Statewide Groundwater Monitoring Program: North Coast 2015-2016 Report

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State of Oregon
Department of Environmental Quality

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This report was revised to correct the 2,4-D result in Table 1 to reflect adjusted concentrations in ng/L. The original report showed 2,4-D results in ug/L though the units displayed in Table 6 were ng/L. This report supercedes the report originally issed 1/25/2018.

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Executive Summary

The stated objective of Oregon statute ORS 468B.155 is "to prevent contamination of Oregon's groundwater resource while striving to conserve and restore this resource and to maintain the high quality of Oregon's groundwater resource for present and future uses." The Statewide Groundwater Monitoring Program began collecting water quality data in 2015 to establish the status of ambient groundwater conditions, identify emerging groundwater quality problems and inform groundwater users of potential risks from contamination. To implement this work, DEQ conducts two regional groundwater studies annually with the goal of monitoring Oregon's vulnerable aquifers over a 10-year period. Regional study areas are selected based on previously identified groundwater vulnerabilities, nitrate data collected during real estate transactions as required by statute ORS 448.271, time elapsed since water quality data were last collected, analysis of potential contamination sources, and community interest, to help with recruitment of volunteer participants. All studies include analysis of nitrate, arsenic, bacteria, pesticides and common ions in 60 to 100 wells. Additional analyses are added based on local risk factors and program capacity.

In 2015 and 2016, the Statewide Groundwater Monitoring Program conducted a groundwater study in the North Coast Basin. Objectives of the study were:

1. To collect high-quality data on nitrate, arsenic, coliform bacteria, pesticides and consumer product constituent concentrations in groundwater throughout the study area;
2. To identify areas of groundwater contamination related to these parameters;
3. To inform well water users of the results of this study and provide information regarding potential risks to human health, and
4. To identify areas needing additional investigation in order to describe the extent of contamination and help focus efforts to prevent further contamination.

Topics outside the scope of this study and report:

- Hydrogeologic characterization of the study area and contamination
- Investigation of the sources of contamination
- Health risk assessments

The study area spanned Clatsop and Tillamook counties from the cities of Astoria to Tillamook. DEQ staff sampled 69, mostly domestic, wells for nitrate, lead, arsenic, bacteria, pesticides, consumer product constituents, metals and common ions over two sampling events in September 2015 and January 2016. These wells serve as sources of drinking water, sports field irrigation, and fish hatchery use, along with other household uses such as for farm animals, outdoor garden and lawn irrigation.

Key findings include:

- Elevated nitrate levels [3 milligrams per liter (mg/L) or higher] in the area were found in 8 of the 69 wells (11 percent). Three wells had nitrate concentrations above the maximum contaminant level (10 mg/L) set by the U.S. Environmental Protection Agency for public water systems. Those three exceedances were located in the Gearhart area and the wells had no associated well log information.
- Arsenic was measured in 4 of the 69 wells (6 percent). High arsenic [above the maximum contaminant level of 10 micrograms per liter (µg/L)] was measured in two of the wells.
- Coliform bacteria were detected in 37 of 69 wells (54 percent), and *E. coli* was also detected in nine of the 37 wells.
- Ten different pesticide-related chemicals were detected in this study, representing eight different parent pesticides. At least one current use pesticide or pesticide breakdown product was found in 8 of the 69 (11 percent) wells tested. Three wells had at least one chemical originating from a legacy pesticide detected in their water. The most commonly detected pesticide was 2,6-dichlorobenzamide, a breakdown product of dichlobenil. Five of the wells had two or more pesticide chemicals detected, and three wells had chemicals from more than one parent pesticide detected. All pesticide detections were well below their

associated screening levels (U.S. EPA, 2013, Toccalino et. al, 2014). However, very little research has been done on the effect of multiple chemicals on human health.

- Manganese was detected in 54 of the wells sampled in this study. Twenty-two wells were above the 50 µg/L secondary drinking water standard and three were above the 300 µg/L Lifetime Health Advisory (U.S. EPA, 2012). While low concentrations are likely due to natural geochemical processes, further investigation is necessary to determine the sources of manganese in the wells with very high concentrations.
- Low concentrations of uranium and vanadium were found in a small percentage of wells.
- Sulfamethoxazole, a common antibiotic, was detected in one well sampled during the September 2015 sampling period.
- Nitrate and bacteria results were not different between September and January sampling events. Pesticide detections and concentrations were slightly higher in the September sampling period than in the January sampling period.

The results of this study can be used to focus outreach and education activities that encourage private well owners to routinely test wells for nitrate, bacteria and arsenic and encourage well protection and maintenance best practices to protect the aquifer. Additional monitoring of nitrate and pesticides is recommended, especially in the area north of Gearhart. A network of wells should be established and monitored to detect any changes over time.

1. Background

1.1 Statewide Groundwater Quality Monitoring Program

Groundwater is a vital resource in Oregon. Over 600,000 Oregonians rely on private wells for their drinking water (Maupin et al., 2014). Public water systems, the agricultural community and industry also rely on groundwater to meet their operational needs. In addition, Oregon's rivers and streams depend on groundwater for the maintenance of adequate summer flows to sustain fish populations and for recreational opportunities. Groundwater is a critical water reserve that can be used when available surface water is inadequate to meet demands.

Oregon's goal is "to prevent contamination of Oregon's groundwater resource while striving to conserve and restore this resource and to maintain the high quality of Oregon's groundwater resource for present and future uses (ORS 468B.155)." To understand how Oregon is doing in meeting this goal, the Statewide Groundwater Monitoring Program began collecting water quality data in 2015 to establish the status of ambient groundwater conditions, identify emerging groundwater quality problems and inform groundwater users of potential risks from contamination.

To implement this work, two regional groundwater studies are conducted annually with the goal of monitoring Oregon's vulnerable aquifers over a 10-year period. Regional study areas are selected based on previously identified groundwater vulnerabilities, nitrate data collected during real estate transactions as required by statute (ORS 448.271), time elapsed since water quality data were collected, analysis of potential contamination sources and community interest, to help with recruitment of volunteer participants. All studies include analysis of nitrate, arsenic, bacteria, pesticides and common ions in 60 to 100 wells. Additional analyses are added based on local risk factors and program capacity.

1.2 Study Area Description

In September 2015 and January 2016, the Oregon DEQ Statewide Groundwater Monitoring Program collected and analyzed water samples in the North Coast Basin. The study area encompassed the Clatsop Plains region, which had been studied previously due to concern about high septic tank densities, sandy soil geologies and high water tables leading to potential groundwater contamination sensitivities. The current study also included the previously studied area of Tillamook, in addition to some inland towns in Tillamook and Clatsop counties (Figure 1).

The land use in this region is mostly forest with some urban, commercial or industrial, agricultural and residential uses. The geology includes volcanic rocks, marine sedimentary rocks, alluvium and a dunal sand complex. Aquifers in this region are shallow, often in unconfined and unconsolidated sedimentary material like sand and gravel (ODEQ, 2004). A study by Frank (1970) describes that the sandy dunal areas near the Clatsop Plains are primarily recharged by infiltrating precipitation and only minorly from irrigation, domestic activities, and runoff from the Coast Range foothills. There is also evidence of surface water and groundwater interactions in the shallow dunal lakes of the Clatsop Plains (PSU, 2005).

Since 1989, the Oregon Health Authority has collected data per the Real Estate Transaction Act (ORS 448.271), which indicated some elevated nitrate concentrations in this region. A 1996 DEQ groundwater investigation in the Clatsop Plains found levels of nitrate and lead that exceeded EPA Maximum Contaminant Levels in a small number of the wells sampled (ODEQ, 1996). The same study also found low levels of arsenic, copper, cadmium, chromium and barium within the study area. Two years later, a follow up study conducted by Clatsop Community College in coordination with DEQ found bacteria detections in 30-66 percent of drinking water wells (ODEQ, 2004). In addition, testing of local landfills and Public Water Supply systems by DEQ resulted in detections of the pesticide atrazine, trace amounts of volatile organic compounds and lead (ODEQ, 2004).

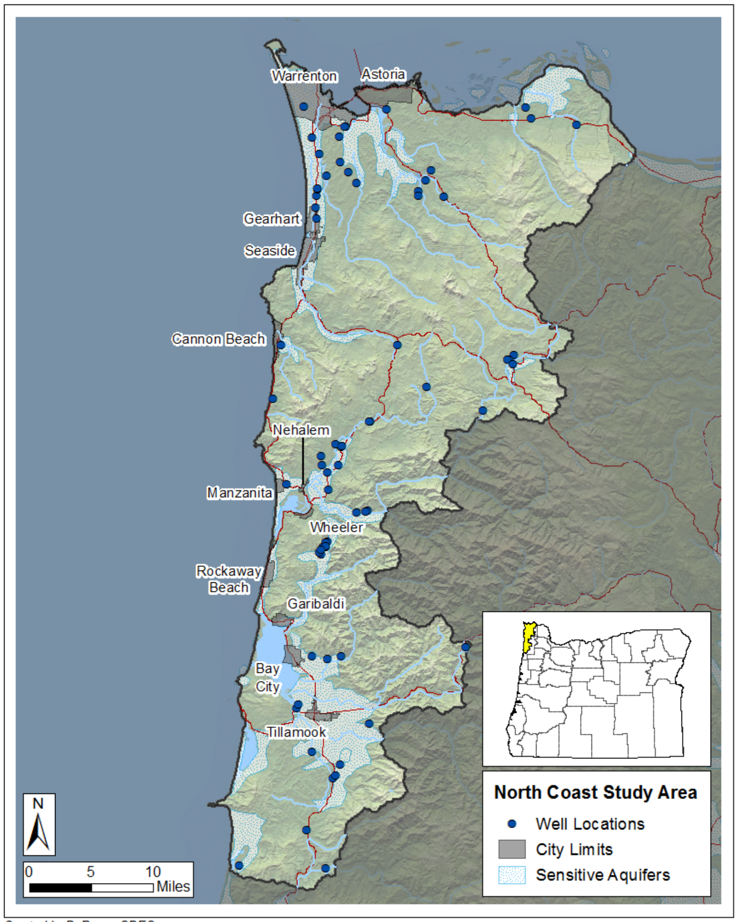

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Figure 1. Study area and sample locations (Water table aquifer from Sweet et al., 1980).

