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Town of Torrington, Wyoming

# Results of Nitrate Sampling in the Torrington, Wyoming, Wellhead Protection Area, 1994-98

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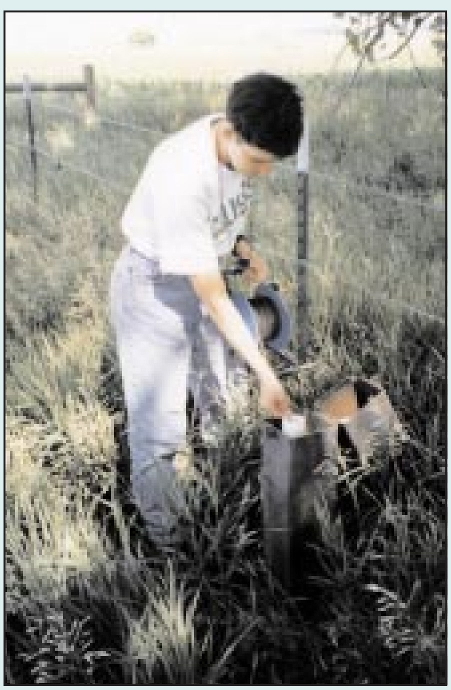
## ABSTRACT

**A monitoring program for nitrate in ground water in and near Torrington, Wyoming was conducted by the Town of Torrington from April 1994 through March 1997, and cooperatively by the Town of Torrington and the U.S. Geological Survey from May 1997 through August 1998. Trends in nitrate concentrations were determined for the period of time covered by both monitoring programs. A significant trend was detected at 34 of the 72 sites. Twenty-six sites had nitrate concentrations that were increasing, and eight sites had nitrate concentrations that were decreasing. Nitrogen isotope data were also collected at selected sites. These data indicate that the source of nitrate in ground water in and around Torrington is probably not from human or animal waste, but rather organic soil nitrogen, or ammonium or nitrate fertilizer.**

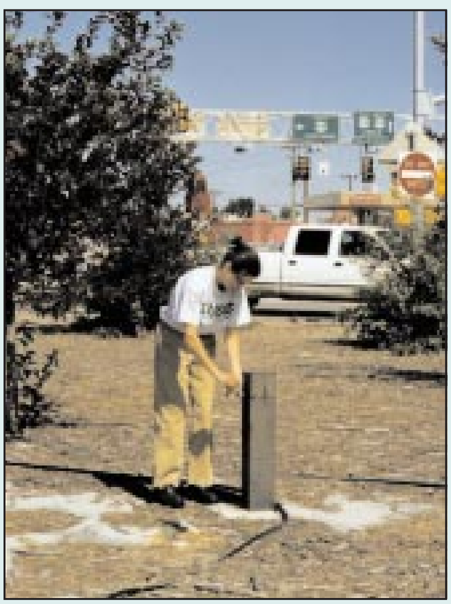


## INTRODUCTION

During 1986, personnel analyzing results of routine sampling of Torrington's water-supply wells noticed increased concentrations of nitrate in samples from several of these wells. In spring 1988, samples from several of the water-supply wells had large increases in nitrate concentrations. Water from two wells had nitrate concentrations in excess of 10 mg/L as N (milligrams per liter as nitrogen) (Town of Torrington, 1997), the Maximum Contaminant Level (MCL) for drinking water established by the U.S. Environmental Protection Agency (USEPA) (1996). In response to the high concentrations of nitrate in the water-supply wells, the Town of Torrington initiated a monitoring program in April 1994 to obtain baseline nitrate data for ground water in the Torrington Wellhead Protection Area (WHP). Sampling was conducted by the Town of Torrington from April 1994 through March 1997, and cooperatively by the town and the U.S. Geological Survey (USGS) from May 1997 through August 1998. The baseline data were to be used to describe the source and extent of nitrate in ground water in and near Torrington, as well as provide initial data for trend analyses. Nitrate concentrations greater than 3 mg/L as N generally are an indicator that human activities (anthropogenic) are contributing to the nitrate concentrations (Madison and Brunett, 1985).

