Pesticides and Nutrients in Surface Water on the William L. Finley National Wildlife Refuge, Oregon, 1998

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SUMMARY

Samples collected from six sites on three streams in the William L. Finely National Wildlife Refuge during 1998 were analyzed for pesticide, nitrogen (N), and phosphorus (P) compounds. The number of pesticides detected in refuge streams and the concentrations of pesticide, N, and P compounds measured were generally lower than in other Willamette Valley studies that targeted the same analytes. However, in a few samples, some pesticide concentrations were high enough to warrant concern. The highest concentrations of atrazine—the most frequently detected pesticide on the refuge—were in samples from Brown Creek; in two of these samples, atrazine concentrations exceeded Environment Canada's water-quality guideline for the protection of aquatic life. In Muddy Creek, the highest concentrations of atrazine and 2,4-D approached Environment Canada's water-quality guidelines.

In general, pesticide concentrations were highest in Muddy Creek, which flows through an agricultural region prior to entering the refuge and serves as the surface-water outflow from the refuge. Concentrations of most compounds were lowest in samples from Gray Creek, which enters the refuge from a pristine, forested area. The data further suggest that sources upstream of the refuge can account for most pesticide, N, and P in refuge streams. Except for 2,4-D concentrations measured in spring, concentrations at the refuge outflow site were similar to concentrations at refuge inflow sites.

MOTIVATION FOR STUDY

The William L. Finley National Wildlife Refuge (NWR) is located in the central part of the Willamette Valley, just south of Corvallis, Oregon (fig. 1). A considerable portion of the refuge is planted in grasses to provide winter forage for Canada geese, and pesticides are regularly applied to these cultivated lands. Much of the land adjacent to the refuge is also cultivated crop and timber land, which receives regular applications of a variety of pesticides.

Streams throughout the Willamette Valley have been sampled by the U.S. Geological Survey (USGS) and a number of pesticides have been detected, particularly in agricultural areas (Anderson et. al, 1997; Rinella and Janet, 1998). The Environmental Contaminants Program of the Oregon Office of the U.S. Fish and Wildlife Service conducted a field investigation in 1998 to determine whether pesticides used on or near the Finley NWR enter streams and thus pose a potential threat to aquatic communities on the refuge. The Oregon chub (*Oregonichthys crameri*), which was listed as endangered in 1993, is a species of particular concern in the area (U.S. Fish and Wildlife Service, 1998) . As part of this investigation, water samples were collected from six surface-water sites on the refuge (table 1) and analyzed for pesticide, nitrogen (N), and phosphorus (P) compounds. The assessment also included (1) a compilation of pesticide-use data for the refuge and nearby lands (Brunkal, 1997); (2) collection and interpretation of hourly water temperature, dissolved oxygen, pH, and specific conductance data at six sites on the refuge for the period February through May, 1998 (Mochan, 2000); and (3) the collection of carp and turtle for general health assessments and analyses of blood hormone levels. The results of pesticide, N, and P analyses are presented and discussed in this report.

Table 1. Data-collection sites, Finely National Wildlife Refuge, 1998.

Site Name	Latitude	Longitude
Gray Creek Reference Site	44° 24' 44"	123° 21' 36"
Gray Creek at Beaver Pond	44° 23' 50"	123° 20' 43"
Gray Creek at Cattail Pond	44° 24' 08"	123° 19' 25"
Brown Creek at Bellfountain Road	44° 25' 30"	123° 20' 01"
Muddy Creek at Bruce Road	44° 23' 22"	123° 18' 07"
Muddy Creek at North Bridge	44° 25' 31"	123° 18' 47"

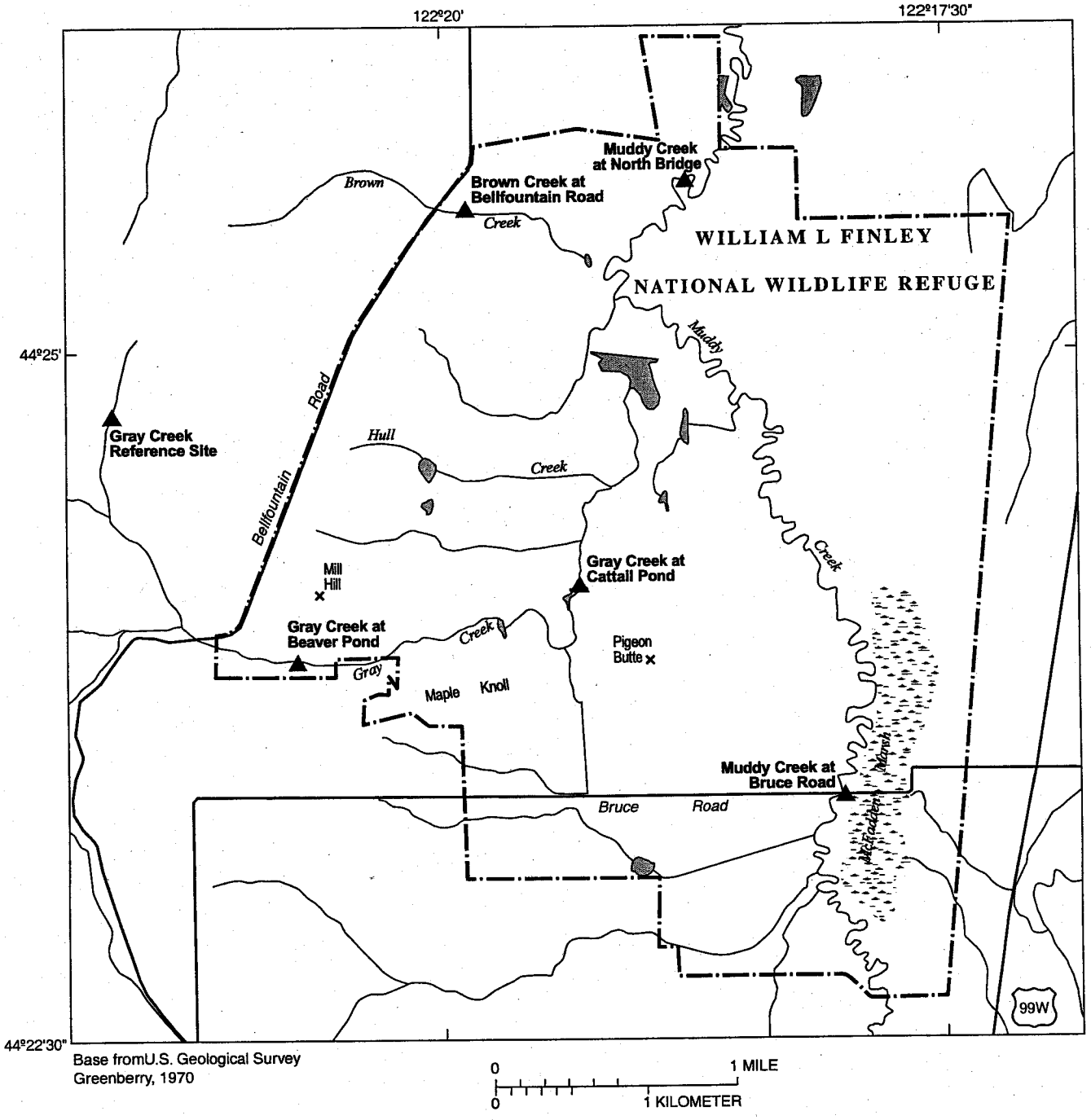

Figure 1. Location of study area and data-collection sites.

METHODS

To allow direct comparisons with pesticide data reported previously for studies in the Willamette Valley (Anderson et al, 1997; Rinella and Janet, 1998), the same data-collection, processing, and analytical methods were used. The very low pesticide detection levels associated with these analytical methods also made them particularly suited for the refuge investigation. Only a brief description of these methods is given here; Anderson et al. (1997) and Rinella and Janet (1998) provide more detailed discussions.

