Trend Analyses for Idaho's Nitrate Priority Areas, 2002-2011

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Executive Summary

In 1998, the Idaho Department of Environmental Quality (IDEQ), in cooperation with the Ground Water Monitoring Technical Committee (GWMTC), delineated 33 Nitrate Priority Areas (NPAs) based on several existing data sources. The NPAs were ranked on the basis of several factors including the presence or absence of nitrate trends. In 2000, the U.S. Geological Survey (USGS) performed nitrate trend analyses on a total of 8,465 nitrate analyses from 2,931 wells with dates ranging from 1961 to 2001. At that time, the number of NPAs was reduced to 25 on the basis of buffering and regrouping. The USGS analyses revealed that long-term increasing trends (over 10-year time periods) occurred at 6 NPAs, long-term decreasing trends occurred at 4 NPAs, short-term increasing trends (over 4-year time periods) occurred at 7 NPAs and short –term decreasing trends occurred at only 1 NPA. These results were based on the 95% confidence level.

By 2008, several NPAs had been eliminated, some new areas had been added, and several boundaries had been modified, resulting in a new total of 32 NPAs. At that time, the Idaho Department of Water Resources (IDWR) was contracted by IDEQ to conduct an updated analysis to the original USGS study, using a new threshold of 85% for the confidence level that was considered indicative of a significant change. This second analysis compared Time Period 1 (1994 to 2000) to Time Period 2 (2001 to July 2007). The IDWR extracted the Maximum nitrate value for each site for the two time periods. The non-parametric Mann Whitney Rank Sum test was used to determine changes in the median values between the two time periods. This test is used when data sets are unequal in the number of records, and therefore termed Non-Paired, even though many (but not all) of the sites were sampled in both time periods. Overall, the results indicated that five NPAs (Ada-Canyon, Marsing, Northeast Star, Twin Falls, and Weiser) had increasing nitrate trends at the greater than 85% confidence level, and one NPA (Homedale) had a decreasing nitrate trend at the greater than 85% confidence level. Northeast Star had an increasing nitrate trend at a greater than 95% confidence level. Nineteen NPAs had increases in median values ranging from 0.1 mg/L to 6.7 mg/L. Three of the 32 NPAs did not have enough data for statistical analyses.

In 2012, the IDEQ contracted with the IDWR to conduct another trend analysis. In the time since the 2008 analysis, the IDEQ added two NPAs, eliminated one NPA, and modified the boundaries of 15 NPAs, resulting in a new total of 34 NPAs. The IDWR selected two time periods for the analysis: Time Period 1 is from 2002 to 2006, and Time Period 2 is from 2007 to 2011.

The IDWR expanded the analyses in three ways in an effort to increase the confidence of the trend tests. First, the IDWR added Paired data analyses to the testing. Paired data are those sites that had at least one result in both time periods. Statistical test results using Paired data are considered to be more powerful that results using Non-Paired data. The Mann Whitney Rank Sum test was used for the Non-Paired data and the Wilcoxon Signed Rank test was used for the Paired data. Second, the IDWR used the Most Recent value, instead of the Maximum value, for each site in each Time Period. Observations on

individual sites revealed that peaks in nitrate values sometimes occurred in the middle of a Time Period as opposed to the end of the Time Period. Thus, the Most Recent values probably better reflect the actual nitrate concentration conditions for the Time Period. Third, the IDWR determined the number of sites with nitrate concentration increases and decreases over 1.0 milligrams per Liter from Time Period 1 to Time Period 2 for each NPA, and calculated the ratios of increases to decreases (in cases when there were more increases) and decreases to increases (in cases when there were more decreases).

Twenty-one of the 34 NPAs had enough sites to perform statistical analyses (i.e., they had at least 10 Paired sites sampled in both time periods). Based on the two statistical tests and the ratio calculations, 10 of the 21 NPAs exhibited enough evidence to conclude that either a Trend (two or more significant test results) or a Tendency (one significant test result) had occurred between the two time periods. Four NPAs had decreasing trends (Lower Payette, Minidoka, Purple Sage, and Twin Falls), three NPAs had increasing trends (Blackfoot, Cassia, and Lindsay Creek), two NPAs had decreasing tendencies (Ashton-Drummond, and Clearwater), and one NPA had an increasing tendency (Mud Lake). Eleven NPAs had no trend or tendency (Ada-Canyon, Bliss, Emmett North Bench, Grace, Homedale, Lapwai Creek, Marsing, Mountain Home, Northeast Star, Preston, and Weiser). Thirteen NPAs had less than 10 Paired sites and thus were not analyzed statistically (Black Cliffs, Bruneau, Fort Hall, Georgetown-Bennington, Glenns Ferry, Grand View, Malad, Mink Creek, Mountain Home Air Force Base, North Pocatello, Notus, Parma, and South Fremont).

Previous Analyses

The Ground Water Monitoring Technical Committee[1] played a substantial role in developing a process and criteria to be used in prioritizing areas of nitrate-degraded ground water. Trend analyses, together with population, water quality, number of public water systems and beneficial use were criteria that the committee felt should be used in the scoring process. In 2002, the U.S. Geological Survey (USGS) completed nitrate trend analyses of ground water for the Idaho Department of Environmental Quality (IDEQ) to use in scoring the nitrate areas. The study was designed to compile and assess nitrate data for 33 Nitrate Priority Areas (NPAs) in Idaho; however, the number of NPAs was reduced to 25 based on a buffering and regrouping procedure.

The USGS examined 8,465 individual nitrate samples from 2,931 wells. The dates of the nitrate analyses used in the assessment ranged 1961 to 2002. The USGS used time-period and time-series comparisons in the trend analysis. Specifically, summary statistics, boxplots, and the Mann-Whitney Rank Sum test were statistical tools used in the nitrate analysis. The USGS conducted "long-term" and "short-term" analyses for nitrate trends. Long-term trend assessments were accomplished by grouping the data into the following decades: 1970s, 1980s, and 1990s. Short term evaluations were done by grouping the data from 1990 to 2000 into three time categories based on the sampling intervals for the Statewide Ground Water Quality Monitoring Program; 1991 – 1994, 1995-1998, and 1999-2000. The analyses indicated that there were six increasing long-term trends and seven increasing short-term trends, compared to four decreasing long-term trends and one decreasing short-term trend. There were no long-term trends for seven NPAs, and no short-term trends for 15 NPAs.

In the second trend analyses, which was performed by the IDWR in 2008, the nitrate data from 1994 to July 2007 were analyzed for increasing and decreasing trends. Two time periods of nearly equal length were selected for the analyses. Time 1 encompassed the nitrate data collected from 1994 through 2000 (7 full years), and Time 2 included the nitrate data collected from 2001 through July of 2007 (6.5 years). In July, 2008, the GWMTC decided to use a confidence level of 85% as the cutoff between No Trend and Significant Trend. The results from this study showed that six NPAs had nitrate trends at a greater than 85% confidence level. Five NPAs (Ada/Canyon, Marsing, NE Star, Twin Falls and Weiser) had increasing nitrate trends; one NPA (Homedale) has a decreasing nitrate trend. Only NE Star had an increasing nitrate trend at a greater than 95% confidence level. Nineteen NPAs had increases in median values ranging from 0.1 mg/L to 6.7 mg/L, nine NPAs had decreases in median values ranging from 0.1 mg/L to 13.0 mg/L, and one area showed no change in median values.

[1] The committee consisted of members from IDEQ, IDWR, ISDA, Idaho Health and Welfare, Idaho Health Districts, Soil Conservation Districts, USGS and Idaho Universities.

Data Sources and Compilation

The IDEQ provided a database to IDWR that contained 41,708 records with nitrate sample dates ranging from 1976 to 2011. The data sources for the records are the IDEQ, the Idaho State Department of Agriculture (ISDA), the Idaho Department of Water Resources (IDWR), and the U.S. Geological Survey (USGS).

The database file was converted to a shapefile, which was added to a project in ESRI ArcMap®. IDEQ also provided a shapefile of the 34 Nitrate Priority Areas (Figures 1-6). The data shapefile was clipped with the NPA shapefile in order to extract the records that were contained within the boundary of each NPA. The data were sorted into the two Time Periods. Time Period 1 is from 2002 to 2006. Time Period 2 is from 2007 to 2011. The files for each NPA were filtered in Microsoft Excel® to select the Most Recent value for each site according to the two Time Periods. Basic descriptive statistics (mean, median, etc.) were conducted in Excel®. The data were imported into Systat™ where boxplots were created to view the data distributions, and where non-parametric Mann-Whitney Rank Sum and Wilcoxon Signed Rank tests were run in order to analyze for trends in the median values. Finally, the data were imported into Minitab™ which was used to create the final graphic versions of the boxplots.

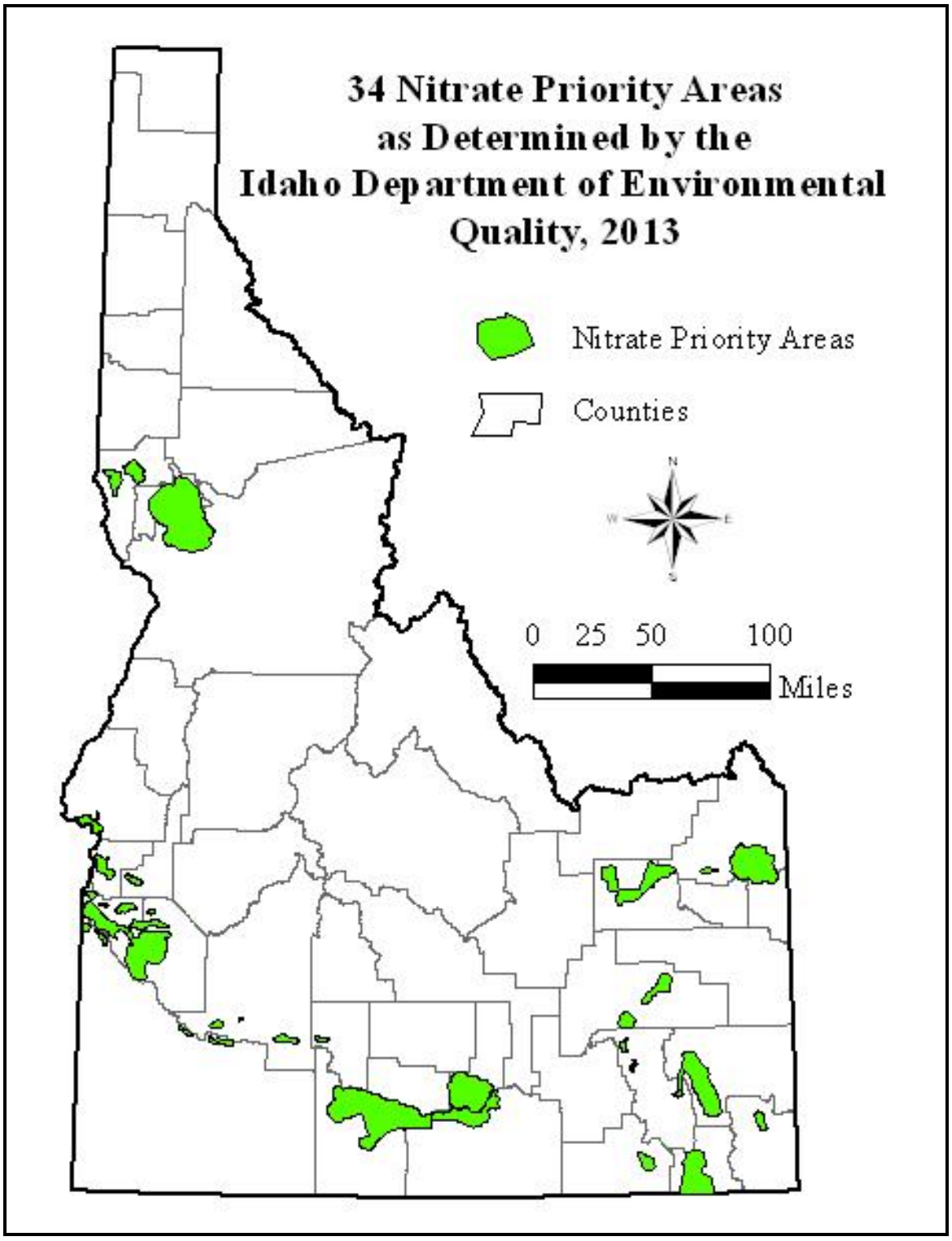

Figure 1. 34 Nitrate Priority Areas as designated by the Idaho Department of Environmental Quality, 2012.

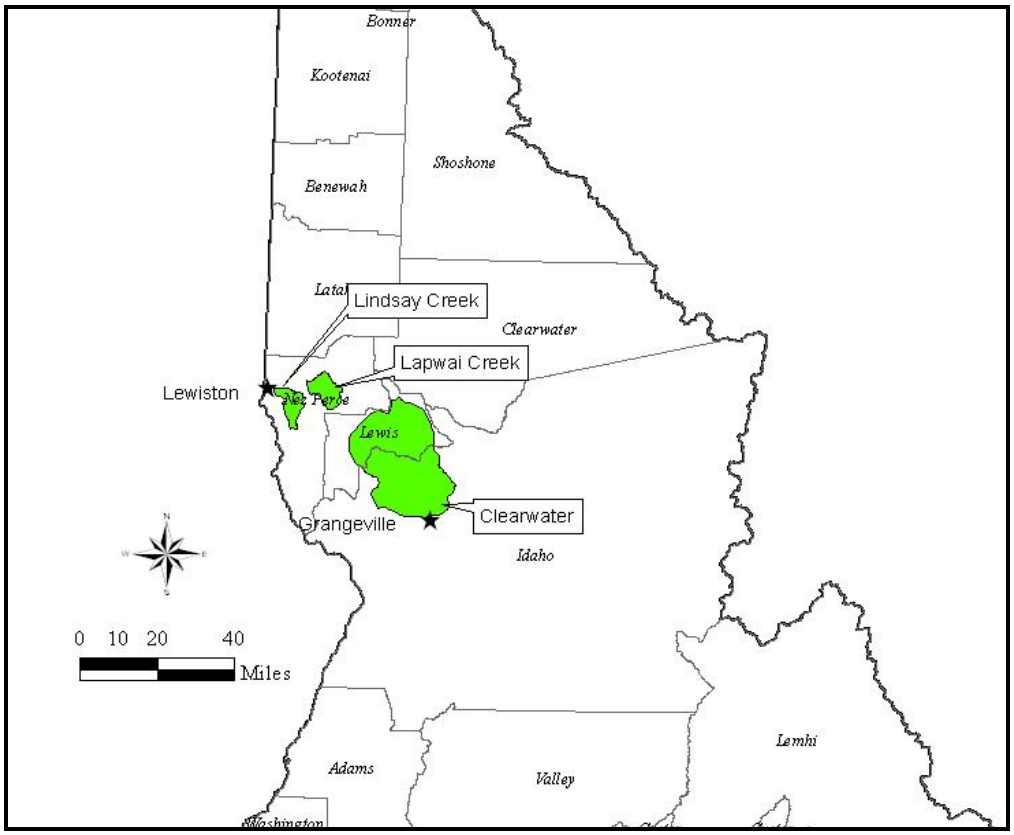

Figure 2. Nitrate Priority Areas in north-central Idaho, 2012.

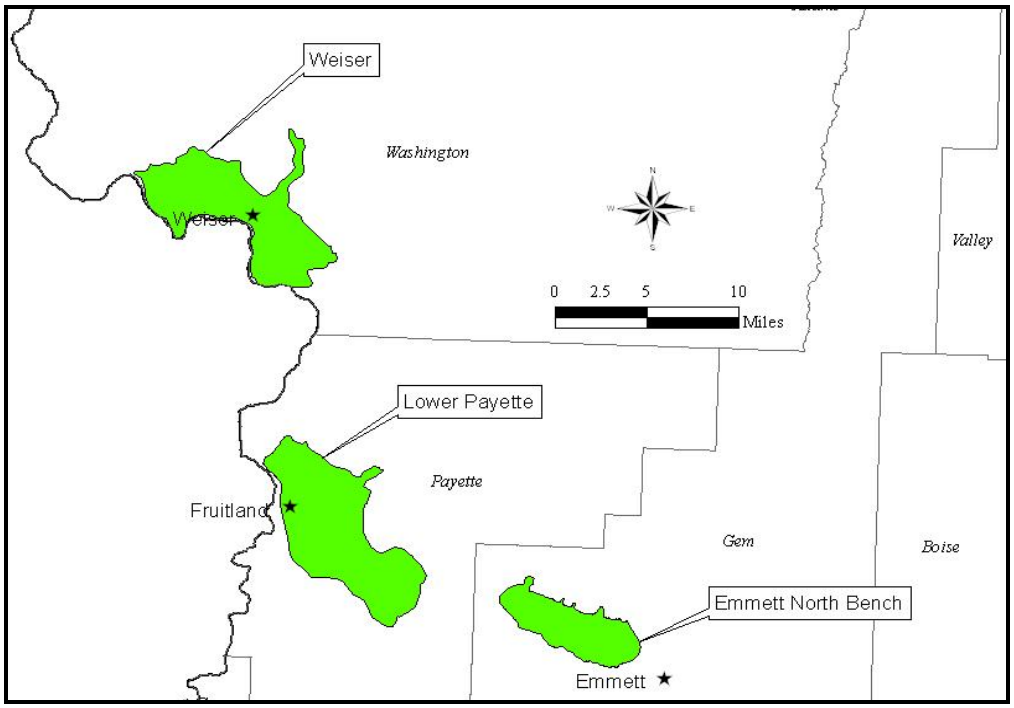

Figure 3. Nitrate Priority Areas in west-central of Idaho, 2012.

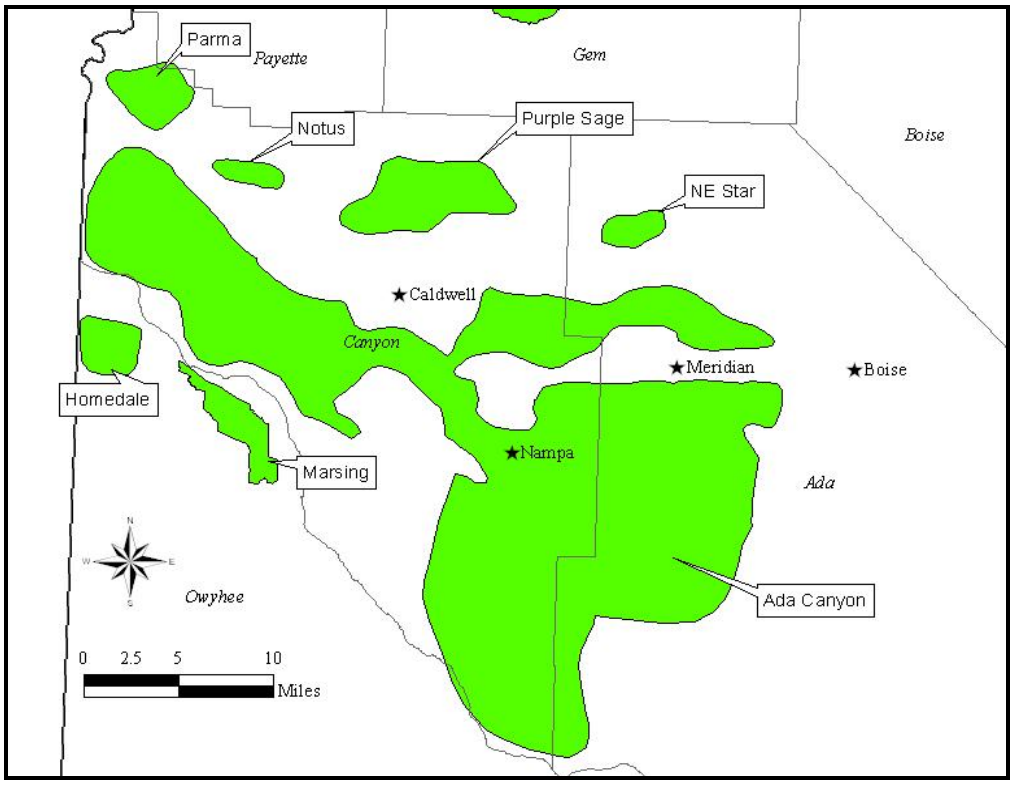

Figure 4. Nitrate Priority Areas in southwest Idaho, 2012.

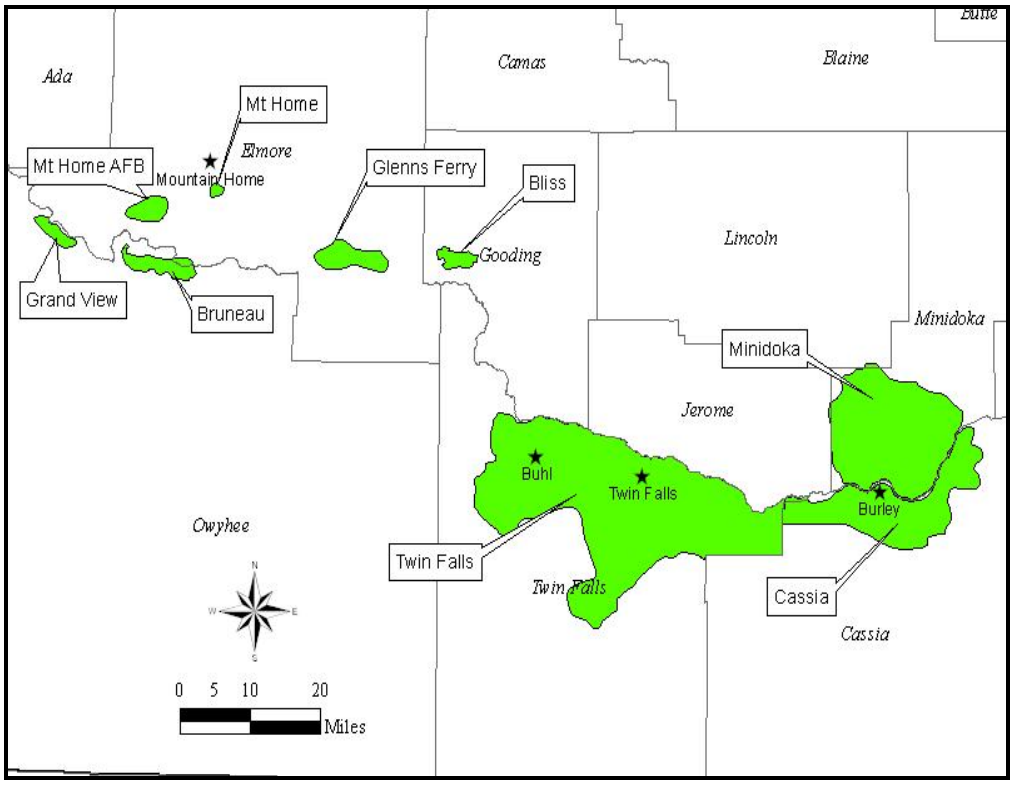

Figure 5. Nitrate Priority Areas in south central Idaho, 2012.

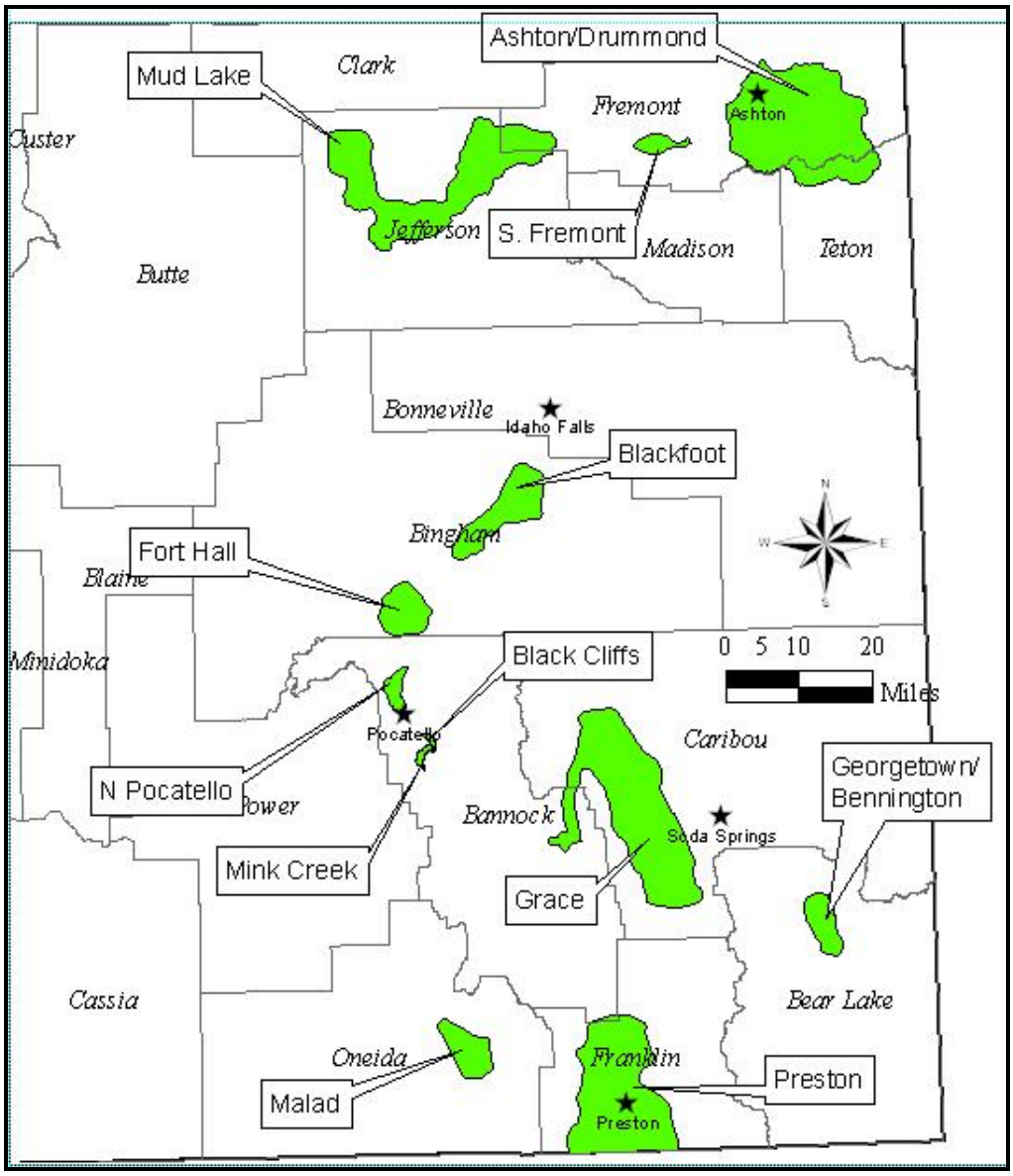

Figure 6. Nitrate Priority Areas in eastern Idaho, 2012.

