Prepared in cooperation with the Washoe County Department of Water Resources

Quantification of the Contribution of Nitrogen from Septic Tanks to Ground Water in Spanish Springs Valley, Nevada

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Abstract

Analysis of total dissolved nitrogen concentrations from soil water samples collected within the soil zone under septic tank leach fields in Spanish Springs Valley, Nevada, shows a median concentration of approximately 44 milligrams per liter (mg/L) from more than 300 measurements taken from four septic tank systems. Using two simple mass balance calculations, the concentration of total dissolved nitrogen potentially reaching the ground-water table ranges from 25 to 29 mg/L. This indicates that approximately 29 to 32 metric tons of nitrogen enters the aquifer every year from natural recharge and from the 2,070 houses that use septic tanks in the densely populated portion of Spanish Springs Valley. Natural recharge contributes only 0.25 metric tons because the total dissolved nitrogen concentration of natural recharge was estimated to be low (0.8 mg/L). Although there are many uncertainties in this estimate, the sensitivity of these uncertainties to the calculated load is relatively small, indicating that these values likely are accurate to within an order of magnitude. The nitrogen load calculation will be used as an input function for a ground-water flow and transport model that will be used to test management options for controlling nitrogen contamination in the basin.

Introduction

The municipal water-supply wells in Spanish Springs Valley, Nevada (fig. 1), have shown increasing nitrate concentrations during the last 15 years. Seiler (1999) and Seiler and others (1999) concluded that nitrate increases resulted from an increased use of septic tank systems in the valley during this time. More than 2,000 septic tank systems were installed from the early 1970s to 1995. In 1995, the Nevada Division of Environmental Protection (NDEP) issued a ruling requiring Washoe County to ensure that all new housing development be connected to the municipal sewer system because of increasing nitrate concentrations in this sole-source aquifer. In April 2000, NDEP issued a directive to have all existing housing connected to the sewer system. Although the cause of increasing nitrate concentrations is relatively well known (Seiler, 2005), estimates of the amount of nitrate entering the aquifer and a nitrogen budget for the basin have not been developed. This study uses current data from soil water samples collected beneath septic tank leach fields to estimate the amount of nitrogen derived from septic tanks in the valley. This estimate will be used to develop a nitrogen budget for the basin, which then can be used by

Sample of soil water collected from Spanish Springs Valley lysimeter. Photograph by Michael R. Rosen.

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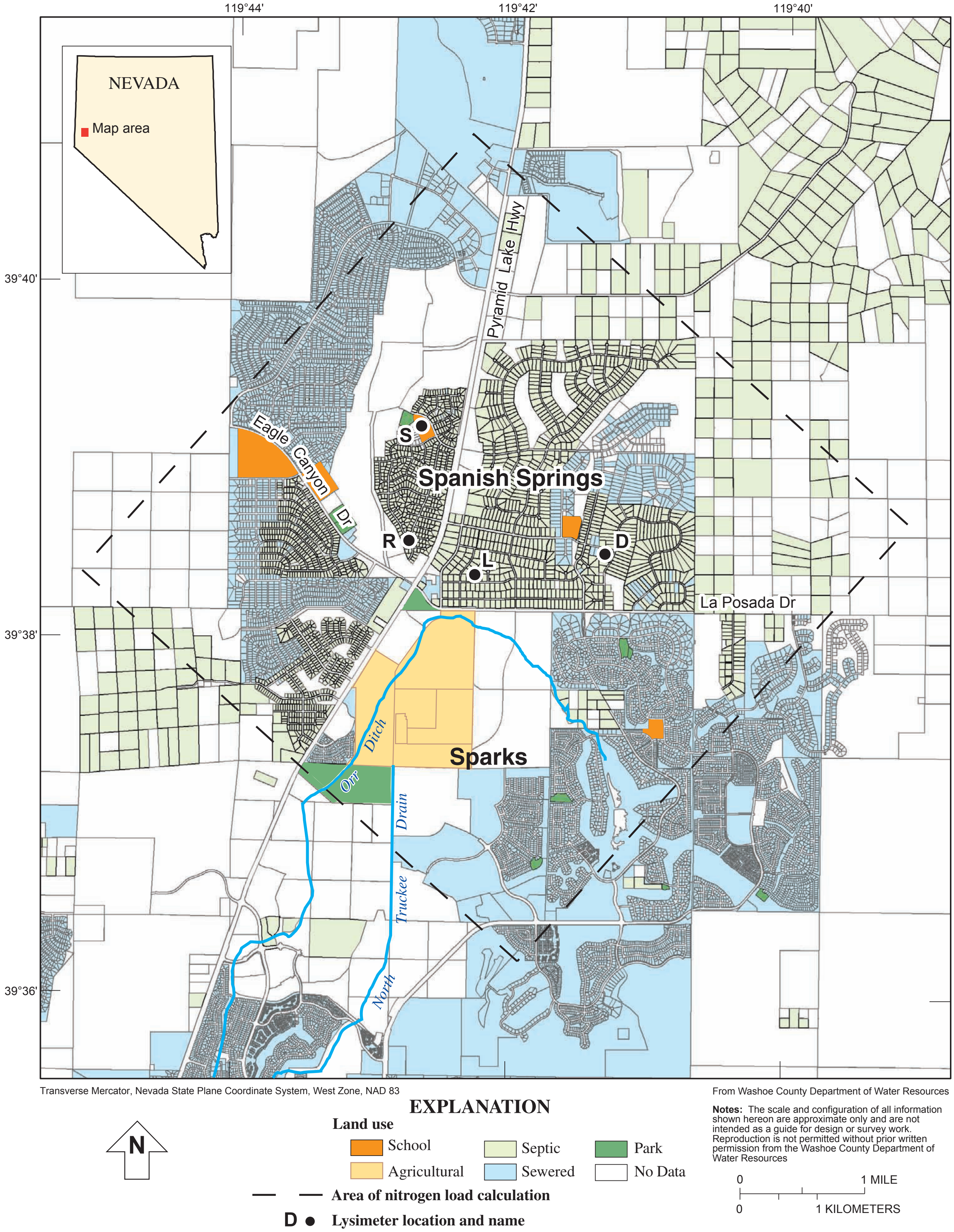

