DEQ Water Quality Division

State of Oregon Department of Environmental Quality

Third Trend Analysis of Food Processor Land Application Sites in the Lower Umatilla Basin Groundwater Management Area

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http://www.deq.state.or.us/wq/groundwater/lubgwma.htm

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LIST OF TABLES

LIST OF FIGURES

APPENDICES

LIST OF ACRONYMS

DEQ	Oregon Department of Environmental Quality
EPA	United States Environmental Protection Agency
GWMA	Groundwater Management Area
LOWESS	LOcally WEighted Scatterplot Smoothing
LUB GWMA	Lower Umatilla Basin Groundwater Management Area
mg/l	milligram per liter
ODA	Oregon Department of Agriculture
ppm	part per million
ppm/yr	part per million per year

EXECUTIVE SUMMARY

This document describes the third trend analysis of groundwater nitrate concentrations in wells at twelve sites operated by six facilities located in the Lower Umatilla Basin Groundwater Management Area (LUB GWMA) where food processor wastewater is treated through land application.

Purpose of this Report

The purpose of this report is to (1) evaluate one specific measure of progress detailed in the LUB GWMA Action Plan (the Action Plan) that relates solely to the food processors, and (2) to assist in the evaluation of two other measures of progress that relate to the entire GWMA. The measure of progress that relates solely to the land application of food processor wastewater (Section VIII, Item G.3.d) states that by December 2009 "monitoring data shows no violation of permit specific concentration limits since its establishment".

One measure of progress that relates to the entire GWMA occurs in the Action Plan as a December 2009 goal for all five sources of nitrate and reads "analysis and trending of monitoring well network data indicates a downward trend in nitrate levels throughout most of the GWMA". The second measure of progress that relates to the entire GWMA (Section VIII, Item E.3.b) states the evaluation of success will depend (in part) on the "evaluation of nitrate changes along several groundwater flow paths from upgradient to downgradient sites".

These goals, as well as the other December 2009 goals, will be evaluated in a separate document titled "Third Four-Year Evaluation of Action Plan Success". The current evaluation of trends at the food processor land application sites is the third time nitrate trends were evaluated at those sites, and will be used in the broader evaluation of GWMA-wide trends.

Methods

Trends in nitrate concentrations at 113 groundwater monitoring wells were calculated. Site-wide trends were calculated for each of the 12 sites using both the entire data set for the site, as well as only data from 2005 through 2009. A data smoothing algorithm was used to produce a LOWESS line, which is useful for identifying non-linear water quality changes. Maps depicting the nitrate trends and average nitrate concentrations at each well were produced. Upgradient to downgradient nitrate comparisons were made. Conclusions regarding changes in nitrate trends between trend analyses were drawn.

Conclusions

The measure of progress stating that by December 2009 "monitoring data shows no violation of permit specific concentration limits since its establishment" was met. However, it is worth noting that only five of 12 sites have concentration limits, remedial action goals, or trigger levels established. Additional work is needed at other sites to allow establishment of concentration limits.

Nitrate concentrations are still increasing at most wells, and at most sites. Overall, the rate of increase is slower than it was during previous analyses. These results suggest there is no downward trend in nitrate levels throughout most of the GWMA. The area-wide decreasing nitrate goal, as well as the other December 2009 goals, will be evaluated in a separate document titled "Third Four-Year Evaluation of Action Plan Success".

Recommendations

Both site-specific and general recommendations are made in this report. The site-specific recommendations involve additional assessment activities at several facilities in order to better define the site's groundwater flow regime and/or to determine the source of nitrate in groundwater. The general recommendations include:

- pursuing funding to gauge the effects of BMP implementation,
- continued and, when possible, expanded BMP implementation, and
- completion of the Action Plan-required trend analysis in 2014.

Although nitrate concentrations are increasing at most wells and most sites, there are some wells and sites where nitrate concentrations are decreasing. It is also recommended that DEQ and the food processors work together to identify what combination of factors produces the improving water quality trends, then apply those factors elsewhere, with the hope of improving water quality trends across the GWMA.

REGISTERED PROFESSIONAL GEOLOGIST SEAL

In accordance with Oregon Revised Statutes Chapter 672.505 to 672.705, specifically ORS 672.605 that states:

"All drawings, reports, or other geologic papers or documents, involving geologic work as defined in ORS 672.505 to 672.705 which shall have been prepared or approved by a registered geologist or a subordinate employee under the direction of a registered geologist for the use of or for delivery to any person or for public record within this state shall be signed by the registered geologist and impressed with the seal or the seal of a nonresident practicing under the provisions of ORS 672.505 to 672.705, either of which shall indicate responsibility for them.",

I hereby acknowledge that the document cited below was prepared by me.

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1.0 INTRODUCTION

1.1 Establishment of the Lower Umatilla Basin Groundwater Management Area

Oregon's Groundwater Protection Act of 1989 requires the DEQ to declare a Groundwater Management Area (GWMA) if area-wide groundwater contamination, caused primarily by nonpoint source pollution, exceeds certain trigger levels. In the case of nitrate, the trigger level is 7 milligrams per liter (mg/l) nitrate-nitrogen. Nonpoint source pollution of groundwater results from contaminants coming from diffuse land use practices, rather than from discrete sources such as a pipe or ditch. The contaminants of nonpoint source pollution can be the same as from point source pollution, and can include sediment, nutrients, pesticides, metals, and petroleum products. The sources of nonpoint source pollution can include construction sites, agricultural areas, forests, stream banks, roads, and residential areas.

When a GWMA is declared, the Groundwater Protection Act requires the establishment of a local Groundwater Management Area Committee comprised of affected and interested parties. The committee works with and advises the state agencies that are required to develop an action plan to reduce groundwater contamination in the area.

The Lower Umatilla Basin Groundwater Management Area (LUB GWMA) was declared in 1990 after nitrate contamination was identified in a 352,000-acre area in the northern portions of Umatilla and Morrow counties. The location of the LUB GWMA is shown in Figure 1-1. Groundwater samples from private wells had nitrate contaminations above the federal safe drinking water standard in many samples collected from the area. A four-year comprehensive study of the area was conducted in the early 1990s by the DEQ, the Oregon Water Resources Department, and the Oregon Health Division (now known as the Oregon Department of Human Services). The 1995 report titled "Hydrogeology, Groundwater Chemistry, & Land Use in the Lower Umatilla Basin Groundwater Management Area" identified five potential sources of nitrate loading to groundwater:

1. Confined Animal Feeding Operations,
2. Irrigated Agriculture
3. Land Application of Food Processing Wastewater
4. Septic Systems (rural residential areas), and
5. The Umatilla Chemical Depot Washout Lagoons

The LUB GWMA Action Plan was finalized in December 1997. The Action Plan details the activities to be conducted by the various agencies and organizations involved. The Umatilla and Morrow County Soil and Water Conservation Districts are the local agencies leading implementation of the Action Plan. The DEQ and the Oregon Department of Agriculture (ODA) have oversight responsibility. Local governments, private industry, and the US Army are also involved in implementation of the Action Plan.

DEQ and the Committee decided to implement the Action Plan on a voluntary basis recognizing that individuals, businesses, organizations, and governments will, if given adequate information and encouragement, take positive actions to adopt or modify practices and activities to reduce contaminant loading to groundwater.

The Action Plan recommends general activities and specific tasks to be conducted by involved agencies and groups representing the five sources of nitrate loading. The Action Plan also identifies methods and a schedule for evaluating progress in implementing the Action Plan.

1.2 Purpose of This Report

The purpose of this report is to (1) evaluate one specific measure of progress detailed in the LUB GWMA Action Plan (the Action Plan) that relate solely to the food processors, and (2) to assist in the evaluation of two other measures of progress that relates to the entire GWMA. The measure of progress that relates solely to the land application of food processor wastewater (Section VIII, Item G.3.d) states that by December 2009 "monitoring data shows no violation of permit specific concentration limits since its establishment".

One measure of progress that relates to the entire GWMA occurs in the Action Plan as a December 2009 goal for all five sources of nitrate and reads "analysis and trending of monitoring well network data indicates a downward trend in nitrate levels throughout most of the GWMA". The second measure of progress that relates to the entire GWMA (Section VIII, Item E.3.b) states the evaluation of success will depend (in part) on the "evaluation of nitrate changes along several groundwater flow paths from upgradient to downgradient sites".

These goals, as well as the other December 2009 goals, will be evaluated in a separate document titled "Third Four-Year Evaluation of Action Plan Success". The current evaluation of trends at the food processor land application sites is the third time nitrate trends were evaluated at those sites, and will be used in the broader evaluation of GWMA-wide trends. The first trend analysis is described in DEQ (2004) while the second trend analysis is described in DEQ (2007a), both of which are available at http://www.deq.state.or.us/wq/groundwater/lubgwma.htm .

It is worth noting that many of the increasing trends identified in this report are at upgradient wells, which indicates there is some contribution from offsite sources. Increasing site-wide trends do not necessarily indicate nitrate contributions from the site.

1.3 Methodology

The evaluation described in this report involved four aspects:

1) an evaluation of nitrate trends at wells located near where food processing wastewater is land applied,
2) an evaluation of average nitrate concentrations at these wells,
3) a comparison to previous trends and average concentrations (where well networks allowed), and
4) an evaluation of site-wide trends.

Nitrate concentrations at groundwater monitoring wells were evaluated for monotonic trends using the Seasonal Kendall technique (when no data were censored[1]) or the Akritas-Theil-Sen version of Kendall's tau technique (when data were censored). Site-wide trends were calculated using the Regional Kendall technique for each site using the entire data set for the site as well as data from 2005 through 2009. A data smoothing algorithm was used to produce a LOWESS line, which is useful for identifying non-linear water quality changes. Maps depicting the nitrate trends and average nitrate concentrations at each well were produced. Nitrate trends and average nitrate concentrations were compared between this and the previous trend analysis. Conclusions regarding changes in nitrate trends between the three analyses were drawn.

Analysis of Data Where Nitrate Was Not Detected

Some wells exhibited some data censoring (i.e., when values are reported as below a detection limit). For those wells with some data censoring, two values were entered into the electronic files for each result. The first value was the measured concentration for detected concentrations or the detection limit for censored values. The second value was a code indicating if the first value represents a detected concentration or the detection limit for a censored observation.

The censored data were recorded in this manner to allow more statistically robust evaluations of data set characteristics and trends. The procedures recommended in Helsel (2005) for computing summary statistics, estimating seasonality, and calculating trends were followed using macros written by Dr. Helsel for use within the Minitab statistical software program. These include the following:

- For wells with a small amount of censoring (<50%), the mean and median were calculated by the Kaplan-Meier method using the KMSTATS macro.
- For wells with a significant amount of censoring (50% to 80%), the mean and median were calculated by the Maximum Likelihood Estimation method using the MLEBoot macro.

[1] In the statistical literature, data reported as below or above a detection limit are called "censored" data. For this report, nitrate data reported as below a detection limit are censored.

- Seasonality at wells with censoring was evaluated using the nonparametric Kruskal-Wallis test for comparing medians. The CensKW macro was used for these calculations.

Trend Analysis Technique Used

Nitrate results from wells with no censoring were analyzed for a monotonic trend using the Seasonal Kendall test. The Seasonal Kendall test was developed by the United States Geological Survey in the 1980s and has become the most frequently used test for trend in the environmental sciences (Helsel, et.al. 2006). The Seasonal Kendall test performs separate tests for trends in each season, and then combines the results into one overall result.

The Seasonal Kendall test accounts for seasonality by computing the Mann-Kendall test on each season separately, and then combining the results. For example, February data are compared only to February data. No comparisons are made across seasonal boundaries. The overall Seasonal Kendall trend slope is computed as the median of all slopes between data points within the same season. No cross-season slopes contribute to the overall estimate of the Seasonal Kendall trend slope. This slope is the median rate of change over time. This overall result reflects whether there is a trend with time for that location, blocking out all seasonal differences in the pattern of change (Helsel and Frans, 2006).

Trends at wells with censoring were calculated by the Akritas-Theil-Sen version of Kendall’s tau technique. This is a nonparametric regression line based on Kendall’s tau correlation coefficient. The ATS macro was used for these calculations.

Site-wide trends were calculated using a variation of the Seasonal Kendall test called the Regional Kendall test. Helsel and Frans (2006) describe the test as follows. The Regional Kendall test is a test to determine whether a consistent pattern of trend occurs across an entire area, at multiple locations. The Regional Kendall test substitutes location for season and computes the equivalent of the Seasonal Kendall test. The Regional Kendall test looks for consistency in the direction of trend at each location, and tests whether there is evidence for a general trend in a consistent direction throughout the region. Patterns at an individual location occurring in the same direction as the regional trend provide some evidence toward a significant regional trend, even if there is insufficient evidence of trend for that one location.

The Seaken macro written by Dr. Helsel for use within Minitab was used to calculate the linear area-wide trend. One-half the detection limit was substituted for censored values in site-wide trend calculations.

In order to be consistent with previous trend analyses conducted by DEQ in Eastern Oregon GWMAs, a confidence level of 80% was used to distinguish between statistically significant trends (i.e., those with an 80% or higher confidence level) versus statistically insignificant trends (i.e., those with less than 80% confidence level). Appendix 1 of DEQ (2004) includes a discussion of the principles of trend analysis, including the Seasonal Kendall technique.

In addition to calculation the Seasonal Kendall trend, a locally weighted scatterplot smoothing (LOWESS) line was also calculated for each well. The LOWESS line is similar to a moving average and provides a good depiction of the underlying structure of the data. The LOWESS technique is discussed in more detail in Appendix 1 of DEQ (2004).

Average Nitrate Concentrations

The monitoring wells at the twelve land application sites were installed at various times. The average values indicated in summary tables of this report include the entire data set used for the trend analysis. However, in order to better facilitate comparisons across a particular site, the average values indicated in the figures of this report use the timeframe in which all wells were installed and sampled.

Comparison to Previous Analysis
A comparison of nitrate trends at each well is made between the first (through 2001), the second (through 2005) and the third (through 2009) trend analyses. The changes between the nitrate trends between the second and third trend analyses are summarized in two ways:

1. The changes in the number of increasing and decreasing trends for the whole site, and
2. Whether changes in each well suggest or show a worsening trend or an improving trend[2].

Trend Analysis Steps
The specific steps used to conduct the trend analyses and prepare the tables and figures in this report include the following 16 steps:

1. *Compile the data submitted to DEQ by the permittee for each site*. Most of the data were in electronic format. Some recent data were provided verbally or from documents recently submitted to DEQ. It was assumed that the data sets were correct and complete. No attempts were made by DEQ to verify the data submitted. Furthermore, it was assumed that sampling and analytical procedures were consistent at each well.
2. *Thin the data to one sample per quarter*. Some wells at some facilities were sampled monthly for a while and then were sampled quarterly. In order to avoid biasing summary statistics, these data sets were thinned. The data point closest to the middle of the quarter was retained while the remainder of the data points was deleted.
3. *Condition the data*. Data conditioning was performed on censored data and sample dates. Data conditioning of censored data consisted of entering two values into the electronic file for each result. The first value was the measured concentration for detected concentrations or the detection limit for censored values. The second value was a code indicating if the first value represents a detected concentration or a censored observation. Data conditioning of sample dates consisted of (1) replacing “month/year” sample dates with the 15th day of the month (e.g., February 1995 was replaced with 2/15/95), (2) replacing “quarter/year” sample dates with the date of the middle of the quarter (e.g., 1st Quarter 1995 was replaced with 2/15/95), and (3) converting sample dates to a decimal date format (e.g., 2/15/95 = 1995.123) for plotting purposes.
4. *Look for outliers.* The data were visually examined for obvious outliers and potential transcription errors. If a data point was suspected of being an error, efforts were made to trace the data back to the original laboratory report to confirm the result. Statistical outliers were not deleted from the data set.
5. *Create input files for the statistical and graphing software programs used*. Input files for the software programs used to calculate summary statistics, evaluate data set characteristics, perform the trend analyses, and prepare graphs were prepared. Software programs used in this study include Minitab version 14 (from Minitab, Inc.), and Grapher version 8 (from Golden Software, Inc). The use of product names is for information purposes only. DEQ does not advocate the use of any particular software.
6. *Evaluate data set characteristics* including minimum, maximum, mean, median, sample size, and percentage of censored data.
7. *Calculate a monotonic trend line using the Seasonal Kendall or Censored Kendall technique.*
8. *Calculate a LOWESS line through nitrate data for each well.*

[2] If both nitrate trend confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as “showing” a change in trend. If either nitrate trend confidence level is less than 80% (e.g., a statistically insignificant trend), then the change is termed as “suggesting” a change in trend. An improving trend could be either a decreasing trend decreasing more steeply or an increasing trend increasing less steeply. A worsening trend could be either a decreasing trend decreasing less steeply or an increasing trend increasing more steeply.

9. *Create time series plots for each well including the trend line and LOWESS line at a scale appropriate for the nitrate range at each well.*
10. *Create a one-page summary of LOWESS and trend lines at a scale appropriate for the nitrate range at* each site.
11. Create a plot of all nitrate data from the site with a LOWESS line fit through the data.
12. *Calculate the site-wide trend* using the entire data set from the site.
13. *Calculate the site-wide trend* using only data from 2005 through 2009.
14. *Calculate the site-wide average nitrate concentration* using only data from 2005 through 2009.
15. *Create a map illustrating the magnitude and direction of nitrate trends at each well.*
16. *Create a map illustrating the average nitrate concentration at each well.*

2.0 PORT OF MORROW SITES

2.1 Introduction

The Port of Morrow currently land applies approximately 1.8 billion gallons of processing wastewater and approximately 4.6 billion gallons of supplemental water annually to approximately 5700 acres of farm land near Boardman, Oregon. The wastewater stream is primarily potato processing water. Other wastewater streams include cooling tower blow down, boiler blow down, onion process water, cheese processing water, corn processing ethanol plant water and storm water. This water is land applied using sprinkler irrigation systems to three farms and provides nutrients to grow a variety of crops. The supplemental water consists of Columbia River water, several groundwater wells, and canal water. This water, as evidenced by the above volumes, is the primary source of irrigation to the farms and applied in order to provide enough moisture for proper crop growth. The city of Boardman's treated sewer water is applied to circle 52. Future plans include non-contact cooling water from a data center and a small waste water stream from a cellulosic ethanol plant.

The wastewater in 2009 contained, on average, approximately:

- 86 mg/l Total Kjeldahl Nitrogen (TKN)
- 18.9 mg/l of the TKN is ammonia
- 1.69 mg/l Nitrates
- 1518 mg/l Total Dissolved Solids

The Port of Morrow land application areas are located approximately 3 miles east of the City of Boardman, in the vicinity of US Interstate 84 and US Highway 730 (Figure 1-2). The wastewater, along with supplemental fresh water consisting of some low nitrate river and canal water and various historically high nitrate groundwater sources such as farm wells, is land applied on three parcels of land known as Farm 1, Farm 2, and Farm 3.

Principal components of the Port of Morrow's wastewater treatment and disposal system include:

- vibratory screens and roll screens
- sand separation systems
- a clarifier with a vacuum filter
- a dissolved air floatation unit
- two pump stations, one which includes a lined surge pond
- land application areas
- a 196 million gallon lined storage lagoon which is divided into an aerated section and a winter storage section

Farm 1 is located north of Interstate 84 on 1365.9 acres. Farm 2 is located south of Interstate 84 on 1,466.6 acres. Farm 3 is located immediately east of Farm 1 and consists of 3810.1 acres; of which 2838.0 acres are permitted for receiving wastewater. The remainder of Farm 3 (south of Highway 730) continues to be farmed using conventional irrigated agricultural practices. The Port of Morrow contracts for management of the farming activity on Farm 1, while Farms 2 and 3 are privately owned.

2.2 Farm 1

As indicated in Section 2.1, the Port of Morrow Farm 1 consists of 1,365.9 acres located north of Interstate 84. Crops grown using the wastewater most recently include alfalfa, triticale, corn, sorghum, garlic, orchard grass, timothy grass, potatoes, onions, ryegrass and wheat.

The land application system at Farm 1 began in 1971 in the area where circles 53, 54, and 55 are located today (i.e., between the sewage lagoons and Coyote Springs Wildlife Area). Prior to the land application system, the land occupied by Farm 1 was operated as a commercial farm.

Farm 1 is located within the Columbia Basin physiographic province. The area is underlain by Columbia River Flood basalts overlain by sand, gravel, and silt. The overlying sediments were deposited during past flooding and damming of the Columbia River, and further reworked by wind. The soils at land surface are well drained to excessively drained loamy fine sands and sands (SCS, 1983). Topographic slopes are typically small (0 to 5%; some up to 12%) but pockets of dune lands slope 5 to 60% (SCS, 1983). Land surface topography at Farm 1 ranges from approximately 265 to 370 feet above mean sea level.

Nearby surface water features include the John Day Pool of the Columbia River and the West Extension Irrigation Canal (Figure 2-1). The John Day Pool forms a portion of the northwestern boundary of Farm 1 and extends approximately 76 miles from the upstream side (i.e., the fore bay) of the John Day Dam to the downstream side (i.e., the tail water) of the McNary Dam. The West Extension Irrigation Canal crosses the southeastern portion of Farm 1 and delivers water from the Umatilla River to irrigated lands in the area. The Coyote Springs Wildlife Area is located on the southern portion of Farm 1 in an area that periodically receives canal water. Water is released through a spillway gate on occasions such as at irrigation startup, when irrigation tail water volume is high, during canal repairs, and during gate malfunctions.

The depth to water beneath Farm 1 ranges from less than 6 (typically about 2½) feet below land surface (at well MW-6 located just south of Farm 1) to more than 80 feet below land surface (at wells MW-2, MW-4, MW-SP1, and MW-SP2 (located in the northeastern portion of the site). With all other variables being equal, wells with a greater depth to water would be slower to respond to changes in practices at land surface.

2.2.1 Concentration Limits

Concentration limits have not been set for the Port of Morrow Farm 1 because the Port of Morrow and DEQ have yet to agree on the hydrogeology of the site to the degree which appropriate hydrogeologic units (which includes paired upgradient and downgradient wells) can be established.

2.2.2 Nitrate Trends at Individual Wells

A trend analysis of nitrate concentrations at each of the Port of Morrow Farm 1 wells still being sampled was conducted as described in Section 1.3. Table 2-1 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS[3] pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each Port of Morrow well are included in Appendix 1.

Table 2-1 lists the individual results of the trend analyses for each well. The results can be summarized as follows:

- 6 wells have increasing trends
- 2 wells have decreasing trends
- 4 wells have statistically insignificant trends

In summary, half of the wells (50%) have statistically significant increasing trends. The trends range from increasing at 1.52 ppm/yr at MW-7 to decreasing at 0.46 ppm/yr at MW-SP1. The site-wide average nitrate trend (i.e., the average of all 12 slopes) is increasing at approximately 0.35 ppm/yr. The average trend of the eight statistically significant results is increasing at approximately 0.47 ppm/yr.

It is important to note that three of the four statistically insignificant trends have average concentrations greater than 20 ppm. The fact that a statistically significant linear trend cannot be drawn through the data does not

[3] The distinction between a trend line and a LOWESS line is that a trend line is the best straight line fit through the data that describes the overall change in water quality across the entire timeframe, while a LOWESS line is a type of data smoothing that describes the general pattern of the data throughout the timeframe. Changes in nitrate concentration are usually not a straight line. So, although it is useful to characterize changes as a "straight" trend line, additional useful information can be gained by evaluating "smoothed" LOWESS lines.

mean that the concentrations are insignificant or unworthy of attention. Instead, it means that the statistical test could not identify a linear trend with a high degree of assurance.

Table 2-1 also lists a description of the LOWESS pattern for the 12 wells. The LOWESS patterns observed can be summarized as follows:

- Two wells show a consistently increasing pattern,
- One wells shows a decreasing then leveling off pattern,
- Five wells show an increasing then decreasing pattern,
- One well shows an increasing then decreasing then increasing pattern,
- One well shows a decreasing then increasing then decreasing pattern,
- One well shows a decreasing then increasing pattern, and
- One well shows an increasing then decreasing, then leveling off pattern.

In other words, two-thirds of the wells exhibit either consistently decreasing or recently decreasing LOWESS patterns.

Figure 2-2 includes the nitrate trends and LOWESS lines at each of the 14 Port of Morrow Farm 1 wells (not just the 12 wells currently sampled). The 14 graphs are plotted at the same scale to allow a comparison of trends between wells. Useful information can be gained by comparing trend lines with LOWESS lines. Examination of LOWESS lines through the nitrate data illustrates non-linear changes in nitrate concentrations. For example, Figure 2-2 illustrates the following:

- The increasing trend line at MW-3 simplifies the pattern illustrated by the LOWESS line which indicates concentrations slowly increased from 1987 through 1993, then rapidly increased through about 1999, then rapidly decreased through 2009,
- The increasing trend line at MW-11 reflects the overall increasing trend, but the LOWESS line identifies a decrease in concentrations since about 2003, and
- The decreasing trend line at MW-SP2 reflects the overall decreasing trend, but the LOWESS line identifies an increase in concentrations since about 2005.

Figure 2-3 is a map view of all three Port of Morrow farms illustrating nitrate trends at each well. Red arrows pointing up indicate increasing trends while green arrows pointing down indicate decreasing trends. Asterisks indicate statistically insignificant trends. The size of each arrow is proportional to the trend line slope. Steeper trends are represented with larger arrows. The steepest increasing trend is at well MW-7 (1.52 ppm/yr). The steepest decreasing trend is at well MW-SP1 (-0.46 ppm/yr). Half of the wells (6 of 12) exhibit statistically significant increasing trends (ranging from 0.33 to 1.52 ppm per year) and another four wells exhibit statistically insignificant increasing trends (ranging from 0.05 to 0.16 ppm per year). The average slope of all trends at currently sampled wells is about 0.4 ppm per year indicating that nitrate concentrations are generally increasing at Farm 1.

2.2.3 Average Nitrate Concentrations at Individual Wells

Figure 2-4 illustrates the average nitrate concentrations at all Port of Morrow wells from 2002 through 2009, the timeframe in which most Port of Morrow were installed and being sampled (MW-6 has not been sampled since June 2000, MW-26 and MW-27 were not yet sampled in 2009). The averages in Table 2-1 use all data since each well was installed. One well (MW-3a) exhibits an average concentration less than the 7 ppm GWMA target level (4.2 ppm). Two more wells exhibit average concentrations less than the 10 ppm drinking water standard (5.1 ppm at MW-3 and 9.4 ppm at MW-4). The remaining nine wells exhibit higher average nitrate concentrations.

The highest average concentrations are at wells along the northern boundary (35.6 ppm at MW-8; 33.7 ppm at MW-11; and 31.8 ppm at MW-10) and near the wastewater storage lagoon (36.1 ppm at MW-SP2 and 32.0 ppm at MW-SP1).

2.2.4 Site-Wide NitrateTrends

Figure 2-5 is a graph of all nitrate data from the 12 currently sampled Farm 1 wells, with a LOWESS line drawn through the data. Figure 2-5 consists of many stacks of data points at approximately 3-month intervals. Each of these stacks of data represents one quarterly sampling event and contains one data point for each well sampled that event. It is evident from Figure 2-2 that the highest concentrations detected have occurred in the middle portion of the dataset (late 1990s to early 2000s). The LOWESS line suggests nitrate concentrations at Farm 1 increased from 1987 through about 2001, and then began decreasing.

Figure 2-5 also includes two estimates of the site-wide trend using the 12 currently sampled wells: one through the entire history of the site (i.e., 1987 through 2009), and another through the most recent 5 years of data (i.e., 2005 through 2009). These monotonic trends are consistent with the LOWESS line. The 1987 through 2009 site-wide trend increases at 0.41 mg/l per year with a 99% confidence level. The 2005 through 2009 site-wide trend decreases at 0.69 mg/l per year with a 99% confidence level. In other words, the overall site-wide trend is increasing, but it is decreasing in recent years. However, because not all wells currently sampled existed in 1987, the two trends use information from different locations within the site and are therefore not exactly comparable.

2.2.5 Upgradient to Downgradient Comparison

The groundwater flow direction at the Port of Morrow Farms is described in DEQ (2004). Groundwater elevation contours are also indicated on Figures 2-3 and 2-4. In general, groundwater flow across Farms 1 and 3 is to the north-northwest with discharge to the John Day Pool of the Columbia River. Both the regional water table map presented in Figure 2-1 of DEQ (2004) and groundwater elevation maps produced by Port of Morrow consultants show a generally north-northwesterly groundwater flow direction. Based on this flow direction, upgradient wells at Farm 1 are located south and southeast of the land application activities, and downgradient wells at Farm 1 are located north and northwest of land application activities. As indicated in Section 2.2.1, the Port of Morrow and DEQ have yet to agree on the hydrogeology of the site to the degree which paired upgradient and downgradient wells can be established. The general groundwater flow direction has, however, been agreed upon.

Western Portion of Farm 1

Upgradient wells for the western portion of Farm 1 include MW-3a and MW-6. However, the five foot deep MW-6 has been dry since 2000, presumably due to nearby landowners switching from flood irrigation to sprinkler irrigation. Well MW-3 is not considered an upgradient well because it is located primarily downgradient of Circle 52, and it is likely that water in this well is perched above the regional water table. Water recharging well MW-3 is expected to come from a relatively nearby source (e.g., the irrigation water discharged to the wetland located directly west of the well or Circle 52 located directly east of the well). Downgradient wells for the western portion of Farm 1 include MW-10 and MW-11.

Figure 2-6(a) is a time series graph showing nitrate concentrations at the upgradient and downgradient wells for the western portion of Farm 1. In addition to the individual data points connected by a thin line, a thick LOWESS line is drawn through the data. Figure 2-6(a) shows the upgradient nitrate concentration at MW-6 remained fairly constant at approximately 1 ppm from 1987 through 1999 when it began to incrase shortly before well sampling ended. Similarly, the upgradient nitrate concentration at MW-3a remains fairly constant at about 4 ppm during the time it has been sampled. The LOWESS line drawn through these data therefore increases from about 1 ppm to about 4 ppm when these two data sets are combined.

Figure 2-6(a) shows concentrations at the downgradient wells MW-10 and MW-11 started higher than the upgradient concentrations and have increased over time. The Port of Morrow's consultants have calculated groundwater flow velocities and estimate it takes approximately 2 years to cross the western portion of Farm 1.

Figure 2-6(b) is a box and whisker plot summarizing the nitrate concentrations from the upgradient wells (MW-3a and MW-6) and the downgradient wells (MW-10 and MW-11)[4]. Figure 2-6(b) shows the average upgradient nitrate concentration is approximately 2 ppm, and the IQR (representing the middle half of the data) is from approximately 0.4 to 4 ppm. Figure 2-6(b) also shows the average downgradient nitrate concentration is approximately 30 ppm, and the IQR is approximately 24 to 35 ppm.

Given the higher nitrate concentrations in the downgradient wells and the estimated groundwater flow velocity, it is concluded that facility operations have impacted and continue to impact groundwater quality at the western portion of Farm 1.

Eastern Portion of Farm 1 and Farm 3

Wells MW-19 and MW-20 are upgradient wells for the eastern portion of Farm 1 and for the western portion of Farm 3. MW-19 will remain an upgradient well until wastewater is applied south of the well. Well MW-27 is an upgradient well installed in February 2010, and should serve as an upgradient well in future trend analyses.

Downgradient wells for the eastern portion of Farm 1 include MW-5 and MW-8 (Figure 2-1). Downgradient wells for the Farm 3 include MW-24 and MW-25. In early 2010, wells MW-5 and MW-20 were replaced with wells MW-5d and MW-20b, respectively, which are screened shallower and are therefore more representative of nearby land surface activities. Also in early 2010, well MW-26 was installed as the downgradient well for Farm 3. Wells MW-20b and MW-27 should serve as upgradient wells in future trend analyses. Wells MW-5d and MW-26 should serve as downgradient wells in future trend analyses.

Figure 2-7(a) is a time series graph showing nitrate concentrations at the upgradient and downgradient wells for the eastern portion of Farm 1 and western portion of Farm 3. In addition to the individual data points connected by a thin line, a thick LOWESS line is drawn through the data. Figure 2-7(a) shows the LOWESS line through the upgradient nitrate concentrations decreased from approximately 20 ppm to 15 ppm from 2002 until mid-2004, then increased to about 24 ppm by the end of 2009. The LOWESS line through the downgradient nitrate concentrations increased from about 15 ppm to about 35 ppm from 1987 through about 2004 when it leveled off. The Port of Morrow's consultants have calculated groundwater flow velocities, and estimate it can take 1.3 to 5.7 years to cross the eastern portion of Farm 1 and Farm 3.

Figure 2-7(b) is a box and whisker plot summarizing the nitrate concentrations from the upgradient wells (MW-19 & MW-20) and the downgradient wells (MW-5, MW-8, MW-24, and MW-25). Figure 2-7(b) shows the average upgradient nitrate concentration is approximately 21 ppm, and the IQR (representing the middle half of the data) is approximately 14 to 27 ppm. Figure 2-7(b) also shows the average downgradient nitrate concentration is approximately 33 ppm, and the IQR is approximately 22 to 44 ppm.

Given the elevated nitrate concentrations in the upgradient wells, it is concluded that offsite activities have and continue to impact groundwater quality at the eastern portion of Farm 1 and the western portion of Farm 3. Given the higher nitrate concentrations in the downgradient wells and the estimated groundwater flow velocity, it is concluded that facility operations have impacted and likely continue to impact groundwater quality at the eastern portion of Farm 1 and the western portion of Farm 3.

2.2.6 Comparison to Previous Analyses

The trends calculated for each well during each of the three trend analyses are indicated in Table 2-2. The changes in trends are summarized in Table 2-2 in two ways:

1. Wells showing similar changes are grouped together, with a summary of the change indicated along the right side of Table 2-2. These changes are interpreted as indications of improving or worsening water quality between 2005 and 2009.

[4] The "box" portion of the plot identifies the interquartile range (IQR). The IQR is the middle half of the data (i.e., those data between the 25^{th} and 75^{th} percentiles). The "whisker" portion of the plot extends outwards from the box to any point within 1.5 times the IQR. Any point beyond the whiskers is plotted individually. The horizontal line through the box represents the median value. The star represents the average value.

2. The number of decreasing and increasing trends per analyses are summarized along the bottom of Table 2-2, with a summary of the changes indicated at the bottom right side of Table 2-2.

The confidence levels of the trends influence the words chosen to summarize changes between analyses in Table 2-2. For example, if both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as "showing" a change in trend. Conversely, if either confidence level is less than 80% (e.g., a statistically insignificant trend), then the change is termed as "suggesting" a change in trend. An "improving" trend is defined as either a steeper decreasing trend or a less steeply increasing trend. A "worsening" trend is defined as either a steeper increasing trend or a less steeply decreasing trend.

As shown in Table 2-2, indications of improving water quality between the second and third trend analyses include:

- 8 wells show or suggest improving trends by increasing less steeply,
- There were fewer increasing trends, and
- The site-wide average trend slope improved by increasing less steeply.

Indications of worsening water quality since the previous analysis include:

- Five wells show or suggest worsening trends by increasing trends getting steeper, decreasing trends getting less steep, or switching from decreasing to increasing.

In summary, although the majority of wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2009 than they did through 2001 and 2005.

2.2.7 Conclusions

Based on the discussion of the data for the Port of Morrow Farm 1 site discussed above, the following conclusions have been made, and are grouped by topic:

Concentration Limits

Concentration limits have not been set for the Port of Morrow Farm 1 because the Port of Morrow and DEQ have yet to agree on the hydrogeology of the site to the degree which appropriate hydrogeologic units (consisting of paired upgradient and downgradient wells) can be established.

Nitrate Trends at Individual Wells

- Nitrate concentrations at Farm 1 are generally increasing, as evidenced by:
    - Half of the wells exhibit statistically significant increasing trends, and
    - Trends range from decreasing at 0.46 ppm/yr to increasing at 1.52 ppm/yr with the site-wide average nitrate trend increasing at least 0.35 ppm/yr.
- Nitrate concentrations at Farm 1 are recently improving, as evidenced by:
    - Two thirds of the wells exhibit either consistently decreasing or recently decreasing LOWESS patterns.

Average Nitrate Concentrations at Individual Wells

- One well exhibits an average concentration less than the 7 ppm GWMA target level. Two more wells exhibit average concentrations less than the 10 ppm drinking water standard. The remaining nine wells exhibit higher average nitrate concentrations.
- The highest average concentrations are at wells along the northern boundary and near the wastewater storage lagoon.