Analyses Approaches and Statistical Methods

In Neely (2008), the **Mann-Whitney Rank Sum** test was used for analyzing trends between two datasets (i.e., time period 1 and time period 2) for each NPA. The test is used to determine if there has been a shift in the centers (medians) of the datasets. The test is used when some, or all, of the sites in the first dataset are unmatched with the sites in the second dataset. Thus, the datasets are called **Non-Paired**, even though some of the sites may have been sampled in both time periods. In the 2008 study, the **Maximum** nitrate value for each site for each time period was used in the Mann-Whitney analyses.

In this study, three changes to the statistical analyses were made:

1. The Mann-Whitney Rank Sum test used the **Most Recent** data.
2. The Wilcoxon Signed Rank test was added, using the **Paired**, **Most Recent** data. This test determines if there is a difference between two datasets.
3. For each site in each NPA, the change in the nitrate concentration from Time Period 1 to Time Period 2 was determined. Then, a ratio of the number of increases to the number of decreases (or the number of decreases to the number of increases) was calculated for sites with changes greater than 1.0 mg/L.

The **Most Recent** nitrate result for each site for each time period was used instead of the Maximum value because it was observed that some sites had their Maximum nitrate values prior to the Most Recent result in a Time Period. Thus, the Most Recent values were considered to be the most representative nitrate results for each time period.

Analyses using **Paired** data were added in this study for two reasons: 1) some NPAs had major differences in the number of sample results for the two Time Periods, which may have a significant effect on the test results, and 2) statistical tests using Paired data are generally considered to be more powerful than those using Non-Paired data, assuming that the number of paired sites is adequate. Twenty one of the 34 NPAs had at least 10 Paired sites, which was considered the minimum number for statistical trend analyses. The **Wilcoxon Signed Rank** test was used to conduct these analyses.

Ratios were calculated using the number of sites in each NPA that had increases and decreases in nitrate concentrations that were greater than 1.0 mg/L.

The **Thresholds** for a significant statistical result were Confidence Levels exceeding 85% and Ratios greater than 1.50. The ratio threshold of 1.50 was determined by IDEQ and IDWR. The following guidelines were used for determining if an NPA had an increasing or decreasing **Trend**, an increasing or decreasing **Tendency**, or **No Trend**:

1. If two or three thresholds were met, and were in agreement, then a Trend existed.
2. If only one threshold was met, and other criteria were in agreement but thresholds were not met, then a Tendency existed.
3. If two thresholds were met, but they were not in agreement, there was No Trend.
4. If no thresholds were met, there was No Trend.

Results for the Non-Paired and Paired Analyses

Twenty-one of the 34 NPAs had enough nitrate sample results to allow for statistical trend analyses. Based on the results from the three statistical tests described in the previous section, the following conclusions were made:

1. Four NPAs had Decreasing Trends: Lower Payette, Minidoka, Purple Sage, and Twin Falls.

2. Three NPAs had Increasing Trends: Blackfoot, Cassia, and Lindsay Creek.

3. Two NPAs had Decreasing Tendencies: Ashton-Drummond, and Clearwater.

4. One NPA had an Increasing Tendency: Mud Lake.

5. Eleven NPAs had No Trend: Ada-Canyon, Bliss, Emmett North Bench, Grace, Homedale, Lapwai Creek, Marsing, Mountain Home, Northeast Star, Preston, and Weiser.

6. Thirteen NPAS did not have enough sample results for statistical testing: Black Cliffs, Bruneau, Fort Hall, Georgetown-Bennington, Glenns Ferry, Grand View, Malad, Mink Creek, Mountain Home Air Force Base, North Pocatello, Notus, Parma, and South Fremont. These NPAs had less than 10 paired sites with results in both time periods.

Tables 1-3 show the changes in the medians for the Non-Paired and Paired datasets, and the statistical test results for the trend analyses.

Table 1. Nitrate medians for the Non-Paired, Most Recent (MR) analyses in Time Period 1 (2002-2006) and Time Period 2 (2007-2011).

NPA	Time 1/ Time 2 # of Sites	Time 1 Median MR	Time 2 Median MR	Diff T1 to T2 MR
Ada-Canyon	294/367	4.4	3.5	-0.9
Ashton-Drummond	72/75	6.1	5.9	-0.2
Black Cliffs[1]	0/13			
Blackfoot	16/22	3.7	4.0	+0.3
Bliss	18/23	3.6	3.6	0
Bruneau[1]	4/4			
Cassia	279/179	6.1	7.2	+1.1
Clearwater	114/96	4.7	3.5	-1.2
Emmett North Bench	20/33	3.7	2.1	-1.6
Fort Hall[1]	6/6	12.4	9.3	-3.1
Georgetown-Bennington[1]	5/20			
Glenns Ferry[1]	6/13	7.9	1.5	-6.4
Grace	30/42	2.9	3.0	+0.1
Grand View[1]	13/11	11.0	8.2	-2.8
Homedale	18/13	0.7	2.0	+1.3
Lapwai Creek	13/12	5.4	4.1	-1.3
Lindsay Creek	44/39	3.9	4.3	+0.4
Lower Payette	60/143	4.5	4.1	-0.4
Malad[1]	4/9			
Marsing	28/33	8.1	2.9	-5.2
Minidoka	240/134	4.2	3.3	-0.9
Mink Creek[1]	37/5	3.0	2.5	-0.5
Mountain Home	29/36	5.7	9.0	+3.3
Mountain Home AFB[1]	30/9	5.4	4.3	-1.2
Mud Lake	50/68	2.8	3.5	+0.7
North Pocatello[1]	7/25	2.4	4.2	+1.8
Northeast Star	23/36	12.0	11.1	-0.9
Notus[1]	1/2			
Parma[1]	5/9			
Preston	42/46	3.4	4.4	+1.0
Purple Sage	97/57	4.4	4.4	0
South Fremont[1]	7/8	4.2	1.9	-2.3
Twin Falls	467/303	5.0	4.6	-0.4
Weiser	82/106	12.0	12.0	0

[1]Insufficient sample numbers for statistical tests.

Table 2. Nitrate medians for the Paired, Most Recent (MR) analyses in Time Period 1 (2002-2006) and Time Period 2 (2007-2011).

NPA	# of Paired Sites	Time 1 Median MR	Time 2 Median MR	Diff T1 to T2 MR
Ada-Canyon	190	4.2	4.7	+0.5
Ashton-Drummond	54	5.7	5.6	-0.1
Black Cliffs[1]	0			
Blackfoot	10	3.3	4.6	+1.3
Bliss	17	3.9	3.6	-0.3
Bruneau[1]	3			
Cassia	111	6.0	6.4	+0.4
Clearwater	82	4.0	3.7	-0.3
Emmett North Bench	10	2.1	3.6	+1.5
Fort Hall[1]	6	12.4	9.3	-3.1
Georgetown-Bennington[1]	1			
Glenns Ferry[1]	4			
Grace	23	2.6	3.2	+0.6
Grand View[1]	9	10.0	9.0	-1.0
Homedale	13	0.9	2.0	+1.1
Lapwai Creek	10	5.2	4.9	-0.3
Lindsay Creek	16	4.9	5.1	+0.2
Lower Payette	45	4.7	3.9	-0.8
Malad[1]	3			
Marsing	24	8.0	4.5	-3.5
Minidoka	98	4.4	4.2	-0.2
Mink Creek[1]	2			
Mountain Home	27	5.8	6.0	+0.2
Mountain Home AFB[1]	8	3.4	4.9	+1.5
Mud Lake	44	2.7	3.3	+0.6
North Pocatello[1]	6			
Northeast Star	21	10.1	11.3	+1.2
Notus[1]	1			
Parma[1]	5			
Preston	21	4.2	4.7	+0.5
Purple Sage	45	4.4	4.4	0
South Fremont[1]	4			
Twin Falls	226	5.0	4.9	-0.1
Weiser	69	12.0	12.0	0

[1]Insufficient sample numbers for statistical tests.

Table 3. Probabilities and select Confidence Levels for Statistical Tests for the Non-Paired and Paired analyses for 21 Nitrate Priority Areas[1], Time Period 1 (2002-2006) and Time Period 2 (2007-2011).

NPA	Non-Paired Most Recent Probability[2] & Confidence Levels[4]	Paired Most Recent Probability[3] & Confidence Levels[4]	# of Increases >1 divided by # of Decreases > 1, and Ratio	# of Decreases >1 divided by # of Increases > 1, and Ratio	Summary of Trend Results
Ada-Canyon	*0.001 (>95%)*	0.180	39/25 = 1.56		No Trend
Ashton-Drummond	0.713	0.230		8/3 = 2.67	*Decreasing Tendency*
Blackfoot	0.595	**0.013 (>95%)**	4/0, uncalculatable		**Increasing Trend**
Bliss	0.645	*0.121 (>85%)*	6/2 = 3.00		No Trend
Cassia	**0.017 (>95%)**	**0.132 (>85%)**	24/11 = 2.18		**Increasing Trend**
Clearwater	*0.082 (>90%)*	0.528		18/17 = 1.06	*Decreasing Tendency*
Emmett North Bench	0.275	0.674		3/2 = 1.50	No Trend
Grace	0.815	0.833	3/3 = 1.00		No Trend
Homedale	0.776	0.515		3/2 = 1.50	No Trend
Lapwai Creek	0.399	0.515	1/1 = 1.00		No Trend
Lindsay Creek	0.651	**0.116 (>85%)**	6/1 = 6.00		**Increasing Trend**
Lower Payette	0.801	*0.085 (>90%)*		15/7 = 2.14	*Decreasing Trend*
Marsing	0.545	0.570	7/6 = 1.17		No Trend
Minidoka	*0.009 (>95%)*	0.958		25/12 = 2.08	*Decreasing Trend*
Mountain Home	0.452	0.742		8/6 = 1.33	No Trend
Mud Lake	0.437	0.167	5/3 = 1.67		**Increasing Tendency**
Northeast Star	0.895	0.840		6/5 = 1.20	No Trend
Preston	0.584	0.614		8/5 = 1.60	No Trend
Purple Sage	0.660	*0.081 (>90%)*		12/3 = 4.00	*Decreasing Trend*
Twin Falls	*0.009 (>95%)*	*0.034 (>95%)*		38/24 = 1.58	*Decreasing Trend*
Weiser	0.474	0.811		26/23 = 1.13	No Trend

[1]Thirteen NPAs were not analyzed because of inadequate sample numbers, i.e., less than 10 paired sites.

[2]Probability values are from the Mann-Whitney Rank Sum test, which tests two groups to see if there is a shift in the center (medians) of the groups. The null hypothesis for the test is that there is no shift. When the probability values are less than 0.15, then the null hypothesis is rejected at the greater than 85% confidence level.

[3]Probability values are from the Wilcoxon Signed Rank test, which tests matched pairs by ranking them and then calculating the positive and negative differences between the pairs. The null hypothesis for the test is that there is no difference between the two groups (i.e., the sum of positive differences and negative differences is zero). When the probably values are less than 0.15, then the null hypothesis is rejected at the greater than 85% confidence level.

[4]Confidence level in percentage is equal to 1 minus the probability times 100.

Bold Probabilities, Confidence Levels, and Summary of Trend Results indicate Increasing nitrate concentrations.

Italicized Probabilities, Confidence Levels, and Summary of Trend Results indicate Decreasing nitrate concentrations.

Summaries for the 21 NPAs With Statistical Test Results.

The following 21 NPAs had at least 10 paired sites with analyses in both Time Period 1 (2002-2006) and Time Period 2 (2007-2011). Four NPAs had decreasing trends, three NPAs had increasing trends, two NPAs had decreasing tendencies, and one NPA had an increasing tendency. Eleven NPAs had no trends or tendencies.

Ada-Canyon (No Trend)

For the non-paired analyses, Time Period 1 had 294 sites and Time Period 2 had 367 sites. There were 190 paired sites sampled in both time periods.

The median value decreased 0.9 mg/L from Time Period 1 to Time Period 2 for the non-paired sites (Table 1; [1]Figure A-1). The change in the median was significant at the greater than 95% confidence level (Table 3). For the paired analysis, the median increased 0.5 mg/L (Table 2; Figure A-2); the change was not significant at the greater than 85% confidence level (Table 3). The ratio of sites with increases greater than 1.0 mg/L to sites with decreases greater than 1.0 mg/L for the paired sites was 1.56 (Table 3).

An explanation for the different results between the non-paired and paired analyses is that there were two regions in the southern arm that were sampled more extensively in Time Period 2 than in Time Period 1. The first area exists from about 2.5 miles south of Meridian to about 4.5 miles southeast of Meridian. The second area is centered on Nampa and extends about 1.5 miles from the city center. Both of these areas had many sites with low nitrate concentrations, which impacted the median value for Time Period 2 (Figures 7 and 8).

Some distinct clustering of sites with increases and decreases over 1.0 mg/L occurred in the western and southern parts of the NPA (Figure 9).

The thresholds were exceeded for two of the three tests, but the results were conflicting (Table 3). Thus, the Ada-Canyon NPA had no trend.

[1]Figures named A-1, A-2, etc., are boxplots found in the Appendix. Boxplots were created for the NPAs analyzed statistically. Not all boxplots are referenced in the body of this report.

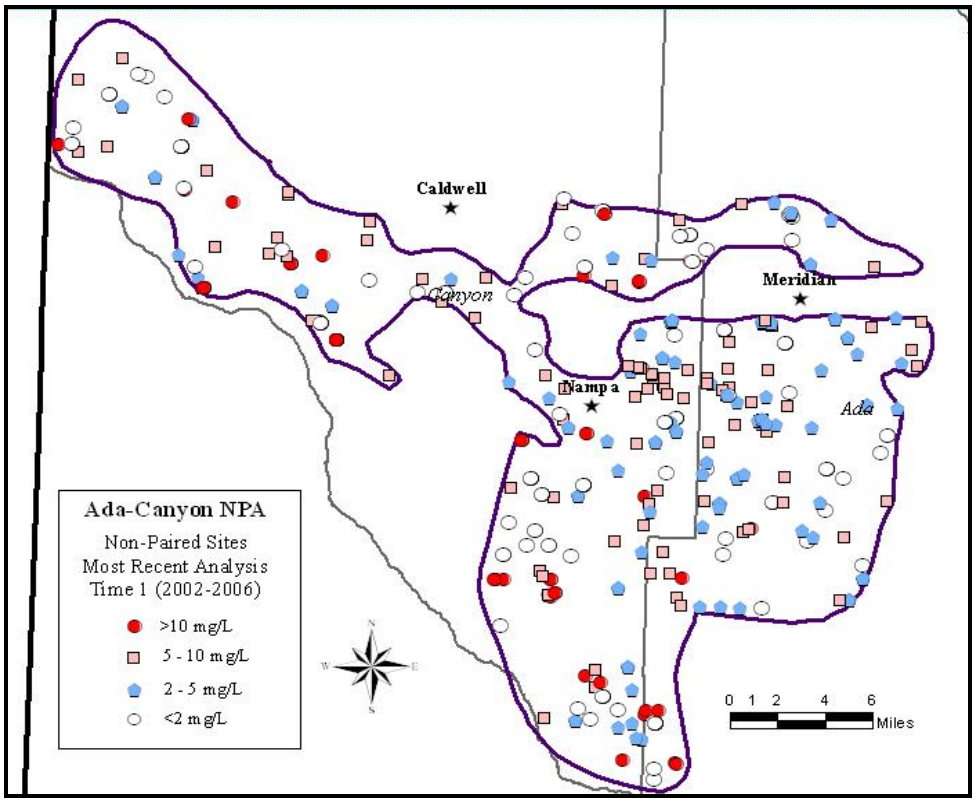

Figure 7. Sites sampled in Time Period 1 in the Ada-Canyon Nitrate Priority Area.

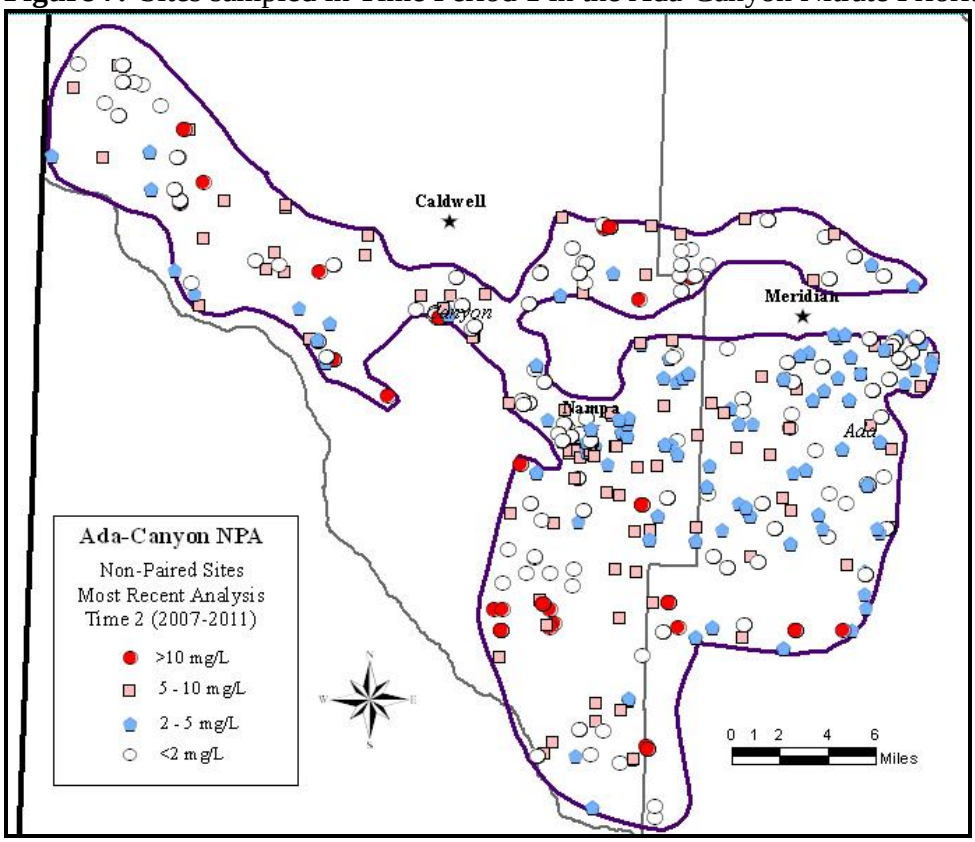

Figure 8. Sites sampled in Time Period 2 in the Ada-Canyon Nitrate Priority Area.

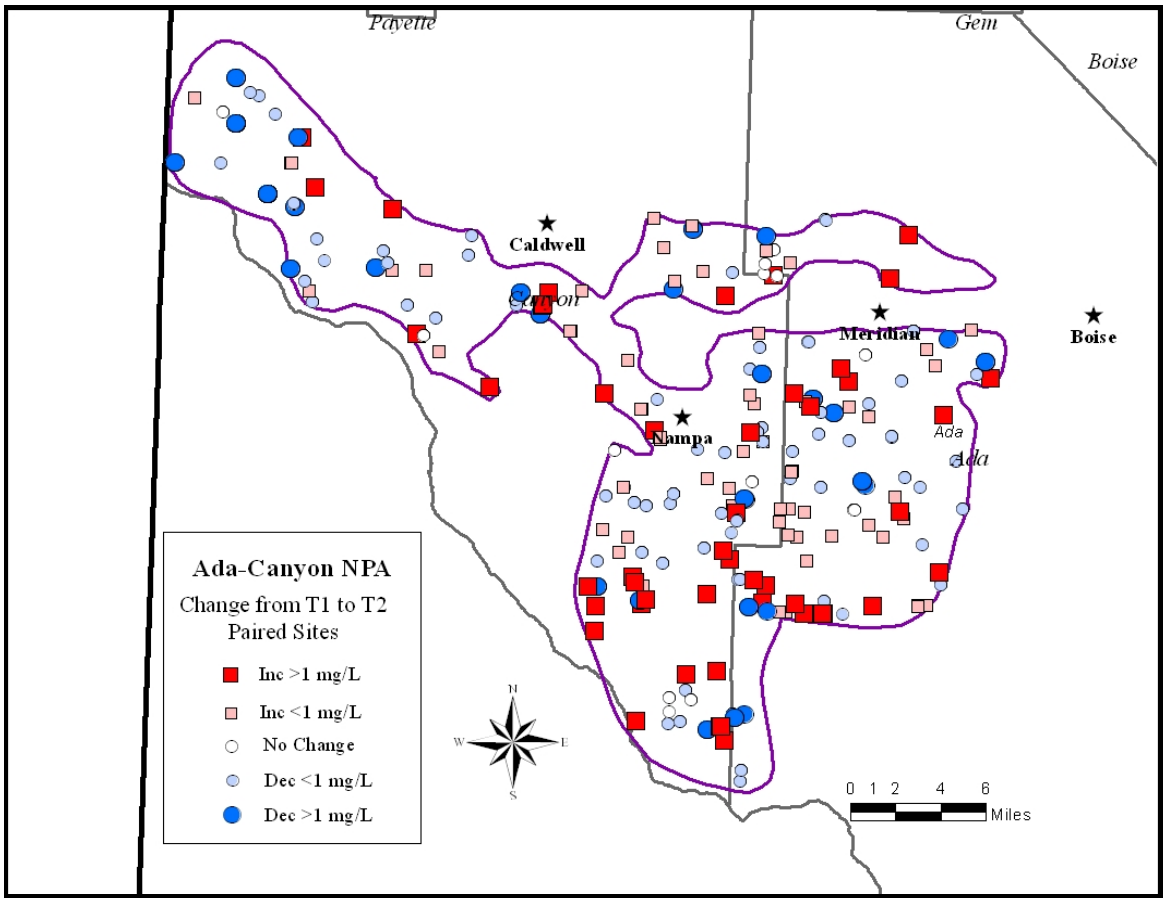

Figure 9. Changes in nitrate concentrations from Time 1 to Time 2 for the Ada-Canyon Nitrate Priority Area, Paired Sites.

Ashton-Drummond (Decreasing Tendency)

For the non-paired analyses, Time Period 1 had 72 sites and Time Period 2 had 75 sites. There were 54 paired sites sampled in both time periods.

The median value decreased 0.2 mg/L from Time Period 1 to Time Period 2 for the non-paired sites (Table 1; Figure A-3). The change in the median was not significant at the greater than 85% confidence level (Table 3). For the paired analysis, the median decreased 0.1 mg/L (Table 2; Figure A-4). The probability for the paired analysis was much lower than the non-paired analysis, but the change was not significant at the greater than 85% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1.0 mg/L for the paired sites was 2.67 (Table 3). Some clustering of sites with decreases occurred between Ashton and Drummond, and southwest and north of Ashton (Figure 10).

Based on the high ratio of sites with decreases over 1.0 mg/L to sites with increases over 1.0 mg/L, there is a decreasing tendency for the Ashton-Drummond NPA.

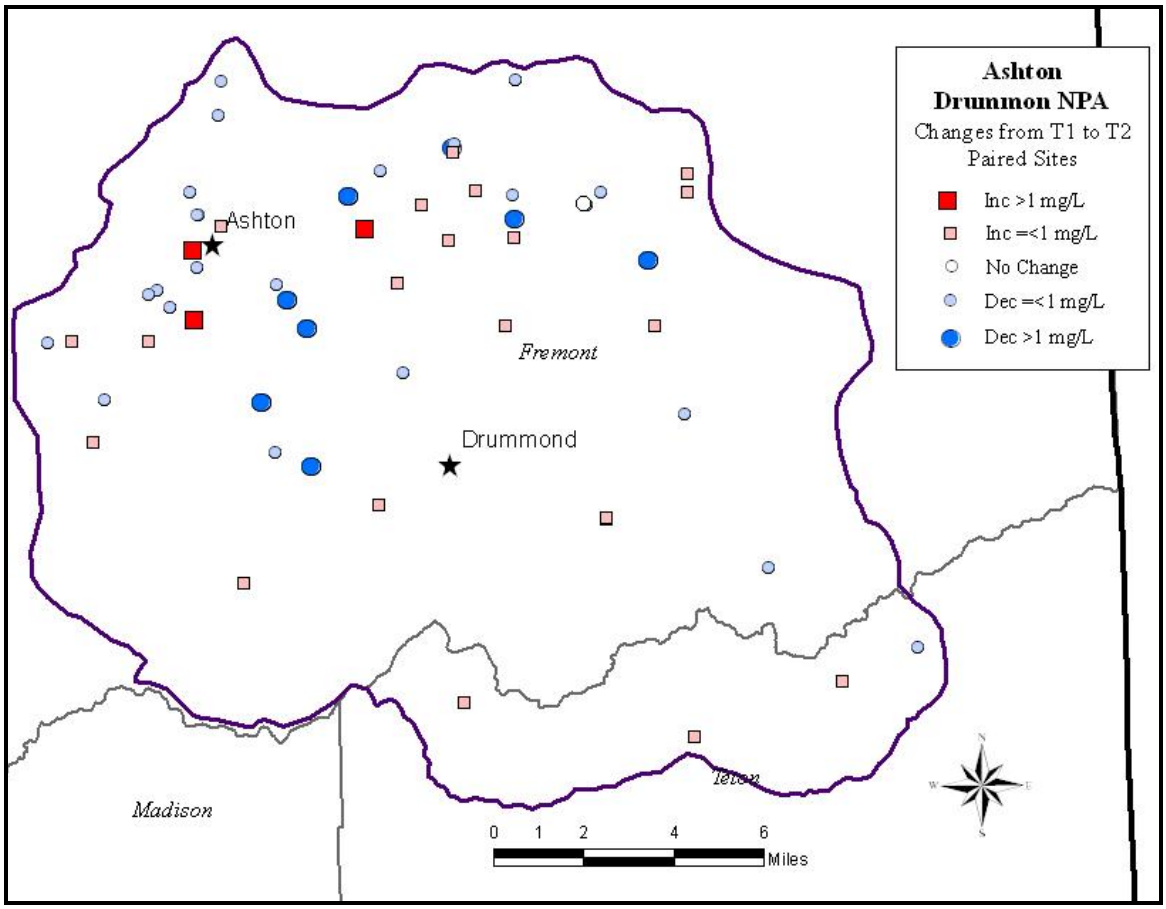

Figure 10. Changes in nitrate concentrations from Time 1 to Time 2 for the Ashton-Drummond Nitrate Priority Area; Paired Sites.

Blackfoot (Increasing Trend)

For the non-paired analyses, Time Period 1 had 16 sites and Time Period 2 had 22 sites. There were 10 paired sites sampled in both time periods.