Transverse Mercator, Nevada State Plane Coordinate System, West Zone, NAD 83

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Figure 1. Location map of the Spanish Springs Valley study area. The dashed box, which is an area of approximately 34 km^2, used in the calculation of nitrogen loads. The letters R, L, S, and D are locations of the septic tank systems sampled.

Spanish Springs Valley looking west. Photograph by Michael R. Rosen.

managers to evaluate the effect of connecting all houses to the sewer system and the nitrate concentrations in the basin over time. Determining the amount of nitrogen originating from septic tanks will help Washoe County manage the existing water-quality problems with respect to nitrogen, plan the development of sewer systems that would maximize reductions of nitrate to the ground water, and provide information for different management scenarios that may include reuse of wastewater in the basin.

Description of the study area

The study area encompasses the most densely populated area of Spanish Springs Valley, Nevada (fig. 1), a rural and suburban area north of Reno and Sparks, where septic tank systems have been used extensively since the 1970s. According to Washoe County parcel information, 2,070 septic tank systems currently are in the area within the dashed box in figure 1 [approximately 34 square kilometers (km^2)], and approximately 2,300 septic tank systems are in the entire basin. The valley is predominantly residential, with houses principally located on the valley floor and alluvial aprons in the central part of the valley. Alfalfa is grown in the southern part of Spanish Springs Valley in the area south of Orr Ditch. Sources of recharge in the study area are infiltration of precipitation, lawn percolation, septic tank system effluent, and infiltration of imported water used for irrigation (Berger and others, 1997). Annual precipitation on the valley floor generally is less than 20–25 centimeters (cm). Irrigation water is imported from the Truckee River to the Orr Ditch and into Spanish Springs Valley and is estimated to provide 54 percent of the annual recharge in the valley (Berger and others, 1997), and recharge from septic tank system effluent is estimated to provide about 17 percent of the annual recharge. Ground water discharges into the North Truckee Drain where it flows out to the south end of the valley. Ground water also discharges through evapotranspiration and subsurface outflow to the southern and possibly the northern parts of the valley (Berger and others, 1997). The basin-fill aquifer in the valley is primarily unconsolidated, interbedded deposits of gravel, sand, silt, and discontinuous lacustrine clay. These deposits are highly permeable and commonly transmit water rapidly (Berger and others, 1997).

Why was this study needed?

The recognition that high concentrations of nitrogen (more than 10 mg/L), specifically nitrate (NO_3^-), in drinking-water supplies could cause health problems was identified more than 50 years ago by Comly (1945). Methemoglobin, a form of hemoglobin that has been oxidized so that it is unable to carry oxygen, causes the disease called Methemoglobinemia. A bluish discoloration of the skin occurs when there are high amounts of methemoglobin in the blood. This condition, also known as blue baby syndrome, can be fatal. Infants under the age of 6 months are more susceptible to this disease because they lack the appropriate enzyme that reduces methemoglobin back to hemoglobin (Avery, 1999). Comly's research became widely accepted when subsequent research indicated a consistent pattern of high-nitrate drinking water in infantile methemoglobinemia cases. In 1975, the U.S. Environmental Protection Agency (USEPA) established a maximum contaminant level for nitrate in drinking water of 10 mg/L as nitrogen.

High nitrate concentrations also have been linked to hypertension (Malberg and others, 1978), central nervous system birth defects (Dorsch and others, 1984), certain cancers (Hill and others, 1973), non-Hodgkin's lymphoma (Ward and others, 1996; Weisenburger, 1991), and diabetes (Parslow and others, 1997). However, definitive relationships are lacking and more research is needed to confirm the links (Spalding and Exner, 1993). Avery (1999) suggested that the correlation between high nitrate concentrations and reported cases of methemoglobinemia may not be related to nitrate specifically, but to associated bacterial contamination that occurs with high nitrate concentrations in rural areas (for example, septic tanks and farm animal waste).

