Willamette Basin, Oregon—

Nitrogen in Streams and Ground Water, 1980-90

National Water-Quality Assessment Program

Willamette Basin Study Area

U.S.Geological Survey
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WILLAMETTE NAWQA STUDY In 1991, the U.S. Geological Survey's National Water-Quality Assessment (NAWQA) Program began studies in the Willamette Basin. The goals of the NAWQA Program are to document the quality of surface and ground water throughout the Nation, and to explain the natural and human factors affecting water quality.

One of the initial tasks of the Willamette Basin study was to review and analyze water quality data collected since 1980. This publication describes the nitrogen data from that review. Most of the surface water data were collected by the Oregon Department of Environmental Quality (ODEQ) as part of routine water quality monitoring. The ground water data were collected by ODEQ and the Oregon Health Division (OHD).

IMPORTANCE OF NITROGEN IN AQUATIC ENVIRONMENTS Nitrogen is a primary nutrient, or food source, that plants use to make tissue. Although nitrogen is required by all plants, large inputs of nitrogen to lakes and streams can cause eutrophication, which is the excessive growth of aquatic plants, particularly algae. Excessive plant growth is aesthetically unpleasant and may clog waterways and impede navigation. As the vegetation decays, oxygen is consumed; eventually the water body may become unable to support desirable species of fish, such as salmon and trout, that require high concentrations of oxygen.

The most important forms of nitrogen in aquatic environments are nitrate, ammonia, and organic nitrogen (which includes amino acids, proteins, and urea). Most forms of nitrogen are not toxic. Elevated

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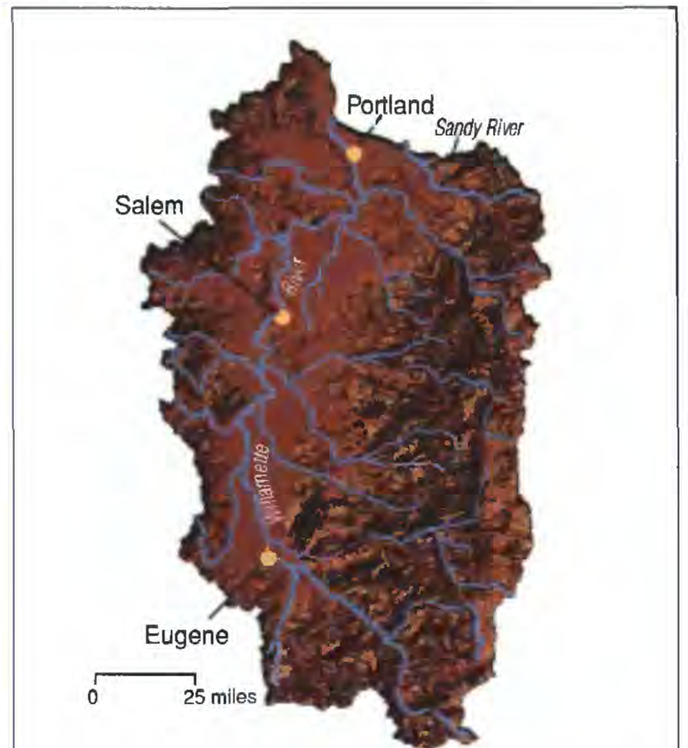
ammonia concentrations are harmful to some species of fish. Nitrate in drinking water poses a human health concern, especially for young children who may develop methemoglobinemia (blue baby syndrome). As a result, the U.S. Environmental Protection Agency (USEPA) has established 10 mg/L (as nitrogen) as the maximum contaminant level (MCL) of nitrate allowed in drinking water.



The Willamette Basin study area includes the Willamette and Sandy River Basins.

NITRATE IN WILLAMETTE BASIN GROUND WATER Ground water data were less plentiful than surface water data. Nonetheless, data from wells sampled by ODEQ and OHD between 1980 and 1990 indicate that nitrate concentrations in ground water were related to well depth. The highest concentrations were from shallow wells, but not all shallow wells yielded water with high nitrate concentrations. For wells that were less than 50 feet deep and located in agricultural areas, the MCL for nitrate (10 mg/L) was exceeded 27% of the time. Six shallow wells in urban areas were sampled, but none produced water with nitrate concentrations that exceeded the MCL. Only one well that was more than 100 feet deep (of 180 such wells) yielded water with a nitrate concentration that exceeded the MCL. Shallow well depth increases susceptibility to contamination from activities at the land surface.