Site-Wide Trends

- The overall site-wide trend is increasing, but it is decreasing in recent years.
- The 1987 through 2009 site-wide trend increases at 0.41 mg/l per year with a 99% confidence level.

- The 2005 through 2009 site-wide trend decreases at 0.69 mg/l per year with a 99% confidence level.
- These monotonic trends are consistent with the LOWESS line that suggests nitrate concentrations at Farm 1 increased from 1987 through about 2001, and then began decreasing.

Upgradient to Downgradient Comparisons

- Given the higher nitrate concentrations in the downgradient wells and the estimated groundwater flow velocity, it is concluded that facility operations have impacted and continue to impact groundwater quality at the western portion of Farm 1.
- Given the elevated nitrate concentrations in the upgradient wells, it is concluded that offsite activities have and continue to impact groundwater quality at the eastern portion of Farm 1 and the western portion of Farm 3.
- Given the higher nitrate concentrations in the downgradient wells and the estimated groundwater flow velocity, it is concluded that facility operations have impacted and likely continue to impact groundwater quality at the eastern portion of Farm 1 and the western portion of Farm 3.

Comparison to Previous Analysis

Although half of the wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2009 than they did through 2001 and 2005.

2.3 Farm 2

As indicated in Section 2.1, the Port of Morrow Farm 2 consists of 1,466.6 acres located south of Interstate 84. Crops grown using the wastewater most recently include a rotation of alfalfa, triticale, corn, mint, sorghum, garlic, orchard grass, timothy grass, potatoes, onions, peas, lima beans and wheat.

The land application system at Farm 2 began in 1992. Prior to the land application system, the land occupied by Farm 2 was farmed by a local farmer.

As is the case with Farm 1, Farm 2 is located within the Columbia Basin physiographic province. The area is underlain by Columbia River Flood basalts overlain by sand, gravel, and silt. The overlying sediments were deposited during past flooding and damming of the Columbia River, and further reworked by wind. The soils at land surface are somewhat excessively drained to excessively drained loamy fine sands and sands. Topographic slopes are typically small to moderate (0 to 12%) but pockets of dune lands slope 5 to 60%. Land surface topography at Farm 2 ranges from approximately 370 to 470 feet above mean sea level.

Nearby surface water features include the West Extension Irrigation Canal and two wetlands. The West Extension Irrigation Canal is primarily located north of Farm 2 but also forms a portion the farm's northwestern boundary. Two wetlands straddle the eastern boundary of Farm 2 (Figure 2-1).

The depth to water beneath Farm 2 ranges from approximately 22 feet below land surface (at well MW-18 located in the northeastern corner of the site) to approximately 58 feet below land surface (at well MW-15 (located in the southeastern corner of the site). With all other variables being equal, wells with a greater depth to water would be slower to respond to changes in practices at land surface.

2.3.1 Concentration Limits

Concentration limits have not been set for the Port of Morrow Farm 2 because the Port of Morrow and DEQ have yet to agree on the hydrogeology of the site to the point where a monitoring strategy can be established.

2.3.2 Nitrate Trends at Individual Wells

A trend analysis of nitrate concentrations at each of the 10 Port of Morrow Farm 2 wells that consistently (or recently in the case of MW-12s) have water in them[5] was completed using the methodology described in Section 1.3. Table 2-3 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (i.e., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each Port of Morrow well are included in Appendix 1.

The results of the trend analysis shown in Table 2-3 indicate five wells have increasing trends, one well has a decreasing trend, and four wells have statistically insignificant trends. Three of the five wells with increasing trends (i.e, MW-15, MW-15s, and MW-18) are located along the upgradient side of Farm 2 (Figure 2-3). The trends range from increasing at 1.47 ppm/yr at MW-12 to decreasing at 1.66 ppm/yr at MW-16. The site-wide average nitrate trend (i.e., the average of all 10 slopes) is decreasing at approximately 0.21 ppm per year. The average of the six statistically significant slopes is increasing at approximately 0.63 ppm/yr.

It is important to note that the four statistically insignificant trends have average concentrations greater than 25 ppm. The fact that a statistically significant linear trend cannot be drawn through the data does not mean that the concentrations are insignificant or unworthy of attention. Instead, it means that the statistical test could not identify a linear trend with a high degree of assurance.

Table 2-3 also lists a description of the LOWESS pattern for individual wells. The LOWESS patterns observed can be summarized as follows:

- four wells shows a consistently increasing pattern
- one well shows an increasing then decreasing, then increasing pattern
- one well shows a decreasing then increasing pattern
- three wells show an increasing then decreasing pattern
- one well shows an increasing then leveling off pattern

In other words, six of 10 wells exhibit consistently increasing or recently increasing LOWESS patterns.

Figure 2-8 includes the nitrate trends and LOWESS lines at each of the 10 Port of Morrow Farm 2 wells that are being sampled. The 10 graphs are plotted at the same scale to allow a comparison of trends between wells. As mentioned previously, useful information can be gained by comparing trend lines with LOWESS lines. For example, Figure 2-8 illustrates that nitrate trends at four wells (MW-13, MW-14, MW-14s and MW-16) increased until about 1999 or 2000 then began to decrease. MW-14s began increasing again in about 2003.

The graph for MW-12s shows a LOWESS line that decreasing very steeply then increases very steeply while the trend line decreases. As mentioned previously, there are only nine data points from this well. The large shift in the LOWESS line is caused by three of the data points being much lower than the other six.

Figure 2-3 is a map view of all three Port of Morrow sites illustrating the nitrate trends at each well. Five of 10 Farm 2 wells (both upgradient and downgradient) have increasing trends. One well has a decreasing trend. Four wells have statistically insignificant trends. The steepest increasing trend (1.47 ppm/yr) is at well MW-12 located near the northwestern corner of Farm 2. The decreasing trend (-1.66 ppm/yr) is at well MW-16 located along the southern boundary of Farm 2. The high percentage of increasing trends (5 of 10 wells) illustrates that nitrate concentrations are generally increasing at Farm 2. The fact that 3 of the 5 increasing trends are located along the upgradient boundary of Farm 2 suggests offsite activities are contributing to the increasing nitrate trend at the site.

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[5] Wells MW-12s, MW-13s and MW-16s rarely have enough water to collect a sample.

2.3.3 Average Nitrate Concentrations at Individual Wells

Figure 2-4 illustrates the average nitrate concentrations at all Port of Morrow wells from 2002 through 2009, the timeframe in which most Port of Morrow wells were installed and being sampled. The averages in Table 2-3 use all data since each well was installed. With the exception of well MW-18 (which averages 13 ppm), the average nitrate concentration at each Farm 2 well is greater than 25 ppm. The highest average concentrations are at the southeastern boundary (49.0 ppm at MW-15 and 48.6 ppm at MW-15s). The next highest averages are near the southwestern and northwestern corners of Farm 2 at well MW-17 (45.5 ppm) and well MW-12 (42.5 ppm).

2.3.4 Site-Wide Nitrate Trends and Concentrations

Figure 2-9 is a graph of all nitrate data from the 10 Farm 2 wells, with a LOWESS line drawn through the data. Figure 2-9 consists of many stacks of data points at approximately 3-month intervals. Each of these stacks of data represents one quarterly sampling event and contains one data point for each well sampled that event. It is evident from Figure 2-7 that the highest overall concentrations detected have occurred in the middle and latter portions of the dataset. The LOWESS line increases steeply from 1992 through about 2000, then decreases through 2009.

Figure 2-7 also includes two estimates of the site-wide trend using the nine wells with sufficient data (i.e., all wells except MW-12s): one through the entire history of the site (i.e., October 1991 through 2009), and another through the most recent 5 years of data (i.e., 2005 through 2009). These monotonic trends are generally consistent with the LOWESS line. The 1991 through 2009 trend increases at 0.79 mg/l per year with a 99% confidence level. The 2005 through 2009 site-wide trend increases less steeply at 0.69 mg/l per year but with a confidence level of < 80%. In other words, the overall site-wide trend is increasing, but may be increasing less steeply in recent years. The LOWESS line actually suggests concentrations are slightly declining in recent years.

It is also evident that there are many fewer data points between approximately 5 ppm and 30 ppm between late 1995 through 2004. As indicated in Figure 2-7, this gap is due to three wells: MW-14, MW-16, and MW-18. Wells MW-14 and MW-16 increased during the 1990s and decreased in the early 2000s. Well MW-18 steadily increased throughout the 1990s and 2000s.

2.3.5 Upgradient to Downgradient Comparisions

As indicated in Section 2.3.1, the Port of Morrow and DEQ have yet to agree on the hydrogeology of the site to the point where a monitoring strategy can be established. Therefore, no upgradient to downgradient comparisons are made in this document.

2.3.6 Comparison to Previous Analysis

The trends calculated for each well during each of the three trend analyses are indicated in Table 2-4. The changes in trends are summarized in Table 2-4 in two ways:

1. Wells showing similar changes are grouped together, with a summary of the change indicated along the right side of Table 2-4. These changes are interpreted as indications of improving or worsening water quality between 2005 and 2009.
2. The number of decreasing and increasing trends per analyses are summarized along the bottom of Table 2-4, with a summary of the changes indicated at the bottom right side of Table 2-4.

The confidence levels of the trends influence the words chosen to summarize changes between analyses in Table 2-4. For example, if both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as "showing" a change in trend. Conversely, if either confidence level is less than 80% (e.g., a statistically insignificant trend), then the change is termed as "suggesting" a change in trend. An "improving" trend is defined as either a steeper decreasing trend or a less steeply increasing trend. A "worsening" trend is defined as either a steeper increasing trend or a less steeply decreasing trend.

As shown in Table 2-4, indications of improving water quality between the second and third trend analyses include:

- four wells show improving trends by increasing less steeply, and
- three wells suggest improving trends by increasing less steeply or switching from increasing to decreasing,
- The site-wide average of statistically significant trend slopes shows improving trends by increasing less steeply,
- The site-wide average of all trend slopes suggests improving trend by switching from increasing to decreasing, and
- There were fewer increasing trends and one new decreasing trend.

Indications of worsening water quality since the previous analysis include:

- one well shows a worsening trend by increasing steeper, and
- one well suggests a worsening trend by switching from decreasing to increasing.

In summary, although half of the wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2009 than they did through 2001 and 2005.

2.3.7 Conclusions

Based on the discussion of the data for the Port of Morrow Farm 2 site discussed above, the following conclusions have been made, and are grouped by topic:

Concentration Limits

- Concentration limits have not been set for the Port of Morrow Farm 2 because the Port of Morrow and DEQ have yet to agree on the hydrogeology of the site to the point where a monitoring strategy can be established.

Nitrate Trends

- Nitrate concentrations at the Port of Morrow Farm 2 are increasing, as evidenced by:
    - Half of the wells exhibit statistically significant increasing trends.
    - Trends range from increasing at 1.47 ppm/yr to decreasing at 1.66 ppm/yr with the site-wide average nitrate trend increasing approximately 0.6 ppm/yr.
    - Over half of the wells exhibit consistently increasing or recently increasing LOWESS patterns.

Average Nitrate Concentrations

- With the exception of well MW-18 (which averages 13 ppm), the average nitrate concentration at each Farm 2 well is greater than 25 ppm.
- The highest average concentrations are at the southeastern boundary (49.0 ppm at MW-15 and 48.6 ppm at MW-15s).
- The next highest averages are near the southwestern and northwestern corners of Farm 2 at well MW-17 (45.5 ppm) and well MW-12 (42.5 ppm).

Site-Wide Trends

- The overall site-wide trend is increasing, but it is increasing less steeply in recent years.
- The 1991 through 2009 site-wide trend increases at 0.79 ppm/yr with a 99% confidence level.
- The 2005 through 2009 site-wide trend increases at 0.2 ppm/yr with a 60% confidence level.
- These monotonic trends are generally consistent with the LOWESS line that suggests nitrate concentrations increased from 1991 through about 2000, when they began to decrease and level off.

Comparison to Previous Analysis

- Although half of the wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2009 than they did through 2001 and 2005.

2.4 Farm 3

As indicated in Section 2.1, the Port of Morrow Farm 3 is located immediately east of Farm 1 and consists of 3810.1 acres; of which 2838.0 acres currently receive wastewater. The remainder of Farm 3 (south of Highway 730) continues to be farmed using conventional irrigated agricultural practices. The Port of Morrow contracts for management of the farming activity on Farm 1, while Farms 2 and 3 are privately owned. Crops grown using the wastewater most recently include a rotation of alfalfa, triticale, corn, mint, sorghum, garlic, orchard grass, timothy grass, potatoes, onions, peas, lima beans and wheat. The land application system at Farm 3 was approved in August 2002, with wastewater first applied to fields north of Highway 730 in October 2002. As of the date of this report, wastewater has not been applied to fields south of Highway 730. Prior to the land application system, the land occupied by Farm 3 was operated as a commercial farm.

As with Farms 1 and 2, Farm 3 is located within the Columbia Basin physiographic province. The area is underlain by Columbia River Flood basalts overlain by sand, gravel, and silt. The overlying sediments were deposited during past flooding and damming of the Columbia River, and further reworked by wind. The soils at land surface are excessively drained loamy fine sands and sands (SCS, 1983). Topographic slopes are typically small (0 to 12%) but pockets of dune lands slope 5 to 60% (SCS, 1983). Land surface topography at Farm 3 ranges from approximately 290 to 470 feet above mean sea level.

Nearby surface water features include the John Day Pool of the Columbia River and the West Extension Irrigation Canal (Figure 2-1). The West Extension Irrigation Canal crosses Farm 3 and delivers water from the Umatilla River to irrigated lands in the area.

The depth to water beneath Farm 3 ranges from less than 10 feet below land surface (at well MW-20 located along the southern boundary) to more than 80 feet below land surface (at well MW-23 (located in the northeastern corner of the site). With all other variables being equal, wells with a greater depth to water would be slower to respond to changes in practices at land surface.

2.4.1 Concentration Limits

Concentration limits have not been set for the Port of Morrow Farm 3 because the Port of Morrow and DEQ have yet to agree on the hydrogeology of the site to the degree which appropriate hydrogeologic units (which includes paired upgradient and downgradient wells) can be established.

2.4.2 Nitrate Trends at Individual Wells

A trend analysis of nitrate concentrations at six Port of Morrow Farm 3 wells was conducted as described in Section 1.3. By the end of 2009, MW-25 had been sampled four times so there was insufficient data to calculate a trend at that location. Table 2-5 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each Port of Morrow well are included in Appendix 1.

Most Port of Morrow Farm 3 wells were sampled monthly for a year, then quarterly thereafter. For this report, the first year of data was trimmed to quarterly results so as to not overemphasize early time data.

Table 2-5 lists the individual results of the trend analyses for each well. The results can be summarized as follows:

- four wells have increasing trends
- one well has a decreasing trend
- one well has a statistically insignificant trend

The trends range from increasing at 3.17 ppm/yr to decreasing at 2.02 ppm/yr. The site-wide average nitrate trend (i.e., the average of all slopes) is increasing at 1.9 ppm/yr. The average of the five statistically significant trends is increasing at approximately 2.4 ppm/yr.

It is important to note that well MW-23, which has the statistically insignificant trend, has an average nitrate concentration of approximately 54 ppm. The fact that a statistically significant linear trend cannot be drawn through the data does not mean the concentrations are insignificant or unworthy of attention. Instead, it means that the statistical test could not identify a linear trend with a high degree of assurance.

Table 2-5 also lists a description of the LOWESS pattern for individual wells. The LOWESS patterns observed can be summarized as follows:

- Three wells showed consistently or recently increasing trends. These include:
  - One well increased then leveled off,
  - One well increased, leveled off, then increased less steeply, and
  - One well decreased then increased.

- Four wells showed consistently or recently decreasing trends. These include:
  - one well consistently decreased,
  - one well decreased, then increased, then decreased again
  - one well decreased, leveled off, then decreased again
  - one well increased then decreased

In other words, more than half of the wells exhibit either consistently or recently decreasing LOWESS patterns.

Figure 2-10 includes the nitrate trends and LOWESS lines at each of the seven Port of Morrow Farm 3 wells. The seven graphs are plotted at the same scale to allow a comparison of trends between wells. Useful information can often be gained by comparing trend lines with LOWESS lines. For example, Figure 2-10 illustrates the following:

- nitrate concentrations at MW-19 decreased, increased steeper, then decreased again but showed an overall increase, and
- nitrate concentrations at MW-22 increased steeper than the overall trend until about 2006 then increased less steep than the overall trend.

Figure 2-3 is a map view of all three Port of Morrow farms illustrating nitrate trends at each well. At Farm 3, most of the wells are increasing. One well along the southern boundary (MW-20) is decreasing. The well in the northeastern corner of Farm 3 (MW-23) exhibits a statistically insignificant trend. The steepest increasing trend (4.68 ppm/yr) is at well MW-22 along the eastern boundary, which suggests offsite activities are contributing significant amounts of nitrate to the alluvial aquifer. The decreasing trend (-2.02 ppm/yr) is at well MW-20 located along the southern boundary which suggests a change in offsite activities resulting in less nitrate being added to the alluvial aquifer. The high percentage of increasing trends illustrates that nitrate concentrations are generally increasing at Farm 3.

2.4.3 Average Nitrate Concentrations

Figure 2-4 illustrates the average nitrate concentrations at all Port of Morrow wells from 2002 through 2009, the timeframe in which six Farm 3 wells were installed and being sampled. All six Farm 3 wells exhibit an average greater than 18 ppm. The highest average nitrate concentration (52.5 ppm) is at well MW-24 located in the northwestern portion of Farm 3. The lowest average nitrate concentration (19.0 ppm) is at well MW-20 located along the southern boundary of Farm 3.

2.4.4 Site-Wide Nitrate Trends and Concentrations
Figure 2-11 is a graph of all[6] nitrate data from the seven Farm 3 wells, with a LOWESS line drawn through the data. Figure 2-11 consists of many stacks of data points at approximately three-month intervals. Each of these stacks of data represents one quarterly sampling event and contains one data point for each well sampled that event. The LOWESS line in Figure 2-9 shows an overall increasing trend with nitrate concentrations increasing consistently until about 2007 when they leveled off.

Figure 2-9 also includes two estimates of the site-wide trend using the six currently sampled wells: one through the entire history of the site (i.e., 2002 through 2009), and another through the most recent 5 years of data (i.e., 2005 through 2009). These monotonic trends are consistent with the LOWESS line. The 2002 through 2009 site-wide trend increases at 2.29 ppm/yr with a 99% confidence level. The 2005 through 2009 site-wide trend increases less steeply at 1.17 ppm/yr with a 98% confidence level. In other words, the site-wide trend is increasing, but it is increasing less steeply in recent years.

2.4.5 Upgradient to Downgradient Comparison
The upgradient to downgradient comparison for the western portion of Farm 3 (as well as the eastern portion of Farm 1) is discussed in Section 2.2.5. Based on the elevated nitrate concentrations in the upgradient wells, it was concluded that offsite activities have and continue to impact groundwater quality at the eastern portion of Farm 1 and the western portion of Farm 3. Based on the higher nitrate concentrations in the downgradient wells and the estimated groundwater flow velocity, it was also concluded that facility operations have impacted and likely continue to impact groundwater quality at the eastern portion of Farm 1 and the western portion of Farm 3.

2.4.6 Comparison to Previous Analysis
The trends calculated for each well during the two most recent trend analyses are indicated in Table 2-6. Farm 3 wells were not sampled during the timeframe of the first analysis. The changes in trends are summarized in Table 2-6 in two ways:

1. Wells showing similar changes are grouped together, with a summary of the change indicated along the right side of Table 2-6. These changes are interpreted as indications of improving or worsening water quality between 2005 and 2009.
2. The number of decreasing and increasing trends per analyses are summarized along the bottom of Table 2-6, with a summary of the changes indicated at the bottom right side of Table 2-6.

The confidence levels of the trends influence the words chosen to summarize changes between analyses in Table 2-6. For example, if both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as “showing” a change in trend. Conversely, if either confidence level is less than 80% (e.g., a statistically insignificant trend), then the change is termed as “suggesting” a change in trend. An “improving” trend is defined as either a steeper decreasing trend or a less steeply increasing trend. A “worsening” trend is defined as either a steeper increasing trend or a less steeply decreasing trend.

As shown in Table 2-6, indications of improving water quality between the second and third trend analyses include:

- two wells showed improving trends by increasing less steeply,
- one well suggests an improving trend by switching from increasing to decreasing,
- the site-wide average of statistically significant trend slopes show improving trends by increasing less steeply, and
- the site-wide average of all trend slopes suggests improving trends by increasing less steeply.

[6] Most Port of Morrow Farm 3 wells were sampled monthly for a year, then quarterly thereafter. For this analysis, the first year of data was trimmed to quarterly results so as to not overemphasize early time data.

Indications of worsening trends since the previous analysis include:

- one well shows a worsening trend by switching from decreasing to increasing,
- one well suggests a worsening trend by switching from decreasing to increasing,
- one well shows a worsening trend by decreasing less steeply, and
- there were more increasing trends and fewer decreasing trends.

In summary, although the majority of wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2009 than they did through 2005.

2.4.7 Conclusions

Based on the discussion of the data for the Port of Morrow Farm 3 site discussed above, the following conclusions have been made, and are grouped by topic:

Concentration Limits

Concentration limits have not been set for the Port of Morrow Farm 3 because the Port of Morrow and DEQ have yet to agree on the hydrogeology of the site to the degree which appropriate hydrogeologic units (which includes paired upgradient and downgradient wells) can be established.

Nitrate Trends at Individual Wells

- Nitrate concentrations at the Port of Morrow Farm 3 are generally increasing, as evidenced by:
    - Two-thirds of the wells exhibit statistically significant increasing trends.
    - Trends range from increasing at 3.17 ppm/yr to decreasing at 2.02 ppm/yr.
    - The site-wide average nitrate trend (i.e., the average of all slopes) is increasing at 1.9 ppm/yr while the average of the five statistically significant trends is increasing at approximately 2.4 ppm/yr.
    - Most wells exhibit either steadily or recently increasing LOWESS patterns.
- Nitrate concentrations at Farm 3 are recently improving, as evidenced by:
    - More than half of the wells exhibit either consistently or recently decreasing LOWESS patterns.

Average Nitrate Concentrations

- All six Farm 3 wells exhibit averages greater than 18 ppm.
- The highest average nitrate concentration (52.5 ppm) is at well MW-24 located in the northwestern portion of Farm 3.
- The lowest average nitrate concentration (19.0 ppm) is at well MW-20 located along the southern boundary of Farm 3.

Site-Wide Trends

- The overall site-wide trend is increasing, but increasing less steeply in recent years.
- The 2002 through 2009 site-wide trend increases at 2.29 ppm/yr with a 99% confidence level.
- The 2005 through 2009 site-wide trend increases at 1.17 ppm/yr with a 98% confidence level.
- These monotonic trends are consistent with the LOWESS line that shows nitrate concentrations increasing consistently until about 2007 when they leveled off.

Upgradient to Downgradient Comparisons

- Given the elevated nitrate concentrations in the upgradient wells, it is concluded that offsite activities have and continue to impact groundwater quality at the eastern portion of Farm 1 and the western portion of Farm 3.
- Given the higher nitrate concentrations in the downgradient wells and the estimated groundwater flow velocity, it is concluded that facility operations have impacted and likely continue to impact groundwater quality at the eastern portion of Farm 1 and the western portion of Farm 3.

Comparison to Previous Analysis

Although the majority of wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2009 than they did through 2005.

2.5 Recommendations

Based on the conclusions and discussion above, the following recommendations are made:

- The Port of Morrow and DEQ should work together to develop an acceptable monitoring plan.
- In order to gauge when the effects of BMP implementation will be observed as improving groundwater quality, it is recommended that funding be pursued to allow additional research into factors including: (1) quantifying the amount of nitrate that exists between the root zone and the water table, (2) the rate of nitrate transport through the unsaturated zone, and (3) more precisely quantifying groundwater flow velocity at the site.
- Due to the high percentage of increasing trends and likely affects to groundwater from land application activities, it is recommended that BMP implementation to reduce the area-wide extent of elevated nitrate concentrations be continued and, when possible, improved. BMPs should include detailed procedures to:
    - establish appropriate crop specific nitrogen loading rates,
    - accurately quantify hydraulic loading from all sources,
    - document nutrient additions from all sources,
    - insure uniform sample acquisition and analysis,
    - characterize and monitor nitrogen concentration and movement in the soil column,
    - monitor moisture content and movement in the soil column, and
    - perform annual site-specific analysis to identify farming activities and/or soil conditions that increase the potential for impact to groundwater.
- A trend analysis of data from the same wells should be conducted in 2014 to evaluate progress towards improving groundwater quality at the food processing wastewater land application sites.

3.0 CONAGRA SITES

3.1 Introduction

ConAgra (known as Lamb-Weston in previous trend analyses) currently land applies approximately 700 million gallons of wastewater annually consisting of potato processing wastewater, defrost wastewater and wash water from Americold, and the Hermiston Co-Generation facility wastewater. During 2009, average values for ConAgra's wastewater include:

- 2,347 mg/l Chemical Oxygen Demand (COD)
- 107 mg/l Total Kjeldahl Nitrogen (TKN)
- 31 mg/l ammonia
- 1,553 mg/l total dissolved solids (TDS)
- 704 mg/l total suspended solids (TSS)
- 4.9 pH

Principal components of ConAgra's wastewater treatment system include screens, a primary clarifier, an oil/grease separator, a lined surge pond, and an unlined five million gallon storage lagoon. The wastewater is applied on two parcels of land: the North Farm and Madison Ranch. The locations of the North Farm and Madison Ranch are indicated in Figure 1-2. The North Farm is owned by ConAgra and consists of 693 acres, while the Madison Ranch site is owned by Madison Farms and consists of approximately 4,900 acres. Both sites are managed by Madison Farms and are irrigated with center pivot and wheel line systems. Crops grown using the wastewater include a rotation of alfalfa, wheat, corn, peas, pasture grass, and canola.

It should be noted that nitrate data from both ConAgra sites collected prior to October 1995 are not included in this analysis because sampling procedures (and hence analytical results) changed at that time.

3.2 North Farm

The ConAgra North Farm is located approximately 4 miles west of the City of Hermiston, northwest of Interstate 82 and east of the Umatilla Ordnance Depot (Figure 1-2). The land application system at the North Farm began in 1972 or 1973. Prior to the land application system, the land occupied by the North Farm was dry land. Approximately 50 million gallons of wastewater are applied on the North Farm per year.

The North Farm is located on the southeast flank of a relatively broad topographic ridge trending northeast/southwest. The ridge slopes down to the Umatilla River to the east and down to the Columbia River to the north and west. Coyote Coulee (a dry ravine) bisects the ridge and is located approximately ½ mile northwest of the North Farm.

Soils at the North Farm are excessively drained loamy fine sands and sands. Topographic slopes of up to 25% are present. Land surface elevation at the North Farm drops fairly evenly approximately 90 feet from the northwest corner (approximately 650 feet above mean sea level) to the southeastern boundary (approximately 560 feet above mean sea level). Based solely on land surface topography, groundwater flow across the North Farm would be expected to be towards the southeast. However, as discussed in the previous trend analysis (in Section 3.2.1), that is not the case. A groundwater mound exists beneath the North Farm. It is assumed that the groundwater mound is shaped somewhat like the northeast/southwest trending topographic ridge on which the North Farm sits with groundwater flowing radially away from the center of the mound.

Nearby surface water features include the unlined pond located in the south-central portion of the site, and the Westland A canal, which parallels the southeastern boundary of the property. The gravel pits located immediately south of the Farm occasionally receive overflow from the Westland A Canal.

The average depth to water beneath the North Farm ranges from approximately 13 feet (at the "shallow" well MW-7 located southeast of the storage lagoon) to approximately 76 feet (at the "deep" well MW-3 located on the western property boundary). With all other variables being equal, wells with a greater depth to water would be slower to respond to changes in practices at land surface.

3.2.1 Concentration Limits

Concentration limits have not yet been set for Lamb-Weston North Farm because Lamb-Weston and DEQ have yet to agree on the hydrogeology of the site to the degree which appropriate hydrogeologic units (consisting of pairs of upgradient and downgradient wells) can be established.

3.2.2 Nitrate Trends at Individual Wells

The 13 wells at the ConAgra North Farm are completed at different depths and in different materials. Seven wells are considered "deep" while six wells are considered "shallow". Two of the deep wells (MW-5 and MW-6) are partially screened in basalt, while well MW-9 is completely screened in basalt. ConAgra's consultants have concluded that the shallow wells tap a perched[7] aquifer in coarse sediments near a contact with underlying finer sediments.

Nitrate concentrations and water levels at the shallow well MW-12 and the adjacent deep well MW-5 are highly correlated. This correlation suggests these wells could tap deep and shallow portions of the same aquifer, with no unsaturated material between the wells. Correlations between water levels and nitrate concentrations at the other well nests range from not correlated to weakly correlated.

A trend analysis of nitrate concentrations at the 13 ConAgra North Farm wells was conducted as described in Section 1.3. Table 3-1 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each ConAgra well are included in Appendix 2.

Table 3-1 lists the individual results of the trend analyses for each well. The results can be summarized as follows:

- Seven wells exhibit increasing trends,
- Two wells exhibit decreasing trends, and
- Four wells exhibit statistically insignificant trends.

The trends range from increasing at 19.7 ppm/yr at MW-12 to decreasing at 0.13 ppm/yr at MW-9. The site-wide average nitrate trend (i.e., the average of all 13 slopes) is increasing at 2.1 ppm/yr. The average of the nine statistically significant trends is 2.9 ppm/yr.

Table 3-1 also lists the description of the LOWESS pattern for individual wells. The LOWESS patterns observed can be summarized as follows.
Six wells show a consistently or recently increasing pattern:

- one well shows a decreasing then increasing pattern,
- one well shows an increasing then level then increasing pattern, and
- four wells show a consistently increasing pattern.

Four wells show a consistently or recently decreasing pattern:

- one well shows a decreasing pattern,
- one well shows a decreasing, increasing, then decreasing pattern,
- one well shows an increasing then decreasing pattern, and
- one well shows an increasing then decreasing then leveling off pattern.

[7] The American Geological Institutes "Dictionary of Geological Terms" defines perched groundwater as unconfined groundwater separated from the underlying main body of groundwater by unsaturated rock.

Three wells show an essentially flat pattern:

- one well shows a slightly increasing then slightly decreasing pattern,
- one well shows a slightly decreasing pattern, and
- one well shows an increasing, decreasing, and then leveling off pattern.

In other words, about half of the wells exhibit consistently or recently increasing patterns while about one-third exhibit consistently or recently decreasing patterns and about one-quarter exhibit essentially flat patterns.

Figure 3-1 includes the nitrate trends and LOWESS lines at each of the 13 North Farm wells. The 13 graphs are plotted at the same scale to allow a comparison of trends between wells. Useful information can be gained by comparing trend lines with LOWESS lines. For example, Figure 3-1illustrates the following:

- Nitrate concentrations at well MW-7 (which shows an overall increasing trend) increased through about 2002 then started decreasing,
- Nitrate concentrations at MW-8 increased until about 2000, then decreased through about 2003, then leveled off.

Figure 3-2 is a map view of the site illustrating the nitrate trends at each of the wells. The six shallow wells exhibit three increasing trends and three statistically insignificant trends. The seven deep wells are a mix of four increasing trends, two decreasing trends, and one statistically insignificant trend. The steepest increasing trend (19.7 ppm/yr) is at the shallow well MW-12 located near the northern property boundary. The next steepest increasing trend (3.65 ppm/yr) is at the shallow well MW-11 located along the western property boundary. The steepest decreasing trend is at deep well MW-9 located near the wastewater storage lagoon. The high percentage of increasing trends illustrates that the nitrate concentrations are generally increasing at the North Farm.

3.2.3 Average Nitrate Concentrations at Individual Wells

Figure 3-3 is a map view of the site illustrating the average nitrate concentrations at each of the North Farm wells. Since three of the wells are relatively new additions to the well network, two averages are indicated in Figure 3-3:

- The average nitrate concentration from August 2006 through November 2009 (i.e., the timeframe in which all wells were installed and sampled), and
- The average nitrate concentration from January 1996 through November 2009 (i.e., the timeframe in which 10 of the 13 wells were installed and sampled).

Figure 3-3 shows that the shallow well in each well pair averages more than 30 ppm higher nitrate than the adjacent deep well. The highest average nitrate concentrations over the past three years are at the shallow wells (63.3 ppm at MW-12, 59.3 ppm at MW-11, 47.1 ppm at MW-8, and 46.4 ppm at MW-10). The lowest average nitrate concentrations are at the two wells completed at least partially in basalt (9.5 ppm at MW-6 and 5.8 ppm at MW-9).

3.2.4 Site-Wide Trends and Concentrations

Figure 3-4 is a graph of all nitrate data from the 13 North Farm wells, with a LOWESS line drawn through the data. Figure 3-4 consists of many stacks of data points at approximately 3-month intervals. Each of these stacks of data represents one quarterly sampling event and contains one data point for each well sampled that event. It is evident from Figure 3-1 that most the highest concentrations detected have occurred since the three shallow wells were installed in 2006. The LOWESS line increases from 1996 through about 1999 then levels off through 2005, then increases through 2009. The increase since 2005 is likely due to the higher concentrations in the three recent shallow wells.

Figure 3-4 also includes two estimates of the site-wide trend using the 13 wells: one through the entire history of the site (i.e., October 1995 through November 2009, and another through the most recent 5 years of data (i.e., 2005 through 2009). These monotonic trends are consistent with the LOWESS line. The 1995 through 2009 site-wide trend increases at 0.11 ppm per year at a 99% confidence level. The 2005 through 2009 site-wide trend increases at 0.32 ppm per year with a 99% confidence level. In other words, the overall site-wide trend is increasing, and may be increasing steeper in recent years. However, because the three recent shallow wells were not sampled prior to 2006, the two trends are not exactly comparable.

3.2.5 Upgradient to Downgradient Comparison

As described in Section 3.2.2, the 13 wells at the ConAgra North Farm are completed at different depths and in different materials. Seven wells are considered “deep” while six wells are considered “shallow”. Two of the deep wells (MW-5 and MW-6) are partially screened in basalt, while well MW-9 is completely screened in basalt.

DEQ and ConAgra’s consultants have contoured water levels at the site differently. DEQ’s interpretation is that a groundwater mound exists beneath the North Farm. It is assumed that the groundwater mound is shaped somewhat like the northeast/southwest trending topographic ridge on which the North Farm sits with groundwater flowing radially away from the center of the mound. Because no water level data are available from north of the North Farm, it is not possible to determine either the exact shape of the mound or the location of the center of the mound. Additional wells were installed at the North Farm in the summer of 2006 but information from these new wells is still being incorporated into an understanding of the site hydrogeology. Based on existing information, the center of the mound is believed to be located near, or somewhere northeast of well MW-4.

ConAgra’s consultants have concluded that the shallow wells tap a perched aquifer in coarse sediments near a contact with underlying finer sediments. Nitrate concentrations and water levels at one of the five well nests (i.e., the shallow well MW-12 and the adjacent deep well MW-5) are highly correlated. This correlation suggests these wells could tap deep and shallow portions of the same aquifer, with no unsaturated material between the wells. Correlations between water levels and nitrate concentrations at the other well nests range from not correlated to weakly correlated.

While DEQ and ConAgra’s consultants have contoured water level data differently at the site, both interpretations show shallow groundwater flow in the northeast portion of the North farm is eastward towards the Umatilla River and groundwater flow in the southwest portion of the site to the southwest. In other words, both interpretations show well MW-12 is generally upgradient of MW-8.

Figure 3-5(a) is a time series graph showing nitrate concentrations at the shallow upgradient well MW-12 and the shallow downgradient well MW-8. MW-12 has been sampled since 2006 while MW-8 has been sampled since 1995. In addition to the individual data points connected by a thin line, a thick LOWESS line is drawn through the data.

Figure 3-5(a) shows the upgradient nitrate concentrations increase steeply from about 35 ppm in 2006 to about 100 ppm by late 2009. Figure 3-5(a) also shows the downgradient nitrate concentrations increased from about 40 ppm to about 70 ppm from 1995 through 1999, decreased to about 50 ppm by 2002, then decreased slower to about 45 ppm by the end of 2009.

It is evident from Figure 3-5(a) that during the time in which both wells were sampled, the nitrate trends are different (i.e., the upgradient well is steeply increasing while the downgradient well is gently decreasing).