Sample collection, processing, and analyses.—Water samples for pesticide, N, and P analyses were collected and processed following the methods of Shelton (1994). Samples were processed on the day of collection at the USGS laboratory in Portland, Oregon. Samples for nutrient analyses were filtered through 0.45-µm cellulose-acetate filters. Samples for pesticide analyses were filtered through 0.7-µm glass-fiber filters and extracted through solid-phase extraction cartridges (Zaugg et al., 1995; Werner et al., 1996). Processed samples were shipped on ice to the USGS National Water Quality Laboratory in Arvada, Colorado, for analyses. N and P samples were analyzed using the methods described by Fishman (1993); pesticide samples were analyzed using the methods described by Zaugg et al. (1995), Lindley et al. (1996), and Werner et al. (1996).

Quality control.—Field quality-control samples (tables 2-5) included duplicate samples to assess sampling and processing variability and analytical precision, field-equipment blanks to quantify contamination from sample handling and processing, and field-matrix spikes—added after filtration and prior to extraction—to evaluate the efficiency of analyte extraction as well as analytical recovery and precision. In addition, surrogate analytes were added to environmental samples in the field to assess analytical recovery and precision. Shelton (1994) provides a more in-depth discussion of quality-control samples.

Site selection.—The six data-collection sites were located on three refuge streams—Muddy Creek, Gray Creek, and Brown Creek (fig. 1). Muddy Creek is the largest stream on the refuge and serves as the ultimate surface-water drain for the area. The creek frequently overflows its banks during periods of high precipitation and typically carries a considerable sediment load. The creek flows through an agricultural area before entering the refuge at its southern boundary, and the site on Muddy Creek at Bruce Road was selected to characterize this agriculturally impacted inflow to the refuge. Muddy Creek follows a meandering northward path through the refuge and exits at the northern boundary. The site on Muddy Creek at North Bridge was chosen to represent the integrated surface-water outflow from the refuge.

Gray Creek originates in a nearly pristine, steep, forested area just west of Finley NWR and enters the refuge at its southwestern boundary. Upstream of the refuge, Gray Creek is usually clear, but during rain events the lower reach often overflows its banks and carries a substantial sediment load. The most upstream Gray Creek site—located approximately 1 mile upstream of the refuge boundary—was selected as the study reference site. Approximately one-half mile downstream of the boundary, a beaver dam on Gray Creek, coupled with a considerable flattening of the terrain, has produced an area of slow, diffuse streamflow through reeds and other aquatic vegetation. The site on Gray Creek at Beaver Pond was chosen to characterize water quality in the stream as it flows through this marshy area. Near the center of the refuge, an artificial pond has been constructed along Gray Creek; the Cattail Pond site was selected to characterize the outflow from this pond.

Brown Creek flows through a Christmas tree farm before entering the refuge at its northwestern boundary. Brown Creek typically runs clear, but responds quickly to rainfall with increased flow and sediment load. The site on Brown Creek at Bellfountain Road was selected to characterize refuge inflow impacted by Christmas tree farming practices.

Sample collection dates.—Typically, few pesticides are applied in the vicinity of the refuge during winter. Samples were collected in February and early March to characterize conditions near the end of the winter period. A variety of pesticides is applied in the spring, and moderate, intermittent precipitation events typically occur during this period. Samples collected in late March and April reflect conditions during this period, when the potential for stream contamination by pesticides is relatively high. In addition to monthly sampling during this February through April period, samples were collected during rainfall events on March 4, March 24, and April 24.

Four sites were also sampled in mid-August to evaluate water-quality conditions during the period of lowest streamflow. The last samples were collected in early November to assess the effects of pesticide applications during the fall seeding period.

In late September, during an in-stream fish assessment, a number of native sticklebacks expired in traps in the vicinity of the Beaver Pond site on Gray Creek (Scheerer et al., 1999). To investigate water-quality conditions associated with this event, two additional samples were collected in early October—one approximately 100 m above and one approximately 100 m below these traps.

Hydrologic conditions.—Precipitation data collected by the Oregon Climate Service at the Hyslop Experiment Station, approximately 16 miles northwest of the study area, were used in lieu of streamflow measurements as indicators of runoff conditions on sampling dates (fig. 2).

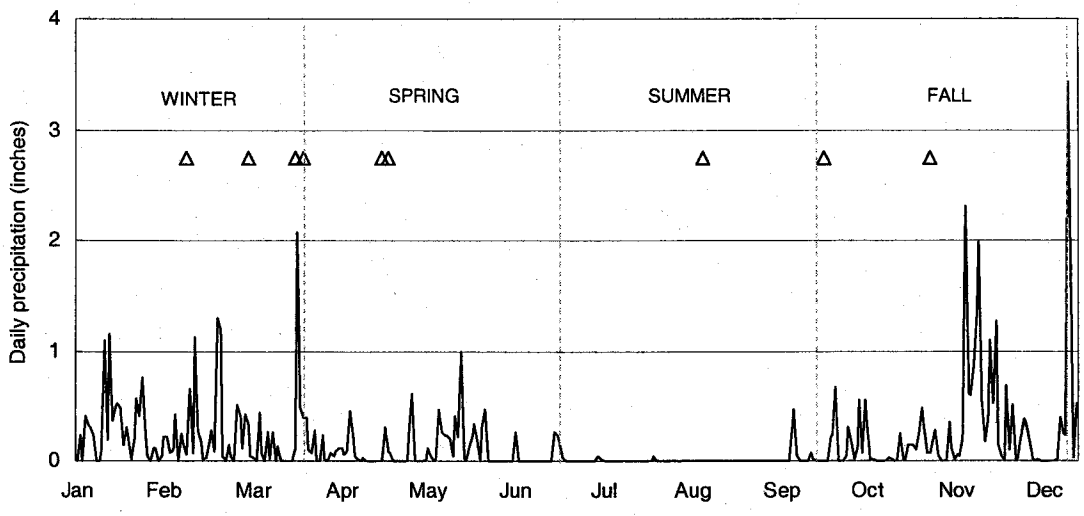

Figure 2. Daily precipitation for 1998 measured near Finley National Wildlife Refuge at Oregon Climate Service station 351862 (data from Oregon Climate Service). Triangular symbols indicate sampling dates.

RESULTS

Quality-control data

Pesticides.—Results from pesticide spike analyses (table 2) show that recoveries were fairly consistent for most compounds, and nearly all were within the range of 60-140 percent, which is considered acceptable for the analytical methods used. 2,4-D, deethylatrazine, dicamba, and MCPA were recovered at lower percentages in one sample each, which is not unusual for these particular compounds (Anderson et al., 1997; Rinella and Janet, 1998). The unusually low recovery of atrazine in the March 24 Brown Creek spike sample can probably be attributed to the relatively high concentration of atrazine already present in the native water sample to which the spike was added—the small amount of additional atrazine in the spike was of the same order as the error associated with measuring the native water sample. The reason for the low recovery of tebuthiuron in the February 10 Muddy Creek spike sample is not known. Although pesticide spike recoveries in general suggest adequate analytical recovery efficiencies for the study, it is important to note that many of the spikes had concentrations considerably higher than native water samples. Spike

recovery data are therefore not necessarily indicative of recovery efficiencies at the concentrations of interest.

No pesticides were detected in the majority of duplicate samples pairs or in any of the field-equipment blank samples (table 3). However, duplicate pairs in which analytes were detected showed good agreement. Ten of the 13 analyte pairs for which relative differences could be calculated had relative differences of less than 20 percent. The remaining three pairs had relative differences of 22, 28, and 53 percent—still reasonable agreement for samples at nanogram-per-liter (ng/L) concentrations. Note that relative differences are not reported for pairs in which one or both of the reported concentrations were either estimates or below the method detection limit (MDL). In a few cases, either atrazine, deethylatrazine, or simazine were detected in one sample of the duplicate pair at a concentration near the MDL, but were not detected in the companion sample. Such discrepancies are fairly common and illustrate the uncertainty in analytical results; particular caution is advisable when interpreting concentration data near the MDL.

Pesticide surrogate recoveries were good, ranging from 82 to 129 percent (table 4). Recoveries ranging from 60 to 140 percent signify adequate recovery efficiency for the methods used.

These quality-control data indicate that pesticide data generated during this study are of generally good quality and are comparable in quality to those from other studies involving similar analytes. However, due to normal uncertainties in analytical results, data reported near or below MDLs should be interpreted cautiously.