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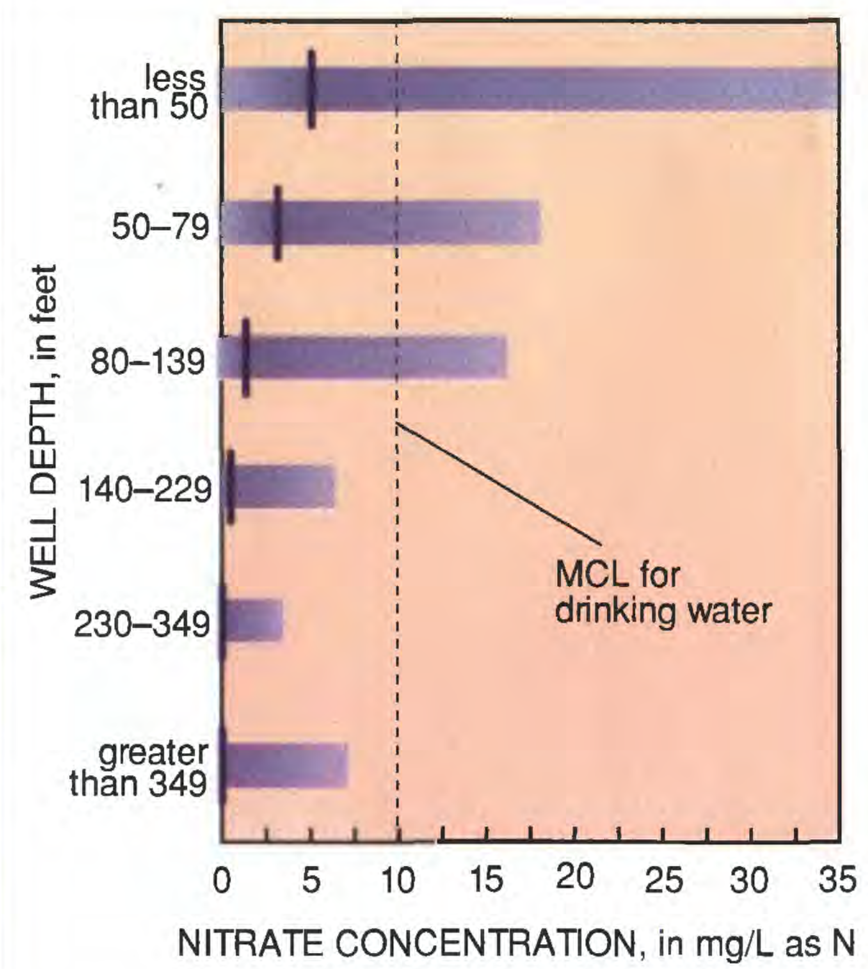

Ground water with high nitrate concentration tends to come from shallow wells. The middle line in each bar shows the median; the shaded area shows the range.

Irrigation can accelerate the transport of nitrate in the soil to shallow ground water.

ADDITIONAL INFORMATION

About the NAWQA program—

Leahy, P. P., and Thompson, T. H., 1994, U.S. Geological Survey—National Water-Quality Assessment Program: USGS OFR 94–70, 4 p.

Wentz, D. A., and McKenzie, S. W., 1991, National Water-Quality Assessment Program— The Willamette Basin, Oregon: USGS OFR 91–167, 2 p.

World Wide Web at
"http://wwwrvares.er.usgs.gov/nawqa/nawqa_home.html"
"http://wwworegon.wr.usgs.gov/projs_dir/pn366/nawqa.html"

About nutrient concentrations and other water-quality data in the Willamette Basin—

Bonn, B. A., Hinkle, S. R., Wentz, D. A., and Uhrich, M. A., 1995, Analysis of nutrient and ancillary water-quality data for surface and ground water of the Willamette Basin, Oregon, 1980–90: USGS WRIR 95–4036, 88 p.

Tetra Tech, 1995, Willamette River Basin Water Quality Study—Summary and synthesis of study findings: Redmond, Washington, report prepared for ODEQ, 119 p.