## Environmental Setting

The Town of Torrington is located in east-central Wyoming, about 10 miles from the Nebraska State line. The North Platte River flows through the southern part of Torrington, and several irrigation canals deliver water to the local area. The land use in the study area is both urban and agricultural. Primary crops grown are corn, sugar beets, dry beans, hay, and small grains. Large-scale irrigation has been in operation since the early 1900s (Rapp and others, 1957). The average daily temperature during the coldest month, January, is 25.3 °F; the average daily temperature during the warmest month, July, is 72.6 °F (Martner, 1986). The average yearly precipitation is 13.05 inches, of which more than one-third falls during the months of May and June (Martner, 1986).



The surficial geology of the area in and around Torrington is primarily unconsolidated deposits of Quaternary age. These deposits generally are composed of sand and gravel and are as much as 200 feet thick. These deposits are underlain by the Brule Formation of Tertiary age (Rapp and others, 1957).

Wells drilled into the unconsolidated deposits typically yield significant quantities of water (up to 3,500 gallons per minute) (Rapp and others, 1957). The deposits are hydraulically connected to the North Platte River in most places. The eight wells that currently supply water to the town are completed in these deposits. During 1995, the average daily pumping rate from the system (any or all of the 8 wells) in the wintertime was 1.5 million gallons per day. Maximum usage during the summer was 6.9 million gallons per day.

## Methods of Data Collection

The monitoring program used newly installed monitoring wells located in and around the town, as well as existing domestic and municipal wells (figure 1). Additionally, two sites on the North Platte River were sampled because the river can either receive or discharge water to the local ground-water system, depending on the time of the year (Parks, 1991). Monthly samples were collected by the town from April 1994 through March 1997. In May 1997, the USGS began sampling the monitoring and domestic wells and the two North Platte River sites. Monthly sampling continued through August 1997. Duplicate samples were collected concurrently by the USGS from a different set of 10 wells during May, June, and July 1997 to determine if the laboratory analyses used by the Town and the USGS were equivalent. It was determined that the data collected

by the town and the USGS were not statistically different. Therefore, the data collected by the town and the data collected by the USGS were analyzed as one data set. In August 1997, the number of sampling sites was reduced from 72 to 52. The 52 sites were sampled quarterly until the program ended in August 1998.


## Acknowledgements

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## NITRATE DATA

Samples collected from the 72 ground- and surface-water sites in the monitoring program had a wide range of nitrate concentrations (table 1). The lowest concentration of nitrate was a sample from the North Platte

