Water Quality of the Wapsipinicon River at Frederika

Summer 2007

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Introduction

The Wapsipinicon River is a tributary to the Mississippi River which runs approximately 200 miles through north-eastern Iowa. Geologically, it lies in the Iowan Surface, which is characterized by gently rolling, wide-open landscapes.[1] Like many rivers in Iowa, land use in the 2400 square mile watershed is dominated by agriculture, with approximately 70% of the area devoted to row crops.[2] The Iowa Department of Natural Resources lists several stretches of the river as "impaired", largely due to siltation, elevated levels of nutrients, and excessive levels of indicator bacteria.[3] In response to a request from a local watershed group, Restore our Wapsie (ROW), a study has been carried out to measure baseline water quality parameters of the river near Frederika. This report includes the methods used in the study, the findings, and suggestions for further investigation of this part of the Wapsipinicon.

Sampling and Analysis

Sampling began on May 15, 2007 and continued with weekly sampling occurring during the first month. Sampling then moved to a biweekly basis through mid-August. Four sites were sampled from north to south, as shown in table 1.

Table 1. Sampling Sites

Site	**Latitude**	**Longitude**	**Description**
County Line	42°54.428'	92°19.808'	Bridge on Bremner-Chickasaw County line
Farm	42°53.493'	92°18.876'	Pier at Karlowski Farm
Cabin	42°53.220'	92°18.730'	Pier at Kip Ladage's cabin
Bridge	42°52.613'	92.18.645'	Bridge south of Frederika

Sampling from the bridges was carried out by lowering a bucket to the river, rinsing with water from the river, and pulling up a sample. Sampling from the piers was carried out by grab sampling. It should be noted that the middle two sites required sampling from the bank. The pier at the farm usually had significant flow, while the pier at the cabin was in an area that was typically still. This can have a significant impact on the water quality parameters measured at these sites.

All bottles were field-rinsed with sample before collection. 50 mL of sample was filtered in the field through a 0.45 μm filter for dissolved reactive phosphorus analysis. All samples for laboratory analysis were immediately stored in a cooler with ice packs until they were transferred to a refrigerator at 4 °C. Samples were generally analyzed the day after collection.

A YSI Model 556 Multiprobe System was used to measure dissolved oxygen, temperature, pH, and conductivity in the field. The instrument was calibrated according to manufacturer's instructions each day prior to measurements. A Hach 2100P Turbidimeter was used in the field for turbidity measurements. Calibration was checked each day with Hach Gelex secondary standards.

Ion chromatography was utilized to measure chloride, nitrite, nitrate, and sulfate concentrations.[4] Spectroscopic methods were used to measure ammonia[5] and dissolved reactive phosphorus.[6] Total phosphorus[7] was measured using a persulfate digestion prior to analysis. Total suspended solids measurements were made gravimetrically. Spectroscopic analyses are carried out on Perkin Elmer EZ150 spectrophotometers and ion chromatographic analyses are carried out on a Dionex DX-80. All chromatographic and spectroscopic analyses utilized a minimum of four standards prepared by dilution of a purchased stock solution (Hach stock solutions for the spectroscopic analyses; Dionex seven-anion standard for the ion chromatographic analysis). Any other reagents used were of reagent grade or higher.