About nutrients in the environment—

Mueller, D.K., and Helsel, D.R., 1996, Nutrients in the Nation's waters—Too much of a good thing?: USGS Circular 1136, 24 p.

Smith, R. A., Alexander, R. B., and Lanfear, K. J., 1993, Stream water quality in the conterminous United States—Status and trends of selected indicators during the 1980's, *in* National water summary 1990–91—Hydrologic events and stream water quality: USGS WSP 2400, p. 111–140.

Wetzel, R. G., 1983, Limnology (2nd ed.): Philadelphia, Pennsylvania., Saunders, 767 p.

About water-quality regulations and standards—

U.S. Environmental Protection Agency, 1994, EPA drinking water regulations and health advisories: Washington, D.C., EPA 882–R–94–001, 11 p.

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Grasses and grains are the primary crops in the Calapooia Basin (left). In the Pudding Basin (below), crops are much more diverse, including vegetables, berries, hops, and orchards.

SOURCES OF NITROGEN Nitrogen fixation, the conversion of nitrogen gas from the Earth's atmosphere to ammonia, is an important natural source of biologically available nitrogen. Nitrogen is fixed by soil bacteria, bacteria that live on the roots of some plants (including peas, beans, and alder), and cyanobacteria (commonly called blue-green algae), which are found in lakes and streams.

Most nitrogen contamination arises from human and animal wastes, certain industrial wastes, and fertilizer use. In the Willamette Basin, 353 licensed point sources (including 79

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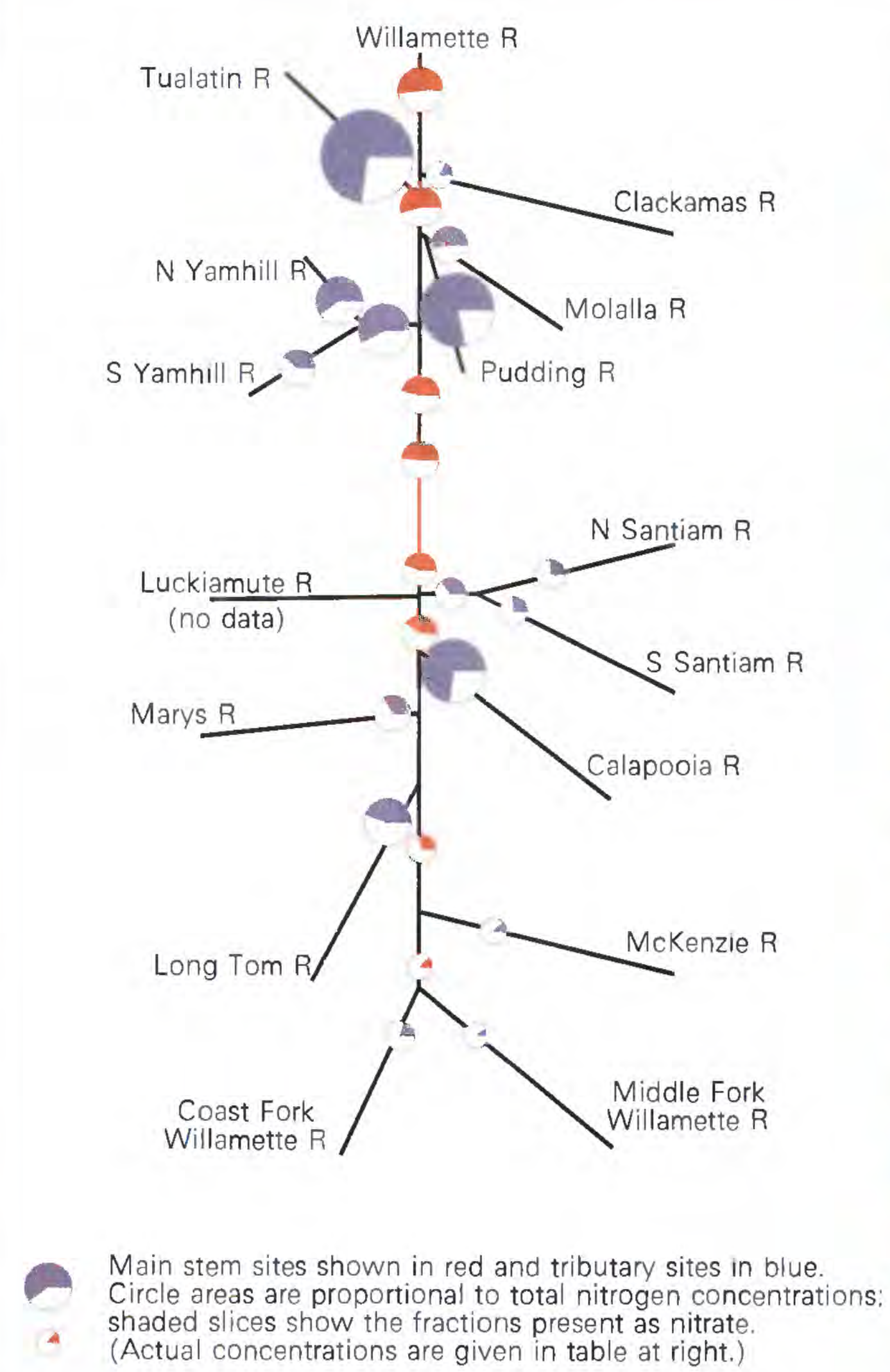
sewage treatment plants) discharge wastes directly into the Willamette River or its tributaries, but the amount of nitrogen that they contribute is not well documented. In addition, nonpoint sources, such as manure and fertilizer, distribute nitrogen across large areas of land within the basin. Combustion and other processes contribute ammonia and nitrate that are carried by precipitation. Nitrogen from these nonpoint sources is transported to rivers by runoff, erosion, and leaching from soil. How much nitrogen is transported depends on factors such as hydrologic conditions, soil type, land use, type of vegetation, and farming and irrigation practices. The amount of nitrogen from fertilizer and manure that eventually enters the Willamette River is not known.