Further, the DEQ Tillamook Groundwater Study, which took place over parts of 1997 and 1998, found 20 percent of wells sampled in 1997 exceeded the drinking water standard for antimony. One well exceeded the EPA MCL of 0.015 mg/L for lead. Neither antimony nor lead were found in sampling conducted in 1998.

In 2004, the DEQ North Coast Basin Groundwater Quality report identified potential sources of contamination including high onsite septic system densities in areas with permeable, sandy soils, poor well construction and maintenance activities and potentially other point sources such as local landfills. The study area for the 2004 North Coast Basin groundwater study was more broadly defined than the current study and included parts of Clatsop, Columbia, Lincoln, Polk, Tillamook, Washington and Yamhill counties.

The 2011 DEQ Water Quality Status and Action Plan for the North Coast Basin identified program priorities related to groundwater including reviewing the effectiveness of the Clatsop Plains Geographic Rule, determining if the area should be declared an Area of Groundwater Concern or a Groundwater Management Area, continuing groundwater studies in the Clatsop Plains and assessing the "transport of contaminants via groundwater inputs to surface water drinking sources (DEQ, 2011). A North Clatsop Plain Sub-Area Plan developed by Clatsop County in 2014 outlined the concern with development in the area and made recommendations for further groundwater studies to inform local management decisions (Clatsop Co., 2014).

1.3 Study Objectives

Informed by previous investigations and guided by the objectives of the Statewide Groundwater Monitoring Program, the goals of the 2015-2016 North Coast Basin Groundwater Study were:

1. To collect high-quality data on nitrate, arsenic, coliform bacteria, pesticides and consumer product constituent concentrations in groundwater throughout the study area;
2. To identify areas of groundwater contamination related to these parameters;
3. To inform well water users of the results of this study and provide information regarding potential risks to human health, and
4. To identify areas needing additional investigation in order to describe the extent of contamination and help focus efforts to prevent further contamination.

Topics outside the scope of this study and report:

- Hydrogeologic characterization of the study area and contamination
- Investigation of the sources of contamination
- Health risk assessments

2. Study Design and Methods

2.1 Study Design

2.1.1 Study Area Selection

The study area included the communities of Astoria, Gearhart, down to Manzanita and Tillamook and inland toward Elsie (Figure 1). The study area was identified based on previous studies and history of contamination. It was narrowed down to a geographic area appropriate for a sample selection of approximately 100 wells, and to include the major, sensitive aquifers.

2.1.2 Sample Selection

Our study focused primarily on private, domestic wells and relied on homeowners who volunteered to have their wells tested in exchange for a complete report of the analytical results from their well. No personal data was included in the final results. Only the location of the well and an existing well log, if available, connects the results with a particular well. DEQ recruited volunteers using flyers, emails and other announcements with the help of the Clatsop County Soil and Water Conservation District, Tillamook County Soil and Water Conservation District, the Young's Bay Watershed Council, the Lower Columbia River Estuary Partnership, the Necanicum Watershed Council, the Lower Nehalem Watershed Council, the Ecola Creek Watershed Council, the Skipanon Watershed Council, the Olney General Store, and the Tillamook Saturday Farmer's Market.

Seventy to eighty wells were identified in the designated study area. From those candidate wells, DEQ sampled 69 wells as a part of the study based on location, availability of a well log and known or suspected depth of the well. DEQ collected samples during two events, each lasting three weeks. The first 60 wells were sampled between September14 and September 30, 2015. The second sampling event occurred between January19 and January 28, 2016. Forty-nine wells from the first event were resampled in the second event along with nine new wells, for a total of 58 wells sampled in January 2016. Wells were resampled to capture potential seasonal variability. Known depths were based on a confirmed well log while suspected depths were based on conversations with the homeowner. Due to limitations of the study design and inclusion of wells without well logs, results from this study represent the conditions in the well sampled and not the broader aquifer. Additional hydrogeologic analysis was outside the scope of this report.

Previous DEQ groundwater studies tried to include only wells with well logs, which may have introduced bias to the dataset. Older wells are more likely to not have well logs and may be more vulnerable to contamination due to poor construction or location in areas that have a longer history of agricultural activity, a known risk factor for groundwater contamination. This study did not require wells to have a well log in an effort to identify a potential increased risk of contamination in this population. A full site list including information on presence or absence of a well log can be found in Appendix A. Figure 1 shows the locations of the wells selected for this study and the location of water table aquifers as described by Sweet et al. (1980). A water table aquifer, also known as an unconfined aquifer, is groundwater that is overlain by permeable material (i.e., sand) and therefore, is expected to be more vulnerable to contamination from surface activities.

2.1.3 Analyte Selection

Sample analyses included nitrate/nitrite as N (henceforth referred to as nitrate), total coliform bacteria, *E. coli* bacteria, current use and legacy pesticides, consumer product constituents, arsenic, lead, common ions and field parameters. A complete analyte list can be found in Appendix B and the corresponding laboratory methods can be found in the Sampling and Analysis Plan (DEQ15-LAB-0046-SAP).

This study marks the first time that DEQ has analyzed groundwater samples for consumer product constituents. Consumer product constituents are considered indicators of improperly designed or failing septic tank performance, which is a concern in the North Coast when combined with permeable soils. Due to laboratory capacity limits, legacy pesticides were analyzed in 40 of the 60 wells sampled in September 2015 but were included in all 58 of the wells sampled in January 2016. These pesticides are highlighted in green in Appendix B.

2.2 Methods

2.2.1 Sampling Methods

DEQ water quality monitoring staff collected and processed samples according to standard procedures found in the Manual of Methods (DEQ03-LAB-0036-SOP_V3), Sampling and Analysis Plan (DEQ15-LAB-0046-SAP) and Quality Assurance Project Plan (DEQ93-LAB-0024-QAPP). Samples were collected from an outdoor spigot closest to the well head, whenever possible, and always before any water filtration or treatment. Some samples were collected from a pressure tank or large storage reservoir when access to water directly from the well head or spigot was not available. Wells were purged for at least five minutes and until field readings of conductivity, temperature and dissolved oxygen stabilized. Bacteria samples were collected last, after the sample point was disinfected with isopropyl alcohol.

2.2.2 Context for Data Interpretation

The results from this study can be interpreted in two different contexts: the impacts of human activities on groundwater quality and the potential for human health impacts when the groundwater is used for drinking water. Many of the chemicals analyzed in this study are not found naturally in groundwater (e.g., pesticides), or have very low natural concentrations (e.g., nitrate). Detection of these chemicals indicates an influence from human activities such as leaching from agricultural or residential use of fertilizers and pesticides, improperly designed or maintained septic systems or poor well construction. These contaminants, along with some naturally occurring minerals such as arsenic, may be harmful to human health when present in drinking water above certain levels.

Well water was tested for lead. However, in order to measure the quality of the water coming from the groundwater aquifer, rather than the water sitting in the pipes, sampling procedures included a 5-10 minute flushing period before a sample was collected. If there is concern about lead contamination from plumbing, wells should be retested using the “first flush” method.

In Oregon, there are no regulatory criteria that apply to water from private, domestic wells. However, it can be useful to compare water quality results to the criteria set by EPA for public water systems. EPA sets a maximum contaminant level goal at the concentration of a contaminant below which there is no known or expected health risk. The EPA then sets the maximum contaminant level as close to the maximum contaminant goal as feasible considering treatment technologies and cost. Maximum contaminant levels are enforceable water quality criteria for public water systems (U.S. EPA, 2014).

However, many of the chemicals measured in this study do not have a maximum contaminant level. There are several other sources of health risk information, such as the lists of Health Advisories, Human Health Benchmarks for Pesticides, and Regional Screening Levels developed by EPA (U.S. EPA, 2012; U.S. EPA, 2013; U.S. EPA, 2016) and the Health-Based Screening Levels developed by the United States Geological Survey (Toccalino et al., 2014). These non-regulatory screening values are based on the available toxicological research and can be used to determine whether the concentration of a contaminant in drinking water may pose a risk to human health. In this report, results are compared to maximum contaminant level goal and maximum contaminant levels when available. If no maximum contaminant level is available, the result is compared to the lowest value of the current Health Advisories, Human Health Benchmarks for Pesticides, Regional Screening Levels, or Health-Based Screening Levels.

