Idaho Department of Water Resources

NITRATE IN IDAHO'S GROUND WATER

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What is nitrate?

Nitrate is an oxidized form of nitrogen that typically comes from inorganic fertilizers, decaying organic matter, waste water from commercial operations, animal manure and human sewage (Figure 1). In rare cases, nitrate can also originate from geologic formations. Nitrate is mobile in water and thus can easily move into ground water. Nitrate is the most widespread of the preventable contaminants in Idaho's ground water supplies and therefore is an important indicator of ground water quality impacts.

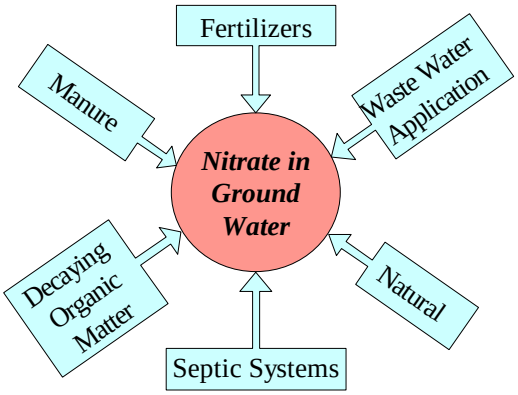

Figure 1. Some potential sources of nitrate to ground water.

Nitrate is also significant because of the health concerns associated with elevated levels. It can cause blue baby syndrome which is an oxygen deficiency that can induce illness and death in infants. This risk may be greatly increased by bacteria and other microbes in drinking water. Boiling the water is not a treatment option for nitrate; in fact, it will increase the concentration of nitrate in the water. Health officials recommend that water with greater than 10 milligrams per liter (mg/l) nitrate not be used for drinking, cooking or formula preparation for infants under 6 months of age or for pregnant women. Water with nitrate concentrations greater than 10 mg/l can also be a factor in health concerns for elderly infirm.

For this summary, nitrate concentrations were grouped into four reporting ranges: *less than the reporting level* (of 0.05 mg/l which is the laboratory detection limit), *low end* (0.05 to 1.99 mg/l) which reflect minor land use influences on the ground water or natural occurrences, *impacted* (2 to 10 mg/l) which are elevated concentrations primarily due to some form of land use, and *MCL exceedence* (greater than 10 mg/l) which is the primary Maximum Contaminant Level (MCL) for public drinking water (Table 1).

Table 1. Reporting ranges for nitrate concentrations.

Reporting Range	***Concentration***
Less than the Reporting Level	< 0.05 mg/l
Low End	0.05 to 1.99 mg/l
Impacted	2 to 10 mg/l
MCL Exceedence	> 10 mg/l

Statewide Ambient Ground Water Quality Monitoring Program

The nitrate data and results presented in this summary come from the Statewide Ambient Ground Water Quality Monitoring Program (Statewide Program). In 1989, the Ground Water Quality Protection Act authorized a comprehensive approach for maintaining and improving Idaho's ground water quality. The Ground Water Quality Plan, which was adopted in 1992, outlined a plan for statewide, regional and local monitoring. The Idaho Department of Water Resources (IDWR) was charged with developing the Statewide Program. The Idaho Department of Health and Welfare-Division of Environmental Quality and the Idaho State Department of Agriculture (ISDA) were tasked with regional and local monitoring. As the primary cooperator in the Statewide Program, the U.S. Geological Survey (USGS) provides federal matching funds and services such as logistical support, data collection and sample analyses (Figure 2). The ISDA has helped fund pesticide testing since 1993.

Figure 2. Keith Hein from the U.S. Geological Survey prepares to collect ground water quality samples at one of the Statewide Program sites.

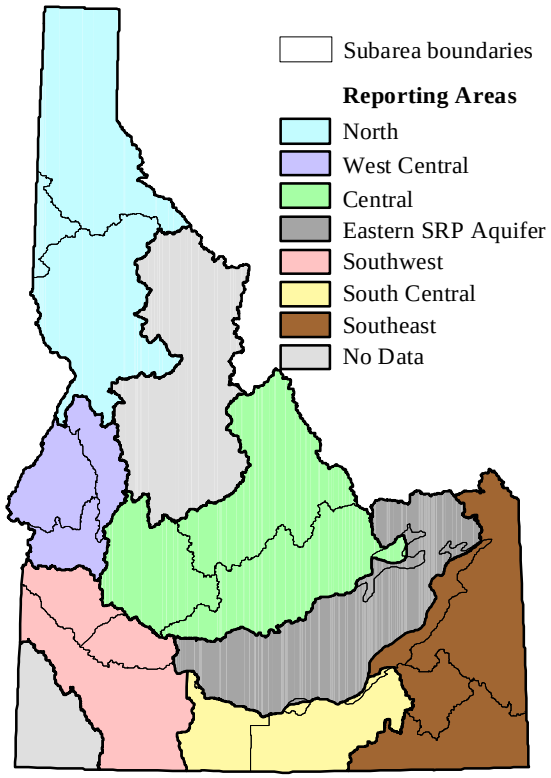

Figure 3. Hydrogeologic Subareas and Reporting Areas for this results summary.

The IDWR and the USGS collected ground water samples from 97 monitoring sites in 1990 as a prototype for the Statewide Program. This initial effort showed that the network of statewide monitoring sites needed to be based on a statistical design in order to eliminate bias and to ensure that meaningful data analyses could be conducted. In 1991, the network was developed using a stratified random selection technique. Aquifers were grouped into 22 subareas based on hydrogeological similarities. Sites were selected randomly in 20 hydrogeologic subareas (Figure 3); two subareas were not sampled because they are very remote. The number of sites selected for each subarea was based on population, aquifer size and available ground water quality data.

During the First Round of the Statewide Program (1991-1994), 1,540 monitoring sites (existing wells and springs) were sampled. Most First Round sites were resampled during the Second Round (1995-1998). Some sites called Annual Sites are sampled every year. Subareas with similar hydrogeology were grouped into 7 *Reporting Areas* for this summary (Figure 3).