The median value increased 0.3 mg/L from Time Period 1 to Time Period 2 for the non-paired sites (Table 1; Figure A-5). The change in the median was not significant at the greater than 85% confidence level (Table 3). For the paired analysis, the median increased 1.3 mg/L (Table 2; Figure A-6). The change in the median was significant at the greater than 95% confidence level (Table 3). Four paired sites had nitrate increases greater than 1.0 mg/L; zero sites had decreases greater than 1.0 mg/L (Figure 11).

Based on the paired data analysis and the ratio of increases to decreases, the Blackfoot NPA had an increasing nitrate concentration trend.

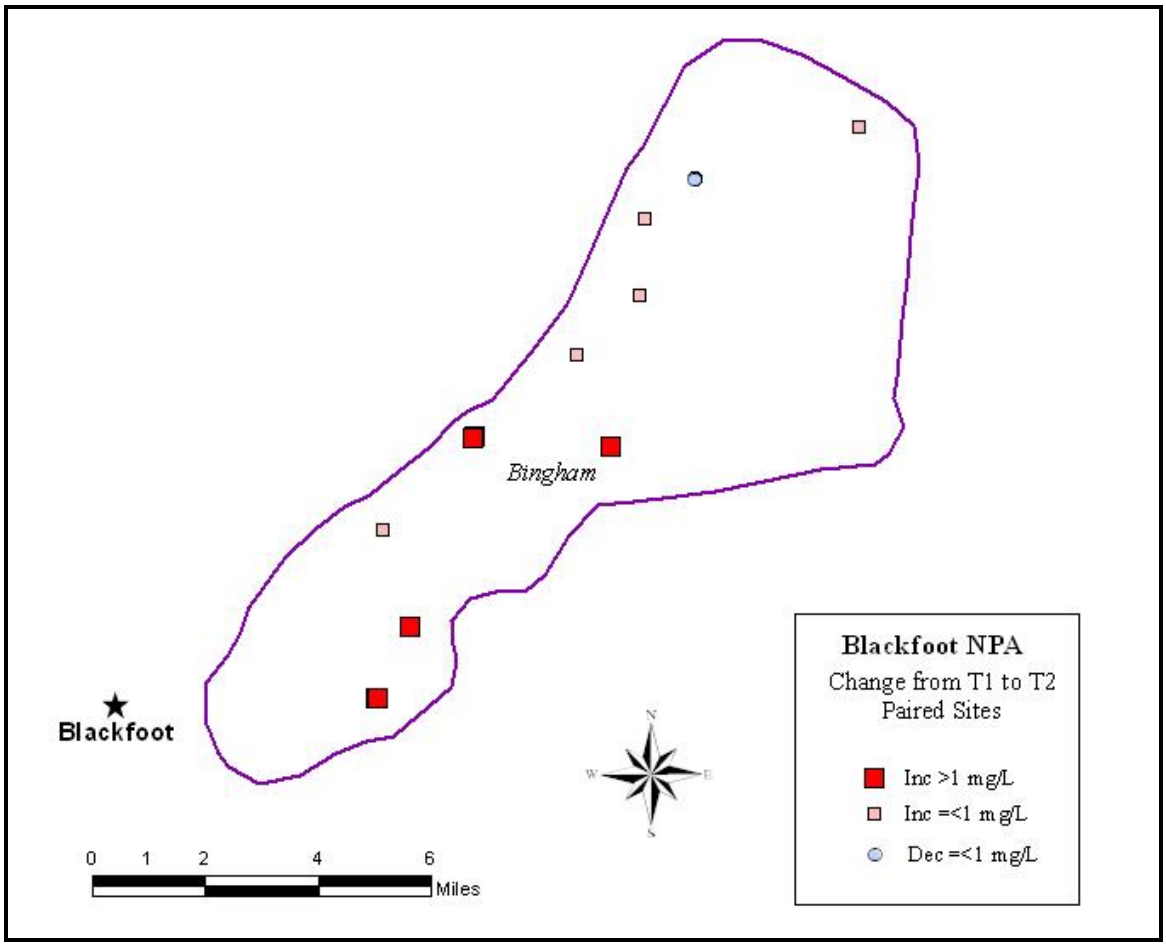

Figure 11. Changes in nitrate concentrations from Time 1 to Time 2 for the Blackfoot Nitrate Priority Area; Paired Sites.

Bliss (No Trend)

For the non-paired analyses, Time Period 1 had 18 sites and Time Period 2 had 23 sites. There were 17 paired sites sampled in both time periods.

The median values were the same for both Time Period 1 and Time Period 2 for the non-paired sites (Table 1; Figure A-7). For the paired analysis, the median decreased 0.3 mg/L (Table 2; Figure A-8). The change in the median was significant at the greater than 85% confidence level (Table 3). However, the ratio of sites with increases greater than 1.0 mg/L to sites with decreases greater than 1.0 mg/L for the paired sites was 3.00 (Table 3).

Based on the conflicting statistical results, the Bliss NPA had no discernible trend or tendency.

Cassia (Increasing Trend)

For the non-paired analyses, Time Period 1 had 279 sites and Time Period 2 had 179 sites. There were 111 paired sites sampled in both time periods.

The median value increased 1.1 mg/L from Time Period 1 to Time Period 2 for the non-paired sites (Table 1; Figure A-9). The change in the median was significant at the greater than 95% confidence level (Table 3). For the paired analysis, the median increased 0.4 mg/L (Table 2; Figure A-10); the change was significant at the greater than 85% confidence level (Table 3). The ratio of sites with increases greater than 1.0 mg/L to sites with decreases greater than 1.0 mg/L for the paired sites was 2.18 (Table 3).

Significant clustering of sites with nitrate increases over 1.0 mg/L occurred in a 20 square mile area centered about five miles southeast of Burley (Figure 12). This area also had a larger percentage of sites with nitrate over 10 mg/L in both time periods than the rest of the NPA.

Based on all three analyses, the Cassia NPA had an increasing nitrate concentration trend.

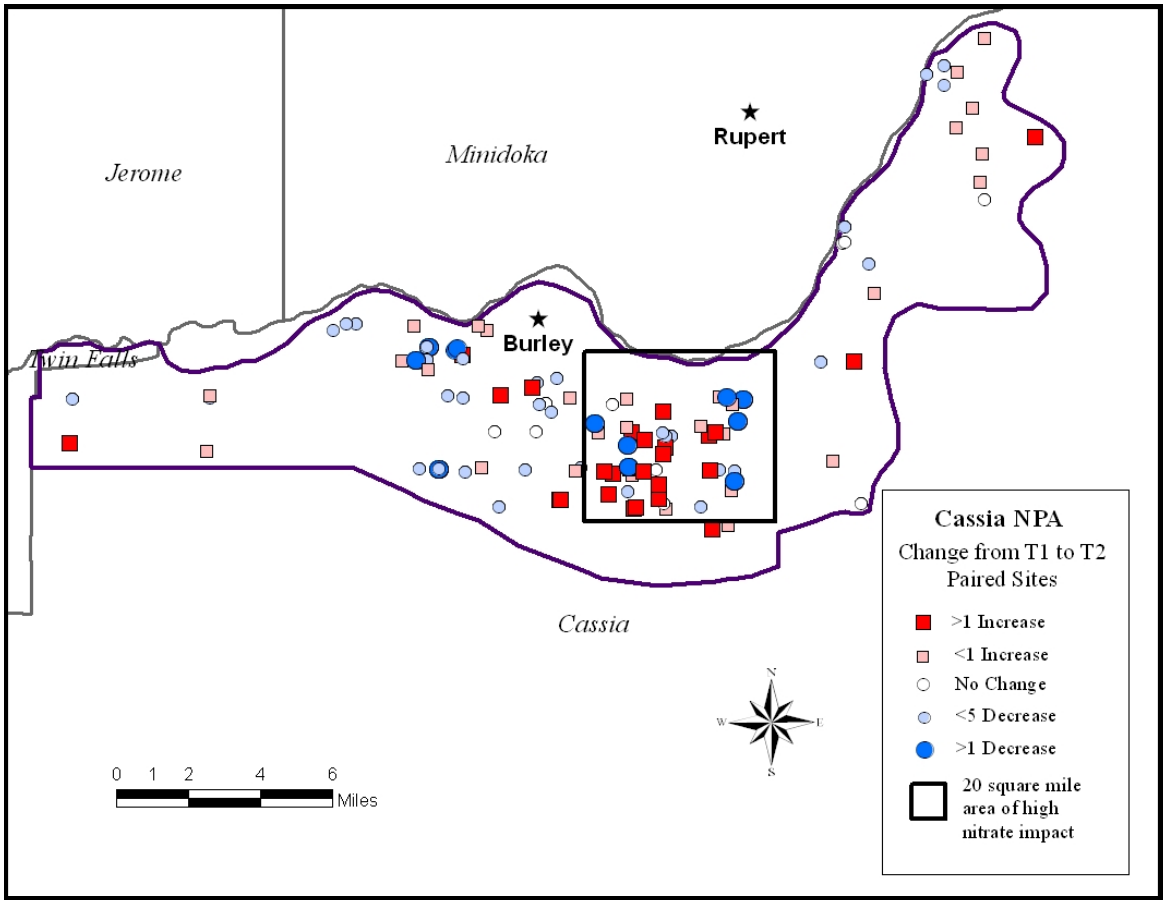

Figure 12. Changes in nitrate concentrations from Time 1 to Time 2 for the Cassia Nitrate Priority Area, Paired Sites.

Clearwater (Decreasing Tendency)

For the non-paired analyses, Time Period 1 had 114 sites and Time Period 2 had 96 sites. There were 82 paired sites sampled in both time periods.

The median value decreased 1.2 mg/L from Time Period 1 to Time Period 2 for the non-paired sites (Table 1; Figure A-11). The change in the median was significant at the greater than 90% confidence level (Table 3). For the paired analysis, the median decreased 0.3 mg/L (Table 2; Figure A-12); the change was not significant at the greater than 85% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1.0 mg/L for the paired sites was 1.06 (Table 3). There are some clusters of increases and decreases in parts of the NPA (Figure 13).

Based on the statistical test result for the non-paired data, there is a tendency toward decreasing nitrate concentrations for the Clearwater NPA.

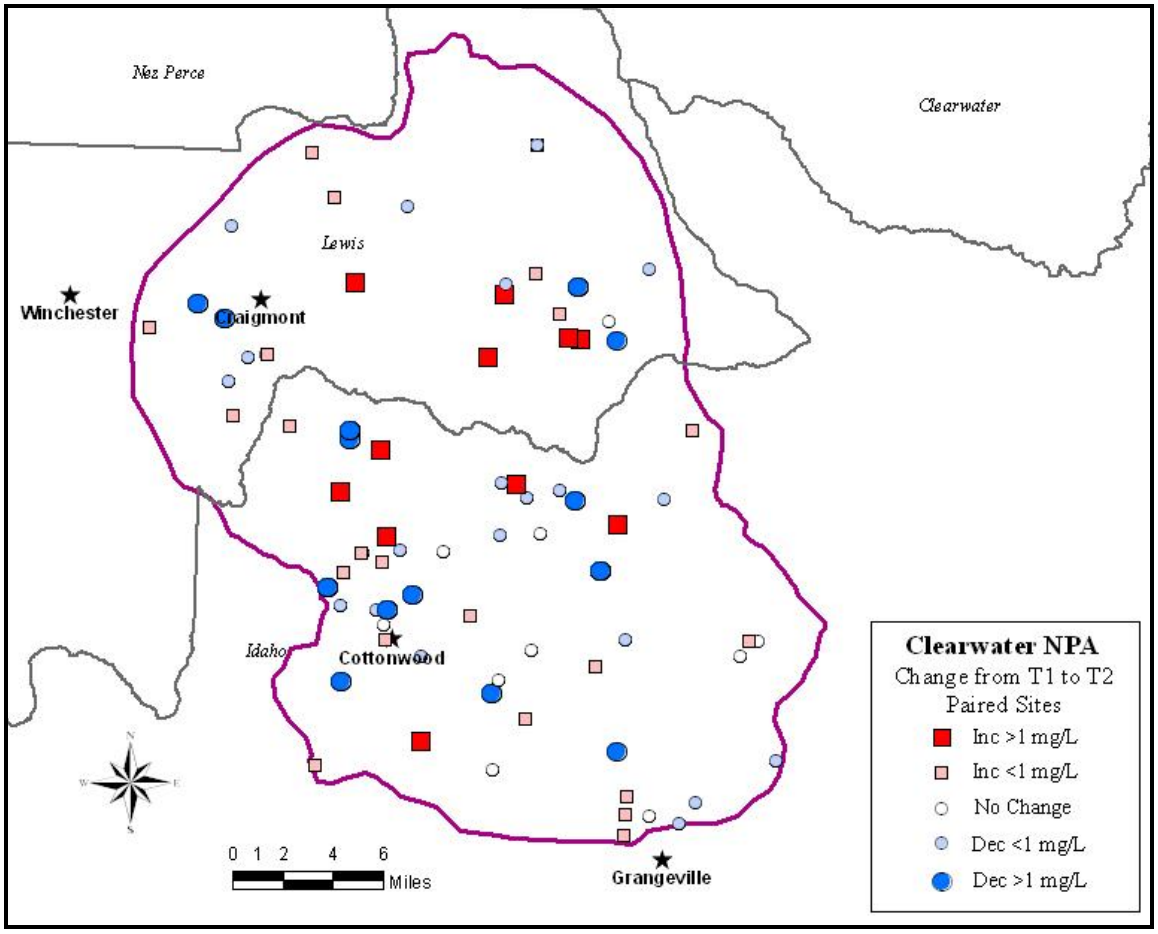

Figure 13. Changes in nitrate concentrations from Time 1 to Time 2 for the Clearwater Nitrate Priority Area, Paired Sites.

Emmett North Bench (No Trend)

For the non-paired analyses, there were 20 sites in Time Period 1 and 33 sites in Time Period 2. There were 10 paired sites sampled in both time periods.

The median value decreased 1.6 mg/L from Time Period 1 to Time Period 2 for the non-paired sites (Table 1; Figure A-13). The change in the median was not significant at the greater than 85% confidence level (Table 3). For the paired analysis, the median increased 1.5 mg/L (Table 2; Figure A-14); the change was not significant at the greater than 85% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1.0 mg/L for the paired sites was 1.50 (Table 3).

The Emmett North Bench NPA had no discernible trend or tendency.

Grace (No Trend)

For the non-paired analyses, there were 30 sites in Time Period 1 and 42 sites in Time Period 2. There were 23 paired sites sampled in both time periods.

The median value increased 0.1 mg/L from Time Period 1 to Time Period 2 for the non-paired sites (Table 1; Figure A-15). The change in the median was not significant at the greater than 85% confidence level (Table 3). For the paired analysis, the median increased 0.6 mg/L (Table 2; Figure A-16); the change was not significant at the greater than 85% confidence level (Table 3). There were an equal number of paired sites with increases and decreases greater than 1.0 mg/L (Table 3).

The Grace NPA had no discernible trend or tendency.

Homedale (No Trend)

For the non-paired analyses, there were 18 sites in Time Period 1 and 13 sites in Time Period 2. There were 13 paired sites sampled in both time periods.

The median value increased 1.3 mg/L from Time Period 1 to Time Period 2 for the non-paired sites (Table 1; Figure A-17). The change in the median was not significant at the greater than 85% confidence level (Table 3). For the paired analysis, the median increased 1.1 mg/L (Table 2; Figure A-18); the change was not significant at the greater than 85% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1.0 mg/L for the paired sites was 1.50 (Table 3).

The Homedale NPA had no discernible trend or tendency.

Lapwai Creek (No Trend)

For the non-paired analyses, there were 13 sites in Time Period 1 and 12 sites in Time Period 2. There were 10 paired sites sampled in both time periods.

The median value decreased 1.3 mg/L from Time Period 1 to Time Period 2 for the non-paired sites (Table 1; Figure A-19). The change in the median was not significant at the greater than 85% confidence level (Table 3). For the paired analysis, the median decreased 0.3 mg/L (Table 2; Figure A-20); the change was not significant at the greater than 85% confidence level (Table 3). There were an equal number of paired sites with increases and decreases greater than 1.0 mg/L (Table 3).

The Lapwai Creek NPA had no discernible trend or tendency.

Lindsay Creek (Increasing Trend)

For the non-paired analyses, Time Period 1 had 44 sites and Time Period 2 had 39 sites. There were 16 paired sites sampled in both time periods.

The median value increased 0.4 mg/L from Time Period 1 to Time Period 2 for the non-paired sites (Table 1; Figure A-21). The change in the median was not significant at the greater than 85% confidence level (Table 3). For the paired analysis, the median increased 0.2 mg/L (Table 2; Figure A-22). The change in the median was significant at the greater than 85% confidence level (Table 3). The ratio of sites with increases greater than 1.0 mg/L to sites with decreases greater than 1.0 mg/L for the paired sites was 6.00 (Table 3). The sites with increases occurred in the northwest part of the NPA (Figure 14).

Based on the statistical test result for the paired sites and the high ratio of increases to decreases, the Lindsay Creek NPA had an increasing nitrate concentration trend.

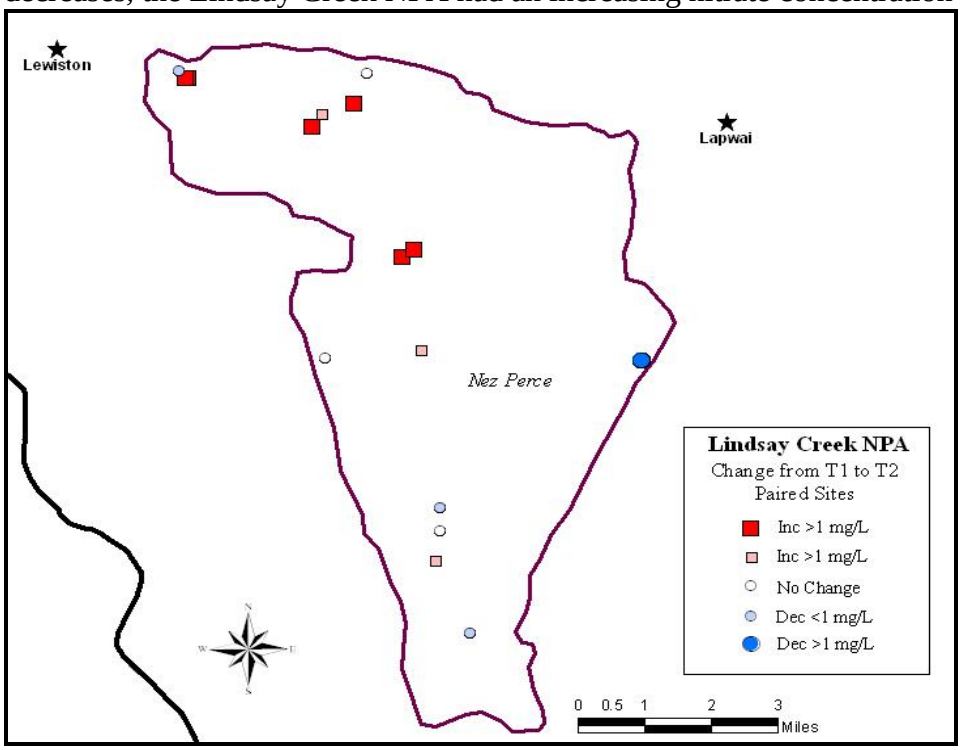

Figure 14. Changes in nitrate concentrations from Time 1 to Time 2 for the Lindsay Creek Nitrate Priority Area, Paired Sites.

Lower Payette (Decreasing Trend)

For the non-paired analyses, Time Period 1 had 60 sites and Time Period 2 had 143 sites. There were 45 paired sites sampled in both time periods.

The median value decreased 0.4 mg/L from Time Period 1 to Time Period 2 for the non-paired sites (Table 1; Figure A-23). The change in the median was not significant at the greater than 85% confidence level (Table 3). For the paired analysis, the median decreased 0.8 mg/L (Table 2; Figure A-24); the change was significant at the greater than 90% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1.0 mg/L for the paired sites was 2.14 (Table 3). Figure 15 shows that most of the sites in the central part of the NPA had decreases.

The results from the statistical test for the paired data, and the high ratio of sites with decreases to sites with increases indicate a decreasing trend for the Lower Payette NPA.

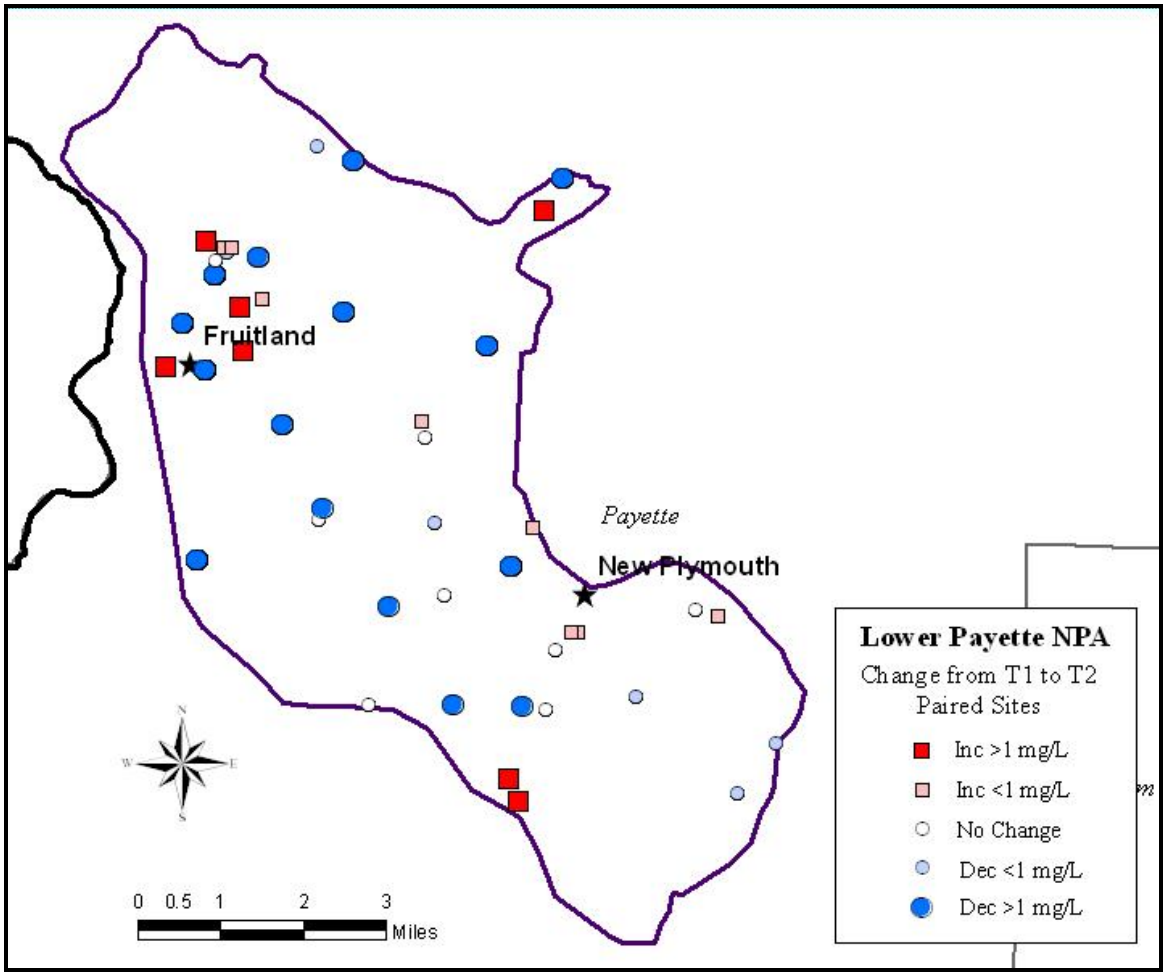

Figure 15. Changes in nitrate concentrations from Time 1 to Time 2 for the Lower Payette Nitrate Priority Area, Paired Sites.

Marsing (No Trend)

For the non-paired analyses, there were 28 sites in Time Period 1 and 33 sites in Time Period 2. There were 24 paired sites sampled in both time periods.

The median value decreased 5.2 mg/L from Time Period 1 to Time Period 2 for the non-paired sites (Table 1; Figure A-25). The change in the median was not significant at the greater than 85% confidence level (Table 3). For the paired analysis, the median decreased 3.5 mg/L (Table 2; Figure A-26); the change was not significant at the greater than 85% confidence level (Table 3). The statistical results and the boxplot patterns are conflicting for the Marsing NPA. Although the medians decreased, the boxplot patterns for both the Non-Paired and Paired data suggest an increase in nitrate concentrations. The ratio of sites with increases greater than 1.0 mg/L to sites with decreases greater than 1.0 mg/L for the paired sites was 1.17 (Table 3). Figure 16 shows that most of the sites in the central part of the NPA had increases.

The Marsing NPA had no discernible trend or tendency.