3. Results and Discussion

3.1 Well Characteristics

Of the 69 wells sampled in this study, 31 had a verified well log. A DEQ hydrogeologist evaluated wells logs for aquifer confinement, depth of water bearing interval, and potential for vertical fluid migration below the well seal (Appendix A):

- **Aquifer Confinement.** Aquifers are considered confined when an impermeable layer (e.g., silt) caps the aquifer so that the aquifer does not connect with shallow groundwater. Aquifers can also be semi-confined, which means that there is limited connection with shallow groundwater. An aquifer is confined or semi-confined if the static water level in the well is higher than the water bearing zone. In the current study, most of the well logs suggested that the wells were under pressure, within semi-confined or confined aquifers below a layer of silt or clay. A few wells were very shallow and were within an unconfined sand/gravel aquifer.
- **Depth of Water Bearing Interval.** The presence of contamination may be related to the depth of the water bearing interval. Contamination may come from surface activities such as fertilizer or pesticide application, which may impact shallow waters or dissolution of geologic minerals in deeper, and likely older, waters. Depth to top of the water bearing zone was determined for 29 wells and ranged from 3 to 222 feet below ground surface.
- **Potential for Vertical Fluid Migration.** The potential for vertical fluid migration is determined on how adequately the well is sealed below the surficial aquifer by layers of silt/clay or rock (e.g., granite, sandstone, claystone, lava, basalt, or diorite). Leakage along the casing below the seal depends on the geology surrounding the casing. In addition, drilling methods may influence susceptibility to leakage by affecting the precision and accuracy of the well hole into which the well casing is inserted and sealed. Sandy soils, like those found in the North Coast Basin, tend to backfill the holes created during drilling and does a good job at filling in vertical migration paths that may leave wells susceptible to contamination from the surface. The goal is to reduce any gaps or spaces between the well casing and the surrounding geology. Twenty-six wells were determined to have low relative potential, three were determined to have medium potential, and two were determined to have high relative potential for vertical fluid migration below the seal. These determinations were based on the geologic material in which the well was located

The differences between the wells sampled in this study include: depth the well was drilled, age of the well, well construction or alterations/deepenings, land use around the well, the geology of the land and aquifer, how frequently the well is used, distance of transport piping and piping material between well and faucet, whether an inline filter system needed to be removed to take the sample, the type of faucet the sample was collected from and the presence of and/or the size of holding tank or pressure tank connected to system.

3.2 Water Quality

The following sections discuss results for analytes that indicate contamination due to human activities, or present a potential health risk for people drinking the water. Comprehensive analytical reports may be obtained by contacting the DEQ Laboratory and Environmental Assessment Program. Data can also be accessed through the Ambient Water Quality Monitoring System by visiting the DEQ Water Quality Monitoring Data webpage (http://www.oregon.gov/deq/wq/Pages/WQdata.aspx).

3.2.1 Nitrate

While nitrate is a natural and necessary nutrient found in soil and surface water, human activities can enrich the level of nitrate found in the environment. Nitrate enriched water can leach into aquifers from areas of fertilizer use, manure storage or application, or improperly designed or maintained septic systems (Powers and Schepers, 1989). While background concentrations of nitrate in groundwater may only be up to 1 mg/L (Nolan and Hitt, 2003), this report considers values of 3 mg/L or greater as elevated. This represents a level sufficiently above background to indicate an impact from human activities on groundwater quality. Drinking water with high nitrate may cause serious health problems for infants, pregnant women and nursing mothers. To protect the public from these health risks, the EPA set the maximum contaminant level for nitrate (as N) at 10 mg/L. As mentioned previously, nitrate in this study was measured as nitrate/nitrite as N. While nitrite is rarely found in groundwater at significant levels due to geochemical conditions, these results represent a conservative measurement of nitrate. More information on nitrate risks and recommendations can be found on DEQ’s Fact Sheet: Nitrate in Drinking Water (http://www.deq.state.or.us/wq/pubs/factsheets/groundwater/nitratedw.pdf).

In this study, 8 of the 69 (11 percent) wells sampled had an elevated nitrate concentration (3 mg/L or above). Three of which were above the maximum contaminant level of 10 mg/L (Figure 2). The three wells with results over the maximum contaminant level were concentrated north of Gearhart. While the wells with elevated results were spread out across the study area. Only one well had elevated nitrate concentrations during both sampling periods. The remaining wells were either sampled only once or had concentrations below 3 mg/L during the other sampling period.

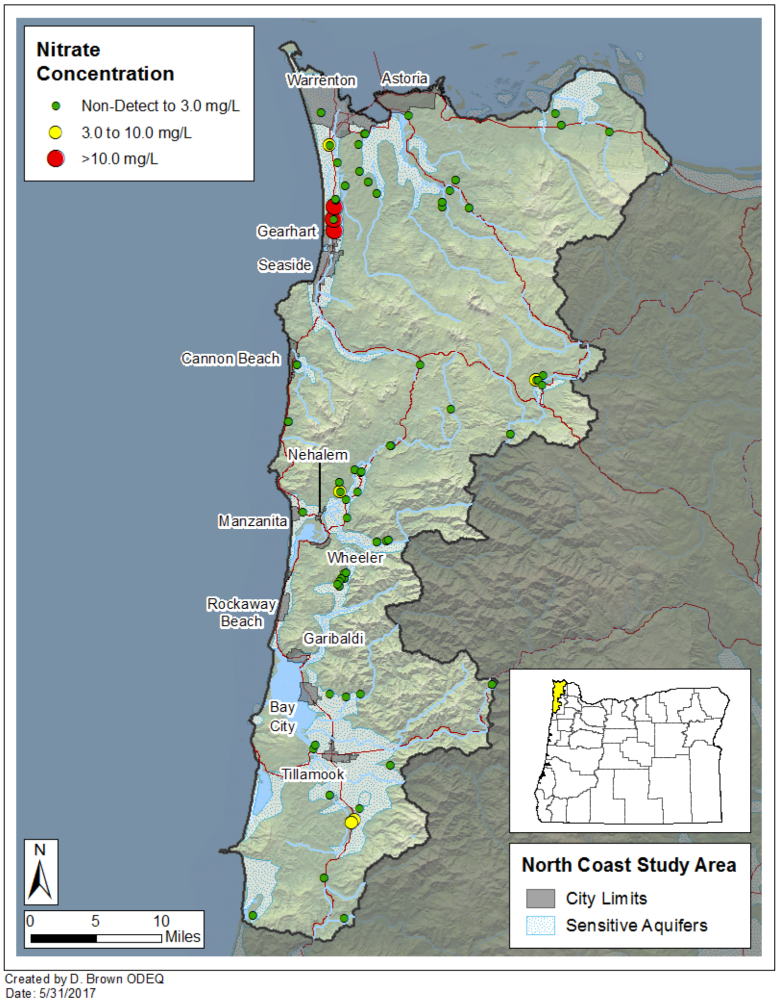

Figure 2. Nitrate concentration in sampled wells. Results higher than 3 mg/L are considered elevated due to human activities. The maximum contaminant level for nitrate in drinking water is 10 mg/L.

3.2.2 Arsenic

Arsenic is a naturally occurring element found in the earth's crust. It is found in groundwater throughout Oregon, often associated with volcanic geology. Past uses included agricultural use, especially in orchards, as an insecticide and as embalming fluids prior to 1945, indicating historic cemeteries as potential sources of arsenic (Konefes and McGee, 1996). While it is not believed that embalming fluids are a common source of arsenic in groundwater, arsenic geochemistry is complex and several factors may influence the mobility of arsenic from these sources into shallow groundwater (Welch et al., 2000). Most arsenic in groundwater is a result of dissolution of arsenic-containing minerals in soil and rock. Arsenic in drinking water is a health hazard and EPA has established a maximum contaminant level for total arsenic at 10 µg/L (parts per billion). However, the maximum contaminant level goal is zero.

Arsenic was detected in 4 of the 69 (6 percent) wells in this study (measured as total recoverable arsenic). Two wells had arsenic concentrations above the maximum contaminant level of 10 µg/L (Figure 3). Both wells exceeded the maximum contaminant level during both the September and January sampling events. In both wells, the January sampling result was lower than the September sampling result. Further investigation is necessary to understand the contributing factors for these high concentrations.

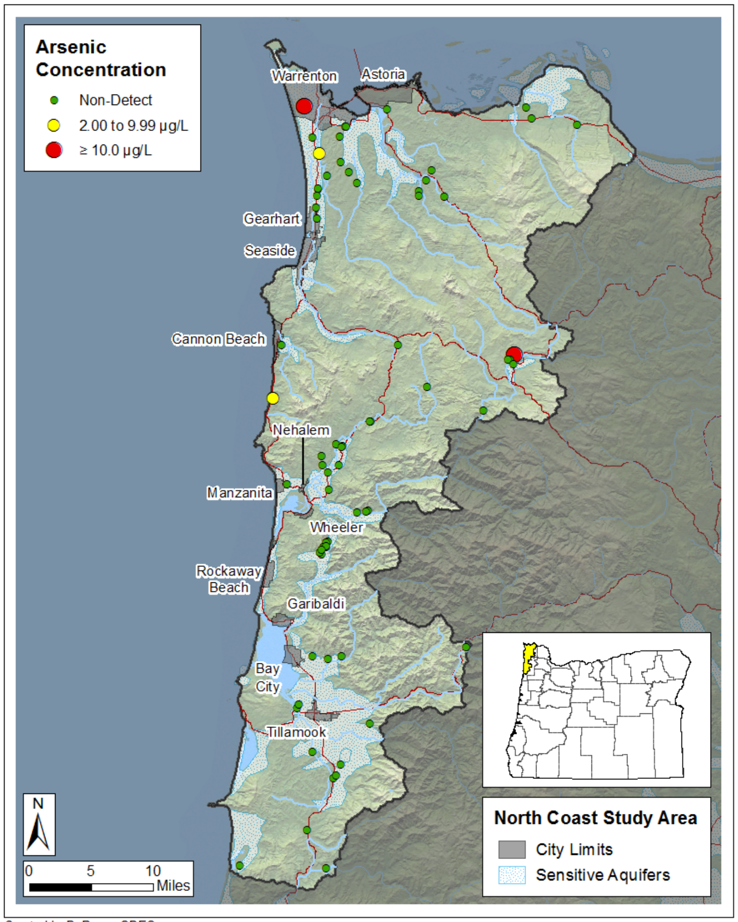

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Figure 3. Arsenic concentrations in sampled wells. The maximum contaminant level goal for arsenic is zero. The maximum contaminant level for total arsenic is 10 µg/L.

