	1.10	0
Imidacloprid	0	<0.05	0.385	0.01	0

*Aquatic invertebrates

Appendix

Table A1. Pollen tested weekly for neonicotinoids from 2 honey bee hives, 2012

Sample ID: Hive 1 (Hay/Pasture)			
Sample week	Thiamethoxam (ppb)	Clothianidin (ppb)	Imidacloprid (ppb)
5/6/12 – 5/12/12	*	*	*
5/13/12 – 5/19/12	*	*	*
5/20/12 – 5/26/12	*	*	*
5/27/12 – 6/2/12	*	*	*
6/3/12 – 6/9/12	*	*	*
6/10/12 – 6/16/12	*	*	*
6/17/12 – 6/23/12	*	*	*
7/15/12 – 7/21/12	*	*	*
7/22/12 – 7/28/12	*	*	*
7/29/12 – 8/4/12	*	*	*
8/5/12 – 8/11/12	*	*	*
8/12/12 – 8/18/12	*	*	*
8/19/12 – 8/25/12	*	*	*
8/26/12 – 9/1/12	*	*	*
9/2/12 – 9/7/12	*	*	*
Sample ID: Hive 2 (conventional corn)			
6/11/12 – 6/15/12	*	*	0.70
6/18/12 – 6/22/12	*	*	*
6/25/12 – 7/2/12	*	*	*
7/9/12 – 7/13/12	*	*	*
7/16/12 – 7/20/12	*	*	*
7/25/12 – 8/1/12†	*	*	*
8/2/12 – 8/9/12†	*	*	*

Detection limit: 0.50–0.80 ppb

* Not detected

† Corn tasseling

Table A2. Pollen tested weekly for neonicotinoids from 2 honey bee hives.

Sample ID: Hive 1 (Hay / Pasture)			
Sample week	Thiamethoxam (ppb)	Clothianidin (ppb)	Imidacloprid (ppb)
5/5/13- 5/11/13	*	*	*
5/12/13 - 5/18/13	*	*	*
5/19/13 -5/25/13	*	*	*
5/26/13 - 6/1/13	*	*	*
6/2/13 - 6/8/13	*	*	*
6/9/13 - 6/15/13	*	*	*
6/16/13 - 6/22/13	*	*	*
6/23/13 - 6/29/13	*	*	*
7/7/13– 7/13/13	*	*	*
7/14/13 –7/20/13	*	*	*
7/21/13 – 7/27/13	*	*	*
7/28/13 – 8/3/13	*	*	*

8/4/13 – 8/10/13	*	*	*
8/11/13 – 8/17/13	*	*	*
8/18/13 – 8/24/13	*	*	*
Sample ID: Hive 2 (conventional corn) ‡			
5/11/13 – 5/14/13	0.80	6.20	*
5/15/13 – 5/18/13	1.20	*	*
5/19/13 – 5/23/13	*	*	*
5/24/13 – 6/3/13	*	*	*
6/4/13 – 6/5/13	*	*	*
6/6/13 – 6/19/13	*	*	*
6/20/13 – 7/3/13	*	*	*
7/4/13 – 7/7/13	*	*	*
7/8/13 – 7/18/13	*	*	*
7/24/13 – 7/31/13†	*	*	*
8/1/13 – 8/7/13†	*	*	*

Detection limit: 0.50–0.80 ppb
* Not detected
† Corn tasseling
‡ Different field of continuous corn

Table A3. Surface water samples analyzed for neonicotinoids throughout Vermont (2015-2018).

Sample site	County	Sample Date	Thiamethoxam (ppb)	Clothianidin (ppb)	Imidacloprid (ppb)
Alburgh Center (Lake Champlain)	Grand Isle	7/21/2016	*	*	*
		8/3/2016	*	*	*
		7/20/2017	*	*	*
		8/3/2017	*	*	*
		5/29/2018	*	*	*
		6/14/2018	*	*	*
		6/29/2018	*	*	*
		7/9/2018	*	*	*
		8/16/2018	*	*	*
Black River	Orleans	5/4/2018	*	*	*
		6/11/2018	*	*	*
		7/9/2018	*	*	*
		6/25/2018	*	*	*
		8/15/2018	*	*	*
		7/23/2018	*	*	*
		8/29/2018	*	*	*
		9/18/2018	*	*	*
Burlington Bay (Lake Champlain)	Chittenden	5/21/2018	*	*	*
Connecticut River	Orange	5/2/2018	*	*	*
		6/12/2018	*	*	*