Figure 3-5(b) is a box and whisker plot summarizing the nitrate concentrations from the upgradient well MW-12 and the downgradient well MW-8. Figure 3-5(b) shows the average upgradient nitrate concentration is approximately 63 ppm, and the IQR (representing the middle half of the data) is approximately 42 to 82 ppm. Figure 3-5(b) also shows the average downgradient nitrate concentration is approximately 51 ppm, and the IQR is approximately 46 to 54 ppm.

Given the elevated nitrate concentrations in the upgradient well, it is concluded that offsite activities have and continue to impact groundwater quality at the North Farm. The dissimilar nitrate trends and concentrations at wells MW-12 and MW-8 suggest either (1) they are not along the same groundwater flow path, or (2) the wells are along the same flow path but the groundwater flow velocity is slow enough that the high concentrations observed at MW-12 have not had enough time to reach the downgradient well MW-8. The existing well network may not be adequate to evaluate impacts from facility operations. Data from future sampling events should help determine the effectiveness of the existing well network.

3.2.5 Comparison to Previous Analysis

The trends calculated for each well during each of the three trend analyses are indicated in Table 3-2. The changes in trends are summarized in Table 3-2 in two ways:

1. Wells showing similar changes are grouped together, with a summary of the change indicated along the right side of Table 3-2. These changes are interpreted as indications of improving or worsening water quality between 2005 and 2009.
2. The number of decreasing and increasing trends per analyses are summarized along the bottom of Table 3-2, with a summary of the changes indicated at the bottom right side of Table 3-2.

The confidence levels of the trends influence the words chosen to summarize changes between analyses in Table 3-2. For example, if both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as “showing” a change in trend. Conversely, if either confidence level is less than 80% (e.g., a statistically insignificant trend), then the change is termed as “suggesting” a change in trend. An “improving” trend is defined as either a steeper decreasing trend or a less steeply increasing trend. A “worsening” trend is defined as either a steeper increasing trend or a less steeply decreasing trend.

As shown in Table 3-2, indications of improving water quality between the second and third trend analyses include:

- four wells show improving trends by increasing less steeply,
- two wells suggest improving trends by switching from increasing to decreasing,
- the site-wide average of statistically significant trend slopes show improving trends by increasing less steeply when only wells MW-1 through MW-10 are considered. If the recent shallow wells are included in the analysis, the site-wide trend shows a worsening trend by increasing steeper.

Indications of worsening water quality since the previous analysis include:

- one well shows a worsening trend by increasing steeper,
- one well shows a worsening trend by decreasing less steeply, and
- there were more increasing trends, fewer decreasing trends, and more statistically insignificant trends.

In summary, although the majority of wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2009 than they did through 2005.

3.2.6 Conclusions

Based on the discussion of the data for the ConAgra North Farm site presented above, the following conclusions have been made, and are grouped by topic:

Concentration Limits

- Concentration limits have not yet been set for Lamb-Weston North Farm because Lamb-Weston and DEQ have yet to agree on the hydrogeology of the site to the degree which appropriate hydrogeologic units (consisting of pairs of upgradient and downgradient wells) can be established.

Nitrate Trends at Individual Wells

- Nitrate concentrations at the North Farm are generally increasing, as evidenced by:
    - 54% of the wells have statistically significant increasing trends.

- Another 15% of the wells have statistically insignificant increasing trends.
- Trends range from decreasing at 0.13 ppm/yr to increasing at 19.7 ppm/yr with the site-wide average nitrate trend increasing at least 2.1 ppm/yr.
- Two-thirds of the wells exhibit either flat or increasing LOWESS patterns.
- Most of the highest concentrations occur in the latter portion of the data set.

Average Nitrate Concentrations

- The shallow well in each well pair averages more than 30 ppm higher nitrate than the adjacent deep well.
- The highest average nitrate concentrations over the past three years are at the shallow wells (63.3 ppm at MW-12, 59.3 ppm at MW-11, 47.1 ppm at MW-8, and 46.4 ppm at MW-10).
- The lowest average nitrate concentrations are at the two wells completed at least partially in basalt (9.5 ppm at MW-6 and 5.8 ppm at MW-9).

Site-Wide Trends

- The overall site-wide trend is increasing, and because three shallow wells were recently installed, appears to be steeper in recent years.
- The 1995 through 2009 site-wide trend increases at 0.11 ppm per year with a 99% confidence level.
- The 2005 through 2009 site-wide trend increases at 0.38 ppm per year with a 99% confidence level.
- These monotonic trends are consistent with the LOWESS line that increases from 1996 through about 1999 then levels off through 2005, then increases through 2009. The increase since 2005 is likely due to the higher concentrations in the three recent shallow wells.

Upgradient to Downgradient Comparison

- Given the elevated nitrate concentrations in the upgradient well, it is concluded that offsite activities have and continue to impact groundwater quality at the North Farm.
- The dissimilar nitrate trends and concentrations at wells MW-12 and MW-8 suggest either (1) they are not along the same groundwater flow path, or (2) the wells are along the same flow path but the groundwater flow velocity is slow enough that the high concentrations observed at MW-12 have not had enough time to reach the downgradient well MW-8.
- The existing well network may not be adequate to evaluate impacts from facility operations. Data from future sampling events should help determine the effectiveness of the existing well network.

Comparison to Previous Analysis

- In summary, although the majority of wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2009 than they did through 2005.

3.3 Madison Ranch

The ConAgra Madison Ranch site is located approximately 5 miles south of the City of Hermiston, south of Interstate 84 and west of State Road 207 (Figure 1-2). The land application system at Madison Ranch began in 1991. The Butter Creek flood plain portion of Madison Ranch has been farmland since the 1800's. Prior to the land application system, the land occupied by the upland portion of Madison Ranch was unfarmed dry land. Approximately 650 million gallons of wastewater are applied on Madison Ranch per year.

The Madison Ranch site includes portions of both the Butter Creek flood plain and the uplands to the west of the flood plain. Soils within the flood plain include silt loams, loamy sands, and sandy loams that are predominantly well drained. Soils that are somewhat poorly drained, moderately well drained, and excessively drained also occur in the flood plain. Topographic slopes are generally 0 to 5%, but slopes of 5% to 25% also occur. The dominant soils within the uplands also include silt loams, loamy sands, and sandy loams, but are well drained to excessively drained. Topographic slopes within the uplands are generally less than 7%, but slopes of up to 25% are common. Small portions of the site have steeper slopes.

Land surface elevation within the Butter Creek flood plain slopes fairly evenly from approximately 800 feet above mean sea level at the southern property boundary to 640 feet above mean sea level at the northern property boundary. The uplands are cut by several ephemeral drainages with land surface elevation ranging from approximately 1,040 feet above mean sea level at the southern property boundary to approximately 640 feet above mean sea level at the northern property boundary.

Nearby surface water features include Butter Creek which flows northward through the eastern portion of the site, several unnamed irrigation canals and ditches within the Butter Creek flood plain, and the High Line canal which forms a portion of the northern property boundary before emptying into Lost Lake located approximately ½ mile north/northwest of the property.

The average depth to water beneath the Butter Creek flood plain portion of the Madison Ranch site ranges from approximately 12 feet below land surface (at well MW-10) to 15 feet below land surface (at wells MW-11 and MW-12). The average depth to water beneath the upland portion of the Madison Ranch site ranges from approximately 33 feet below land surface (at well MW-3) to more than 150 feet below land surface (at well MW-2). With all other variables being equal, wells with a greater depth to water would be slower to respond to changes in practices at land surface.

3.3.1 Concentration Limits

Concentration limits have not yet been set for Lamb-Weston Madison Ranch because Lamb-Weston and DEQ have yet to agree on the hydrogeology of the site to the degree which appropriate hydrogeologic units (consisting of pairs of upgradient and downgradient wells) can be established.

3.3.2 Nitrate Trends at Individual Wells

A trend analysis of nitrate concentrations at the 15 ConAgra Madison Ranch wells was conducted as described in Section 1.3. Two of the 15 wells analyzed are considered offsite wells because they are located in an area that received wastewater from 1992 through 1998 but is no longer part of the ConAgra permit. Table 3-3 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each ConAgra well are included in Appendix 2.

Table 3-3 lists the individual results of the trend analysis for each well. The results can be summarized as follows:

- nine onsite wells exhibit increasing trends,
- one onsite well and two offsite wells exhibit decreasing trends, and
- three onsite wells exhibit statistically insignificant trends.

In summary, two-thirds of the wells exhibit statistically significant increasing trends. Statistically significant trends range from increasing at 0.99 ppm/yr (at MW-6) to decreasing at 0.35 ppm/yr (at MW-5). The site-wide average nitrate trend (i.e., the average of all 13 slopes) is increasing at approximately 0.19 ppm/yr. The average of the 10 statistically significant trends is approximately 0.24 ppm/yr.

Table 3-3 also lists the description of the LOWESS pattern for each individual well. The LOWESS patterns observed can be summarized as follows:

- five wells show a consistently or recently increasing pattern
- two wells show a consistently or recently decreasing pattern
- six wells show a basically flat pattern

In summary, about half of the wells exhibit basically flat LOWESS patterns. Most of the remaining wells exhibit a consistently or recently increasing pattern.

Figure 3-5 includes the nitrate trends and LOWESS lines at each of the Madison Ranch wells (including the two offsite wells). The 15 graphs are plotted at the same scale to allow a comparison of trends between wells. As mentioned previously, useful information can be gained by comparing trend lines with LOWESS lines. For example, Figure 3-5 illustrates that while well MW-6 exhibits an overall increasing trend, nitrate concentrations increased through about 2005, then started to decrease.

Figure 3-6 is a map view of the site illustrating the nitrate trends at each of the wells. Increasing trends occur in both the uplands and the floodplain. Decreasing trends occur in the floodplain. Statistically insignificant trends occur in the uplands and floodplain.

MW-6 (located on the eastern edge of the flood plain) exhibits the steepest increasing trend (0.99 ppm/yr). The next steepest trend (0.36 ppm/yr) is at well MW-9 located along the northern boundary of the uplands.

3.3.3 Average Nitrate Concentrations at Individual Wells

Figure 3-7 illustrates the average nitrate concentrations at each of the Madison Ranch wells from two specific timeframes: August 2006 through 2009 (i.e., when all wells were installed and sampled) and 1996 through 2009 (i.e., the entire period of record for most wells). The highest average nitrate concentration is at well MW-6 (located on the eastern edge of the floodplain). The lowest average nitrate concentrations are at the two deepest upland wells (0.2 ppm at MW-2 and 1.9 ppm at MW-7) and at an upland well likely affected by leakage from the Highline canal (0.9 ppm at MW-4a). The remaining wells have average nitrate concentrations ranging from 3.4 to 8.3 ppm.

3.3.4 Site-Wide Nitrate Trends and Concentrations

Figure 3-8 is a graph of all nitrate data from the 13 Madison Ranch wells that are currently being sampled, with a LOWESS line drawn through the data. Figure 3-8 consists of many stacks of data points at approximately 3-month intervals. Each of these stacks of data represents one quarterly sampling event and contains one data point for each well sampled that event.

It is evident from Figure 3-8 that the highest concentrations detected have occurred at well MW-6. The LOWESS line has a gentle downward curve through 2002, gently increases through 2005, and then increases steeper through 2009. The relatively flat LOWESS line prior to 2006 reflects the generally consistent nitrate concentrations between wells and relatively flat trends at most wells. The steeper increase in the LOWESS line since 2006 reflects the new wells with generally higher nitrate concentrations than other wells.

Figure 3-8 also includes two estimates of the site-wide trend using the currently sampled onsite wells: one through the entire history of the site (i.e., late 1995 through 2009), and another through the most recent five years of data (i.e., 2005 through 2009). These monotonic trends are consistent with the LOWESS line. The 1995 through 2009 site-wide trend increases at 0.09 ppm per year with a 99% confidence level. The 2005 through 2009 site-wide trend increases at 0.13 ppm per year with a 99% confidence level. In other words, the overall site-wide trend is increasing, and it is increasing slightly steeper in recent years. However, because not all wells currently being sampled were installed in 1995, the two trends are not exactly comparable.

3.3.5 Upgradient to Downgradient Comparison

The groundwater flow system at the ConAgra Madison Ranch site is described in DEQ (2004). In general, groundwater within the Butter Creek floodplain is expected to flow straight down the floodplain. Groundwater on the flanks of the floodplain is expected to flow into the floodplain. Groundwater flow beyond the flanks of the floodplain is expected to be controlled by land surface topography, location of surface water features, location of recharge (i.e., where irrigation water is applied), and the elevation of the underlying basalt surface.

Well MW-12 is an upgradient well for the Butter Creek drainage. Wells MW-5 and MW-11 are located on land that received wastewater from 1992 through 1998 but are no longer part of the ConAgra permit. Therefore, MW-5 and MW-11 are not suitable downgradient wells. There are currently no downgradient wells for the floodplain portion of Madison Ranch.

Groundwater flow directions in the uplands are not well understood. Based on the discussion in DEQ (2004), upgradient wells would be located either at the upper ends of drainages (e.g., where Fourmile Canyon enters the property) or near the center of topographic and hydraulic "islands" (e.g., Ward Butte). Currently there are no upgradient wells for the uplands.

Additional wells were installed at Madison Ranch in the summer of 2006 but information from these new wells is still being incorporated into an understanding of the site hydrogeology.

Based on the groundwater flow regime discussed above, there are currently no Butter Creek flood plain wells that are solely downgradient of ConAgra activities. Similarly, there are currently no upgradient wells located within the uplands. Therefore, no meaningful comparisons of upgradient to downgradient concentrations within the Butter Creek flood plain or within the uplands can be made.

3.3.6 Comparison to Previous Analysis

The trends calculated for each well during each of the three trend analyses are indicated in Table 3-4. The changes in trends are summarized in Table 3-4 in two ways:

1. Wells showing similar changes are grouped together, with a summary of the change indicated along the right side of Table 3-4. These changes are interpreted as indications of improving or worsening water quality between 2005 and 2009.
2. The number of decreasing and increasing trends per analyses are summarized along the bottom of Table 3-2, with a summary of the changes indicated at the bottom right side of Table 3-4.

The confidence levels of the trends influence the words chosen to summarize changes between analyses in Table 3-4. For example, if both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as "showing" a change in trend. Conversely, if either confidence level is less than 80% (e.g., a statistically insignificant trend), then the change is termed as "suggesting" a change in trend. An "improving" trend is defined as either a steeper decreasing trend or a less steeply increasing trend. A "worsening" trend is defined as either a steeper increasing trend or a less steeply decreasing trend.

As shown in Table 3-4, indications of improving water quality between the second and third trend analyses include:

- two wells show improving trends by increasing less steeply,
- two wells suggest improving trends by increasing less steeply,
- the site-wide average trend shows improving trends by increasing less steeply, and
- while there were two more increasing trends, the percentage of increasing trends is lower.

Indications of worsening water quality since the previous analysis include:

- one well shows a worsening trend by decreasing less steeply, and
- four wells show a worsening trend by increasing steeper,

In summary, although the majority of wells and the site as a whole exhibit increasing trends, the trends are increasing a little less steep through 2009 than they did through 2005.

3.3.7 Conclusions

Based on the discussion of the data for the ConAgra Madison Ranch site discussed above, the following have been made, and are grouped by topic:

Concentration Limits
Concentration limits have not yet been set for Lamb-Weston Madison Ranch because Lamb-Weston and DEQ have yet to agree on the hydrogeology of the site to the degree which appropriate hydrogeologic units (consisting of pairs of upgradient and downgradient wells) can be established.

Nitrate Trends
- Nitrate concentrations at Madison Ranch are generally increasing, as evidenced by
    - two-thirds of the wells exhibit statistically significant increasing trends,
    - the site-wide average nitrate trend is increasing at approximately 0.2 ppm/yr.
    - only 15% of wells exhibit consistently or recently decreasing LOWESS patterns.

Average Nitrate Concentrations
- The highest average nitrate concentration is at well MW-6 (located on the eastern edge of the floodplain).
- The lowest average nitrate concentrations are at the two deepest upland wells (0.2 ppm at MW-2 and 1.9 ppm at MW-7) and at an upland well likely affected by leakage from the Highline canal (0.9 ppm at MW-4a).
- The remaining wells have average nitrate concentrations ranging from 3.4 to 8.3 ppm.

Site-Wide Trends
- The overall site-wide trend is increasing, and it is increasing slightly steeper in recent years.
- The 1996 through 2009 site-wide trend is increasing at 0.09 ppm per year with a 99% confidence level.
- The 2005 through 2009 site-wide trend is increasing at 0.13 ppm per year with a 99% confidence level.
- These monotonic trends are consistent with the LOWESS line that suggests nitrate concentrations at Madison Ranch slightly declined from 1996 through 2002, gently increased through 2005, and then increased steeper through 2009.

Upgradient to Downgradient Comparison
- There are currently no Butter Creek flood plain wells that are solely downgradient of ConAgra activities, nor are there are any upgradient wells located within the uplands.
- Therefore, no meaningful comparisons of upgradient to downgradient concentrations within the Butter Creek flood plain or within the uplands can be made.

Comparison to Previous Analysis
Although the majority of wells and the site as a whole exhibit increasing trends, the trends are increasing a little less steep through 2009 than they did through 2005.

3.4 Recommendations
Based on the conclusions above, the following recommendations are made:
- ConAgra and DEQ should work together to expand the existing well network and develop an acceptable monitoring plan.
- In order to gauge when the effects of BMP implementation will be observed as improving groundwater quality, it is recommended that funding be pursued to allow additional research into factors including: (1) quantifying the amount of nitrate that exists between the root zone and the water table, (2) the rate of nitrate transport through the unsaturated zone, and (3) more precisely quantifying groundwater flow velocity at the site.
- Due to the high percentage of increasing trends and likely affects to groundwater from land application activities, it is recommended that BMP implementation to reduce the area-wide extent of elevated nitrate concentrations be continued and, when possible, improved. BMPs should include detailed procedures to:
    - establish appropriate crop specific nitrogen loading rates,
    - accurately quantify hydraulic loading from all sources,

  - document nutrient additions from all sources,
  - insure uniform sample acquisition and analysis,
  - characterize and monitor nitrogen concentration and movement in the soil column,
  - monitor moisture content and movement in the soil column, and
  - perform annual site-specific analysis to identify farming activities and/or soil conditions that increase the potential for impact to groundwater.
- A trend analysis of data from the same wells should be conducted in 2014 to evaluate progress towards improving groundwater quality at the food processing wastewater land application sites.

4.0 SIMPLOT SITES

4.1 Introduction

The Simplot potato processing facility began operations in 1977. Over the years, Simplot modified practices and procedures to reduce the amount of nitrate and hydraulic loading to the groundwater system. In the late 1990s, Simplot voluntarily entered into a Remedial Investigation / Feasibility Study to identify and document potential remedies for the increasing groundwater nitrate concentrations. Best Management Practices implemented because of Simplot's investigation included the following:

- *Expansion of land application areas* – Simplot increased the land area used to apply wastewater to include the Terrace Site in 1981, the Expansion Site in 1991, and the Levy Site in 2002.
- *Improved waste treatment process* – In 1987, Simplot built a digester and improved solids removal by installing a centrifuge. In 1995, Simplot built a larger clarifier and installed a second centrifuge for additional solids removal.
- *Limiting winter irrigation* – In 1991, Simplot built the Terrace Site Lagoon so that water could be stored during a portion of the winter months rather than land applied.
- *Eliminating winter irrigation* **–** In 2002, Simplot built a second lagoon so that water could be stored during the entire winter, which eliminated winter irrigation.
- *Reducing nitrogen loading* – In 2001, Simplot stopped taking credit for ammonia volatilization, which equates to a 40% reduction in planned nitrogen loading. Agronomic loadings were used on most crops starting in 1998 but due to lack of land, agronomic loadings were sometimes exceeded on some crops until 2002. In 2002, Simplot reduced the loading on alfalfa at the Levy property to 250 lb/acre.
- *Improved soil moisture monitoring* **–** Soil moisture monitoring was occurring prior to 1995 but it was recorded once a week. In 2002, Simplot started continuous soil moisture monitoring that took readings every 2 hours.
- *Improved equipment* – Telemetry and electronic valves were installed in 2002, which allowed Simplot to monitor water application much closer. The system included an alarm feature, which notified Simplot the minute a pivot broke and shut the water off immediately to prevent the pivot from sitting in one place while continuing to irrigate. The telemetry and electronic valves also allowed for more precise applications of commercial fertilizer, which reduced the amount of excess nitrogen applied.
- *Improved water need estimation* – Starting in 2000, Simplot began using the Agrimet weather website for hydraulic requirement estimates. Prior to 2000, Simplot hired a consultant who would provide a recommendation at the beginning of the year, which does not reflect weather changes throughout the season.
- *Improved training and oversight* – in 1997, Simplot reorganized employee responsibilities to create a position devoted exclusively to oversee land application. Furthermore, Simplot created classes to teach employees about land application of wastewater and the importance of doing it correctly. Employees were given a binder with copies of the piping systems, spill procedures, troubleshooting procedures and a copy of the WPCF permit. Pay increases were given which reduced the turnover rate. After a month of hands-on training, every employee was given a test. If they did not pass the test, they were removed from the irrigation position. If they passed the test, they were allowed to irrigate on the site alone.

The Simplot potato processing facility shut down in November 2004. At that time, some potato processing wastewater remained in the Terrace Site Lagoon. The CalPine power plant continued to generate wastewater that was added to the lagoon throughout the winter of 2004/2005. Wastewater associated with potato processing was gradually pumped out during 2005. Wastewater from the power plant continues to be piped to the lagoon for use as irrigation water. After expansion to the Levy farm in 2002, Simplot did not have enough nitrogen to fulfill the needs of all crops grown so they began applying commercial fertilizer at that time. The amount of commercial fertilizer applied has increased since the plant shut down.

Simplot's wastewater system can handle approximately 2.35 million gallons per day (MGD). Prior to November 2004, the bulk of the water (2.0 MGD) was food processing wastewater from the preparation and packaging of potato products. Other sources of wastewater that are land applied include co-generation wastewater from the adjacent CalPine steam electric generation facility (0.35 MGD), and filter back wash wastewater from the Umatilla Regional Water Facility.

In 2000, Simplot land applied approximately 616 million gallons. From 1991 through 2000, average values for Simplot's wastewater include:

- 1,350 mg/l Chemical Oxygen Demand (COD)
- 145 mg/l Total Kjeldahl Nitrogen (TKN)
- 104 mg/l ammonia
- 1,672 mg/l total dissolved solids (TDS)
- 1 mg/l nitrate-nitrogen (NO_3)
- 107 mg/l chloride (Cl)
- 28 mg/l calcium (Ca)
- 103 mg/l sodium (Na)
- 46 mg/l magnesium (Mg)
- 363 mg/l potassium (K)
- 795 mg/l bicarbonate (HCO_3)
- 58 mg/l total phosphorus (P)

In 2005, Simplot land applied approximately 510.5 million gallons of water. Because there was no more potato processing water being generated, the CalPine waste stream (513,000 gallons) was the only significant wastewater stream going to the wastewater lagoon. To decrease the TDS concentration in the water prior to irrigation, 510 million gallons of groundwater was pumped into the lagoon. The water pumped from the lagoon used for irrigation contained an average 17 mg/l TKN and 399 mg/l TDS.

As of the end of 2005, the water was applied on four parcels of land: the Plant Site, the Terrace Site, the Expansion Site, and the Levy Site. The locations of the Plant Site, Terrace Site, and Expansion Site are indicated in Figure 1-2.

From 2006 to 2009, the average annual flow of wastewater from CalPine was 93.8 million gallons. Average TKN was 7.11 mg/l and average TDS was 1,015 mg/l. Due to a water right issue, Simplot did not mix very much groundwater with the wastewater between 2005 and 2009. However, at the end of 2009, Simplot did obtain a new water right for Umatilla River water which has a lower TDS concentration. Due to the low nitrogen content of the CalPine wastewater, almost all nitrogen applied from 2006 through 2009 was commercial fertilizer.

4.2 Plant Site

The Simplot Plant Site is located approximately 3 miles south of the City of Hermiston, northeast of the junction of US Interstate 84 and Oregon 207 (Figure 1-2). Until November 2004, wastewater was screened, treated (using a primary clarifier, diffused air flotation system, and an anaerobic digester) at the Plant Site, and then stored in a surge pond or a storage pond before being applied to agricultural land at one of Simplot's parcels of land. At the Plant Site, wastewater was historically applied to as many as 12 fields comprising as much as 220 acres. Crops grown using the wastewater included a rotation of grain (corn, wheat, and barley), forage grasses (tall fescue, reed canary grass, and other suitable forage grass species), and alfalfa. When alfalfa was used in a rotation, it was maintained for four or more years.

The land application system at the Plant Site began in 1977. Prior to the land application system, the land occupied by the Plant Site included houses and small farming operations using Umatilla River water for irrigation.

The geomorphology of the Plant Site includes an upland terrace and the Umatilla River flood plain. The terrace and flood plain generally exhibit gentle slopes (0 to 5%) except where they meet, when slopes reach 25%. Topography at the Plant Site ranges from approximately 530 to 610 feet above mean sea level.

Nearby surface water features include the Umatilla River (which flows east to west across the property), Manns Pond and several un-named irrigation canals located south of the River, and the Feed Canal (delivering water from the Umatilla River to Cold Springs Reservoir) approximately ½ mile northeast of the Plant Site. Because deep percolation of irrigation water is a major source of recharge to the alluvial aquifer, wells closer to leaky fresh water canals (and for that matter fresh water streams) are more likely to exhibit lower nitrate concentrations due to dilution from the surface water.

The depth to water beneath the Plant Site ranges from approximately 6 feet below land surface (at wells MW-17 and MW-19; located within the flood plain) to approximately 122 feet below land surface (at well MW-59 located on the terrace). Wells monitoring the deeper portion of the aquifer beneath the terrace (i.e., MW-13d) have water levels as deep as 149 feet below land surface. With all other variables being equal, wells with a greater depth to water would be slower to respond to changes in practices at land surface.

4.2.1 Concentration Limits

Concentration limits for a facility such as Simplot are typically calculated after a hydrogeologic characterization is completed, and sufficient groundwater monitoring data is collected. Facilities are then asked to submit a Water Quality Analysis Report to evaluate the data and propose concentration limits. During preparation of their Water Quality Analysis Report, Simplot recognized they would not be able to meet the calculated concentration limits. At that point, Simplot voluntarily entered into a Remedial Investigation / Feasibility Study to identify and document potential remedies for the increasing groundwater nitrate concentrations. One outcome of the RI/FS was the decision to establish remedial action goals at downgradient compliance wells (i.e., concentrations goals lower than currently observed) for the Simplot Plant Site rather than establishing concentration limits (i.e., concentrations higher than currently observed and are upper limits of acceptable levels) that could not be met. As a result, the Simplot Plant Site has remedial action goals rather than concentration limits. Remedial goals were achieved at some, but not all wells at the Simplot Plant Site. As with the other Simplot application sites, the site continues to operate under the nutrient and water loading restrictions contained in the permit, but commercial fertilizer is used to supply all the plant nutrient requirements (i.e., no food processing wastewater is applied).

4.2.2 Nitrate Trends

A trend analysis of nitrate concentrations at the 11 wells currently being sampled was conducted as described in Section 1.3. Twelve wells at the site are no longer being sampled. Table 4-1 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each Simplot well are included in Appendix 3.

Table 4-1 lists the individual results of the trend analysis for each well (including those no longer being sampled). The results can be summarized as follows:

- four wells have increasing trends,
- three wells have decreasing trends, and
- four wells have statistically insignificant trends.

In summary, approximately 45% of the wells have increasing trends. Statistically significant trends range from increasing at 0.25 ppm/yr (at MW-10S) to decreasing at 2.97 ppm/yr (at MW-48). The site-wide average nitrate trend (i.e., the average of all 11 slopes) is decreasing at approximately 0.25 ppm/yr. The average of the seven statistically significant trends is decreasing at approximately 0.4 ppm/yr.

Table 4-1 also lists the description of the LOWESS patterns for individual wells. The wells were split in approximate thirds with one-third of the wells showing consistently or recently increasing patterns, one-third showing consistently or recently decreasing patterns, and the other third showing essentially flat patterns. It is noteworthy that the wells with flat patterns have low nitrate concentrations (e.g., average concentrations less than 1.2 ppm). In other words, approximately two-thirds of the wells show consistently or recently decreasing patterns, or have consistently low concentrations.

Figure 4-1 includes the nitrate trends and LOWESS lines at each of the 23 Simplot Plant Site wells (not just the 11 wells that are currently being sampled). The 23 graphs are plotted at the same scale to allow a comparison of trends between wells. Useful information can be gained by comparing trend lines with LOWESS lines. For example, Figure 4-1 illustrates that nitrate concentrations at several wells (most notably MW-18, MW-47, & MW-48) increased then decreased.

Figure 4-3 is a map view of the site illustrating the nitrate trends at each of the 11 wells currently being sampled. The increasing trends are observed at in the north and northwestern portion of the site. The decreasing trends are observed in both the eastern and western portions of the site. The statistically insignificant trends are observed throughout the site.

There are three well pairs at the site: MW-10s, MW-10d, MW-11s/MW-11d, and MW-13s/MW-13d. At the MW-10 well pair, the shallow well shows an increasing trend while the deep well has a statistically insignificant trend. At the MW-11 well pair, the shallow well shows a decreasing trend while the deep well shows an increasing trend. At the MW-13 well pair, the shallow well shows an increasing trend but the deep well is no longer sampled.

4.2.3 Average Nitrate Concentrations

Figure 4-3 is a map view of the site illustrating the average nitrate concentrations at the 11 wells still being sampled. The average in Figure 4-3 is from 1996 through 2009, the timeframe in which these wells were installed and sampled. The averages in Table 4-1 use all data since each well was installed.

In summary, average nitrate concentrations were highest in the shallow wells away from the river and lowest in the deep wells and wells near the river. The highest average nitrate concentration (32 ppm) is at well MW-48. The lowest average nitrate concentrations (about 1 ppm) are at wells MW-50 and MW-19 near the river, and at deep wells MW-11s and MW-10d. The remaining wells have average nitrate concentrations ranging from 6.2 to 22.3 ppm.

4.2.4 Site-Wide Nitrate Trends and Concentrations

Figure 4-4 is a graph of all nitrate data from the 11 Simplot Plant Site wells still sampled, with a LOWESS line drawn through the data. Figure 4-4 consists of many stacks of data points at approximately 3-month intervals. Each of these stacks of data represents one quarterly sampling event and contains one data point for each well sampled that event. It is evident from Figure 4-4 that the highest concentrations detected have occurred largely at wells MW-13s, MW-48, and MW-12. The LOWESS line gently decreases through about 1996, and then gently increases until about 2000, and then it gently decreases through 2009.

Figure 4-4 also includes two estimates of the site-wide trend using the 11 currently sampled wells: one through the entire history of the site (i.e., 1988 through 2009), and another through the most recent 5 years of data (i.e., 2005 through 2009). These monotonic trends are consistent with the LOWESS line. The 1988 through 2009 site-wide trend is flat (i.e., a slope of zero) with a 97% confidence level. The 2005 through 2009 site-wide trend is declining at 0.21 ppm per year with a 92% confidence level. In other words, the site-wide trend is flat overall, but is decreasing in recent years.

4.2.5 Upgradient to Downgradient Comparison

The groundwater flow direction at the Simplot Plant site is described in DEQ (2004). In general, groundwater flows northwest across the site regardless of season. Groundwater flows toward the Umatilla River from the south but not from the north. DEQ (2004) classifies the wells at the Simplot Plant site as either a flood plain well or an alluvial well. This distinction is based on location, typical water level, timing of water level fluctuations, typical lithology, and general water quality. Flood plain wells are located within the Umatilla River flood plain, are generally screened in coarser-grained sediments (sand and gravel), exhibit water levels near 540', fluctuate annually with highest water levels typically in the winter or spring, and lowest water levels in the summer and fall. Total Dissolved Solids (TDS) concentrations of flood plain wells are less than alluvial wells but higher than river concentrations.

Flood plain wells are located within the Umatilla River flood plain, are generally screened in coarser-grained sediments (sand and gravel), exhibit water levels near 540', fluctuate annually with highest water levels typically in the winter or spring, and lowest water levels in the summer and fall. In addition, the TDS concentrations of flood plain wells are less than alluvial wells but higher than river concentrations.

Alluvial wells are located on the terrace on either side of the flood plain, are generally screened in finer-grained sediments (silty sands), exhibit water levels near 500', and fluctuate annually with highest water levels in summer and fall, and lowest water levels in winter and spring. TDS concentrations are higher in alluvial wells than in flood plain wells or the river.

Based on the discussion above, upgradient wells for the Simplot Plant site would be located south and east of facility operations, while downgradient wells would be located north and west of facility operations. Wells MW-50, MW-19, and MW-49 are located upgradient of current facility operations. Wells MW-50 and MW-19 are located north of the River while MW-49 is located south of the River. It should be noted that wastewater was historically applied at the four fields located upgradient of MW-49 and MW-19 (between Umatilla Meadows Road and I-84) from 1981 to not later than 1990. Therefore, the potential exists for these wells to be affected by those facility operations. However, time versus concentration graphs indicate low nitrate concentrations (always less than 2 mg/l) at all three of these wells, suggesting these wells have not been affected by facility operations. However, because MW-49 is on the south side of the River and all current facility operations are north of the river, it is not an ideal upgradient well. Therefore, for the purposes of this report, wells MW-50 and MW-19 are considered upgradient wells.

Wells MW-16, MW-17, MW-20, MW-21, and MW-45 are located within the flood plain and downgradient of facility operations, thus making them potentially usable in upgradient to downgradient comparisons of flood plain water quality. These wells have not been sampled since August 2005 so no comparison of upgradient to downgradient nitrate concentrations in the flood plain was made in this document. However, DEQ (2007a) concluded "facility operations impacted groundwater quality in the past but are currently having little impact".

Wells MW-10s, MW-11s, and MW-46 are located onsite and downgradient of facility operations. However, based on the elevated nitrate concentrations at wells MW-12, MW-48, MW-13s, and others, there are no upgradient alluvial wells unaffected by facility operations. Therefore, all upgradient to downgradient comparisons in this report are made with wells MW-50 and MW-19 as the only upgradient wells.

As indicated in Section 4.2.1, there are currently no upgradient flood plain wells that are unaffected by facility operations. Therefore, wells MW-50 and MW-19 are considered the best upgradient wells available for comparisons to downgradient alluvial wells. Because alluvial wells generally have higher nitrate concentrations than floodplain wells, a hypothetical upgradient alluvial well would likely exhibit slightly higher nitrate concentrations than those at MW-19 and MW-50.

Figure 4-5(a) is a time series graph showing the nitrate concentrations at the upgradient *flood plain* wells MW-50 and MW-19 and the downgradient *alluvial* wells MW-10s, MW-11s, and MW-46. Figure 4-5(a) shows upgradient nitrate concentrations are consistently low (less than 2 ppm) while the downgradient nitrate concentration are significantly higher (the LOWESS line begins at approximately 12 ppm).

Figure 4-5(b) is a box and whisker plot summarizing the nitrate concentrations from the upgradient wells (MW-19 & MW-50) and the downgradient wells (MW-10s, MW-11s, and MW-46). Figure 4-5(b) shows the average upgradient nitrate concentration is less than 1 ppm with all concentrations less than 2 ppm. Figure 4-5(b) also shows the average downgradient nitrate concentration is approximately 8 ppm with half of the concentrations between approximately 6 and 12 ppm.

Based on comparisons of nitrate concentrations at upgradient flood plain wells and downgradient alluvial wells, facility operations have impacted groundwater quality.

4.2.6 Comparison to Previous Analysis

The trends calculated for each well during each of the three trend analyses are indicated in Table 3-4. The changes in trends are summarized in Table 3-4 in two ways:

1. Wells showing similar changes are grouped together, with a summary of the change indicated along the right side of Table 3-4. These changes are interpreted as indications of improving or worsening water quality between 2005 and 2009.
2. The number of decreasing and increasing trends per analyses are summarized along the bottom of Table 3-2, with a summary of the changes indicated at the bottom right side of Table 3-4.

The confidence levels of the trends influence the words chosen to summarize changes between analyses in Table 3-4. For example, if both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as “showing” a change in trend. Conversely, if either confidence level is less than 80% (e.g., a statistically insignificant trend), then the change is termed as “suggesting” a change in trend. An “improving” trend is defined as either a steeper decreasing trend or a less steeply increasing trend. A “worsening” trend is defined as either a steeper increasing trend or a less steeply decreasing trend.