3.2.3 Coliform Bacteria and *E. coli*

Coliform bacteria are a group of closely related bacteria that are typically not harmful to humans. However, coliform bacteria are a useful indicator to determine if similar, disease-causing microorganisms (e.g., bacteria, viruses) may be present in water bodies. *E.coli* is a specific class of coliform bacteria more commonly associated with illness. Presence of coliform bacteria may indicate a problem with the integrity of a well's construction allowing contamination from surface or soil sources into the well. Bacterial contamination may also affect shallow aquifers through improperly designed or maintained septic systems or leaching from areas where manure or biosolids are spread. The maximum contaminant level goal for coliform bacteria is zero.

Coliform bacteria were detected in 37 of 69 wells (54 percent), and *E. coli* was detected in 9 of those 37 wells. Detections were evenly distributed throughout the study area (Figure 4). Public health officials recommend testing well water for coliform bacteria annually and the prevalence of coliform bacteria detected in this study strongly supports that recommendation.

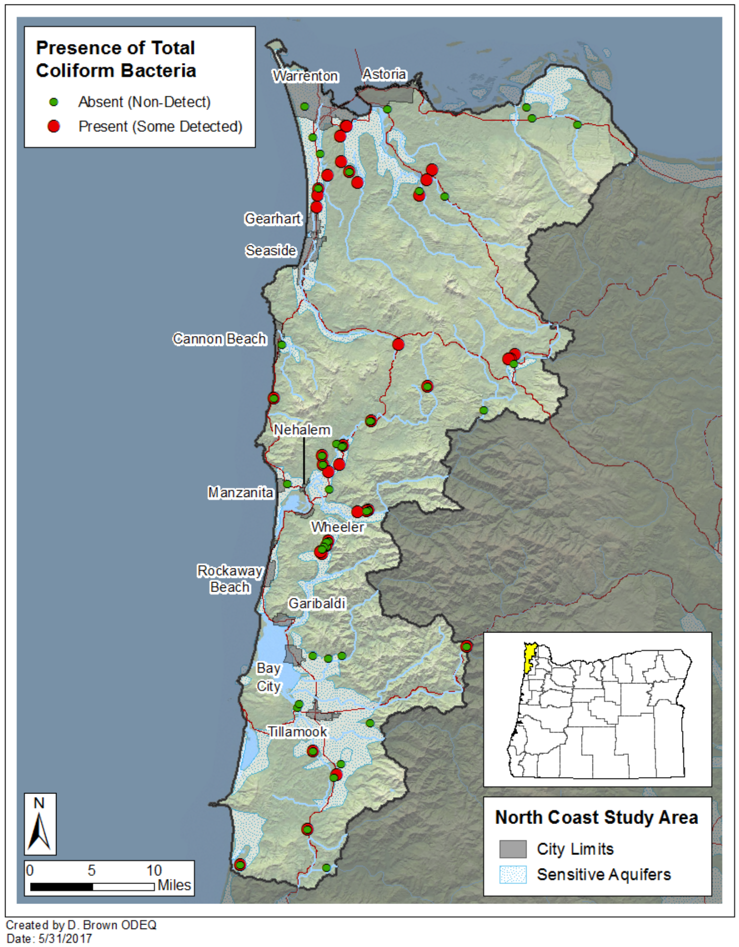

Figure 4. Bacteria results for sampled wells.

3.2.4 Pesticides

Pesticides are a broad class of chemicals that includes insecticides, herbicides and fungicides. Pesticides that are currently used and those no longer in use (legacy) were included in this study. Legacy pesticides refer to chlorinated insecticides, such as DDT, which were banned in the United States. This study also measured several chemicals that are breakdown products of pesticides. Physical processes, such as photo-degradation by sunlight, or biological processes, such as metabolism by bacteria, can break parent pesticides down into different chemicals that may be more water soluble and travel more easily into groundwater. In general, less information is known about the potential health impacts of these breakdown products than the parent pesticide. It is common to detect the breakdown product of a pesticide in a water sample, but not the parent pesticide, due to differences in solubility and other chemical properties.

Ten different pesticide-related chemicals were detected in this study, representing eight different parent pesticides (Table 1). At least one current use pesticide related chemical was detected in 8 of the 69 wells (11 percent) sampled in this study. In addition, four wells had at least one chemical originating from a legacy pesticide detected in their water (Figure 5). Pesticides were detected near most of the populated areas of the study area, however, the highest density of detections occurred in the areas near Gearhart and Warrenton (Figure 6).

The most commonly detected pesticide was 2,6-dichlorobenzamide, a breakdown product of dichlobenil. Dichlobenil is used to kill unwanted weeds in shrub beds, orchards and berry fields (Cox, 1997). While the Pesticide Action Network rates dichlobenil as a potential water contaminant hazard, 2,6-dichlorobenzamide is approximately 87 times more water soluble than its parent compound. One of these two compounds was found in five of the study wells (Table 1).

Table 1. Summary of pesticides and breakdown products detected.

	# Wells Detected	Max. Conc.	Units	Screening Level	Use
Current Use Pesticides					
Total Dichlobenils[#]	6	468.8	ng/L	2,000[3]	
2,6-Dichlorobenzamide	5	399	ng/L	29,000[2]	Breakdown product of dichlobenil
Dichlobenil	1	69.8	ng/L	70,000[2]	Herbicide
2,4-D	1	700	ng/L	70,000[1]	Herbicide
Desethylatrazine	1	33.5	ng/L	Not Available	Breakdown product of atrazine and simazine
Diuron	3	25.8	ng/L	2,000[3]	Herbicide
Imidacloprid	2	57.2	ng/L	399,000[2]	Insecticide
Legacy Pesticides					
*Total DDTs**	2	0.246	ng/L	100[3]	
4,4´-DDE	1	0.106	ng/L	100[3]	Breakdown product of banned insecticide DDT
4,4´-DDD	1	0.14	ng/L	100[3]	Breakdown product of banned insecticide DDT
gamma-BHC (Lindane)	1	0.797	ng/L	200[1]	Banned insecticide
Methoxychlor	1	0.8	ng/L	40,000[1]	Banned insecticide

[#]includes 2,6-Dichlorobenzamide and Dichlobenil

*includes 4,4'-DDE and 4,4'-DDD

[1]USEPA Maximum Contaminant Level

[2]USEPA non-regulatory Human Health Benchmark

[3]USGS Health-based Screening Level

All detected chemicals were well below any known human health screening level. Five of the wells had two or more pesticide chemicals detected (Figure 5), and three wells had chemicals from more than one parent pesticide detected (Figure 6). Very little research has been done on the combined effects of chemical mixtures on human health. A common practice is to add the concentration of all related chemicals (parent pesticides and their breakdown products, or chemically similar pesticides) and compare that concentration to the lowest screening level of those chemicals. This method assumes that the combined effect of the chemicals is no worse than the most toxic of the individual chemicals. Using this method, the results for total dichlobenils and total DDTs and are still far below a level that may cause any health risk (Table 1).

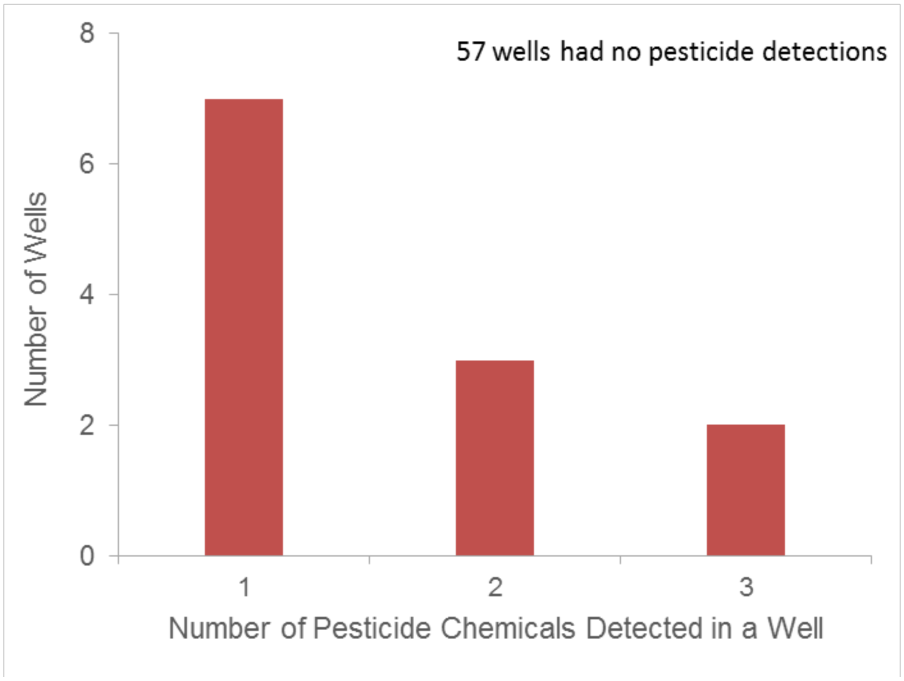

Figure 5. Histogram of total number of pesticide chemicals detected in a well.