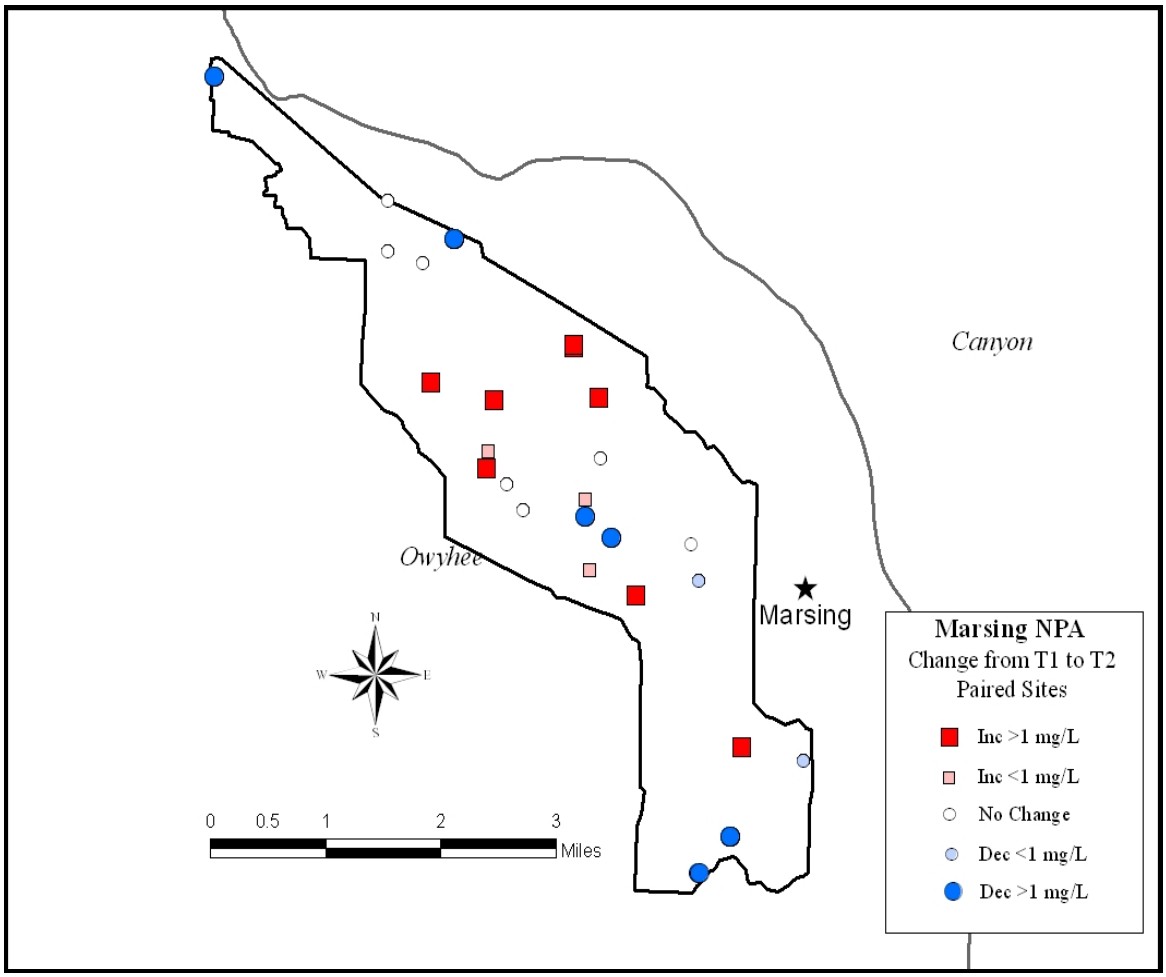

Figure 16. Changes in nitrate concentrations from Time 1 to Time 2 for the Marsing Nitrate Priority Area, Paired Sites.

Minidoka (Decreasing Trend)

For the non-paired analyses, Time Period 1 had 240 sites and Time Period 2 had 134 sites. There were 98 paired sites sampled in both time periods.

The median value decreased 0.9 mg/L from Time Period 1 to Time Period 2 for the non-paired sites (Table 1; Figure A-27). The change in the median was significant at the greater than 95% confidence level (Table 3). For the paired analysis, the median decreased 0.2 mg/L (Table 2; Figure A-28); the change was not significant at the greater than 85% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1.0 mg/L for the paired sites was 2.08 (Table 3). Most of the NPA had a mix of increases and decreases with minor clustering; however, the northern part was characterized by increases less than 1.0 mg/L (Figure 17).

Overall, the statistical tests indicated that the median nitrate value decreased from Time Period 1 to Time Period 2 for the Minidoka NPA indicating a decreasing trend.

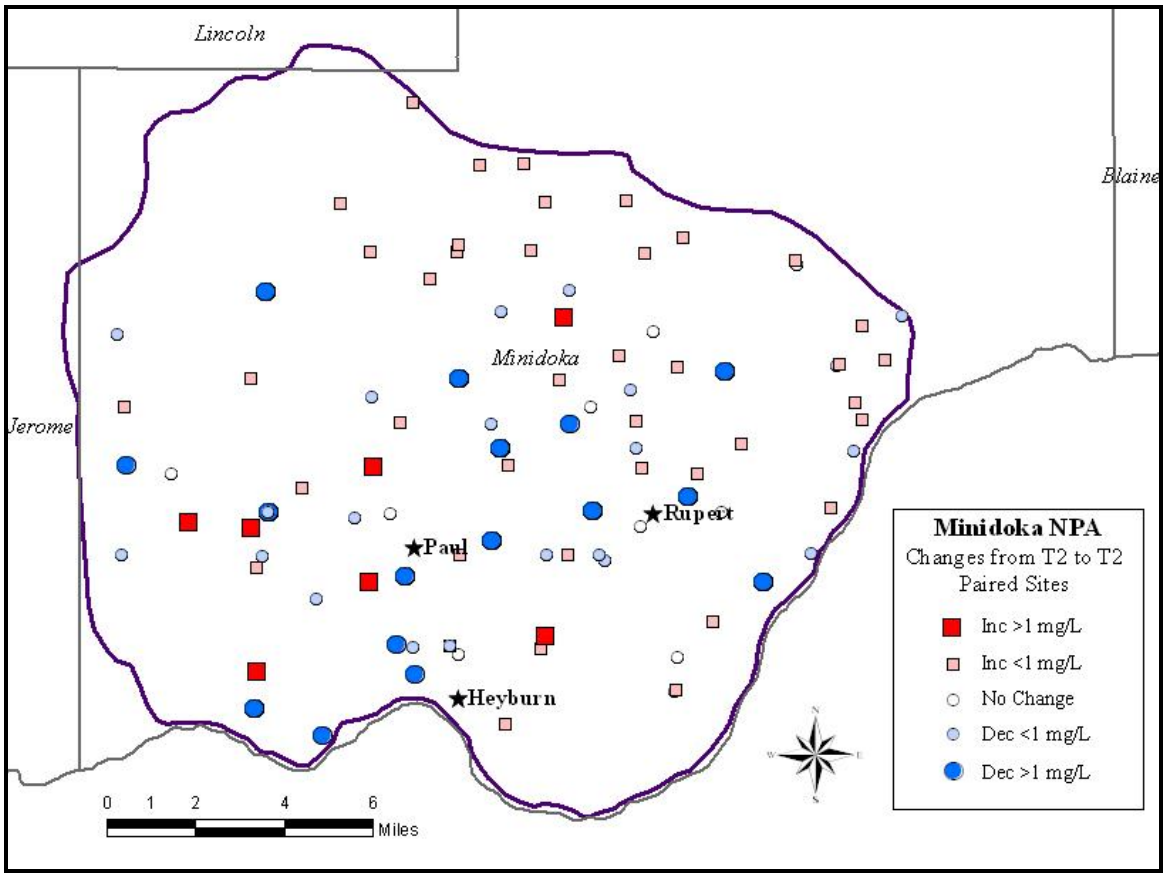

Figure 17. Changes in nitrate concentrations from Time 1 to Time 2 for the Minidoka Nitrate Priority Area, Paired Sites.

Mountain Home (No Trend)

For the non-paired analyses, there were 29 sites in Time Period 1 and 36 sites in Time Period 2. There were 27 paired sites sampled in both time periods.

The median value increased 3.3 mg/L from Time Period 1 to Time Period 2 for the non-paired sites (Table 1; Figure A-29), but change in the median was not significant at the greater than 85% confidence level (Table 3). For the paired analysis, the median increased 0.2 mg/L (Table 2; Figure A-30); the change was not significant at the greater than 85% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1.0 mg/L for the paired sites was 1.33 (Table 3).

The Mountain Home NPA had no discernible trend or tendency.

Mud Lake (Increasing Tendency)

For the non-paired analyses, there were 50 sites in Time Period 1 and 68 sites in Time Period 2. There were 44 paired sites sampled in both time periods.

The median value increased 0.7 mg/L from Time Period 1 to Time Period 2 for the non-paired sites (Table 1; Figure A-31). The change in the median was not significant at the greater than 85% confidence level (Table 3). For the paired analysis, the median increased 0.6 mg/L (Table 2; Figure A-32); the change was not significant at the greater than 85% confidence level (Table 3). The ratio of sites with increases greater than 1.0 mg/L to sites with decreases greater than 1.0 mg/L for the paired sites was 1.67 (Table 3). Figure 18 shows that the majority of sites in the northeast arm of the NPA had increases in nitrate concentrations from Time Period 1 to Time Period 2.

The ratio of sites with increases over 1.0 mg/L to sites with decreases indicates that there is an increasing tendency in nitrate concentrations for the Mud Lake NPA.

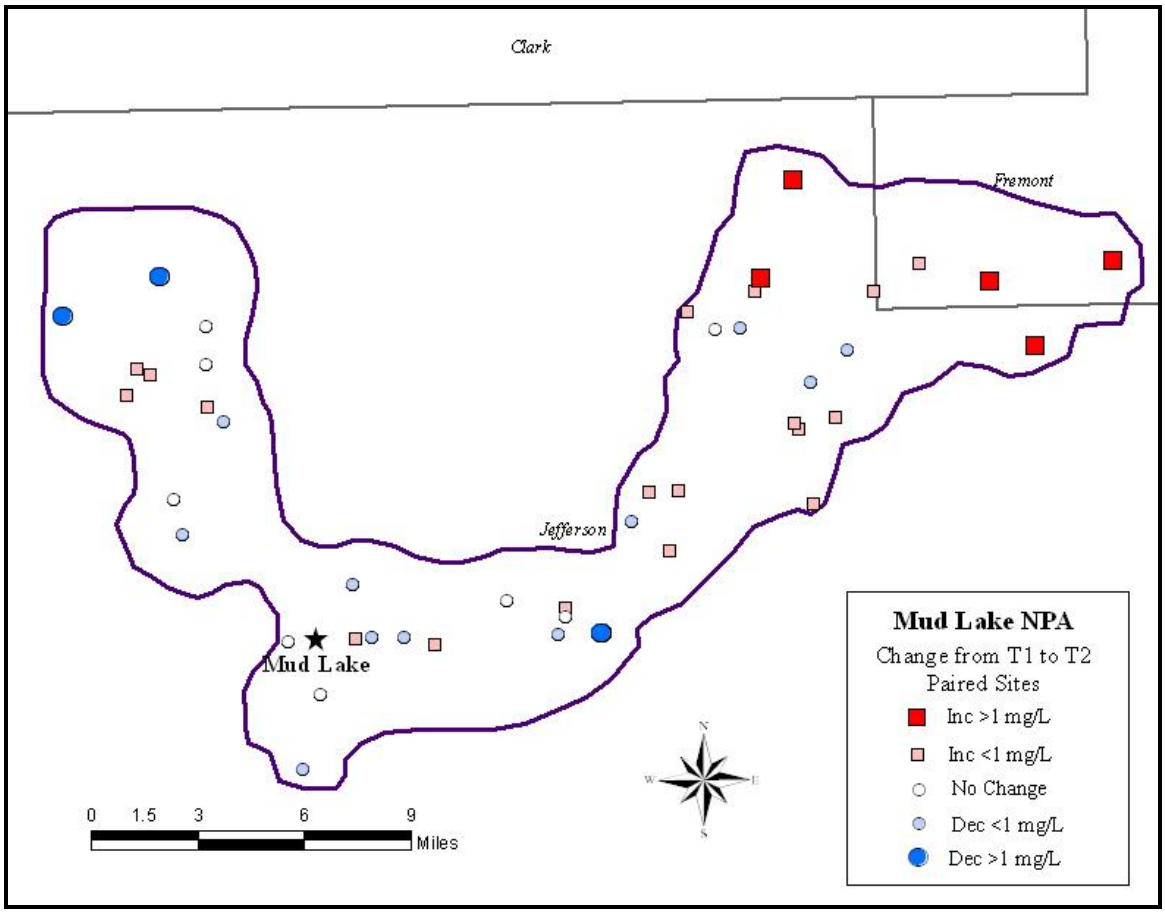

Figure 18. Changes in nitrate concentrations from Time 1 to Time 2 for the Mud Lake Nitrate Priority Area; Paired Sites.

Northeast Star (No Trend)

For the non-paired analyses, Time Period 1 had 23 sites and Time Period 2 had 36 sites. There were 21 paired sites sampled in both time periods.

The median value decreased 0.9 mg/L from Time Period 1 to Time Period 2 for the non-paired sites (Table 1); however, the boxplots indicate higher sample concentrations in Time Period 2 (Figure A-33). The change in the median was not significant at the greater than 85% confidence level (Table 3). For the paired analysis, the median increased 1.2 mg/L (Table 2; Figure A-34); the change was not significant at the greater than 85% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1.0 mg/L for the paired sites was 1.20 (Table 3).

The Northeast Star NPA had no discernible trend or tendency.

Preston (No Trend)

For the non-paired analyses, there were 42 sites in Time Period 1 and 46 sites in Time Period 2. There were 21 paired sites sampled in both time periods.

The median value increased 1.0 mg/L from Time Period 1 to Time Period 2 for the non-paired sites (Table 1; Figure A-35). The change in the median was not significant at the greater than 85% confidence level (Table 3). For the paired analysis, the median increased 0.5 mg/L (Table 2; Figure A-36); the change was not significant at the greater than 85% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1.0 mg/L for the paired sites was 1.60 (Table 3). Figure 19 shows the changes in concentrations between Time Period 1 and Time Period 2.

Based on the conflicting results, (the medians indicated an increase in nitrate concentrations, the thresholds for two of the tests were not met, and the ratio indicated a decreasing trend), the Preston NPA had no discernible trend or tendency.

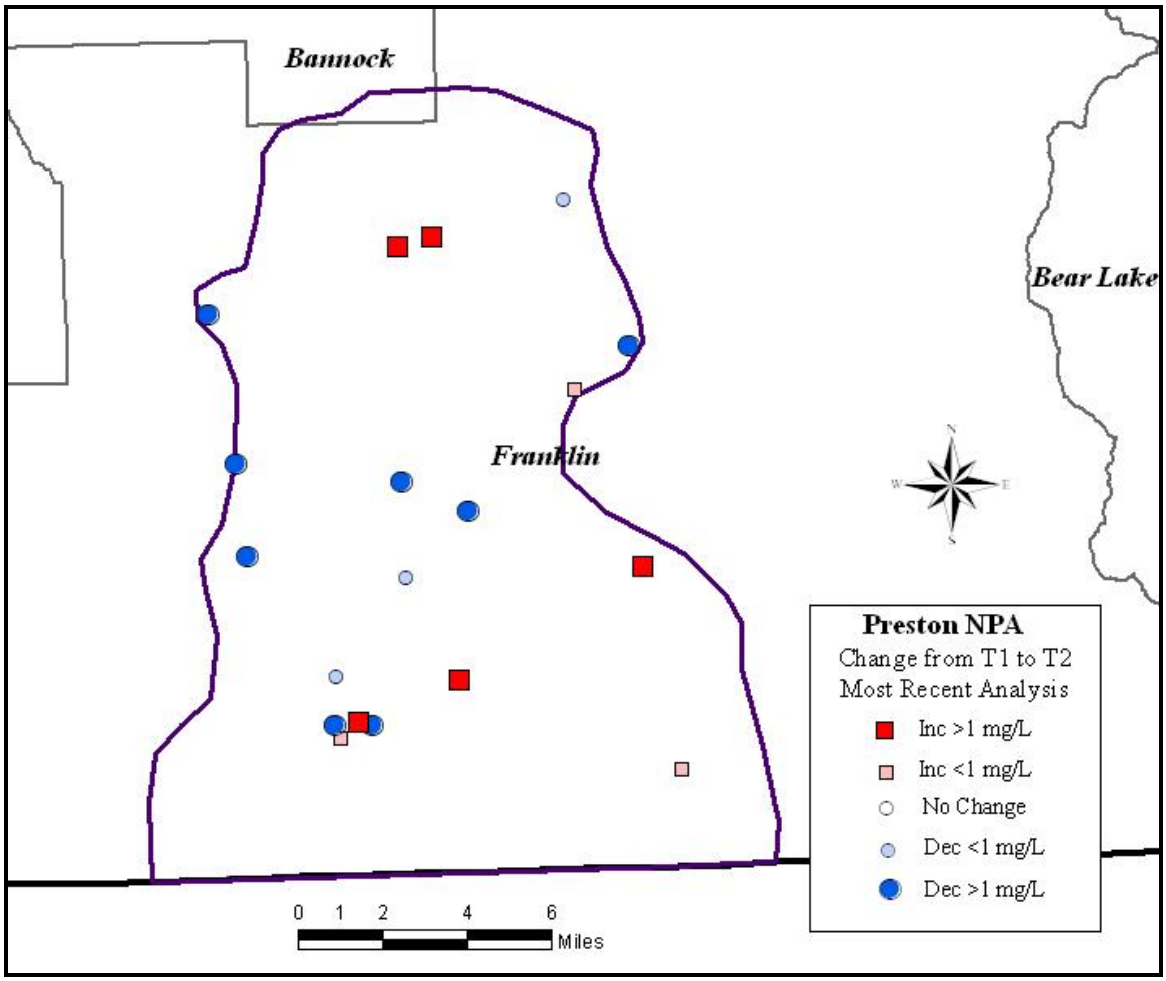

Figure 19. Changes in nitrate concentrations from Time 1 to Time 2 for the Preston Nitrate Priority Area; Paired Sites.

Purple Sage (Decreasing Trend)

For the non-paired analyses, Time Period 1 had 97 sites and Time Period 2 had 57 sites. There were 45 paired sites sampled in both time periods.

The median values for the non-paired and paired sites did not change from Time Period 1 to Time Period 2 (Tables 1 and 2; Figures A-37 and A-38). The test result for the non-paired data was not significant at the greater than 85% confidence level; however the test result for the paired data indicated a significant change in nitrate concentrations occurred between the two time periods at the greater than 90% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1.0 mg/L for the paired sites was 4.00. Figure 20 shows that some distinct clustering of sites with increases and decreases occurred, especially in the northeast part of the NPA where almost every site had a decrease in nitrate concentration.

Although no changes in the medians occurred for the non-paired and paired datasets, the statistical test results for the paired analysis and the ratio results indicate that the nitrate concentrations decreased from Time Period 1 to Time Period 2, resulting in a decreasing trend for the Purple Sage NPA.

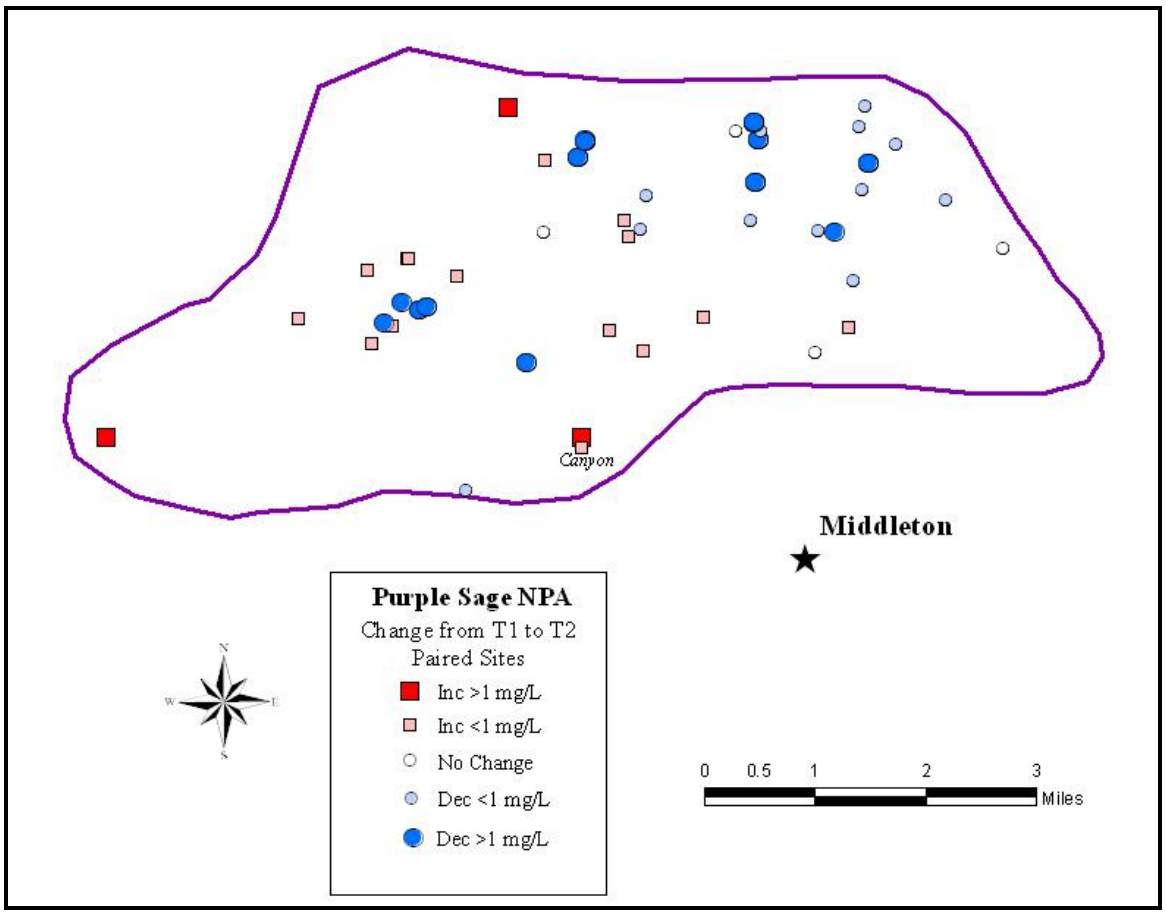

Figure 20. Changes in nitrate concentrations from Time 1 to Time 2 for the Purple Sage Nitrate Priority Area, Paired Sites.

Twin Falls (Decreasing Trend)

For the non-paired analyses, Time Period 1 had 467 sites and Time Period 2 had 303 sites. There were 226 paired sites sampled in both time periods.

The median value decreased 0.4 mg/L from Time Period 1 to Time Period 2 for the non-paired sites (Table 1; Figure A-39). The change in the median was significant at the greater than 95% confidence level (Table 3). For the paired analysis, the median decreased 0.1 mg/L (Table 2; Figure A-40); the change was significant at the greater than 95% confidence level (Table 3). The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1.0 mg/L for the paired sites was 1.58 (Table 3). Clustering of sites with increases and decreases occurred in some parts of the NPA, especially in the western and eastern regions (Figure 21).

The three statistical test results indicate that the nitrate concentrations decreased from Time Period 1 to Time Period 2 for the Twin Falls NPA, resulting in a decreasing trend.

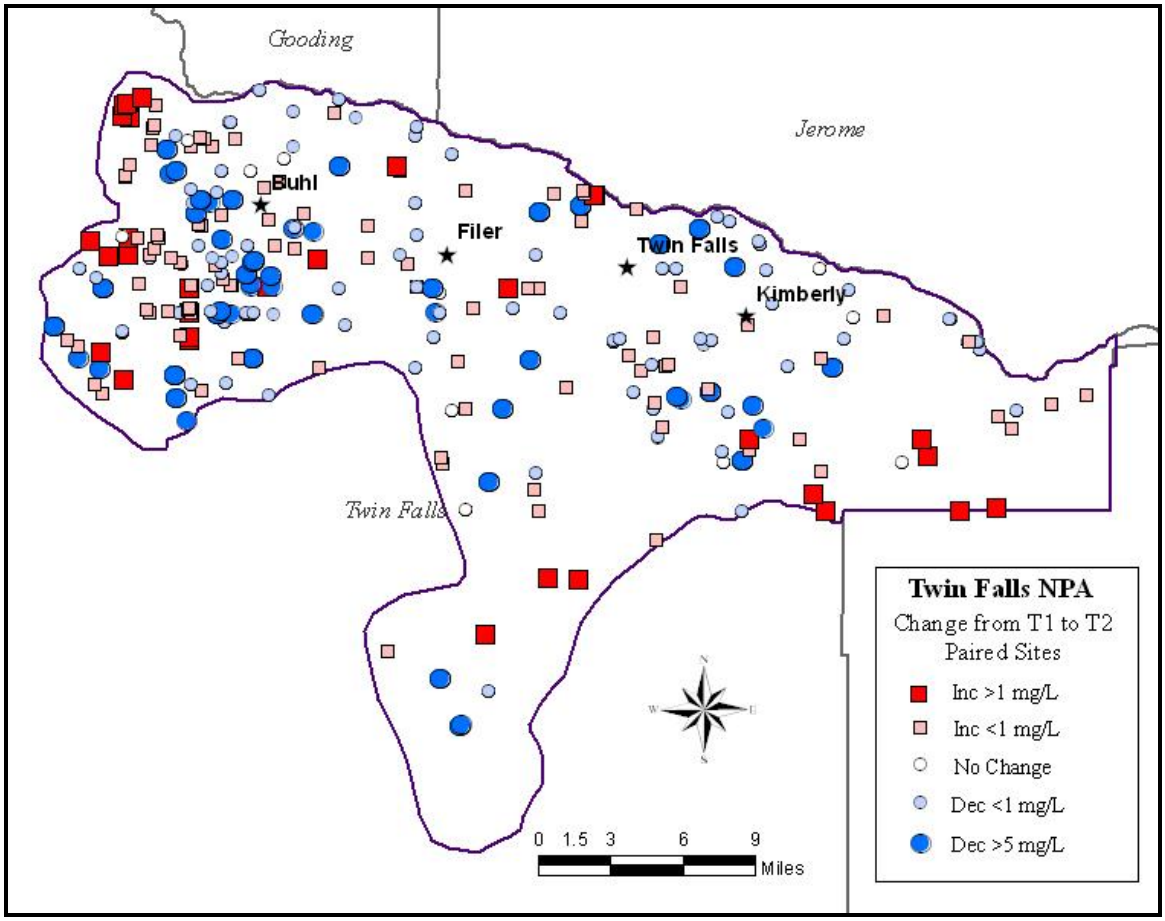

Figure 21. Changes in nitrate concentrations from Time 1 to Time 2 for the Twin Falls Nitrate Priority Area, Paired Sites.

Weiser (No Trend)

For the non-paired analyses, there were 82 sites in Time Period 1 and 106 sites in Time Period 2. There were 69 paired sites sampled in both time periods.

The median values were the same for both Time Periods for the non-paired sites (Table 1; Figure A-41), and the statistical test result did not indicate a significant change at the greater than 85% confidence level (Table 3). For the paired analysis, the median values were the same for both Time Periods (Table 2; Figure A-42), and the statistical test was not significant at the greater than 85% confidence level. The ratio of sites with decreases greater than 1.0 mg/L to sites with increases greater than 1.0 mg/L for the paired sites was 1.13 (Table 3).

Based on the statistical results, the Weiser NPA had no discernible trend or tendency. However, there were some distinct clustering of sites with increases and decreases (Figure 22).