Nitrogen and phosphorus compounds.—In one field-equipment blank sample, orthophosphorus was detected at a concentration near the minimum reporting limit (MRL), and nitrite-plus-nitrate N was detected at approximately twice the MRL (table 5). These concentrations are similar to or higher than those measured in some environmental samples and suggest that nutrient concentrations near the MRL should be interpreted cautiously. All other N and P

species were below the MRL in the three blank samples. Agreement between duplicate pairs was adequate for a reconnaissance level study—all pairs had relative differences of less than 25 percent (table 5).

Environmental data

Pesticides.—Of the 83 pesticides investigated during this study, 17 were detected at least once in water samples collected on the Finley NWR (tables 6 and 7). Atrazine and its degradation product, deethylatrazine, were the most frequently detected compounds, found in 76 and 67 percent of samples, respectively. These two compounds were detected even at the reference site during the rainy spring sampling period, and throughout the year—during both rainy and dry periods—at the other sites. These compounds are not known to be applied upstream of the reference site, and their presence there was likely due to atmospheric transport and subsequent deposition by precipitation (Thurman and Cromwell, 2000). Besides atrazine and deethylatrazine, only diuron, metolachlor, and simazine were detected in more than 10 samples (> 25% detections) over the course of the study.

The number of pesticides detected, the frequency of detection, and the concentrations measured were lowest at the reference site and generally increased from Gray Creek to Brown Creek and were highest in Muddy Creek.

Nitrogen and phosphorus compounds.—The concentrations of N and P compounds measured were fairly low in all samples analyzed (table 8), although concentrations of nitrite-plus-nitrate N exceeded 1 mg/L in most samples collected from Brown Creek. With the exception of the November sampling, concentrations of ammonia and organic N were quite low at all three sites on Gray Creek and were highest in Muddy Creek. P species were also lowest in Gray Creek, somewhat higher in Brown Creek, and highest in Muddy Creek.

DISCUSSION

Pesticides.—Considerably fewer pesticides were detected during this study than during other Willamette Valley studies that targeted the same 83 compounds (table 6). Anderson et al. (1997) detected 36 pesticides—more than twice the 17 detected during the refuge investigation—and Rinella and Janet (1998) detected nearly 3 times as many (49). For most compounds, the maximum concentrations detected during these other studies were also considerably higher than the maximum concentrations measured on the refuge (table 6). The differences between this study and other studies that encompassed most of the entire Willamette Valley reflect the limited diversity of crops and the managed use of pesticides on and near the refuge. However, it is noteworthy that the compounds detected most frequently during the current study—atrazine, deethylatrazine, diuron, metolachlor, and simazine—were also detected most frequently during other Willamette Valley studies (Anderson et al., 1997; Rinella and Janet, 1998).

Comparisons of pesticides in Muddy, Brown, and Gray Creeks (fig. 3) show that for many of the most frequently detected pesticides, the highest concentrations occurred in Muddy Creek. Furthermore, except for 2,4-D in the March 24 samples, concentrations of many of these pesticides were similar at both Muddy Creek sites, suggesting that sources upstream of the refuge contribute much of the pesticide load to the stream. The concentration of 2,4-D measured in March at the North Bridge Muddy Creek site was considerably higher than at any other site sampled during the current study, and among the highest concentrations recorded in streams in the Willamette Valley (Anderson et al., 1997; Rinella and Janet, 1998); this indicates that recent on-refuge use of 2,4-D was an important source. In contrast, atrazine and its degradation product deethylatrazine were both highest in Brown Creek, and the highest concentration of metolachlor was in the fall in Gray Creek.

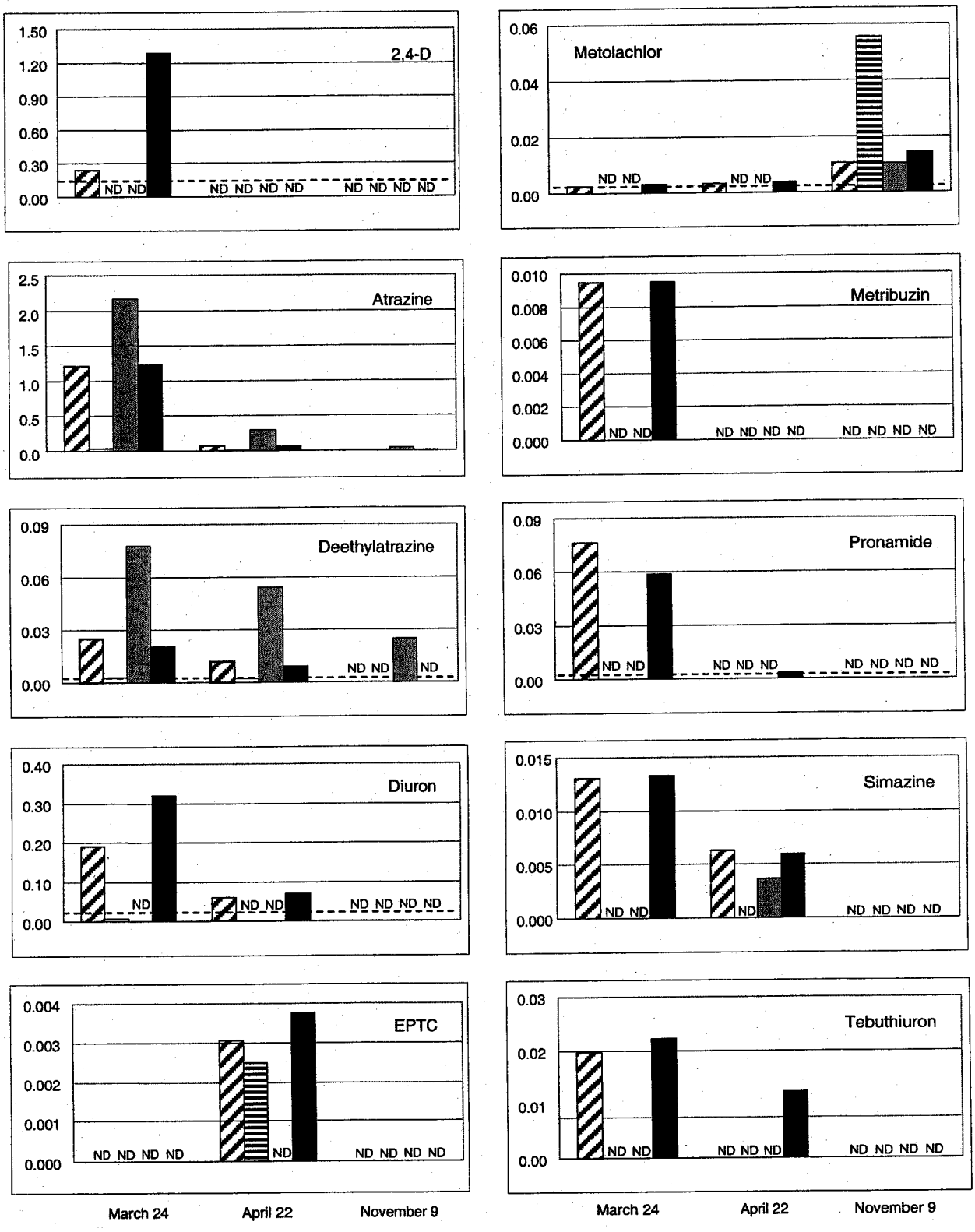

Figure 3. Comparisons of pesticide concentrations (µg/L) in Muddy, Brown and Gray Creeks, Finley National Wildlife Refuge, 1998. "ND" indicates compound not detected. Dashed line indicates long-term minimum detection limit. [The data graphed here, as well as data for additional sampling dates, are given in table 6.]

Because of the small number of samples and their uneven distribution among seasons and rainy-versus-dry periods, statistical evaluations of trends in the data were not appropriate. However, some qualitative patterns are apparent (fig. 3; table 7). For example, the three compounds detected most frequently—atrazine, deethylatrazine, and diuron—were detected during all four seasons. In contrast, all detections of 2,4-D, chlorpyrifos, dicamba, EPTC, MCPA, tebuthiuron, and triclopyr occurred during spring sampling, and the highest concentrations of atrazine, deethylatrazine, pronamide, and simazine were measured during the spring. Metolachlor, on the other hand, was detected at all sites but the reference site during fall sampling, but in spring was measured only in samples from Muddy Creek and in one sample from Brown Creek. Comparisons of data collected during wet and dry periods reveal that all detections of 2,4-D, alachlor, dicamba, ethoprop, metribuzin, and triclopyr were in samples collected during rainy periods (table 7). In addition, the maximum detected concentration of all compounds except bromacil, chlorpyrifos, and EPTC occurred in samples collected during rainy periods. Three of the four detections of EPTC, in contrast, occurred during dry periods.