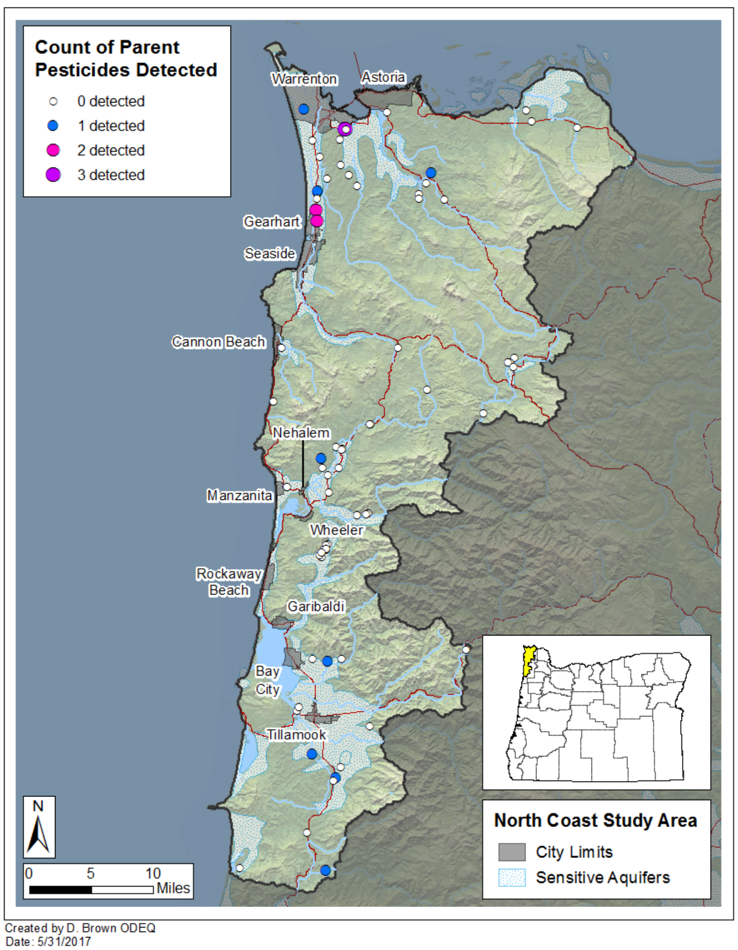

Figure 6. Number of parent pesticides detected in sampled wells.

3.2.5 Manganese

Manganese is an element found in many soils, rocks and minerals. In areas with manganese-containing minerals, manganese may be present in the groundwater under low-oxygen conditions. At high concentrations, manganese has been associated with neurological disease. EPA has set a secondary drinking water standard for manganese at 50 µg/L to avoid discoloration, staining and a metallic taste. EPA also has calculated a Lifetime Health Advisory for manganese in drinking water at 300 µg/L. Manganese was detected in 54 of the wells sampled in this study. Twenty-two wells were above the 50 µg/L secondary drinking water standard and three were above the 300 µg/L Lifetime Health Advisory (Figure 7). While low concentrations are likely due to natural geochemical processes, further investigation is necessary to determine the sources of manganese in the wells with very high concentrations. Water above the secondary drinking water standard would not be palatable for drinking without treatment.

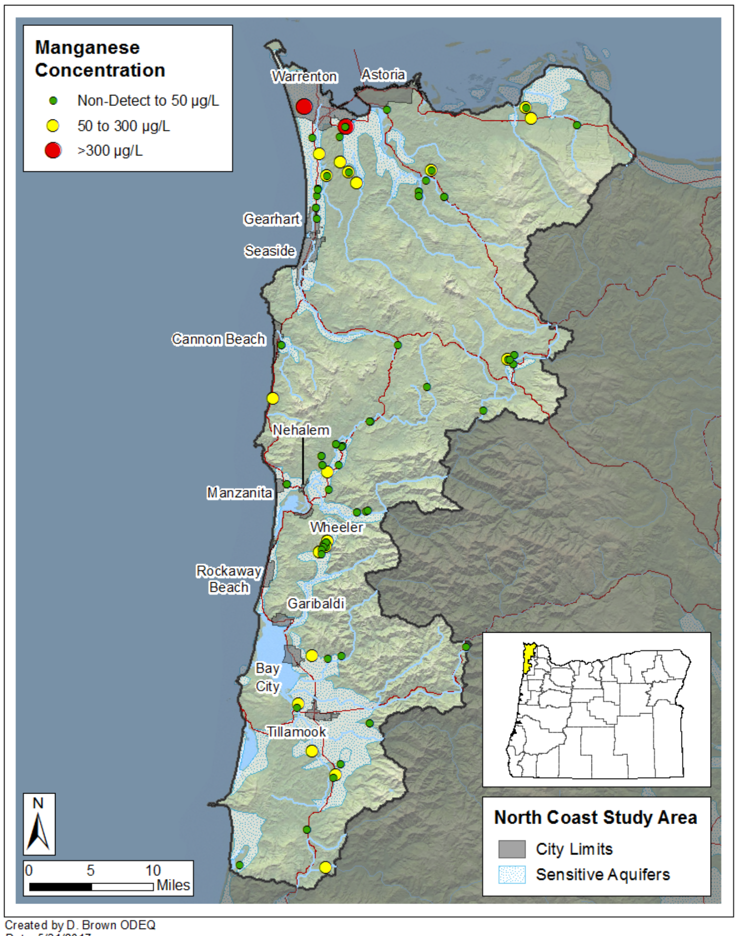

Figure 7. Manganese results in sampled wells. The secondary drinking water standard for manganese is 50 µg/L and the Lifetime Health Advisory is 300 µg/L.

3.2.6 Uranium

Uranium is a natural element found throughout the environment. Uranium in water comes mainly from rocks and soil as water passes over them. Nearly all naturally occurring uranium is non-radioactive (Oregon Department of Human Services, 2007). EPA has established a maximum contaminant level of 30 µg/L for uranium in drinking water. Low concentrations of uranium were detected in 4 of the 69 wells sampled in this study. The maximum concentration measured was 0.76 µg/L, well below the maximum contaminant level.

3.2.7 Vanadium

Vanadium is found in many different minerals as well as in coal and other fossil fuels. Vanadium may be released to the environment through the combustion of fossil fuels, or through natural weathering processes of rocks and soils. There is no federal or state regulatory standard for vanadium in drinking water. However, EPA has set a Regional Screening Level for resident tap water of 86 µg/L for vanadium. Vanadium was detected in 5 of the 69 study wells. The maximum concentration measured was 12 µg/L, which is one seventh of the Regional Screening Level.

3.2.8 Consumer Product Constituents

Consumer product constituents include fragrances, pharmaceuticals, insect repellants and other products found in everyday household chemicals, cleaning products, beauty products, clothing, and medications. One of the goals for this Statewide Groundwater Monitoring Program was to investigate emerging groundwater quality problems. Consumer product constituents are considered indicators of improperly designed or failing septic tank performance. These analytes were included in the North Coast Basin study because concerns about leaching potential in the soil and geology of the area as well as septic tank density among residentially zoned areas of the North Coast region (ODEQ, 2004). This study marks the first time that DEQ has analyzed groundwater samples for consumer product constituents.

Examples of commonly detected consumer products in other studies include the insect repellant DEET, the stimulant caffeine, and the antibiotic sulfamethoxazole. These constituents likely make their way into the water through wastewater discharges and septic systems. Although detected levels are significantly lower than a human pharmaceutical dose, presence of these chemicals in aquatic systems may lead to aquatic life impacts (Gagne et al., 2006). Detections of these chemicals in groundwater wells indicates a potential aquatic life impact through possible surface and groundwater interactions. No water quality criteria or benchmarks currently exist for most of these compounds. Only one of the 12 compounds in this group was detected during this study. Sulfamethoxazole, a common antibiotic, was detected in one well sampled during the September sampling period just north of the town of Gearhart, it was not confirmed upon resampling in January 2016.

3.2.9 Lead

Lead, like manganese and arsenic, can end up in aquifers due to the erosion of natural deposits; however, the most common source of lead in drinking water is from the corrosion of household plumbing systems. Lead is typically tested using the “first flush” method, which collects water that had been sitting in the pipes. For this study, however, DEQ staff flushed each well for 5-10 minutes prior to sampling to ensure that samples indicated background lead levels present in the groundwater rather than water sitting in the pipes. Lead was detected in 55 of the wells sampled in this study. Only one well exceeded the EPA established maximum contaminant level of 0.015 mg/L. Neither a duplicate sample, collected immediately after the original sample for quality assurance, nor a resample collected during the January 2016 sampling event exceeded the maximum contaminant level indicating that the system may not have been fully flushed during the initial sample. Well owners concerned about lead concentrations were instructed to contact their county environmental health department about retesting their water.