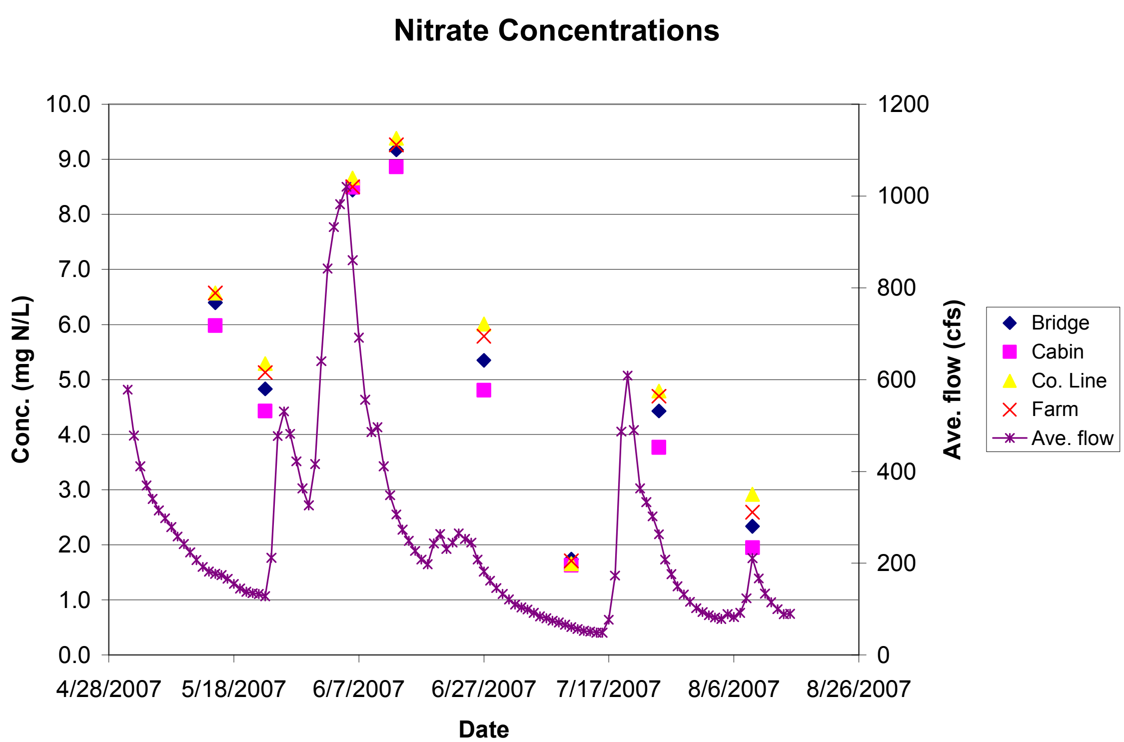
Samples for bacteria analysis were collected in sealed, sterile bottles containing sodium thiosulfate as a preservative. Analysis was carried using IDEXX Colilert/Quanti-Tray 2000 most probable number technique.[8]

Results

A compilation of the data collected is included as appendix 1. Field parameters such as dissolved oxygen (DO), pH, temperature, and conductivity generally fell into the range expected for an Iowa stream in the summer. In many cases, the DO measurements at the bridge were the highest of the set, which is due to the oxygenation caused by the dam just upstream of the bridge. In some cases, high dissolved oxygen measurements were observed at the cabin. These typically coincided with significant levels of aquatic plants producing oxygen on sunny days.

Nutrient values are of particular importance in understanding the water quality of the Wapsipinicon. As mentioned in the introduction, essentially all Iowa surface waters receive run-off and tile drainage from agricultural land. The nitrogen and phosphorus contained in this run-off leads to local problems with nutrient enrichment, as well as contributing eventually to