Metolachlor was the only pesticide detected during the October sampling on Gray Creek near the Beaver Pond site. A month later, a similar concentration was measured at the Beaver Pond site, but farther downstream at the Cattail Pond site, the concentration was an order of magnitude higher. It is noteworthy that the fish kill observed near the Beaver Pond site occurred several days prior to the October sampling, and in-stream concentrations may have been different at that time. However, the data provide no evidence that the fish kill was associated with pesticides in the stream.

For most pesticides for which criteria are available, concentrations measured on the refuge were more than 1 or 2 orders of magnitude below concentrations considered protective of aquatic life. However, atrazine was measured in two samples from Brown Creek in late March at 3.0 and 2.2 µg/L, exceeding Environment Canada's water-quality guideline of 1.8 µg/L for the

protection of aquatic life (Environment Canada, 1998); samples collected on March 24 from both sites on Muddy Creek approached this level. The maximum concentration of 2,4-D (1.3 µg/L, measured in Muddy Creek) approached the Environment Canada guideline of 4 µg/L (Environment Canada, 1998), and the highest concentration of chlorpyrifos (0.012 µg/L, measured in Brown Creek) approached the chronic criterion of 0.041 µg/L for protection of freshwater aquatic life (Oregon Department of Environmental Quality).

Brunkal (1997) documented nearly all of the pesticides detected during this study as being used on or near the refuge for crop cultivation, facilities maintenance, or forestry activities. 2,4-D, atrazine, alachlor, chlorpyrifos, dicamba, EPTC, ethoprop, and metolachlor are all used during various stages in the cultivation of field or sweet corn. 2,4-D, dicamba, diuron, MCPA, metolachlor, and metribuzin are all commonly used on pasture and other grasses, which are prevalent crops throughout the refuge area. Atrazine, chlorpyrifos, pronamide, simazine, and triclopyr are typically applied during the cultivation of Christmas trees. 2,4-D, atrazine dicamba, pronamide, and triclopyr may all be used in commercial forestry operations. Finally, 2,4-D is sometimes used for maintenance of facilities on the refuge.

Although the available data cannot support a thorough explanation of pesticide occurrence and distribution in refuge streams, the observed patterns can be attributed to factors such as (1) the timing, frequency, location, and mode of application of each pesticide, (2) the physical and chemical properties of individual compounds such as environmental partitioning characteristics, solubility in water, and degradation potential, and (3) precipitation patterns.

Nitrogen and phosphorus compounds.—Except for the relatively high concentrations in Brown Creek—probably due to the cultivation of Christmas trees in the area just upstream of the sampling site—N and P compounds were distributed similarly to pesticides. This distribution suggests that N and P in these streams results at least partially from agricultural practices. As with several of the

pesticides, similar concentrations at both Muddy Creek sites suggest that N and P levels may be largely attributed to sources upstream of the refuge.

Although agricultural activities likely contribute N and P to refuge streams, median and maximum values (table 9) were all lower than corresponding values reported in Rinella and Janet (1998). However, the U.S. Environmental Protection Agency is currently considering nutrient-concentration criteria to prevent nuisance conditions and degradation of water quality. The criteria being considered range from 0.25 to 1.5 mg/L for total N, and from 0.02 to 0.09 mg/L for total P (Dodds et al., 2000; U.S. Environmental Protection Agency, 2000). All of the N and P concentrations measured in Brown and Muddy Creeks during this study were within these ranges. In addition, concentrations of N within these ranges were measured in Gray Creek at Cattail Pond in all but the March 4 sample, in Gray Creek at Beaver Pond in February and November, and at the reference site in November. P concentrations greater than .02 mg/L were measured in many samples from Gray Creek, including February, March, and November samples from the reference site. These data suggest that nutrients may pose a water-quality concern on the refuge.

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Table 2. Pesticide spike recoveries, in percent, from water samples from the Finely National Wildlife Refuge, 1998.

Site Name	Date	2,4-D	Acetochlor	Alachlor	Atrazine	Bromacil	Chlorpyrifos	Deethylatrazine	Dicamba	Diuron
		39732	49260	46342	39632	04029	38933	04040	38442	49300
Gray Creek at Cattail Pond	04/22/98	75	97	99	98	77	95	56	45	89
Brown Creek at Bellfountain Road	03/24/98	74	94	98	-71	73	88	60	70	87
Muddy Creek at Bruce Road	02/10/98	--	85	90	92	--	81	67	--	--
Muddy Creek at Bruce Road	03/04/98	74	--	--	--	69	--	--	73	81
Muddy Creek at Bruce Road	11/09/98	33	106	103	95	96	84	65	27	103

Site Name	Date	EPTC	Ethoprop	MCPA	Metolachlor	Metribuzin	Pronamide	Simazine	Tebuthiuron	Triclopyr
		82668	82672	38482	39415	82630	82676	04035	82670	49235
Gray Creek at Cattail Pond	04/22/98	86	87	69	100	101	102	96	130	59
Brown Creek at Bellfountain Road	03/24/98	90	85	55	96	86	96	106	100	59
Muddy Creek at Bruce Road	02/10/98	76	89	--	105	75	87	97	33	--
Muddy Creek at Bruce Road	03/04/98	--	--	62	--	--	--	--	--	64
Muddy Creek at Bruce Road	11/09/98	104	94	60	105	99	94	92	96	

Number below compound name is USEPA STORET code

--, no data

Table 3. Pesticide concentrations, in µg/L, in duplicate and field-equipment-blank water samples from the Finely National Wildlife Refuge, 1998. (Only those compounds detected during the current study are reported here).

Site Name	Date	2,4-D	Alachlor	Atrazine	Bromacil	Chlorpyrifos	Deethylatrazine	Dicamba	Diuron
		39732	46342	39632	04029	38933	04040	38442	49300
				Duplicates					
Gray Creek at Cattail Pond	04/22/98	< 0.15	< 0.002	0.006	< 0.035	< 0.004	E 0.002	< 0.035	< 0.02
	04/22/98	< 0.15	< 0.002	0.005	< 0.035	< 0.004	< 0.002	< 0.035	< 0.02
% relative difference		--	--	**3%**	--	--	--	--	--
Brown Creek at Bellfountain Road	03/24/98	< 0.15	< 0.002	2.2	< 0.035	< 0.004	E 0.08	< 0.035	< 0.02
	03/24/98	< 0.15	< 0.002	2.0	< 0.035	< 0.004	E 0.07	< 0.035	< 0.02
% relative difference		--	--	**6%**	--	--	--	--	--
Muddy Creek at Bruce Road	02/10/98	< 0.15	< 0.002	0.12	< 0.035	< 0.004	E 0.01	< 0.035	0.98
	02/10/98	< 0.15	< 0.002	0.10	< 0.035	< 0.004	E 0.01	< 0.035	0.85
% relative difference		--	--	**13%**	--	--	--	--	**14%**
Muddy Creek at Bruce Road	03/04/98	< 0.15	E 0.004	0.13	< 0.035	< 0.004	E 0.009	< 0.035	0.31
	03/04/98	< 0.15	E 0.004	0.13	< 0.035	< 0.004	E 0.008	< 0.035	0.31
% relative difference		--	--	**0%**	--	--	--	--	**0%**
Muddy Creek at Bruce Road	11/09/98	< 0.15	< 0.002	0.006	< 0.035	< 0.004	< 0.002	< 0.035	< 0.02
	11/09/98	< 0.15	< 0.002	0.005	< 0.035	< 0.004	E 0.003	< 0.035	< 0.02
% relative difference		--	--	**9%**	--	--	--	--	--
Muddy Creek at North Bridge	08/18/98	< 0.15	< 0.002	< 0.001	E 0.09	< 0.004	< 0.002	< 0.035	0.04
	08/18/98	< 0.15	< 0.002	0.007	E 0.10	< 0.004	< 0.002	< 0.035	0.05
% relative difference		--	--	--	--	--	--	--	**22%**
				Blanks					
Gray Creek at Cattail Pond	04/22/98	< 0.15	< 0.002	< 0.001	< 0.035	< 0.004	< 0.002	< 0.035	< 0.02
Muddy Creek at Bruce Road	02/10/98	< 0.15	< 0.002	< 0.001	< 0.035	< 0.004	< 0.002	< 0.035	< 0.02
Muddy Creek at North Bridge	03/04/98	--	< 0.002	< 0.001	--	< 0.004	< 0.002	--	--
Muddy Creek at North Bridge	03/04/98	< 0.15	--	--	< 0.035	--	--	< 0.035	< 0.02

Table 3. Pesticide concentrations, in µg/L, in duplicate and field-equipment-blank water samples from the Finely National Wildlife Refuge, 1998, Continued. (Only those compounds detected during the current study are reported here).