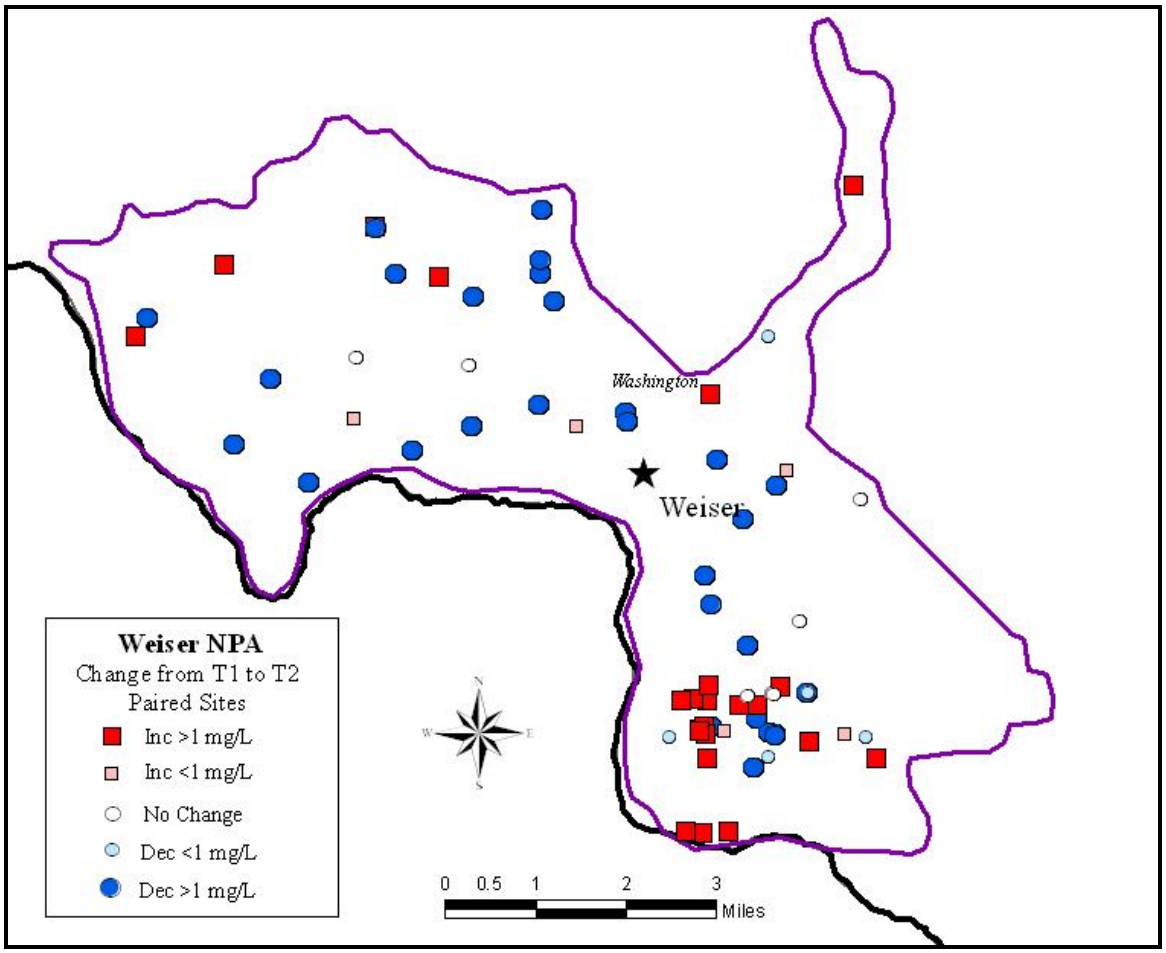

Figure 22. Changes in nitrate concentrations from Time 1 to Time 2 for the Weiser Nitrate Priority Area, Paired Sites.

Appendix Figures

Figure 23 is an explanation of boxplots for Figures A-1 through A-42, which show the boxplots for the 21 NPAs analyzed for nitrate trends in this study.

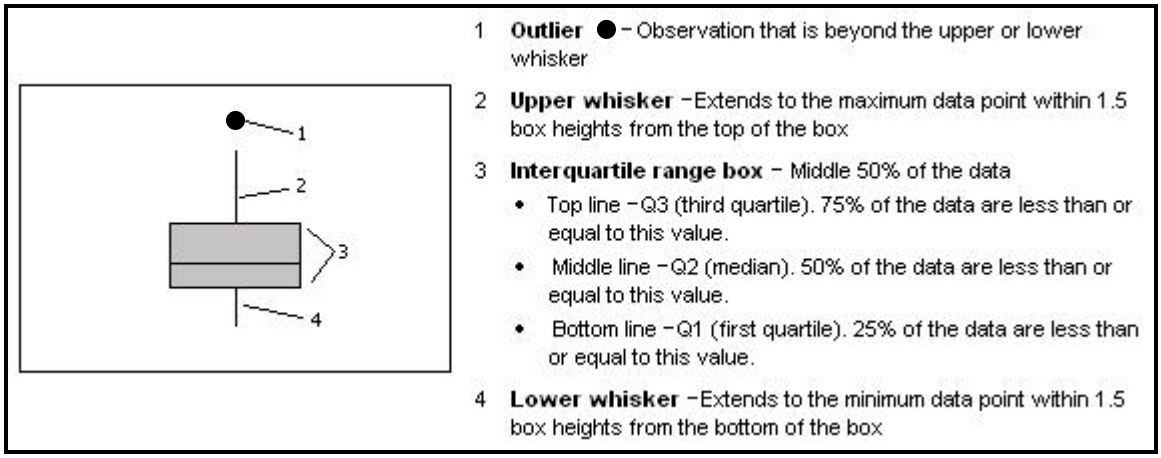

Figure 23. Explanation for boxplots in Figures A-1 through A-42.

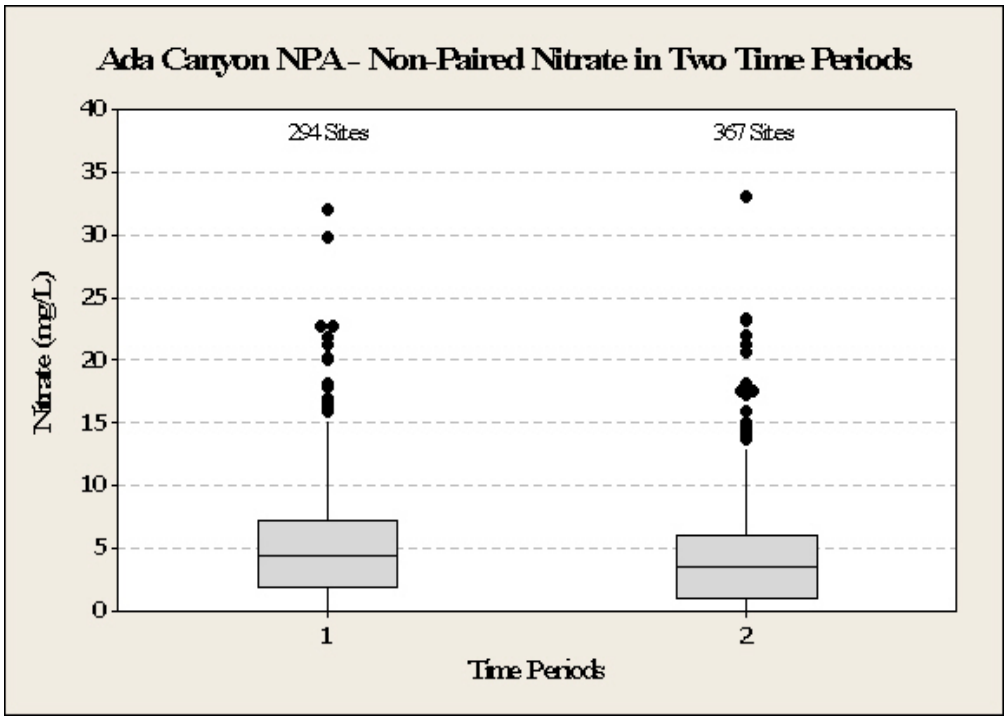

Figure A-1. Boxplots for the Non-Paired nitrate data for the Ada Canyon NPA, Time Periods 1 and 2.

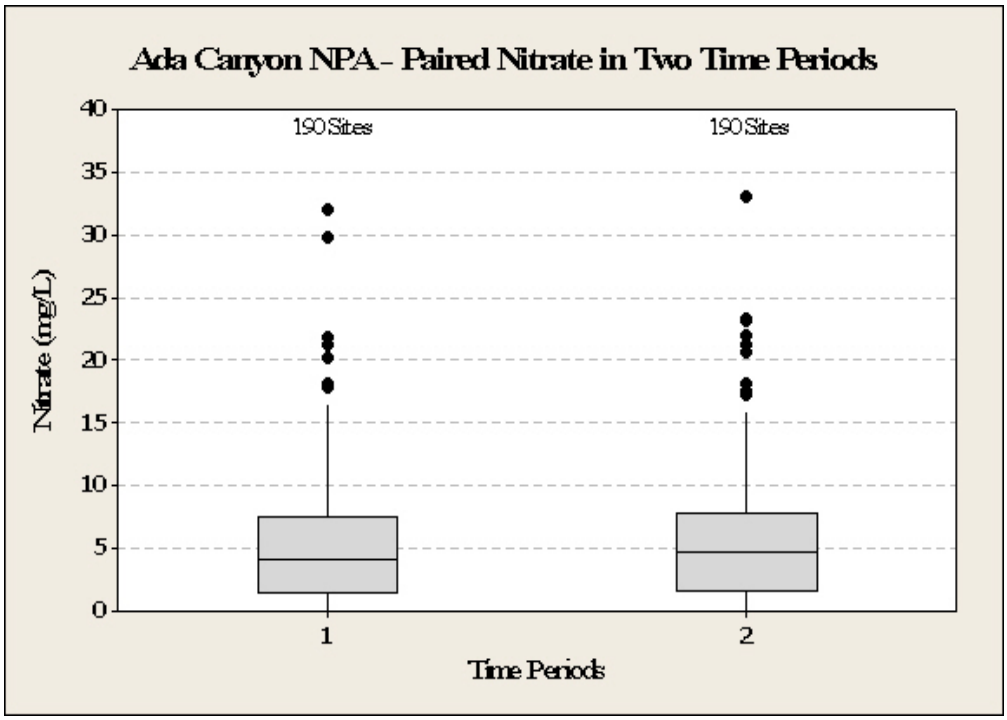

Figure A-2. Boxplots for the Paired nitrate data for the Ada Canyon NPA, Time Periods 1 and 2.

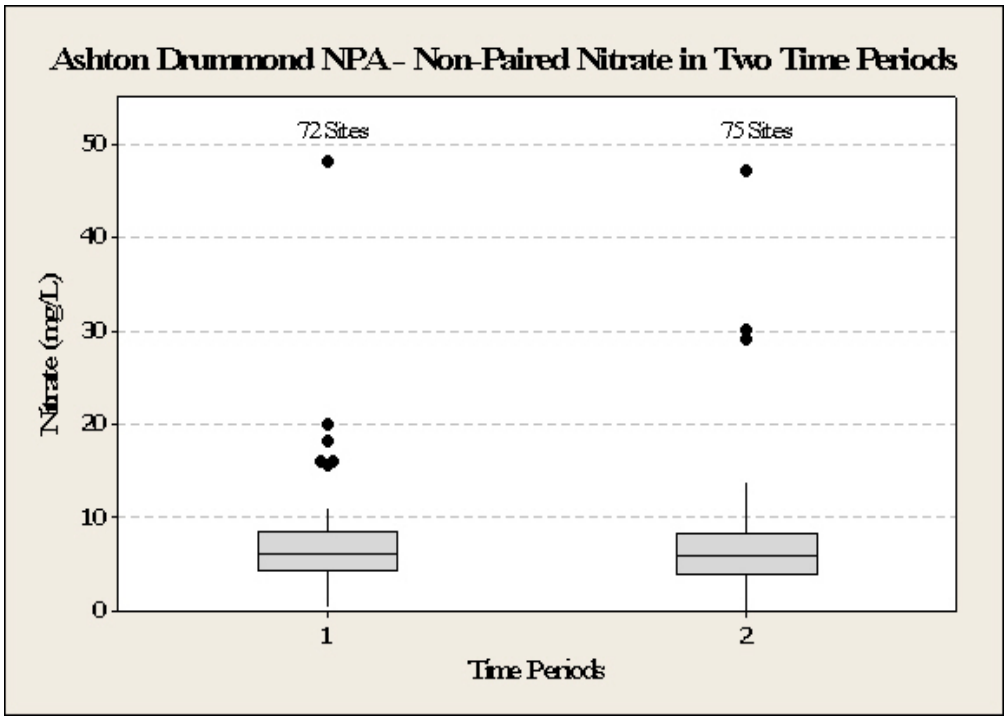

Figure A-3. Boxplots for the Non-Paired nitrate data for the Ashton Drummond NPA, Time Periods 1 and 2.

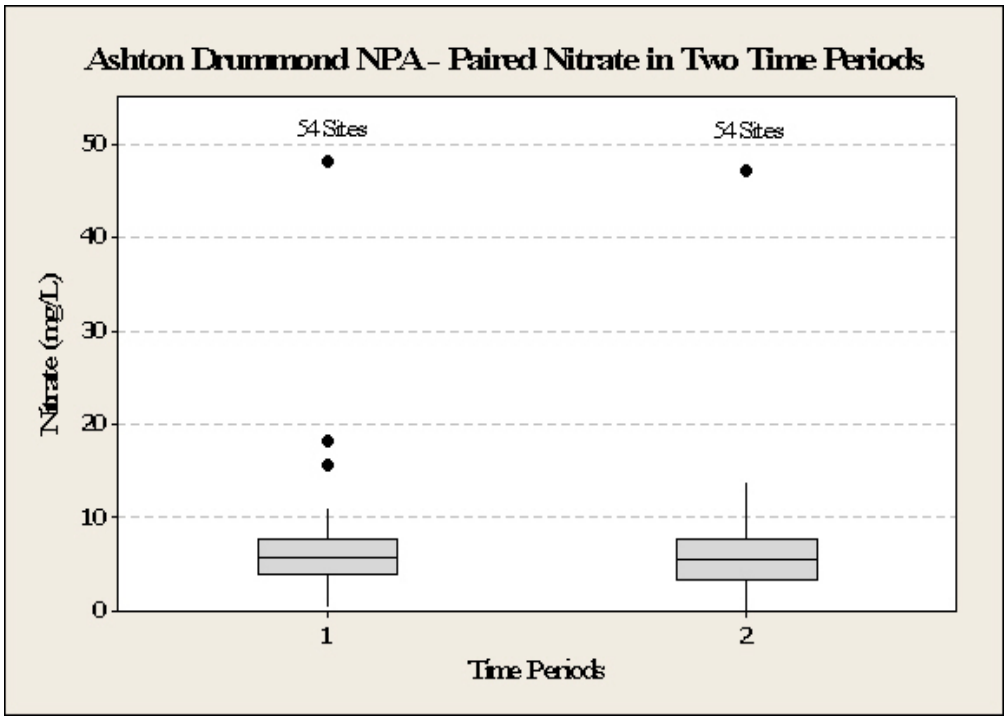

Figure A-4. Boxplots for the Paired nitrate data for the Ashton Drummond NPA, Time Periods 1 and 2.

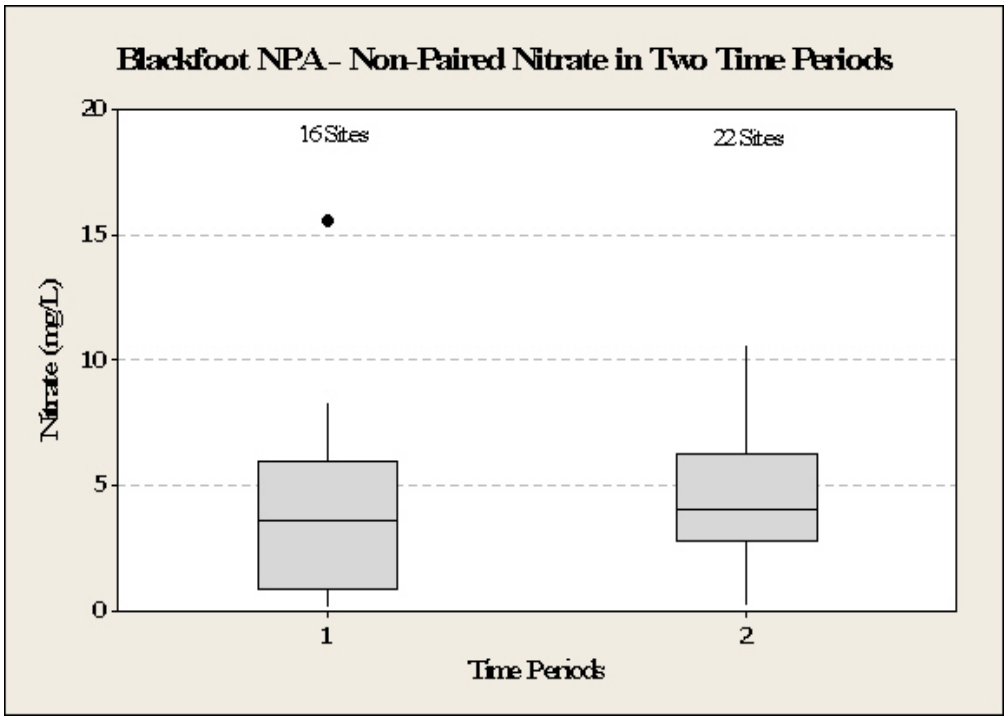

Figure A-5. Boxplots for the Non-Paired nitrate values for the Blackfoot NPA, Time Periods 1 and 2.

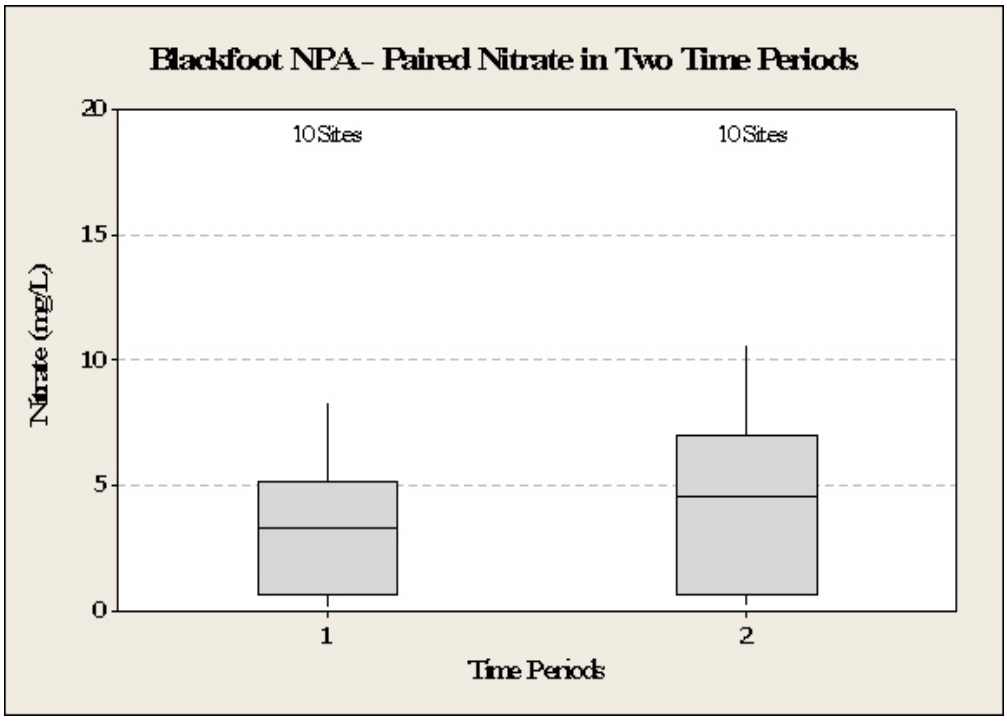

Figure A-6. Boxplots for the Paired nitrate values for the Blackfoot NPA, Time Periods 1 and 2.

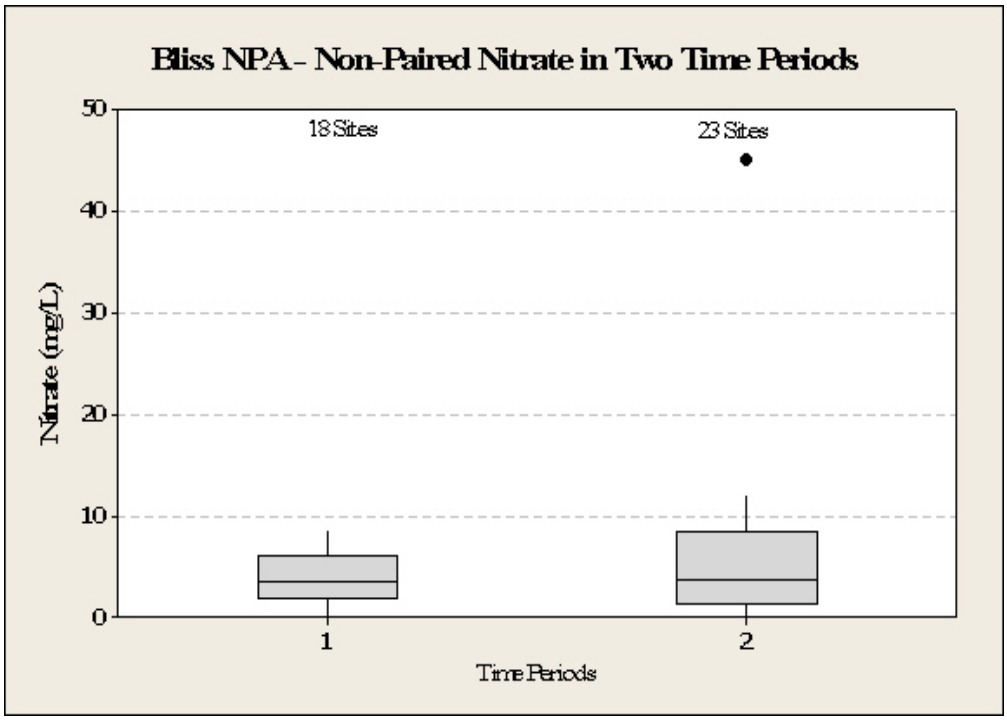

Figure A-7. Boxplots for the Non-Paired nitrate values for the Bliss NPA, Time Periods 1 and 2.

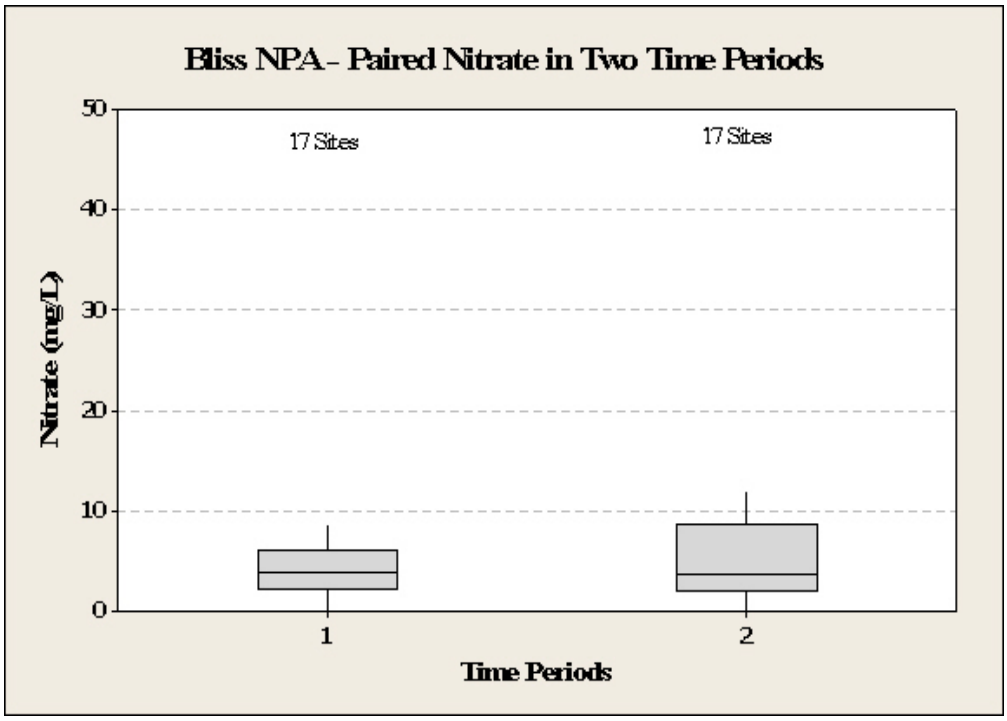

Figure A-8. Boxplots for the Paired nitrate values for the Bliss NPA, Time Periods 1 and 2.

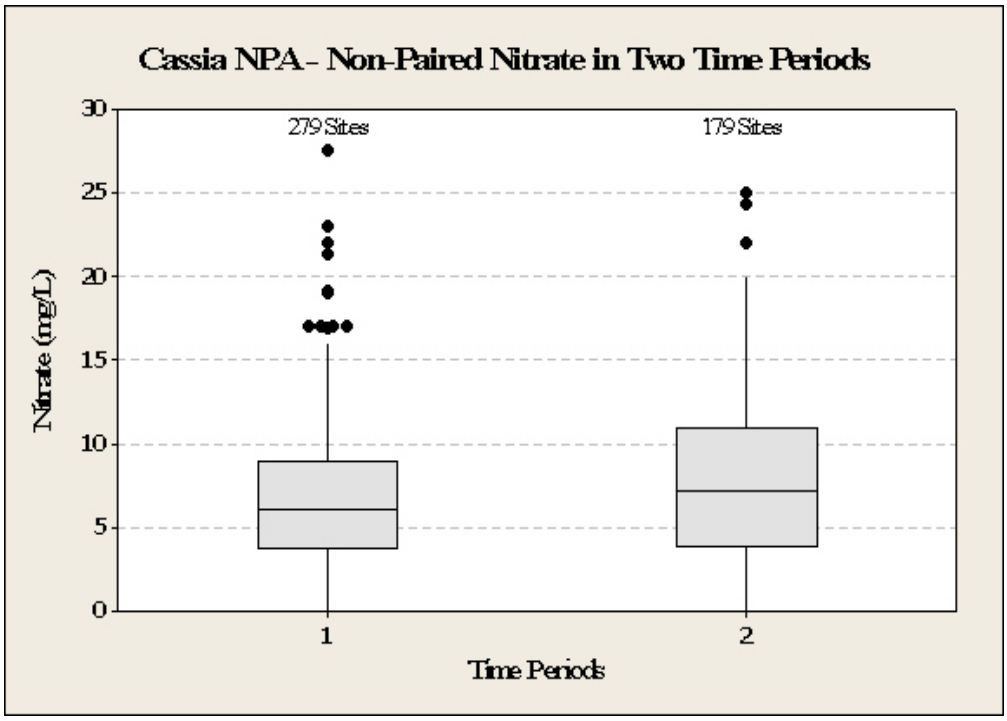

Figure A-9. Boxplots for the Non-Paired nitrate values for the Cassia NPA, Time Periods 1 and 2.