As shown in Table 3-4, indications of improving water quality between the second and third trend analyses include:

- two wells show improving trends (by decreasing steeper),
- one well shows an improving trend (by increasing less steeply),
- two wells suggest an improving trend (by switching from increasing to decreasing),
- one well shows an improving trend (by increasing less steeply), and
- site-wide average trends show improving trends (by decreasing steeper).

Indications of worsening water quality since the previous analysis include:

- one well shows a worsening trend (by decreasing less steeply),
- two wells suggest worsening trends (by increasing steeper), and
- there were more increasing trends than during the previous analysis.

In summary, although there are more wells showing increasing trends than decreasing trends, nitrate concentrations are decreasing in recent years. This decrease is reflected both in the average of the trends at individual wells (Table 4-2) and the site-wide trends (Figure 4-4).

4.2.7 Conclusions

Based on the discussion of the data for the Simplot Plant site presented above, the following conclusions have been made, and are grouped by topic:

Concentration Limits

In the late 1990’s, Simplot voluntarily entered into a Remedial Investigation / Feasibility Study to identify and document potential remedies for the increasing groundwater nitrate concentrations. One outcome of the RI/FS was the decision to establish remedial action goals for the Simplot Plant Site rather than establishing concentration limits that could not be met. Remedial goals have been achieved at some, but not all wells at the Simplot Plant Site.

Nitrate Trends

- Nitrate concentrations are generally decreasing at the Simplot Plant site, as evidenced by:
  - approximately two-thirds of the wells show consistently or recently decreasing patterns, or have consistently low concentrations,
  - Statistically significant trends range from increasing at 0.25 ppm/yr (at MW-10S) to decreasing at 2.97 ppm/yr (at MW-48).
  - The site-wide average nitrate trend (i.e., the average of all 11 slopes) is decreasing at approximately 0.25 ppm/yr.
  - The average of the seven statistically significant trends is decreasing at approximately 0.4 ppm/yr.

Average Nitrate Concentrations

- Average nitrate concentrations were highest in the shallow wells away from the river and lowest in the deep wells and wells near the river.
- The highest average nitrate concentration (32 ppm) is at well MW-48.
- The lowest average nitrate concentrations (about 1 ppm) are at wells MW-50 and MW-19 near the river, and at deep wells MW-11s and MW-10d.

Site-Wide Trends

- The 1988 through 2009 site-wide trend is flat (i.e., a slope of zero) with a 97% confidence level.
- The 2005 through 2009 site-wide trend is declining at 0.21 ppm per year with a 92% confidence level.
- These monotonic trends are consistent with the LOWESS line in that the site-wide trend is flat overall, but is decreasing in recent years.

Upgradient to Downgradient Comparison

Based on comparisons of nitrate concentrations at upgradient flood plain wells and downgradient alluvial wells, facility operations have impacted groundwater quality.

Comparison to Previous Analysis

Although there are more wells showing increasing trends than decreasing trends, nitrate concentrations are decreasing in recent years. This decrease is reflected both in the average of the trends at individual wells and the site-wide trends.

4.3 Terrace Site

The Simplot Terrace Site is located approximately 4 miles south of the City of Hermiston, southeast of the junction of US Interstate 84 and Oregon 207 (Figure 1-2). As indicated in Section 4.1, the potato processing facility shut down in November 2004. Prior to closure, wastewater was screened, treated at the Plant Site, and then stored in a surge pond or a storage pond before being applied to agricultural land at one of Simplot's parcels of land. At the Terrace Site, wastewater was applied to as many as six fields comprising as much as 582 acres.

The land application system at the Terrace Site began in 1981. Prior to the land application system, the land occupied by the Terrace Site was a mixture of farmland and unfarmed dry land.

The Terrace Site is located on an upland terrace, situated between Emigrant Buttes (the surface expression of the Service Anticline) and the Butter Creek flood plain. The terrace exhibits a gentle northward slope (0 to 5%). Topography at the Terrace Site ranges from approximately 610 to 700 feet above mean sea level.

Nearby surface water features include Butter Creek (which is located just west of the site and flows south to north), and the Hunt Ditch (a component of the Westland Irrigation District delivering water from the Umatilla River to irrigated land in the vicinity) which wraps around the east, north, and west property boundaries. The Hunt Ditch is closest to the Terrace site at the northeast property boundary. The depth to water beneath the Terrace Site ranges from approximately 50 feet below land surface (at MW-51; a well located close to the Butter Creek flood plain) to approximately 90 feet below land surface (at MW-53; a well in the northern portion of the site).

4.3.1 Concentration Limits

As indicated previously, Simplot voluntarily entered into a Remedial Investigation / Feasibility Study in the late 1990’s to identify and document potential remedies for the increasing groundwater nitrate concentrations. One outcome of the RI/FS was the decision to establish remedial action goals for the downgradient wells at the Simplot Terrace Site rather than establishing concentration limits that could not be met. Remedial goals have not yet been achieved at the Terrace Site. As with the other Simplot sites, the site continues to operate under the nutrient and water loading restrictions contained in the permit, but commercial fertilizer is used to supply all the plant nutrient requirements (i.e., no food processing wastewater is applied).

4.3.2 Nitrate Trends

A trend analysis of nitrate concentrations at the eight currently sampled wells at the Simplot Terrace Site was conducted as described in Section 1.3. Table 4-3 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each Simplot well are included in Appendix 3.

Table 4-3 lists the individual results of the trend analysis for each well. The results can be summarized as follows:

- seven wells exhibit increasing trends,
- two wells exhibits a decreasing trend, and
- one well exhibit statistically insignificant trends.

In summary, over half (62%) of the wells exhibit increasing trends. Statistically significant trends range from increasing at 1.70 ppm/yr (at MW-14) to decreasing at 1.68 ppm/yr (at MW-53). The site-wide average nitrate trend (i.e., the average of all 8 slopes) is increasing at 0.32 ppm/yr. The average of the seven statistically significant trends is increasing at 0.39 ppm/yr.

Table 4-3 also lists the description of the LOWESS pattern for individual wells. The LOWESS patterns observed can be summarized as follows:

- two wells show increasing patterns,
- one well shows an increasing then increasing less steeply pattern,
- one well shows a flat, decreasing , then flat again pattern,
- two wells show an increasing then decreasing pattern, and
- one well shows an increasing then slightly decreasing pattern, and
- one well shows an increasing then leveling off pattern.

In summary, five of the wells exhibit consistently decreasing or recently decreasing LOWESS patterns. The other three exhibit consistently or recently increasing patterns.

Figure 4-5 includes the nitrate trends and LOWESS lines at each of the 10 Simplot Terrace Site wells. The 10 graphs are plotted at the same scale to allow a comparison of trends between wells. Note that wells MW-15 and MW-38 are no longer being sampled. Figure 4-5 illustrates that nitrate concentrations at a few wells (most notably MW-39 & MW-52) increased then decreased.

Figure 4-6 is a map view of the site illustrating the nitrate trends at each of the eight wells still being sampled. Five out of eight wells exhibit increasing trends. MW-14 (located in the northwestern portion of the property) exhibits the steepest increasing trend (1.70 ppm/yr). Well MW-53 exhibits the steepest decreasing trend (1.68 ppm/yr). The LOWESS line for the well with a statistically insignificant trend (MW-39; Figure 4-5) indicates a shift from increasing to decreasing trends at that location.

4.3.3 Average Nitrate Concentrations

Figure 4-7 illustrates the average nitrate concentrations at each of the Simplot Terrace Site wells from 1996 through 2009, the timeframe in which most wells were installed and sampled. In summary, average nitrate concentrations range from 17.4 to 52 ppm. The highest average nitrate concentration (52 ppm) is at well MW-53, located along the northern property boundary. The lowest average nitrate concentration (17.4 ppm) is at well MW-51. Most wells exhibit average nitrate concentrations between approximately 20 and 30 ppm.

4.3.4 Site-Wide Nitrate Trends and Concentrations

Figure 4-8 is a graph of all nitrate data from the eight Simplot Terrace Site wells still being sampled, with a LOWESS line drawn through the data. The solid data points represent those from well MW-53. It is evident from Figure 4-8 that (1) nitrate concentrations at well MW-53 are substantially higher than at all other wells, and (2) the highest concentrations detected have occurred in the middle and latter portions of the dataset, even if well MW-53 is not considered. The LOWESS line has an upward slope reflecting the overall increase in nitrate concentrations at the site.

Figure 4-8 also includes two estimates of the site-wide trend using the eight currently sampled wells: one through the entire history of the site (i.e., 1988 through 2009), and another through the most recent 5 years of data (i.e., 2005 through 2009). These monotonic trends are consistent with the LOWESS line. The 1988 through 2009 trend increases at 0.63 ppm per year with a 99% confidence level. The 2005 through 2009 trend increases at 0.2 ppm per year with a confidence level of less than 80%. In other words, the overall site-wide trend is increasing, but appears to be increasing less steeply in recent years.

4.3.5 Upgradient to Downgradient Comparison

The groundwater flow direction at the Terrace Site is described in DEQ (2004). In general, groundwater flows north to northwest across the site. Based on this groundwater flow direction, upgradient wells for the Simplot Terrace site would be located south and east of facility operations, while downgradient wells would be located north and west of facility operations. Wells MW-40 and MW-54 are located upgradient of current facility operations. Wells MW-22, MW-52, and MW-53 are located downgradient of current facility operations.

Figure 4-10(a) is a time series graph showing the nitrate concentrations at the upgradient wells MW-40 and MW-54 and the downgradient wells MW-22, MW-52, and MW-53. In addition to the individual data points connected by a thin line, thick LOWESS lines are drawn through the data to illustrate general patterns. Figure 4-10(a) shows both upgradient and downgradient nitrate concentrations are increasing at similar rates through about 2001 when the downgradient concentrations start to decline while the upgradient concentrations continue to increase (but at a slower rate). If downgradient well MW-53 is not considered, concentrations increase less steeply through 2001 and decrease more steeply through 2009 ending up at approximately the same as upgradient concentrations (Figure 4-10a).

Figure 4-10(b) is a box and whisker plot summarizing the nitrate concentrations from the upgradient wells (MW-40 & MW-54) and the downgradient wells (MW-22, MW-52, and MW-53). Because the downgradient well MW-53 is substantially different than the other downgradient wells, box plots for both the individual wells and the combined data are presented. Figure 4-10(b) shows the average upgradient nitrate concentration is approximately 21 ppm with all concentrations less than 34 ppm. Figure 4-10(b) also shows the average downgradient nitrate concentration is approximately 34 ppm.

Based on the continued increasing trend at upgradient wells and the recent downward trend at the downgradient wells, it is concluded that facility operations impacted groundwater quality in the past, but have significantly lessened in recent years, perhaps to the point where they are no longer detectable.

4.3.6 Comparison to Previous Analysis

The trends calculated for each well during each of the three trend analyses are indicated in Table 4-4. The changes in trends are summarized in Table 4-4 in two ways:

1. Wells showing similar changes are grouped together, with a summary of the change indicated along the right side of Table 4-4. These changes are interpreted as indications of improving or worsening water quality between 2005 and 2009.
2. The number of decreasing and increasing trends per analyses are summarized along the bottom of Table 4-4, with a summary of the changes indicated at the bottom right side of Table 4-4.

The confidence levels of the trends influence the words chosen to summarize changes between analyses in Table 4-4. For example, if both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as “showing” a change in trend. Conversely, if either confidence level is less than 80% (e.g., a statistically insignificant trend), then the change is termed as “suggesting” a change in trend. An “improving” trend is defined as either a steeper decreasing trend or a less steeply increasing trend. A “worsening” trend is defined as either a steeper increasing trend or a less steeply decreasing trend.

As shown in Table 4-4, indications of improving water quality between the second and third trend analyses include:

- one well suggests an improving trend (by decreasing steeper),
- one well suggests an improving trend (by switching from increasing to decreasing),
- the site-wide average of trend slopes suggests improving trends (by increasing less steeply), and
- there were more decreasing trends than previously.

Indications of worsening water quality since the previous analysis include:

- one well shows a worsening trend (by decreasing less steeply),
- one well shows a worsening trend (by increasing steeper), and
- four wells show worsening trends (by decreasing less steeply).

In summary, although the majority of wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2009 than they did through 2001 and 2005.

4.3.7 Conclusions

Based on the discussion of the data for the Simplot Terrace site presented above, the following conclusions have been made, and are grouped by topic:

Concentration Limits

Simplot voluntarily entered into a Remedial Investigation / Feasibility Study in the late 1990’s to identify and document potential remedies for the increasing groundwater nitrate concentrations. One outcome of the RI/FS was the decision to establish remedial action goals for the Simplot Terrace Site rather than establishing concentration limits that could not be met. Remedial goals have not yet been achieved at the Terrace Site.

Nitrate Trends

- Nitrate concentrations are generally increasing, as evidenced by:
    - Over half of the wells exhibit statistically increasing trends, and
    - The site-wide average trend is increasing at least 0.32 ppm per year
- Nitrate concentrations are recently improving, as evidenced by:
    - Over half of the wells exhibit consistently decreasing or recently decreasing LOWESS patterns.

Average Nitrate Concentrations

- All eight Simplot Terrace Site wells exhibit averages greater than 15 ppm. Most wells exhibit average nitrate concentrations between approximately 20 and 30 ppm.
- The highest average concentration (54.6 ppm) is at well MW-53 located along the northern property boundary.
- The lowest average nitrate concentration (17.4 ppm) is at well MW-51.

Upgradient to Downgradient Comparison

Based on the continued increasing trend at upgradient wells and the recent downward trend at the downgradient wells, it is concluded that facility operations impacted groundwater quality in the past, but have significantly lessened in recent years, perhaps to the point where they are no longer detectable.

Comparison to Previous Analysis

Although the majority of wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2009 than they did through 2001 and 2005.

4.4 Expansion Site

The Simplot Expansion Site is located approximately 4 miles south of the City of Hermiston, southwest of the junction of US Interstate 84 and Oregon 207 (Figure 1-2).

The land application system at the Expansion Site began in 1991. Prior to the land application system, the land occupied by the Expansion Site was used for farmland and cattle grazing.

The Expansion Site is located primarily within the Butter Creek flood plain but the western portion of the site also includes a portion of an upland terrace. The flood plain exhibits a gentle northward slope (0 to 5%). The terrace portion exhibits a steeper eastward slope (5 to 25%). Topography at the Expansion Site ranges from approximately 550 to 680 feet above mean sea level.

Nearby surface water features include Butter Creek (which flows south to north through the Site), as well as the Hunt Ditch, the High Line Canal, and various un-named irrigation canals (components of the Westland Irrigation District delivering water from the Umatilla River to irrigated land in the vicinity) which flow across the property at several locations. The depth to water beneath the Expansion Site ranges from as shallow as 2½ feet below land surface (at MW-25; a well close to an irrigation ditch) to 87 feet below land surface (at MW-42; an upland well located along the western property boundary).

4.4.1 Concentration Limits

As indicated previously, Simplot voluntarily entered into a Remedial Investigation / Feasibility Study in the late 1990's to identify and document potential remedies for the increasing groundwater nitrate concentrations. One outcome of the RI/FS was the decision to establish remedial action goals for the downgradient wells at the Simplot Expansion Site rather than establishing concentration limits that could not be met.

In 2008, Simplot requested to remove the northern portion of the Expansion Site from their permit. When the water quality data were re-evaluated, it was determined that remedial goals had been achieved for a portion of the site. Therefore, the northern portion of the property was removed from the permit, and the entire site was released from the RI/FS in March 2009. A new monitoring well (MW-60) was installed in May 2009 at the new northern property boundary to serve as a new downgradient well for the site. Therefore, thre are no more medial goals for the site, and the site is operating under normal monitoring conditions. As with the other Simplot sites, the site continues to operate under the nutrient and water loading restrictions contained in the permit, but commercial fertilizer is used to supply all the plant nutrient requirements (i.e., no food processing wastewater is applied). Establishing concentration limits for the site is the next step.

4.4.2 Nitrate Trends

A trend analysis of nitrate concentrations at the 12 currently sampled wells located at the Simplot Expansion Site was conducted as described in Section 1.3. Table 4-5 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each Simplot well are included in Appendix 3.

Table 4-5 lists the individual results of the trend analysis for each well. The results can be summarized as follows:

- nine wells exhibit increasing trends,
- one well exhibits a decreasing trend, and
- two wells exhibit a statistically insignificant trend.

In summary, 75% of wells have statistically significant increasing trends. Statistically significant trends range from increasing at 0.75 ppm/yr (at MW-42) to decreasing at 0.18 ppm/yr (at MW-31). The site-wide average nitrate trend is increasing at least 0.24 ppm/yr.

Table 4-5 also lists the description of the LOWESS patterns for individual wells. The LOWESS patterns observed can be summarized as follows:

- one well shows a consistently increasing pattern,
- one well shows an increasing then increasing steeper pattern,
- one well shows an increasing, decreasing, then slight increasing pattern,
- one well shows an increasing, leveling off, then increasing pattern,
- six wells show an increasing then decreasing pattern,
- one well shows an increasing, leveling off, then decreasing pattern, and
- one well shows an increasing then leveling off pattern.

In summary, more than half of the wells (58%) exhibit a recently decreasing LOWESS pattern while a third of the wells exhibit a recently increasing pattern. The large percentage of recently decreasing LOWESS patterns suggests nitrate concentrations at the site are beginning to decline.

Figure 4-9 shows the nitrate trends and LOWESS lines at each of the 20 Simplot Expansion Site wells (not just the 12 currently sampled wells). The 20 graphs are plotted at the same scale to allow a comparison of trends between wells. Figure 4-9 illustrates that nitrate concentrations at several wells (most notably MW-28, MW-31, MW-37, and MW-41) increased then decreased.

Figure 4-10 is a map view of the site illustrating the nitrate trends at each of the currently sampled wells. Nine of 12 wells exhibit increasing trends. The most northerly well exhibits a decreasing trend while the two other wells exhibit statistically insignificant increasing trends. The steepest increasing trend (0.75 ppm/y at MW-42) is located along the western property boundary.

The large percentage of recently decreasing LOWESS lines suggests implementation of the feasibility study recommendations is beginning to improve groundwater quality.

4.4.3 Average Nitrate Concentrations

Figure 4-11 illustrates the average nitrate concentrations at each of the 12 currently sampled wells from 1996 through 2008, the period in which most wells were installed and sampled. The averages in Table 4-5 represent the entire data set at each well. In summary, average nitrate concentrations range from approximately 7 to 17 ppm, and were generally higher in the northwestern portion of the property.

The highest average nitrate concentration (17.5 ppm) is at well MW-55 located near the northwestern property boundary. The lowest average nitrate concentration (6.9 ppm) is at the upgradient well MW-44, located near the southwest corner of the property.

4.4.4 Site-Wide Trends and Concentrations

Figure 4-12 is a graph of all nitrate data from the 12 Simplot Expansion Site wells still being sampled, with a LOWESS line drawn through the data. It is evident from Figure 4-12 that the highest concentrations detected have occurred in the latter portions of the dataset. The LOWESS line increases through about 1999 then it slightly decreases through 2009.

Figure 4-12 also includes two estimates of the site-wide trend using the 12 currently sampled wells: one through the entire history of the site (i.e., 1990 through 2009), and another through the most recent 5 years of data (i.e., 2005 through 2009). These monotonic trends are partially consistent with the LOWESS line in that the long-term trend is increasing and the recent trend is increasing less steeply. The 1990 through 2009 trend increases at 0.19 ppm per year with a 99% confidence level. The 2005 through 2009 trend increases at 0.1 ppm per year with a confidence level of 88%. In other words, the overall site-wide trend is increasing, but is increasing less steeply in recent years.

4.4.5 Upgradient to Downgradient Comparison

The groundwater flow direction at the Simplot Expansion site is described in DEQ (2004). In general, groundwater flows north-northeast across the site. Based on the regional water table map presented in Figure 3-8 of DEQ (2004), upgradient wells for the Simplot Expansion site would be located south and west of facility operations, while downgradient wells would be located north and east of facility operations. Wells MW-36, MW-41, MW-42, MW-43, and MW-44 are located upgradient of current facility operations. Wells MW-31, MW-32, MW-33, and MW-55 are located downgradient of current facility operations.

Figure 4-15(a) is a time series graph showing the nitrate concentrations at the upgradient wells MW-36, MW-41, MW-42, MW-43, and MW-44 and the downgradient wells MW-31, MW-32, MW-33, and MW-55. In addition to the individual data points connected by a thin line, thick LOWESS lines are drawn through the data to illustrate general patterns. Figure 4-15(a) shows the LOWESS lines through both upgradient and downgradient nitrate concentrations follow similar patterns from 1991 through about 1999 (i.e., increase at approximately 1 ppm/yr with downgradient concentrations approximately 3 ppm higher than upgradient concentrations). Starting in about 1999, the LOWESS lines indicate downgradient concentrations level off then decline as upgradient concentrations continue to increase, although less steeply. The LOWESS lines cross in 2002 reflecting the fact that downgradient concentration continue to decrease while upgradient concentrations continue to increase at a slow rate.

Figure 4-15(b) is a box and whisker plot summarizing the nitrate concentrations from the upgradient wells and the downgradient wells. Figure 4-15(b) shows the average upgradient nitrate concentration is approximately 9.6 ppm with half of the concentrations between 6 and 12.5 ppm. Figure 4-15(b) also shows the average downgradient nitrate concentration is approximately 10 ppm with half of the concentrations between 7.5 and 12 ppm.

Based on comparisons of nitrate concentrations at upgradient wells and downgradient wells, facility operations impacted groundwater quality in the early 1990s but implementation of the Feasibility Study recommendations reduced downgradient nitrate concentrations starting in the late 1990s. As of 2009, upgradient concentrations were higher than downgradient concentrations.

4.4.6 Comparison to Previous Analyses

The trends calculated for each well during each of the three trend analyses are indicated in Table 4-6. The changes in trends are summarized in Table 4-6 in two ways:

1. Wells showing similar changes are grouped together, with a summary of the change indicated along the right side of Table 4-6. These changes are interpreted as indications of improving or worsening water quality between 2005 and 2009.
2. The number of decreasing and increasing trends per analyses are summarized along the bottom of Table 4-6, with a summary of the changes indicated at the bottom right side of Table 4-6.

The confidence levels of the trends influence the words chosen to summarize changes between analyses in Table 4-6. For example, if both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as "showing" a change in trend. Conversely, if either confidence level is less than 80% (e.g., a statistically insignificant trend), then the change is termed as "suggesting" a change in trend. An "improving" trend is defined as either a steeper decreasing trend or a less steeply increasing trend. A "worsening" trend is defined as either a steeper increasing trend or a less steeply decreasing trend.

As shown in Table 4-6, indications of improving water quality between the second and third trend analyses include:

- six wells show improving trends (by increasing less steeply),
- one well shows an improving trend (by switching from increasing to decreasing),
- one well suggests an improving trend (by increasing less steeply),
- the site-wide average trend slope shows improving trends (by increasing less steeply), and
- there were fewer increasing trends and more decreasing trends.

Indications of worsening water quality since the previous analysis include:

- three wells show worsening trends (by increasing steeper), and
- one well suggests a worsening trend (by increasing steeper).

In summary, although most wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2009 than they did through 2001 and 2005.

4.4.7 Conclusions

Based on the discussion of the data for the Simplot Expansion site presented above, the following conclusions have been made, and are grouped by topic:

Concentration Limits

One result of Simplot's Remedial Investigation / Feasibility Study was the establishment remedial action goals (rather than concentration limits that could not be met). When water quality data were evaluated in early 2009, it was determined that remedial goals had been achieved for a portion of the site. Therefore, the northern portion of the property was removed from the permit in March 2009.

Nitrate Trends

- Nitrate concentrations at the Expansion Site are generally increasing, as evidenced by:
    - 75% of wells have statistically significant increasing trends.
    - Statistically significant trends range from increasing at 0.75 ppm/yr (at MW-42) to decreasing at 0.18 ppm/yr (at MW-31).
    - The site-wide average nitrate trend is increasing at least 0.24 ppm/yr.
- Nitrate concentrations at the Expansion Site are recently improving, as evidenced by:
    - 58% exhibit a recently decreasing LOWESS pattern

Average Nitrate Concentrations

- Average nitrate concentrations range from approximately 7 to 17 ppm, and were generally higher in the northwestern portion of the property.

- The highest average nitrate concentration (17.5 ppm) is at well MW-55 located near the northwestern property boundary.
- The lowest average nitrate concentration (6.9 ppm) is at the upgradient well MW-44, located near the southwest corner of the property.

Site-Wide Trends

- The overall site-wide trend is increasing, but is increasing less steeply in recent years.
- The 1990 through 2009 trend increases at 0.19 ppm per year with a 99% confidence level.
- The 2005 through 2009 trend increases at 0.1 ppm per year with a confidence level of 88%.
- These monotonic trends are partially consistent with the LOWESS line in that the long-term trend is increasing and the recent trend is increasing less steeply.

Upgradient to Downgradient Comparison

Based on comparisons of nitrate concentrations at upgradient wells and downgradient wells, facility operations impacted groundwater quality in the early 1990s but implementation of the Feasibility Study recommendations reduced downgradient nitrate concentrations starting in the late 1990s. As of 2009, upgradient concentrations were higher than downgradient concentrations.

Comparison to Previous Analysis

Although most wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2009 than they did through 2001 and 2005.

4.5 Levy Site

The Simplot Levy Site is located approximately 8 miles south of the City of Hermiston, east of SR 207 (Butter Creek Highway) and north and south of SR 320 (Echo-Lexington Highway; Figure 1-2). The land application system at the Levy Site began in 2002. Prior to the land application system, the land occupied by the Levy Site was used for farmland.

The Levy Site is located south of Emigrant Buttes and north of Service Buttes (the surface expression of the Service Anticline). Two intermittent drainages (Spikes Gulch and Service Canyon) cross the site from southwest to northeast. Fine sandy loam is the dominant soil type with slopes predominantly less than 7%. Soils within Spikes Gulch and Service Canyon slope as much as 20%. The site exhibits a northward slope with topography ranging from approximately 640 to 800 feet above mean sea level.

Nearby surface water features include Butter Creek (which is located approximately one mile west of the site and flows south to north), and the Hunt Ditch (a component of the Westland Irrigation District delivering water from the Umatilla River to irrigated land in the vicinity) which is adjacent to the northeast end of the site. The depth to water beneath the Levy site ranges from approximately 23 feet below land surface (at HL-5; a well located in the north central portion of the site) to approximately 43 feet below land surface (at SP-1; a well in the southeastern portion of the site).

4.5.1 Concentration Limits

As indicated previously, Simplot voluntarily entered into a Remedial Investigation / Feasibility Study in the late 1990’s to identify and document potential remedies for the increasing groundwater nitrate concentrations. One outcome of the RI/FS was the decision to establish remedial action goals for downgradient wells at the Simplot Plant Site, Terrace Site, and Expansion Site rather than establishing concentration limits that could not be met. Another outcome of the RI/FS was the recommendation to add acreage so that the wastewater could be spread out more. Additional acreage known as the Simplot Levy Site was added to the program in 2002. However, Simplot closed before sufficient time had elapsed to collect the required groundwater quality data to calculate concentration limits or remedial action goals. Therefore, no concentration limits or remedial action goals have been set for the Simplot Levy Site. As with the other Simplot sites, the site continues to operate under the nutrient and water loading restrictions contained in the permit, but commercial fertilizer is used to supply all the plant nutrient requirements (i.e., no food processing wastewater is applied).

4.5.2 Nitrate Trends

A trend analysis of nitrate concentrations at the nine wells located at the Simplot Levy Site was conducted as described in Section 1.3. Table 4-7 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each Simplot well are included in Appendix 3.

Table 4-7 lists the individual results of the trend analysis for each well. The results can be summarized as follows:

- three wells exhibit increasing trends,
- one well exhibits a decreasing trend,
- one well exhibits a flat trend, and
- four wells exhibit a statistically insignificant trend (two increasing and two decreasing).

In summary, one-third of the wells exhibit statistically significant increasing trends while 55% of all trends are increasing. Statistically significant trends range from increasing at 4.75 ppm per year at HL-5 to decreasing at 0.20 ppm per year at SP-1. The site-wide average of all trends is approximately 0.7 ppm per year while the average of statistically significant trends is approximately 1.2 ppm per year.

It is important to note that three of the four wells exhibiting statistically insignificant trends have average concentrations greater than 10 ppm. The fact that a statistically significant trend cannot e drawn through the data does not mean that the concentrations are insignificant or unworthy of attention. Instead, it means that the statistical test could not identify a linear trend with a high degree of assurance.

Table 4-7 also lists the description of the LOWESS patterns for individual wells. The LOWESS patterns observed can be summarized as follows:

- one well shows an increasing then increasing less steeply pattern,
- one well shows an increasing, decreasing, then increasing pattern,
- two wells show an increasing pattern,
- one well shows a flat, increasing, then decreasing pattern,
- one well shows an increasing then decreasing pattern,
- one well shows a slightly decreasing pattern,
- one well shows a decreasing, then increasing, then leveling off pattern, and
- one well shows a basically flat pattern.

In summary, almost half of the wells show a consistently or recently increasing LOWESS pattern, one third of the wells exhibit a consistently or recently decreasing pattern, and about one quarter of the wells exhibit basically flat patterns at relatively low concentrations.

Figure 4-13 includes the nitrate trends and LOWESS lines at each of the nine Simplot Levy Site wells. The nine graphs are plotted at the same scale to allow a comparison of trends between wells. Useful information can be gained by comparing trend lines with LOWESS lines. Examination of LOWESS lines through the nitrate data illustrates non-linear changes in nitrate concentrations. For example, Figure 4-13 illustrates:

- The overall nitrate trend at HL-5 is increasing rapidly, but appears to be lessening in recent years,
- The nitrate concentrations at L-9 increased, decreased, then increased again while the overall trend suggests a declining trend, and
- While the overall trend at L-11 appears to be increasing, nitrate concentrations were decreasing in recent years.

Figure 4-14 is a map view of the site illustrating the nitrate trends at each of the wells. The flat trend is at well L-8 in the southwestern portion of the site. Trends at wells further down Service Canyon include two statistically insignificant decreasing trends (at wells HL-3 and L-9) and the steepest increasing trend (at well HL-5). Well L-6 is located at the southern property boundary in Spikes Gulch and exhibits a statistically insignificant trend. Further down Spikes Gulch is well HL-4, which exhibits an increasing trend. An increasing trend was also observed at well L-10 in the eastern portion of the site. The decreasing trend was observed at well SP-1 located near the wastewater lagoon. Well L-11, located in the northeastern corner of the property exhibited a statistically insignificant trend.

4.5.3 Average Nitrate Concentrations

Figure 4-15 illustrates the average nitrate concentrations at each of the Simplot Levy Site wells from 2003 through 2009, the timeframe in which all wells were installed and sampled. In summary, average nitrate concentrations range from approximately 1 to 48 ppm, and are higher in the northern portion of the site.

The highest average nitrate concentration (48.7 ppm) is at well HL-5, located along the northern property boundary. The lowest average nitrate concentration (1.0 ppm) is at well L-8, located along the southwest border of the property in Service Canyon. The second lowest average nitrate concentration (2.1 ppm) is at well L-6 located along the southwest border of the property in Spikes Gulch. Nitrate concentrations increase along groundwater flow paths through both Service Canyon and Spikes Gulch.

4.5.4 Site-Wide Trends

Figure 4-16 is a graph of all nitrate data from the nine Simplot Levy Site wells, with a LOWESS line drawn through the data. It is evident from Figure 4-18 that the highest concentrations detected have occurred in the latter portions of the dataset and are at well HL-5. The LOWESS line slightly decreases through early 2006, slightly increases until late 2007, and then slightly decreases through 2009. Overall, the LOWESS line is fairly flat and declines less than 1 ppm over the seven-year record.

Figure 4-16 also includes two estimates of the site-wide trend using the nine wells: one through the entire history of the site (i.e., 2002 through 2009), and another through the most recent five years of data (i.e., 2005 through 2009). The site-wide trends were calculated using one-half the detection limit for values reported as not detected. The 2002 through 2009 trend increases at 0.3 ppm per year with a 99% confidence level. The 2005 through 2009 trend increases at 0.25 ppm per year with a 99% confidence level. In other words, the overall site-wide trend is increasing, but it is increasing less steeply in recent years.

The direction of these trends (i.e., increasing) is not consistent with the direction of the LOWESS line (i.e., decreasing). The cause of this discrepancy is unknown but could be due to differences in the way the LOWESS line and the site-wide trends are calculated.

The LOWESS line is calculated by weighting values within a moving "window" across the time series. Values closest to the middle of the window (in both the x and y directions) are weighted more than those nearer the edges of the window. Because the nitrate concentrations from well HL-5 are so different from nitrate concentrations from the other eight wells at the site (especially in the latter part of the time series), HL-5 values are weighted much less than other values.

The site-wide trend compares values from one well during a particular season to the same well during the same season of every other year. The median slope of all possible slopes is taken as the final site-wide trend. Because the nitrate concentrations from well HL-5 are so much higher and increasing so much steeper than at the other eight wells at the site, the final trend is significantly influenced by well HL-5.

4.5.5 Upgradient to Downgradient Comparison

The groundwater flow direction at the Simplot Levy site is described in DEQ (2007a). In general, groundwater flow is towards the northeast. The groundwater flow direction is based on the assumption that topographic relief affects water table elevations. This assumption is reflected in the curvature of the groundwater contours in the northern portion of the site. Groundwater contours are not included in the southwest portion of the site between Spikes Gulch and Service Canyon to reflect the fact that no alluvial groundwater was found at soil borings between the drainages. The extreme curvature of groundwater contours in Spikes Gulch reflects the idea that groundwater in the southeastern portion of the site is restricted to the drainage areas.

Based on a northeasterly flow direction, upgradient wells for the Simplot Levy site would be located south and west of facility operations, while downgradient wells would be located north and east of facility operations. Wells L-6 and L-8 are located upgradient of facility operations. Wells L-9 and SP-1 are located downgradient of current facility operations approximately along groundwater flow paths from the upgradient wells. HL-5 is a downgradient well but there is no water in the alluvial aquifer upgradient of facility operations at this location for comparison.

There is an anecdotal account of fertilizer over-application in the vicinity of well HL-5 that some suspect may be influencing current groundwater nitrate concentrations. Sometime in 1974 or 1975 (prior to involvement by the current owner) the center pivot irrigation system became stuck in the northeast quadrant of the circle, ran in place, and pumped a large amount of fertilizer on just a few acres.

Figure 4-20(a) is a time series graph showing the nitrate concentrations at the upgradient wells L-8 and L-6 and the downgradient wells L-9 and SP-1. In addition to the individual data points connected by a thin line, thick LOWESS lines are drawn through the data to illustrate general patterns. Figure 4-20(a) shows upgradient concentrations are always less than 4 ppm while downgradient nitrate concentrations are generally between 15 and 25 ppm.

Figure 4-20(b) is a box and whisker plot summarizing the nitrate concentrations from the upgradient wells and the downgradient wells. Figure 4-20(b) shows the average upgradient nitrate concentration is approximately 1.6 ppm with half of the concentrations between less than 1 ppm and 2.2 ppm. Figure 4-20(b) also shows the average downgradient nitrate concentration is approximately 19.6 ppm with half of the concentrations between approximately 16 and 20 ppm.

Based on comparisons of nitrate concentrations at upgradient wells and downgradient wells, onsite activities have impacted groundwater quality.

4.5.6 Comparison to Previous Analysis

The trends calculated for each well during the second and third trend analyses are indicated in Table 4-8 (the Simplot Levy wells were not yet installed at the time of the first trend analysis). The changes in trends are summarized in Table 4-8 in two ways:

1. Wells showing similar changes are grouped together, with a summary of the change indicated along the right side of Table 4-8. These changes are interpreted as indications of improving or worsening water quality between 2005 and 2009.
2. The number of decreasing and increasing trends per analyses are summarized along the bottom of Table 4-8, with a summary of the changes indicated at the bottom right side of Table 4-8.

The confidence levels of the trends influence the words chosen to summarize changes between analyses in Table 4-8. For example, if both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as "showing" a change in trend. Conversely, if either confidence level is less than 80% (e.g., a statistically insignificant trend), then the change is termed as "suggesting" a change in trend. An "improving" trend is defined as either a steeper decreasing trend or a less steeply increasing trend. A "worsening" trend is defined as either a steeper increasing trend or a less steeply decreasing trend.