First Round Nitrate Results

Nitrate results from 1,523 of the 1,540 First Round sites were used for statistical analyses. A few samples were not used because the sites did not represent major aquifers. Each nitrate sample represents total dissolved nitrate. Laboratory analyses were conducted by the U.S. Geological Survey Laboratory in Arvada, Colorado.

First Round results showed that 33 percent of the sites had nitrate concentrations equal to or greater than 2 mg/l (Figure 4). However, only 3 percent of the samples had concentrations in the *MCL exceedence* range. Nitrate influences on ground water quality were greatest in the Southwest and South Central areas where nearly half of the sites had concentrations equal to or greater than 2 mg/l (Figure 5). The majority of all nitrate *MCL exceedences* also occurred in these areas.

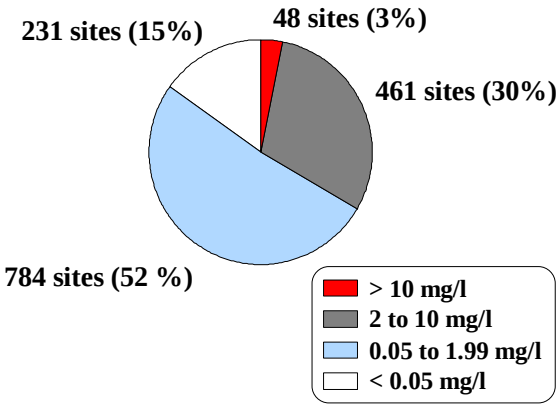

Figure 4. First Round results for nitrate by reporting ranges.

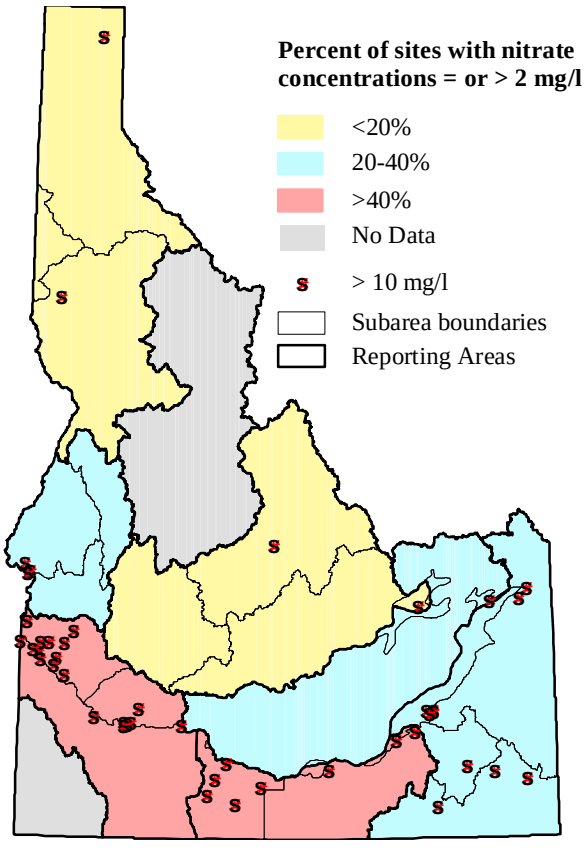

Figure 5. Percentages of sites equal to or greater than 2 milligrams per liter (mg/l) by Reporting Area and locations of sites with nitrate MCL exceedences.

Median nitrate values ranged from less than 0.5 mg/l for the North, West Central and Central areas to 2.3 mg/l for the South Central area (Figure 6). Overall, nitrate concentrations decreased with increasing well depths as indicated by Spearman's rho rank-order test results.

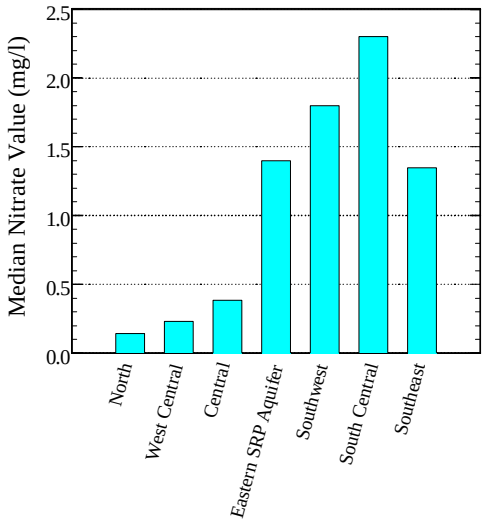

Figure 6. Median nitrate values by area from First Round analyses

First Round to Second Round Comparisons

Second Round nitrate samples were collected at 1,289 of the 1,540 First Round sites (84%). Some sites were not resampled due to non-use, owner request or other reasons. More than half of the sites had nitrate increases; however, only 141 sites (11%) had increases greater than 1 mg/l (Figure 7). The median nitrate value increased 0.11 mg/l from the First to the Second Round. Although this change was small in magnitude, it was statistically significant. Compared to the First Round, fewer Second Round sites had concentrations below the laboratory detection limit and more Second Round sites had values in the *impacted* and *MCL exceedences* ranges (Table 2). Four of the areas had more than 10 percent of the sites with nitrate concentration increases exceeding 1 mg/l (Figure 8). Clustering of sites with either increases or decreases greater than 1 mg/l occurred in some areas (Figure 9).

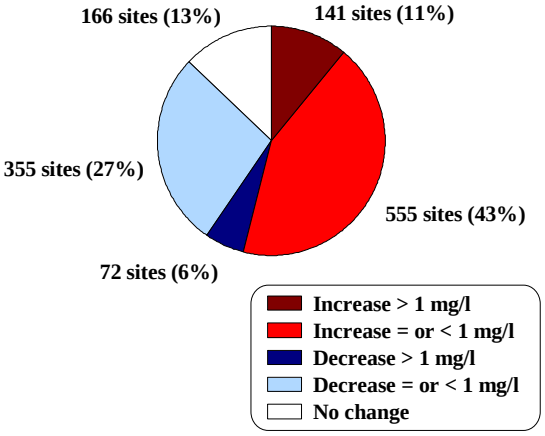

Figure 7. Nitrate concentration changes from the First Round to the Second Round.