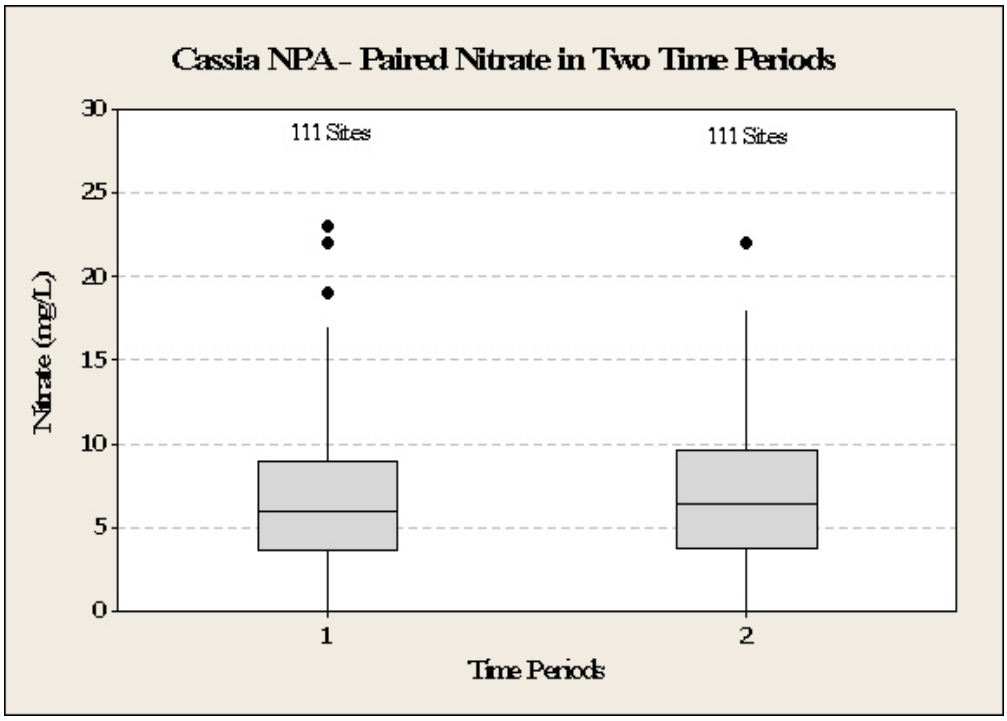

Figure A-10. Boxplots for the Paired nitrate values for the Cassia NPA, Time Periods 1 and 2.

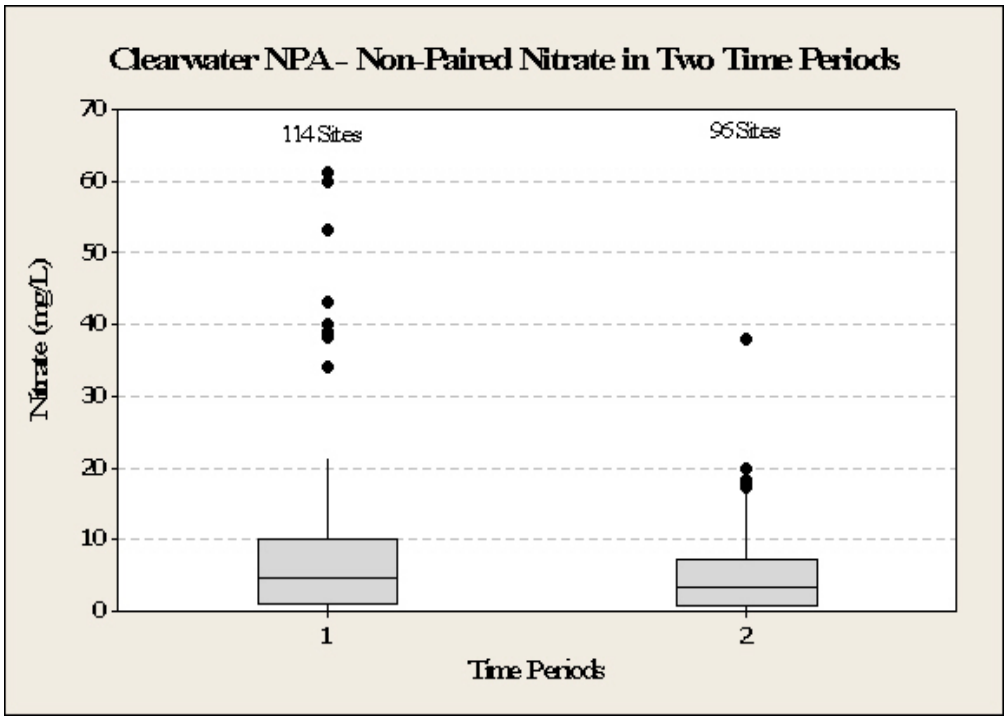

Figure A-11. Boxplots for the Non-Paired nitrate values for the Clearwater NPA, Time Periods 1 and 2.

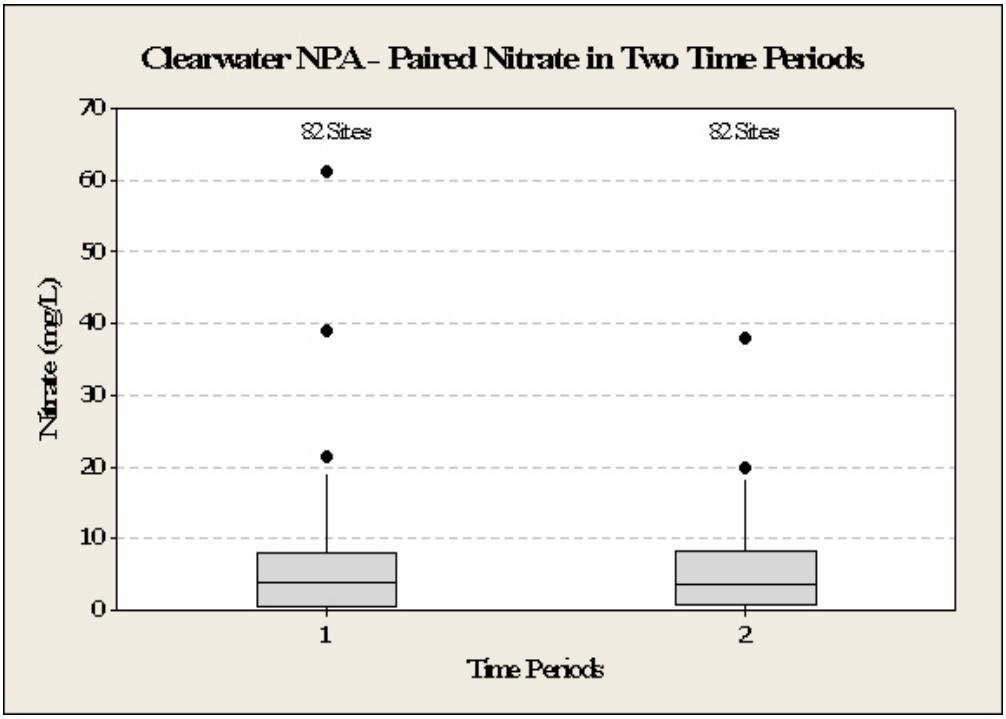

Figure A-12. Boxplots for the Paired nitrate values for the Clearwater NPA, Time Periods 1 and 2.

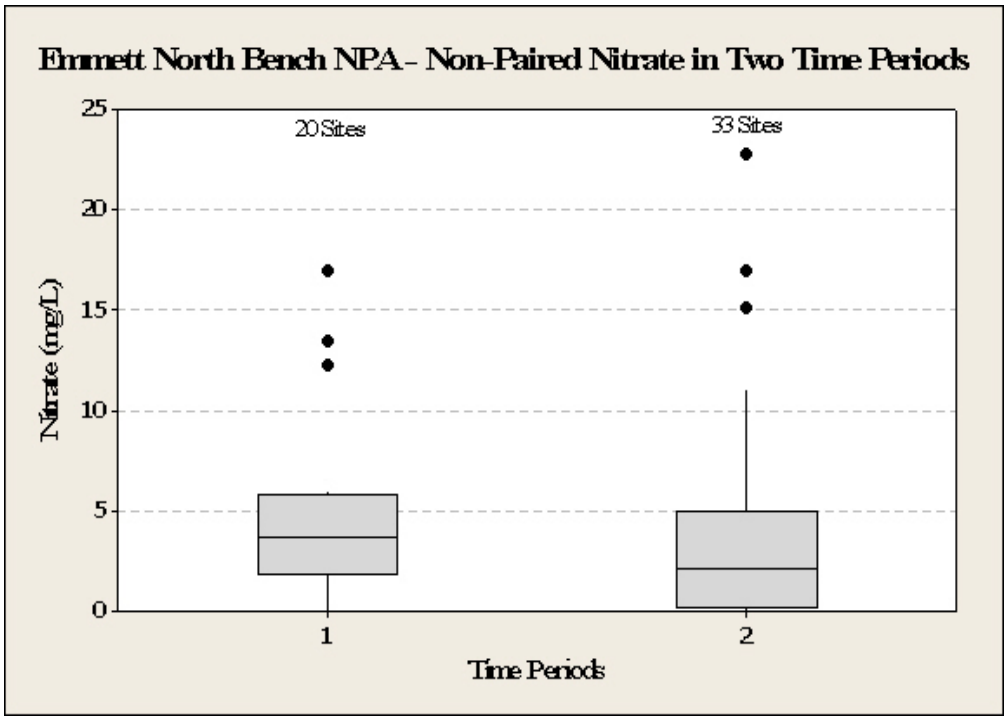

Figure A-13. Boxplots for the Non-Paired nitrate values for the Emmett North Bench NPA, Time Periods 1 and 2.

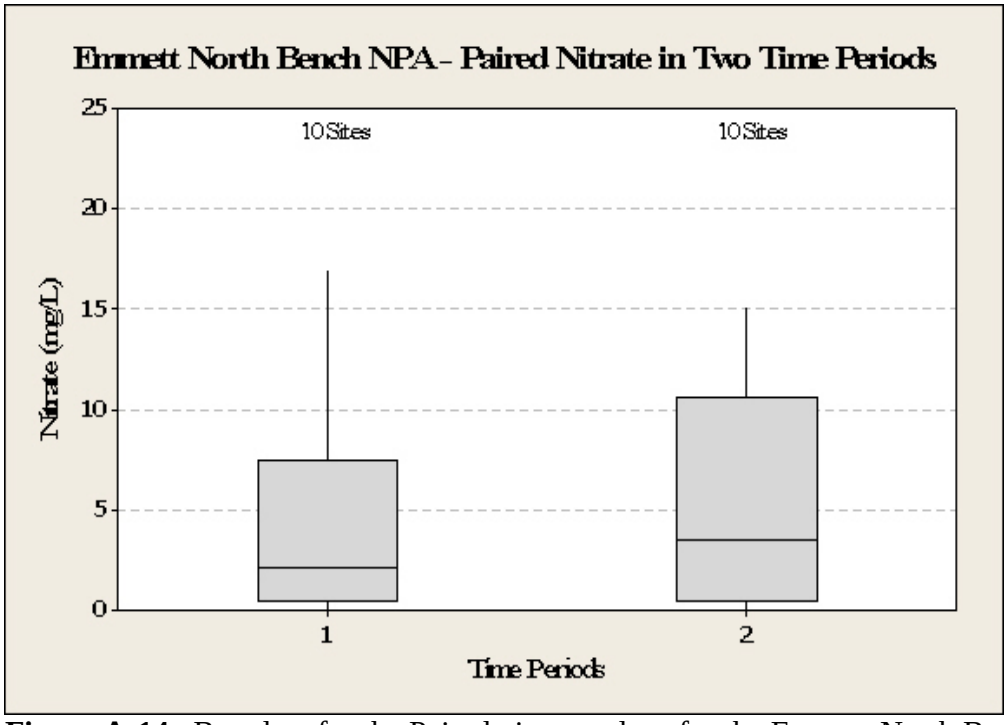

Figure A-14. Boxplots for the Paired nitrate values for the Emmett North Bench NPA, Time Periods 1 and 2.

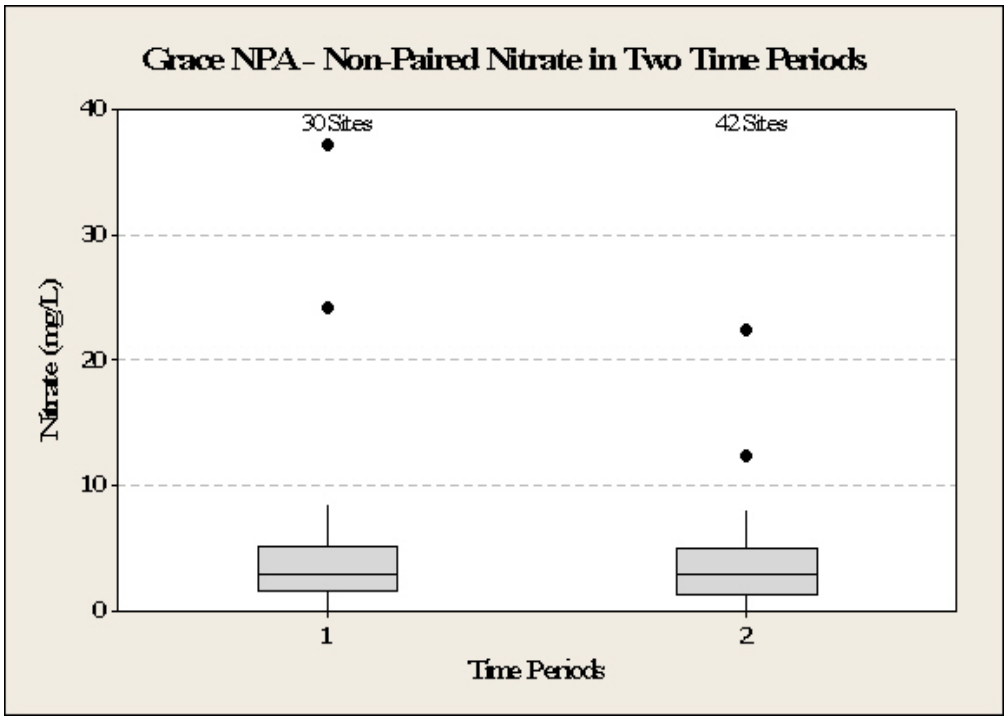

Figure A-15. Boxplots for the Non-Paired nitrate values for the Grace NPA, Time Periods 1 and 2.

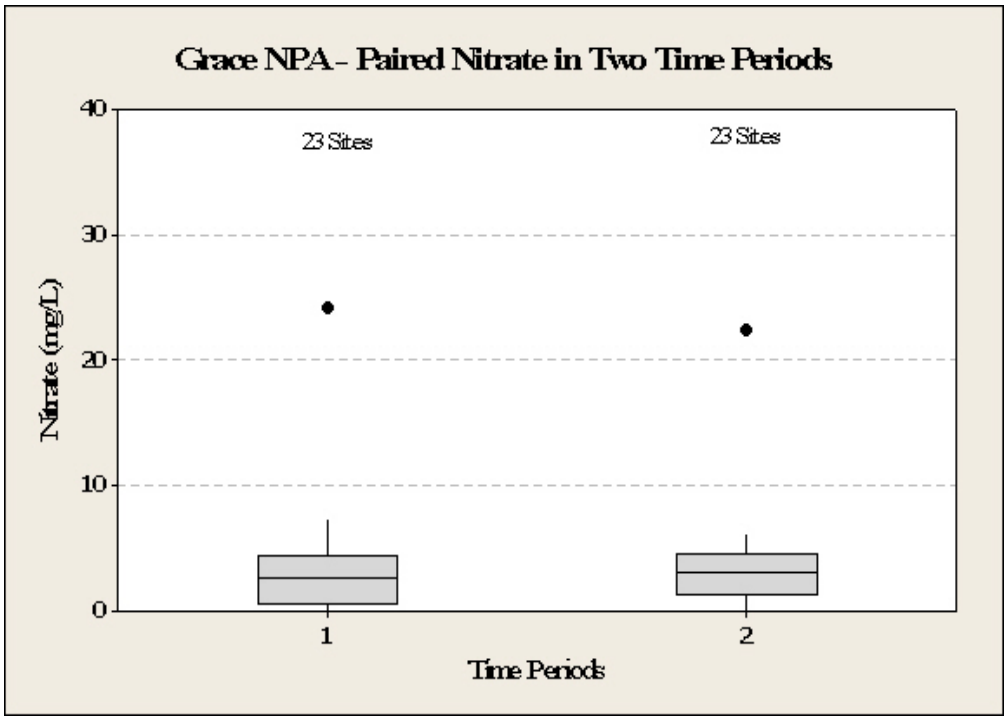

Figure A-16. Boxplots for the Paired nitrate values for the Grace NPA, Time Periods 1 and 2.

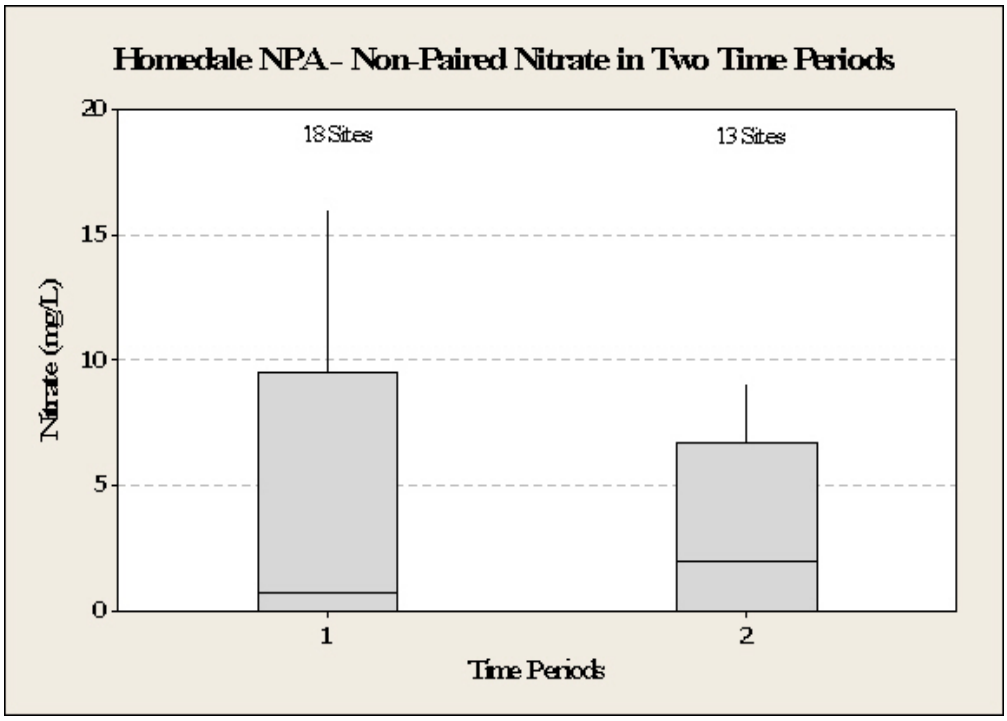

Figure A-17. Boxplots for the Non-Paired nitrate values for the Homedale NPA, Time Periods 1 and 2.

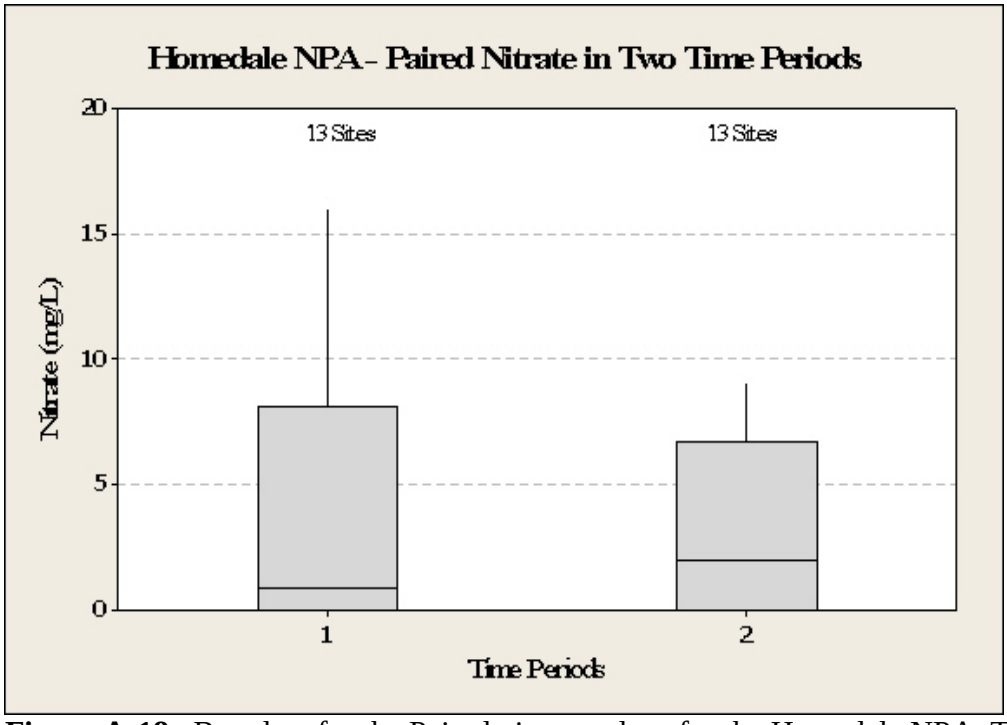

Figure A-18. Boxplots for the Paired nitrate values for the Homedale NPA, Time Periods 1 and 2.

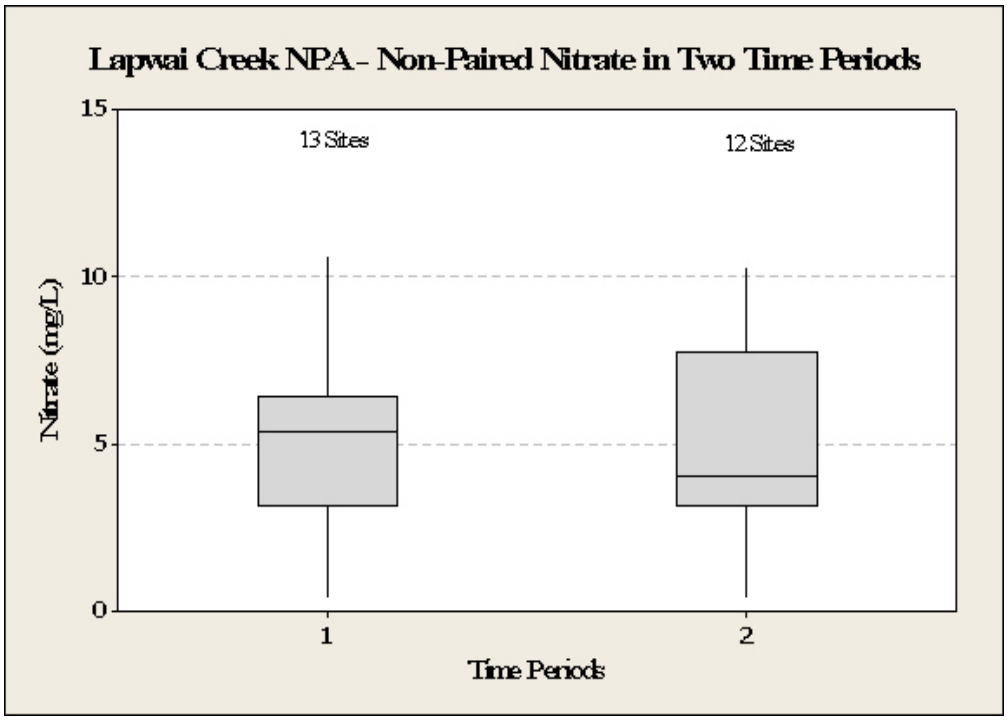

Figure A-19. Boxplots for the Non-Paired nitrate values for the Lapwai Creek NPA, Time Periods 1 and 2.

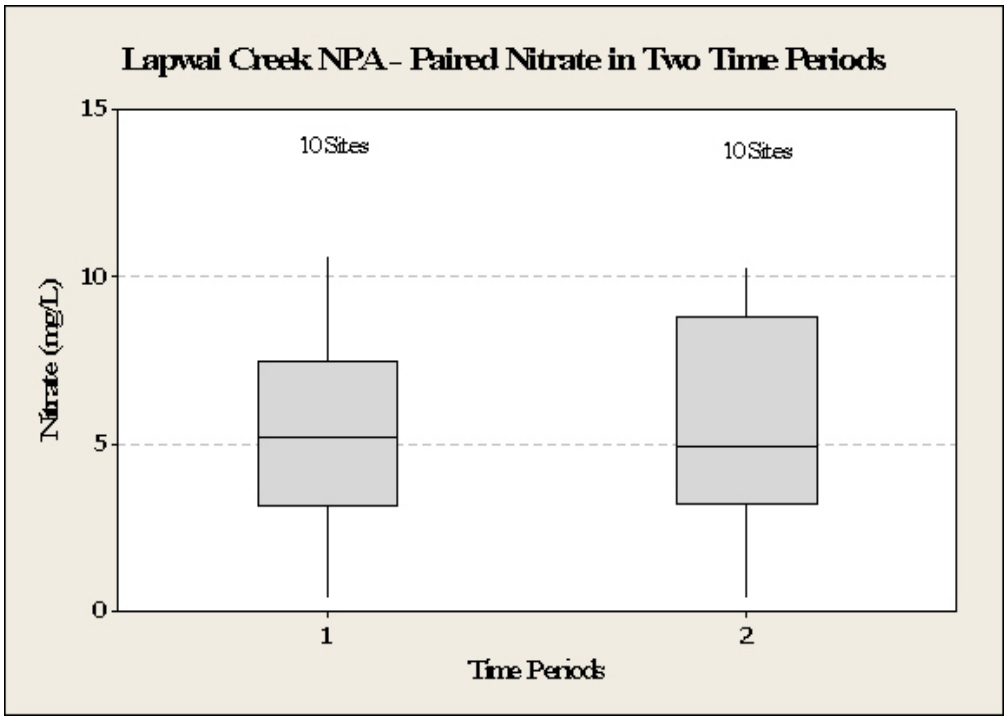

Figure A-20. Boxplots for the Paired nitrate values for the Lapwai Creek NPA, Time Periods 1 and 2.