		7/16/2018	*	*	*
		9/4/2018	*	*	*
Diamond Island (Lake Champlain)	Addison	10/14/2015	*	*	*
		8/4/2016	*	*	*
		8/23/2016	*	*	*
		6/8/2017	*	*	*
		6/8/2018	*	*	*
		6/27/2018	*	*	*
Hungerford Brook	Franklin	4/5/2018	*	*	*
		5/10/2018	*	*	*
		6/13/2018	*	*	*
		6/26/2018	0.083	0.059	*
		7/13/2018	*	*	*
		8/2/2018	*	*	*
		8/24/2018	*	*	*
		9/17/2018	*	*	*
Jewett Brook- Site 1	Franklin	8/14/2014	*	0.100	NT
		5/19/2015	*	*	*
		6/2/2015	0.06	0.29	*
		6/10/2015	0.69	0.13	*
		6/17/2015	0.10	0.05	*
		7/1/2015	0.28	0.12	*
		9/14/2015	*	*	*
		10/1/2015	*	*	*
		10/29/2015	*	*	*
		12/3/2015	*	*	*
		2/25/2016	*	*	*
		3/17/2016	*	*	*
		3/29/2016	*	*	*
		5/6/2016	*	*	*
		6/6/2016	1.070	0.480	0.050
		7/26/2016	0.070	0.090	0.070
		9/8/2016	*	*	*
		10/19/2016	*	*	*
		12/8/2016	*	*	*
		4/5/2017	*	*	*
		5/2/2017	*	*	*
		6/7/2017	0.267	0.125	0.203
		6/20/2017	0.372	0.326	*
		6/30/2017	0.575	0.129	*

		3/30/2018	*	*	*
		4/17/2018	*	*	*
		4/30/2018	*	*	*
		6/26/2018	*	*	*
Jewett Brook- Site 2	Franklin	7/29/2014	0.500	0.500	NT
		8/14/2014	*	0.100	NT
		6/10/2015	0.24	0.08	*
		6/17/2015	0.13	0.05	*
		7/1/2015	0.31	0.28	*
		9/14/2015	*	*	*
		5/6/2016	*	*	*
		6/6/2016	1.73	1.37	*
		7/26/2016	0.21	0.10	*
		9/8/2016	*	*	*
		10/19/2016	*	*	*
		12/8/2016	*	*	*
Little Otter Creek	Addison	12/3/2015	*	*	*
		2/25/2016	*	*	*
		3/17/2016	*	*	*
		3/29/2016	*	*	*
		4/5/2017	*	*	*
		5/2/2017	*	*	*
		11/28/2017	*	*	*
		3/30/2018	*	*	*
		4/17/2018	*	*	*
		4/26/2018	*	*	*
		3/30/2018	*	*	*
		4/30/2018	*	*	*
		6/26/2018	*	*	*
		4/9/1948	*	*	*
		6/8/2018	*	*	*
		6/21/2018	*	*	*
		8/27/2018	*	*	*
		9/28/2018	*	*	*
Main Lake (Lake Champlain)	Chittenden	8/11/2016	*	*	*
		8/30/2016	*	*	*
		9/21/2016	*	*	*
		6/21/2017	*	*	*
		8/7/2017	*	*	*
		6/6/2018	*	*	*

		6/22/2018	*	*	*
		7/5/2018	*	*	*
		9/12/2018	*	*	*
Mettawee River	Rutland	11/28/2017	*	*	*
		4/9/2018	*	*	*
		6/8/2018	*	*	*
		6/21/2018	*	*	*
		8/27/2018	*	*	*
		9/28/2018	*	*	*
Missisquoi Bay (Lake Champlain)	Franklin	7/29/2014	*	*	NT
		8/14/2014	*	*	NT
		10/21/2015	*	*	*
		4/20/2017	*	*	*
		6/14/2017	*	*	*
		7/20/2017	*	*	*
		8/3/2017	*	*	*
		5/29/2018	*	*	*
		6/14/2018	*	*	*
		6/29/2018	*	*	*
		7/9/2018	*	*	*
		8/16/2018	*	*	*
Missisquoi Bay Central (Lake Champlain)	Franklin	7/21/2016	*	*	*
		8/3/2016	*	*	*
		9/16/2016	*	*	*
		8/21/2017	*	*	*
		8/16/2018	*	*	*
Missisquoi River	Franklin	10/30/2015	*	*	*
		12/3/2015	*	*	*
		2/25/2016	*	*	*
		3/17/2016	*	*	*
		3/29/2016	*	*	*
		4/5/2017	*	*	*
		5/2/2017	*	*	*
		6/7/2017	*	*	*
		6/30/2017	*	*	*
		3/30/2018	*	*	*
		4/17/2018	*	*	*
		4/30/2018	*	*	*
		6/26/2018	*	*	*
Missisquoi River	Orleans	5/4/2018	*	*	*