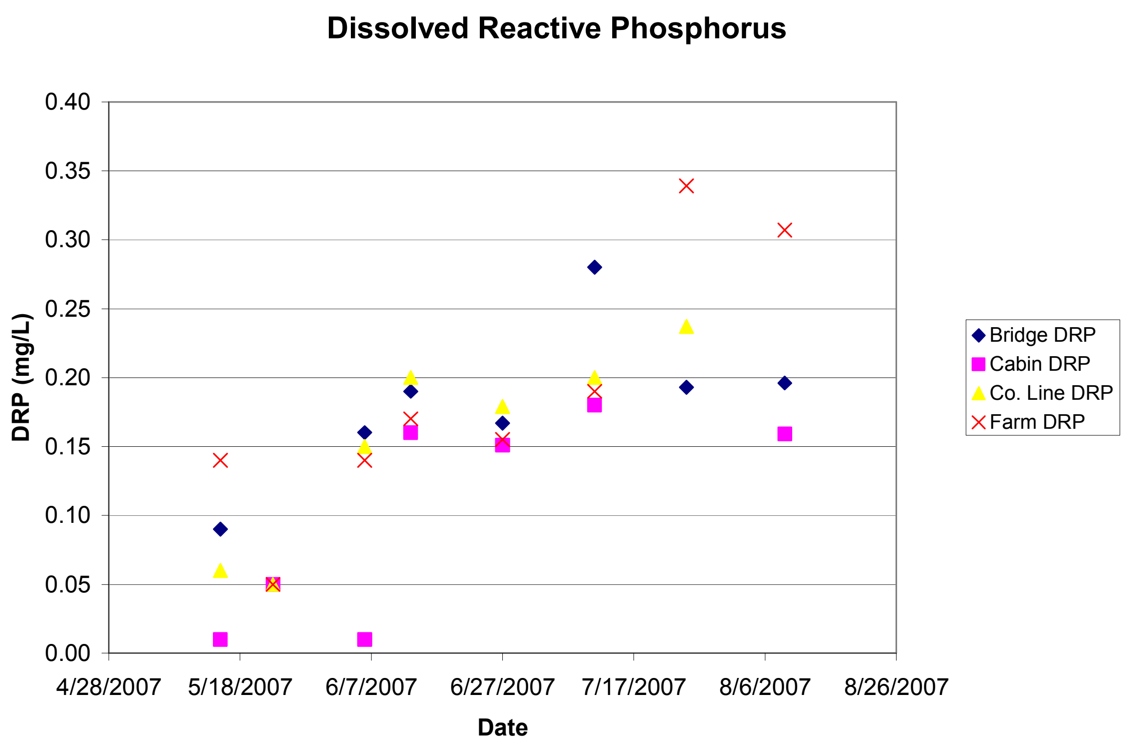
Figure 1. Nitrate-N concentrations in Wapsipinicon near Frederika



hypoxia in the Gulf of Mexico. Nitrate values in the Wapsipinicon are fairly typical for eastern Iowa streams. As seen in figure 1, nitrate concentrations approached, but did not exceed, the EPA's standard of 10 mg NO_3^--N/liter for drinking water. Flow data (from a USGS monitoring station on the Wapsipinicon near Tripoli) illustrates that nitrate concentrations tend to increase after significant rainfall events. This is consistent with a primarily agricultural source; nitrate is extremely water soluble, and is typically carried off of fields in tile drainage.