3.3 Well log comparison

The Oregon Water Resources Department has required wells logs since 1955. The logs are completed by a well driller and provide details on well construction including a description of the geologic material drilled through and material used to case and seal the well. While the information in well logs is extremely useful in interpreting groundwater data, well logs can be difficult to locate and verify. Some of the reasons for this include:

- A well log may never have been completed.
- The location of a well is described by township, range, and section on the well log, and there may be more than one well in any given section.

- There may be mistakes, especially in the location, that cause the well log to be misfiled and difficult to find.

With the emergence of electronic record keeping and the requirements to have new well locations tagged with their GPS coordinates (since 2009), it is much easier to locate well logs for recently drilled wells. This study included wells with and without well logs. While the absence of some well logs limits the interpretation of the data, it also provides an opportunity to compare the results between these two groups and identify any potential bias that may be introduced when excluding wells without a well log from a study.

Out of the 69 wells sampled in this study, 32 had associated well logs on file with the Water Resources Department and whose locations could be confirmed by groundwater staff at DEQ. A comparison of these two groups indicates that nitrate levels were significantly higher in wells without well logs than in wells with well logs (ANOVA: $F = 4.13$, df = 74, $P = 0.05$). This difference can also be seen in the number of wells without well logs that exceed the elevated (3 mg/L) and maximum contaminant (10 mg/L) levels (Figure 8). Figure 9 shows the geographic distribution of wells with and without well logs in the study area.

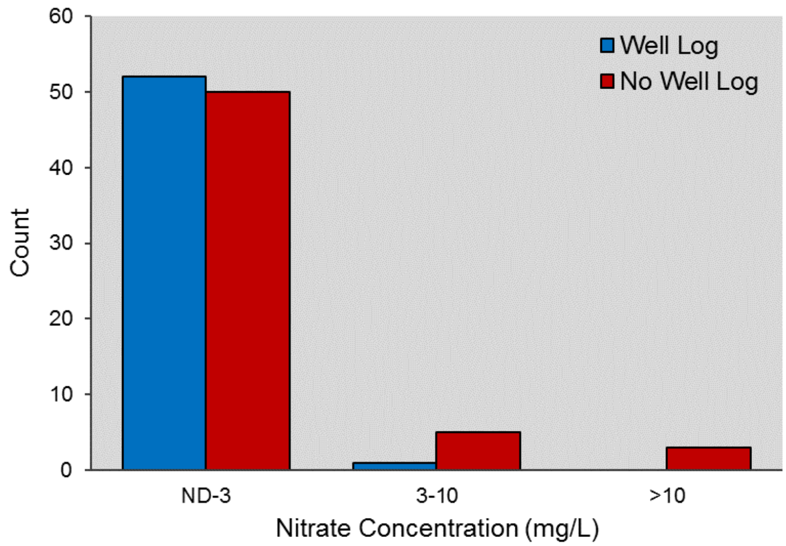

Figure 8. Comparison of the distribution of nitrate results for wells with and without well logs.

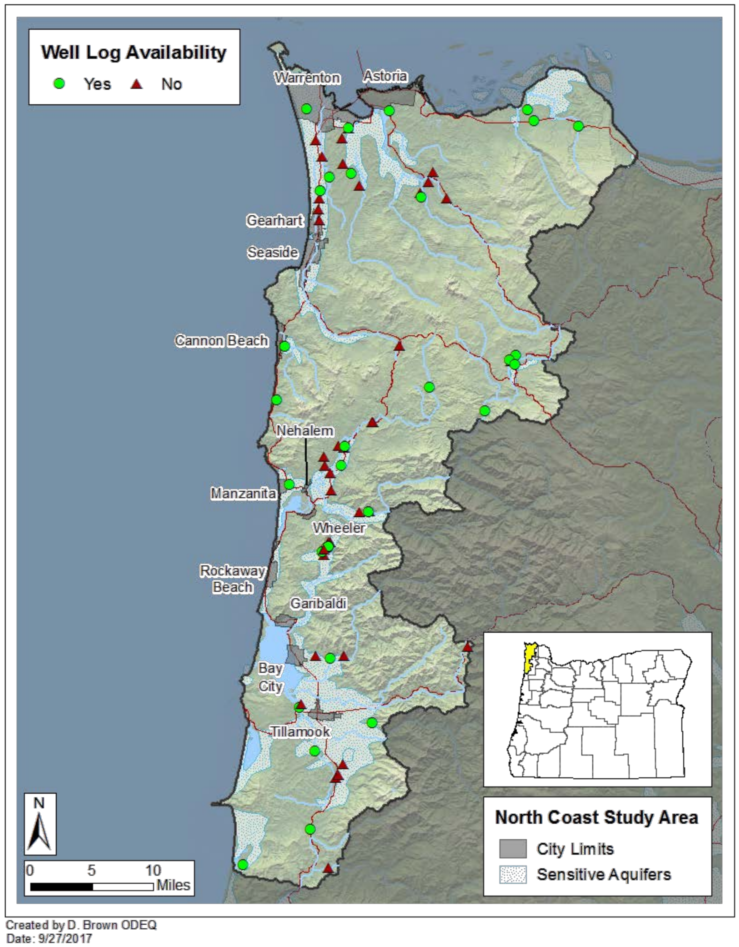

Figure 9. Distribution of wells with and without well log records.

3.4 Seasonal differences

Forty-nine wells were sampled during both the September 2015 and January 2016 sampling events in an effort to capture any seasonal variability in the results. Resampled wells were chosen based on availability for sampling and geographic distribution within the study area. In addition to the 49 wells sampled during both sampling events, nine new wells were available to participate in our study during the January 2016 sampling event. This means that 58 total wells were sampled during the January sampling event, while 60 total wells were sampled during the September sampling event.

Of the twelve wells with pesticide detections in this study, only two showed any seasonal variation in pesticide concentration. In both wells, 2,6-dichlorobenzamide was detected at higher levels in January than in September (Figure 10). In the other wells, pesticides were detected during one of the sampling events with no pattern as to when the detections would occur (Figure 10). Legacy pesticides were only analyzed for in 31 of the 58 wells sampled during the January sampling event, which potentially limited the ability to further compare pesticides across seasons.

Figure 11 depicts the seasonal variation in nitrate concentrations in the 49 resampled wells. Nitrate concentrations were higher at 14 wells during the September sampling event and higher at 22 wells during the January sampling event. Nitrate was not detected at the remaining 13 wells during either sampling event. The biggest difference in nitrate concentration occurred at a sampling location near Gearhart, where there were a number of high results during the September sampling event. Despite these results, nitrate concentrations were not significantly higher during a particular sampling event.

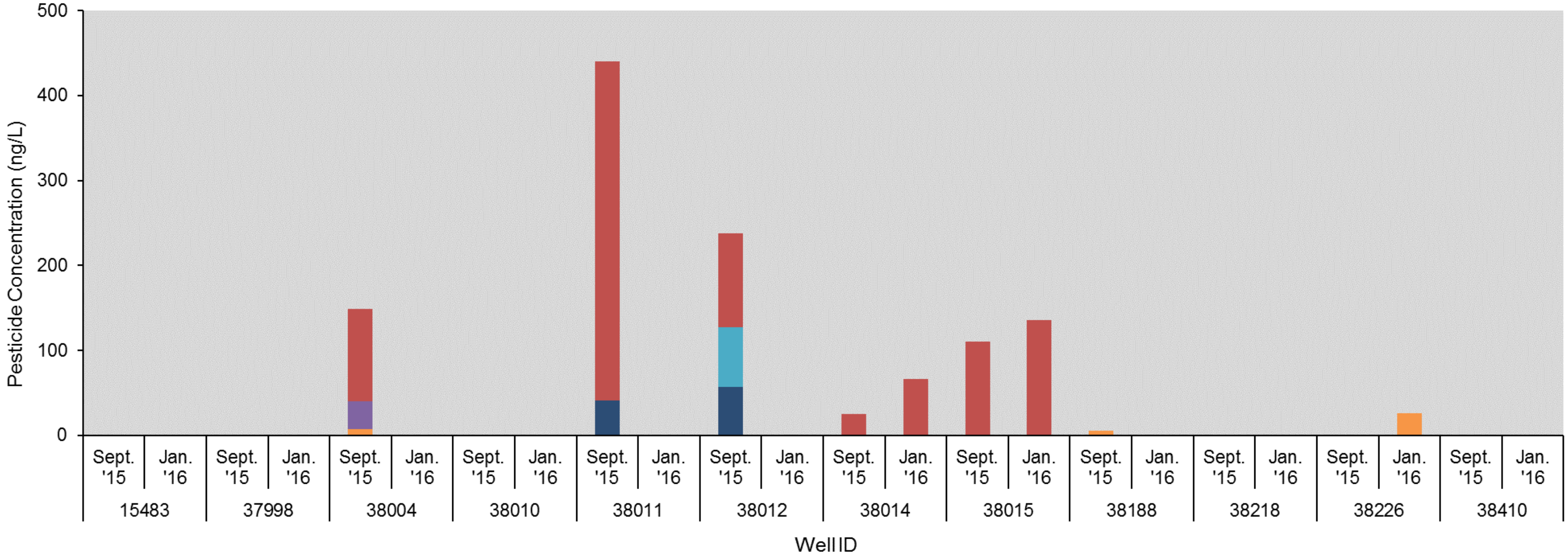

Figure 10. Pesticide concentrations for wells sampled during the September 2015 and January 2016 sampling events. Wells without detected pesticides were excluded from this figure.