		6/11/2018	*	*	*
		6/25/2018	*	*	*
		7/9/2018	*	*	*
		7/23/2018	*	*	*
		8/15/2018	*	*	*
		8/29/2018	*	*	*
		9/18/2018	*	*	*
Otter Creek	Addison	11/28/2017	*	*	*
		4/9/2018	*	*	*
		6/8/2018	*	*	*
		6/21/2018	*	*	*
		8/27/2018	*	*	*
		9/28/2018	*	*	*
Pike River	Franklin	7/21/2014	*	*	NT
		7/29/2014	*	*	NT
		8/14/2014	*	*	NT
		10/29/2015	*	*	*
		2/25/2016	*	*	*
		3/29/2016	*	*	*
		4/5/2017	*	*	*
		5/2/2017	*	*	*
		6/7/2017	0.052	*	*
		6/20/2017	0.095	0.151	*
		3/30/2018	*	*	*
		4/17/2018	*	*	*
		4/30/2018	*	*	*
		6/26/2018	*	*	*
Mill River	Franklin	9/14/2017	0.053	*	*
		10/16/2017	*	*	*
		4/5/2018	*	*	*
		6/13/2018	*	*	*
		6/26/2018	*	*	*
		7/13/2018	*	*	*
		8/2/2018	*	*	*
		8/24/2018	*	*	*
		9/17/2018	*	*	*
Rock River	Franklin	7/21/2014	*	*	NT
		7/29/2014	*	*	NT
		8/14/2014	*	*	NT
		10/29/2015	*	*	*

		12/3/2015	*	*	*
		2/25/2016	*	*	*
		3/17/2016	*	*	*
		3/29/2016	*	*	*
		4/5/2017	*	*	*
		5/2/2017	*	*	*
		6/7/2017	0.296	0.232	*
		6/20/2017	0.262	0.140	*
		6/30/2017	0.056	0.144	*
		3/30/2018	*	*	*
		4/17/2018	*	*	*
		4/30/2018	*	*	*
		6/26/2018	*	*	*
Saint Albans Bay (Lake Champlain)	Franklin	10/15/2015	*	*	*
		8/18/2016	*	*	*
		9/9/2016	*	*	*
		10/19/2016	*	*	*
		4/20/2017	*	*	*
		6/15/2017	*	*	*
		6/27/2017	*	*	*
		7/18/2017	*	*	*
		7/31/2017	*	*	*
		8/9/2017	*	*	*
		6/7/2018	*	*	*
		8/13/2018	*	*	*
Stevens Brook - Site 1	Franklin	7/21/2014	*	*	NT
		8/14/2014	*	*	NT
		6/10/2015	*	*	*
		6/17/2015	*	*	*
		7/1/2015	*	*	*
		9/14/2015	*	*	*
		5/6/2016	*	*	*
		6/6/2016	*	*	*
		7/26/2016	*	*	*
		9/8/2016	*	*	*
		10/19/2016	*	*	*
		12/8/2016	*	*	*
Stevens Brook - Site 2	Franklin	6/10/2015	0.05	*	*
		6/17/2015	*	*	*
		7/1/2015	*	*	*

		9/14/2015	*	*	*
		5/6/2016	*	*	*
		6/6/2016	0.06	0.08	*
		7/26/2016	*	*	*
		9/8/2016	*	*	*
		10/19/2016	*	*	*
		12/8/2016	*	*	*
Stevens Brook - Site 3	Franklin	6/10/2015	0.10	0.06	*
		6/17/2015	*	*	*
		7/1/2015	*	*	*
		9/14/2015	*	*	*
		5/6/2016	*	*	*
		6/6/2016	0.23	0.44	*
		7/26/2016	*	*	*
		9/8/2016	*	*	*
		10/19/2016	*	*	*
		12/8/2016	*	*	*
Sutton (5 grab sample sites)	Caledonia	7/30/2018	*	*	*
		7/31/2018	*	*	*
		7/30/2018	*	*	*
		7/30/2018	*	*	*
		7/31/2018	*	*	*
White River 2nd Tributary	Orange	12/7/2017	*	*	*
		6/12/2018	*	*	*
		7/16/2018	*	*	*
White River 3rd Branch	Orange	12/6/2017	*	*	*
		5/2/2018	*	*	*
Williams River	Windsor	12/7/2017	*	*	*
		5/2/2018	*	*	*
		6/12/2018	*	*	*
		7/16/2018	*	*	*
		9/4/2018	*	*	*

Detection limit 0.05 – 0.10 ppb
* Not detected
NT: Not tested

Table A4. Tile drain water samples analyzed for neonicotinoids in Northern Vermont (2017 and 2018).