Nitrate concentrations approaching the USEPA maximum contaminant level in drinking water have been documented in water-supply wells in Spanish Springs during the past five years (Seiler, 2005). In addition, the water quality of other alluvial basins in Nevada also is being affected by increasing nitrate concentrations caused by septic tank systems (Seiler and others, 1999; Rosen, 2003; Shipley and Rosen, 2005). In order to address whether increasing trends in nitrate concentrations will continue, and how successful various management options may be in addressing nitrate issues in the basin, an accurate estimate of the amount (load) of nitrogen entering the ground water from septic tank systems is needed. The objectives of this study are to (1) determine the amount of nitrogen discharged from individual septic tanks by measuring the concentrations of the following nitrogen species: nitrate, nitrite, ammonia, and total dissolved nitrogen, that pass through the soil zone around septic tanks in Spanish Springs Valley; (2) determine if nitrate is lost in the soil zone by either chemical or biological reactions in the soil or both; and (3) estimate the total amount of nitrogen from Spanish Springs Valley septic tank systems that may enter the ground-water system.

Drilling to place lysimeters at Site D, Spanish Springs Valley. Photograph by Don Schaefer, USGS.

What Was Measured?

To estimate the amount of nitrogen originating from septic tank systems in Spanish Springs Valley, suction-cup lysimeters (Peters and Healy, 1988) were installed at four different septic tank locations labeled **R**, **L**, **S**, and **D** in figure 1. Suction cup lysimeters are porous ceramic cups that are placed in the soil at various depths using an augering device. The cup is sealed but has two plastic tubes at the top that reach the surface. The hole above the ceramic cup was sealed with bentonite and backfilled with native soil. Soil moisture from around the cup is drawn into the porous cup by applying

Placing a suction-cup lysimeter, sealing the hole with bentonite, and final hole showing sampling line after being backfilled with native soil. Left and center photographs by Christian Kropf; right photograph by Michael R. Rosen.

a vacuum on one tube using a handheld pump while the other tube is held closed. The vacuum is released the following day and the soil water sample is withdrawn from the ceramic cup by reversing the pressure on the vacuum tube and forcing the water up the opposite tube (sampling line) to the surface.

The four septic tank systems sampled for this study have been in use for various lengths of time and have different effluent volumes (because of the difference in the size of the systems). Three of the sites (**R**, **L**, and **D**) are septic tank systems for single family housing, and one site (**S**) is a septic tank system for a year-round elementary school. All of the leach fields have different configurations (fig. 2). The **R** site has a pipe that runs out of the septic tank to a "T" where the leach line is connected. At the **L** site, the leach line is laid out in two branches from the "T" pipe. At the **D** site, the leach line is connected straight from the septic tank, and at the **S** site, there are three branches to the leach line. The gravel packs around the leach lines are generally between 2–3 meters (m) deep because of low permeability soils on the valley floor. At each location, five paired lysimeters were installed, one at a shallow depth within the leach field gravel pack (less than one meter), and one below the gravel pack of the leach field (greater than two meters). All five pairs were installed below the leach line and within the leach field area of each septic tank. Two locations at site **R** did not have shallow lysimeters installed. A total of 38 lysimeters were installed within all the leach fields. One pair of deep and shallow lysimeters was installed outside of the septic leach field at each site as a reference site (**L1** in fig. 2). A total of 10 reference lysimeters were installed for this study. The nitrogen concentrations from the reference sites are not included in the calculations of the nitrogen load from septic tanks to the ground water. Nitrogen species and chloride concentrations were monitored monthly at each lysimeter from August 2004 to December 2005. Samples were not collected in January and February 2005 because heavy snow buried the lysimeters. A total of 424 samples were collected for this study: 331 samples (including 16 replicates) from the leach field lysimeters and 93 samples (including 5 replicates) from the reference lysimeters.

On the first day of sampling, a vacuum to 4.1 bar was created at each suction-cup lysimeter. However, some lysimeters did not hold a vacuum. On the second day, water was recovered from each lysimeter only if enough water had entered the lysimeter. The vacuum was never left on the lysimeters for more than 24 hours in order to minimize disturbance to the soil surrounding the lysimeter, which might create preferred pathways for contaminants (Peters and Healy, 1988). Water was not recovered from every lysimeter; water was recovered only periodically due to seasonal influences at some lysimeters. Water retrieved from the lysimeters was analyzed for total dissolved nitrogen, nitrate plus nitrite, nitrite, ammonia, and chloride. Organic nitrogen was determined as the difference between total dissolved nitrogen and the other nitrogen species measured. Due to limited quantities of water from some sites, analysis for nitrogen species was given the highest priority. If enough of the sample was available, chloride would be analyzed. For quality assurance, replicate samples were collected for five percent of the samples collected. Replicate concentrations of total dissolved nitrogen were all within 10 percent of the original sample and more than 50 percent were within five percent. Samples were filtered through a 0.45-micron filter to obtain only the dissolved fraction (although this fraction may include colloids or other fine particulates) and were collected and analyzed using standard U.S. Geological Survey (USGS) methods (U.S. Geological Survey, variously dated; Fishman, 1993; Patton and Kryskalla, 2003). All samples were analyzed at the USGS National Water Quality Laboratory in Lakewood, CO. All the data collected for this study are available from the National Water Information System web site (NWISweb; *http://waterdata.usgs.gov/nv/nwis/nwis*). Some lysimeters were dominated by high concentrations of ammonia, which is stable in low oxygen concentrations and some were dominated by nitrate, which is more stable in oxygenated conditions. Because of these different conditions, all diagrams in this report and all calculations of nitrogen loads were made on the total dissolved nitrogen concentrations, so that all lysimeters could be accounted for in the same way.