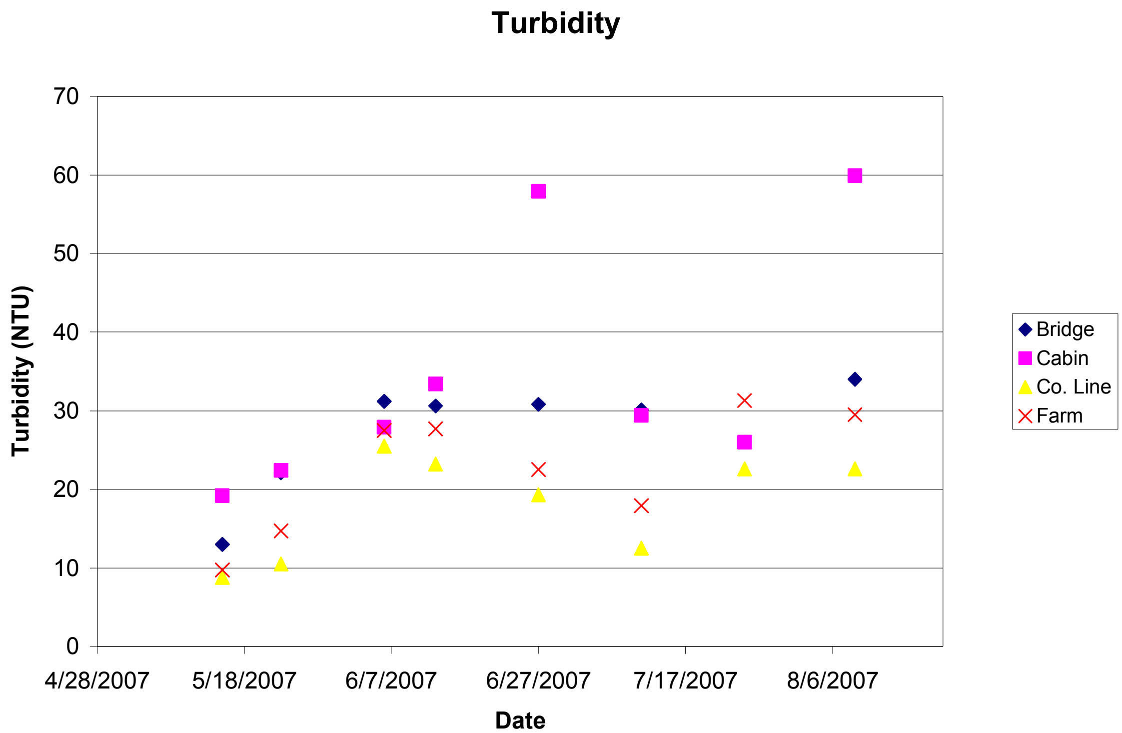
Phosphorus, whether measured in the dissolved form or as total phosphorus, remained relatively steady during the period of study. In the presence of large excesses of nitrogen, phosphorus will generally be the limiting nutrient for plant growth, and thus tends to be more readily utilized. It typically enters the river by overland run-off (attached to soil particles), and thus the phosphorus concentrations do not vary as much with flow as does nitrate. The dissolved reactive phosphorus values, shown in Figure 2, were generally fairly constant.

Figure 2. Dissolved reactive phosphorus concentrations in Wapsipinicon near Frederika



Sediment is also an issue of considerable concern in the Wapsipinicon. Run-off in the watershed can carry significant quantities of soil into the river. Fine sediments in particular can have a negative impact on fish reproduction.[9] They also result in the "muddy" appearance and lack of transparency of the water. Turbidity (a field measurement that measures light scattering) and total suspended solids (TSS; samples are filtered and weighed in the lab) are measurements that assess the clarity of the water and the amount of solids carried by the water. As shown in Figure 3, these values are relatively constant throughout the summer. The higher values observed at the cabin site reflect periods of high plant growth, which also can contribute to turbidity.