Site	County	Sample Date	Thiamethoxam (ppb)	Clothianidin (ppb)	Imidacloprid (ppb)
Mill River	Franklin	9/14/2017	*	1.554	*
		10/16/2017	*	1.055	*
		4/5/2018	*	0.268	*
		6/26/2018	0.111	0.350	*
		6/13/2018	*	0.153	*
		7/13/2018	0.065	0.252	*
		8/2/2018	*	*	*
		8/24/2018	*	0.059	*
		9/17/2018	*	0.100	*
Hungerford Brook	Franklin	6/26/2018	*	*	*
Missisquoi River	Orleans	5/4/2018	*	0.130	*
		7/9/2018	0.146	0.069	*
		6/25/2018	0.309	0.086	*

Detection limit: 0.05–0.10 ppb
* Not detected
NT: Not tested

Table A5. Tile drain water samples analyzed for neonicotinoids, Franklin County, VT (2015 and 2016)

Site	Sample date	Thiamethoxam (ppb)	Clothianidin (ppb)	Imidacloprid (ppb)
Corn - Rep 1	6/10/2015	*	1.20	*
	6/17/2015	*	0.05	*
	7/1/2015	*	0.34	*
	5/6/2016	*	*	*
	6/6/2016	0.13	0.31	*
	7/26/2016	*	0.08	*
	12/8/2016	*	*	*
Corn - Rep 2	6/10/2015	0.11	0.06	*
	6/17/2015	*	0.24	*
	7/1/2015	*	0.07	*
	6/6/2016	0.057	0.06	*
Corn - Rep 3	6/10/2015	0.16	0.43	*
	6/17/2015	0.09	0.20	*
	7/1/2015	0.06	0.15	*
	9/14/2015	*	*	*
	6/6/2016	0.15	0.31	*
	7/26/2016	0.61	0.19	*
	10/19/2016	*	0.13	*
Corn - Rep 4	6/10/2015	0.26	0.88	*
	6/17/2015	0.15	0.25	*
	7/1/2015	0.14	0.32	*
	9/14/2015	*	0.18	*

	6/6/2016	0.18	0.54	*
Corn - Rep 5	6/10/2015	0.12	0.55	*
	6/17/2015	0.06	0.27	*
	7/1/2015	0.12	0.53	*
	9/14/2015	*	0.48	*
	6/6/2016	0.21	0.58	*
	7/26/2016	*	0.13	*
	10/19/2016	*	0.06	*
	12/8/2016	*	0.10	*
Corn - Rep 6	6/10/2015	0.05	0.31	*
	6/17/2015	*	0.18	*
	7/1/2015	0.08	0.42	*
	9/14/2015	*	0.18	*
	5/6/2016	*	*	*
	6/6/2016	0.23	0.47	*
	9/8/2016	*	0.06	*
Soy/Corn - Rep 1	6/10/2015	0.06	0.28	0.29
	6/17/2015	0.06	0.27	0.20
	7/1/2015	0.10	0.73	0.84
	9/14/2015	*	0.44	0.21
	5/6/2016	*	*	*
	6/6/2016	1.31	4.17	0.10
	7/26/2016	0.30	0.51	*
	9/8/2016	0.07	0.40	*
	10/19/2016	*	0.25	*
	12/8/2016	*	0.22	*
Soy/Soy - Rep 1	6/10/2015	*	0.64	0.54
	6/17/2015	*	0.33	0.20
	7/1/2015	*	0.46	0.31
	9/14/2015	*	0.54	0.13
	5/6/2016	*	*	*
	6/6/2016	*	0.60	1.12
	7/26/2016	*	0.36	0.85
	12/8/2016	*	0.13	0.09
Alfalfa/Grass - Control	6/10/2015	*	*	*
	6/17/2015	*	*	*
	7/1/2015	*	*	*
	9/14/2015	*	*	*
	5/6/2016	*	*	*
	6/6/2016	*	*	*
	9/8/2016	*	*	*
	10/19/2016	*	*	*
	12/8/2016	*	*	*