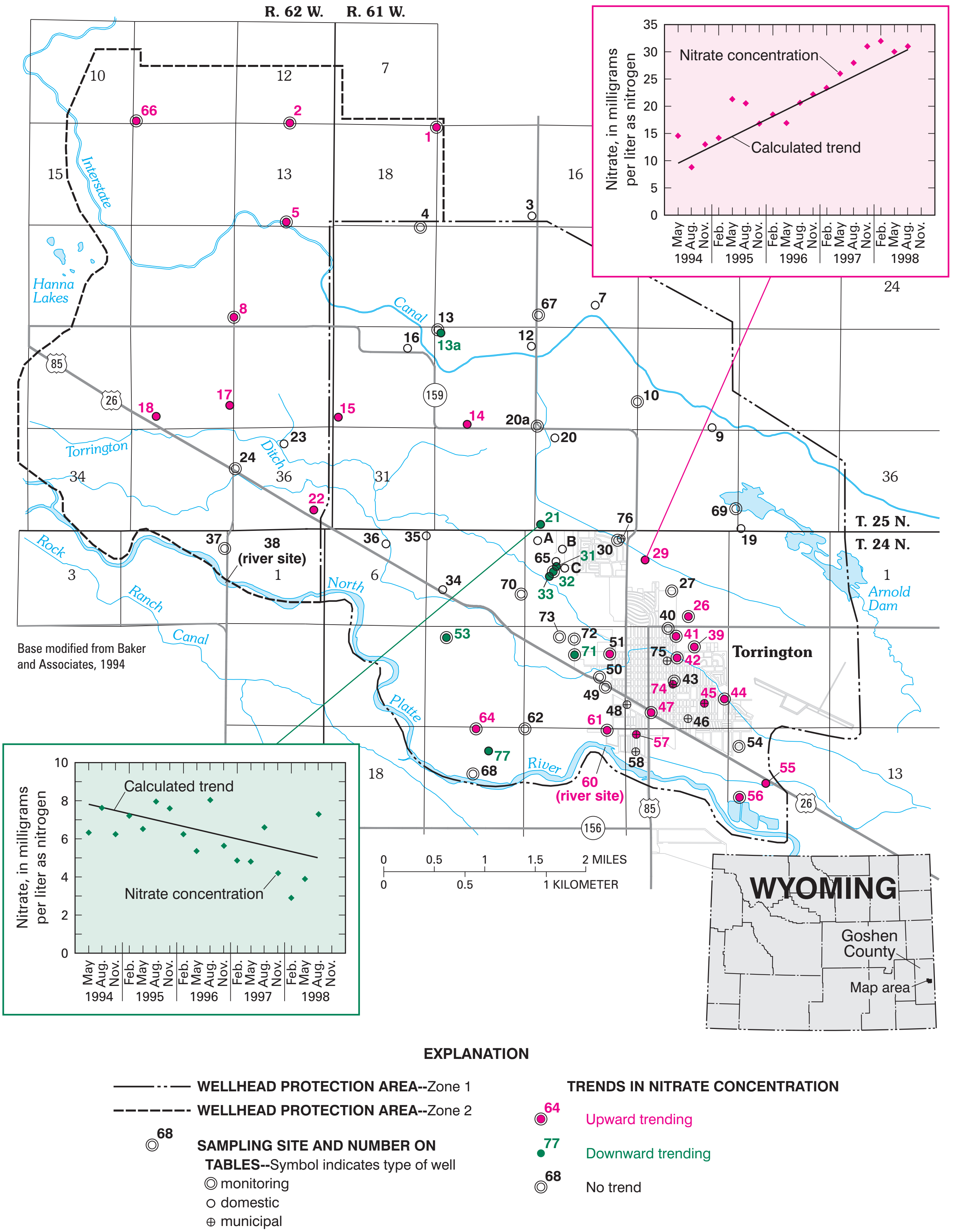


**Figure 1.** Location of sampling sites and trends in nitrate concentrations near Torrington, Wyoming.

**Table 1.** *Well information and summary statistics for ground- and surface-water samples collected in the Torrington area, April 1994 through August 1998.*
[mg/L as N, in milligrams per liter as nitrogen; N/A, not applicable; LR, less than analytical reporting limit (<0.05 mg/L as N); number in parentheses is the Torrington municipal well number]