Retrieving soil water sample from suction-cup lysimeter. Photograph by Anna Makowski, University of Nevada, Reno.

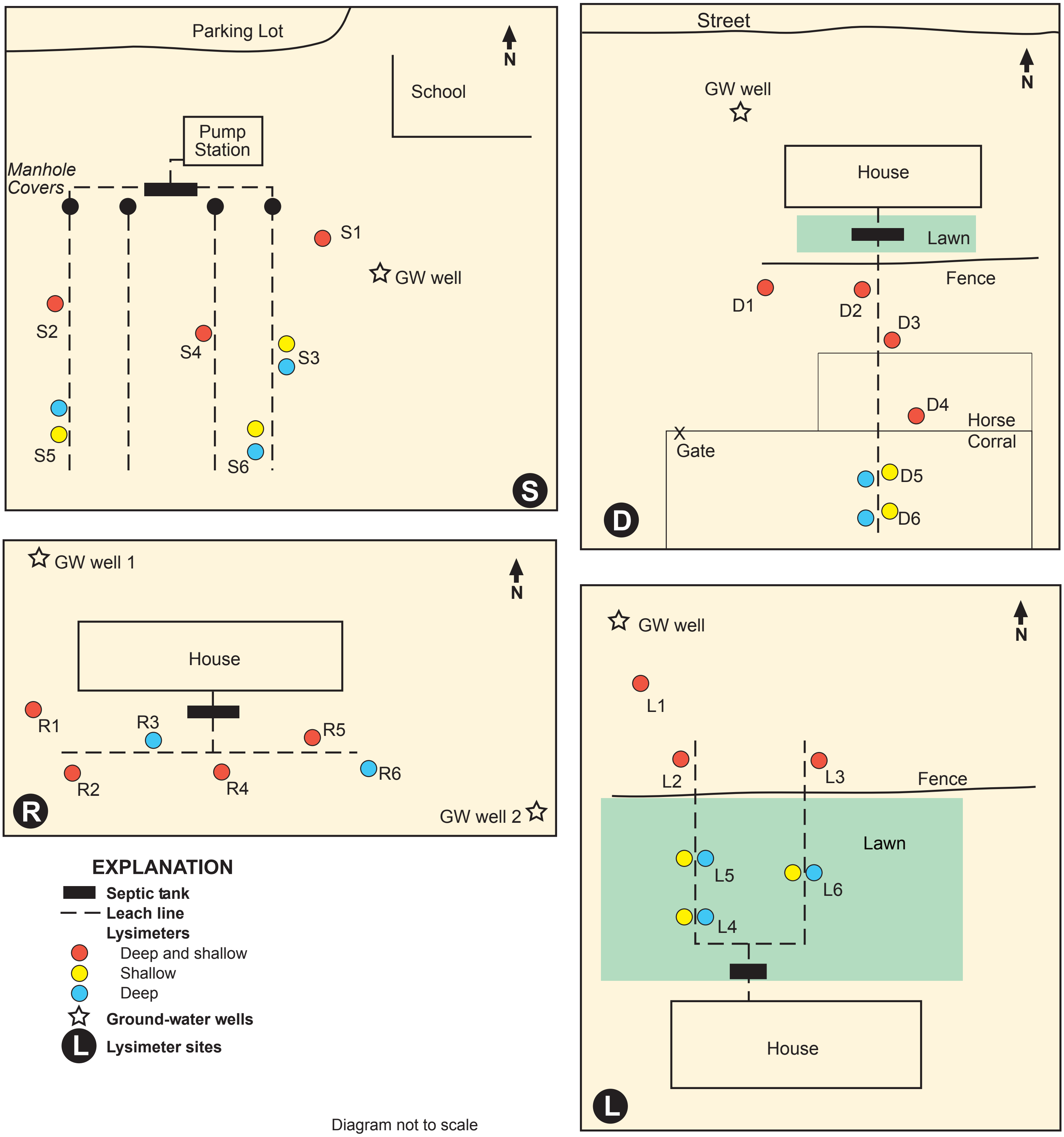

Figure 2. Location of lysimeters installed in the leach fields of the four locations used in this study. Except where lawn is indicated, the ground cover over the lysimeters is bare soil. See figure 1 for location of each system within Spanish Springs Valley.

The amount of dissolved nitrogen entering the ground-water system from these septic tanks was estimated using the data collected for this study. This value was used as a source term for septic tanks and extrapolated to estimate the total dissolved nitrogen, which is representative of nitrate loads from septic tanks for the area within the dashed box in figure 1.

How Were Nitrogen Loads Calculated?

Nitrogen loads were calculated using two different mass balance calculation methods developed by Bauman and Schafer (1985) and Hantzsche and Finnemore (1992). The difference between these two methods is that the Bauman and Schafer (1985) method includes input of ground-water flow and nitrogen concentrations upgradient from the areas of interest. It also includes mixing with water in the aquifer. The Hantzsche and Finnemore (1992) calculation only includes rainfall recharge as a water source directly on the area of interest. Therefore, the Bauman and Schafer (1985) nitrogen concentration calculations are lower (because of mixing with lower concentrations from lower in the aquifer and upgradient sources) than those calculated using the equation formulated by Hantzsche and Finnemore (1992). However, the change in mass of nitrogen added is small (less than 0.2 metric tons; 1 metric ton is equivalent to 1.1 U.S. tons) because the concentration of nitrogen in the water coming in from the aquifer (background nitrogen) is low.