As shown in Table 4-8, indications of improving water quality between the second and third trend analyses include:

- two wells show improving trends (by increasing less steeply),
- one well suggests an improving trend (by increasing less steeply),
- two wells suggest an improving trend (by switching from increasing to decreasing),
- the site-wide average of trend slopes suggests improving trends (by increasing less steeply), and
- there were fewer increasing trends and more decreasing trends than previously.

Indications of worsening water quality since the previous analysis include:

- one well shows a worsening trend (by increasing steeper),
- one well suggests a worsening trend (by switching from a decreasing to a flat trend), and
- one well suggests a worsening trend (by switching from a decreasing to an increasing trend).

In summary, although most wells (although not all are statistically significant) and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2009 than they did through 2005.

4.5.7 Conclusions

Based on the discussion of the data for the Simplot Levy site presented above, the following conclusions have been made, and are grouped by topic:

Concentration Limits

Simplot voluntarily entered into a Remedial Investigation / Feasibility Study in the late 1990's to identify and document potential remedies for the increasing groundwater nitrate concentrations. However, the Simplot facility closed before sufficient time had elapsed to collect the required groundwater quality data to calculate concentration limits or remedial action goals. Therefore, no concentration limits or remedial action goals have been set for the Simplot Levy Site.

Nitrate Trends

- Nitrate concentrations at the Simplot Levy Site are generally increasing, as evidenced by:
  - Increasing trends dominate (33% are statistically significant increasing trends; 55% of all trends are increasing).
  - Statistically significant trends range from increasing at 4.75 ppm per year at HL-5 to decreasing at 0.20 ppm per year at SP-1.
  - The site-wide average of all trends is approximately 0.7 ppm per year while the average of statistically significant trends is approximately 1.2 ppm per year.
  - Almost half of the wells show a consistently or recently increasing LOWESS pattern.

- Nitrate concentrations at the Simplot Levy Site are recently improving, as evidenced by:
  - One third of the wells exhibit a consistently or recently decreasing pattern, and about one quarter of the wells exhibit basically flat patterns at relatively low concentrations.

Average Nitrate Concentrations

- Average nitrate concentrations range from approximately 1 to 48 ppm, and are higher in the northern portion of the site.
- The highest average nitrate concentration (48.7 ppm) is at well HL-5, located along the northern property boundary.
- The lowest average nitrate concentration (1.0 ppm) is at well L-8, located along the southwest border of the property in Service Canyon.
- Nitrate concentrations increase along groundwater flow paths through both Service Canyon and Spikes Gulch.

Site-Wide Trends

- The overall site-wide trend is increasing, but it is increasing less steeply in recent years.
- The 2002 through 2009 trend increases at 0.3 ppm per year with a 99% confidence level.
- The 2005 through 2009 trend increases at 0.25 ppm per year with a 99% confidence level.
- The direction of these trends (i.e., increasing) is not consistent with the direction of the LOWESS line (i.e., decreasing). The cause of this discrepancy is unknown but could be due to differences in the way the LOWESS line and the site-wide trends are calculated.

Upgradient to Downgradient Comparison

Based on comparisons of nitrate concentrations at upgradient wells and downgradient wells, onsite activities have impacted groundwater quality.

Comparison to Previous Analysis

Although most wells (although not all are statistically significant) and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2009 than they did through 2005.

4.6 Recommendations

Based on the conclusions and discussion above, the following recommendation is made for all Simplot sites:

- In accordance with the Action Plan, it is recommended that a trend analysis of data from the same wells be conducted in 2014 to evaluate progress towards improving groundwater quality at the food processing wastewater land application sites.

The Simplot potato processing facility shut down in November 2004 so it is no longer generating or land applying food processing wastewater. The facility does, however, continue to apply some non-food processing wastewater and commercial fertilizer under a DEQ permit to land that has high groundwater nitrate concentrations. At those locations, the following recommendations apply.

- In order to gauge when the effects of BMP implementation will be observed as improving groundwater quality, it is recommended that funding be pursued to allow additional research into factors including: (1) quantifying the amount of nitrate that exists between the root zone and the water table, (2) the rate of nitrate transport through the unsaturated zone, and (3) more precisely quantifying groundwater flow velocity at the site.
- Due to the high percentage of increasing trends and impacts to groundwater from land use activities, it is recommended that BMP implementation to reduce the area-wide extent of elevated nitrate concentrations be continued and, when possible, improved. BMPs should include detailed procedures to:
    - establish appropriate crop specific nitrogen loading rates,
    - accurately quantify hydraulic loading from all sources,
    - document nutrient additions from all sources,
    - insure uniform sample acquisition and analysis,
    - characterize and monitor nitrogen concentration and movement in the soil column,
    - monitor moisture content and movement in the soil column, and
    - perform annual site-specific analysis to identify farming activities and/or soil conditions that increase the potential for impact to groundwater.
- Concentration limits for the Simplot Expansion Site should be set.

5.0 HERMISTON FOODS SITE

5.1 Introduction

Hermiston Foods, LLC (Hermiston Foods) operates a vegetable processing plant and wastewater treatment facility near Hermiston, Oregon. The vegetable processing plant was constructed in 1990 and operates seasonally to process asparagus, peas, sugar snap peas, lima beans, potatoes, and carrots. As of December 2009, the company's wastewater land application system was located approximately one mile south of the plant at a site known as the Windblown Ranch. The wells at the Windblown Ranch have been properly decommissioned. Beginning in 2010, wastewater was land applied on property north of the Windblown Ranch site. Hermiston Foods land applies approximately 103 million gallons of wastewater and 419.5 million gallons of supplemental irrigation water annually. Average values for the composite of Hermiston Food's wastewater and supplemental water in 2009 include:

- 10 mg/l Total Kjeldahl Nitrogen (TKN)
- 1 mg/l Nitrate (NO_3)
- 1.3 mg/l ammonium (NH_4)
- 172 mg/l total dissolved solids (TDS)

5.2 Hermiston Foods Site

As of December 2009, the Hermiston Foods land application site was located approximately 3 miles south of the City of Hermiston, east of the junction of US Highway 395 and Feedville Road at property owned by the Windblown Ranch (Figure 1-2). In 2010, the land application system moved to property north of the Windblown Ranch. The land application system at the Hermiston Foods site began in 1990. The wastewater was land applied at two 125-acre center pivot irrigation circles (one installed in 1990, the other installed in 1991) for the purpose of growing alfalfa and small grains. In addition, during the months of April through September, a portion of the wastewater was discharged to a 14.6 acre hybrid poplar tree plantation (installed in 1999). Prior to the land application system, the land occupied by the Hermiston Foods site was undeveloped.

When wastewater does not meet crop needs (typically from approximately April through October), supplemental irrigation water from an irrigation ditch is applied on the site.

The Hermiston Foods Site is located within the Deschutes-Umatilla Plateau physiographic province. The site generally exhibits gentle slopes of 0 to 5%. Soils at the site include well drained fine sandy loam and excessively drained fine sand. Topography at the Hermiston Foods Site ranges from approximately 650 to 700 feet above mean sea level.

Nearby surface water features include the Furnish Ditch (which delivers irrigation water to nearby fields) located northwest of the site, and an unnamed canal extending southwest from the Furnish Ditch that passes within approximately 300 feet of the northwest corner of the site and terminates approximately 800 feet west of the site into several ponds.

The average depth to water beneath the Hermiston Foods Site ranges from approximately 30 feet below land surface (at well MW-1; located in the southeastern corner of the site) to approximately 70 feet below land surface (at well MW-4 located in the northeastern corner of the site). The depth to water at well MW-2 averages approximately 55 feet below land surface but exceeds 85 feet below land surface when a nearby irrigation well is pumping. The site-wide average depth to water is approximately 50 feet below land surface.

In 2009, Hermiston Foods installed wells north of the Windblown Ranch site to characterize land to be used for future land application activities. As part of that characterization, DEQ staff reviewed drilling logs from the new wells and the Windblown Ranch wells and observed that all of the wells at the Windblown Ranch site were screened too deep to have the water table bracket the well screen. Monitoring wells are typically designed so that well screens bracket the water table so that the shallow groundwater flow direction can be determined, and also so that contaminants from land surface are detected quicker and closer to the source. Water levels at the

Windblown Ranch were 30 to 40 feet above the well screens in most wells, but about 60 feet above the well screen at well MW-3. Using these wells limits the ability to accurately evaluate shallow groundwater flow direction and potential facility impacts. These wells were abandoned in 2010 when Hermiston Foods moved their land application activities to the north.

5.2.1 Concentration Limits

Concentration limits were set for the Hermiston Foods Site effective April 1, 2004. The concentration limits were set for well MW-4 and include the following:

- 470 mg/l total dissolved solids,
- 36 mg/l chloride, and
- 13 mg/l nitrate.

The concentration limits for total dissolved solids and nitrate were not exceeded. The concentration limit for chloride was exceeded once: 42 mg/l chloride was reported on 11/16/04. All subsequent samples from well MW-4 were below the chloride concentration limit. DEQ reviewed the data and concluded that beneficial uses were being protected (the drinking water standard is 250 mg/l) so no remedial investigations were required.

5.2.2 Nitrate Trends

A trend analysis of nitrate concentrations at the seven wells located at the Hermiston Foods site was conducted as described in Section 1.3. Table 5-1 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each Hermiston Foods well are included in Appendix 4.

Table 5-1 lists the individual results of the trend analysis for each well. The results indicate three wells show increasing trends while four wells show decreasing trends. Trends range from increasing at 0.61 ppm/yr (at well MW-7) to decreasing at 0.15 ppm/yr (at well MW-6). Despite the dominance of decreasing trends, the site-wide average nitrate trend is increasing at approximately 0.05 ppm/yr (Table 5-1). This increasing site-wide average nitrate trend is due to the trend at MW-7, which is increasing about six times faster than the next steepest increasing trend.

Table 5-1 also lists the description of the LOWESS patterns for individual wells. The LOWESS patterns are summarized as follows:

- one well shows a decreasing pattern
- one well shows a decreasing then slightly increasing then decreasing pattern
- one well shows a flat then decreasing pattern,
- two wells show an increasing then gently decreasing pattern
- one well shows a decreasing then increasing pattern, and
- one well shows an increasing then increasing less steeply pattern.

In summary, five of the seven wells exhibit consistently decreasing or recently decreasing LOWESS patterns while two wells exhibit consistently or recently increasing patterns.

Figure 5-1 includes the nitrate trends and LOWESS lines at each of the seven Hermiston Foods wells. The seven graphs are plotted at the same scale to allow a comparison of trends between wells. Useful information can be gained by comparing trend lines with LOWESS lines. For example, Figure 5-1 illustrates that nitrate concentrations at well MW-2 increased for several years then decreased for several years. Figure 5-1 also illustrates that the nitrate concentrations at well MW-6 decreased for several years then slightly increased for several years.

Figure 5-2 is a map view of the site illustrating the nitrate trends at each of the wells. The two wells along the northern property boundary (i.e., MW-2 and MW-4) and the well along the southern property boundary (i.e., MW-7) exhibit increasing trends while the other four wells exhibit decreasing trends. MW-4 is located downgradient of facility operations and is the well with established concentration limits.

5.2.3 Average Nitrate Concentrations

Figure 5-3 is a map view of the site illustrating the average nitrate concentrations at each of the Hermiston Foods wells. The averages in Figure 5-5 are from August 2004 through November 2009 (the timeframe in which all wells were installed and sampled). The averages in Table 5-1 use all data since each well was installed. In summary, average nitrate concentrations are highest in the eastern portion of the property, and lowest in the northwestern portion of the property. Specifically, the highest average nitrate concentration is at well MW-6 (9.7 ppm), followed by well MW-1 (9.0 ppm). The lowest average nitrate concentration is at well MW-3 (3.1 ppm). The lower nitrate concentrations at this well are likely in part the result of dilution by surface water from the nearby irrigation canal and ponds.

5.2.4 Site-Wide Nitrate Trends

Figure 5-4 is a graph of all nitrate data from the seven Hermiston Foods wells, with a LOWESS line drawn through the data. Figure 5-4 consists of many stacks of data points at approximately 3-month intervals. Each of these stacks of data represents one quarterly sampling event and contains one data point for each well sampled that event. It is evident from Figure 5-4 that the nitrate concentrations have not varied considerably since sampling began, but the highest concentrations have occurred in the early and middle portions of the dataset. The LOWESS line has an upward slope from 1991 through 2000, then slightly decreases through 2005, then slightly increases through 2009.

Figure 5-4 also includes two estimates of the site-wide trend using the seven wells: one through the entire history of the site (i.e., 1991 through 2009), and another through the most recent five years of data (i.e., 2005 through 2009). The 1991 through 2009 site-trend decreases at 0.61 ppm per year with a 99% confidence level. The 2005 through 2009 site-wide trend increases at 0.05 ppm per year at a confidence level of less than 80%. These monotonic trends are consistent with the LOWESS line in the middle and latter portions of the data set.

The change from a decreasing trend to an increasing trend is due to the inclusion of data from well MW-7. Well MW-7 was installed in August 1994, where nitrate concentrations are increasing at 0.61 ppm per year. As a check on the influence of well MW-7 on the site-wide trend, data from MW-7 were excluded and the site-wide trend recalculated. This check showed that if MW-7 data were excluded, the 2005 through 2009 site-wide trend would be the same as the 1991 through 2009 site-wide trend (i.e., decreasing at 0.06 ppm per year).

In summary, the overall site-wide nitrate trend is decreasing, but may be increasing in recent years due to inclusion of a new well.

5.2.5 Upgradient to Downgradient Comparison

The groundwater flow direction at the Hermiston Foods site is described in DEQ (2004) and DEQ (2007a). In general, upgradient wells for the Hermiston Foods site are located south and west of facility operations, while downgradient wells are located north and east of facility operations. Wells MW-3, MW-5, and MW-7 are located upgradient of current facility operations. Wells MW-4 and MW-6 are located downgradient of current facility operations. Well MW-5 is approximately upgradient of well MW-4. Well MW-7 is approximately upgradient of well MW-6. Well MW-3 is an upgradient well with no associated downgradient well.

Well MW-2 is located downgradient of well MW-3, but much of the land between the wells does not include any land application activities. When the offsite irrigation well is not pumping, groundwater apparently flows from well MW-3 towards MW-2 beneath the land that is not part of the Hermiston Foods site. However, when the offsite irrigation well is pumping, groundwater apparently flows towards the pumping well from all directions, including from a portion of the Hermiston Foods site. This change in groundwater flow direction indicates well MW-2 is sometimes downgradient from a portion of the Hermiston Foods site but is never entirely downgradient of the facility operations. Therefore, well MW-2 is not an adequate downgradient well for evaluating potential effects of facility operations. It is, however, very useful in evaluating the groundwater flow regime of the site.

Figure 5-5(a) is a time series graph showing the nitrate concentrations at the upgradient wells MW-3, MW-5, and MW-7; and the downgradient wells MW-4 and MW-6. In addition to the individual data points connected by a thin line, thick LOWESS lines are drawn through the data to illustrate general patterns. MW-5 is approximately upgradient of MW-4 while MW-7 is approximately upgradient of MW-6; so comparing the nitrate concentrations between these sets of wells is an appropriate way to gauge potential impacts from facility operations. However, upgradient well MW-3 cannot be used for evaluating potential impacts from facility operations because the well has no associated downgradient well.

Figure 5-5(a) indicates that since 1997 (when corresponding upgradient and downgradient wells were in place) upgradient nitrate concentrations were a few ppm less than downgradient nitrate concentrations. The upgradient LOWESS line decreases from 1997 until about 2005, then increases through 2009. The downgradient LOWESS line is generally flat, but does slightly increase from 1997 through 2000, then slightly decreases until about 2005, then slightly increases through 2009.

Figure 5-5(b) shows downgradient well MW-6 generally has higher nitrate concentrations than its corresponding upgradient well MW-7. During the timeframe in which these wells were installed and sampled (22 events over 5.2 years), the upgradient well averaged 6.7 ppm while the downgradient well averaged 9.7 ppm, with the upgradient well exhibiting a higher nitrate concentration than the downgradient well 100% of the time.

Figure 5-5(b) shows upgradient well MW-5 and its corresponding downgradient well MW-4 have similar nitrate concentrations. During the timeframe in which these wells were installed and sampled (46 sampling events over 12.5 years), the upgradient well averaged 7.0 ppm nitrate while the downgradient well averaged 6.7 ppm, with the upgradient well exhibiting a higher nitrate concentration than the downgradient well 52% of the time.

The fact that downgradient nitrate concentrations exceed upgradient nitrate concentrations suggests facility operations have affected groundwater quality. However, because these wells were too deep to bracket the water table, conclusions regarding shallow groundwater flow directions and potential facility impacts are less certain at this site than at other sites.

5.2.6 Comparison to Previous Analysis

The trends calculated for each well during each trend analyses are indicated in Table 5-2. The changes in trends are summarized in Table 5-2 in two ways:

1. Wells showing similar changes are grouped together, with a summary of the change indicated along the right side of Table 5-2. These changes are interpreted as indications of improving or worsening water quality between 2005 and 2009.
2. The number of decreasing and increasing trends per analyses are summarized along the bottom of Table 5-2, with a summary of the changes indicated at the bottom right side of Table 5-2.

The confidence levels of the trends influence the words chosen to summarize changes between analyses in Table 5-2. For example, if both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as “showing” a change in trend. Conversely, if either confidence level is less than 80% (e.g., a statistically insignificant trend), then the change is termed as “suggesting” a change in trend. An “improving” trend is defined as either a steeper decreasing trend or a less steeply increasing trend. A “worsening” trend is defined as either a steeper increasing trend or a less steeply decreasing trend.

As shown in Table 5-2, indications of improving water quality between the second and third trend analyses include:

- one well shows an improving trends (by decreasing steeper), and

- two wells (including the well with concentration limits) show improving trends (by increasing less steeply).

Indications of worsening water quality since the previous analysis include:
- two wells show worsening trends (by decreasing less steeply), and
- the site-wide average of trend slopes show a worsening trend by decreasing less steeply.

In summary, most wells exhibit decreasing trends and the overall site-wide nitrate trend is decreasing, but may be increasing in recent years due to inclusion of a new well.

5.2.7 Conclusions

Based on the discussion of the data for the Hermiston Foods site presented above, the following conclusions have been made, and are grouped by topic:

Concentration Limits

Concentration limits were set for the Hermiston Foods Site effective April 1, 2004. The concentration limits for total dissolved solids and nitrate were not exceeded. The concentration limit for chloride was exceeded once: 42 mg/l chloride was reported on 11/16/04. All subsequent samples from well MW-4 were below the chloride concentration limit. DEQ reviewed the data and concluded that beneficial uses were being protected (the drinking water standard is 250 mg/l) so no remedial investigations were required.

Nitrate Trends

- Nitrate concentrations at the Hermiston Foods Site are generally decreasing, as evidenced by:
    - Four wells show decreasing trends while three wells show increasing trends.
    - Trends range from increasing at 0.61 ppm/yr (at well MW-7) to decreasing at 0.15 ppm/yr (at well MW-6).
    - Five of the seven wells exhibit consistently decreasing or recently decreasing LOWESS patterns while two wells exhibit consistently or recently increasing patterns.

- Nitrate concentrations may be recently increasing, as evidenced by:
    - The site-wide average nitrate trend is increasing at approximately 0.05 ppm/yr despite the dominance of decreasing trends. This increasing site-wide average nitrate trend is due to the trend at MW-7, which is increasing about six times faster than the next steepest increasing trend.

Average Nitrate Concentrations

- Average nitrate concentrations are highest in the eastern portion of the property, and lowest in the northwestern portion of the property.
- The highest average nitrate concentration is at well MW-6 (9.7 ppm), followed by well MW-1 (9.0 ppm).
- The lowest average nitrate concentration is at well MW-3 (3.1 ppm). The lower nitrate concentrations at this well are likely in part the result of dilution by surface water from the nearby irrigation canal and ponds.

Site-Wide Trends

- The overall site-wide nitrate trend is decreasing, but may be increasing in recent years due to inclusion of a new well.
- The 1991 through 2009 site-trend decreases at 0.61 ppm per year with a 99% confidence level.
- The 2005 through 2009 site-wide trend increases at 0.05 ppm per year at a confidence level of less than 80%.

- These monotonic trends are consistent with the LOWESS line in the middle and latter portions of the data set.

Upgradient to Downgradient Comparison
The fact that downgradient nitrate concentrations exceed upgradient nitrate concentrations suggests facility operations have affected groundwater quality. However, because these wells were too deep to bracket the water table, conclusions regarding shallow groundwater flow directions and potential facility impacts are less certain at this site than at other sites.

Comparison to Previous Analysis
Most wells exhibit decreasing trends and the overall site-wide nitrate trend is decreasing, but may be increasing in recent years due to inclusion of a new well.

5.3 Recommendations

Because the Windblown Ranch is no longer used for land application of wastewater, no site-specific recommendations are made. However, the following regional recommendations are made:

- In order to gauge when the effects of BMP implementation will be observed as improving groundwater quality, it is recommended that funding be pursued to allow additional research into factors including: (1) quantifying the amount of nitrate that exists between the root zone and the water table, (2) the rate of nitrate transport through the unsaturated zone, and (3) more precisely quantifying groundwater flow velocity in the GWMA.
- Due to the high percentage of increasing trends and likely affects to groundwater from land application activities, it is recommended that BMP implementation to reduce the area-wide extent of elevated nitrate concentrations be continued and, when possible, improved. BMPs should include detailed procedures to:
  - establish appropriate crop specific nitrogen loading rates,
  - accurately quantify hydraulic loading from all sources,
  - document nutrient additions from all sources,
  - insure uniform sample acquisition and analysis,
  - characterize and monitor nitrogen concentration and movement in the soil column,
  - monitor moisture content and movement in the soil column, and
  - perform annual site-specific analysis to identify farming activities and/or soil conditions that increase the potential for impact to groundwater.

6.0 MORSTARCH SITE

6.1 Introduction

The MorStarch Site (known as the Staley site in DEQ 2004) processes reclaimed potato starch into starch flakes for use in the production of paper products. DEQ has not received 2009 wastewater quantity and quality data from MorStarch. MorStarch land applied approximately 8.5 million gallons of wastewater in 2005, with an average monthly flow of 0.7 million gallons. Average values for MorStarch's wastewater in 2005 include:

- 4,370 mg/l Chemical Oxygen Demand (COD)
- 200 mg/l Total Kjeldahl Nitrogen (TKN)
- 15.0 mg/l ammonia (NH_3)
- 5,709 mg/l total dissolved solids (TDS)
- 0.6 mg/l nitrate-nitrogen (NO_3)
- 1,675 mg/l chloride (Cl)
- 627 mg/l calcium (Ca)
- 193 mg/l sodium (Na)
- 35 mg/l magnesium (Mg)
- 263 mg/l potassium (K)
- 125 mg/l bicarbonate (HCO_3)
- 18 mg/l total phosphorus (P)
- 55 mg/l sulfate (SO_4)

6.2 MorStarch Site

The MorStarch Site is located on the western edge of the City of Stanfield, northwest of the junction of US Interstate 84 and US Highway 395 (Figure 1-2). The site is bounded by the City of Stanfield Wastewater Treatment Plant land application site to the north, municipal and commercial development (including the City of Stanfield Wastewater Treatment Plant) to the east, and the Umatilla River to the south and west. The land application system at the MorStarch Site began in 1977. The original land application area consisted of 8.9 acre tract (Field A), which received approximately 7 million gallons of wastewater annually. In early 1990, MorStarch expanded the land application acreage to approximately 40 acres by adding fields B (10.5 acres) and C (20 acres). Subsequently, fields E (12 acres) and F (16 acres) were added to the land application system. Currently, MorStarch applies the wastewater to 67.4 acres. Prior to the land application system, the land occupied by the MorStarch Site was used for agricultural purposes.

Wastewater from this facility is land applied daily on 67.4 acres of agricultural land where fescue and alfalfa hay are grown. When wastewater does not meet crop needs (typically from approximately April through October), supplemental irrigation water obtained from the Stanfield Drain and an infiltration well is applied on the site.

The MorStarch Site is located within the Umatilla River flood plain. The flood plain generally exhibits gentle slopes of 0 to 5%. Topography at the MorStarch Site ranges from approximately 570 to 590 feet above mean sea level.

Nearby surface water features include the Umatilla River (which forms the southern and western boundaries of the property), and the Stanfield Drain (which bisects the site). The Umatilla River flows west then north around the site. The Stanfield Drain flows west across the site where it empties into the Umatilla River. The Stanfield Drain is an unlined ditch excavated in the late 1920's to drain shallow groundwater beneath the irrigated land near, and northeast of Stanfield in the area known as Fourmile Gap (Kopacz, 2004). Groundwater seeps into the Drain at a rate sufficient to maintain flow year round within the lower 3 to 4 miles of the Drain (including the MorStarch Site).

The depth to water beneath the MorStarch Site ranges from approximately 9 feet below land surface (at well MW-3S; located in the western portion of the site near the Umatilla River) to approximately 18 feet below land surface (at well MW-1D located in the northeastern portion of the site). The site-wide average depth to water is approximately 13 feet below land surface.

6.2.1 Concentration Limits

In 2007, DEQ conducted a review of the hydrogeology and groundwater chemistry of the MorStarch site with the goal of establishing concentration limits (DEQ, 2007b). The following discussion summarizes the establishment of concentration limits at the site as documented in DEQ (2007b).

The comparison of background concentrations (MW-E2S) to the downgradient well (MW-4S) on the south side of the Drain show that the downgradient well generally significantly exceeds background and indicates that practices at the facility have significantly impacted groundwater at the site. Concentration limit variances (CLVs) and/or additional treatment and enhanced management practices will be necessary at the facility. The facilities consultant previously conducted a statistical analysis at the site, without taking into consideration effects from recharge at the Stanfield Drain, and concentration limits or CLVs of 11.5 mg/l for NO3, 202 mg/l for Cl, 124 mg/l for Na, and 1000 mg/l were agreed upon. However, the consultant submitted a request to have the limits re-evaluated because of increasing background concentrations.

Based on the second review of the data, it was clear that the facility could not meet the background concentrations on the south side of the Drain. Based on the concentrations seen in groundwater samples from MW-4S, DEQ proposed and later established the following concentration limit variances (CLVs) for wells MW-2s, MW-3s, and MW-4s located south of the Drain:

- 226 mg/l chloride
- 9.0 mg/l nitrate
- 128 mg/l sodium
- 135 mg/l sulfate
- 1,100 mg/l Total Dissolved Solids (TDS)

Data from the north side of the Drain is more difficult to evaluate. Without knowing the degree of connectivity of the Drain to the groundwater, and how much the groundwater flow is pushed to the north from the Drain, the groundwater flow direction north of the Drain is somewhat ambiguous. Without additional monitoring wells, it is not possible to identify a representative upgradient well north of the Drain. Groundwater quality data indicate that impacts to the aquifer from the facility have generally leveled off.

It is likely that several new monitoring wells will be needed to augment the monitoring well network to better understand groundwater flow at the site. However, because groundwater quality has generally leveled off at the site, that additional cost to install and monitor new wells may not be the cost effective way to protect groundwater quality at the site at this time. Therefore, the Department proposes setting a series of trigger levels for the wells north of the Drain. If the trigger levels are exceeded in any of the wells north of the Drain, the facility will be required to provide a plan to the Department to investigate the trigger levels that were exceeded. If the cause of levels that are exceeded cannot be readily identified and corrected, the facility will be required to submit a plan for upgrading the monitoring well network to facilitate accurate determination of groundwater flow at the site.

In July 2007, DEQ established the following trigger levels for wells north of the Drain:

- Chloride at monitoring wells MW-1S, MW-E1S, MW-5S, and MW-6S at 226 mg/l;
- Sulfate at monitoring wells MW-1S, MW-E1S, MW-5S, and MW-6S at 135 mg/l;
- TDS at monitoring wells MW-1S, MW-E1S, MW-5S, and MW-6S at 1,100 mg/l;
- Nitrate at monitoring wells MW-E1S, MW-5S, and MW-6S at 9.0 mg/l;
- Nitrate at monitoring wells MW-1S at 19.32 mg/l;

- Sodium at monitoring wells MW-5 and MW-6 at 128 mg/l;
- Sodium at monitoring well MW-E1S at 142 mg/l; and
- Sodium at monitoring well MW-1S at 203 mg/l.

Based on a review of the water quality data since the concentration limits were adopted, there were no violations of permit specific concentration limit variances or trigger levels.

6.2.2 Nitrate Trends

A trend analysis of nitrate concentrations at the eight currently sampled wells located at the MorStarch site was conducted as described in Section 1.3. Table 6-1 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each MorStarch well are included in Appendix 5.

Table 6-1 lists the individual results of the trend analysis for each well. The results indicate five increasing trends, two decreasing trends, and one statistically insignificant trend. Trends range from decreasing at 0.02 ppm/yr (at MW-2S) to increasing at 0.37 ppm/yr (at MW-1S). The site-wide average nitrate trend (i.e., the average of all eight slopes) is increasing at approximately 0.1 ppm/yr.

Table 6-1 also lists the description of the LOWESS patterns for individual wells. The LOWESS patterns observed can be summarized as follows:

- seven wells show an increasing then decreasing pattern, and
- one well shows an increasing, decreasing, and then increasing pattern.

In summary, seven of the eight wells that are still sampled exhibit recently decreasing LOWESS patterns.

Figure 6-1 includes the nitrate trends and LOWESS lines at each of the 10 MorStarch wells (not just the eight currently sampled wells). The 10 graphs are plotted at the same scale to allow a comparison of trends between wells. Useful information can be gained by comparing trend lines with LOWESS lines. For example, Figure 6-1 illustrates that the increasing monotonic trend simplifies nitrate concentrations at wells MW-1S, MW-5S, and MW-E2S, which increased for several years, then decreased.

Figure 6-2 is a map view of the site illustrating the nitrate trends at each of the eight currently sampled wells. Five of the eight wells exhibit increasing trends. All four wells north of the Stanfield Drain, plus one well south of the drain, exhibit increasing trends. The two decreasing trends and the statistically insignificant trend are at wells located south of the drain. It is worth noting that recent concentrations at four of the five wells with increasing trends are recently decreasing, but their overall trend remains increasing.

6.2.3 Average Nitrate Concentrations

Figure 6-3 illustrates the average nitrate concentrations at the eight currently sampled MorStarch wells from 1994 through 2009, the timeframe in which most wells were installed and sampled. The averages in Table 6-1 use all data since each well was installed. In summary, average nitrate concentrations are highest along the eastern property boundary, followed by the northern property boundary, and lowest near the southwestern property boundary.

The highest average nitrate concentration (10.6 ppm) is at well MW-1S. The source of nitrate at this well is unknown but may be from offsite. The lowest average nitrate concentration is at well MW-2S (0.9 ppm). The lower nitrate concentrations at the southwestern portion of the site are likely in part the result of dilution by surface water "cutting the corner" of the Umatilla River meander[8].

6.2.4 Site-Wide Trends

Figure 6-4 is a graph of all nitrate data from the eight currently sampled MorStarch wells, with a LOWESS line drawn through the data. Figure 6-4 consists of many stacks of data points at approximately 3-month intervals. Each of these stacks of data represents one quarterly sampling event and contains one data point for each well sampled that event. It is evident from Figure 6-4 that the highest concentrations detected have occurred in the middle portion of the dataset. The LOWESS line has an upward slope through the 1990s then flattens out and decreases slightly through 2009. This pattern reflects an overall increase then leveling off of nitrate concentrations at the site.

Figure 6-4 also includes two estimates of the site-wide trend using the eight wells: one through the entire history of the site (i.e., 1989 through 2009), and another through the most recent five years of data (i.e., 2005 through 2009). The 1989 through 2009 site-trend increases slightly at 0.03 ppm per year with a 99% confidence level. The 2005 through 2009 site-wide trend decreases at 0.09 ppm per year at a 99% confidence level. These monotonic trends are consistent with the LOWESS line in that the LOWESS line starts out by increasing but then decreases. In other words, the overall site-wide trend is increasing, but it is decreasing in recent years.

6.2.5 Upgradient to Downgradient Comparison

As discussed in Section 6.2.1, DEQ conducted a review of the hydrogeology and groundwater chemistry of the MorStarch site in 2007 with the goal of establishing concentration limits. As part of that review, DEQ concluded it was likely that the Stanfield Drain had some interaction with groundwater at the site. Based on that conclusion, DEQ designated well MW-E2S as an upgradient well on the south side of the drain and wells MW-2s, MW-3s, and MW-4s as downgradient wells on the south side of the drain.

Not enough information existed to identify an upgradient well to the north of the Drain. Because groundwater quality data generally leveled off at wells north of the Drain, DEQ did not require additional characterization work north of the Drain at that time.

Figure 6-5(a) is a time series graph showing the nitrate concentrations at the upgradient well MW-E2S and the downgradient wells MW-2s, MW-3s, and MW-4s. In addition to the individual data points connected by a thin line, thick LOWESS lines are drawn through the data to illustrate general patterns. Figure 6-5(a) shows nitrate concentrations at well MW-E2S increased from 1994 to 1999, then decreased through 2009. Figure 6-5(a) also shows that nitrate concentrations at the downgradient wells showed a similar pattern (i.e., increased from about 1989 to about 1999, then decreased through 2009) but were generally 2 to 3 ppm lower than the upgradient concentrations. Nitrate concentrations at wells MW-2s and MW-3s exhibit lower nitrate concentrations than MW-4s likely due to dilution from the nearby Umatilla River. While the last 18 of 20 sampling events have shown higher nitrate concentrations at the downgradient well MW-4s, the difference in concentration is not large enough to be deemed a significant increase over the entire history of the background well.

Figure 6-5(b) is a box and whisker plot summarizing the nitrate concentrations from the upgradient well and the downgradient wells. Figure 6-5(b) shows the nitrate concentrations are higher at the upgradient well than at the downgradient wells.

Based on a comparison of nitrate concentrations at wells located south the Stanfield Drain, it is concluded that facility operations have not significantly increased the groundwater nitrate concentrations beneath the facility.

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[8] As the Umatilla River approaches the meander at the southwestern portion of the site, some surface water is believed to "cut the corner". In other words, some water exits the channel by moving northwest, enters the groundwater system, crosses the southwest portion of the site, and re-enters the river channel.

6.2.6 Comparison to Previous Analysis

The trends calculated for each well during each trend analyses are indicated in Table 6-2. The changes in trends are summarized in Table 6-2 in two ways:

1. Wells showing similar changes are grouped together, with a summary of the change indicated along the right side of Table 6-2. These changes are interpreted as indications of improving or worsening water quality between 2005 and 2009.
2. The number of decreasing and increasing trends per analyses are summarized along the bottom of Table 6-2, with a summary of the changes indicated at the bottom right side of Table 6-2.

The confidence levels of the trends influence the words chosen to summarize changes between analyses in Table 6-2. For example, if both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as “showing” a change in trend. Conversely, if either confidence level is less than 80% (e.g., a statistically insignificant trend), then the change is termed as “suggesting” a change in trend. An “improving” trend is defined as either a steeper decreasing trend or a less steeply increasing trend. A “worsening” trend is defined as either a steeper increasing trend or a less steeply decreasing trend.

As shown in Table 6-2, indications of improving water quality between the second and third trend analyses include:

- one well suggests an improving trends (by decreasing steeper),
- one well suggests an improving trend (by switching from increasing to decreasing),
- five wells show improving trends (by increasing less steeply),
- the site-wide average of trend slopes shows an improving trend (by increasing less steeply), and
- there were fewer increasing trends and more decreasing trends.

Indications of worsening water quality since the previous analysis include:

- one well shows a worsening trend (by decreasing less steeply).

In summary, while the majority of wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2009 than they did through 2001 and 2005.

6.2.7 Conclusions

Based on the discussion of the data for the MorStarch site presented above, the following conclusions have been made, and are grouped by topic:

Concentration Limits

- Based on a review of the water quality data since the concentration limits were adopted, there were no violations of permit specific concentration limit variances or trigger levels.

Nitrate Trends

- Nitrate concentrations at the MorStarch Site are increasing over the entire data set, as evidenced by:
  - Most wells exhibit increasing trends.
  - Trends range from decreasing at 0.02 ppm/yr to increasing at 0.37 ppm/yr with the site-wide average nitrate trend increasing at approximately 0.1 ppm/yr.
- Nitrate concentrations at the MorStarch Site are decreasing in recent years, as evidenced by:
  - Seven of the eight wells that are still sampled exhibit recently decreasing LOWESS patterns.
  - The highest concentrations occur in the middle portion of the dataset.