Figure 3. Turbidity values (NTU) in Wapsipinicon near Frederika

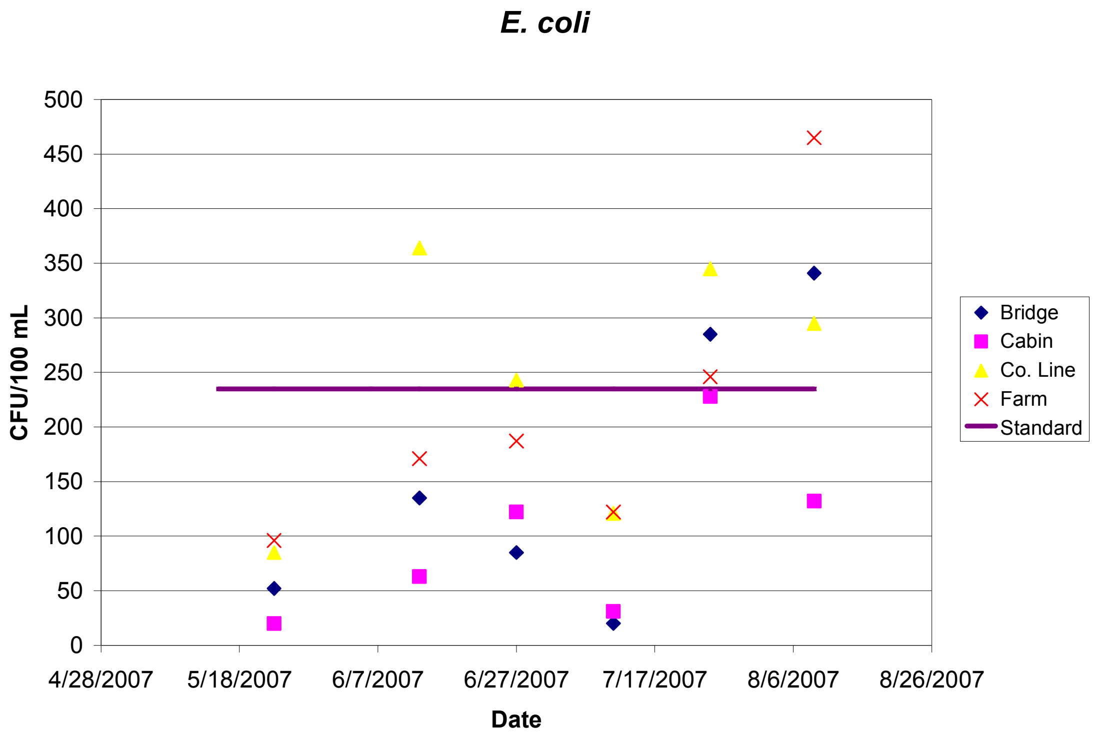


One final area of concern in many Iowa waters is bacteria. *E. coli* is an indicator bacteria; while it is not itself disease-causing, its presence can indicate that other bacteria may also be present. Water-borne bacteria may come from animals, or may result from leaking septic systems or outhouses. The bacteria standard for Iowa's recreational waters consists of two components:[10]

- A geometric mean standard based on 5 samples in a 30-day period (126 colony forming units of *E. coli* bacteria per 100 mL of water).
- A one-time maximum standard based on a single sample (235 colony forming units of *E. coli* bacteria per 100 mL of water).

As shown in Figure 4, samples were not collected frequently enough to calculate a geometric mean. However, based on the one-time maximum standard, one third of the samples analyzed from water in this stretch of the Wapsipinicon would be above the standard. Interestingly, none of the samples taken in the most populated area of this section of the river exceeded the standard.

Figure 4. *E. coli* values in Wapsipinicon near Frederika



Comparison to Other Studies

A significant amount of data has been collected by governmental agencies on the Wapsipinicon near this particular stretch of river. The United States Geological Survey has a gaging station at Tripoli, Iowa (approximately 9 miles downstream) which records constant flow information.[11] The USGS also collected water quality data at this site from 1996 to 2004. Farther downstream, the Iowa Geological Survey Bureau has collected samples on a monthly basis at Independence (approximately 35 miles downstream) from 1999 to present.[12]

Table 2. Average values (May to August) of USGS measurements at Tripoli and IGSB measurements at Independence

Summer averages	USGS Turbidity	USGS Nitrate	USGS DRP	IGSB Turbidity	IGSB Nitrate	IGSB E. coli
1996	NA	5.16	0.16	NA	NA	NA
1997	NA	5.70	0.12	NA	NA	NA
1998	NA	9.05	0.10	NA	NA	NA
1999	NA	NA	NA	NA	NA	NA
2000	NA	NA	NA	25.5	7.05	273
2001	45.0	6.18	0.09	29.1	6.84	2358
2002	66.2	8.84	0.18	25.8	7.55	423
2003	14.6	6.08	0.18	12.1	6.90	959
2004	34.5	8.50	0.21	26.3	9.38	2167
2005	NA	NA	NA	14.6	6.10	200
2006	NA	NA	NA	11.9	6.68	128
2007	NA	NA	NA	12.7	8.43	216
This study				*25.6*	*5.38*	*177*

Table 2 summarizes averages of summer data from the USGS Tripoli and IGSB Independence sites in comparison to the data from this summer. Both USGS and IGSB sites are usually sampled monthly, so the averages are typically based on four sample dates. As a result, they are more likely to be skewed by one unusually high or low sample. (This is particularly true for *E. coli* samples.)