| Site number | Well depth | Number of nitrate samples collected | Nitrate concentration (mg/L as N) | | |
|---|---|---|---|---|---|
| | | | Minimum | Maximum | Average |
| ***Domestic wells*** | | | | | |
| 03 | 90 | 40 | 12 | 15 | 13 |
| 07 | 80 | 40 | 0.34 | 3.3 | 1.1 |
| 09 | 110 | 40 | 0.75 | 1.6 | 1.0 |
| 12 | 180 | 44 | 0.53 | 3.6 | 1.6 |
| 13a | 140 | 43 | 2.3 | 9.9 | 5.9 |
| 14 | 137 | 44 | 5.8 | 10 | 8.8 |
| 15 | 120 | 43 | 6.1 | 9.4 | 7.2 |
| 16 | ND | 36 | 5.7 | 14 | 9.2 |
| 17 | 100 | 44 | 5.8 | 8.7 | 7.0 |
| 18 | 60 | 44 | 8.0 | 12 | 9.6 |
| 19 | 98 | 44 | 2.3 | 4.1 | 3.1 |
| 20 | 154 | 44 | 1.8 | 2.9 | 2.3 |
| 21 | 135 | 44 | 2.9 | 8.2 | 6.4 |
| 22 | 124 | 44 | 6.1 | 13 | 8.1 |
| 23 | 100 | 44 | 1.4 | 4.1 | 2.5 |
| 29 | 150 | 47 | 8.8 | 32 | 20 |
| 31 | 140 | 40 | 14 | 20 | 16 |
| 33 | 65 | 40 | 11 | 16 | 13 |
| 34 | 80 | 44 | 0.64 | 4.0 | 2.2 |
| 35 | 60 | 44 | 3.5 | 6.0 | 4.4 |
| 36 | 60 | 44 | 0.05 | 2.8 | 1.1 |
| 55 | 100 | 44 | 8.3 | 12 | 9.9 |
| 65 | ND | 47 | 12 | 21 | 15 |
| 77 | ND | 36 | 2.9 | 7.2 | 4.7 |
| ***Monitoring wells*** | | | | | |
| 01 | 98.5 | 36 | 7.4 | 11 | 9.8 |
| 02 | 140 | 43 | 5.6 | 13 | 7.0 |
| 04 | 125 | 37 | 19 | 27 | 22 |
| 05 | 85 | 44 | 0.28 | 16 | 2.1 |
| 08 | 72 | 43 | 3.7 | 14 | 6.0 |
| 10 | ND | 42 | 1.7 | 5.2 | 3.2 |
| 13 | 95 | 48 | 17 | 37 | 21 |
| 20a | 72 | 40 | 2.9 | 6.1 | 3.8 |
| 24 | 25 | 44 | 4.6 | 11 | 7.4 |
| 26 | 55 | 44 | 5.9 | 17 | 12 |
| 27 | 77 | 44 | 3.6 | 17 | 9.1 |
| 30 | 105 | 43 | 2.4 | 12 | 6.3 |
| 32 | 50 | 44 | 11 | 17 | 14 |
| 37 | 25 | 40 | 0.26 | 9.8 | 7.0 |
| ***Monitoring wells--Continued.*** | | | | | |
| 39 | 45 | 44 | 8.7 | 15 | 10 |
| 40 | 44 | 44 | 5.4 | 9.7 | 7.0 |
| 41 | 40 | 40 | 6.8 | 15 | 11 |
| 42 | 35 | 44 | 9.3 | 16 | 12 |
| 43 | 35 | 44 | 10 | 16 | 13 |
| 44 | 39 | 40 | 8.7 | 15 | 11 |
| 47 | 35 | 42 | 5.1 | 17 | 12 |
| 49 | 39 | 44 | 3.9 | 140 | 26 |
| 50 | 30 | 28 | 7.0 | 22 | 11 |
| 51 | 37 | 44 | 3.8 | 13 | 7.0 |
| 53 | 25 | 44 | 4.9 | 18 | 11 |
| 54 | 30 | 43 | 9.8 | 17 | 15 |
| 56 | 18 | 44 | 0.8 | 18 | 9.1 |
| 61 | 32 | 44 | 4.4 | 19 | 10 |
| 62 | 25 | 44 | 2.5 | 14 | 5.2 |
| 64 | 25 | 43 | 5.3 | 15 | 8.4 |
| 66 | 137 | 40 | 0.7 | 4.2 | 2.8 |
| 67 | 65 | 39 | 6.6 | 12 | 10 |
| 68 | 23 | 40 | 2.2 | 4.2 | 3.1 |
| 69 | 24 | 45 | 2.0 | 43 | 10 |
| 70 | 29 | 40 | 5.4 | 15 | 9.3 |
| 71 | 33 | 40 | 11 | 21 | 16 |
| 72 | 34 | 36 | 2.1 | 11 | 6.3 |
| 73 | 32 | 36 | 9.9 | 28 | 15 |
| ***Municipal wells*** | | | | | |
| 45(12) | 65 | 36 | 8.4 | 12 | 9.5 |
| 46(7) | 83 | 36 | 4.4 | 11 | 8.4 |
| 48(5) | 90 | 36 | 4.0 | 10 | 7.9 |
| 57(15) | 128 | 36 | 3.4 | 5.6 | 4.7 |
| 58(9) | 100 | 36 | 4.1 | 10 | 6.5 |
| 74(4) | 81 | 34 | 7.3 | 11 | 9.1 |
| 75(3) | 57 | 24 | 7.3 | 11 | 9.2 |
| 76(13) | 90 | 34 | 4.9 | 11 | 7.3 |
| ***River sites*** | | | | | |
| 38 | N/A | 44 | LR | 2.1 | 1.0 |
| 60 | N/A | 42 | 0.12 | 25 | 1.7 |