Detection limit: 0.05 ppb
* Not detected

Table A6. Soil samples adjacent to water sampling sites analyzed for neonicotinoids, Franklin County, VT (2016)

Site	Sample date	Sample depth†	Thiamethoxam (ppb)	Clothianidin (ppb)	Imidacloprid (ppb)
Corn - Rep 1	6/17/2016	0 - 12	3.36	2.35	*
		12–24	*	*	*
		24–36	*	3.23	*
	9/13/2016	0–12	*	*	*
		12–24	*	*	*
		24–36	*	*	*
	12/8/2016	0–12	*	*	*
		12–24	*	*	*
		24–36	NT	NT	NT
Corn - Rep 2	6/17/2016	0–12	8.24	4.59	*
		12–24	*	*	*
		24–36	*	*	*
	9/13/2016	0–12	*	14.13	*
		12–24	*	*	*
		24–36	*	*	*
	12/8/2016	0–12	*	*	*
		12–24	*	*	*
		24–36	*	*	*
Corn - Rep 3	6/17/2016	0–12	*	2.51	*
		12–24	*	*	*
		24–36	*	*	*
	9/13/2016	0–12	*	3.64	*
		12–24	*	*	*
		24–36	*	*	*
	12/8/2016	0–12	*	*	*
		12–24	*	*	*
		24–36	*	*	*
Soy/Corn - Rep 1	6/17/2016	0–12	*	3.48	*
		12–24	*	*	*
		24–36	*	*	*
	9/13/2016	0–12	*	*	*
		12–24	*	*	*
		24–36	*	*	*
	12/8/2016	0–12	*	2.08	*
		12–24	*	*	*
		24–36	*	*	*
Soy/Soy - Rep 1	6/17/2016	0–12	*	*	*
		12–24	*	*	*
		24–36	*	*	*
	9/13/2016	0–12	*	*	18.08

		12–24	*	*	*
		24–36	*	*	*
	12/8/2016	0–12	*	*	6.43
		12–24	*	*	*
		24– 36	*	*	*
Alfalfa / Grass - Control	7/26/2016	0–12	*	*	*
		12–24	*	*	*
		24–36	*	*	*
	9/13/2016	0–12	*	*	*
		12–24	*	*	*
		24–36	*	*	*
	12/8/2016	0–12	*	*	*
		12–24	*	*	*
		24–36	*	*	*

Detection limit: 2.0 ppb
NT: Not tested
* Not detected
† Inches below ground surface

Table A7. Vegetation samples adjacent to water sampling sites analyzed for neonicotinoids, Franklin County, VT (2015 and 2016).

Vegetation/associated site	Sample date	Thiamethoxam (ppb)	Clothianidin (ppb)	Imidacloprid (ppb)
Steven's Brook - Site 1	9/14/2015	*	*	*
	9/8/2016	*	*	*
Steven's Brook - Site 2	9/14/2015	*	*	*
	9/8/2016	*	*	*
Steven's Brook - Site 3	9/14/2015	*	*	*
	9/8/2016	*	*	*
Jewett Brook - Site 1	9/14/2015	*	*	*
	9/8/2016	*	*	*
Jewett Brook - Site 2	9/14/2015	*	*	*
	9/8/2016	*	*	*
Veg - Rep 1 (corn)	9/14/2015	*	*	*
	9/8/2016	*	*	*
Veg-Rep 2 (corn)	9/14/2015	*	*	*
	9/8/2016	*	*	*
Veg-Rep 3 (corn)	9/14/2015	*	*	*
	9/8/2016	*	*	*
Veg-Rep 1 (soy/corn)	9/14/2015	*	*	*
	9/8/2016	*	*	*
Veg-Rep 1 (soy)	9/14/2015	*	*	*
	9/8/2016	*	*	*
Corn leaves, positive control	9/8/2016	*	2.91	*

Detection limit varies by sample 5 –13.9 ppb for non-detected
*Not detected

Table A8. Subsurface and surface water samples analyzed for neonicotinoids, Miner Institute, Chazy, NY (2017 and 2018.