Attached as Appendix 2 is a publication of the Iowa Geological Survey Bureau which summarizes their data for the past seven years of monitoring surface waters across the state of Iowa. This is particularly useful for putting the results from the Wapsipinicon in context. Using the average values from this summer's study, the nitrate values fall at slightly less than the 50^{th} percentile, turbidity results are between the 50^{th} and 75^{th} percentile, dissolved reactive phosphorus values are slightly under the 75^{th} percentile, and E. coli counts are between the 50^{th} and 75^{th} percentile.

<u>Summary and suggestions for further study</u>

Once a set of physical and chemical measurements are made for a given section of a river or stream, the data must be interpreted – are these values too high? What do the results mean? There are numerous criteria for evaluating the results of this study. For example, nitrate values are often compared to the Environmental Protection Agency's standard for drinking water of 10 mg NO_3^--N/liter. However, that standard was set for human consumption of the water, at a given rate per day over a lifetime, to avoid specific health risks. Similarly, the state limit for *E. coli* in water is set to protect swimmers who are in contact with the water. Comparisons to other rivers and streams in Iowa show this section of the Wapsipinicon to be somewhere in the middle.

In 2000, the EPA released the results of a study intended to assist states in setting water quality standards.[13] In their words: "The criteria are empirically derived to represent conditions of surface waters that are minimally impacted by human activities and protective of aquatic life and recreational uses." The EPA attempted to identify water bodies in each of 14 ecoregions in the U.S. with minimal human impact and used those to develop standards intended to minimize "cultural eutrophication" – the effects (algae and turbidity) of too many nutrients (nitrogen and phosphorus). Stated more plainly, they put forward numerical criteria intended to protect the biological health of the stream in a particular region of the country. For the region that the Wapsipinicon River lies in, the EPA suggested that total phosphorus concentrations should not exceed 0.08 mg/L and total nitrogen should not exceed 2.18 mg/L. The results from this summer indicate total phosphorus levels are approximately 6 times the target level; dissolved phosphorus alone is about twice the phosphorus criteria. Nitrate concentrations (which compose the vast majority of nitrogen in eastern Iowa streams and rivers) comes in at about two to three times the desired value for total nitrogen.

To have a significant impact on these levels would require action in the upstream part of the watershed. Short of drastically reducing the acreage devoted to cultivation of corn, or dramatic cuts in fertilizer application rates, the best prospects for bringing nutrient levels in streams down toward the nutrient criteria levels lie in increased support for "best management" practices[14] and for development of methods of reducing nitrogen "leakage" from fields. Recent installations of biofilters on drainage tile lines[15] and use of precision fertilizer application show some promise in reducing the loading of nutrients in Midwestern surface waters.

While additional physical and chemical measurements of this stretch of the Wapsipinicon might lead to some better understanding of the river, current monitoring at Independence by the IGSB will likely yield similar results. A biological study – perhaps studying the macroinvertebrate population of the river – might yield more interesting insights. Quantifying the insects which live in a section of the river, along with classifying them with respect to their preference for pristine versus “dirty” water, gives an integrated assessment of a river’s health. Macroinvertebrates are sensitive to a number of environmental factors, and may indicate problems with factors that we simply are not measuring yet.

Acknowledgements

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Appendix 1. Compilation of data from summer 2007 sampling and analysis