The equation formulated by Hantzsche and Finnemore (1992) to determine the average concentration, n_r, of total dissolved nitrogen in recharge water to the aquifer is:

$$n_r = \frac{I * n_w(1-d) + R * n_b}{(I+R)} \tag{1}$$

where

I is the volume rate of wastewater entering the soil averaged over the gross developed area;

n_w is the total dissolved nitrogen concentration of the septic tank water;

d is the fraction of nitrogen lost due to denitrification or ammonia volatilization;

R is the average recharge rate of rainfall in the area;

n_b is the background nitrogen concentration of rainfall recharge at the water table, exclusive of septic tank influences.

Values used for these parameters are listed in table 1. Most of the values for these parameters were taken from Berger and others (1997), Washoe County land parcel information, and unpublished soil core analyses. The total dissolved nitrogen concentrations for the septic tank systems (n_w) were derived from this study. In equation 1, n_w is the concentration of total dissolved nitrogen in the septic tank itself. In this study, the values for n_w are taken from the deepest lysimeters (below two meters depth). Because these concentrations represent nitrogen that has passed through the soil zone, it is assumed that any loss of nitrogen either through denitrification (nitrogen lost to the atmosphere as a gas by bacterial reduction of the nitrate in solution) or volatilization of ammonia (Heaton, 1986) has already occurred. Therefore, $d = 0$ for the calculations done for this study.

The Bauman and Schafer (1985) model treats the contribution of nitrogen from the septic tank systems in the same way as equation 1. However, Bauman and Schafer (1985) also consider ground-water flow from outside of the area (using Darcy's Law for ground-water flow) affected by septic tank effluent and also mixing of effluent with background aquifer water to a specified depth.

Table 1. Variables and values used for the Hantzsche and Finnemore (1992) model used to calculate loads.

[Abbreviations: mg/L, milligrams per liter; mm/yr, millimeters per year]

Variable	Units	Description	Value used in calculations
n_r	mg/L	Resultant average concentration of nitrate-nitrogen in recharge water.	Result of calculation
I	mm/yr	Volume rate of wastewater entering the soil averaged over the gross development area	19
n_w	mg/L	Total dissolved nitrogen concentration of effluent from Spanish Springs Valley	44-50
d	percentage	Fraction of nitrate-nitrogen loss due to nitrogen losses in the soil	0[1]
R	mm/yr	Average recharge rate of rainfall	10
n_b	mg/L	Background nitrate-nitrogen concentration of rainfall recharge at the water table, exclusive of wastewater influences	0.8

[1] Nitrogen loss is assumed to be zero because the value for n_w is derived from measurements from below the root zone

In the Spanish Springs calculations it was determined that mixing occurred to at least 18.3 m based on nitrogen concentrations in ground-water samples. These other two background inputs tend to decrease the expected nitrogen concentrations to the aquifer because the natural concentration of nitrogen in the Spanish Springs aquifer was low (less than 2 mg/L). The system is assumed to be in a steady-state condition and although water and nitrogen leave the system through downgradient flow, the equations assume that no water or nitrogen is lost by pumping or consumptive use within the area of interest.

Calculations were made using both the Hantzsche and Finnemore (1992) and Bauman and Schafer (1985) models so that a range of estimated loads could be obtained. The median total dissolved nitrogen value rather than the average was used in the calculations because total dissolved nitrogen concentrations are highly variable and the use of an average value may be more influenced by outlier values than the median.

Drilling to place lysimeters at Site D, Spanish Springs Valley. Photograph by Don Schaefer, USGS.

How Did Nitrogen Concentrations Vary?

Total dissolved nitrogen concentrations ranged from less than 3 mg/L to greater than 800 mg/L at individual lysimeter sampling sites depending on the time of year and location. Table 2 lists the average and median concentrations of total dissolved nitrogen measured for each site, for all the deep and shallow lysimeters separately, and for all sites together. Most of the highest concentrations were from the shallow lysimeters, although concentrations greater than 300 mg/L also were recorded in some deep lysimeters. One lysimeter pair at site **D** that was located within a horse corral and had no lawn showed some total dissolved nitrogen concentrations greater than 800 mg/L, with a median value of 408 mg/L, but the deep lysimeter showed a median concentration of only 50 mg/L. The shallow lysimeter may be influenced by contributions of horses in the corral, whereas the deep lysimeter may better reflect the septic tank system input. Even without the influence of horses, total dissolved nitrogen concentrations varied by more than 100 mg/L at some shallow sites, although the deep sites were less variable (figures 3A-D).

Table 2. Average, range, and median total dissolved nitrogen concentrations (TN), one standard deviation (SD) of the average values, and sample counts for each sample site.