Table 2. Nitrate changes from First Round (FR) to Second Round (SR) for paired data.

Range (mg/l)	# of FR samples	# of SR samples	Percent Change
<0.05	199	169	-15%
0.05-1.99	660	663	<1%
2-10 mg/l	393	404	3%
>10 mg/l	37	53	43%

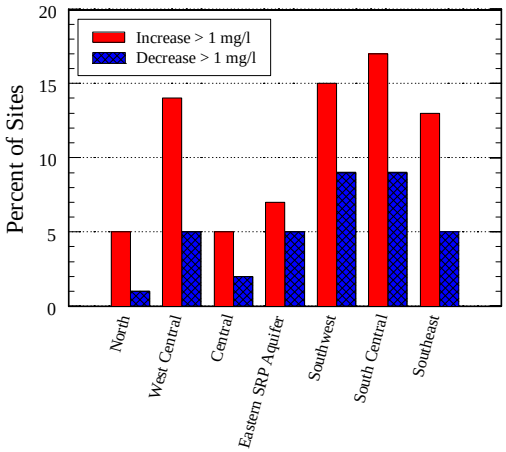

Figure 8. Percent of sites by area with nitrate concentration increases or decreases greater than 1 mg/l from First Round to Second Round.

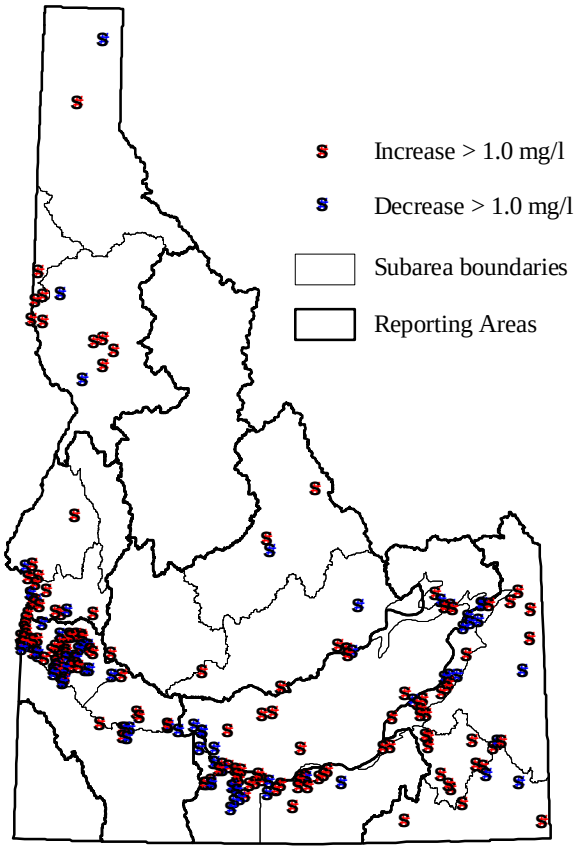

Figure 9. Locations of sites with nitrate increases or decreases greater than 1 mg/l.

North

Aquifers in the North area are found in the sands and gravels of alluvial and glacial sediments and in the Columbia River basalt. The sand and gravel aquifers occur mainly in the northern part of this area and the Columbia River basalt aquifers are in the southern half.

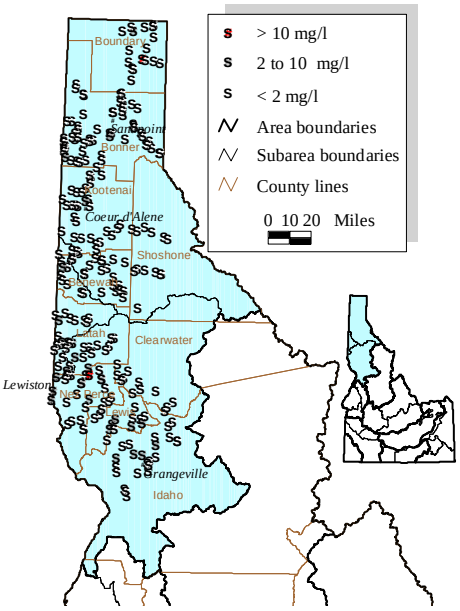

Figure 11. First Round nitrate concentrations for the North area.

Nitrate samples were collected at 264 sites in the North area during the First Round. The median nitrate concentration was 0.13 mg/l. Only 2 sites (< 1 percent) had ground water with nitrate concentrations in the *MCL exceedence* range and 27 sites (10 percent) were in the *impacted* range (Figure 10). Ground water quality impacts from nitrate were less in the North area compared to the other six areas as indicated by the high percentage of sites in the *low end* and *less than the reporting level* ranges. Most sites with impacted nitrate values were in the southern part of the North area (Figure 11).

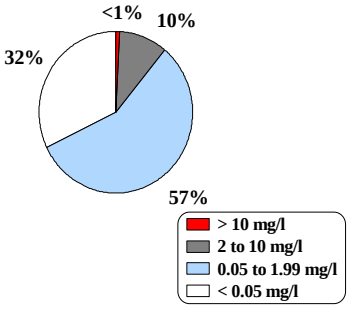

Figure 10. First Round nitrate results by concentration range for the North area.

Second Round nitrate samples were collected at 219 of the First Round sites (83 percent). The median decreased 0.01 mg/l for the paired data. Although nitrate concentrations increased at about twice as many sites as they decreased, over 90 percent of the Second Round analyses were within ± 1 mg/l of the First Round results (Figure 12). Ten sites (5 percent) had increases greater than 1 mg/l and 3 sites (1 percent) had decreases greater than 1 mg/l. Sites with increases greater than 1 mg/l occurred in clusters near Lewiston and north of Grangeville (Figure 13). Two sites (1 percent) moved from the *impacted* to the *MCL exceedence* range.