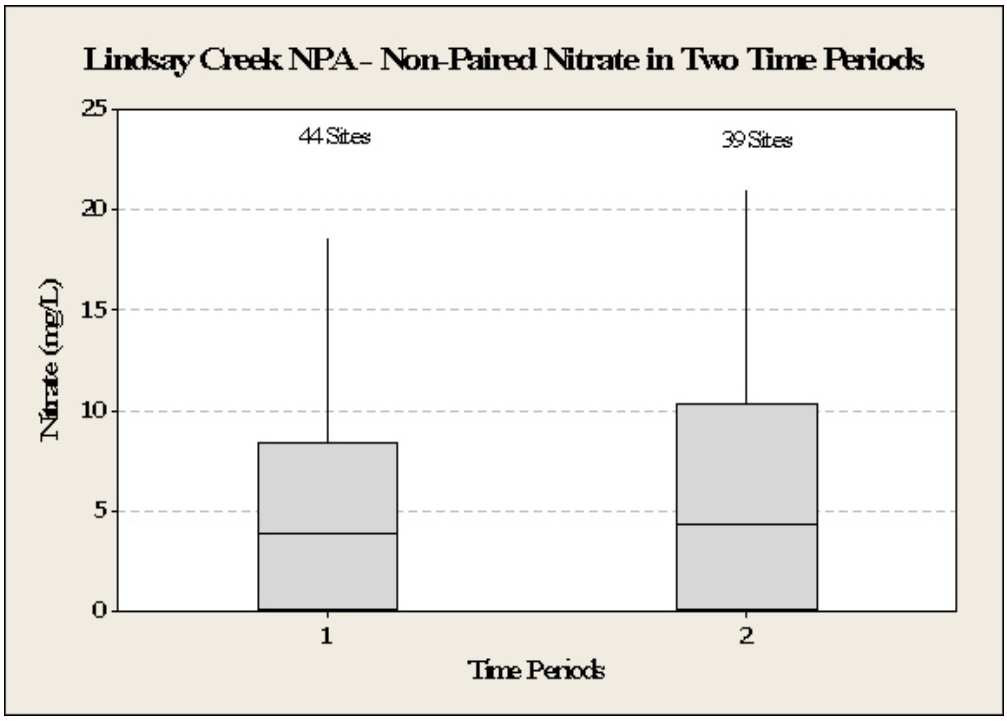

Figure A-21. Boxplots for the Non-Paired nitrate values for the Lindsay Creek NPA, Time Periods 1 and 2.

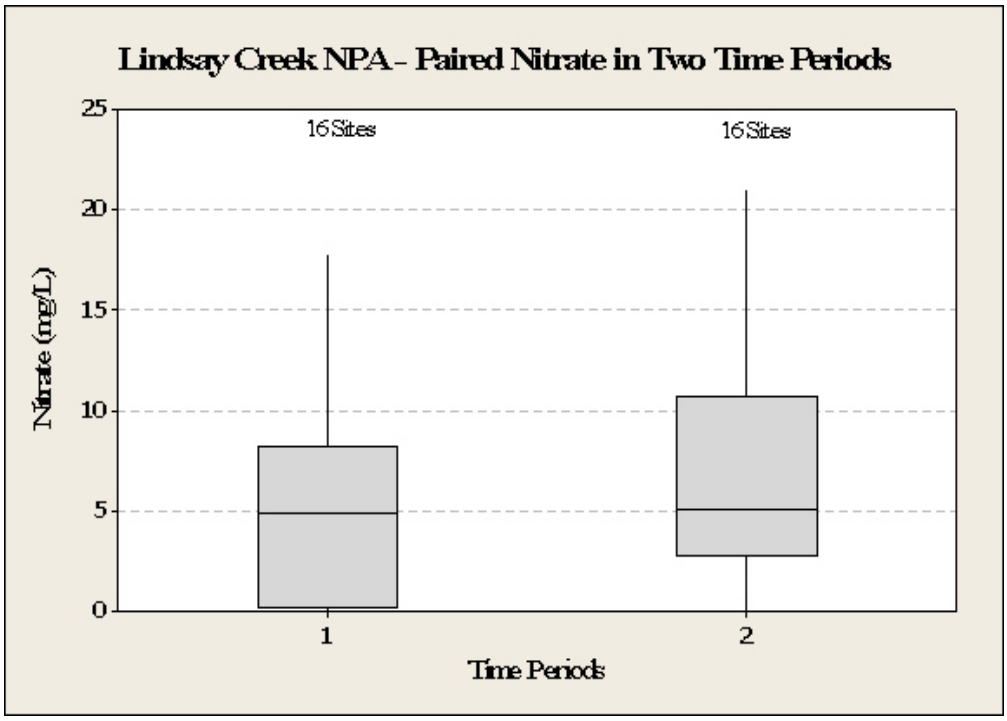

Figure A-22. Boxplots for the Paired nitrate values for the Lindsay Creek NPA, Time Periods 1 and 2.

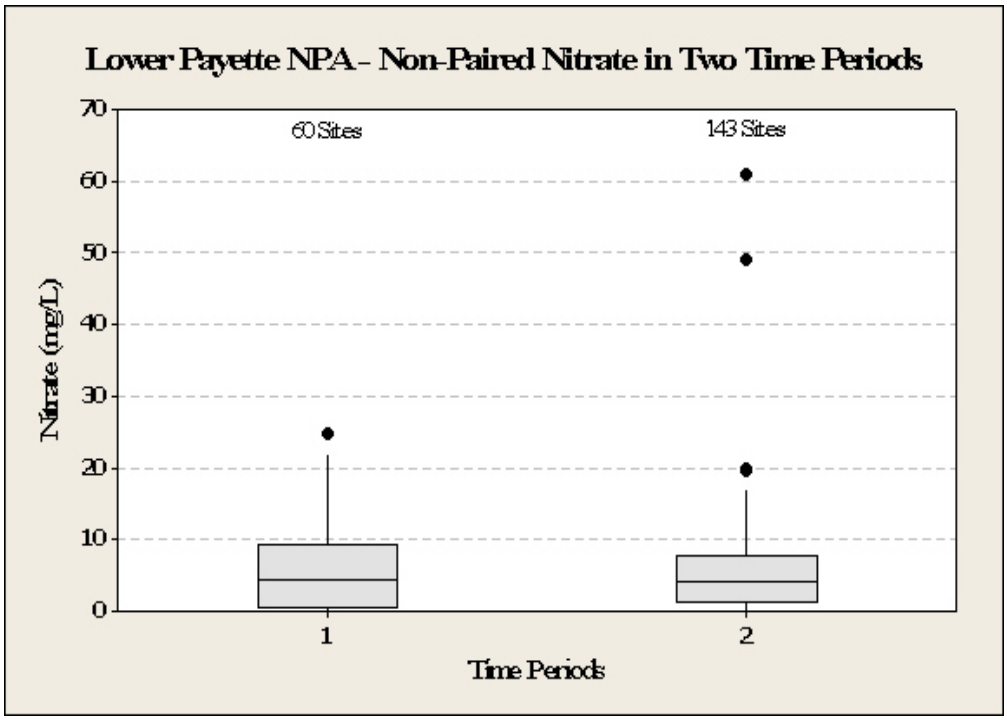

Figure A-23. Boxplots for the Non-Paired nitrate values for the Lower Payette NPA, Time Periods 1 and 2.

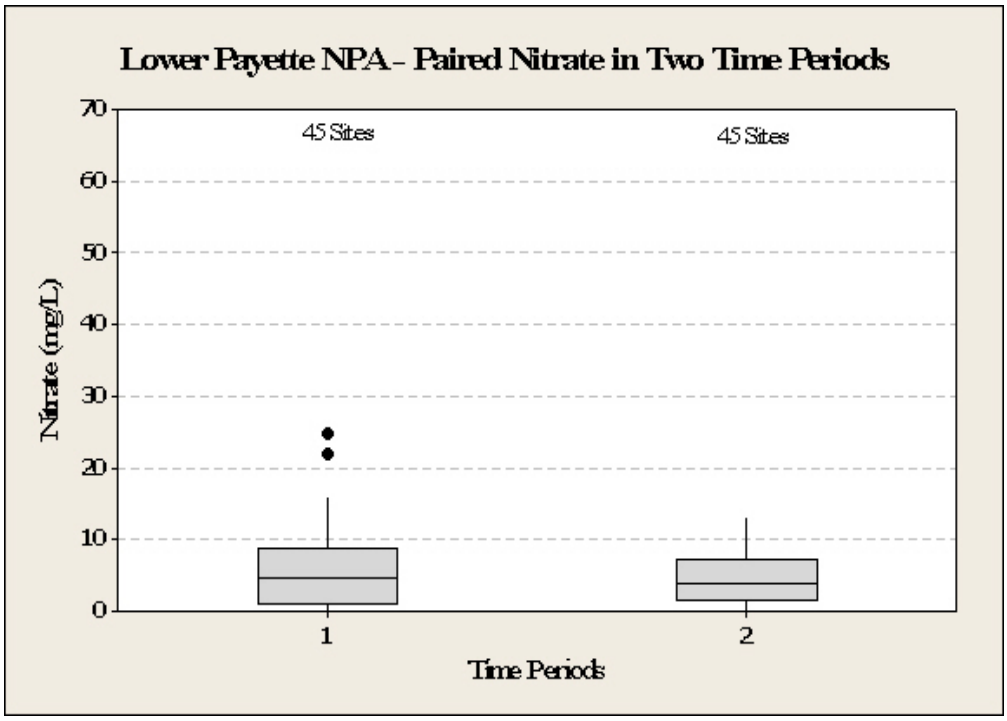

Figure A-24. Boxplots for the Paired nitrate values for the Lower Payette NPA, Time Periods 1 and 2.

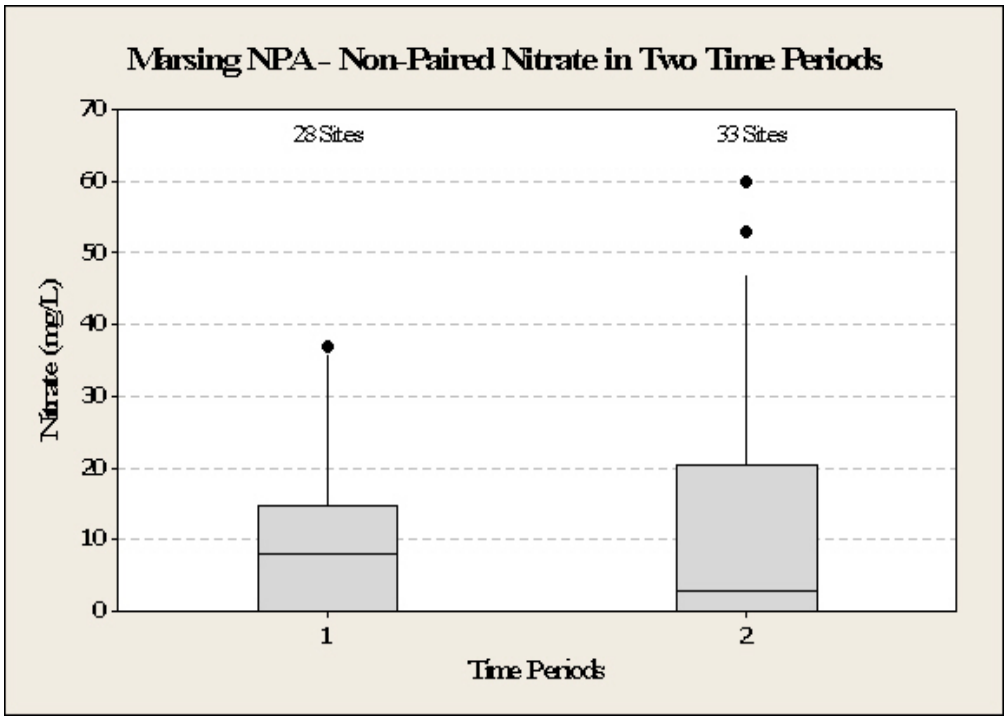

Figure A-25. Boxplots for the Non-Paired nitrate values for the Marsing NPA, Time Periods 1 and 2.

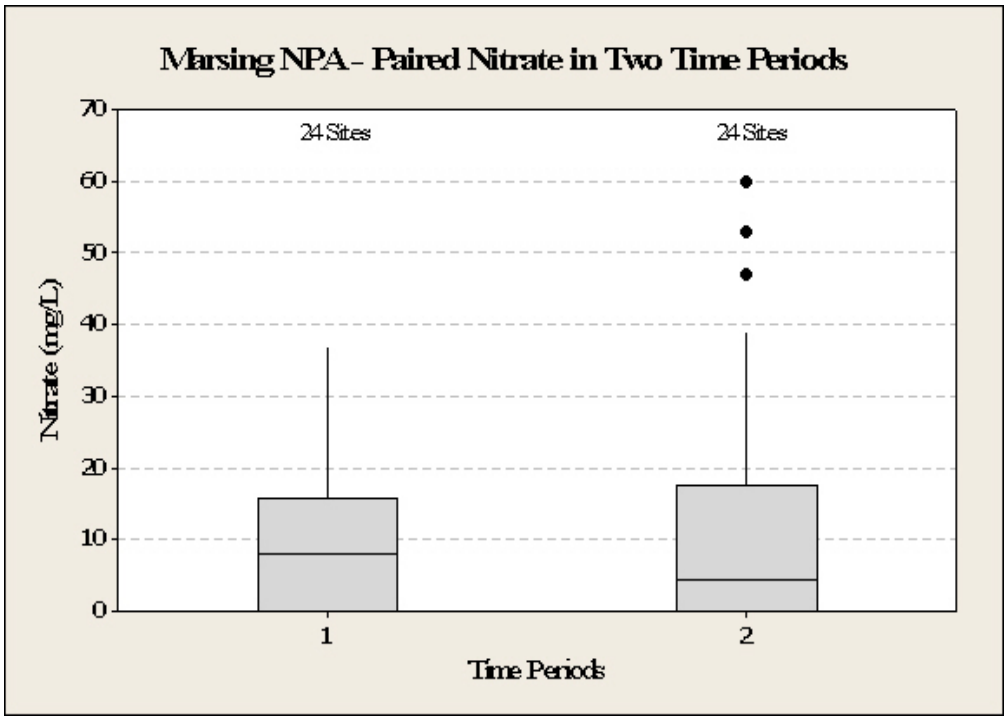

Figure A-26. Boxplots for the Paired nitrate values for the Marsing NPA, Time Periods 1 and 2.

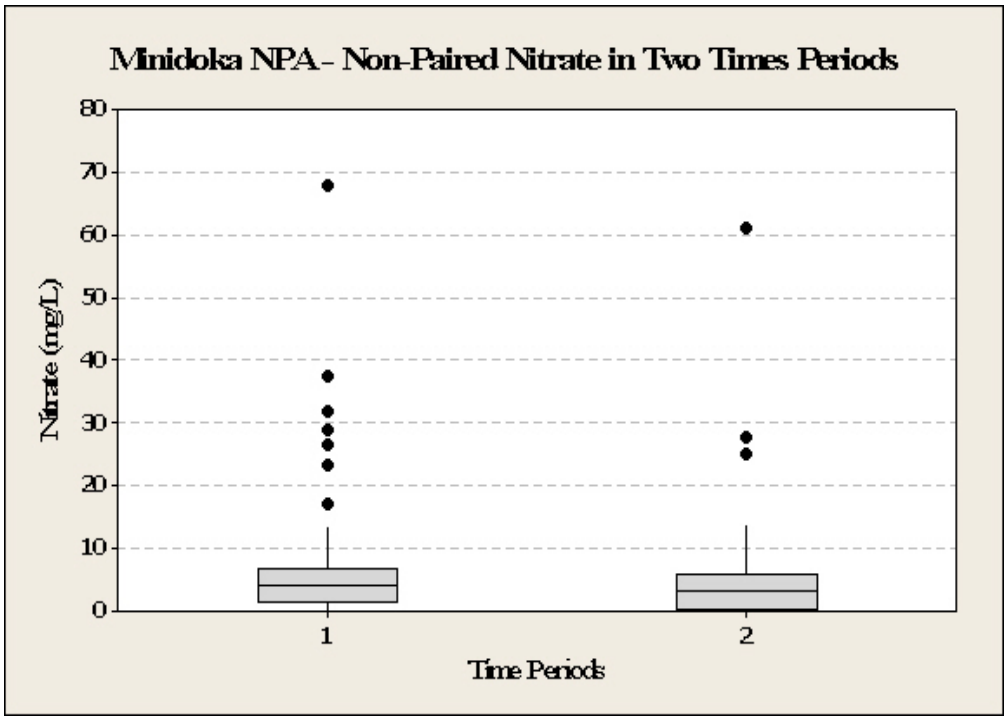

Figure A-27. Boxplots for the Non-Paired nitrate values for the Minidoka NPA, Time Periods 1 and 2.

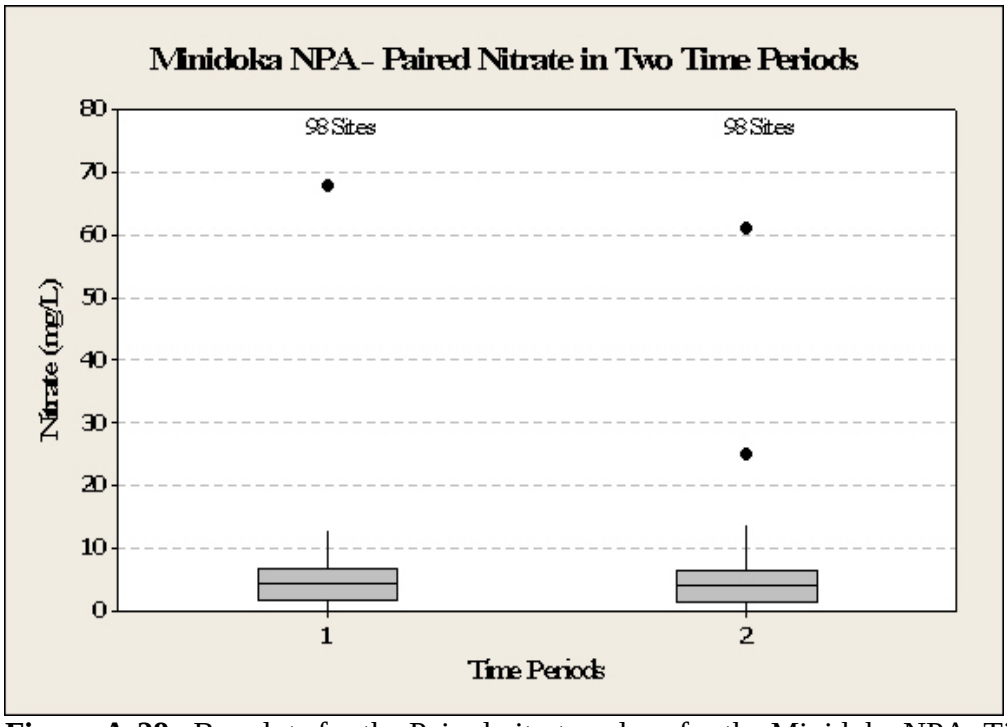

Figure A-28. Boxplots for the Paired nitrate values for the Minidoka NPA, Time Periods 1 and 2.

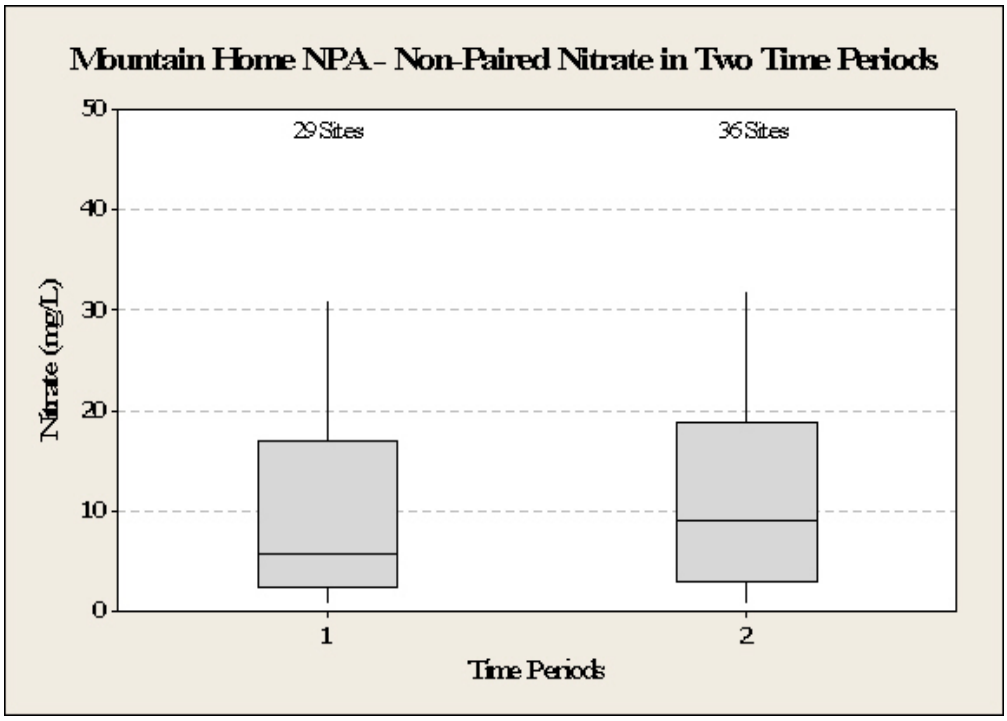

Figure A-29. Boxplots for the Non-Paired nitrate values for the Mountain Home NPA, Time Periods 1 and 2.

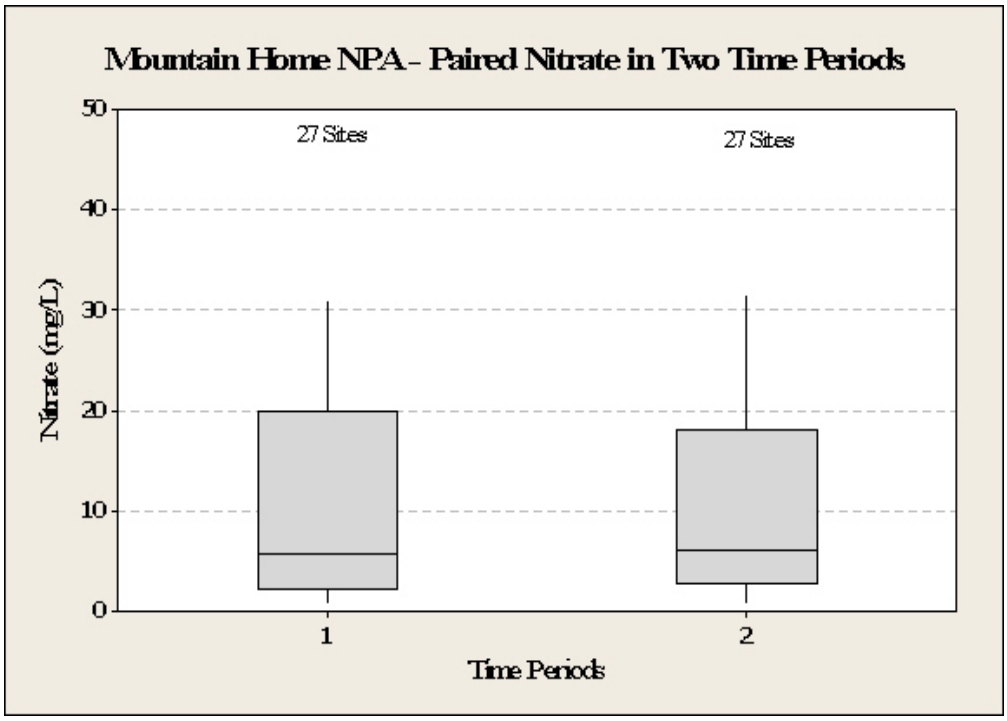

Figure A-30. Boxplots for the Paired nitrate values for the Mountain Home NPA, Time Periods 1 and 2.

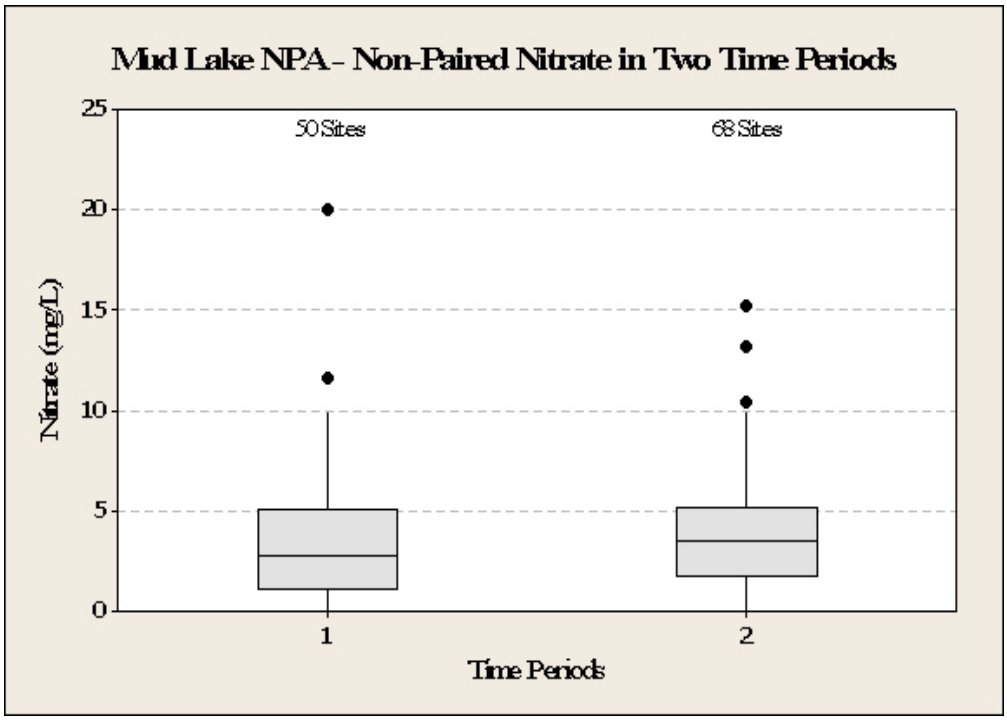

Figure A-31. Boxplots for the Non-Paired nitrate values for the Mud Lake NPA, Time Periods 1 and 2.