Average Nitrate Concentrations

- Average nitrate concentrations are highest along the eastern property boundary, followed by the northern property boundary, and lowest near the southwestern property boundary.

- The highest average nitrate concentration (10.6 ppm) is at well MW-1S. The source of nitrate at this well is unknown but may be from offsite.
- The lowest average nitrate concentration is at well MW-2S (0.9 ppm). The lower nitrate concentrations at the southwestern portion of the site are likely in part the result of dilution by surface water “cutting the corner” of the Umatilla River meander.

Site-Wide Trends

- The overall site-wide trend is increasing, but it is decreasing in recent years.
- The 1989 through 2009 site-trend increases slightly at 0.03 ppm per year with a 99% confidence level.
- The 2005 through 2009 site-wide trend decreases at 0.09 ppm per year at a 99% confidence level.
- These monotonic trends are consistent with the LOWESS line in that the LOWESS line starts out by increasing but then decreases.

Upgradient to Downgradient Comparison

Based on a comparison of nitrate concentrations at wells located south the Stanfield Drain, it is concluded that facility operations have not significantly increased the groundwater nitrate concentrations beneath the facility.

Comparison to Previous Analysis

While the majority of wells and the site as a whole exhibit increasing trends, the trends are increasing less steeply through 2009 than they did through 2001 and 2005.

6.3 Recommendations

Based on the conclusions above, the following recommendations are made:

- To maintain and potentially expand the observed water quality improvements, it is recommended that BMP implementation to reduce the area-wide extent of elevated nitrate concentrations be continued and, when possible, improved. BMPs should include detailed procedures to:
    - establish appropriate crop specific nitrogen loading rates,
    - accurately quantify hydraulic loading from all sources,
    - document nutrient additions from all sources,
    - insure uniform sample acquisition and analysis,
    - characterize and monitor nitrogen concentration and movement in the soil column,
    - monitor moisture content and movement in the soil column, and
    - perform annual site-specific analysis to identify farming activities and/or soil conditions that increase the potential for impact to groundwater.
- A trend analysis of data from the same wells should be conducted in 2014 to evaluate progress towards improving groundwater quality at the food processing wastewater land application sites.

7.0 SNACK ALLIANCE SITE

7.1 Introduction

Snack Alliance, Inc. (Snack Alliance, known as SnakCorp in DEQ, 2004) operates a potato chip and cheese puff processing plant and wastewater treatment facility near Hermiston, Oregon. The company operates the plant seasonally. In 2009, 39.7 million gallons of wastewater was land applied on approximately 301 acres of cropland owned and operated by Snack Alliance. Wastewater is generated from potato washing, peeling, slicing, waste elimination, and starch recovery. In addition, the company accepts approximately 5,000 gallons per day, or approximately 1.82 million gallons per year, of potato rinsate from the adjacent Bud Rich fresh pack facility.

Average values for Snack Alliance’s wastewater include:

- 2,603 mg/l Chemical Oxygen Demand (COD)
- 153 mg/l Total Kjeldahl Nitrogen (TKN)
- 23 mg/l ammonia, and
- 1,379 mg/l Total Dissolved Solids (TDS)

7.2 Snack Alliance Site

The Snack Alliance land application site is located approximately 3 miles south of the City of Hermiston, west of the junction of US Interstate 84 and Oregon 207 (Figure 1-2). The land application system at the Snack Alliance site began in 1992 and was operated by Columbia Sun, Inc. (until 10/92), then by Universal Frozen Foods (until 10/94), then by ConAgra (until 5/96), then by Snakcorp until 2005, and finally by Snack Alliance, Inc. The wastewater is land applied at up to six center pivot irrigation circles for the purpose of growing primarily alfalfa, but also cereal grains, grass, onions, potatoes, corn and turf grass. When wastewater does not meet crop needs (typically from approximately April through October), supplemental irrigation water obtained from the Westland Irrigation District system is applied on the site. Prior to the land application system, the land occupied by the Snack Alliance site was irrigated agricultural land.

The Snack Alliance Site is located within the Deschutes-Umatilla Plateau physiographic province. The site generally exhibits gentle slopes of 0 to 5%. Soils at the site are predominantly excessively drained loamy fine sand, but also include well-drained silt loam. Topography at the Snack Alliance Site ranges from approximately 565 to 520 feet above mean sea level.

Nearby surface water features include the Umatilla River (which forms much of the northern property boundary), Butter Creek (which forms the southeastern property boundary), and a Westland Irrigation District canal (which forms a portion of the southern property boundary). The Umatilla River is perennial (i.e., it has flow all year) while Butter Creek and the canal are intermittent (i.e., they have flow only part of the year).

The average depth to water beneath the Snack Alliance Site ranges from approximately 29 feet below land surface (at well MW-4; located near the Umatilla River in the northern portion of the site) to approximately 47 feet below land surface (at well MW-1; located near the southern edge of the site).

7.2.1 Concentration Limits

Concentration limits have not been set at the Snack Alliance Site due to a perceived lack of groundwater quality impacts from site activities and DEQ’s limited resources.

7.2.2 Nitrate Trends

A trend analysis of nitrate concentrations at the four wells located at the Snack Alliance site was conducted as described in Section 1.3. Table 7-1 summarizes the data used in this analysis and includes some data set statistics (e.g., mean and maximum values), a summary of the trend analysis (e.g., the slope and confidence level of the line) and a description of the LOWESS pattern (e.g., increasing then decreasing). Time series graphs of nitrate concentrations and trends at each Snack Alliance well are included in Appendix 6.

Table 7-1 lists the individual results of the trend analysis for each well. The results indicate three wells show a decreasing trend and the other well shows an increasing trend. Trends range from decreasing at 0.90 ppm/yr to increasing at 0.20 ppm/yr. The site-wide average nitrate trend is decreasing at approximately 0.3 ppm/yr (Table 7-1). In summary, most wells, and the site as a whole, exhibit decreasing trends.

Table 7-1 also lists the description of the LOWESS patterns for individual wells. The LOWESS patterns observed can be summarized as follows:

- one well shows a decreasing then increasing pattern,
- one well shows an increasing then decreasing pattern, and
- two wells show a decreasing pattern.

In other words, most wells exhibit consistently or recently decreasing LOWESS patterns.

The single highest concentration reported was 128.2 ppm at MW-4 in July 2004. This result is difficult to interpret. The second highest concentration reported at the site was 33.2 ppm at MW-4 in 2000. Resampling to confirm the anomalously high concentration was not conducted. The sample collected from this well the following quarter contained 6.84 ppm nitrate. The fact that conductivity and total dissolved solids concentrations were higher than normal in July 2004 suggests some real change in water quality. However, the fact that a near 100% conversion of the organic nitrogen in the wastewater to nitrate would be required to create such a high nitrate concentration in groundwater suggests this value does not represent a wastewater spill. Furthermore, the rapid return to “normal” nitrate values suggests a wastewater spill is unlikely.

Figure 7-1 includes the nitrate trends and LOWESS lines at each of the four Snack Alliance wells. The four graphs are plotted at the same scale to allow a comparison of trends between wells. Useful information can be gained by comparing trend lines with LOWESS lines. For example, Figure 7-1 illustrates that although the trend line shows nitrate concentrations at well MW-2 to be decreasing over time, the LOWESS line shows the concentrations increased for several years then began decreasing.

Figure 7-2 is a map view of the site illustrating the nitrate trends at each of the wells. The wells closest to the river exhibit decreasing trends. The southernmost well exhibits an increasing trend.

7.2.3 Average Nitrate Concentrations

Figure 7-3 is a map view of the site illustrating the average nitrate concentrations at each of the Snack Alliance wells from August 1999 through November 2009, the timeframe in which all wells were installed and sampled. The averages in Table 7-1 use all data since each well was installed. In summary, average nitrate concentrations are lowest in the southern portion of the property and increase northward. Specifically, the lowest average nitrate concentration (5.1 ppm) is at well MW-1, followed by the intermediate wells MW-3 (8.0 ppm) and MW-2 (9.2 ppm). The highest average nitrate concentration is at well MW-4 (13.6 ppm).

7.2.4 Site-Wide Trends

Figure 7-4 is a graph of all nitrate data from the four Snack Alliance wells, with a LOWESS line drawn through the data. Figure 7-4 consists of many stacks of data points at approximately 3-month intervals. Each of these stacks of data represents one quarterly sampling event and contains one data point for each well sampled that event. It is evident from Figure 7-4 that the nitrate concentrations detected have not varied considerably since sampling began, but the highest concentrations have occurred at MW-4 in the middle portion of the dataset. The LOWESS line gently increases from 1994 through about 2000 then decreases through 2009.

Figure 7-4 also includes two estimates of the site-wide trend using the four wells: one through the entire history of the site (i.e., 1994 through 2009), and another through the most recent five years of data (i.e., 2005 through 2009). The 1994 through 2009 site-trend decreases at 0.21 ppm per year with a 99% confidence level. The 2005 through 2009 site-wide trend also decreases at 0.21 ppm per year but at an 82% confidence level. In other words, the site-wide trend is decreasing at the same rate from 1994 through 2009 as it did from 2005 through 2009. These monotonic trends are consistent with the LOWESS line in that the LOWESS is predominantly decreasing.

7.2.5 Upgradient to Downgradient Comparison

The groundwater flow direction at the Snack Alliance site is described in DEQ (2004). In general, groundwater flows northeast across the site toward the Umatilla River. Based on the groundwater flow direction, upgradient wells for the Snack Alliance site would be located south and perhaps west of facility operations, while downgradient wells would be located north and perhaps east of facility operations. Well MW-1 is located upgradient of current facility operations. Well MW-4 is located downgradient of current facility operations. Wells MW-2 and MW-3 are located within the land application area between fields.

Much of the site boundary consists of intermittent or perennial surface water bodies. However, the nature of the interaction between groundwater and surface water at the site is unknown. Although the relationship between groundwater and surface water could be assessed through the evaluation of groundwater and surface water levels, it is unlikely to affect the current interpretation of upgradient and downgradient wells.

Figure 7-5(a) is a time series graph showing the nitrate concentrations at the upgradient well MW-1 and the downgradient well MW-4. In addition to the individual data points connected by a thin line, thick LOWESS lines are drawn through the data to illustrate general patterns. Figure 7-5(a) shows nitrate concentrations at well MW-1 decreased from 1995 through 1999, increased through 2009. Figure 7-5(a) also shows that nitrate concentrations at MW-4 decreased steeply from 2000 through 2005, then decreased less steeply through 2009. The difference between upgradient and downgradient concentrations has decreased over time, and downgradient concentrations have been similar to upgradient concentrations since about 2005. Upgradient concentrations have been higher than downgradient concentrations 8 times over the last 10 years, and in 4 of the last 5 sampling events. The average upgradient nitrate concentration in 2009 was 6.7 ppm while the average downgradient nitrate concentration was 5.6 ppm.

Figure 7-5(b) is a box and whisker plot summarizing the nitrate concentrations from the upgradient well and the downgradient well. Figure 7-5(b) shows the nitrate concentrations are higher at the downgradient well MW-4 than at the upgradient well MW-1.

Based on a comparison of nitrate concentrations at wells MW-1 and MW-4, it is concluded that facility operations affected groundwater quality in the past, but had smaller impacts in recent years, and may now be having little to no impact.

7.2.6 Comparison to Previous Analysis

The trends calculated for each well during each trend analyses are indicated in Table 7-2. The changes in trends are summarized in Table 7-2 in two ways:

1. Wells showing similar changes are grouped together, with a summary of the change indicated along the right side of Table 7-2. These changes are interpreted as indications of improving or worsening water quality between 2005 and 2009.
2. The number of decreasing and increasing trends per analyses are summarized along the bottom of Table 7-2, with a summary of the changes indicated at the bottom right side of Table 7-2.

The confidence levels of the trends influence the words chosen to summarize changes between analyses in Table 7-2. For example, if both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as “showing” a change in trend. Conversely, if either confidence level is less than 80% (e.g., a statistically insignificant trend), then the change is termed as “suggesting” a change in trend. An “improving” trend is defined as either a steeper decreasing trend or a less steeply increasing trend. A “worsening” trend is defined as either a steeper increasing trend or a less steeply decreasing trend.

As shown in Table 7-2, indications of improving water quality between the second and third trend analyses include:

- one well shows an improving trend (by decreasing steeper)

Indications of worsening water quality since the previous analysis include:

- two wells shows a worsening trend (by decreasing less steeply),
- one well shows a worsening trend (by increasing steeper), and
- the site-wide average of trend slopes shows worsening trends (by decreasing less steeply).

In summary, most wells and the site as a whole exhibit decreasing trends. However, they are decreasing less steeply through 2009 than they did through 2001 and 2005.

7.2.7 Conclusions

Based on the discussion of the data for the Snack Alliance site presented above, the following conclusions have been made, and are grouped by topic:

Concentration Limits

- Concentration limits have not been set at the Snack Alliance Site due to a perceived lack of groundwater quality impacts from site activities and DEQ’s limited resources.

Nitrate Trends

- Nitrate concentrations at the Snack Alliance Site are generally decreasing, as evidenced by:
    - Three of four wells show a decreasing trend.
    - Trends range from increasing at 0.20 ppm/yr to decreasing at 0.90 ppm/yr with the site-wide average nitrate trend decreasing at approximately 0.3 ppm/yr.
    - Most wells exhibit consistently or recently decreasing LOWESS patterns.

Average Nitrate Concentrations

- Average nitrate concentrations are lowest in the southern portion of the property and increase northward.
- The lowest average nitrate concentration (5.1 ppm) is at well MW-1, followed by the intermediate wells MW-3 (8.0 ppm) and MW-2 (9.2 ppm).
- The highest average nitrate concentration is at well MW-4 (13.6 ppm).

Site-Wide Trends

- The site-wide trend is decreasing at the same rate from 1994 through 2009 as it did from 2005 through 2009.
- The 1994 through 2009 site-trend decreases at 0.21 ppm per year with a 99% confidence level.
- The 2005 through 2009 site-wide trend also decreases at 0.21 ppm per year at an 82% confidence level.
- These monotonic trends are consistent with the LOWESS line in that the LOWESS is predominantly decreasing.

Upgradient to Downgradient Comparison

Based on a comparison of nitrate concentrations at wells MW-1 and MW-4, it is concluded that facility operations affected groundwater quality in the past, but had smaller impacts in recent years, and may now be having little to no impact.

Comparison to Previous Analysis

Most wells and the site as a whole exhibit decreasing trends. However, they are decreasing less steeply through 2009 than they did through 2001 and 2005.

7.3 Recommendations

Based on the conclusions and discussion above, the following recommendations are made:

- To maintain and potentially expand the observed water quality improvements, it is recommended that BMP implementation to reduce the area-wide extent of elevated nitrate concentrations be continued and, when possible, improved. BMPs should include detailed procedures to:
    - establish appropriate crop specific nitrogen loading rates,
    - accurately quantify hydraulic loading from all sources,
    - document nutrient additions from all sources,
    - insure uniform sample acquisition and analysis,
    - characterize and monitor nitrogen concentration and movement in the soil column,
    - monitor moisture content and movement in the soil column, and
    - perform annual site-specific analysis to identify farming activities and/or soil conditions that increase the potential for impact to groundwater.
- In accordance with the Action Plan, it is recommended that a trend analysis of data from the same wells be conducted in 2014 to evaluate progress towards improving groundwater quality at the food processing wastewater land application sites.

8.0 DISCUSSION

8.1 Status of Concentration Limits

The measure of progress that states by December 2009 "monitoring data shows no violation of permit specific concentration limits since its establishment" applies to 12 food processing facilities. The status of concentration limits at these 12 facilities is summarized as follows:

- Two facilities have established trigger levels and/or Concentration Limits (Hermiston Foods and MorStarch). One Concentration Limit was exceeded one time at one facility. However, DEQ concluded the beneficial use was protected so no remedial investigations were required.
- Three facilities (Simplot Plant Site, Simplot Terrace Site, and Simplot Expansion Site) have established remedial action goals rather than concentration limits. Remedial Action goals have been met at some wells at two of these facilities,
- Five facilities (Port of Morrow Farm 1, Port of Morrow Farm 2, Port of Morrow Farm 3, ConAgra North Farm, and ConAgra Madison Ranch) need additional hydrogeologic characterization work so that appropriate hydrogeologic units (which includes paired upgradient and downgradient wells) can be established,
- One facility (Snack Alliance) does not have concentration limits established due to a perceived lack of groundwater quality impacts from site activities and DEQ's limited resources.
- One facility (Simplot Levy Site) does not have concentration limits because Simplot closed before sufficient time had elapsed to collect the required groundwater quality data to calculate concentration limits or remedial action goals. Therefore, no concentration limits or remedial action goals have been set for the Simplot Levy Site. As with the other Simplot sites, the site continues to operate under the nutrient and water loading restrictions contained in the permit, but commercial fertilizer is used to supply all the plant nutrient requirements (i.e., no food processing wastewater is applied).

8.2 Summary of All Trends

Nitrate trends at 113 wells located at the 12 sites within the LUB GWMA that land applied food processing wastewater as of 2009 were calculated. For each of the 12 sites, Table 8-1 summarizes the nitrate trends at individual wells, the site-wide trend, and the site-wide average nitrate concentrations from the time of well installation through 2009 (which covers variable lengths of time). This type of summary gives the best overview of all available data at each site. Also indicated in Table 8-1 for each site is the site-wide trend and site-wide average nitrate concentration from 2005 through 2009. This type of summary allows a direct comparison of nitrate trends and concentrations between sites over a specific timeframe.

The table indicates that most wells (54%; 61 of 113) exhibited increasing trends while 20% of wells (23 of 113) exhibited decreasing trends, 1% (1 of 113) exhibited a flat trend, and 25% (28 of 113) exhibited statistically insignificant trends.

In addition to the 113 wells in Table 8-1, two wells downgradient of the ConAgra Madison Ranch site were also evaluated. Results from those wells indicated two decreasing trends

Additional observations made from Table 8-1 that highlight the overall picture of elevated and increasing nitrate concentrations include:

- The site-wide trend is increasing at nine sites (although one is statistically insignificant), decreasing at two sites, and flat at one site.
- The site-wide average nitrate is above the seven ppm GWMA trigger level at 10 of 12 sites.

Observations made from Table 8-1 that highlight improvements in nitrate concentrations trends during the 2005 through 2009 timeframe include:

- There are fewer sites with an increasing trend and more sites with decreasing trends. The site-wide trend is increasing at eight sites (although three are statistically insignificant), and decreasing at four sites.
- Eight of 12 sites show improving site-wide nitrate trends (i.e., increasing less steeply)
- Four of 12 sites show lower site-wide average nitrate concentrations.

Figure 8-1 provides a different way to compare all 113 trends. All 113 trends are illustrated both as a bar graph and as box plots. Figure 8-1(a) is a bar graph in which the length of the bar indicates the timeframe of the data evaluated, and the vertical position of the bar on the graph indicates the nitrate trend. Figure 8-1(b) is a box plot of the 87 statistically significant trends, the 26 statistically insignificant trends, and all 113 trends. As noted in Figure 8-1, 50% of the trends are between -0.03 and 0.6 ppm/yr, while 88% of the trends are between 2.0 and -0.50 ppm/yr.

The timeframe of the data used to calculate the 113 trends ranged from 2.2 to 22.5 years. The average timeframe was 14.3 years. Half of the wells had between 12.5 and 18.1 years of data. An examination of Figure 8-1(a) does not suggest a relationship between the length of the data set and the trend slope (i.e., the shorter time frames are not grouped together). In order to statistically evaluate the potential correlation between data set length and trend slope, the nonparametric Kendall's Tau correlation coefficient was calculated. The correlation coefficient indicates a very low coefficient (0.0003; with a p-value of 0) indicating there is no correlation between data set length and trend slope.

In summary, the trend analysis indicates that nitrate concentrations are increasing at most wells, and at most sites. Furthermore, the average nitrate concentration at most sites exceeds the GWMA trigger level. However, the trend analysis does not by itself provide an indication of whether or not the nitrate contamination is the result of current facility operations. Other factors that can affect nitrate concentrations include historical facility activities, offsite activities (both current and historical), and the site's hydrogeology. Factors affecting the timing of groundwater quality improvement, as well as potential methods to assess current facility operations are discussed in DEQ (2007a).

8.3 Comparison of Trends at Wells Analyzed Multiple Times

Nitrate trends at wells analyzed during multiple trend analyses are compared in Table 8-2. 103 wells were analyzed in both the second and third trend analyses. Because well networks at the Port of Morrow Farm 3 and the Simplot Levy Site were not yet in place in 2001, and some wells at other sites were added or dropped, only 88 of these wells were analyzed in the first trend analysis. Because the number of wells analyzed varied, the percentage of wells exhibiting each type of trend is also indicated in Table 8-2.

Table 8-2 compares the numbers of various types of trends (e.g., increasing or decreasing), the average trend slope, and the average of the average nitrate concentration between the first, second, and third trend analyses at each site[9]. Because the well networks changed over time at some sites, the number of wells used in Table 8-2 is less than the total number of wells analyzed.

The summary at the bottom of Table 8-2 includes a comparison of the following aspects of the two analyses as well as the change between the two analyses:

- number of various types of trends (e.g., increasing or decreasing) at each site,
- average trend slope at each site, and
- the average of average nitrate concentrations at each well.

[9] While the average of the average nitrate concentrations may or may not closely approximate the true population average, the change in the average of the average nitrate concentrations does reflect a change in nitrate concentrations because the same wells were used each time averages were calculated.

The Table 8-2 summary highlights the following indications of improving water quality between the two analyses:

- there were 6% fewer increasing trends and 4% more decreasing trends, and
- the average trend slope improved at 75% of the sites.

The Table 8-2 summary also highlights the following indication of worsening water quality between the two analyses.

- the site-wide average (i.e., the average of the average concentrations at each well) worsened at 67% of the sites.

In other words, while nitrate concentrations are increasing at most wells and at most sites, and average nitrate concentration at most sites exceeds the GWMA trigger level, the rate of increase is slower than it was during the previous analysis.

Figure 8-2 illustrates the changes in trends at wells analyzed in each of the three analyses. Figure 8-2 shows that the percentage of wells exhibiting increasing trends has decreased from 66% in the first analysis to 58% in the second analysis to 52% in the third analysis. During the same timeframe, the percentage of wells exhibiting decreasing trends has increased from 5% in the first analysis, to 18% in the second analysis, to 22% in the third analysis. The percentage of flat trends and statistically insignificant trends has not changed much over time.

In summary, the reduction in the percentage of increasing trends coupled with the rise in the percentage of decreasing trends illustrates that improvements in groundwater quality are occurring. The fact that over twice as many wells still show increasing trends than show decreasing trends illustrates that more time will be required to achieve the goal of an area-wide decreasing nitrate trend.

9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

Site-specific conclusions regarding each site's concentration limit status, nitrate trends and concentrations, site-wide trends, and comparisons to the previous analysis are presented at the end of each facility's chapter. Based on the site-specific information, several overall conclusions were drawn. The major overall conclusions drawn from this study are:

- The measure of progress that relates solely to the land application of food processor wastewater (Section VIII, Item G.3.d) which states that by December 2009 "monitoring data shows no violation of permit specific concentration limits since its establishment" has been met. However, it is worth noting that only five of 12 sites have concentration limits, remedial action goals, or trigger levels established.
- Information gathered from the analysis of 113 wells at 12 food processor land application sites do not support the conclusion that a downward trend in nitrate levels is occurring throughout most of the GWMA. This measure of progress relates to the entire GWMA as a December 2009 goal for all five sources of nitrate. This goal, as well as the other December 2009 goals, will be evaluated in a separate document titled "Third Four-Year Evaluation of Action Plan Success".
- Nitrate concentrations are increasing at most wells, and at most sites.
- Overall, the rate of increase is slower than it was during the previous analyses.

9.2 Recommendations

Both site-specific and general recommendations are made in this report. The site-specific recommendations involve additional assessment activities at several facilities in order to better define the site's groundwater flow regime and/or to determine the source of nitrate in groundwater. The general recommendations include:

- pursuing funding to gauge the effects of BMP implementation,
- continued and, when possible, expanded BMP implementation, and
- completion of the Action Plan-required trend analysis in 2014.

Although nitrate concentrations are increasing at most wells and most sites, there are some wells and sites where nitrate concentrations are decreasing. It is also recommended that DEQ and the food processors work together to identify what combination of factors produces the improving water quality trends, then apply those factors elsewhere, with the hope of improving water quality trends across the GWMA.

10.0 REFERENCES

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Table 2-1
Summary of Nitrate Trend Analyses - Port of Morrow Farm 1
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	n	% BDL	Slope (ppm/yr)	C.L.		
MW-1	Jun-87	Dec-09	11.2	42.6	24.1	22.9	92	0%	0.16	71%	No Significant Trend	Flat, increase, decrease
MW-2	Jun-87	Dec-09	4.81	65.8	26.8	27.3	83	0%	0.56	99%	Increasing	Increase, decrease, increase
MW-3	Jun-87	Nov-09	0.07	95.4	15.8	4.2	70	0%	0.33	99%	Increasing	Increase then decrease
MW-3a	Mar-02	Dec-09	2.99	6.0	4.2	4.0	32	0%	0.06	71%	No Significant Trend	Decrease, increase, decrease
MW-4	Jun-87	Sep-07	<0.08	43.2	9.4	6.2	79	1.2%	0.33	99%	Increasing	Increase, decrease, increase
MW-5	Jun-87	Nov-09	5.19	36.0	21.4	22.6	88	0%	0.05	47%	No Significant Trend	Increase, decrease, level off
MW-6	Jun-87	Jun-00	<0.08	9.7	0.8	0.5	47	15%	-0.03	82%	Decreasing	Decrease then increase
MW-7	Oct-91	Dec-09	9.75	39.9	22.6	21.0	73	0%	1.52	99%	Increasing	Increase, increase steeper, increase less steeply
MW-8	Oct-91	Dec-09	6.48	54.5	35.0	35.4	73	0%	0.19	42%	No Significant Trend	Increase then decrease
MW-9	Oct-91	Nov-09	5.2	34.5	21.6	22.6	75	0%	0.95	99%	Increasing	Increasing
MW-10	Oct-91	Dec-09	11.5	40.4	28.2	28.7	73	0%	0.69	99%	Increasing	Increase then decrease
MW-11	Oct-91	Nov-09	5.35	50.5	30.9	30.9	73	0%	0.59	99%	Increasing	Increase then decrease
MW-SP1	Mar-95	Dec-09	27.3	53.6	34.5	33.5	56	0%	-0.46	98%	Decreasing	Decrease, decrease steeper, level off
MW-SP2	Mar-96	Dec-09	29.8	50.3	38.4	37.5	56	0%	-0.42	98%	Decreasing	Decrease then increase

# of Increasing Trends (currently sampled wells only) ==>	6
# of Decreasing Trends (currently sampled wells only) ==>	2
# of Flat Trends (currently sampled wells only) ==>	0
# of Statistically Insignificant Trends (currently sampled wells only)==>	4
Average slope of significant trends at currently sampled wells only (ppm/yr) ==>	0.47
Average slope of all trends at currently sampled wells only (ppm/yr) ==>	0.35

Notes:
Min = minimum, Max = maximum, n = number of samples
BDL = below detection limit, C.L. = confidence level
shaded cell means well is no longer sampled

E:\LUB\LandApp\Third Trend Analysis\[All Trends.xlsx]POM Farm1 thru 2009

Table 2-2
Comparison of Nitrate Trends Between Analyses - Port of Morrow Farm 1
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Well Identification	First Trend Analysis Results (from well installation through 2001)		Second Trend Analysis Results (from well installation through 2005)		Third Trend Analysis Results (from well installation through 2009)		Summary of Changes in Trends between Second and Third Trend Analyses
	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	
MW-11	2.24	99%	1.51	99%	0.59	99%	5 wells show improving trends *(increasing less steeply)*
MW-3	2.65	99%	1.22	99%	0.33	99%	
MW-10	1.51	99%	1.46	99%	0.69	99%	
MW-7	0.41	90%	1.90	99%	1.52	99%	
MW-9	1.41	99%	1.12	99%	0.95	99%	
MW-1	0.21	< 80%	0.64	99%	0.16	71%	3 wells suggest improving trends *(increasing less steeply)*
MW-5	0.67	99%	0.08	48%	0.05	47%	
MW-8	2.48	99%	0.99	98%	0.19	42%	
MW-6	-0.02	80%	ns	--	ns	--	1 well was not sampled enough to calculate trends twice
MW-2	1.65	99%	0.53	96%	0.56	99%	4 wells show worsening trends *(increasing trends getting steeper or decreasing trends getting less steep)*
MW-4	0.31	90%	0.29	98%	0.33	99%	
MW-SP1	0.67	< 80%	-0.80	99%	-0.46	98%	
MW-SP2	-0.25	< 80%	-1.51	99%	-0.42	98%	
MW-3a	ns	--	-0.10	39%	0.06	71%	1 well suggests a worsening trend *(switched from decreasing to increasing)*

Site-wide average trend slope (statistically significant trends only)	1.33	0.67	0.45	Site-wide average of statistically significant trend slopes shows improving trends *(decreases less steeply)*
Site-wide average trend slope (all trends)	1.07	0.56	0.35	Site-wide average of all trend slopes suggests improving trends *(decreases less steeply)*

# Increasing Trends	9 (69%)	9 (69%)	7 (54%)	There were fewer increasing trends, no change in decreasing trends, and more statistically insignificant trends.
# Decreasing Trends	1 (8%)	2 (15%)	2 (15%)	
# Flat Trends	0 (0%)	0 (0%)	0 (0%)	
# Stat. Insignif. Trends	3 (23%)	2 (15%)	4 (31%)	

Notes:
ns = well not sampled enough to calculate a trend
If both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as "showing" a change in trend.
If either confidence level is less than 80%, (e.g., a statistically insignificant trend), then the change is termed as "suggesting" a change in trend.

Table 2-3
Summary of Nitrate Trend Analyses - Port of Morrow Farm 2
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	n	% BDL	Slope (ppm/yr)	C.L.		
MW-12	Dec-91	Dec-09	13	56.0	35.8	35.6	72	0%	1.47	99%	Increasing	Increasing
MW-12s	Oct-07	Dec-09	<0.08	70.7	38.9	50.7	9	22%	-6.45	60%	No Significant Trend	Decrease then increase
MW-13	Dec-91	Dec-09	16.8	61.6	43.1	43.2	73	0%	-0.03	12%	No Significant Trend	Increase then decrease
MW-14	Dec-91	Dec-09	<0.02	45.2	27.0	28.0	73	1%	0.37	72%	No Significant Trend	Increase then decrease
MW-14s	Jan-95	Dec-09	8.12	52.0	37.0	37.7	38	0%	0.16	19%	No Significant Trend	Increase, decrease, increase
MW-15	Dec-91	Dec-09	9.7	59.3	42.0	44.3	73	0%	1.39	99%	Increasing	Increase, then increase less steeply
MW-15s	Jan-95	Dec-09	15.5	55.4	42.9	43.8	37	0%	1.28	99%	Increasing	Increase, then increase less steeply
MW-16	Dec-91	Dec-09	6.06	58.3	37.8	36.1	73	0%	-1.66	99%	Decreasing	Increase then decrease
MW-17	Dec-91	Dec-09	5.89	53.4	42.1	44.8	73	0%	0.50	99%	Increasing	Increase then level off
MW-18	Dec-91	Dec-09	0.03	17.5	9.0	10.0	73	0%	0.82	99%	Increasing	Increasing

# of Increasing Trends ==>	5
# of Decreasing Trends ==>	1
# of Flat Trends ==>	0
# of Statistically Insignificant Trends ==>	4
Average slope of significant trends (ppm/yr) ==>	0.63
Average slope of all trends (ppm/yr) ==>	-0.21

Notes:
Min = minimum, Max = maximum, n = number of samples
BDL = below detection limit, C.L. = confidence level

E:\LUB\LandApp\Third Trend Analysis\[All Trends.xlsx]POM Farm2 thru 2009

Table 2-4
Comparison of Nitrate Trends Between Analyses - Port of Morrow Farm 2
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	First Trend Analysis Results (from well installation through 2001)		Second Trend Analysis Results (from well installation through 2005)		Third Trend Analysis Results (from well installation through 2009)		Summary of Changes in Trends between Second and Third Trend Analyses
	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	
MW-12	1.63	99%	1.10	99%	1.47	99%	1 well shows a worsening trend (increasing steeper)
MW-14s	2.27	80%	-0.03	0%	0.16	19%	1 well suggests a worsening trend (from decreasing to increasing)
MW-15	2.69	99%	1.94	99%	1.39	99%	4 wells show improving trends (increasing less steeply)
MW-15s	3.85	99%	3.02	99%	1.28	99%	
MW-18	0.89	99%	0.84	99%	0.82	99%	
MW-17	2.32	99%	1.22	99%	0.50	99%	
MW-16	2.63	99%	0.09	17%	-1.66	99%	3 wells suggest improving trends (switch from increasing to decreasing, or increasing less steeply)
MW-14	3.59	99%	0.88	98%	0.37	72%	
MW-13	2.73	99%	1.05	99%	-0.03	12%	
MW-12s	ns	--	ns	--	-6.45	60%	1 well was only evaluated once
Site-wide average trend slope (statistically significant trends only)	2.51		1.43		0.63		Site-wide average of statistically significant trend slopes shows improving trends *(increases less steeply)*
Site-wide average trend slope (all trends)	2.51		1.12		-0.21		Site-wide average of all trend slopes suggests improving trends *(switches from increasing to decreasing)*
# Increasing Trends	9 (100%)		7 (78%)		5 (50%)		There were fewer increasing trends, one decreasing trend, and more statistically insignificant trends.
# Decreasing Trends	0 (0%)		0 (0%)		1 (10%)		
# Flat Trends	0 (0%)		0 (0%)		0 (0%)		
# Stat. Insignif. Trends	0 (0%)		2 (22%)		4 (40%)		

Notes:
ns = well not sampled enough to calculate a trend
If both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as "showing" a change in trend.
If either confidence level is less than 80%, (e.g., a statistically insignificant trend), then the change is termed as "suggesting" a change in trend.

Table 2-5
Summary of Nitrate Trend Analyses - Port of Morrow Farm 3
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	n	% BDL	Slope (ppm/yr)	C.L.		
MW-19	Mar-02	Dec-09	11.5	44.7	24.6	22.5	32	0%	2.89	99%	Increasing	Decrease, increase, then decrease
MW-20	Mar-02	Dec-09	5.05	42.3	18.0	17.6	32	0%	-2.02	99%	Decreasing	Decrease, level off, then decrease
MW-21	Mar-02	Dec-09	13.6	49.3	31.9	34.5	32	0%	3.17	99%	Increasing	Increase, level off, then increase less steeply
MW-22	Mar-02	Dec-09	19.2	68.8	44.9	47.5	32	0%	4.68	99%	Increasing	Increasing then leveling off
MW-23	Mar-02	Dec-09	38.9	68.0	53.7	53.3	32	0%	-0.16	34%	No Significant Trend	Increase then decrease
MW-24	Mar-02	Nov-09	42.1	72.0	53.6	52.0	32	0%	3.07	99%	Increasing	Decrease then increase
MW-25	Mar-09	Nov-09	35.3	43.6	39.9	40.4	4	0%	Not enough data to calculate trend			Decreasing

# of Increasing Trends ==>	4
# of Decreasing Trends ==>	1
# of Flat Trends ==>	0
# of Statistically Insignificant Trends ==>	1
Average slope of significant trends (ppm/yr) ==>	2.4
Average slope of all trends (ppm/yr) ==>	1.9

Notes:

Min = minimum, Max = maximum, n = number of samples

BDL = below detection limit, C.L. = confidence level

E:\LUB\LandApp\Third Trend Analysis\[All Trends.xlsx]POM Farm3 thru 2009

Table 2-6
Comparison of Nitrate Trends Between Analyses - Port of Morrow Farm 3
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	First Trend Analysis Results (from well installation through 2001)		Second Trend Analysis Results (from well installation through 2005)		Third Trend Analysis Results (from well installation through 2009)		Summary of Changes in Trends between Second and Third Trend Analyses
	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	
MW-19	ni	--	-2.00	97%	2.89	99%	1 well shows worsening trend *(switched from decreasing to increasing)*
MW-24	ni	--	-0.21	0%	3.07	99%	1 well suggests worsening trend *(switched from decreasing to increasing)*
MW-20	ni	--	-3.17	99%	-2.02	99%	1 well shows worsening trend *(decreasing less steeply)*
MW-22	ni	--	7.51	99%	4.68	99%	2 wells show improving trends *(increasing less steeply)*
MW-21	ni	--	6.92	99%	3.17	99%	
MW-23	ni	--	5.02	99%	-0.16	34%	1 well suggests improving trend *(switched from increasing to decreasing)*
MW-25	ni	--	ni	--	ns	--	1 well has not been sampled enough

Site-wide average trend slope (statistically significant trends only)	ni	2.86	2.36	Site-wide average of statistically significant trend slopes shows improving trends *(increases less steeply)*
Site-wide average trend slope (all trends)	ni	2.34	1.94	Site-wide average of all trend slopes suggests improving trends *(increases less steeply)*

# Increasing Trends	--	3 (50%)	4 (66%)	There were more increasing trends and fewer decreasing trends
# Decreasing Trends	--	2 (33%)	1 (17%)	
# Flat Trends	--	0 (0%)	0 (0%)	
# Stat. Insignif. Trends	--	1 (17%)	1 (17%)	

Notes:
ni = well not installed yet
ns = well not sampled enough to calculate a trend
If both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as "showing" a change in trend.
If either confidence level is less than 80%, (e.g., a statistically insignificant trend), then the change is termed as "suggesting" a change in trend.