Site	Sample date	Thiamethoxam (ppb)	Clothianidin (ppb)	Imidacloprid (ppb)
Subsurface Field 9	3/13/2017	*	*	*
	3/20/2017	*	*	*
	3/27/2017	*	*	*
	4/3/2017	*	*	*
	4/10/2017	*	*	*
	4/17/2017	*	*	*
	4/24/2017	*	*	*
	5/2/2017	*	*	*
	5/7/2017	*	*	*
	5/15/2017	*	*	*
	5/23/2017	*	*	*
	5/30/2017	0.10	*	*
	6/5/2017	*	*	*
	6/12/2017	0.07	*	*
	6/19/2017	0.18	*	*
	6/26/2017	0.47	0.09	*
	7/4/2017	0.27	0.08	*
	7/11/2017	0.09	*	*
	7/17/2017	0.19	0.08	*
	7/24/2017	0.09	*	*
	7/31/2017	0.06	*	*
	8/21/2017	0.09	*	*
	9/5/2017	0.06	*	*
	9/11/2017	0.07	*	*
	10/10/2017	0.07	0.09	*
	11/20/2017	*	*	*
	11/27/2017	*	*	*
	1/3/2018	*	*	*
	1/15/2018	*	*	*
	1/22/2018	*	*	*
	1/29/2018	*	*	*
	2/5/2018	*	*	*
	2/12/2018	*	*	*
	2/21/2018	*	*	*
	2/26/2018	*	*	*
	3/5/2018	*	*	*
	3/12/2018	*	*	*
	3/22/2018	*	*	*
	3/30/2018	*	*	*
	4/5/2018	*	*	*

	4/12/2018	*	*	*
	4/16/2018	*	*	*
	4/30/2018	*	*	*
	5/3/2018	*	*	*
	5/10/2018	*	*	*
	5/17/2018	*	*	*
	6/7/2018	*	*	*
	6/12/2018	*	*	*
Surface Field 9	3/29/2017	*	*	*
	4/2/2017	*	*	*
	4/7/2017	*	*	*
	6/6/2017	1.36	0.13	*
	7/15/2017	0.46	0.19	*
	1/13/2018	*	*	*
	2/21/2018	*	*	*
	3/30/2018	*	*	*
Subsurface Field 5	3/13/2017	*	*	*
	3/20/2017	*	*	*
	3/27/2017	*	*	*
	4/3/2017	*	*	*
	4/10/2017	*	*	*
	4/17/2017	*	*	*
	4/24/2017	*	*	*
	5/2/2017	*	*	*
	5/7/2017	*	*	*
	5/15/2017	*	*	*
	5/23/2017	*	*	*
	5/30/2017	*	*	*
	6/5/2017	*	*	*
	6/12/2017	0.08	*	*
	6/19/2017	*	*	*
	6/26/2017	0.53	0.10	*
	7/4/2017	0.31	0.09	*
	7/10/2017	0.12	*	*
	7/17/2017	0.19	0.09	*
	7/24/2017	0.10	*	*
	7/31/2017	0.09	*	*
	8/7/2017	*	*	*
	8/14/2017	*	*	*
	8/21/2017	0.07	*	*
	8/28/2017	*	*	*
	9/5/2017	*	*	*
	9/11/2017	*	*	*
	9/18/2017	*	*	*
	9/25/2017	*	*	*

	10/10/2017	*	0.12	*
	10/16/2017	*	*	*
	10/25/2017	*	*	*
	11/20/2017	*	*	*
	11/27/2017	*	*	*
	1/3/2018	*	*	*
	1/9/2018	*	*	*
	1/15/2018	*	*	*
	1/22/2018	*	*	*
	1/29/2018	*	*	*
	2/5/2018	*	*	*
	2/12/2018	*	*	*
	2/21/2018	*	*	*
	2/26/2018	*	*	*
	3/5/2018	*	*	*
	3/12/2018	*	*	*
	3/22/2018	*	*	*
	3/30/2018	*	*	*
	4/5/2018	*	*	*
	4/12/2018	*	*	*
	4/16/2018	*	*	*
	4/30/2018	*	*	*
	5/3/2018	*	*	*
	5/10/2018	*	*	*
	5/17/2018	*	*	*
	5/24/2018	*	*	*
	5/31/2018	*	*	*
	6/7/2018	*	*	*
	6/12/2018	*	*	*
	6/21/2018	*	*	*
	6/28/2018	*	*	*
Surface Field 5	3/29/2017	*	*	*
	4/2/2017	*	*	*
	4/7/2017	*	*	*
	6/6/2017	6.48	0.40	*
	7/15/2017	0.47	0.22	*
	10/9/2017	*	0.11	*
	1/13/2018	*	*	*
	2/21/2018	*	*	*
	3/30/2018	*	*	*
	4/4/2018	*	*	*
	4/16/2018	*	*	*
	4/30/2018	*	*	*

Detection limit: 0.05 ppb
* Not detected