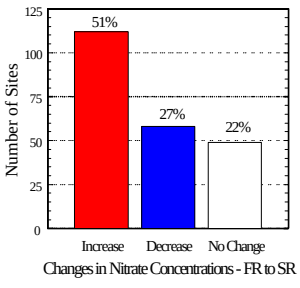

Figure 12. Number and percent of sites according to changes in nitrate concentrations from First to Second Round - North area.

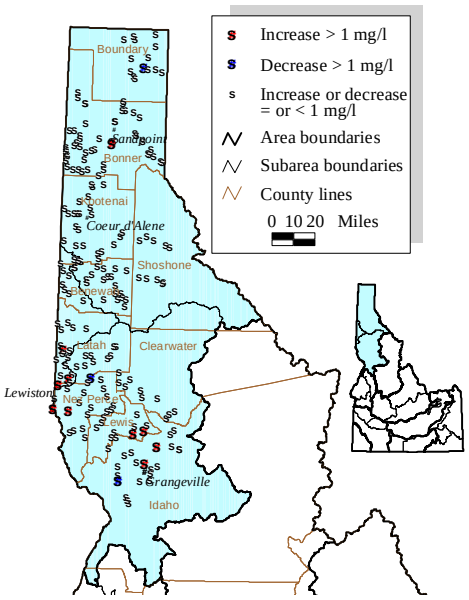

Figure 13. Location of nitrate concentration changes between the First and Second Rounds for the North area.

West Central

Primary aquifers in the West Central (WC) area are in the sands and gravels of alluvial valley fill and in the Columbia River basalt. The valley fill aquifers occur throughout the WC area while the Columbia River basalt aquifers are found mainly in Adams and Washington counties.

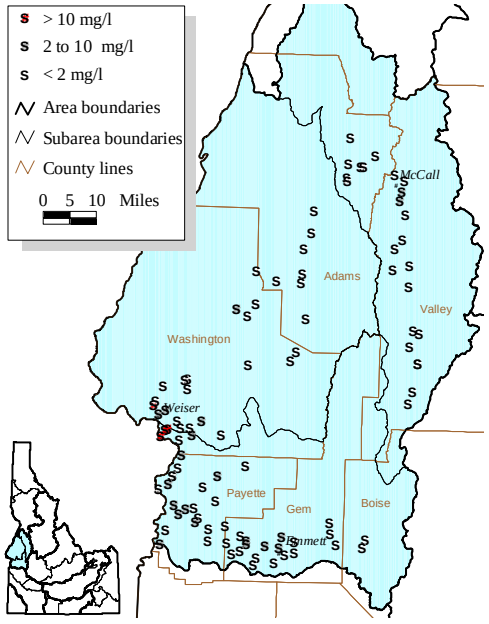

Figure 15. First Round nitrate concentrations for the West Central area.

Nitrate samples were collected at 105 sites in the WC area during the First Round. Four sites (4 percent) were in *MCL exceedence* range and 22 sites (21 percent) were in the *impacted* range (Figure 14). Seventy-five percent of the sites were in the *low end* or *less than the reporting level* ranges. All of the MCL detections occurred around Weiser where depths to ground water are generally less than 50 feet. Most of the impacted sites occurred in the southern and western parts of the WC area (Figure 15).

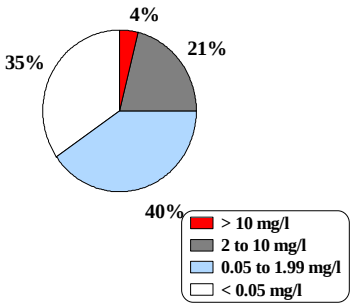

Figure 14. First Round nitrate results by concentration range for the West Central area.

Second Round nitrate samples were collected at 89 of the First Round sites (85 percent). The median value increased 0.08 mg/l for the paired data. More sites had nitrate concentration increases than decreases and the percentage of sites with no concentration change was the highest of the 7 areas (Figure 16). Thirteen sites (15 percent) had increases greater than 1 mg/l and 4 sites (4 percent) had decreases greater than 1 mg/l (Figure 17). All but 1 of the 13 sites with increases greater than 1 mg/l were in the southern part of the WC area (Figure 17). Four sites (4 percent) moved from the *impacted* to the *MCL exceedence* range.

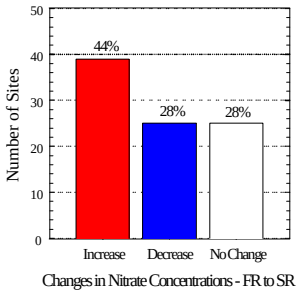

Figure 16. Number and percent of sites according to changes in nitrate concentrations from First to Second Round - West Central area.

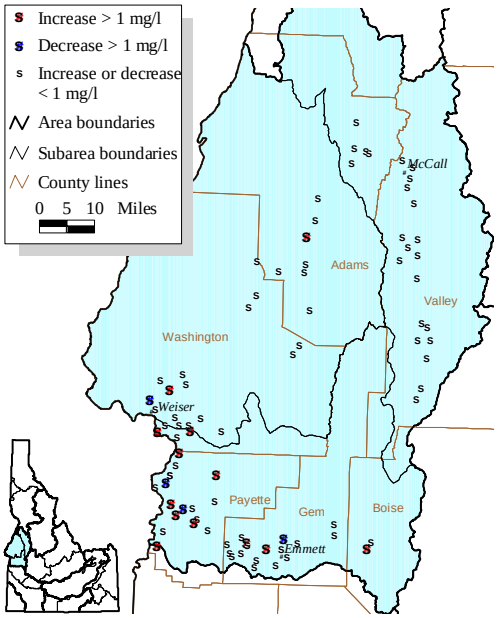

Figure 17. Nitrate concentration changes between the First and Second Round for the West Central area.

Central

The Central area is a mountainous region with river and stream valleys of various sizes. The major aquifers in the Central area are found in the gravels and sands of the valley fill sediments.