Site Name	Date	EPTC	Ethoprop	MCPA	Metolachlor	Metribuzin	Pronamide	Simazine	Tebuthiuron	Triclopyr
		82668	82672	38482	39415	82630	82676	04035	82670	49235
Duplicates										
Gray Creek at Cattail Pond	04/22/98	E 0.003	< 0.003	< 0.17	< 0.002	< 0.004	< 0.003	< 0.005	< 0.01	< 0.250
	04/22/98	< 0.002	< 0.003	< 0.17	< 0.002	< 0.004	< 0.003	< 0.005	< 0.01	< 0.250
% relative difference		--	--	--	--	--	--	--	--	--
Brown Creek at Bellfountain Road	03/24/98	< 0.002	< 0.003	< 0.17	< 0.002	< 0.004	< 0.003	< 0.005	< 0.01	< 0.250
	03/24/98	< 0.002	< 0.003	< 0.17	< 0.002	< 0.004	< 0.003	0.012	< 0.01	< 0.250
% relative difference		--	--	--	--	--	--	--	--	--
Muddy Creek at Bruce Road	02/10/98	< 0.002	0.006	< 0.17	0.005	0.055	< 0.003	E 0.002	< 0.02	< 0.250
	02/10/98	< 0.002	0.004	< 0.17	0.006	0.032	< 0.003	< 0.005	< 0.04	< 0.250
% relative difference		--	**28%**	--	**13%**	**53%**	--	--	--	--
Muddy Creek at Bruce Road	03/04/98	< 0.002	< 0.003	< 0.17	E 0.002	0.012	0.015	< 0.005	< 0.01	< 0.250
	03/04/98	< 0.002	< 0.003	< 0.17	E 0.002	0.012	0.015	E 0.002	< 0.01	< 0.250
% relative difference		--	--	--	--	**0%**	**4%**	--	--	--
Muddy Creek at Bruce Road	11/09/98	< 0.002	< 0.003	< 0.17	0.011	< 0.004	< 0.003	< 0.005	< 0.01	< 0.250
	11/09/98	< 0.002	< 0.003	< 0.17	0.010	< 0.004	< 0.003	< 0.005	< 0.01	< 0.250
% relative difference		--	--	--	**3%**	--	--	--	--	--
Muddy Creek at North Bridge	08/18/98	< 0.002	< 0.003	< 0.17	< 0.002	< 0.004	< 0.003	< 0.005	< 0.01	< 0.250
	08/18/98	< 0.002	< 0.003	< 0.17	< 0.002	< 0.004	< 0.003	< 0.005	< 0.01	< 0.250
% relative difference		--	--	--	--	--	--	--	--	--
Blanks										
Grays Creek at Cattail Pond	04/22/98	< 0.002	< 0.003	< 0.17	< 0.002	< 0.004	< 0.003	< 0.005	< 0.01	< 0.250
Muddy Creek at Bruce Road	02/10/98	< 0.002	< 0.003	< 0.17	< 0.002	< 0.004	< 0.003	< 0.005	< 0.01	< 0.250
Muddy Creek at North Bridge	03/04/98	< 0.002	< 0.003	--	< 0.002	< 0.004	< 0.003	< 0.005	< 0.01	--
Muddy Creek at North Bridge	03/04/98	--	--	< 0.17	--	--	--	--	--	< 0.250

Number below compound name is USEPA STORET code

E, estimated concentrations, which have an increased uncertainty of analytical precision, but not an increased uncertainty of analytical detection

<, less than long-term laboratory minimum detection limit (Pritt, 1994)

--, no data

Percent relative difference, RD, between two values, V_1 and V_2, is calculated as: $$RD = \left| \frac{V_1 - V_2}{(V_1 + V_2) + 2} \right| \cdot 100$$

Table 4. Pesticide surrogate recoveries, in percent, from water samples from the Finely National Wildlife Refuge, 1998.

Site Name	Date	Diazinon-d10	Terbuthylazine	alpha-HCH-d6	4-Bromo-3,5-Dimethyl Phenyl-n-Methyl Carbamate
Grays Creek at Cattail Pond	04/22/98	107	97	103	83
Brown Creek at Bellfountain Road	03/24/98	110	118	96	91
Muddy Creek at Bruce Road	02/10/98	83	98	98	92
Muddy Creek at Bruce Road	03/04/98	93	101	99	82
Muddy Creek at Bruce Road	11/09/98	98	104	101	97
Muddy Creek at North Bridge	08/18/98	129	103	97	84

Table 5. Nutrient concentrations in duplicate and field-equipment-blank water samples from the Finely National Wildlife Refuge, 1998.

Site Name	Date	Ammonia (filtered) (mg/L as N) 00608	Nitrite (filtered) (mg/L as N) 00613	Ammonia plus Organic Nitrogen (filtered) (mg/L as N) 00623	Ammonia plus Organic Nitrogen (whole water) (mg/L as N) 00625	Nitrite plus Nitrate, dissolved (filtered) (mg/L as N) 00631	Phosphorus, total (whole water) (mg/L as P) 00665	Phosphorus, dissolved (filtered) (mg/L as P) 00666	Ortho-phosphorus (filtered) (mg/L as P) 00671
Duplicates									
Muddy Creek at Bruce Road	11/09/98	0.059	0.011	0.32	0.31	<0.05	0.061	0.036	0.043
	11/09/98	0.061	0.011	0.37	0.25	0.05	0.052	E 0.04	0.044
% relative difference		**3%**	**0%**	**16%**	**21%**	**--**	**16%**	**--**	**2%**
Muddy Creek at North Bridge	03/24/98	0.14	0.035	0.50	0.58	0.54	0.133	0.051	0.052
	03/24/98	0.14	0.039	0.46	0.53	0.55	0.132	0.055	0.058
% relative difference		**0%**	**11%**	**9%**	**9%**	**2%**	**1%**	**8%**	**11%**
Blanks									
Finley NWR Headquarters	02/11/98	<0.02	< 0.01	< 0.1	< 0.1	0.102	< 0.01	< 0.01	0.018
Muddy Creek at Bruce Road	03/04/98	--	--	--	< 0.1	--	< 0.01	--	--
Muddy Creek at North Bridge	03/24/98	<0.02	< 0.01	< 0.1	< 0.1	<0.05	< 0.01	< 0.01	0.011

Number below compound name is USEPA STORET code

E, estimated concentrations, which have an increased uncertainty of analytical precision, but not an increased uncertainty of analytical detection

<, less than long-term laboratory minimum reporting limit (Timme, 1995)

--, no data

Percent relative difference, RD, between two values, V_1 and V_2, is calculated as: $$RD = \left| \frac{V_1 - V_2}{(V_1 + V_2) \div 2} \right| \cdot 100$$

For ammonia plus organic nitrogen, concentrations measured in filtered samples may be slightly higher than concentrations measured in whole-water samples, due to random uncertainty and (or) error in sampling and analytical processes

Table 6. Summary of pesticide detections, in µg/L, in water samples from the Finely National Wildlife Refuge, 1998. (Based on 42 samples, excluding quality-control samples).