Table 3-1
Summary of Nitrate Trend Analyses - ConAgra North Farm
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	n	% BDL	Slope (ppm/yr)	C.L.		
MW-1	Oct-95	Nov-09	2.14	56.6	18.2	17.2	55	0%	0.10	24%	No Significant Trend	Decreasing then increasing
MW-2	Oct-95	Nov-09	13.7	46.1	18.8	18.4	55	0%	0.08	96%	Increasing	Slightly increasing then slightly decreasing
MW-3	Oct-95	Nov-09	7.14	50.4	9.3	8.3	57	0%	-0.08	99%	Decreasing	Slightly decreasing
MW-4	Oct-95	Nov-09	13.2	29.2	25.1	25.4	57	0%	0.20	99%	Increasing	Increase, level off, then increase
MW-5	Nov-95	Nov-09	19.2	50.6	28.4	28.2	57	0%	0.71	99%	Increasing	Increasing
MW-6	Nov-95	Nov-09	3.09	10.8	7.0	7.4	57	0%	0.57	99%	Increasing	Increasing
MW-7	Oct-95	Nov-09	11.4	62.8	41.2	43.9	57	0%	1.15	98%	Increasing	Increase then decrease
MW-8	Oct-95	Nov-09	9.12	129	51.4	49.5	57	0%	-0.24	58%	No Significant Trend	Increase, decrease, then level off
MW-9	Oct-95	Nov-09	3.86	8.1	6.6	6.6	57	0%	-0.13	99%	Decreasing	Decreasing
MW-10	Jan-96	Nov-09	9.08	64.7	47.2	48.6	54	0%	-0.12	67%	No Significant Trend	Increase, decrease, then level off
MW-11	Aug-06	Nov-09	46.6	43.5	59.3	59.8	14	0%	3.65	93%	Increasing	Increasing
MW-12	Aug-06	Nov-09	37.0	97.3	63.3	59.6	14	0%	19.7	99%	Increasing	Increasing
MW-13	Aug-06	Nov-09	19.0	44.0	35.8	37.5	14	0%	1.64	45%	No Significant Trend	Decrease, increase, decrease

# of Increasing Trends ==>	7
# of Decreasing Trends ==>	2
# of Flat Trends ==>	0
# of Statistically Insignificant Trends ==>	4
Average slope of significant trends (ppm/yr) ==>	2.9
Average slope of all trends (ppm/yr) ==>	2.1

Notes:
Min = minimum, Max = maximum, n = number of samples
BDL = below detection limit, C.L. = confidence level

E:\LUB\LandApp\Third Trend Analysis\[All Trends.xlsx]L-W North thru 2009

Table 3-2
Comparison of Nitrate Trends Between Analyses - ConAgra North Farm
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	First Trend Analysis Results (from well installation through 2001)		Second Trend Analysis Results (from well installation through 2005)		Third Trend Analysis Results (from well installation through 2009)		Summary of Changes in Trends between Second and Third Trend Analyses
	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	
MW-5	0.30	< 80%	0.61	99%	0.71	99%	1 well shows worsening trend *(by increasing steeper)*
MW-3	-0.33	99%	-0.17	99%	-0.08	99%	1 well shows worsening trend *(by decreasing less steeply)*
MW-1	0.43	< 80%	-0.36	75%	0.10	24%	1 well suggests worsening trend *(by switching from decreasing to increasing)*
MW-9	-0.03	80%	-0.13	99%	-0.13	99%	1 well shows no change in its decreasing trend
MW-4	0.76	99%	0.25	99%	0.20	99%	4 wells show improving trends *(by increasing less steeply)*
MW-6	0.60	99%	0.63	99%	0.57	99%	
MW-2	0.31	99%	0.18	99%	0.08	96%	
MW-7	6.93	99%	3.67	99%	1.15	98%	
MW-10	0.78	80%	0.04	7%	-0.12	67%	2 wells suggest improving trends *(by switching from increasing to decreasing)*
MW-8	1.66	< 80%	0.22	45%	-0.24	58%	
MW-11	ni	--	ni	--	3.65	93%	3 wells were only analyzed once
MW-12	ni	--	ni	--	19.69	99%	
MW-13	ni	--	ni	--	1.64	45%	

	First Trend Analysis	Second Trend Analysis	MW-1 thru 10	MW-1 thru 13	Summary
Site-wide average trend slope (statistically significant trends only)	1.99	0.72	0.35	2.32	Site-wide average of statistically significant trend slopes shows improving trends *(increases less steeply)*
Site-wide average trend slope (all trends)	1.14	0.50	0.22	2.09	Site-wide average of all trend slopes suggests improving trends *(increases less steeply)*

	First Trend Analysis	Second Trend Analysis	Third Trend Analysis	Summary
# Increasing Trends	5 (50%)	5 (50%)	7 (54%)	There were more increasing trends, fewer decreasing trends, and more statistically insignificant trends.
# Decreasing Trends	2 (20%)	2 (20%)	2 (15%)	
# Flat Trends	0 (0%)	0 (0%)	0 (0%)	
# Stat. Insignif. Trends	3 (30%)	3 (30%)	4 (31%)	

Notes:
ni = well not installed yet
ns = well not sampled enough to calculate a trend
If both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as "showing" a change in trend.
If either confidence level is less than 80%, (e.g., a statistically insignificant trend), then the change is termed as "suggesting" a change in trend.

Table 3-3
Summary of Nitrate Trend Analyses - ConAgra Madison Ranch
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Well Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
		Starting Date	Ending Date	Min	Max	Mean	Median	n	% BDL	Slope (ppm/yr)	C.L.		
MW-2	Onsite	Nov-95	Nov-09	0.05	0.47	0.2	0.2	51	0%	0.0003	< 80%	No Significant Trend	Basically flat
MW-3	Onsite	Jan-96	Nov-09	2.68	13.2	4.7	3.7	53	0%	0.23	99%	Increasing	Flat then increasing
MW-4a	Onsite	Nov-95	Nov-09	0.65	1.19	0.9	0.9	54	0%	0.001	< 80%	No Significant Trend	Basically flat
MW-6	Onsite	Nov-95	Nov-09	8.37	41.1	25.1	26.1	53	0%	0.99	99%	Increasing	Increasing then decreasing
MW-7	Onsite	Nov-95	Nov-09	0.32	3.54	0.9	0.4	54	0%	0.12	99%	Increasing	Flat then increasing
MW-8	Onsite	Nov-95	Nov-09	3.52	6.2	5.0	5.0	54	0%	0.11	99%	Increasing	Increasing
MW-9	Onsite	Nov-95	Nov-09	0.2	6.74	2.3	1.6	54	0%	0.36	99%	Increasing	Flat then increasing
MW-10	Onsite	Nov-95	Nov-09	2.93	14.3	6.5	6.0	53	0%	-0.26	99%	Decreasing	Decrease then level off
MW-12/ MW-17	Onsite	Nov-95	Nov-09	2.77	14.3	6.4	5.9	51	0%	0.20	99%	Increasing	Increasing
MW-13	Onsite	Sep-06	Nov-09	6.7	9.1	8.3	8.4	14	0%	0.35	97%	Increasing	Increase then slight decrease
MW-14	Onsite	Sep-06	Nov-09	2.26	5.1	4.3	4.6	14	0%	0.20	97%	Increasing	Basically flat
MW-15	Onsite	Sep-06	Nov-09	4.64	6.0	5.2	5.2	13	0%	0.04	35%	No Significant Trend	Decrease, increase, then decrease
MW-16	Onsite	Sep-06	Nov-09	3.13	4.0	3.4	3.3	14	0%	0.05	84%	Increasing	Basically flat
MW-5	Offsite	Nov-95	Nov-09	0.76	26.1	8.8	7.6	67	0%	-0.35	99%	Decreasing	Decrease then level off
MW-11	Offsite	Nov-95	Nov-09	0.63	25.5	7.4	7.2	56	0%	-0.13	99%	Decreasing	Slight decrease then slight increase

# of Increasing Trends (current onsite wells only) ==>	9
# of Decreasing Trends (current onsite wells only) ==>	1
# of Flat Trends (currrent onsite wells only) ==>	0
# of Statistically Insignificant Trends (current onsite wells only) ==>	3
Average slope of significant trends (current onsite wells only) ==>	0.24
Average slope of all trends (current onsite wells only) ==>	0.19

Notes:
Min = minimum, Max = maximum, n = number of samples
BDL = below detection limit, C.L. = confidence level
Well MW-1 is no longer sampled and is not considered a current onsite well.
Well MW-12 was sampled until 07/08 when it was damaged beyond repair. Replacement well MW-17 was first sampled 11/08

E:\LUB\LandApp\Third Trend Analysis\[All Trends.xlsx]L-W Madison thru 2009

Table 3-4
Comparison of Nitrate Trends Between Analyses - ConAgra Madison Ranch
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location		First Trend Analysis Results (from well installation through 2001)		Second Trend Analysis Results (from well installation through 2005)		Third Trend Analysis Results (from well installation through 2009)		Summary of Changes in Trends between Second and Third Trend Analyses
		Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	
MW-1	Onsite	-0.14	< 80%	abandoned	--	abandoned	--	well was only analyzed once
MW-13	Onsite	ni	--	ni	--	0.35	97%	
MW-14	Onsite	ni	--	ni	--	0.20	97%	
MW-15	Onsite	ni	--	ni	--	0.04	35%	
MW-16	Onsite	ni	--	ni	--	0.05	84%	
MW-10	Onsite	-0.68	< 80%	-0.47	99%	-0.26	99%	1 well shows worsening trend *(by decreasing less steeply)*
MW-9	Onsite	0.04	95%	0.20	99%	0.36	99%	4 wells shows worsening trend *(by increasing steeper)*
MW-3	Onsite	0.05	95%	0.11	99%	0.23	99%	
MW-7	Onsite	0.00	< 80%	0.02	99%	0.12	99%	
MW-8	Onsite	0.24	99%	0.08	99%	0.11	99%	
MW-12/ MW-17	Onsite	1.03	99%	0.22	95%	0.20	99%	2 wells show improving trend *(by increasing less steeply)*
MW-6	Onsite	3.16	99%	2.03	99%	0.99	99%	
MW-4a	Onsite	0.05	90%	0.003	20%	0.001	< 80%	2 wells suggest improving trend *(by increasing less steeply)*
MW-2	Onsite	0.012	95%	0.009	99%	0.0003	< 80%	
MW-5	Offsite	-0.32	< 80%	-0.48	99%	-0.35	99%	2 wells show worsening trend *(by decreasing less steeply)*
MW-11	Offsite	0.05	< 80%	-0.32	99%	-0.13	99%	

	First	Second	Third: MW-1 thru 12	Third: MW-1 thru 16	Summary
Site-wide average trend slope (statistically significant onsite trends only)	0.65	0.28	0.25	0.24	Site-wide average of statistically significant trend slopes shows improving trends *(increases less steeply)*
Site-wide average trend slope (all onsite trends)	0.56	0.25	0.20	0.19	Site-wide average of all trend slopes suggests improving trends *(increases less steeply)*

	First	Second	Third	Summary
# Increasing Trends (onsite only)	7 (70%)	7 (78%)	9 (69%)	There were (proportionally) fewer increasing trends and more statistically insignificant trends
# Decreasing Trends (onsite only)	0 (0%)	1 (11%)	1 (8%)	
# Flat Trends (onsite only)	0 (0%)	0 (0%)	0 (0%)	
# Stat. Insignif. Trends (onsite only)	3 (30%)	1 (11%)	3 (23%)	

Notes:
ni = well not installed yet
ns = well not sampled enough to calculate a trend
abandoned = well was abandoned (and no longer sampled) because it was damaged
If both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as "showing" a change in trend.
If either confidence level is less than 80%, (e.g., a statistically insignificant trend), then the change is termed as "suggesting" a change in trend.

Table 4-1
Summary of Nitrate Trend Analyses - Simplot Plant Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	n	% BDL	Slope (ppm/yr)	C.L.		
MW-10S	Feb-92	Feb-09	0.05	44.9	4.6	1.6	58	26%	0.25	99%	Increasing	Increasing then increasing steeper
MW-10D	Feb-92	Feb-09	0.05	4.9	0.3	<1.0	55	55%	0.04	35%	No Significant Trend	Slight increase then level
MW-11S	Feb-88	Nov-09	6.0	18.0	11.2	11.1	84	0%	-0.15	99%	Decreasing	Decreasing, flat, then decreasing
MW-11D	Feb-88	Nov-09	0.5	3.5	1.1	0.9	84	24%	0.03	99%	Increasing	Flat, increasing, then leveling off
MW-12	Feb-88	Nov-09	12.5	46.7	20.9	19.6	82	0%	-0.02	29%	No Significant Trend	Increasing then decreasing
MW-13S	Nov-88	Nov-09	3.9	53.0	15.4	14.8	85	0%	0.10	92%	Increasing	Decreasing then increasing
MW-13D	Nov-88	Aug-05	0.4	17.0	2.2	1.7	67	0%	0.03	96%	Increasing	Basically level
MW-16	Nov-88	Aug-05	0.2	100	15.4	3.1	68	40%	-2.40	99%	Decreasing	Decreasing then level
MW-17	Nov-88	Aug-05	0.02	31.4	0.9	1.0	66	46%	0	26%	No Significant Trend	Slight increase
MW-18	Nov-88	May-96	0.50	99.3	8.2	2.6	31	29%	0.29	86%	Increasing	Increase then decrease
MW-19	Nov-88	Nov-09	0.05	1.9	0.2	<1.0	84	56%	0.0	59%	No Significant Trend	Slight increase then level
MW-20	Nov-88	Aug-05	<1.0	43.3	13.3	11.8	68	10%	-1.46	99%	Decreasing	Decreasing
MW-21	Nov-88	Aug-05	0.05	8.9	0.9	1.0	68	46%	-0.10	94%	Decreasing	Basically level
MW-45	Feb-92	Aug-05	<1.0	48.3	9.8	4.1	54	33%	-1.95	99%	Decreasing	Decreasing then level
MW-46	Feb-96	Nov-09	5.1	13.2	8.8	8.8	30	0%	0.10	81%	Increasing	Decresing then increasing
MW-47	Feb-96	Nov-08	5.1	28.3	16.4	15.8	36	0%	-0.13	43%	No Significant Trend	Increasing then decreasing
MW-48	Feb-96	May-07	6.9	45.8	32.0	35.8	38	0%	-2.97	99%	Decreasing	Increasing then decreasing
MW-49	Feb-96	Aug-05	<0.5	1.2	0.6	0.5	39	77%	-0.09	84%	Decreasing	Flat
MW-50	Feb-96	Nov-09	0.5	1.3	<1.0	<1.0	56	84%	-0.03	99%	Decreasing	Flat
MW-56	Feb-96	Nov-04	<1.0	31.8	9.0	8.6	25	4%	0.33	92%	Increasing	Slight increase
MW-57	Feb-96	Aug-05	1.0	18.5	7.6	6.5	39	0%	-0.20	94%	Decreasing	Basically level with some fluctuation
MW-58	May-96	Feb-05	<1.0	18.2	8.5	5.6	36	25%	0	25%	No Significant Trend	Decrease then increase
MW-59	Aug-96	Aug-05	0.5	1.1	<1.0	<1.0	37	84%	0	59%	No Significant Trend	Flat

# of Increasing Trends (only onsite wells still being sampled) ==>	4
# of Decreasing Trends (only onsite wells still being sampled) ==>	3
# of Flat Trends (only onsite wells still being sampled) ==>	0
# of Statistically Insignificant Trends (only onsite wells still being sampled) ==>	4
Average slope of significant trends at onsite wells (ppm/yr) ==>	-0.38
Average slope of all trends at onsite wells (ppm/yr) ==>	-0.25

Notes:

Min = minimum, Max = maximum, n = number of samples

BDL = below detection limit, C.L. = confidence level

Wells MW-56 through MW-59 are offsite wells. All other wells are onsite wells.

shaded cell means the well is no longer sampled

E:\LUB\LandApp\Third Trend Analysis\[All Trends.xlsx]Simplot Plant thru 2009

Table 4-2
Comparison of Nitrate Trends Between Analyses - Simplot Plant Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	First Trend Analysis Results (from well installation through 2001)		Second Trend Analysis Results (from well installation through 2005)		Third Trend Analysis Results (from well installation through 2009)		Summary of Changes in Trends between Second and Third Trend Analyses
	Slope (ppm/yr)	**C.L.**	**Slope (ppm/yr)**	**C.L.**	**Slope (ppm/yr)**	**C.L.**	
MW-50	0.0	95%	-0.09	98%	-0.03	99%	1 well shows worsening trend *(by decreasing less steeply)*
MW-13S	-0.1	< 80%	0.05	31%	0.10	92%	2 wells suggests worsening trend *(by increasing steeper)*
MW-10D	0.0	< 80%	0	22%	0.04	35%	
MW-46	-0.1	< 80%	0.10	18%	0.10	81%	2 wells suggest no change in trend
MW-19	0.0	< 80%	0	40%	0.0	59%	
MW-11S	-0.1	80%	-0.12	93%	-0.15	99%	2 wells show improving trends *(by decreasing steeper)*
MW-48	-0.4	< 80%	-2.82	99%	-2.97	99%	
MW-11D	0.0	< 80%	0.07	99%	0.03	99%	1 well shows an improving trend *(by increasing less steeply)*
MW-12	0.1	< 80%	0.03	30%	-0.02	29%	2 wells suggest an improving trend *(by switching from increasing to decreasing)*
MW-47	1.5	95%	0.22	27%	-0.13	43%	
MW-10S	0.0	< 80%	0.59	99%	0.25	99%	1 well shows an improving trend *(by increasing less steeply)*

Sample Location	First Trend Analysis	Second Trend Analysis	Third Trend Analysis	Summary
Site-wide average trend slope (statistically significant trends only)	0.46	-0.47	-0.38	Site-wide average of statistically significant trend slopes shows improving trends *(decreases steeper)*
Site-wide average trend slope (all trends)	0.08	-0.18	-0.25	Site-wide average of all trend slopes suggests improving trends *(decreases steeper)*

# Increasing Trends	1 (9%)	2 (18%)	4 (36%)	There were more increasing trends and fewer statistically insignificant trends.
# Decreasing Trends	1 (9%)	3 (27%)	3 (27%)	
# Flat Trends	1 (9%)	0 (0%)	0 (0%)	
# Stat. Insignif. Trends	8 (73%)	6 (55%)	4 (36%)	

Notes:
Only onsite wells that are still being sampled are included in this table.
If both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as "showing" a change in trend.
If either confidence level is less than 80%, (e.g., a statistically insignificant trend), then the change is termed as "suggesting" a change in trend.

Table 4-3
Summary of Nitrate Trend Analyses - Simplot Terrace Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	n	% BDL	Slope (ppm/yr)	C.L.		
MW-14	Nov-88	Feb-09	9.0	46.6	28.8	29.3	72	0%	1.70	99%	Increasing	Increasing
MW-15	Nov-88	Feb-98	6.2	17.3	10.4	10.0	35	0%	0.73	99%	Increasing	Increasing with some fluctuation
MW-22	Nov-88	Nov-09	10.3	36.4	26.1	28.9	83	0%	0.77	99%	Increasing	Increasing then starting to decrease
MW-38	May-92	Aug-05	2.3	21.1	12.3	12.2	53	0%	0.97	99%	Increasing	Increasing with some fluctuation
MW-39	May-92	Feb-09	9.2	37.2	20.0	14.5	59	0%	-0.17	78%	No Significant Trend	Increase then decrease
MW-40	May-92	Nov-09	1.2	34.2	20.3	20.4	71	0%	1.20	99%	Increasing	Increasing then increase less steeply
MW-51	Feb-96	Feb-09	9.0	22.9	17.4	19.0	44	0%	0.35	99%	Increasing	Increase then slightly decrease
MW-52	Feb-96	Nov-09	10.7	35.2	24.6	24.9	56	0%	-0.30	97%	Decreasing	Increase then decrease
MW-53	Feb-96	Nov-09	20.8	72.3	52.0	53.3	56	0%	-1.68	99%	Decreasing	Flat, decrease, then flat again
MW-54	Feb-96	Nov-09	14.7	26.2	21.0	21.0	56	0%	0.66	99%	Increasing	Increasing

# of Increasing Trends (currently sampled wells only) ==>	5
# of Decreasing Trends (currently sampled wells only) ==>	2
# of Flat Trends (currently sampled wells only) ==>	0
# of Statistically Insignificant Trends (currently sampled wells only) ==>	1
Average slope of significant trends at currently sampled wells (ppm/yr) ==>	0.39
Average slope of all trends at currently sampled wells (ppm/yr) ==>	0.32

Notes:
Min = minimum, Max = maximum, n = number of samples
BDL = below detection limit, C.L. = confidence level
shaded cell means the well is no longer sampled

E:\LUB\LandApp\Third Trend Analysis\[All Trends.xlsx]Simplot Terrace thru 2009

Table 4-4
Comparison of Nitrate Trends Between Analyses - Simplot Terrace Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	First Trend Analysis Results (from well installation through 2001)		Second Trend Analysis Results (from well installation through 2005)		Third Trend Analysis Results (from well installation through 2009)		Summary of Changes in Trends between Second and Third Trend Analyses
	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	
MW-53	0.95	< 80%	-2.07	99%	-1.68	99%	1 well shows worsening trend *(by decreasing less steeply)*
MW-54	1.04	99%	0.62	99%	0.66	99%	1 well shows worsening trend *(by increasing steeper)*
MW-39	1.80	99%	-0.11	41%	-0.17	78%	1 well suggests an improving trend *(by decreasing steeper)*
MW-14	1.80	99%	1.80	99%	1.70	99%	4 wells show worsening trends *(by decreasing less steeply)*
MW-22	1.38	99%	0.96	99%	0.77	99%	
MW-51	1.68	99%	0.71	99%	0.35	99%	
MW-40	1.37	99%	1.70	99%	1.20	99%	
MW-52	2.25	95%	0.41	50%	-0.30	97%	1 well suggests improving trend *(by switching from increasing to decreasing)*

	First	Second	Third	Summary
Site-wide average trend slope (statistically significant trends only)	1.62	0.62	0.39	Site-wide average of statistically significant trend slopes shows improving trends *(increases less steeply)*
Site-wide average trend slope (all trends)	1.53	0.50	0.32	Site-wide average of all trend slopes suggests improving trends *(increases less steeply)*

	First	Second	Third	Summary
# Increasing Trends	7 (87.5%)	5 (62.5%)	5 (62.5%)	There were more decreasing trends and fewer statistically insignificant trends.
# Decreasing Trends	0	1 (12.5%)	2 (25%)	
# Flat Trends	0	0	0	
# Stat. Insignif. Trends	1 (12.5%)	2 (25%)	1 (12.5%)	

Notes:
Only onsite wells that are still being sampled are included in this table.
If both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as "showing" a change in trend.
If either confidence level is less than 80%, (e.g., a statistically insignificant trend), then the change is termed as "suggesting" a change in trend.

Table 4-5
Summary of Nitrate Trend Analyses - Simplot Expansion Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	n	% BDL	Slope (ppm/yr)	C.L.		
MW-23	May-90	Nov-08	4.8	13.2	9.1	8.9	71	0%	0.07	87%	Increasing	Increase then decrease
MW-24	May-90	Aug-05	3.8	12.3	7.7	7.5	53	0%	0.20	98%	Increasing	Increase then slight decrease
MW-25	May-90	Aug-05	3.5	13.8	7.7	7.5	56	0%	0.25	99%	Increasing	Increase then slight decrease
MW-26	May-90	Aug-05	2.4	17.8	9.6	9.6	48	0%	0.51	99%	Increasing	Increase then slight decrease
MW-27	May-90	Aug-05	2.6	13.4	7.3	7.3	48	0%	0.41	99%	Increasing	Increase then start to level off
MW-28	May-90	Aug-05	2.1	22.1	11.5	11.5	59	0%	0.56	99%	Increasing	Increase then decrease
MW-29	May-90	Nov-09	1.7	11.7	7.1	7.1	78	0%	0.22	99%	Increasing	Increase then decrease
MW-30	May-90	Aug-05	0.1	26.5	8.3	8.4	57	2%	0.55	99%	Increasing	Increasing with some fluctuation
MW-31	May-91	Nov-08	0.6	20.0	9.5	9.7	66	2%	-0.18	98%	Decreasing	Increase then decrease
MW-32	May-91	Nov-08	<1	11.8	7.6	7.7	71	1%	0.05	79%	No Significant Trend	Increase then decrease
MW-33	May-91	Nov-08	3.6	13.1	8.1	8.5	70	0%	0.16	99%	Increasing	Increase then level off
MW-34	May-91	Aug-05	4.0	24.5	7.9	6.9	58	0%	0.05	58%	No Significant Trend	Slight increase then slight decrease
MW-35	May-91	Nov-09	2.0	57.6	8.6	7.5	75	0%	0.07	75%	No Significant Trend	Increase, decrease, then slight increase
MW-36	May-91	Nov-09	2.7	8.8	6.1	6.4	75	0%	0.14	92%	Increasing	Increase then decrease
MW-37	May-91	Aug-05	<2.0	37.2	9.3	7.3	56	2%	0.66	99%	Increasing	Increase then decrease
MW-41	May-92	Nov-08	1.5	24.8	10.0	9.7	67	0%	0.61	99%	Increasing	Increase then decrease
MW-42	May-92	Nov-09	2.0	19.8	11.6	10.2	68	1%	0.75	99%	Increasing	Increase then increase steeper
MW-43	May-92	Nov-09	2.1	42.8	8.7	7.6	70	0%	0.56	99%	Increasing	Increase
MW-44	May-92	Nov-09	1.6	26.6	6.4	6.1	71	0%	0.10	93%	Increasing	Increase, level off, then decrease
MW-55	Feb-96	Nov-08	<1	21.2	17.5	18.2	50	1%	0.30	99%	Increasing	Increase, level off, then increase

# of Increasing Trends (currently sampled wells only) ==>	9
# of Decreasing Trends (currently sampled wells only) ==>	1
# of Flat Trends (currently sampled wells only) ==>	0
# of Statistically Insignificant Trends (currently sampled wells only)==>	2
Average slope of significant trends at currently sampled wells (ppm/yr) ==>	0.27
Average slope of all trends at currently sampled wells (ppm/yr) ==>	0.24

Notes:
Min = minimum, Max = maximum, n = number of samples
BDL = below detection limit, C.L. = confidence level
For these calculations, values reported as BDL and those reported as equal to or less than one-half the highest detection limit were counted as BDL.
Shaded cells indicate wells that have not been sampled since the previous trend analysis.

E:\LUB\LandApp\Third Trend Analysis\[All Trends.xlsx]Simplot Expansion thru 2009

Table 4-6
Comparison of Nitrate Trends Between Analyses - Simplot Expansion Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	First Trend Analysis Results (from well installation through 2001)		Second Trend Analysis Results (from well installation through 2005)		Third Trend Analysis Results (from well installation through 2009)		Summary of Changes in Trends between Second and Third Trend Analyses
	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	
MW-42	0.07	< 80%	0.44	99%	0.75	99%	3 wells show worsening trends *(by increasing steeper)*
MW-55	0.80	95%	0.22	93%	0.30	99%	
MW-43	0.75	99%	0.54	99%	0.56	99%	
MW-35	0.46	99%	0.05	54%	0.07	75%	1 well suggests a worsening trend *(by increasing steeper)*
MW-29	0.47	99%	0.30	99%	0.22	99%	6 wells show improving trends *(by increasing less steeply)*
MW-23	0.25	99%	0.15	99%	0.07	87%	
MW-33	0.53	99%	0.30	99%	0.16	99%	
MW-44	0.40	99%	0.24	99%	0.10	93%	
MW-36	0.56	99%	0.29	99%	0.14	92%	
MW-41	2.02	99%	1.04	99%	0.61	99%	
MW-31	0.58	99%	0.10	80%	-0.18	98%	1 well shows improving trend *(by switching from increasing to decreasing)*
MW-32	0.35	99%	0.15	99%	0.05	79%	1 well suggests an improving trend *(by increasing less steeply)*
Site-wide average trend slope (statistically significant trends only)	0.65		0.34		0.27		Site-wide average of statistically significant trend slopes shows improving trends *(increases less steeply)*
Site-wide average trend slope (all trends)	0.60		0.32		0.24		Site-wide average of all trend slopes suggests improving trends *(increases less steeply)*
# Increasing Trends	11 (92%)		11 (92%)		9 (75%)		There were fewer increasing trends, more decreasing trends, and more statistically insignificant trends.
# Decreasing Trends	0		0		1 (8%)		
# Flat Trends	0		0		0		
# Stat. Insignif. Trends	1 (8%)		1 (8%)		2 (17%)		

Notes:
Only onsite wells that are still being sampled are included in this table.
If both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as "showing" a change in trend.
If either confidence level is less than 80%, (e.g., a statistically insignificant trend), then the change is termed as "suggesting" a change in trend.

Table 4-7
Summary of Nitrate Trend Analyses - Simplot Levy Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	n	% BDL	Slope (ppm/yr)	C.L.		
HL-3	May-02	Nov-09	7.2	25.6	11.9	9.3	31	0%	-0.23	60%	No Significant Trend	Flat, increasing, then decreasing
HL-4	May-02	Nov-09	4.1	11.1	8.3	9.7	31	0%	0.93	99%	Increasing	Increase then increase less steeply
HL-5	May-02	Nov-09	6.6	63.8	47.3	46.4	31	0%	4.75	99%	Increasing	Increasing
L-6	Nov-02	Nov-09	1.1	3.2	2.1	2.2	29	0%	0.10	49%	No Significant Trend	Decrease then increase then level off
L-8	Aug-02	Nov-09	<1	1.7	1.1	<1	30	60%	0.00	99%	Flat	Basically flat
L-9	May-02	Nov-09	14.0	40.1	22.1	19.7	31	0%	-0.13	20%	No Significant Trend	Increase, decrease, then increase
L-10	May-02	Nov-09	8.1	36.3	11.3	10.0	31	0%	0.70	99%	Increasing	Increasing
L-11	May-02	Nov-09	12.8	21.9	19.0	19.5	31	0%	0.27	76%	No Significant Trend	Increase then decrease
SP-1	Feb-03	Nov-09	7.5	33.8	16.7	16.3	27	0%	-0.20	91%	Decreasing	Slightly decreasing

# of Increasing Trends ==>	3
# of Decreasing Trends ==>	1
# of Flat Trends ==>	1
# of Statistically Insignificant Trends ==>	4
Average slope of significant trends (ppm/yr) ==>	1.24
Average slope of all trends (ppm/yr) ==>	0.69

Notes:

Min = minimum, Max = maximum, n = number of samples

BDL = below detection limit, C.L. = confidence level

For these calculations, values reported as BDL and those reported as equal to or less than one-half the highest detection limit were counted as BDL.

E:\LUB\LandApp\Third Trend Analysis\[All Trends.xlsx]Simplot Levy Site thru 2009

Table 4-8
Comparison of Nitrate Trends Between Analyses - Simplot Levy Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	First Trend Analysis Results (from well installation through 2001)		Second Trend Analysis Results (from well installation through 2005)		Third Trend Analysis Results (from well installation through 2009)		Summary of Changes in Trends between Second and Third Trend Analyses
	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	
HL-5	ni	--	4.90	99%	4.75	99%	2 wells show improving trends *(by increasing less steeply)*
HL-4	ni	--	1.13	99%	0.93	99%	
L-10	ni	--	0.33	86%	0.70	99%	1 well shows a worsening trend *(by increasing steeper)*
L-8	ni	--	-0.20	70%	0.00	99%	1 well suggests a worsening trend *(by switching from a decreasing to a flat trend)*
SP-1	ni	--	-0.25	50%	-0.20	91%	1 well suggests a worsening trend *(by decreasing less steeply)*
L-11	ni	--	1.50	93%	0.27	76%	1 well suggests an improving trend *(by increasing less steeply)*
HL-3	ni	--	0.40	54%	-0.23	60%	2 wells suggest improving trends *(by switching from increasing to decreasing trends)*
L-9	ni	--	2.07	73%	-0.13	20%	
L-6	ni	--	-0.35	0%	0.10	49%	1 well suggests worsening trend *(by switching from decreasing to increasing)*
Site-wide average trend slope (statistically significant trends only)	ni		1.97		1.24		Site-wide average of statistically significant trend slopes shows improving trends *(increases less steeply)*
Site-wide average trend slope (all trends)	ni		1.06		0.69		Site-wide average of all trend slopes suggests improving trends *(increases less steeply)*
# Increasing Trends	--		4 (44%)		3 (33%)		There were fewer increasing trends, more decreasing trends, more flat trends, and fewer statistically insignificant trends.
# Decreasing Trends	--		0		1 (11%)		
# Flat Trends	--		0		1 (11%)		
# Stat. Insignif. Trends	--		5 (56%)		4 (44%)		

Notes:
ni = well not installed yet
If both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as "showing" a change in trend.
If either confidence level is less than 80%, (e.g., a statistically insignificant trend), then the change is termed as "suggesting" a change in trend.

Table 5-1
Summary of Nitrate Trend Analyses - Hermiston Foods Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	n	% BDL	Slope (ppm/yr)	C.L.		
MW-1	Apr-91	Nov-09	6.8	13.0	9.9	9.7	69	0%	-0.13	99%	Decreasing	Decreasing
MW-2	Apr-91	Nov-09	0.8	16.6	7.9	7.7	60	0%	0.05	91%	Increasing	Increasing then gently decreasing
MW-3	Apr-91	Nov-09	2.4	9.2	3.8	3.7	63	0%	-0.09	99%	Decreasing	Flat, then decreasing
MW-4	Apr-91	Nov-09	0.6	8.1	6.2	6.4	64	0%	0.11	99%	Increasing	Increasing then gently decreasing
MW-5	May-97	Nov-09	4.5	13.0	7.0	6.8	46	0%	-0.07	88%	Decreasing	Decreasing then slight increase then decreasing
MW-6	May-97	Nov-09	7.5	14.5	10.2	9.7	51	0%	-0.15	96%	Decreasing	Decreasing then leveling off
MW-7	Aug-04	Nov-09	4.9	8.9	6.7	6.9	22	0%	0.61	99%	Increasing	Increasing then increasing less steeply

# of Increasing Trends ==>	3
# of Decreasing Trends ==>	4
# of Flat Trends ==>	0
# of Statistically Insignificant Trends ==>	0
Average slope of significant trends (ppm/yr) ==>	0.05
Average slope of all trends (ppm/yr) ==>	0.05

Notes:

Min = minimum, Max = maximum, n = number of samples

BDL = below detection limit, C.L. = confidence level

E:\LUB\LandApp\Third Trend Analysis\[All Trends.xlsx]HF thru 2009

Table 5-2
Comparison of Nitrate Trends Between Analyses - Hermiston Foods Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	First Trend Analysis Results (from well installation through 2001)		Second Trend Analysis Results (from well installation through 2005)		Third Trend Analysis Results (from well installation through 2009)		Summary of Changes in Trends between Second and Third Trend Analyses
	Slope (ppm/yr)	**C.L.**	**Slope (ppm/yr)**	**C.L.**	**Slope (ppm/yr)**	**C.L.**	
MW-6	0.12	< 80%	-0.38	99%	-0.15	96%	2 wells show worsening trends *(by decreasing less steeply)*
MW-5	-0.01	< 80%	-0.16	99%	-0.07	88%	
MW-3	-0.01	< 80%	-0.09	99%	-0.09	99%	1 well shows no change in its decreasing trend
MW-1	-0.12	< 80%	-0.12	98%	-0.13	99%	1 well shows an improving trend *(by decreasing steeper)*
MW-2	0.29	99%	0.08	99%	0.05	91%	2 wells show improving trends *(by increasing less steeply)*
MW-4	0.29	99%	0.17	99%	0.11	99%	
MW-7	ni	--	ns	--	0.61	99%	1 well was analyzed only once

	First Trend Analysis	Second Trend Analysis	Third: MW-1 thru 6	Third: MW-1 thru 7	Summary
Site-wide average trend slope (statistically significant trends only)	0.29	-0.08	-0.05	0.05	Site-wide average of statistically significant trend slopes shows worsening trends *(decreases less steeply)*
Site-wide average trend slope (all trends)	0.09	-0.08	-0.05	0.05	Site-wide average of all trend slopes suggests worsening trends *(decreases less steeply)*

	First Trend Analysis	Second Trend Analysis	Third Trend Analysis	Summary
# Increasing Trends	2 (33%)	2 (33%)	3 (43%)	There was no change in the trend direction at wells sampled for both analyses. The newly installed well shows an increasing trend.
# Decreasing Trends	0	4 (67%)	4 (57%)	
# Flat Trends	0	0	0	
# Stat. Insignif. Trends	4 (67%)	0	0	

Notes:
ni = well not yet installed
ns = well not sampled enough to calculate trend
Only wells that are still being sampled are included in this table.
If both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as "showing" a change in trend.
If either confidence level is less than 80%, (e.g., a statistically insignificant trend), then the change is termed as "suggesting" a change in trend.