Nitrate samples were collected at 114 sites in the Central area during the First Round. The median nitrate concentration was 0.39 mg/l. Two sites (2 percent) had concentrations in the *MCL exceedence* range and 11 sites (10 percent) were in the *impacted* range (Figure 18). Nitrate results for the Central area were very similar to the North area which also has valley-fill aquifers between mountain ranges. Sites having ground water concentrations in the *impacted* or *MCL exceedence* ranges were scattered throughout the area with no distinct patterns (Figure 19).

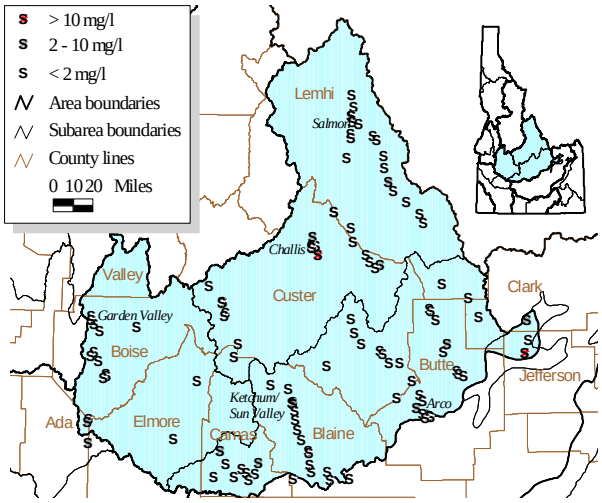

Figure 19. First Round nitrate concentrations for the Central area.

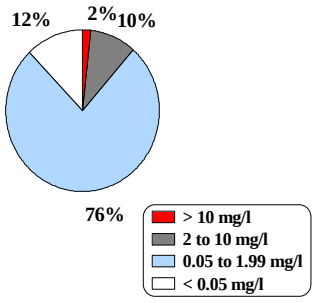

Figure 18. First Round nitrate result by concentration ranges for the Central area.

Second Round nitrate samples were collected at 92 of the First Round sites (81 percent). The median increased 0.04 mg/l for the paired data. There were a few more sites with nitrate increases than sites with nitrate decreases (Figure 20). Six sites (7 percent) had nitrate concentrations that increased more than 1 mg/l and 2 sites (2 percent) had decreases greater than 1 mg/l. These sites were distributed through the Central area with no distinct patterns except that two sites with nitrate increases greater than 1 mg/l were near Arco (Figure 21). One site (1 percent) moved from the *impacted* to *MCL exceedence* range.

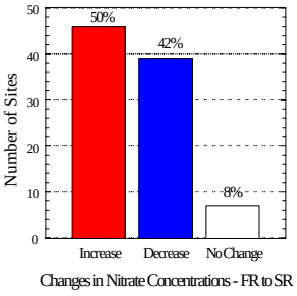

Figure 20. Number and percent of sites according to changes in nitrate concentrations from First to Second Round - Central area.

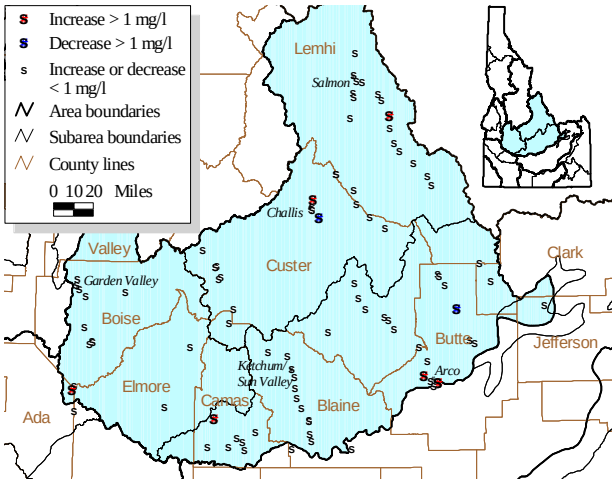

Figure 21. Location of nitrate concentration changes between the First and Second Rounds for the Central area.

Eastern Snake River Plain Aquifer

The Eastern Snake River Plain (ESRP) Aquifer is the largest aquifer in Idaho and one of the most productive ground water systems in the western United States. It is comprised of basaltic lava flows and interbedded sedimentary deposits. Small, overlying alluvial aquifers occur at some places along the edges of the ESRP Aquifer; these local aquifers are not included as part of the ESRP Aquifer.

Nitrate samples were collected at 246 sites in the ESRP Aquifer during the First Round. The median nitrate concentration was 1.4 mg/l. Only one site (< 1 percent) had a nitrate concentration in the *MCL exceedence* range and 76 sites (31 percent) were in the *impacted* range (Figure 22). The ESRP Aquifer had the smallest percentage of sites with nitrate values in the *less than the reporting level* range. Most of the sites with *impacted* concentrations occurred along the southern and eastern edges or in the northeast part of the area (Figure 23).

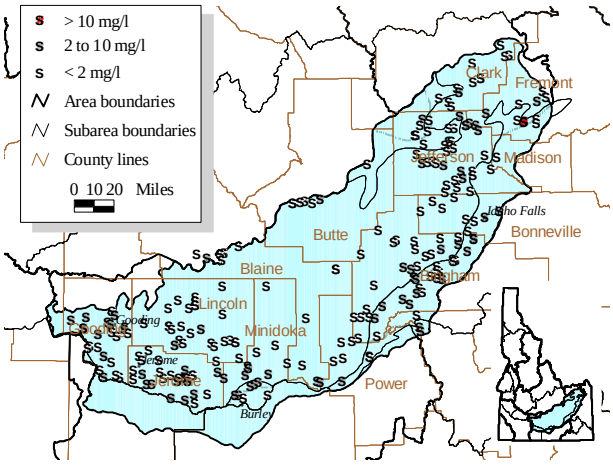

Figure 23. First Round nitrate concentrations for the Eastern Snake River Plain Aquifer.

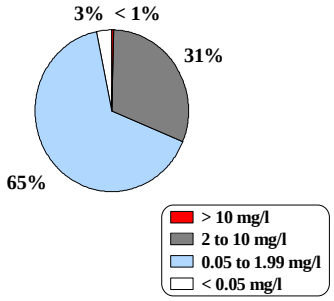

Figure 22. First Round nitrate results by concentration range for the Eastern Snake River Plain Aquifer.