River (site 38) with a concentration of <0.05 mg/L as N (the analytical reporting limit for this constituent). The highest concentration of nitrate (140 mg/L as N) was from a sample collected at well 49. Twenty-two of the 72 sites had average concentrations of nitrate greater than the MCL of 10 mg/L as N during the sampling period. Forty-seven of the 72 sites had at least one sample that exceeded the MCL during the period of sampling. The MCL is applicable only to publicly supplied water, however, it provides a reference to judge the acceptability of water from all wells sampled in this study for drinking. A complete set of the data collected between April 1994 and March 1997 is published in the Final Report submitted by the Town of Torrington to the Wyoming Department of Environmental Quality (Town of Torrington, 1997). Data collected by the USGS during this program are published in Mason and Green (1998) and Mason and others (1999).

## NITRATE TRENDS

Statistical analyses were performed on the data for each well using the seasonal Kendall test to determine if a statistically significant trend exists in the data (Helsel and Hirsch, 1995, p. 327). The seasonal Kendall test was chosen as the method for trend analysis because other statistical tests (Town of Torrington, 1997) indicated that the nitrate concentrations in selected wells had a seasonal pattern. The seasonal pattern was not the same in different wells. The seasonal Kendall test accounts for seasonal patterns by comparing data collected in different years only within a given month or season; for example, data collected in February are compared only to data collected in February in other years.

All monitoring wells, all but one domestic well, and the two river sites were sampled monthly for 3½ years and then sampled quarterly for 1 year. The seasonal Kendall test was performed using a quarterly time frame (data from February, May, August, and November) from May 1994 through August 1998, according to methods described in Helsel and Hirsch (1995, p. 339).

Eight municipal wells and one domestic well were sampled monthly for 3 years, after which sampling at these sites for this monitoring program was discontinued. The seasonal Kendall test was performed on monthly data collected from April 1994 through March 1997.

A statistical trend analysis provides an evaluation of whether concentrations are increasing (upward trending) or decreasing (downward trending) over time. The seasonal Kendall trend analysis indicated a trend in nitrate concentrations (significant at a confidence level greater than 90 percent) at 34 of the 72 sites. Twenty-six sites had nitrate concentrations that were

**Table 2.** *Results of trend analysis for Torrington municipal wells, April 1994 through March 1997.*

[Number in parentheses is Torrington municipal well number. NT indicates no trend; DT indicates downward trend; UT indicates upward trend. A trend is identified if the confidence level is greater than 90 percent. A p-value indicates how likely it is that the trend actually exists. The lower a p-value, the more confident one can be that the trend exists. For more discussion, see text.]

| Site number | Number of samples used in trend test | Results of trend test (p value) |
|---|---|---|
| 45(12) | 34 | UT(0.05) |
| 46(7) | 34 | NT(0.7) |
| 48(5) | 34 | NT(0.4) |
| 57(15) | 34 | UT(0.07) |
| 58(9) | 34 | NT(0.9) |
| 74(4) | 32 | UT(0.05) |
| 75(3) | 14 | NT(0.5) |
| 76(13) | 32 | NT(0.1) |

**Table 3.** *Results of trend analysis for domestic and monitoring wells and river sites sampled in the Torrington area, April 1994 through August 1998.*
[NT indicates no trend; DT indicates downward trend; UT indicates upward trend.
A trend is identified if the confidence level is greater than 90 percent. A p-value indicates how likely it is that the trend actually exists. The lower a p-value, the more confident one can be that the trend exists. For more discussion, see text.]