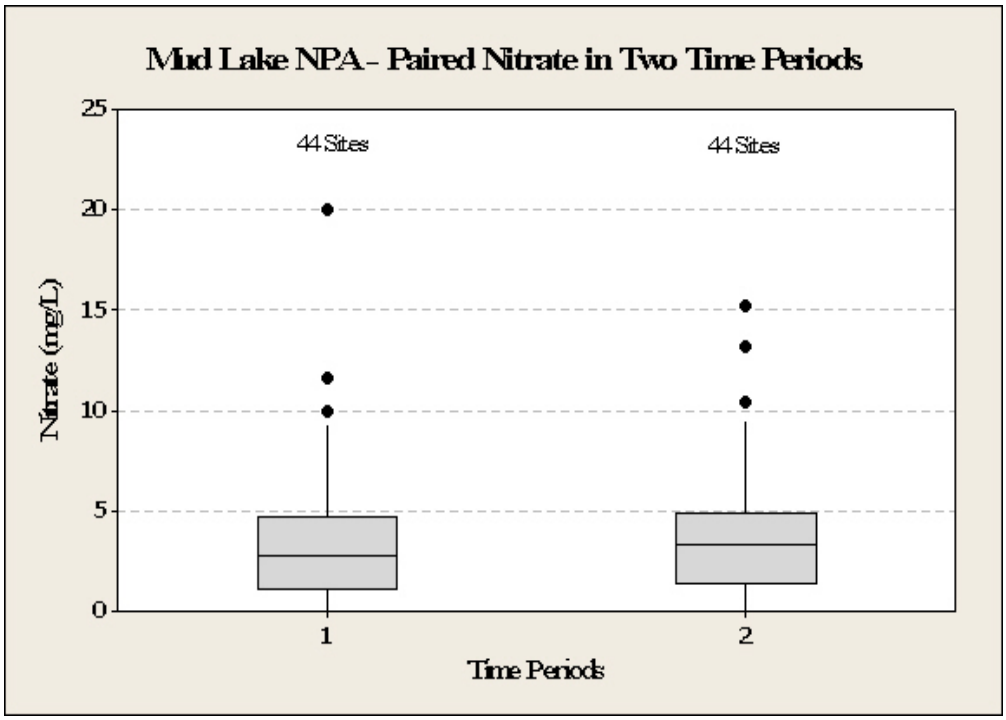

Figure A-32. Boxplots for the Paired nitrate values for the Mud Lake NPA, Time Periods 1 and 2.

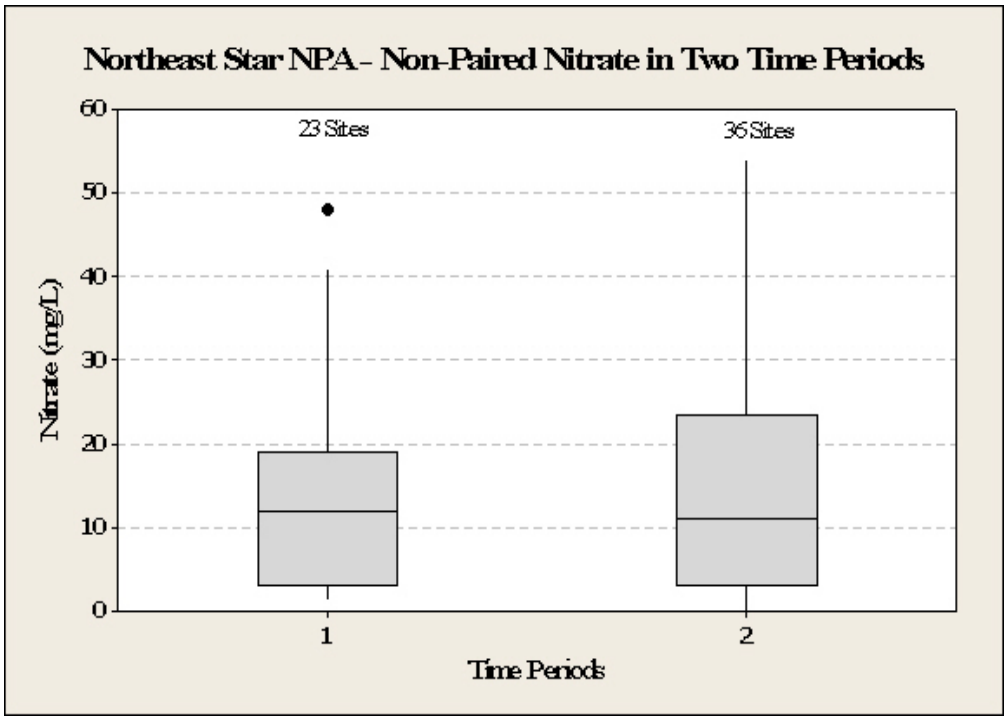

Figure A-33. Boxplots for the Non-Paired nitrate values for the Northeast Star NPA, Time Periods 1 and 2.

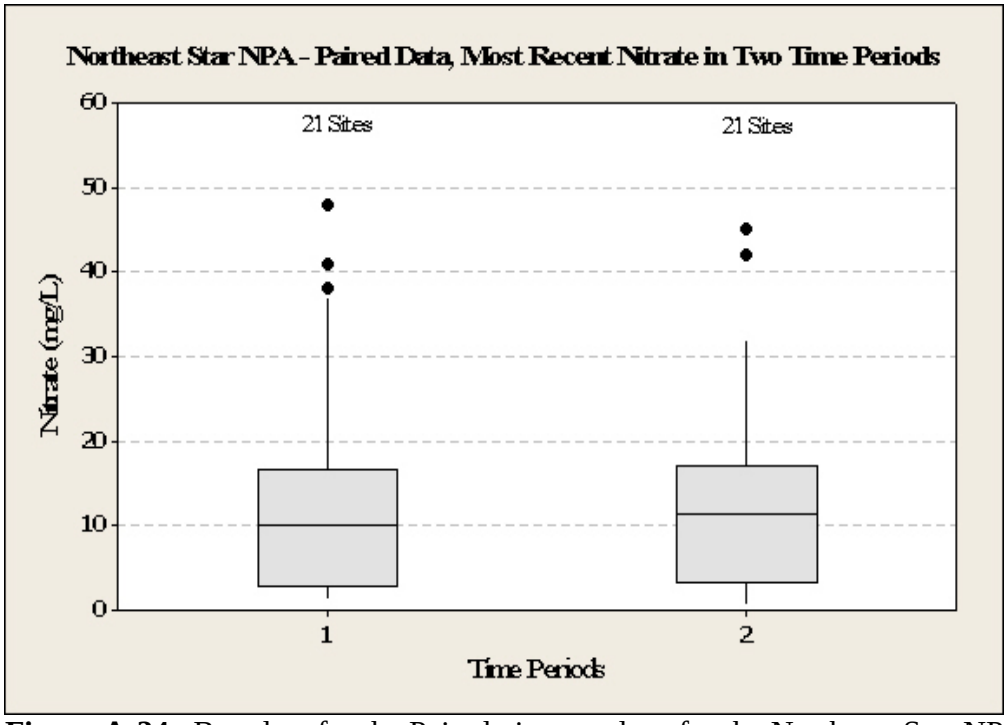

Figure A-34. Boxplots for the Paired nitrate values for the Northeast Star NPA, Time Periods 1 and 2.

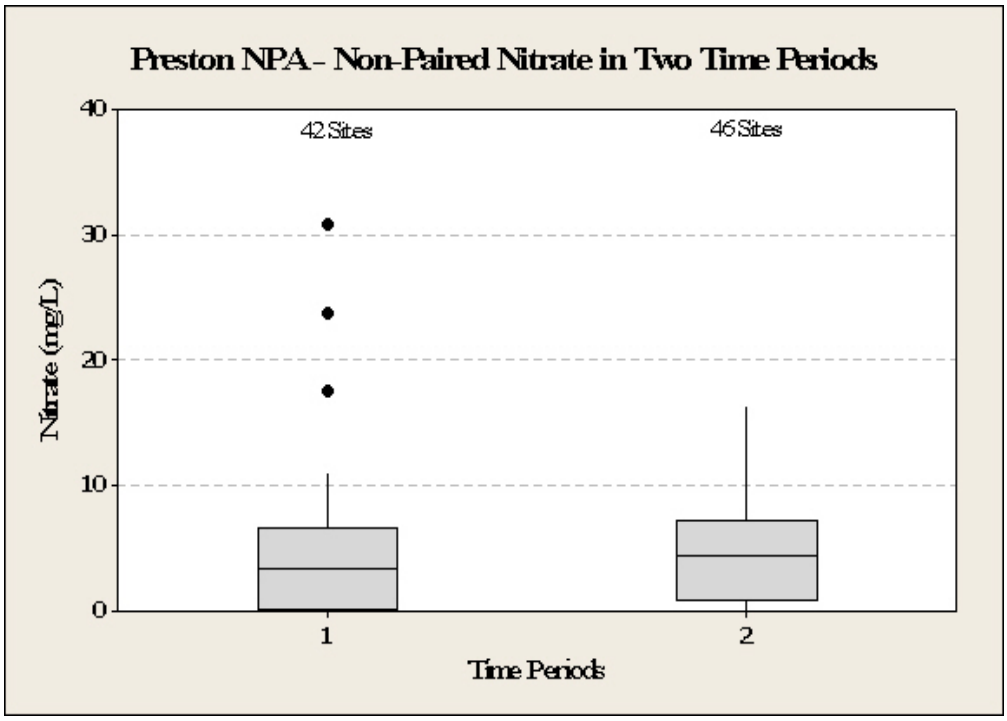

Figure A-35. Boxplots for the Non-Paired nitrate values for the Preston NPA, Time Periods 1 and 2.

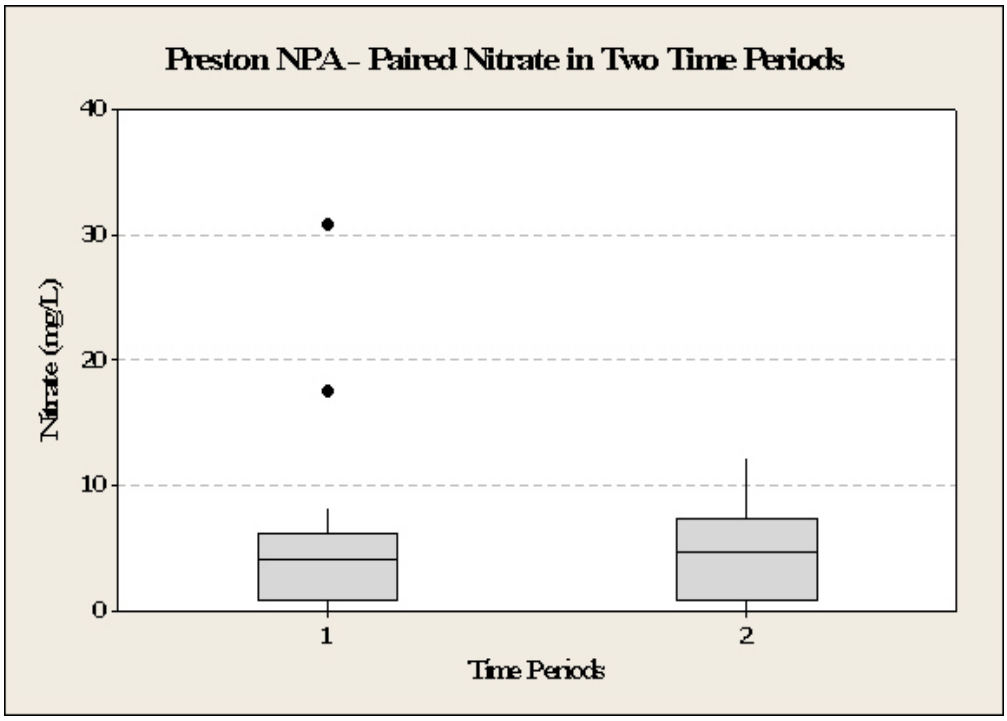

Figure A-36. Boxplots for the Paired nitrate values for the Preston NPA, Time Periods 1 and 2.

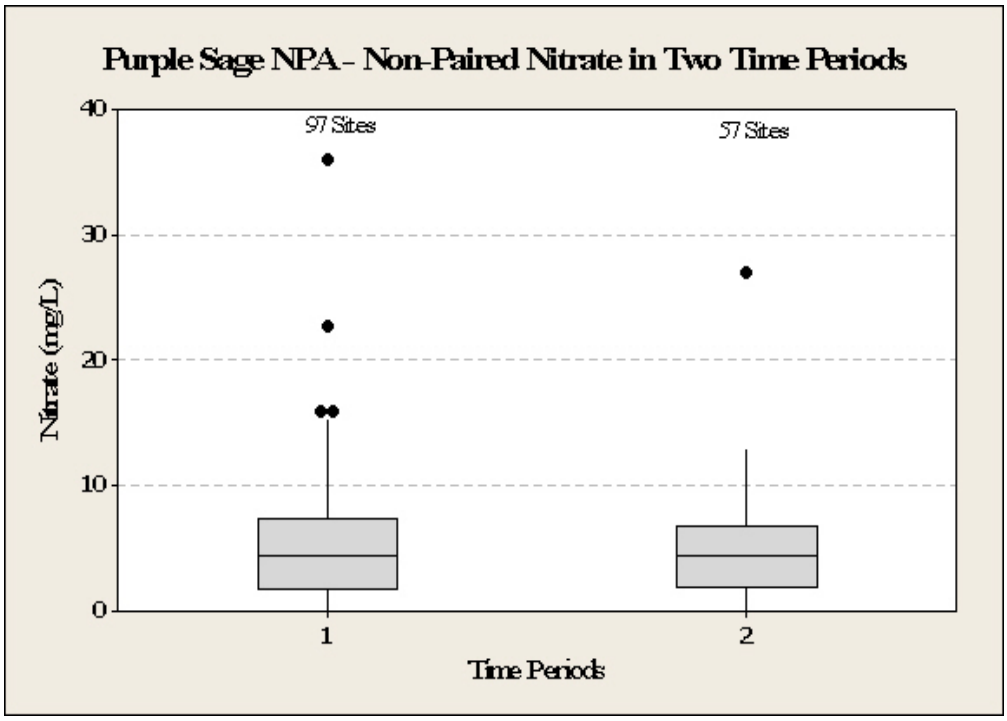

Figure A-37. Boxplots for the Non-Paired ntrate values for the Purple Sage NPA, Time Periods 1 and 2.

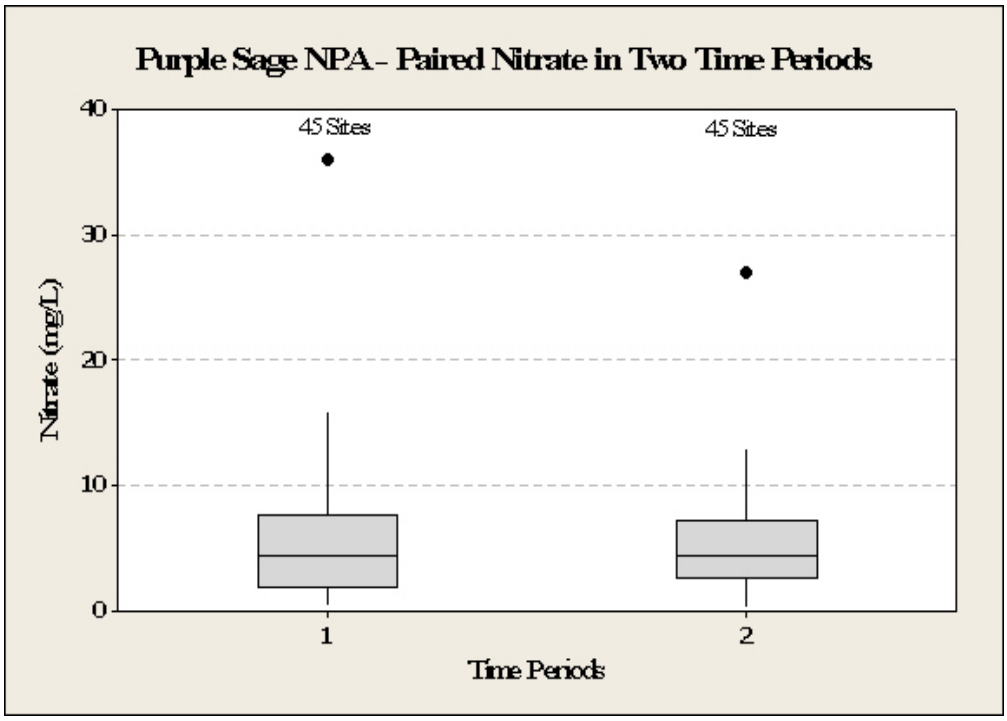

Figure A-38. Boxplots for the Paired nitrate values for the Purple Sage NPA, Time Periods 1 and 2.

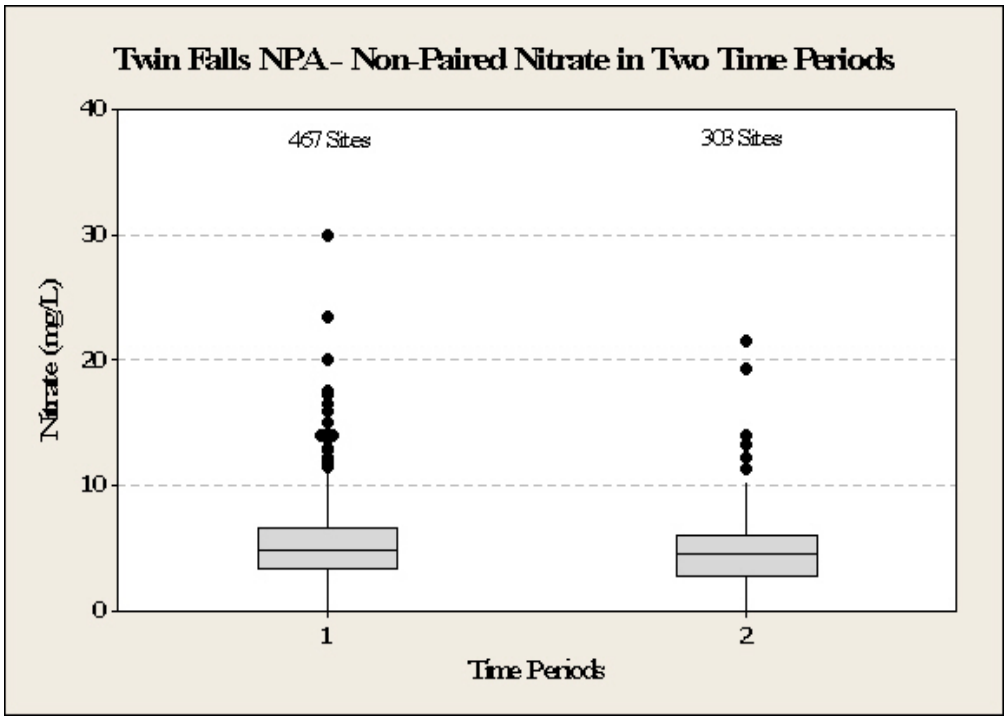

Figure A-39. Boxplots for the Non-Paired nitrate values for the Twin Falls NPA, Time Periods 1 and 2.

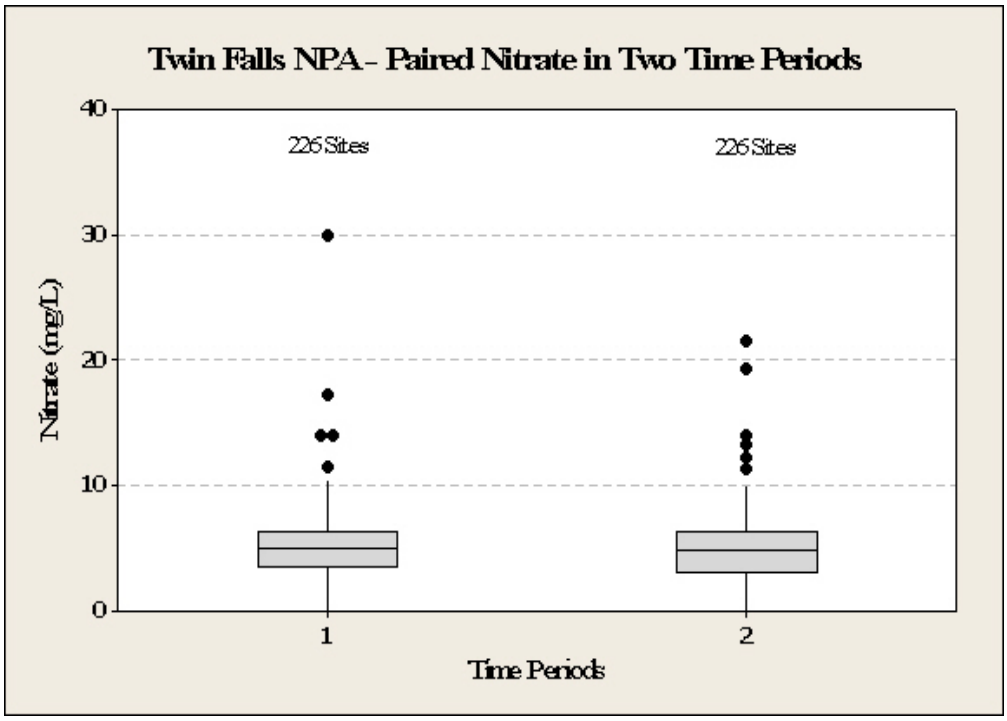

Figure A-40. Boxplots for the Paired nitrate values for the Twin Falls NPA, Time Periods 1 and 2.

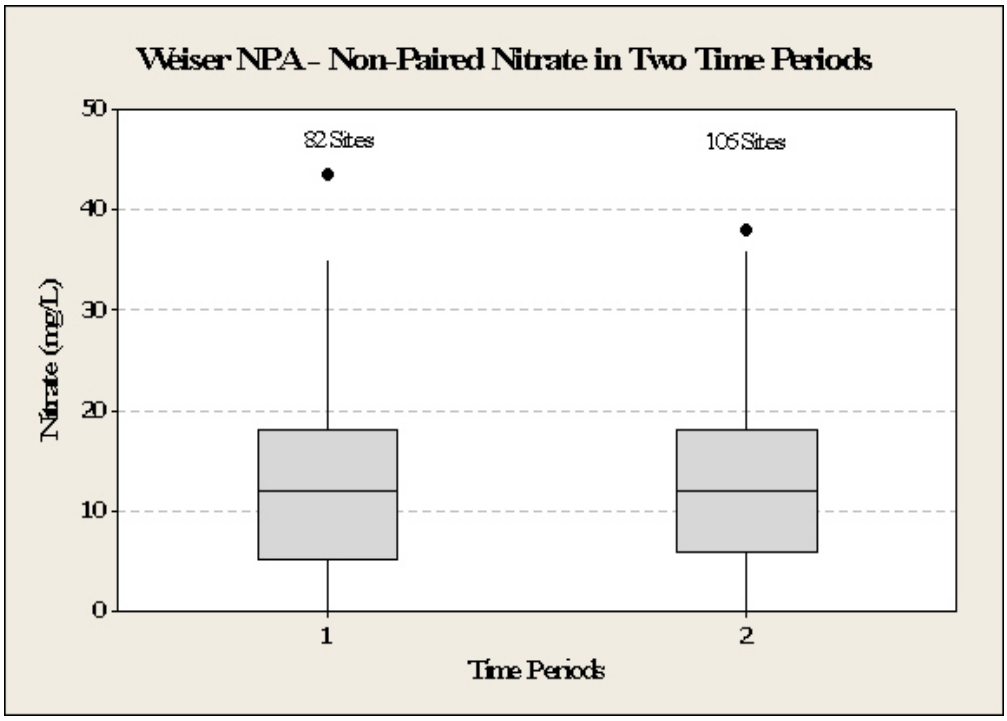

Figure A-41. Boxplots for the Most Recent Nitrate values for the Weiser NPA, Time Periods 1 and 2.

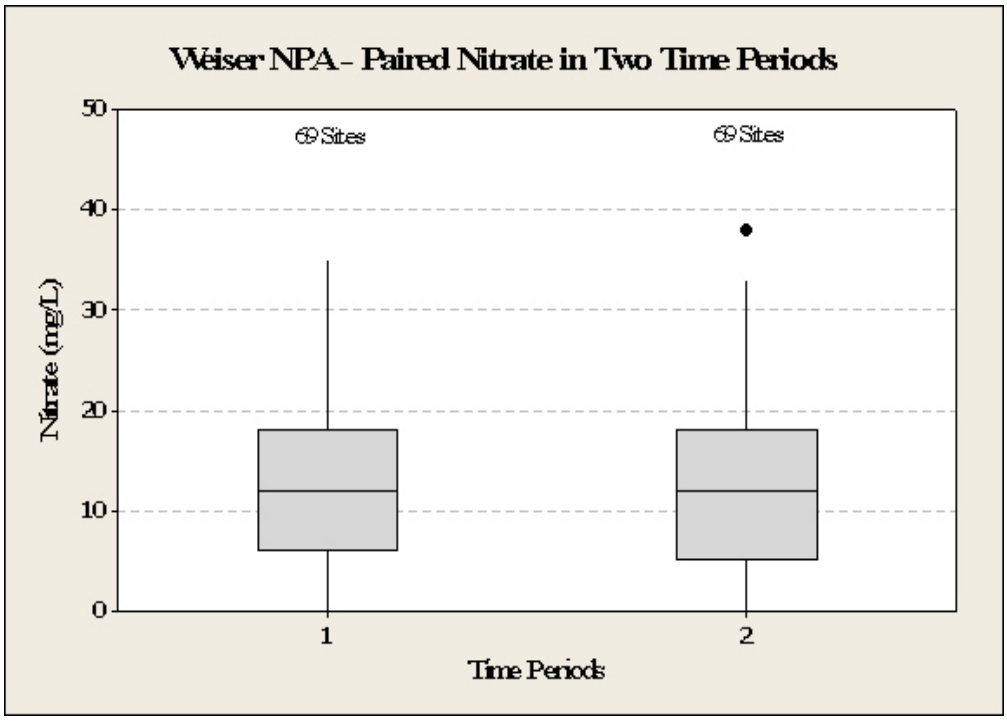

Figure A-42. Boxplots for the Paired nitrate values for the Weiser NPA, Time Periods 1 and 2.

References

Neely, K.W., 2008, Trend Analysis for Idaho's Nitrate Priority Areas, 1994-2007. Idaho Department of Water Resources, Water Information Bulletin Number 50, Part 7, 38 p. http://www.idwr.idaho.gov/WaterInformation/Publications/wib/wib50p7_nitrate_trend_analyses.pdf

Parliman, D.J., 2002, Analysis of nitrate (NO_3-N) concentration trends in 25 ground-water-quality management areas, Idaho, 1961-2001. U.S. Geological Survey Water-Resources Investigations Report 02-4056, 18 p. http://id.water.usgs.gov/PDF/wri024056/trends.pdf