Second Round nitrate samples were collected at 209 of the First Round sites (85 percent). Nitrate values increased at almost twice as many sites as they decreased (Figure 24). The median increased 0.15 mg/l for the paired data. Overall, 88 percent of the Second Round analyses were within ± 1 mg/l of their First Round analyses. However, 15 sites (7 percent) had increases greater than 1 mg/l and 11 sites (5 percent) had decreases greater than 1 mg/l. Clustering of sites with increases or decreases greater than 1 mg/l occurred in some areas (Figure 25). Two sites (1 percent) moved from the *impacted* to the *MCL exceedence* range.

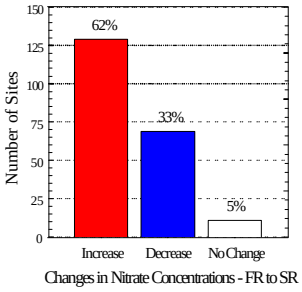

Figure 24. Number and percent of sites according to changes in nitrate concentrations from First to Second Round - ESRP Aquifer.

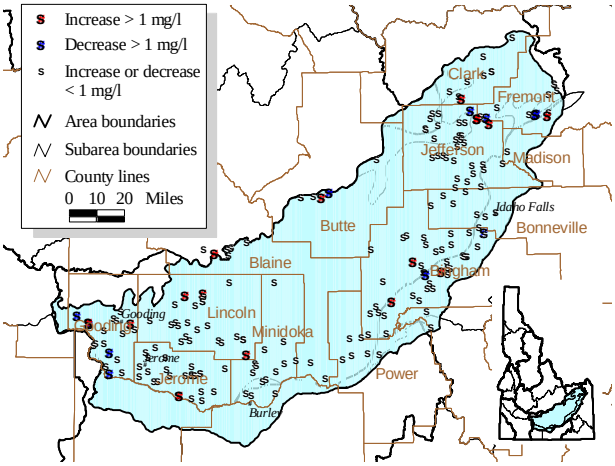

Figure 25. Location of nitrate concentration changes between the First and Second Rounds for the Eastern Snake River Plain Aquifer.

Southwest

The Southwest (SW) area is one of the most complex hydrogeologic areas in Idaho. Two distinct aquifers systems exist in Ada and Canyon counties where fine grained sands of the Treasure Valley Deep (TVD) aquifer are overlain by gravels and coarse grained sands of the Treasure Valley Shallow (TVS) aquifer. The TVS aquifer ranges in thickness from about 50 to 250 feet. In Elmore and Owyhee counties, basalt, rhyolite and sedimentary rocks are the main aquifers.

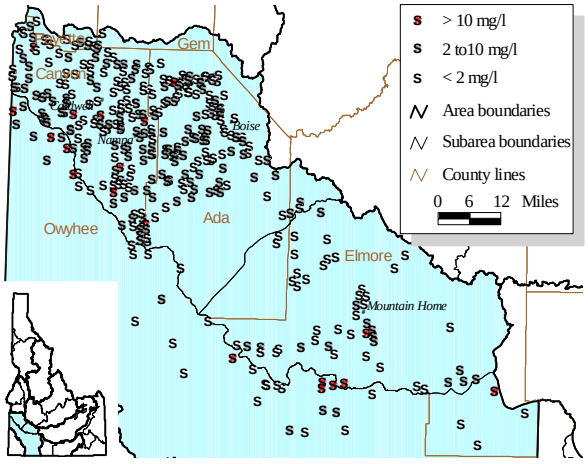

Figure 27. First Round nitrate concentrations for the Southwest area.

Nitrate samples were collected at 369 sites in the SW area during the First Round. The median nitrate value was 1.80 mg/l. Nineteen sites (5 percent) were in the *MCL exceedence* range and 153 sites (41 percent) were in the *impacted* range (Figure 26). Nitrate impacts occurred throughout the SW area (Figure 27). Overall, nitrate concentrations equal to or greater than 2 mg/l occurred at about twice as many TVS sites as TVD sites.

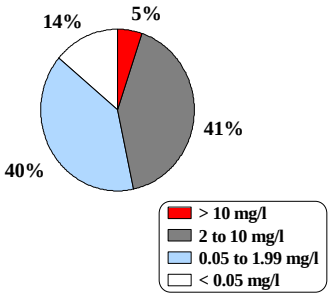

Figure 26. First Round nitrate results by concentration range for the Southwest area.

Second Round nitrate samples were collected at 320 of the First Round sites (87 percent). The median value increased 0.12 mg/l for the paired data. The majority of sites had nitrate concentration increases (Figure 28). Forty-seven sites (15 percent) had increases greater than 1 mg/l and 29 sites (9 percent) had decreases greater than 1 mg/l. The effects of well depth and aquifer type on nitrate concentration changes were apparent in Ada and Canyon counties where 31 TVS sites had increases greater than 1 mg/l and only 7 sites had decreases greater than 1 mg/l (Figure 29). Conversely, the number of increases greater than 1 mg/l for the TVD was only 6 while the number of decreases was 12. Seven sites (2 percent) moved from the *impacted* to the *MCL exceedence* range.

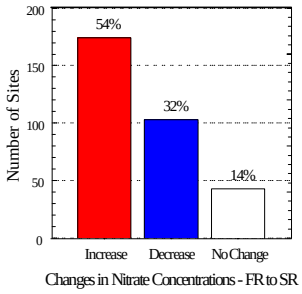

Figure 28. Number and percent of sites according to changes in nitrate concentrations from First to Second Round - Southwest area.