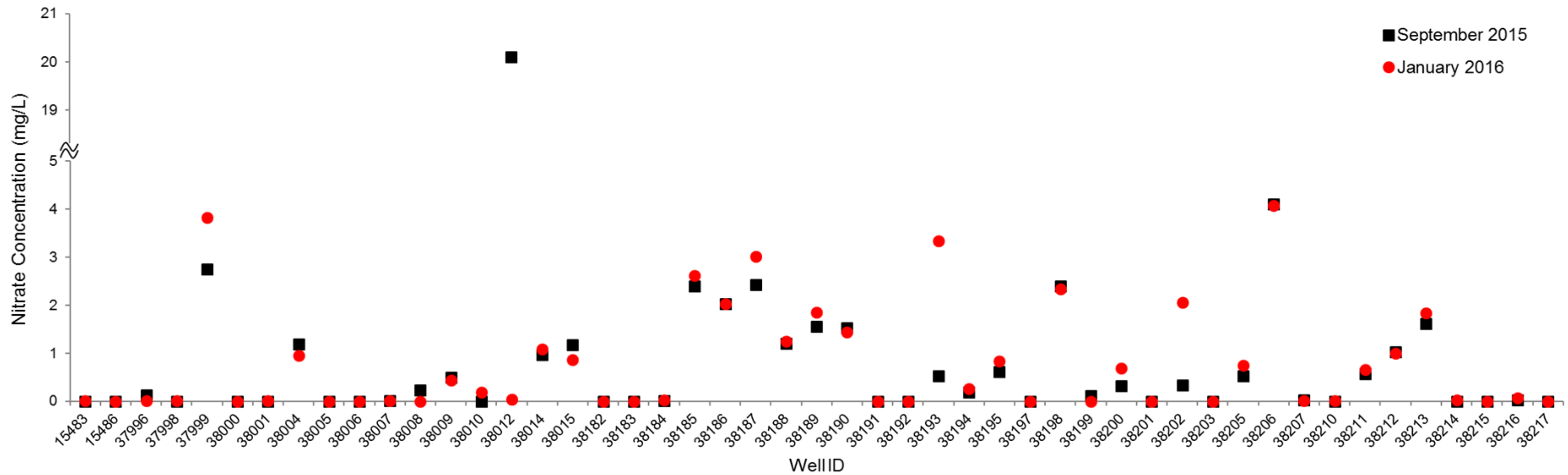

Figure 11. Nitrate concentrations in wells sampled during both the September 2015 and January 2016 sampling events.

4. Summary

The 2015-2016 North Coast Basin Groundwater Study met its objectives in the following ways:

1. *To collect high-quality data on nitrate, arsenic, coliform bacteria and pesticide concentrations in groundwater throughout the study area*
   Groundwater quality data for 69 wells within the study area are available. This represents the largest quality-controlled groundwater investigation in the area since 1996 (ODEQ). These data may be used in future analyses of specific groundwater issues or to support and focus outreach activities.

2. *To identify areas of groundwater contamination related to these parameters*
   Nitrate contamination was found primarily clustered in the Gearhart area of Clatsop County. The only consumer product constituent detection was also found in that area. Arsenic contamination was detected in the Clatsop Plains area and near the town of Elsie. Bacterial contamination was detected throughout the study area as were low levels of pesticides, with more pesticide detections clustered in the Clatsop Plains area.

3. *To inform well water users of the results of this study and provide information regarding potential risks to human health*
   In addition to the 37 wells with total coliform detections, there were two wells with other results exceeding a maximum contaminant level or other health-based benchmark. All of these well owners were notified of these results by DEQ staff and referred to local and state public health resources to discuss potential risks. While pesticides were detected in eight wells, and a consumer product constituents in one well, all results were well below any health-based benchmark and not expected to pose a health risk.

4. *To identify areas needing additional investigation in order to describe the extent of contamination and help focus efforts to prevent further contamination.*
   This study confirmed the presence of nitrate contaminated groundwater in the Clatsop Plains area, as well as a possible vulnerability to septic tank contamination due to sandy soils and unconfined aquifers. Some wells outside this area also had high nitrate and warrant further investigation to determine the extent of the contamination. Hydrogeologic analyses and investigations into the sources of contamination were outside the scope of this study.

5. Recommendations

Aquifer contamination is a long-lasting problem and steps should be taken to reduce any further negative impacts from human activity. Additional analysis of data from this study, as well as data from previous studies and the Oregon Health Authority's Real Estate Transaction Act (ORS 448.271) data, can further refine the extent of aquifer contamination and contribute to identifying the sources of nitrate, pesticide and bacterial contamination. With this information, strategies can be developed to help prevent further degradation of aquifer water quality.

Further investigation of nitrate, pesticides and consumer product constituents is recommended, especially in the Clatsop Plains area. While the concentrations measured in this study are mostly below the health-based benchmarks, these levels may rise over time. A network of wells should be established and monitored to detect any changes over time.

Since there is no regulatory oversight for private wells, and many private well owners are currently unaware of the quality of their drinking water, results from this study can be used to focus public health outreach in areas where contamination exits. Local, county or state public health outreach should encourage homeowners to get their wells tested annually for nitrate and bacteria and to test it at least once for arsenic. Overall results of this study and the on-going statewide monitoring program can be used to better understand the threats to and quality of the groundwater resources of Oregon.

There are many resources available to help domestic well owners in Oregon. As part of the recommendations of this North Coast Basin Groundwater Report, the following list of resources was provided to well owners:

- The *Oregon Domestic Well Safety Program* (www.healthoregon.org/wells) focuses on improving local and state capacity to assess and manage risks associated with private wells. DWSP partners with local health departments and water information providers to further promote domestic well safety.

- The Oregon Water Resources Department and Oregon Health Authority publish a brochure, "Water Well Owner's Handbook: A guide to water wells in Oregon" which provides general information on groundwater, water wells, well construction, operation, maintenance and abandonment information (http://www.oregon.gov/owrd/PUBS/docs/Well_Water_Handbook.pdf).

- DEQ's Drinking Water Protection Program has developed many tools for public water systems that can be readily used for domestic wells:
  - Basic Tips for Keeping Drinking Water Clean and Safe http://www.deq.state.or.us/wq/pubs/factsheets/drinkingwater/BasicTips12WQ005.pdf
  - Groundwater Basics for Drinking Water Protection http://www.deq.state.or.us/wq/pubs/factsheets/drinkingwater/GroundwaterBasics.pdf
  - Other technical assistance fact sheets http://www.deq.state.or.us/wq/dwp/assistance.htm

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Appendix A – Complete Site List

Pages A-1 through A-5

Well ID	North Coast Basin Groundwater Study Site ID	Well Log Availability	Well Log	Top of Water Bearing Zone (ft bgs)	Bottom of Water Bearing Zone (ft bgs)	Well Vertical Migration Potential	September2015 or January 2016 Sampling
37996	**NC-001**	**Yes**	CLAT-50581	70	101	Low	**September and January**
37998	**NC-003**	**Yes**	CLAT 51645	110	135	Low	**September and January**
38000	**NC-005**	**Yes**	CLAT-51153	97	185	Low	**September and January**
38004	**NC-009**	**Yes**	CLAT-54496	101	108	Low	**September and January**
38005	**NC-010**	**Yes**	CLAT-50801	141	185	Low	**September and January**
38014	**NC-019**	**Yes**	CLAT-52915	32	55	Medium	**September and January**
38184	**NC-024**	**Yes**	CLAT-50451	222	230	Low	**September and January**
38185	**NC-025**	**Yes**	CLAT-031	52	110	Low	**September and January**
38186	**NC-026**	**Yes**	CLAT-349	10	27	Medium	**September and January**
38190	**NC-030**	**Yes**	TILL-1285	44	50	Low	**September and January**
38191	**NC-031**	**Yes**	CLAT-52615	60	70	Low	**September and January**
38193	**NC-033**	**Yes**	CLAT-53917	NA	5	High	**September and January**
38194	**NC-034**	**Yes**	CLAT-50362	60	100	Low	**September and January**

Well ID	North Coast Basin Groundwater Study Site ID	Well Log Availability	Well Log	Top of Water Bearing Zone (ft bgs)	Bottom of Water Bearing Zone (ft bgs)	Well Vertical Migration Potential	September 2015 or January 2016 Sampling
38195	**NC-035**	**Yes**	TILL-264	65	67	Low	**September and January**
38201	**NC-041**	**Yes**	CLAT-71	40	50	Low	**September and January**
38203	**NC-043**	**Yes**	TILL-9	115	125	Low	**September and January**
38207	**NC-047**	**Yes**	TILL-496	45	90	Low	**September and January**
38212	**NC-052**	**Yes**	TILL-52288	31 (2)	110	Low	**September and January**
38216	**NC-056**	**Yes**	CLAT-034	76	100	Low	**September and January**
38217	**NC-057**	**Yes**	TILL-1275	83	110	Low	**September and January**
38220	**NC-060**	**Yes**	TILL-262	60	65	Low	**January Only**
15483	**NOC-025**	**Yes**	TILL-662	45	50	Low	**September and January**
38006	**NC-011**	**Yes**	CLAT-258	NA	250	Low	**September and January**
38009	**NC-014**	**Yes**	CLAT-54080	40	73	Low	**September and January**
38015	**NC-020**	**Yes**	CLAT-50861	40	65	Medium	**September and January**
38182	**NC-022**	**Yes**	CLAT-008	35	140	Low	**September and January**
38198	**NC-038**	**Yes**	TILL-850	120	149	Low	**September and January**
38199	**NC-039**	**Yes**	TILL-745	18	133	Low	**September and January**
38215	**NC-055**	**Yes**	TILL-298	65	65	Low	**September and January**