| Site number | Number of samples used in trend test | Results of trend test (p value) |
|---|---|---|
| ***Domestic wells*** | | |
| 03 | 14 | NT(0.3) |
| 07 | 14 | NT(0.3) |
| 09 | 14 | NT(0.5) |
| 12 | 18 | NT(0.4) |
| 13a | 18 | DT(0.04) |
| 14 | 18 | UT(<0.01) |
| 15 | 17 | UT(0.05) |
| 16 | 34[1] | NT(0.3) |
| 17 | 18 | UT(0.04) |
| 18 | 18 | UT(0.07) |
| 19 | 18 | NT(0.2) |
| 20 | 18 | NT(0.2) |
| 21 | 18 | DT(<0.01) |
| 22 | 18 | UT(<0.01) |
| 23 | 18 | NT(0.1) |
| 29 | 18 | UT(<0.01) |
| 31 | 14 | DT(<0.01) |
| 33 | 14 | DT(0.03) |
| 34 | 18 | NT(0.3) |
| 35 | 18 | NT(0.2) |
| 36 | 18 | NT(0.2) |
| 55 | 18 | UT(0.02) |
| 65 | 18 | NT(0.2) |
| 77 | 13 | DT(0.02) |
| ***Monitoring wells*** | | |
| 01 | 16 | UT(<0.01) |
| 02 | 18 | UT(<0.01) |
| 04 | 16 | NT(0.2) |
| 05 | 18 | UT(0.07) |
| 08 | 18 | UT(0.04) |
| 10 | 17 | NT(0.6) |
| 13 | 18 | NT(0.8) |
| ***Monitoring wells--Continued.*** | | |
| 20a | 17 | NT(0.2) |
| 24 | 18 | NT(0.8) |
| 26 | 18 | UT(<0.01) |
| 27 | 18 | NT(0.6) |
| 30 | 17 | NT(0.6) |
| 32 | 17 | DT(<0.01) |
| 37 | 14 | NT(0.2) |
| 39 | 18 | UT(<0.01) |
| 40 | 18 | NT(0.3) |
| 41 | 14 | UT(0.07) |
| 42 | 18 | UT(<0.01) |
| 43 | 18 | NT(0.7) |
| 44 | 14 | UT(0.07) |
| 47 | 18 | UT(<0.01) |
| 49 | 18 | NT(0.2) |
| 50 | 13 | NT(1) |
| 51 | 18 | UT(0.07) |
| 53 | 18 | DT(0.02) |
| 54 | 18 | NT(0.7) |
| 56 | 18 | UT(<0.01) |
| 61 | 18 | UT(0.02) |
| 62 | 18 | NT(0.7) |
| 64 | 18 | UT(0.05) |
| 66 | 17 | UT(<0.01) |
| 67 | 16 | NT(0.2) |
| 68 | 17 | NT(0.4) |
| 69 | 17 | NT(0.3) |
| 70 | 17 | NT(0.4) |
| 71 | 17 | DT(0.05) |
| 72 | 13 | NT(0.4) |
| 73 | 13 | NT(0.2) |
| ***River sites*** | | |
| 38 | 18 | NT(0.2) |
| 60 | 18 | UT(0.04) |

[1]Trend analysis was performed on monthly values, from April 1994 to March 1997.

increasing and 8 sites had nitrate concentrations that were decreasing (indicated by color-codes in figure 1 and tables 2 and 3). The confidence level indicates the probability that the trend indicated is an actual trend in the data, rather than an artifact of the random nature of environmental data. A p-value (tables 2 and 3) can be used to calculate the confidence level of a particular test. To calculate the confidence level, subtract the p-value from 1, and then multiply by 100. A p-value of 0.04 (well 13a) corresponds to a confidence level of 96 percent. The lower the p-value, the more confidence there is in the existence trend. A longer period of record is preferable to determine a long-term trend. The trends in nitrate concentrations indicated in this study, may or may not be confirmed if the trend analyses were performed on nitrate data sets covering a longer time period. Results of the trend analyses, including the p-values are shown in tables 2 and 3. Wells that had a statistically significant trend (a confidence level greater than 90 percent) are shown in color.