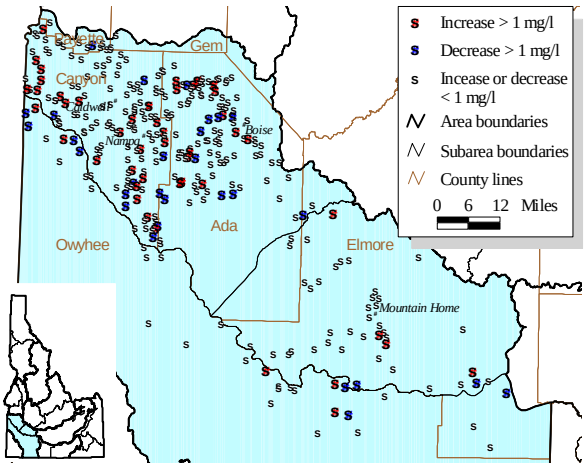

Figure 29. Location of nitrate concentration changes between the First and Second Rounds for the Southwest area.

South Central

Aquifers in the South Central (SC) area are found in sedimentary and volcanic rocks and in unconsolidated alluvium. Basalt and interbedded sediments are the primary aquifers in Twin Falls county. Sedimentary deposits, volcanic rocks and alluvium are the main aquifers in Cassia and Power counties.

Nitrate samples were collected at 181 sites in the SC area during the First Round. The median nitrate concentration of 2.30 mg/l was the highest of the 7 areas. Nine sites (5 percent) were in the *MCL exceedence* range (Figure 30). The SC area had the highest percentage of sites with nitrate concentrations in the *impacted* range. Nitrate impacts to ground water quality were readily apparent in the western and north central parts of the SC area (Figure 31). Seventy-six percent of the sites in Twin Falls county had nitrate values equal to or greater than 2 mg/l. Eastern Cassia county and Power county had smaller percentage of sites with impacted nitrate concentrations than the other parts of the SC area.

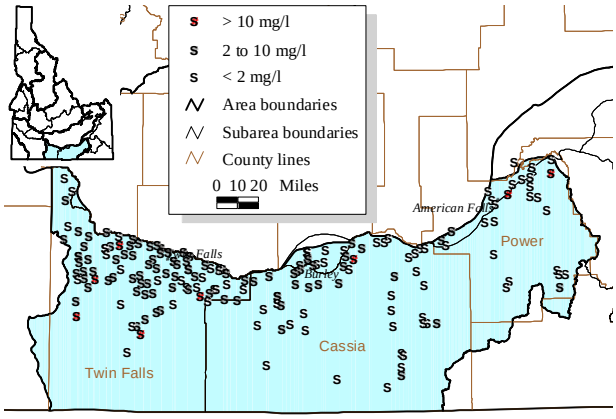

Figure 31. First Round nitrate concentrations for the South Central area.

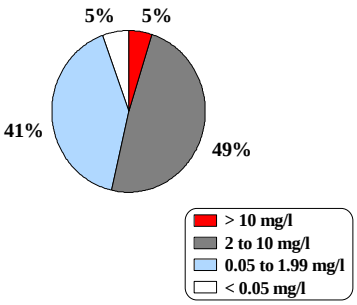

Figure 30. First Round nitrate results by concentration range for the South Central area.

Second Round nitrate samples were collected at 152 of the First Round sites (84 percent). The median decreased 0.07 mg/l for the paired data. However, nitrate concentrations increased at almost twice as many sites as they decreased (Figure 32). The reason for this anomaly is unknown. Twenty-seven sites (18 percent) had increases greater than 1 mg/l and 13 sites (9 percent) had decreases greater than 1 mg/l. Sites with increases greater than 1 mg/l occurred primarily along the northern edge with some clustering patterns apparent (Figure 33). Five sites (3 percent) moved from the *impacted* to the *MCL exceedence* range.

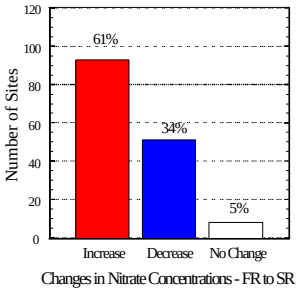

Figure 32. Number and percent of sites according to changes in nitrate concentrations from First to Second Round - South Central area.

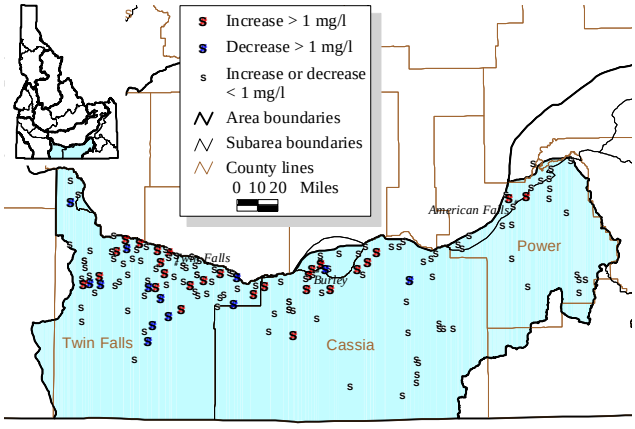

Figure 33. Location of nitrate concentration ranges between the First and Second Rounds for the South Central area.

Southeast

The Southeast area contains aquifers that occur in a wide variety of volcanic rocks, sedimentary deposits and alluvium. Generally, the aquifers in the northern part of the Southeast are found within interbedded sedimentary and volcanic rocks. Alluvium, sedimentary rocks and occasional basalt units are common aquifers south of Bonneville county.

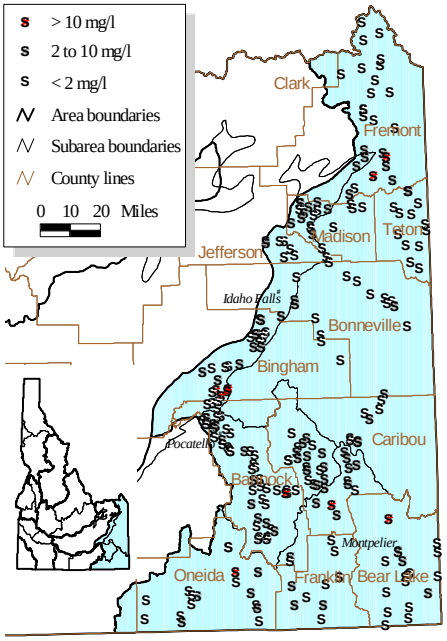

Figure 35. First Round nitrate concentrations for the Southeast area.