NITROGEN CONCENTRATIONS IN WILLAMETTE BASIN STREAMS Concentrations of total nitrogen (the sum of nitrate, ammonia, and organic nitrogen) in the Willamette River and near the mouths of its major tributaries ranged from less than 0.2 mg/L to 4.5 mg/L during 1980–90. Total nitrogen concentrations as low as 0.4 mg/L may be associated with increased rates of eutrophication.

Concentrations of the various forms of nitrogen in the main stem Willamette River increased downstream. This was especially true for nitrate, suggesting that elevated nitrate concentrations are associated with the larger populations and increased industrial and agricultural activity in the northern part of the basin. Annual median nitrate concentrations in the Willamette Basin were generally less than those from a nationwide sampling of 88 agricultural streams (0.72 mg/L) and 24 urban streams (0.47 mg/L). In the Calapooia, Pudding, and Tualatin Rivers, however, median nitrate concentration were higher than the national median concentrations. (The median is the middle value of a group of data; half of the values are greater and half are less than the median.)

Between 1980 and 1990, the 10 mg/L MCL for nitrate was not exceeded at sampling points near the mouths of major tributaries or along the main stem Willamette River. Similarly, at the same locations, no instances of ammonia concentrations that exceeded USEPA guidelines for fish toxicity were observed. Nitrate concentrations greater than 10 mg/L were observed, however, in some small Willamette Basin streams. In general, concentrations of all nitrogen forms are greater in small streams because dilution of contaminants is less than in the main stem river and major tributaries.



Stream (miles upstream from mouth)	Nitrate Nitrogen (mg/L)	Total Nitrogen (mg/L)
Willamette River at SPS Bridge (5)	0.34	0.7
Clackamas River	.04	.2
Tualatin River	2.1	3.0
Willamette River at Canby Ferry (34)	.28	.6
Molalla River	.23	.4
Pudding River	1.4	1.8
Yamhill River	.52	.9
North Yamhill River	.47	.8
South Yamhill River	.16	.4
Willamette River at Wheatland Ferry (72)	.23	.5
Willamette River at Salem (84)	.20	.5
Willamette River at Buena Vista Ferry (106)	.17	.4
Santiam River	.12	.3
North Santiam River	.07	.3
South Santiam River	.08	.3
Willamette River at Albany (119)	.15	.4
Calapooia River	.89	1.4
Marys River	.14	.5
Long Tom River	.32	.8
Willamette River at Harrisburg (161)	.08	.3
McKenzie River	.03	.2
Willamette River at Springfield (185)	.03	.2
Middle Fork Willamette River	.02	.2
Coast Fork Willamette River	.06	.3

Annual median concentrations of nitrate and total nitrogen at selected locations in the Willamette Basin. In the main stem Willamette River, both nitrate and total nitrogen increase downstream. In rivers with mostly forested watersheds (such as the McKenzie), total nitrogen concentrations are low and nitrate accounts for little of the total nitrogen. (Basin diagram is not to scale.)