Well ID	North Coast Basin Groundwater Study Site ID	Well Log Availability	Well Log	Top of Water Bearing Zone (ft bgs)	Bottom of Water Bearing Zone (ft bgs)	Well Vertical Migration Potential	September 2015 or January 2016 Sampling
38218	**NC-058**	**Yes**	TILL-51978	19 (2)	59	Low	**January Only**
38219	**NC-059**	**Yes**	TILL-52416	3	12	High	**January Only**
15481	**NOC-023**	**Yes**	TILL-634	NA	76	Unknown	**September Only**
37997	**NC-002**	**No**	-	-	-	-	**September Only**
37999	**NC-004**	**No**	-	-	-	-	**September and January**
38001	**NC-006**	**No**	-	-	-	-	**September and January**
38002	**NC-007**	**No**	-	-	-	-	**September Only**
38003	**NC-008**	**No**	-	-	-	-	**September Only**
38007	**NC-012**	**No**	-	-	-	-	**September and January**
38008	**NC-013**	**No**	-	-	-	-	**September and January**
38010	**NC-015**	**No**	-	-	-	-	**September and January**
38011	**NC-016**	**No**	-	-	-	-	**September Only**
38012	**NC-017**	**No**	-	-	-	-	**September and January**
38013	**NC-018**	**No**	-	-	-	-	**September Only**
38181	**NC-021**	**No**	-	-	-	-	**September Only**
38183	**NC-023**	**No**	-	-	-	-	**September and January**
38187	**NC-027**	**No**	-	-	-	-	**September and January**
38188	**NC-028**	**No**	-	-	-	-	**September and January**

Well ID	North Coast Basin Groundwater Study Site ID	Well Log Availability	Well Log	Top of Water Bearing Zone (ft bgs)	Bottom of Water Bearing Zone (ft bgs)	Well Vertical Migration Potential	September 2015 or January 2016 Sampling
38189	NC-029	No	-	-	-	-	September and January
38192	NC-032	No	-	-	-	-	September and January
38196	NC-036	No	-	-	-	-	September Only
38197	NC-037	No	-	-	-	-	September and January
38200	NC-040	No	-	-	-	-	September and January
38202	NC-042	No	-	-	-	-	September and January
38204	NC-044	No	-	-	-	-	September Only
38205	NC-045	No	-	-	-	-	September and January
38206	NC-046	No	-	-	-	-	September and January
38208	NC-048	No	-	-	-	-	September Only
38209	NC-049	No	-	-	-	-	September Only
38210	NC-050	No	-	-	-	-	September and January
38211	NC-051	No	-	-	-	-	September and January
38213	NC-053	No	-	-	-	-	September and January
38214	NC-054	No	-	-	-	-	September and January
38221	NC-061	No	-	-	-	-	January Only

Well ID	North Coast Basin Groundwater Study Site ID	Well Log Availability	Well Log	Top of Water Bearing Zone (ft bgs)	Bottom of Water Bearing Zone (ft bgs)	Well Vertical Migration Potential	September 2015 or January 2016 Sampling
38222	NC-062	No	-	-	-	-	January Only
38223	NC-063	No	-	-	-	-	January Only
38410	NC-064	No	-	-	-	-	January Only
38225	NC-065	No	-	-	-	-	January Only
38226	NC-066	No	-	-	-	-	January Only
15486	NOC-028	No	-	-	-	-	September and January

Appendix B – Full Analyte List

Pages B-1 through B-4

List contains all compounds analyzed during the sampling period	Pesticides analyzed in a limited number of samples as discussed in section 2.1.3
Analyte group, *Analyte sub-group*, Analyte name	
Bacteria	**Consumer Product Constituents, cont'd**
Total Coliform	Triclosan
E. Coli	Venlafaxine
Consumer Product Constituents	**Current Use Pesticides**
17a-Estradiol	*Fungicides*
17a-Ethynyl estradiol	Chloroneb
17ß-Estradiol	Chlorothalonil
4-Chloro-3-methylphenol	Etridiazole
Acetaminophen	Fenarimol
bis(2-ethylhexyl)adipate	Pentachlorophenol
bis(2-ethylhexyl)phthalate	Propiconazole
Butylbenzylphthalate	Pyraclostrobin
Caffeine	Triadimefon
Carbamazepine	Tricyclazole
Codeine	*Herbicides*
Cotinine	2,4,5-T
DEET	2,4-D
Diethylphthalate	2,4-DB
Diethylstilbestrol	2,6-Dichlorobenzamide
Dimethyl phthalate	Acetochlor
Di-n-octyl phthalate	Acifluorfen
Diphenhydramine	Alachlor
Estriol	Ametryn
Estrone	Aminocarb
Ibuprofen	Atrazine
N-Nitrosodiethylamine	Bromacil
N-Nitrosodimethylamine	Butachlor
N-Nitroso-di-n-butylamine	Butylate
N-Nitrosopyrrolidine	Cyanazine
Sulfamethoxazole	Cycloate

List contains all compounds analyzed during the sampling period	Pesticides analyzed in a limited number of samples as discussed in section 2.1.3
Analyte group, *Analyte sub-group* , Analyte name	
Current Use Pesticides, cont'd	**Current Use Pesticides, cont'd**
Herbicides	*Herbicides*
Dacthal (DCPA)	Propazine
DCPA acid metabolites	Siduron
Deisopropylatrazine	Simazine
Desethylatrazine	Simetryn
Dichlobenil	Sulfometuron-methyl
Dichloroprop	Tebuthiuron
Dimethenamid	Terbacil
Dinoseb	Terbutryn (Prebane)
Diphenamid	Terbutylazine
Diuron	Triclopyr
EPTC	Trifluralin
Fluometuron	Vernolate
Fluridone	*Insecticides*
Hexazinone	Acetamiprid
Imazapyr	Azinphos-methyl (Guthion)
Linuron	Baygon (Propoxur)
MCPA	Bifenthrin
MCPP	Carbaryl
Metolachlor	Carbofuran
Metribuzin	Chlorpyrifos
Metsulfuron Methyl	Diazinon
Molinate	Dicamba
Napropamide	Dichlorvos
Neburon	Dimethoate
Norflurazon	Ethoprop
Pendimethalin	Fenamiphos
Picloram	Fenvalerate+Esfenvalerate
Pendimethalin	Imidacloprid
Picloram	Malathion
Prometon	Methiocarb
Prometryn	Methomyl
Pronamide	Methyl paraoxon
Propachlor	Mevinphos

List contains all compounds analyzed during the sampling period	[green] Pesticides analyzed in a limited number of samples as discussed in section 2.1.3
Analyte group, *Analyte sub-group* , Analyte name	
Current Use Pesticides, cont'd	**Legacy Pesticides, cont'd**
Insecticides	2,4,5-TP (Silvex)
Mexacarbate	Aldrin
MGK 264	Chlorobenzilate
Mirex	cis-Nonachlor
Oxamyl	Dieldrin
Parathion-ethyl	Endosulfan I
Parathion-methyl	Endosulfan II
Permethrin	Endosulfan sulfate
Pyriproxyfen	Endrin
Terbufos	Endrin aldehyde
Tetrachlorvinphos (Stirophos)	Endrin ketone
Industrial Chemicals or Intermediates	Endrin+cis-Nonachlor
3,5-Dichlorobenzoic acid	Heptachlor
Legacy Pesticides	Heptachlor epoxide
BHC-Technical (HCH)	Hexachlorobenzene
alpha-BHC	Methoxychlor
beta-BHC	**Metals (Total Recoverable)**
delta-BHC	Aluminum
gamma-BHC (Lindane)	Arsenic
Chlordane	Calcium
alpha-Chlordane	Iron
cis-Chlordane	Magnesium
gamma-Chlordane+trans-Nonachlor	Manganese
Oxychlordane	Potassium
trans-Chlordane	Sodium
trans-Nonachlor	Uranium
Total DDT	Vanadium
2,4´-DDD	**Standard Parameters**
2,4´-DDE	Hardness as CaCO3, Total recoverable
2,4´-DDT	Alkalinity, Total as CaCO3
4,4´-DDD	Chloride
4,4´-DDE	Nitrate/Nitrite as N
4,4´-DDT	Oxidation Reduction Potential

List contains all compounds analyzed during the sampling period	Pesticides analyzed in a limited number of samples as discussed in section 2.1.3
Analyte group, *Analyte sub-group* , Analyte name	
Standard Parameters, cont'd	**Field Parameters**
Phosphate, Total as P	Conductivity
Sulfate	Dissolved Oxygen
Total Solids	pH
	Temperature