Nitrate samples were collected at 246 sites in the Southeast area during the First Round. The median nitrate concentration was 1.35 mg/l. Eleven sites (4.5 percent) had nitrate concentration in the *MCL exceedence* range and 82 sites (33 percent) were in the *impacted* range (Figure 34). Impacted nitrate concentrations occurred along the western margin and in the southern half of the area. Many of the sites along the western margin produce water from the shallow alluvial aquifers that overlie a portion of the Eastern Snake River Plain Aquifer. Caribou county had a high percentage of sites with nitrate concentrations in the *impacted* range.

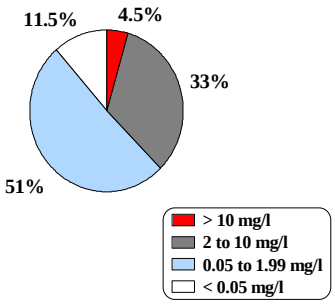

Figure 34. First Round nitrate results by concentration range for the South Central area.

Second Round nitrate samples were collected at 208 of the First Round sites (85 percent). The median value increased 0.20 mg/l for the paired data. Nitrate values increased at slightly more sites than they decreased (Figure 36). Twenty-six sites (13 percent) had increases greater than 1 mg/l and 10 sites (5 percent) had decreases greater than 1 mg/l. Sites with increases greater than 1 mg/l occurred in clusters in Bingham, Bannock and Caribou counties and, to a lesser extent, in the northern part of the area (Figure 37). Three sites (1 percent) moved from the *impacted* to the *MCL exceedence* range.

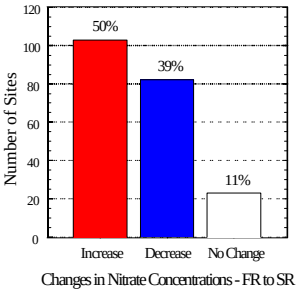

Figure 36. Number and percent of sites according to changes in nitrate concentrations from First to Second Round - Southeast area.

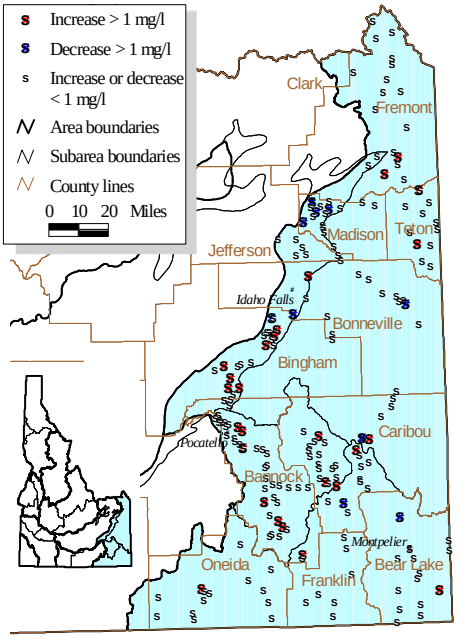

Figure 37. Location of nitrate concentration changes between the First and Second Rounds for the Southeast area.

Current Activities and Future Plans

The Statewide Program is entering the Third Round of sampling, which is planned to be conducted from 1999 through 2002. By the end of the Third Round, most sites will have been sampled at least three times and Annual sites will have data from 8 to 10 sampling events. Statistical tests for trends will become more and valid with each round of data collection. IDWR plans to produce another nitrate results summary after Third Round sampling is completed. IDWR also plans to produce a pesticide summary and additional technical reports like the one published recently for the Treasure Valley subareas (Neely and Crockett, 1998).

Conclusions and Recommendations

Results from the first eight years of monitoring for the Statewide Program indicate that Idaho ground water quality has been impacted by nitrate in some areas. Only 3 percent of the sites had nitrate results greater than the MCL of 10 mg/l; however, another 30 percent had *impacted* concentrations. Initial trend data show that nitrate concentrations increased at more than half of the sites tested in both the First and Second Rounds.

Given that ground water quality impacts from nitrate have been identified and that nitrate concentrations may be increasing in some areas, additional regional and local monitoring as called for in the Ground Water Quality Plan is needed. The Ground Water Quality Technical Committee has prioritized areas in Idaho that may need follow-up ground water quality monitoring.

IDWR recommends that all private homeowners with wells have their water tested for nitrate and bacteria at least once a year.

Data Availability and Contact Information

Statewide Program data are stored in electronic file format and in hard copy at the Idaho Department of Water Resources-Ground Water Monitoring Section. To request data or information about the Statewide Program, or to further inquire about ground water quality in Idaho, contact Janet Crockett at 208-327-5445 (jcrocket@idwr.state.id.us) or Ken Neely at 208-327-5455 (kneely@idwr.state.id.us). For water treatment and health concerns related to ground water quality, contact your local health district.

References

Crockett, J.K., 1995, Idaho statewide ground water quality monitoring program-summary of results, 1991through 1993: Idaho Department of Water Resources Water Information Bulletin No. 50, Part 2, 67 p.

Graham, W.G., and Campbell, L.J., 1981, Groundwater resources of Idaho: Idaho Department of Water Resources, 100 p.

Ground Water Quality Council, 1992, Idaho ground water quality plan: Idaho Ground Water Quality Council in cooperation with Idaho Department of Health and Welfare-Division of Environmental Quality, Idaho Department of Water Resources and Idaho Department of Agriculture, 100 p.

Neely, K.W., 1994, Idaho statewide ground water quality monitoring program network design: Idaho Department of Water Resources Water Information Bulletin No. 50, Part 1, 35 p.

Neely, K.W. and Crockett, J.K., 1998, Ground water quality characterization and initial trend analyses for the Treasure Valley shallow and deep hydrogeologic subareas: Idaho Department of Water Resources Water Information Bulletin No. 50, Part 3, 79 p.

State of Idaho, Idaho State Legislature, 1989, The ground water quality protection act of 1989: Idaho Code section 39-102-39-127, and chapter 65, title 67, section 67-6537.