## NITROGEN ISOTOPE DATA

Most elements occur naturally as mixtures of two or more isotopes. All isotopes of an element exhibit the same chemical properties; however, different chemical, physical, or biological processes can influence how much of each isotope (referred to as the isotopic ratio) is present in a particular sample (Hem, 1985). The relative abundance of the nitrogen isotopes can be expressed as a deviation from a standard using a quantity symbolized by $\delta^{15}N_{NO_3}$. The $\delta^{15}N_{NO_3}$ can be used in many circumstances to determine the source of nitrate in ground water (Nimick and Thamke, 1998). Animal and human wastes generally have the highest $\delta^{15}N_{NO_3}$ (expressed in per mil values), from about +9 to about +22 (Nimick and Thamke, 1998). Nitrogen that comes from organic soil nitrogen has a lower $\delta^{15}N_{NO_3}$ value, about +4 to about +9. The lowest $\delta^{15}N_{NO_3}$

**Table 4.** *Nitrogen isotope values for selected wells in the Torrington area.*

| Site number | Date | $\delta^{15}N_{NO_3}$ (per mil) |
|---|---|---|
| 32 | 2-27-95 | +3.3 |
| 41 | 2-27-95 | +2.6 |
| 53 | 2-27-95 | +3.6 |
| 72 | 2-27-95 | +2.4 |
| 73 | 2-27-95 | +3.8 |
| 70 | 2-27-95 | +3.1 |
| 29 | 7-16-96 | +4.4 |
| C | 7-16-96 | +3.7 |
| 31 | 7-16-96 | +2.4 |
| B | 7-16-96 | +2.3 |
| A | 7-16-96 | +2.9 |
| 26 | 7-16-96 | +5.0 |

comes from nitrogen whose source is ammonium (about -4 to about +2) or nitrate fertilizers (about 0 to about +6) (Nimick and Thamke, 1998), such as those used on croplands or lawns.

In an effort to determine the source of nitrate in the ground water in and around Torrington, samples were collected at 12 sites during two separate sampling events and analyzed for $\delta^{15}N_{NO_3}$ (table 4). Five of the monitoring wells sampled in February 1995 were downgradient of areas having numerous septic tank disposal systems (Town of Torrington, 1997). Monitoring well 70, also sampled in February 1995, was located downgradient from an irrigated farm. The six samples collected in July 1996 were from wells located in the terrace along a bedrock ridge north of town. Five samples were from domestic wells, and one was from a monitoring well (Town of Torrington, 1997). All $\delta^{15}N_{NO_3}$ values indicated (table 4) that the source of most of the nitrogen in the ground water in and around Torrington is probably organic soil nitrogen, or ammonium or nitrate fertilizer, not from human or animal waste.

## STATUS OF MONITORING PROGRAM

Because of the problem of high nitrate concentrations in samples collected from municipal wells, the municipal well field for the Town of Torrington is being relocated to an area where the concentrations of nitrate in the ground water are lower than the MCL. Because of this move, the existing monitoring program was terminated, and a water quality monitoring program for the new well field is being evaluated.

## SUMMARY AND CONCLUSIONS

Data collected during a monitoring program from April 1994 through August 1998 indicated nitrate to be widespread in the ground water in and near Torrington, Wyoming. Twenty-two of the 72 sites sampled had an average concentration of nitrate greater than the MCL of 10 mg/L as N during the sampling period. At least one sample from 47 of the 72 sites exceeded the MCL during the period of sampling.

Analyses indicated a statistically significant trend at a confidence level greater than 90 percent at 34 of the 72 sites. Twenty-six sites had increasing concentrations and 8 sites had decreasing concentrations.

Nitrogen isotope data were used to help determine the source of the nitrate in the ground water. The data indicate that the source of most of the nitrate in the ground water in and around Torrington is probably not from human or animal waste, but rather organic soil nitrogen, or ammonium or nitrate fertilizer.

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