Site	Date	DO	Temp	pH	Cond	Turb	TSS	DRP	Total P	NH3	Cl	NO3 -N	SO4	E coli
Co. Line	5/15/2007	8.8	19.0	7.05	418	9	5	0.06	0.60	0.06	23.3	6.6	26.0	NA
Farm	5/15/2007	7.7	19.0	7.16	418	10	6	0.14	BDL	0.05	23.3	6.6	26.1	NA
Cabin	5/15/2007	8.4	19.2	7.44	418	19	11	0.01	2.38	0.06	23.5	6.0	25.1	NA
Bridge	5/15/2007	8.9	19.0	7.49	416	13	6	0.09	0.88	0.03	23.2	6.4	26.4	NA
Co. Line	5/23/2007	9.9	19.2	7.18	425	11	10	0.05	0.44	0.08	25.3	5.3	26.8	85
Farm	5/23/2007	10.7	19.1	7.63	422	15	12	0.05	0.53	0.18	25.5	5.1	25.8	96
Cabin	5/23/2007	11.7	19.8	7.98	402	22	13	0.05	0.60	0.10	24.5	4.4	25.7	20
Bridge	5/23/2007	10.8	19.4	7.97	414	22	15	0.05	0.53	0.09	26.4	4.8	25.4	52
Co. Line	6/6/2007	9.9	16.6	7.12	451	26	21	0.15	0.34	0.07	15.8	8.7	10.2	NA
Farm	6/6/2007	9.3	16.7	7.29	450	28	10	0.14	0.32	0.09	15.7	8.5	10.3	NA
Cabin	6/6/2007	9.4	16.6	7.39	448	28	6	0.01	0.37	0.08	15.5	8.5	10.1	NA
Bridge	6/6/2007	10.0	16.7	7.44	449	31	7	0.16	0.34	0.07	15.5	8.4	10.1	NA
Co. Line	6/13/2007	8.1	21.6	7.32	454	23	5	0.20	0.35	0.06	18.9	9.4	14.9	364
Farm	6/13/2007	8.0	21.5	7.49	455	28	5	0.17	0.32	0.07	19.0	9.3	14.8	171
Cabin	6/13/2007	7.9	22.8	7.63	454	33	10	0.16	0.38	0.02	19.0	8.9	14.7	63
Bridge	6/13/2007	8.8	22.1	7.73	454	31	7	0.19	0.34	0.06	18.8	9.2	14.6	135
Co. Line	6/27/2007	8.4	24.0	7.50	444	19	6	0.18	0.40	0.36	14.7	6.0	14.5	243
Farm	6/27/2007	8.2	24.0	7.53	439	23	6	0.16	0.41	0.17	14.6	5.8	14.3	187
Cabin	6/27/2007	7.1	24.5	7.40	432	58	19	0.15	0.30	0.14	14.1	4.8	14.1	122
Bridge	6/27/2007	9.2	24.3	7.69	430	31	14	0.17	0.38	0.09	13.8	5.4	13.9	85
Co. Line	7/11/2007	7.3	22.5	7.58	402	13	2	0.20	0.33	0.06	13.1	1.7	17.7	121
Farm	7/11/2007	6.3	22.7	7.54	409	18	4	0.19	0.34	0.10	13.9	1.7	17.8	122
Cabin	7/11/2007	6.2	23.4	7.63	423	29	13	0.18	0.52	0.19	14.5	1.6	18.2	31
Bridge	7/11/2007	7.6	23.8	7.79	417	30	29	0.28	0.46	0.12	14.4	1.7	18.1	20
Co. Line	7/25/2007	8.2	22.8	7.43	403	23	10	0.24	0.42	0.10	16.6	4.8	15.0	345
Farm	7/25/2007	8.7	22.5	7.49	397	31	12	0.34	0.38	0.10	17.5	4.7	15.3	246
Cabin	7/25/2007	12.8	23.6	8.17	368	26	8	NA	0.38	0.11	17.0	3.8	14.9	228
Bridge	7/25/2007	9.1	23.1	7.93	390	26	18	0.19	0.42	0.11	16.4	4.4	14.6	285
Co. Line	8/9/2007	9.2	24.1	7.36	373	23	19	NA	0.39	0.06	14.2	2.9	15.7	295
Farm	8/9/2007	8.9	23.8	7.11	360	30	27	0.31	0.42	0.07	14.1	2.6	15.1	465
Cabin	8/9/2007	9.4	24.5	7.03	339	60	57	0.16	0.35	0.08	15.4	2.0	15.2	132
Bridge	8/9/2007	10.0	24.2	7.33	344	34	33	0.20	0.39	0.06	13.9	2.3	14.7	341
Mean values		8.9	21.4	7.49	416	26	13	0.15	0.48	0.10	17.9	5.4	17.4	177

BDL = Below detection limit; NA = not analyzed