	USEPA STORET Code	Long-term minimum detection limit (µg/L)	Documented use on or near Finley NWR [a]	Number of detections (current study)	Maximum detected value			Percent detections		
					Finley NWR (current study)	Rinella & Janet (1998) [b]	Anderson et al. (1997) [c]	Finley NWR (current study)	Rinella & Janet (1998) [b]	Anderson et al. (1997) [c]
2,4,5-T	39742	.035		0	ND	ND	ND	ND	ND	ND
2,4-D	39732	.15	√	4	1.3	.79	10.	10	13	21
2,4-DB	38746	.24		0	ND	ND	ND	ND	ND	ND
2,6-Diethylaniline	82660	.003		0	ND	ND	ND	ND	ND	ND
3-Hydroxycarbofuran	49308	.014		0	ND	ND	ND	ND	ND	ND
Acetochlor	49260	.002	√	0	ND	ND	ND	ND	ND	ND
Acifluorfen	49315	.035		0	ND	ND	ND	ND	ND	ND
Alachlor	46342	.002	√	2	.005	.36	.005	5	7	1
Aldicarb	49312	.55		0	ND	ND	ND	ND	ND	ND
Aldicarb Sulfone	49313	.10		0	ND	ND	ND	ND	ND	ND
Aldicarb Sulfoxide	49314	.021		0	ND	ND	ND	ND	ND	ND
alpha-BHC	34253	.002		0	ND	ND	ND	ND	ND	ND
Atrazine	39632	.001	√	32	3.0	4.5	90.	76	94	99
Benfluralin	82673	.002		0	ND	ND	ND	ND	ND	ND
Bentazon	38711	.014	√	0	ND	1.2	.24	ND	5	3
Bromacil	04029	.035		1	.090	.20	51	2	2	15
Bromoxynil	49311	.035	√	0	ND	.11	.22	ND	1	1
Butylate	4028	.002	√	0	ND	.004	ND	ND	<1	ND
Carbaryl	82680	.003		0	ND	2.0	.11	ND	24	13
Carbofuran	82674	.003		0	ND	9.0	.084	ND	30	4
Chloramben	49307	.42		0	ND	ND	ND	ND	ND	ND
Chlorothalonil	49306	.48	√	0	ND	ND	ND	ND	ND	ND
Chlorpyrifos	38933	.004 [d]	√	2	.012	.40	3.3	5	34	14
Clopyralid	49305	.23	√	0	ND	ND	ND	ND	ND	ND
Cyanazine	04041	.004	√	0	ND	.024	ND	ND	2	ND
Dacthal	49304	.017		0	ND	ND	ND	ND	ND	ND
DCPA	82682	.002		0	ND	.061	.003	ND	35	4
p,p'-DDE	34653	.006		0	ND	.004	ND	ND	5	ND
Deethylatrazine	04040	.002		28	.078	.27	.24	67	73	93
Diazinon	39572	.002	√	0	ND	1.2	.31	ND	54	26
Dicamba	38442	.035	√	1	.035	.29	14.	2	2	5

Table 6. Summary of pesticide detections, in µg/L, in water samples from the Finely National Wildlife Refuge, 1998, Continued.
(Based on 42 samples, excluding quality-control samples).

	USEPA STORET Code	Long-term minimum detection limit (µg/L)	Documented use on or near Finley NWR [a]	Number of detections (current study)	Maximum detected value			Percent detections		
					Finley NWR (current study)	Rinella & Janet (1998) [b]	Anderson et al. (1997) [c]	Finley NWR (current study)	Rinella & Janet (1998) [b]	Anderson et al. (1997) [c]
Dichlobenil	49303	1.2		0	ND	.42	.23	ND	6	21
Dichlorprop	49302	.032	√	0	ND	ND	ND	ND	ND	ND
Dieldrin	39381	.001		0	ND	.021	ND	ND	6	ND
Dinoseb	49301	.035		0	ND	1.0	.19	ND	6	1
Disulfoton	82677	.017		0	ND	ND	ND	ND	ND	ND
Diuron	49300	.02	√	16	.39	14.	29.	38	59	73
DNOC	49299	.42		0	ND	ND	ND	ND	ND	ND
EPTC	82668	.002	√	4	.004	1.0	.89	10	35	22
Ethalfluralin	82663	.004		0	ND	ND	ND	ND	ND	ND
Ethoprop	82672	.003	√	1	.003	2.0	.44	2	29	22
Fenuron	49297	.013		0	ND	ND	ND	ND	ND	ND
Fluometuron	38811	.035		0	ND	ND	ND	ND	ND	ND
Fonofos	04095	.003	√	0	ND	.10	.012	ND	23	3
Lindane	39341	.004		0	ND	.094	ND	ND	8	ND
Linuron	82666	.002		0	ND	.011	ND	ND	<1	ND
Malathion	39532	.005	√	0	ND	.24	.030	ND	7	1
MCPB	38487	.14		0	ND	ND	ND	ND	ND	ND
MCPA	38482	.17	√	1	.17	.63	.98	2	3	10
Methiocarb	38501	.026		0	ND	.10	ND	ND	<1	ND
Methomyl	49296	.017		0	ND	ND	ND	ND	ND	ND
Methyl Azinphos	82686	.001		0	ND	.18	ND	ND	2	ND
Methyl Parathion	82667	.006		0	ND	ND	ND	ND	ND	ND
Metolachlor	39415	.002	√	15	.056	3.3	4.5	36	79	85
Metribuzin	82630	.004	√	6	.014	.15	5.3	14	17	31
Molinate	82671	.004		0	ND	ND	ND	ND	ND	ND
Napropamide	82684	.003		0	ND	1.7	.011	ND	37	4
Neburon	49294	.015		0	ND	ND	ND	ND	ND	ND
Norflurazon	49293	.024		0	ND	.45	. 02	ND	2	1
Oryzalin	49292	.31 [e]	√	0	ND	1.8	3.2	ND	2	4
Oxamyl	38866	.018		0	ND	.070	ND	ND	<1	ND
Parathion	39542	.004		0	ND	ND	ND	ND	ND	ND
Pebulate	82669	.004		0	ND	.007	ND	ND	<1	ND

Table 6. Summary of pesticide detections, in µg/L, in water samples from the Finely National Wildlife Refuge, 1998, Continued.
(Based on 42 samples, excluding quality-control samples).

	USEPA STORET Code	Long-term minimum detection limit (µg/L)	Documented use on or near Finley NWR [a]	Number of detections (current study)	Maximum detected value			Percent detections		
					Finley NWR (current study)	Rinella & Janet (1998) [b]	Anderson et al. (1997) [c]	Finley NWR (current study)	Rinella & Janet (1998) [b]	Anderson et al. (1997) [c]
Pendimethalin	82683	.004	√	0	ND	.13	ND	ND	7	ND
cis-Permethrin	82687	.005		0	ND	.019	ND	ND	<1	ND
Phorate	82664	.002		0	ND	ND	ND	ND	ND	ND
Picloram	49291	.05	√	0	ND	ND	ND	ND	ND	ND
Prometon	04037	.018		0	ND	.076	.046	ND	27	35
Pronamide	82676	.003	√	6	.077	.065	.62	14	18	36
Propachlor	04024	.007	√	0	ND	.013	.051	ND	5	3
Propanil	82679	.004		0	ND	.003	.066	ND	<1	1
Propargite	82685	.013		0	ND	.054	ND	ND	1	ND
Propham	49236	.035		0	ND	ND	ND	ND	ND	ND
Propoxur	38538	.035		0	ND	ND	ND	ND	ND	ND
Silvex	39762	.021		0	ND	ND	ND	ND	ND	ND
Simazine	04035	.005	√	11	.019	5.8	1.0	26	84	85
Tebuthiuron	82670	.01 [f]		5	.022	.14	.32	12	21	37
Terbacil	82665	.007		0	ND	.11	.97	ND	30	16
Terbufos	82675	.013		0	ND	ND	ND	ND	ND	ND
Thiobencarb	82681	.002		0	ND	ND	ND	ND	ND	ND
Triallate	82678	.001		0	ND	.008	.070	ND	2	13
Triclopyr	49235	.25	√	1	.03E	.72	6.0	2	8	23
Trifluralin	82661	.002	√	0	ND	.036	.023	ND	18	6

ND, not detected
E, estimated
[a] Brunkal (1997)
[b] 141-195 samples analyzed, depending on analyte
[c] 93-95 samples analyzed, depending on analyte
[d] 1 sample analyzed at an MDL of .01 µg/L
[e] 1 sample analyzed at an MDL of .55 µg/L; 1 sample analyzed at an MDL of 1.5 µg/L
[f] 2 samples analyzed at an MDL of .02 µg/L; 1 sample analyzed at an MDL of .04 µg/L

Table 7. Pesticide concentrations, in µg/L, in environmental water samples from the Finely National Wildlife Refuge, 1998.