Site	Sample count	Average TN	SD	Median TN	Range
D shallow	28	296	232	213	18 - 837
D deep	72	43	50	30	2.8 - 311
R shallow	33	99	55	80	7.8 - 212
R deep	56	53	42	48	2.7 - 177
S shallow	24	94	99	57	1.8 - 344
S deep	22	70	64	58	4.2 - 255
L shallow	50	43	24	45	10 - 167
L deep	46	83	92	52	29 - 395
Shallow – all sites	135	120	150	64	1.8 - 837
Deep – all sites	196	57	61	44	2.7 - 395
All sites together	331	83	111	50	1.8 - 837

The average total dissolved nitrogen concentrations generally are higher than the median concentrations. However, large standard deviations of the data, particularly for the shallow lysimeters, reflect a high degree of month-to-month variability. This is expected due to seasonal and random differences in temperature, rainfall, irrigation on lawns, and changes in the number of people living in individual households. Extreme values tend to bias the data when averages are used, so to account for these extremes, the median values were used in all calculations. The median concentrations of the deep lysimeters are relatively similar between sites, ranging from 30 to 58 mg/L (table 2). No apparent correlation exists with location of the tank septic tank system within the valley, but the largest septic tank system (site **S**, at the year-round school) had the highest median total dissolved nitrogen concentration (greater than site **R** by 10 mg/L; table 2). The higher median total dissolved nitrogen concentration at the school may be because the primary use of septic tank system is the bathrooms. Little dilution of the high nitrogen concentrations occurs at the school from washing clothes and bathing, which would dilute nitrogen concentrations at most households.

At each site individually, monthly variations in total dissolved nitrogen concentrations could be highly variable, but when all the deep lysimeters are plotted together on a monthly basis, the median concentrations generally do not vary more than ±10 mg/L from the overall median

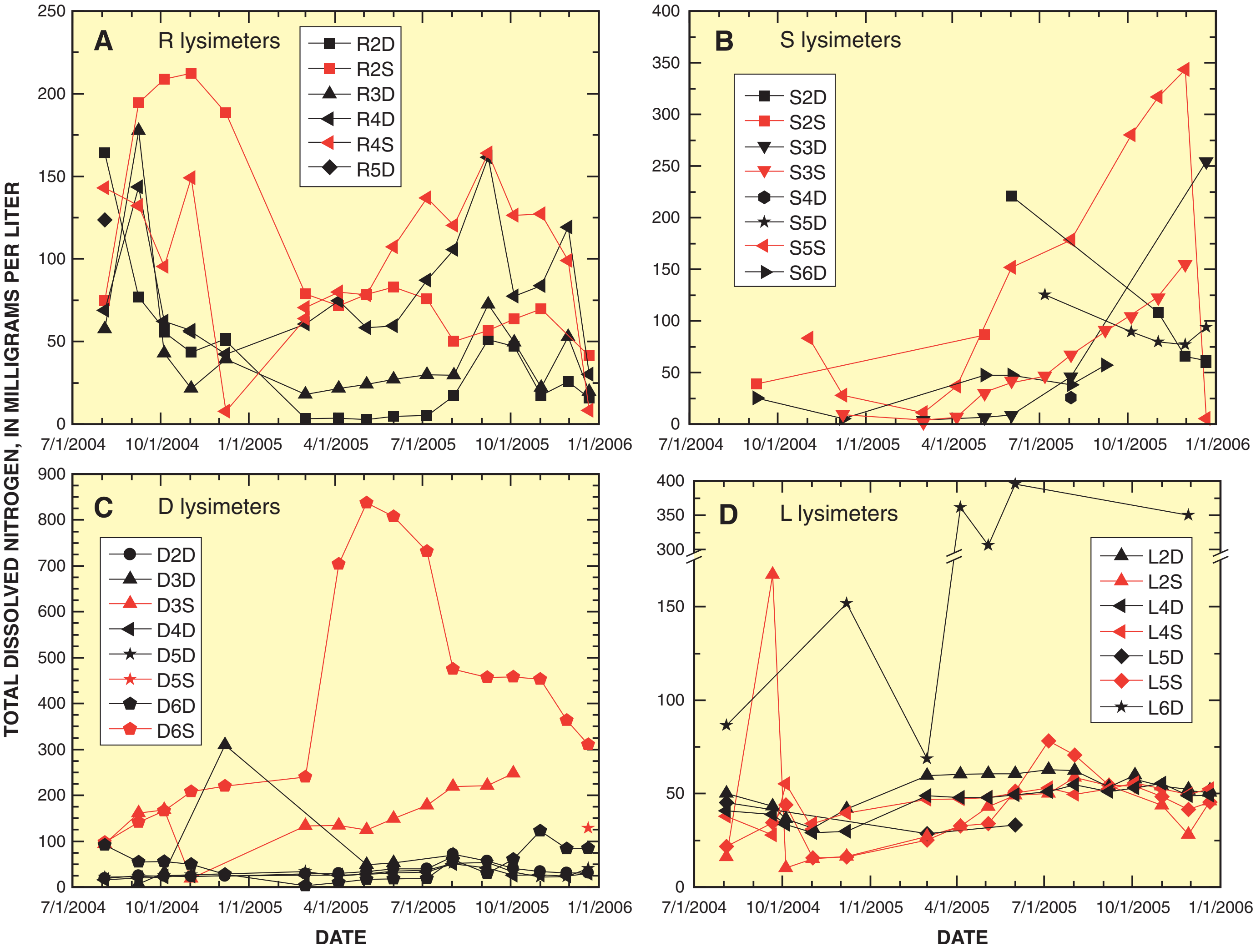

Figure 3. Monthly total dissolved nitrogen measurements from individual lysimeters installed in the four septic tank leach fields (*A*) R site (*B*) S site (*C*) D site (*D*) L site (note axis break on y-axis). Points and lines in red are shallow (S) lysimeters, those in black are deep (D) lysimeters.

concentration of 44 mg/L during the 18 months (fig. 4). This provides some confidence that the median total dissolved nitrogen concentration used in the load calculations is relatively consistent during this study.