At many sampling sites—especially those in forested watersheds, such as the Middle Fork Willamette, McKenzie, and Clackamas River Basins—total nitrogen concentrations were low and nitrate accounted for only a small fraction of total nitrogen. These rivers typically have little algal growth. The

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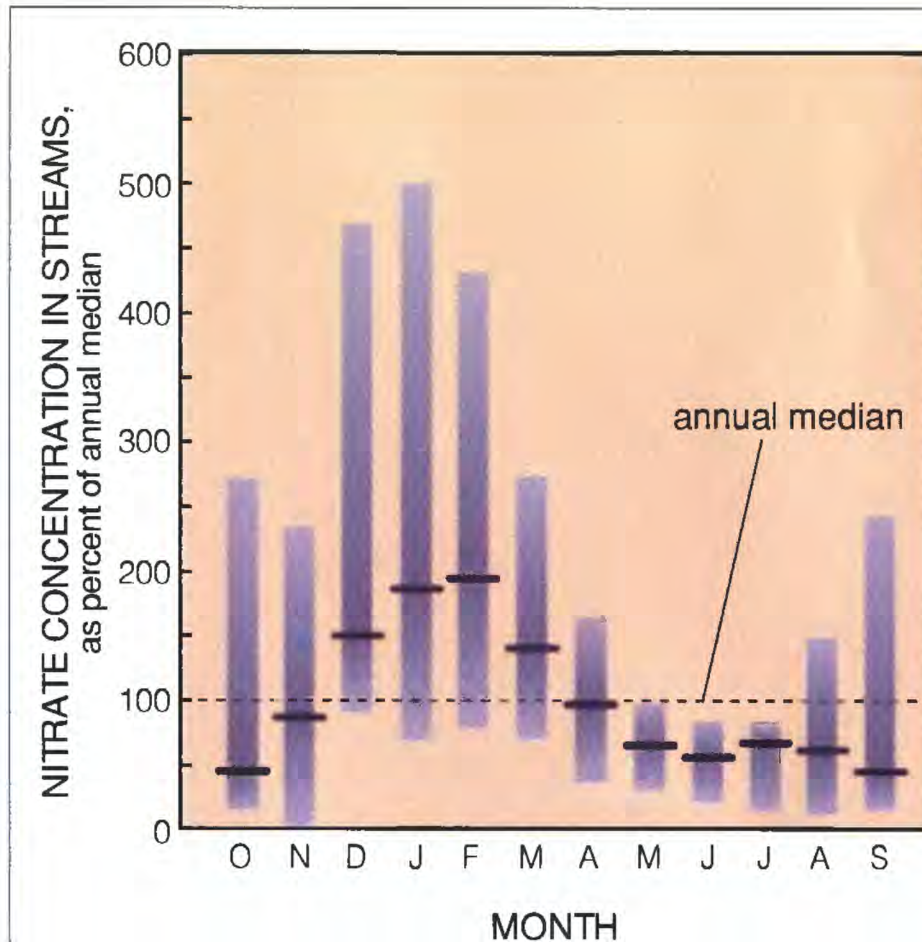
highest nitrate and total nitrogen concentrations were observed in the Calapooia, Pudding, and Tualatin Rivers. The basins of these three rivers support significant agricultural activity; additionally the Tualatin and Pudding Rivers receive discharge from major sewage treatment plants.

Nitrate concentrations in streams generally followed a seasonal pattern. Maximum concentrations occurred in winter; minimum concentrations were found in mid-summer. The winter peak may be caused by (1) leaching of nitrate from soils and subsequent runoff during winter rains and/or (2) less nitrate uptake by algae in streams during winter, when plant growth is limited by cool temperatures and reduced light. The higher nitrate concentrations in winter do not cause eutrophication and its associated problems because plants grow slowly at this time of year.



Nitrate concentrations are highest in winter. The middle line in each bar shows the monthly median; the shaded area shows the range. (Data are for sites listed in table at left.)