Site Name	Date	Weather	2,4-D	Alachlor	Atrazine	Bromacil	Chlorpyrifos	Deethyl-atrazine	Dicamba	Diuron
			39732	46342	39632	04029	38933	04040	38442	49300
Gray Creek Reference Site	02/10/98	rain	< 0.15	< 0.002	< 0.001	< 0.035	< 0.004	< 0.002	< 0.035	< 0.02
	03/04/98	rain	< 0.15	< 0.002	< 0.001	< 0.035	< 0.004	< 0.002	< 0.035	< 0.02
	03/21/98	rain	< 0.15	< 0.002	0.020	< 0.035	< 0.004	E 0.002	< 0.035	< 0.02
	03/24/98	rain	< 0.15	< 0.002	E 0.002	< 0.035	< 0.004	< 0.002	< 0.035	< 0.02
	04/22/98	dry	< 0.15	< 0.002	< 0.001	< 0.035	< 0.004	< 0.002	< 0.035	< 0.02
	04/24/98	rain	< 0.15	< 0.002	< 0.001	< 0.035	< 0.004	< 0.002	< 0.035	< 0.02
	08/18/98	dry	< 0.15	< 0.002	< 0.001	< 0.035	< 0.004	< 0.002	< 0.035	< 0.02
	11/09/98	rain	< 0.15	< 0.002	< 0.001	< 0.035	< 0.004	< 0.002	< 0.035	< 0.02
Gray Creek above Beaver Pond	10/01/98	dry	< 0.15	< 0.002	< 0.001	< 0.035	< 0.004	< 0.002	< 0.035	< 0.02
Gray Creek at Beaver Pond	02/10/98	rain	< 0.15	< 0.002	E 0.003	< 0.035	< 0.004	E 0.001	< 0.035	< 0.02
	03/04/98	rain	< 0.15	< 0.002	E 0.002	< 0.035	< 0.01	E 0.001	< 0.035	< 0.02
	03/24/98	rain	< 0.15	< 0.002	0.008	< 0.035	< 0.004	E 0.002	< 0.035	< 0.02
	04/22/98	dry	< 0.15	< 0.002	E 0.003	< 0.035	< 0.004	E 0.002	< 0.035	< 0.02
	08/18/98	dry	< 0.15	< 0.002	< 0.001	< 0.035	< 0.004	< 0.002	< 0.035	E 0.03
	11/09/98	rain	< 0.15	< 0.002	0.008	< 0.035	< 0.004	E 0.004	< 0.035	0.080
Gray Creek below Beaver Pond	10/01/98	dry	< 0.15	< 0.002	< 0.001	< 0.035	< 0.004	< 0.002	< 0.035	< 0.02
Gray Creek at Cattail Pond	02/10/98	rain	< 0.15	< 0.002	0.004	< 0.035	< 0.004	E 0.001	< 0.035	0.050
	03/04/98	rain	< 0.15	< 0.002	E 0.003	< 0.035	< 0.004	E 0.001	< 0.035	E 0.02
	03/21/98	rain	E 0.06	< 0.002	0.035	< 0.035	< 0.004	E 0.002	< 0.035	0.040
	03/24/98	rain	< 0.15	< 0.002	0.031	< 0.035	< 0.004	E 0.003	< 0.035	E 0.007
	04/22/98	dry	< 0.15	< 0.002	0.006	< 0.035	< 0.004	E 0.002	< 0.035	< 0.02
	04/24/98	rain	< 0.15	< 0.002	0.004	< 0.035	< 0.004	E 0.002	< 0.035	< 0.02
	11/09/98	rain	< 0.15	< 0.002	0.005	< 0.035	< 0.004	< 0.002	< 0.035	< 0.02
Brown Creek at Bellfountain Road	02/10/98	rain	< 0.15	< 0.002	0.073	< 0.035	< 0.004	E 0.03	< 0.035	< 0.02
	03/04/98	rain	< 0.15	< 0.002	0.043	< 0.035	< 0.004	E 0.03	< 0.035	< 0.02
	03/21/98	rain	< 0.15	< 0.002	3.0	< 0.035	< 0.004	E 0.03	< 0.035	E 0.02
	03/24/98	rain	< 0.15	< 0.002	2.2	< 0.035	< 0.004	E 0.08	< 0.035	< 0.02
	04/22/98	dry	< 0.15	< 0.002	0.30	< 0.035	0.012	E 0.05	< 0.035	< 0.02
	04/24/98	rain	< 0.15	< 0.002	0.074	< 0.035	< 0.004	E 0.01	< 0.035	< 0.02
	08/18/98	dry	< 0.15	< 0.002	0.12	< 0.035	< 0.004	E 0.04	< 0.035	< 0.02
	11/09/98	rain	< 0.15	< 0.002	0.040	< 0.035	< 0.004	E 0.02	< 0.035	< 0.02
Muddy Creek at Bruce Road	02/10/98	rain	< 0.15	< 0.002	< 0.001	< 0.035	< 0.004	< 0.002	< 0.035	< 0.02
	03/04/98	rain	< 0.15	< 0.002	< 0.001	< 0.035	< 0.004	< 0.002	< 0.035	< 0.02
	03/24/98	rain	0.24	< 0.002	1.2	< 0.035	< 0.004	E 0.03	E 0.03	0.19
	04/22/98	dry	< 0.15	< 0.002	0.068	< 0.035	< 0.004	E 0.01	< 0.035	0.060
	04/24/98	rain	< 0.15	< 0.002	0.27	< 0.035	0.006	E 0.03	< 0.035	0.080
	11/09/98	rain	< 0.15	< 0.002	0.006	< 0.035	< 0.004	< 0.002	< 0.035	< 0.02
Muddy Creek at North Bridge	02/10/98	rain	< 0.15	< 0.002	0.12	< 0.035	< 0.004	E 0.01	< 0.035	0.30
	03/04/98	rain	< 0.15	0.005	0.14	< 0.035	< 0.004	E 0.01	< 0.035	0.39
	03/21/98	rain	E 0.14	< 0.002	0.066	< 0.035	< 0.004	E 0.007	< 0.035	0.090
	03/24/98	rain	1.3	E 0.003	1.2	< 0.035	< 0.004	E 0.02	< 0.035	0.32
	04/22/98	dry	< 0.15	< 0.002	0.065	< 0.035	< 0.004	E 0.009	< 0.035	0.070
	08/18/98	dry	< 0.15	< 0.002	< 0.001	E 0.09	< 0.004	< 0.002	< 0.035	0.040
	11/09/98	rain	< 0.15	< 0.002	0.010	< 0.035	< 0.004	< 0.002	< 0.035	< 0.02

Table 7. Pesticide concentrations, in µg/L, in environmental water samples from the Finely National Wildlife Refuge, 1998, Continued.