Estimates of Nitrogen Loss

Nitrogen loss was estimated by using a literature value for the total dissolved nitrogen concentration from septic tank leachate before it enters the leach field and by comparing this value to the median total dissolved nitrogen value from the deep lysimeters. A value of 62 mg/L has been determined from analysis of more than 20 studies on septic tank systems throughout the country (Bauman and Schafer, 1985), but Hantzsche and Finnemore (1992) used more conservative values of between 40 and 50 mg/L. If the value of 62 mg/L is used, nitrogen loss of about 30 percent appears to be occurring before the leachate leaves the bottom of the gravel below the leach field. If the value of 50 mg/L is used, nitrogen loss is approximately 12 percent. Hantzsche and Finnemore (1992) estimate nitrogen loss to be approximately 25 percent, which is similar to the value obtained using a septic tank concentration of 62 mg/L. Bauman and Schafer (1985), however, assume no nitrogen loss occurs after nitrogen leaves the septic tank. Our calculations indicate that nitrogen loss between 12 and 25 percent is occurring in the Spanish Springs Valley leach fields; this number could be better refined if chemical and isotopic analyses were performed on the septic tank leachate.

How Much Nitrogen Is Contributed By Septic Tanks?

If the median concentration of all the deep lysimeters (44 mg/L in table 2) is used for n_w in equation 1, the concentration of nitrogen in recharge water in the study area is calculated to be 29 mg/L. If the Bauman and Schafer (1985) calculations are used and a mixing depth of 18.3 m is used, the nitrogen concentration is calculated to be 25 mg/L. The difference is caused by mixing with

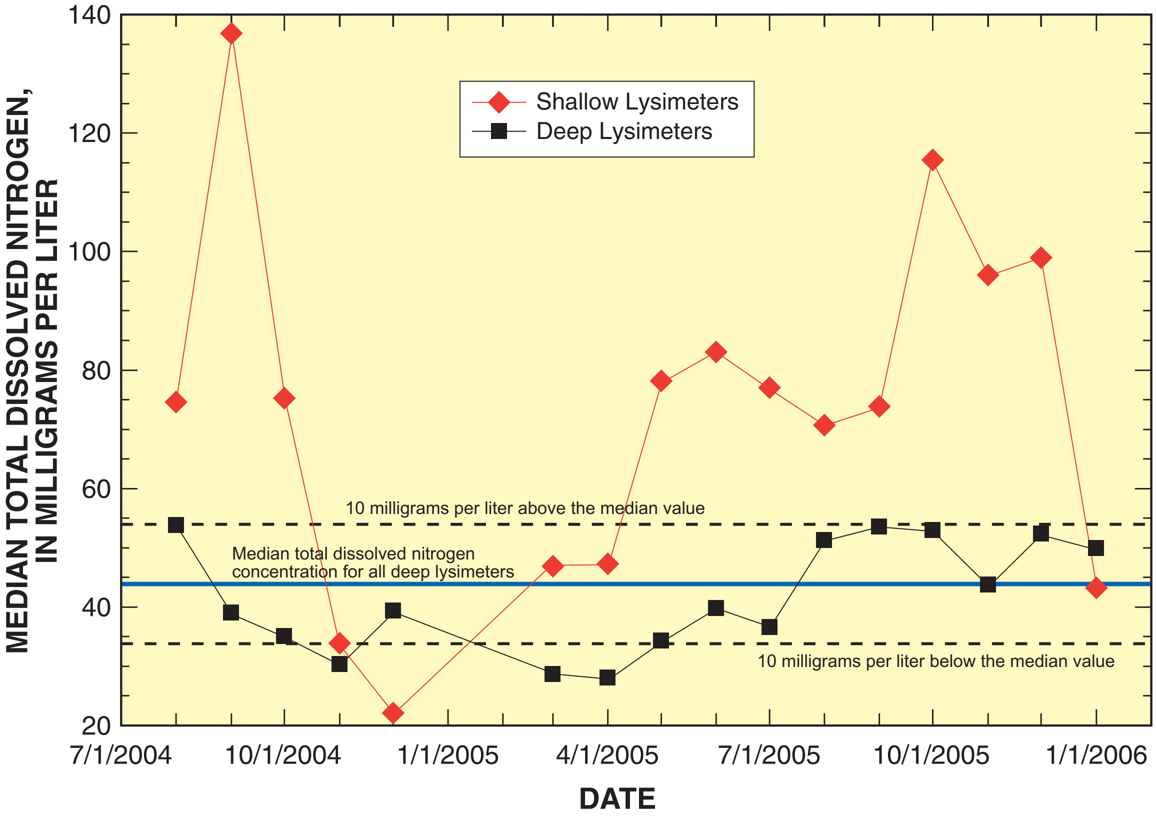

Figure 4. Median total dissolved nitrogen concentrations for all shallow and all deep lysimeters sampled within the leach fields of the septic tank systems. Calculations of nitrogen loads were made from the total dissolved nitrogen concentrations for all deep lysimeters.

upgradient water that contains low nitrogen concentrations (estimated as less than 2 mg/L for this study). The calculated recharge values (25–29 mg/L of total dissolved nitrogen) can be multiplied by the number of septic tanks in the study area (2,070) and the volume of water derived from septic tank systems to determine the load of nitrogen to the basin (both the natural and septic tank recharge load). For the Bauman and Schafer (1985) equation, the volume of water added from upgradient ground water also is included. However, because this water is low in nitrogen, it does not change the mass load by more than 0.2 metric tons. Estimates of the volume of water from septic tank systems in Spanish Springs Valley have been calculated by Washoe County Department of Water Resources by taking the average of household water usage during the winter when there is no irrigation. The value for daily septic tank water volume discharge is 860 liters per day (L/d) per household. The volume of water coming from natural recharge is approximately 460 L/d covering the area where the septic tank systems are operating. Therefore, the total volume of water entering the aquifer is approximately 1,320 L/d. By multiplying this volume by the number of septic tank systems and the concentration of dissolved nitrogen in the recharge, this equates to about 29 metric tons of nitrogen contributed to the aquifer by septic tank systems and natural recharge within the dashed box in figure 1 each year. If the median concentration for all lysimeters is used (50 mg/L in table 2) the amount of nitrogen contributed to the aquifer is approximately 32 metric tons of nitrogen per year. These estimates of total dissolved nitrogen contributions from septic tank systems are based on the median contribution from only four septic tank systems in Spanish Springs Valley. However, the size of the septic tank systems, number of people living in a household, and the location and age of the septic tank systems are typical of the area. Therefore, it is unlikely that these estimates will be grossly inaccurate. Natural recharge contributes only about 0.25 metric tons of nitrogen to the aquifer because the concentration of nitrogen in natural recharge is so small (0.8 mg/L) compared to the septic tank concentrations (44–50 mg/L). This indicates that virtually all of the nitrogen accounted for in the calculations is from septic tank systems in this part of the aquifer. Some contributions from lawn fertilizers and animals also may contribute additional nitrogen to the aquifer, but because the septic tank systems analyzed in this study were mostly in bare soil areas that did not have abundant lawn (except 3 lysimeters at site **L**) or animal impacts (except 3 lysimeters at site **D**). The load calculated here is almost exclusively caused by septic tank system inputs.

Sensitivity analysis of the Hantzsche and Finnemore (1992) equation shows that total dissolved nitrogen recharge from septic tank system inputs is the most important parameter to estimate accurately. Doubling or decreasing by half the infiltration rate of wastewater through the soil (*I*) only changes the nitrogen concentration in recharge water by approximately 6 mg/L (a difference of 4 metric tons of nitrogen). Changing the background nitrate concentration (n_b) will only raise the contribution from septic tank systems if the value is increased significantly (greater than 5 times the concentration used) and a high background total dissolved nitrogen concentration is not possible over the entire aquifer because measurements of deep wells show total dissolved nitrogen concentrations similar to the low background value (less than 2 mg/L) used in this report (Washoe County Department of Water Resources, written commun.). The estimates given here are likely to be accurate to within at least one order of magnitude and probably are better than that, based on the sensitivity analysis. Sensitivity analysis of the Bauman and Schafer (1985) mass balance calculation yields a similar result.

Conclusions

Based on over 300 measurements of total dissolved nitrogen concentrations in soil water below leach fields of 4 septic tank systems in Spanish Springs Valley, two mass balance calculations were made and show that approximately 29 to 32 metric tons of nitrogen are contributed to the shallow ground water from septic tank systems and natural recharge each year. Almost all of the nitrogen is contributed by septic tank systems as the natural recharge accounts for only 0.25 metric tons of nitrogen. The estimates have some error associated with them based on uncertainties in rainfall recharge, septic tank volumes discharged and ground-water flow rates, but even with these uncertainties, the estimates are within one order of magnitude of what is likely. Many of the parameters that are the most uncertain, such as rainfall and volume rate of wastewater entering the ground water, need to double in order to have a significant impact on the mass of nitrogen calculated.

What Future Work Is Needed?

Additional water-quality and ground-water flow data are being collected from monitoring wells and production wells to better understand the distribution and transport of nitrate in the aquifer system. Age dating of the ground water is needed to determine how quickly ground water and contaminants move through the aquifer. The results from this study combined with this additional data is planned to be used as input functions for a contaminant transport and flow model presently being developed by the Desert Research Institute. This model will be used to determine the best management scenarios for controlling and mitigating nitrogen contamination within Spanish Springs Valley.

Obtaining a water sample from the lysimeter at site S. Photograph by Christian Kropf.

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Spanish Springs Valley looking west. Photograph by Christian Kropf.