Site Name	Date	Weather	EPTC	Ethoprop	MCPA	Metolachlor	Metribuzin	Pronamide	Simazine	Tebuthiuron	Triclopyr
			82668	82672	38482	39415	82630	82676	04035	82670	49235
Gray Creek Reference Site	02/10/98	rain	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
	03/04/98	rain	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
	03/21/98	rain	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
	03/24/98	rain	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
	04/22/98	dry	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
	04/24/98	rain	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
	08/18/98	dry	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
	11/09/98	rain	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
Gray Creek above Beaver Pond	10/01/98	dry	<0.002	<0.003	<0.17	0.004	<0.004	<0.003	<0.005	<0.01	<0.25
Gray Creek at Beaver Pond	02/10/98	rain	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
	03/04/98	rain	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
	03/24/98	rain	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
	04/22/98	dry	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
	08/18/98	dry	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
	11/09/98	rain	<0.002	<0.003	<0.17	0.007	<0.004	<0.003	<0.005	<0.01	<0.25
Gray Creek below Beaver Pond	10/01/98	dry	<0.002	<0.003	<0.17	0.007	<0.004	<0.003	<0.005	<0.01	<0.25
Gray Creek at Cattail Pond	02/10/98	rain	<0.002	E0.003	<0.17	<0.002	0.004	<0.003	<0.005	<0.02	<0.25
	03/04/98	rain	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
	03/21/98	rain	<0.002	<0.003	<0.17	<0.002	0.008	<0.003	<0.005	<0.01	<0.25
	03/24/98	rain	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
	04/22/98	dry	E0.003	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
	04/24/98	rain	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
	11/09/98	rain	<0.002	<0.003	<0.17	0.056	<0.004	<0.003	<0.005	<0.01	<0.25
Brown Creek at Bellfountain Road	02/10/98	rain	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	0.007	<0.01	<0.25
	03/04/98	rain	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	E0.004	<0.01	<0.25
	03/21/98	rain	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	0.019	<0.01	<0.25
	03/24/98	rain	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
	04/22/98	dry	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	E0.004	<0.01	<0.25
	04/24/98	rain	E0.003	<0.003	<0.17	E0.002	<0.004	E0.003	0.013	0.013	<0.25
	08/18/98	dry	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
	11/09/98	rain	<0.002	<0.003	<0.17	0.010	<0.004	<0.003	<0.005	<0.01	<0.25
Muddy Creek at Bruce Road	02/10/98	rain	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
	03/04/98	rain	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
	03/24/98	rain	<0.002	<0.003	<0.17	E0.002	0.010	0.077	0.013	0.020	<0.25
	04/22/98	dry	E0.003	<0.003	<0.17	E0.003	<0.004	<0.003	0.006	<0.01	<0.25
	04/24/98	rain	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	E0.03
	11/09/98	rain	<0.002	<0.003	<0.17	0.011	<0.004	<0.003	<0.005	<0.01	<0.25
Muddy Creek at North Bridge	02/10/98	rain	<0.002	<0.003	<0.17	E0.004	0.011	<0.003	<0.005	<0.01	<0.25
	03/04/98	rain	<0.002	<0.003	<0.17	E0.004	0.014	0.007	E0.004	<0.01	<0.25
	03/21/98	rain	<0.002	<0.003	<0.17	E0.002	<0.004	E0.004	E0.005	E0.009	<0.25
	03/24/98	rain	<0.002	<0.003	E0.16	E0.003	0.010	0.059	0.013	0.022	<0.25
	04/22/98	dry	E0.004	<0.003	<0.17	E0.004	<0.004	E0.003	0.006	0.012	<0.25
	08/18/98	dry	<0.002	<0.003	<0.17	<0.002	<0.004	<0.003	<0.005	<0.01	<0.25
	11/09/98	rain	<0.002	<0.003	<0.17	0.014	<0.004	<0.003	<0.005	<0.01	<0.25

Only those compounds detected during the current study are reported here.
Number below compound name is USEPA STORET code.
'dry' weather indicates no measurable rainfall during the 5-day period ending on the sampling date; 'rain' indicates measurable rainfall on the day of sampling
<, less than long-term laboratory minimum detection limit (Pritt, 1994); under particularly favorable analytical conditions, values below the method detection limit are reported (Childress et al., 1999)
E, estimated concentrations, which have an increased uncertainty of analytical precision, but not an increased uncertainty of analytical detection
Shaded cells indicate compound detections
Boxed cells indicate maximum detected value

Table 8. Nutrient concentrations, in mg/L as N or P, in environmental water samples from the Finely National Wildlife Refuge, 1998.

Site Name	Date	Weather	Ammonia Nitrogen (filtered)	Nitrite Nitrogen (filtered)	Ammonia plus Organic Nitrogen (filtered)	Ammonia plus Organic Nitrogen, (whole water)	Dissolved Nitrite + Nitrate Nitrogen (filtered)	Total Phosphorus (whole water)	Dissolved Phosphorus (filtered)	Ortho-phosphorus (filtered)
			00608	00613	00623	00625	00631	00665	00666	00671
Gray Creek Reference Site	02/11/98	rain	<.02	<.01	<.10	<.10	.10	.023	.016	.015
	03/04/98	rain	<.02	<.01	<.10	<.10	< .05	.023	<.01	.020
	03/24/98	rain	<.02	.014	.13	<.10	.077	.015	.010	.021
	04/22/98	dry	.022	<.01	<.10	<.10	.053	<.01	<.01	<.01
	11/09/98	rain	.058	.011	.17	.21	.065	.020	<.05	.022
Gray Creek at Beaver Pond	02/10/98	rain	<.02	<.01	.12	.11	.15	.022	<.01	.014
	03/04/98	rain	.020	<.01	<.10	.10	.079	.015	<.01	.014
	03/24/98	rain	.021	.017	<.10	.11	.11	.032	<.01	.012
	04/22/98	dry	.021	<.01	<.10	<.10	.053	<.01	<.01	.011
	11/09/98	rain	.079	.011	.24	.25	.063	.032	.010	.017
Gray Creek at Cattail Pond	02/11/98	rain	<.02	<.01	.16	.19	.12	.027	<.01	.013
	03/04/98	rain	<.02	<.01	.19	.17	< .05	.019	<.01	.016
	03/24/98	rain	.035	.019	.19	.17	.10	.028	.014	.012
	04/22/98	dry	<.02	<.01	.26	.31	< .05	.032	<.01	.019
	11/09/98	rain	.19	.014	.66	.72	.47	.052	.018	.023
Brown Creek at Bellfountain Road	02/10/98	rain	<.02	<.01	.16	.66	1.0	.11	.022	.027
	03/04/98	rain	<.02	<.01	<.10	.17	1.2	.070	<.01	.021
	03/24/98	rain	<.02	.011	<.10	.10	1.3	.058	.057	.029
	04/22/98	dry	<.02	<.01	.10	<.10	1.1	.022	<.01	.012
	11/09/98	rain	.064	.011	.17	.18	.43	.044	.024	.039
Muddy Creek at Bruce Road	02/10/98	rain	<.02	<.01	.38	.58	< .05	.11	.027	.018
	03/04/98	rain	.077	<.01	.32	.41	.41	.093	.041	.030
	03/24/98	rain	.16	.028	.40	.49	.50	.13	.058	.065
	04/22/98	dry	.27	.016	.50	.67	.25	.090	.044	.041
	11/09/98	rain	.059	.011	.32	.31	< .05	.061	.036	.043
Muddy Creek at North Bridge	02/11/98	rain	.066	.011	.36	.55	.33	.12	.051	.045
	03/04/98	rain	.23	.013	.49	.66	.47	.12	.061	.069
	03/24/98	rain	.14	.035	.50	.58	.54	.13	.051	.052
	04/22/98	dry	.089	.024	.53	.64	.32	.13	.044	.040
	11/09/98	rain	.14	.011	.38	.27	< .05	.065	.054	.060

Number below compound name is USEPA STORET code
'dry' indicates no measurable rainfall during the 5-day period ending on the sampling date; 'rain' indicates measurable rainfall on the day of sampling
<, less than long-term laboratory minimum reporting limit (Timme, 1995)
Shaded/bolded cells indicate compound detections
Boxed cells indicate maximum detected value
Concentrations measured in filtered samples may be slightly higher than concentrations of the same compounds measured in whole-water samples due to random uncertainty and (or) error in sampling and analytical processes

Table 9. Comparisons of nutrient concentrations, in mg/L as N or P, between two Willamette Valley studies (excluding quality-control samples).

	USEPA STORET Code	Long-term minimum reporting limit	Median detected value		Maximum detected value	
			Finley NWR (current study) [a]	Rinella & Janet (1998) [b]	Finley NWR (current study) [a]	Rinella & Janet (1998) [b]
Ammonia + Organic Nitrogen (whole water)	00625	0.10	0.26	.5	.72	4.1
Nitrite + Nitrate Nitrogen (filtered)	00631	0.05	0.29	1.1	1.3	22
Total Phosphorus (whole water)	00665	0.01	.038	.090	.13	7.0
Orthophosphorus (filtered)	00671	0.01	.021	.050	.069	5.8

[a] 30 samples analyzed
[b] 259-289 samples analyzed, depending on analyte