Table 6-1
Summary of Nitrate Trend Analyses - MorStarch Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	n	% BDL	Slope (ppm/yr)	C.L.		
MW-1S	Aug-89	Nov-09	<0.5	23.8	9.2	9.1	76	3%	0.37	99%	Increasing	Increasing then decreasing
MW-1D	Aug-89	May-98	not sampled since previous trend analysis									
MW-2S	Aug-89	Nov-09	<0.02	4.5	0.8	0.5	77	8%	-0.02	99%	Decreasing	Increasing then decreasing
MW-3S	Aug-89	Nov-09	<0.2	5.5	1.2	1.0	77	1%	-0.001	19%	No Significant Trend	Increasing then decreasing
MW-3D	Aug-89	May-98	not sampled since previous trend analysis									
MW-4S	Aug-89	Nov-09	<0.5	10.0	3.7	3.7	77	3%	0.11	99%	Increasing	Increasing then decreasing
MW-5S	Aug-89	Nov-09	<0.5	16.4	5.0	4.5	77	4%	0.08	96%	Increasing	Increasing then decreasing
MW-6S	Apr-94	Nov-09	2.11	6.8	4.0	3.9	63	0%	0.08	99%	Increasing	Increase, decrease, increase
MW-E1S	Apr-94	Nov-09	2.20	12.8	5.6	5.6	63	0%	0.13	99%	Increasing	Increasing then decreasing
MW-E2S	Apr-94	Nov-09	0.30	8.4	3.9	3.5	63	0%	-0.01	99%	Decreasing	Increasing then decreasing

# of Increasing Trends ==>	5
# of Decreasing Trends ==>	2
# of Flat Trends ==>	0
# of Statistically Insignificant Trends ==>	1
Average slope of significant trends (ppm/yr) ==>	0.10
Average slope of all trends (ppm/yr) ==>	0.09

Notes:

Min = minimum, Max = maximum, n = number of samples

C.L. = confidence level

Quarterly sampling is no longer required at wells MW-1D and MW-3D

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Table 6-2
Comparison of Nitrate Trends Between Analyses - MorStarch Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	First Trend Analysis Results (from well installation through 2001)		Second Trend Analysis Results (from well installation through 2005)		Third Trend Analysis Results (from well installation through 2009)		Summary of Changes in Trends between Second and Third Trend Analyses
	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	Slope (ppm/yr)	C.L.	
MW-E2S	0.25	99%	-0.12	92%	-0.01	99%	1 well shows a worsening trend *(by decreasing less steeply)*
MW-2S	0.06	99%	-0.01	66%	-0.02	99%	1 well suggests an improving trend *(by decreasing steeper)*
MW-3S	0.10	99%	0.03	93%	-0.001	19%	1 well suggests an improving trend *(by switching from increasing to decreasing)*
MW-6S	0.39	99%	0.11	99%	0.08	99%	5 wells show improving trends *(by increasing less steeply)*
MW-4S	0.28	99%	0.15	99%	0.11	99%	
MW-E1S	0.44	99%	0.26	99%	0.13	99%	
MW-5S	0.56	99%	0.21	99%	0.08	96%	
MW-1S	1.41	99%	0.62	99%	0.37	99%	
Site-wide average trend slope (statistically significant trends only)	0.44		0.18		0.10		Site-wide average of statistically significant trend slopes shows improving trends *(increases less steeply)*
Site-wide average trend slope (all trends)	0.44		0.16		0.09		Site-wide average of all trend slopes suggests improving trends *(increases less steeply)*
# Increasing Trends	8 (100%)		6 (75%)		5 (62.5%)		There were fewer increasing trends and more decreasing trends.
# Decreasing Trends	0		1 (12.5%)		2 (25%)		
# Flat Trends	0		0		0		
# Stat. Insignif. Trends	0		1 (12.5%)		1 (12.5%)		

Notes:
Only wells that are still being sampled are included in this table.
If both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as "showing" a change in trend.
If either confidence level is less than 80%, (e.g., a statistically insignificant trend), then the change is termed as "suggesting" a change in trend.

Table 7-1
Summary of Nitrate Trend Analyses - Snack Alliance Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	Data Set Statistics								Trend Analysis Results		Trend Direction	LOWESS Pattern
	Starting Date	Ending Date	Min	Max	Mean	Median	n	% BDL	Slope (ppm/yr)	C.L.		
MW-1	Nov-94	Nov-09	0.7	11.1	4.6	4.2	61	0%	0.20	97%	Increasing	Decreasing then increasing
MW-2	Nov-94	Nov-09	1.3	16.3	9.7	9.6	61	0%	-0.19	99%	Decreasing	Increasing then decreasing
MW-3	Nov-94	Nov-09	4.2	20.0	9.0	8.8	61	0%	-0.35	99%	Decreasing	Decreasing
MW-4	Aug-99	Nov-09	5.4	128.2	13.6	8.2	42	0%	-0.90	99%	Decreasing	Decreasing

# of Increasing Trends ==>	1
# of Decreasing Trends ==>	3
# of Flat Trends ==>	0
# of Statistically Insignificant Trends ==>	0
Average slope of significant trends (ppm/yr) ==>	-0.31
Average slope of all trends (ppm/yr) ==>	-0.31

Notes:
Min = minimum, Max = maximum, n = number of samples
BDL = below detection limit, C.L. = confidence level
For these calculations, values reported as BDL and those reported as equal to or less than one-half the highest detection limit were counted as BDL.

E:\LUB\LandApp\Third Trend Analysis\[All Trends.xlsx]SnackAlliance thru 2009

Table 7-2
Comparison of Nitrate Trends Between Analyses - Snack Alliance Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Sample Location	First Trend Analysis Results (from well installation through 2001)		Second Trend Analysis Results (from well installation through 2005)		Third Trend Analysis Results (from well installation through 2009)		Summary of Changes in Trends between Second and Third Trend Analyses
	Slope (ppm/yr)	**C.L.**	**Slope (ppm/yr)**	**C.L.**	**Slope (ppm/yr)**	**C.L.**	
MW-4	-0.25	<80%	-1.14	97%	-0.90	99%	2 wells show worsening trends *(by decreasing less steeply)*
MW-3	-0.64	95%	-0.42	99%	-0.35	99%	
MW-1	-0.28	<80%	0.03	9%	0.20	97%	1 well shows worsening trend *(by increasing steeper)*
MW-2	0.01	<80%	-0.16	85%	-0.19	99%	1 well shows an improving trend *(by decreasing steeper)*
Site-wide average trend slope (statistically significant trends only)	-0.64		-0.42		-0.31		Site-wide average of statistically significant trend slopes shows worsening trends *(decreases less steeply)*
Site-wide average trend slope (all trends)	-0.29		-0.42		-0.31		Site-wide average of all trend slopes suggests worsening trends *(decreases less steeply)*
# Increasing Trends	0		0		1 (25%)		There were more increasing trends and fewer statistically insignificant trends
# Decreasing Trends	1 (25%)		3 (75%)		3 (75%)		
# Flat Trends	0		0		0		
# Stat. Insignif. Trends	3 (75%)		1 (25%)		0		

Notes:
Only wells that are still being sampled are included in this table.
If both confidence levels are at least 80% (e.g., a statistically significant trend), then the change is termed as "showing" a change in trend.
If either confidence level is less than 80%, (e.g., a statistically insignificant trend), then the change is termed as "suggesting" a change in trend.

Table 8-1
Summary of Nitrate Trends and Average Concentrations by Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

		From Well Installation Through 2009 (variable lengths of time)											*From 2005 through 2009*		
Site	***# of Wells***	***Increasing Trends***		***Decreasing Trends***		***Flat Trends***		***Statistically Insignificant Trends***		***Average slope of trends (ppm/yr)***		***Average of Average Nitrate Concentrations at Each Well (ppm)***	***Site Wide Trend***		***Site-Wide Average Concentration (ppm)***
		#	***%***	***#***	***%***	***#***	***%***	***#***	***%***	***Stat. Sig.***	***All***		***slope (ppm/yr)***	***C.L.***	
Port of Morrow (Farm 1)	12	6	50%	2	17%	0	0%	4	33%	0.47	0.35	22.4	-0.69	99%	27.1
Port of Morrow (Farm 2)	10	5	50%	1	10%	0	0%	4	40%	0.63	-0.21	35.6	0.20	53%	35.3
Port of Morrow (Farm 3)	6	4	67%	1	17%	0	0%	1	17%	2.40	1.90	37.8	1.17	98%	41.1
ConAgra (North Farm)	13	7	54%	2	15%	0	0%	4	31%	2.90	2.10	31.7	0.31	99%	29.9
ConAgra (Madison Ranches)	13	9	69%	1	8%	0	0%	3	23%	0.24	0.19	6.0	0.13	99%	6.3
Simplot (Plant Site)	11	4	36%	3	27%	0	0%	4	36%	-0.38	-0.25	9.0	-0.21	92%	8.3
Simplot (Expansion Site)	12	9	75%	1	8%	0	0%	2	17%	0.27	0.24	9.0	0.20	36%	10.4
Simplot (Terrace Site)	8	5	63%	2	25%	0	0%	1	13%	0.39	0.32	23.3	0.10	88%	29.2
Simplot (Levy Site)	9	3	33%	1	11%	1	11%	4	44%	1.24	0.69	15.5	0.25	99%	16.1
Hermiston Foods	7	3	43%	4	57%	0	0%	0	0%	0.05	0.05	7.5	0.05	62%	7.3
MorStarch Site	8	5	63%	2	25%	0	0%	1	13%	0.10	0.09	4.2	-0.09	99%	4.1
Snack Alliance	4	1	25%	3	75%	0	0%	0	0%	-0.31	-0.31	9.2	-0.21	82%	7.1
Totals by Well	***113***	***61***	***54%***	***23***	***20%***	1	1%	***28***	***25%***						

Steepest Decreasing Trend At A Well = *-2.97 ppm/yr*
Steepest Increasing Trend At A Well = *19.7 ppm/yr*

In addition to the 113 wells indicated above, two former ConAgra Madison Ranch wells (now considered offsite) were also analyzed. Results indicated 2 decreasing trends.
In addition to the 113 wells indicated above, one well at the Port of Morrow Farm 3 site does not yet have enough data to evaluate a trend.
The site wide trends were calculated using the Regional Kendall Method.
Because this comparison uses information from all onsite wells regardless of how long they were sampled, some values differ from those in Table 8-2.

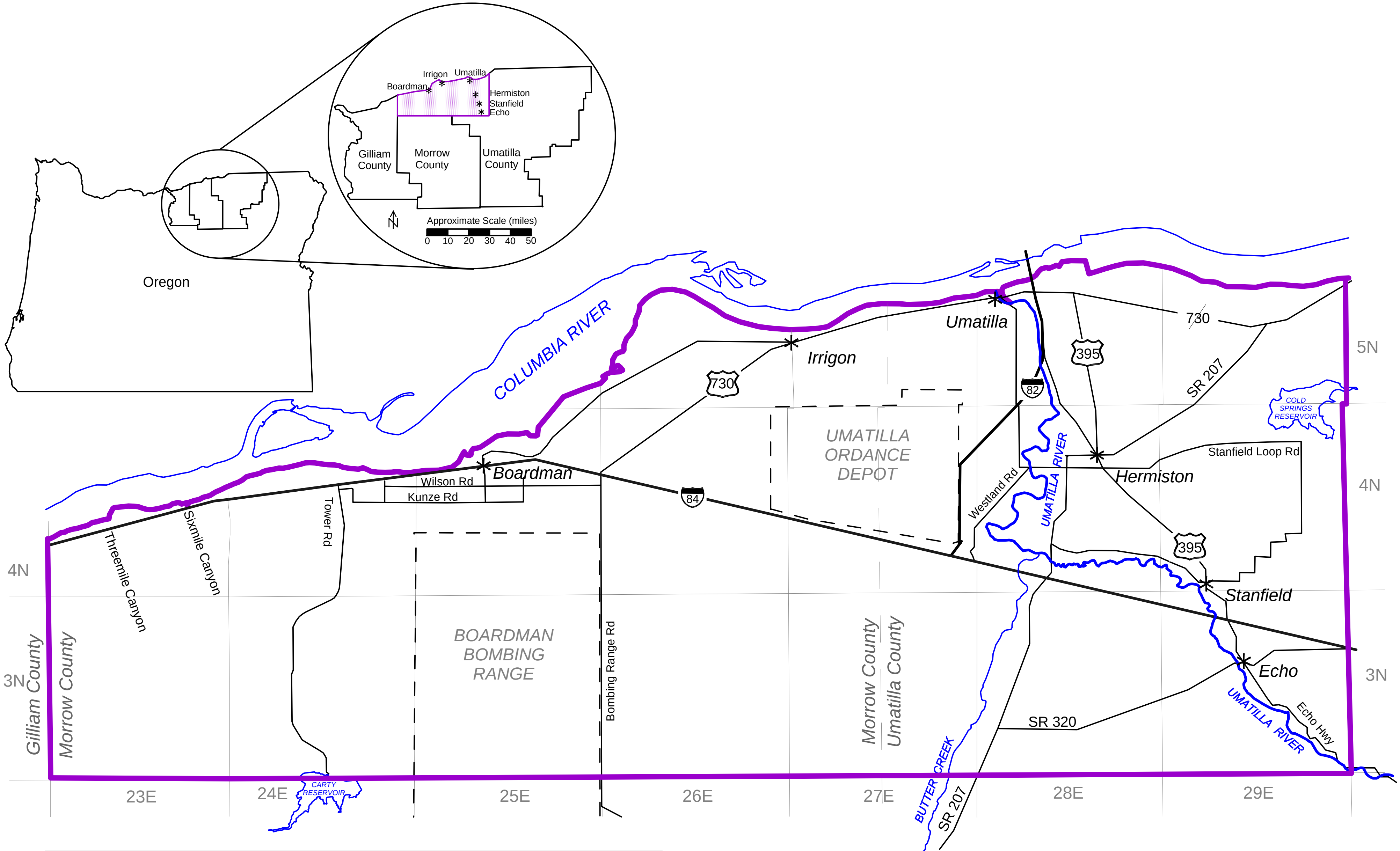
Table 8-2
Comparison of Results From Wells Analyzed Three Times
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

Site	***# Wells***	***# of Increasing Trends***				***# of Decreasing Trends***				***# of Flat Trends***				***# of Statistically Insignificant Trends***				***Average trend slope (ppm/yr)***				***Average of average Nitrate Concentration at Each Well (ppm)***			
		thru 2001	***thru 2005***	***thru 2009***	***2005 to 2009 Change***	***thru 2001***	***thru 2005***	***thru 2009***	***2005 to 2009 Change***	***thru 2001***	***thru 2005***	***thru 2009***	***2005 to 2009 Change***	***thru 2001***	***thru 2005***	***thru 2009***	***2005 to 2009 Change***	***thru 2001***	***thru 2005***	***thru 2009***	***2005 to 2009 Change***	***thru 2001***	***thru 2005***	***thru 2009***	***2005 to 2009 Change***
Port of Morrow (Farm 1)	11	8	8	6	-2	0	2	2	0	0	0	0	0	3	1	3	2	1.63	0.71	0.47	-0.24	26.2	27.1	27.2	0.1
Port of Morrow (Farm 2)	9	9	7	5	-2	0	0	1	1	0	0	0	0	0	2	3	1	2.51	1.43	0.63	-0.80	33.6	34.5	35.2	0.7
Port of Morrow (Farm 3)	4	--	3	4	1	--	2	1	-1	--	0	0	0	--	1	1	0	--	2.86	2.36	-0.50	--	33.0	37.8	4.8
ConAgra (North Farm)	10	5	5	5	0	2	2	2	0	0	0	0	0	3	3	3	0	1.29	0.72	0.35	-0.37	24.2	25.1	25.3	0.2
ConAgra (Madison Ranch)	9	7	7	6	-1	0	1	1	0	0	0	0	0	2	1	2	1	0.65	0.28	0.25	-0.03	4.7	5.3	5.8	0.5
Simplot (Plant Site)	11	1	2	4	2	1	3	3	0	1	0	0	0	8	6	4	-2	0.46	-0.47	-0.38	0.09	10.8	10.3	10.1	-0.2
Simplot (Expansion Site)	12	11	11	9	-2	0	0	1	1	0	0	0	0	1	1	2	1	0.65	0.34	0.27	-0.07	8.4	8.8	9.2	0.4
Simplot (Terrace Site)	8	7	5	5	0	0	1	2	1	0	0	0	0	1	2	1	-1	1.62	0.62	0.39	-0.23	25.4	25.8	26.3	0.5
Simplot (Levy Site)	6	--	4	3	-1	--	0	1	1	--	0	1	1	--	5	4	-1	--	1.97	1.24	-0.73	--	14.4	15.5	1.1
Hermiston Foods	6	2	2	2	0	0	4	4	0	0	0	0	0	4	0	0	0	0.29	-0.08	-0.05	0.03	7.9	7.6	7.5	-0.1
MorStarch Site	8	8	6	5	-1	0	1	2	1	0	0	0	0	0	1	1	0	0.44	0.18	0.10	-0.08	4.2	4.2	4.2	0.0
Snack Alliance	4	0	0	0	0	1	3	3	0	0	0	0	0	3	1	1	0	-0.64	-0.57	-0.57	0.00	10.3	10.4	9.2	-1.2
Total	***98***	***58***	***60***	***54***	***-6***	***4***	***19***	***23***	***4***	***1***	0	***1***	***1***	***25***	***24***	***25***	***1***								
Percentage		***66%***	***58%***	***52%***	***-6%***	***5%***	***18%***	***22%***	***4%***	***1%***	0%	***1%***	***1%***	***28%***	***23%***	***24%***	***1%***								

Summary		
Item	***Result of Analysis through 2009***	***Difference Between Second and Third Analyses***
Number of Increasing and Decreasing Trends	55 increasing trends; 23 decreasing trends	6% fewer increasing trends; 4% more decreasing trends
Average Trend Slope at 12 Sites	Increasing at 9 sites; decreasing at 3 sites	Improved at 9 sites; worsened at 2 sites; no change at 1 site
Average of average nitrate concentration at each well	Exceeded 7 ppm GWMA trigger level at 10 of 12 sites	Improved at 3 sites; worsened at 8 sites; no change at 1 site

Notes:
Because this comparison uses information only from the onsite wells analyzed each time (i.e, 88 wells in 2001, 103 wells in 2005 and 2009), some values differ from those in Table 8-1.
The average trend slope is the average of statistically significant trends only.
The average of the average nitrate concentration at each well uses all onsite wells currently being sampled.

Figure 1-1
Location and Boundaries of Lower Umatilla Basin Groundwater Management Area
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



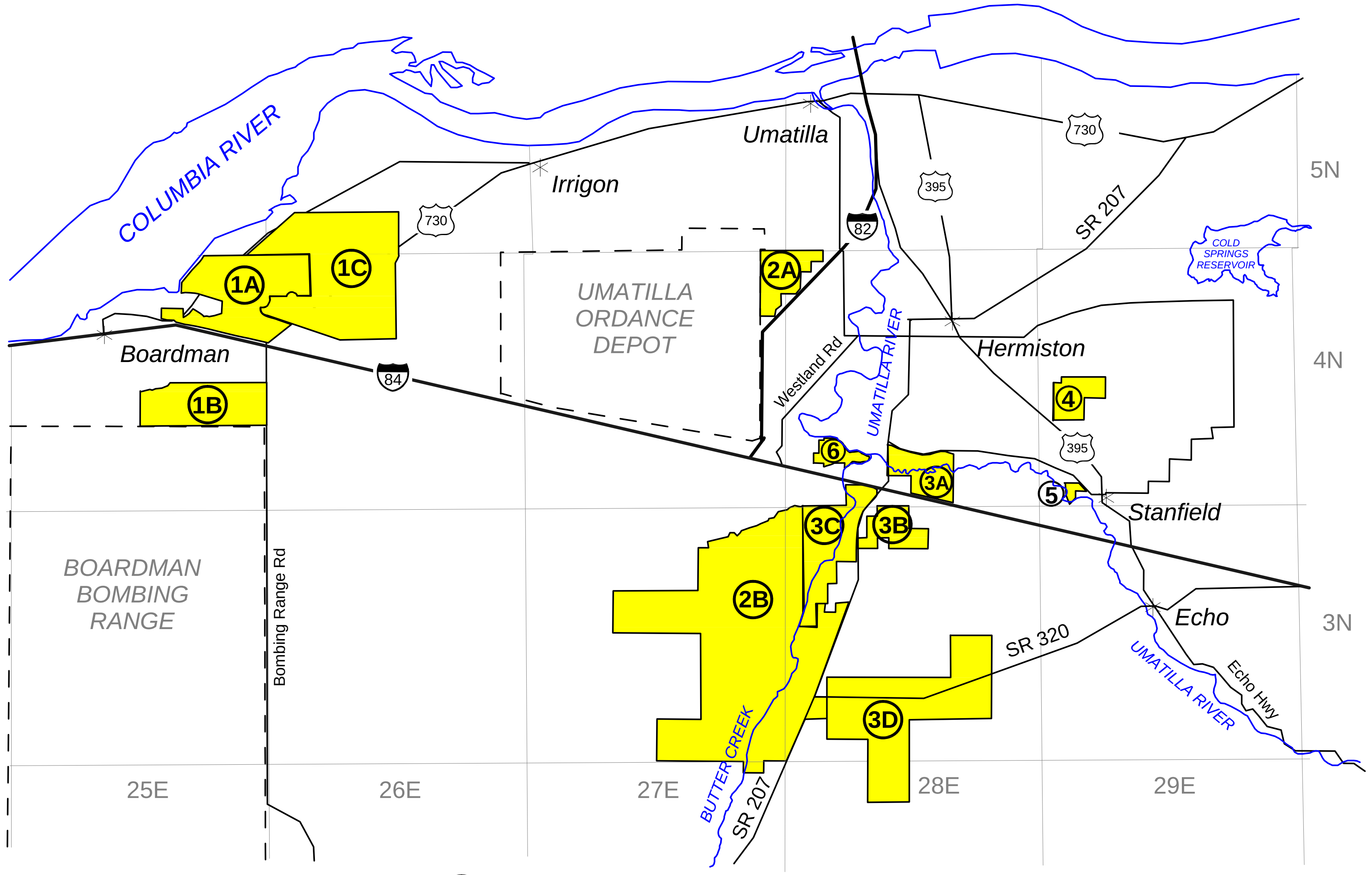
Lower Umatilla Basin Groundwater Management Area Boundaries

North: Columbia River
South: 2N/3N Township Boundary
East: 29E/30E Range Boundary
West: 22E/23E Range Boundary (also the Morrow / Gilliam County line)

Figure 1-2

Location of Food Processor Land Application Sites in the LUBGWMA

Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



1A Port of Morrow Farm 1
1B Port of Morrow Farm 2
1C Port of Morrow Farm 3
2A ConAgra North Farm
2B ConAgra Madison Ranch
3A Simplot Plant Site
3B Simplot Terrace Site
3C Simplot Expansion Site
3D Simplot Levy Site
4 Hermiston Foods
5 MorStarch
6 Snack Alliance

Figure 2-1
Well Locations and Surface Water Bodies - Port of Morrow Farms
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

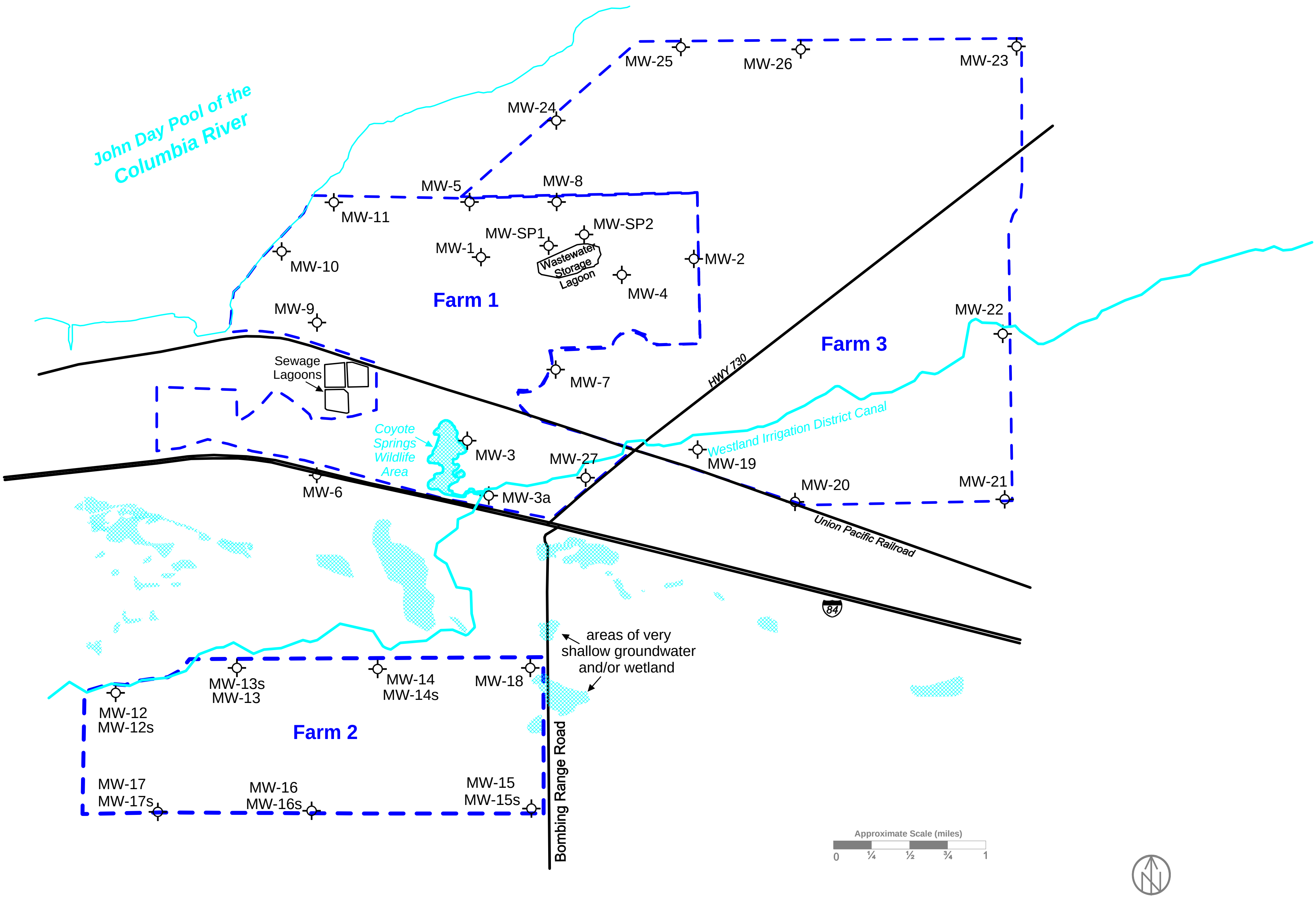
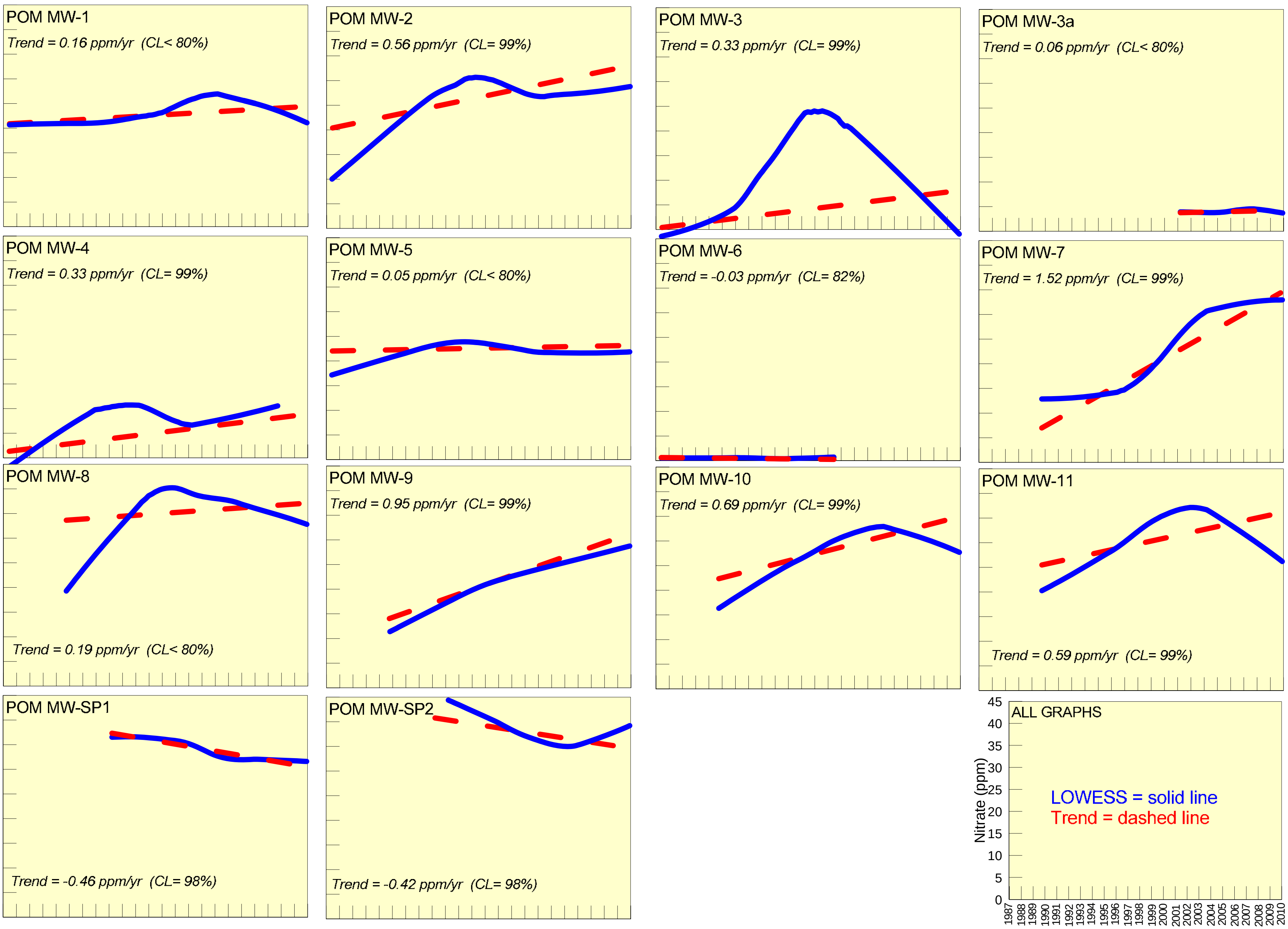


Figure 2-2
LOWESS Lines and Trend Lines Through Nitrate Data - Port of Morrow Farm 1
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalysis pom trends&lowess_1.grf

Figure 2-3
Nitrate Trends - Port of Morrow Farms
Third Trend Analysis of Food Processor Land Application Sites
in the LUBGWMA

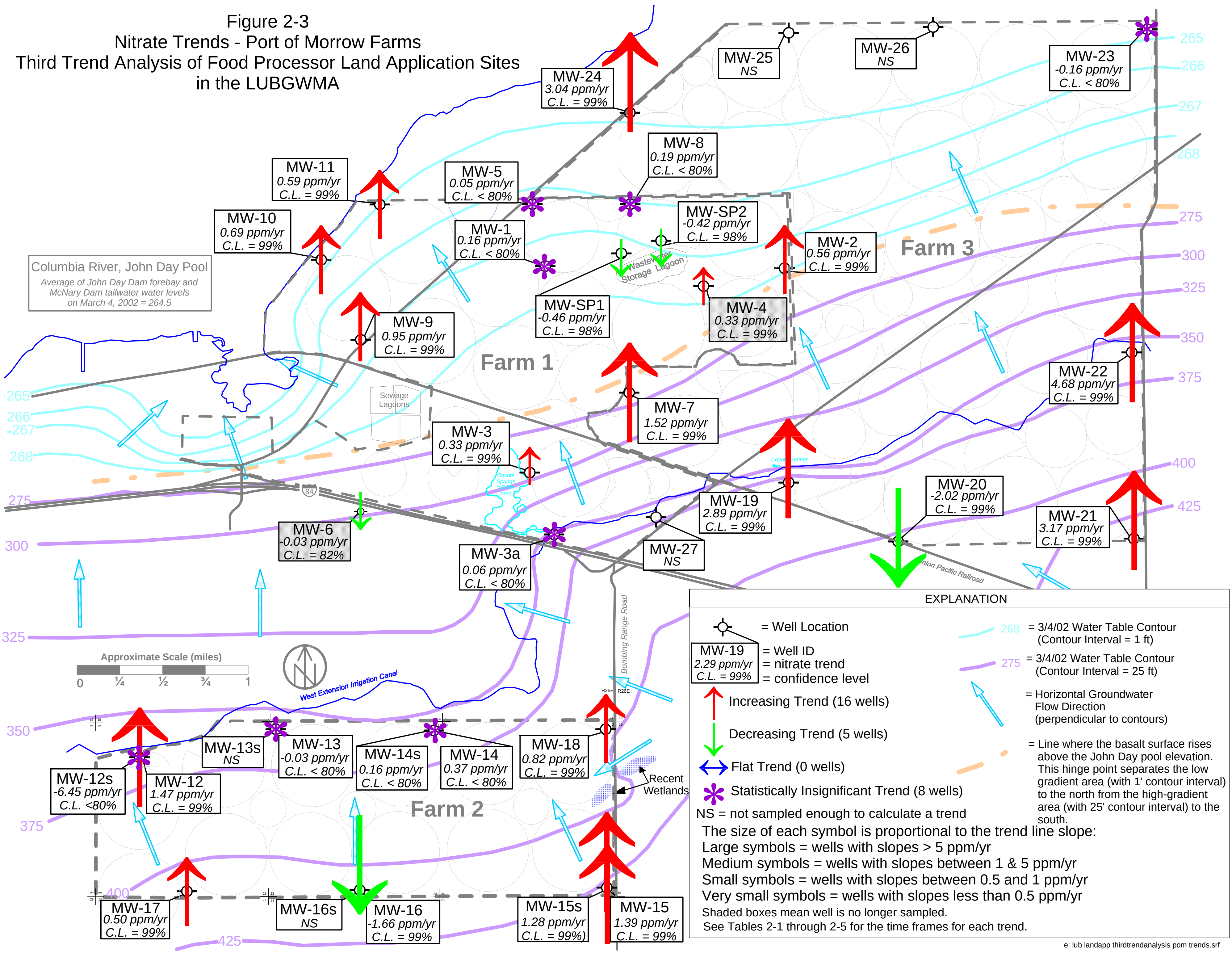


Figure 2-4
Average Nitrate Concentrations - Port of Morrow Farms
Third Trend Analysis of Food Processor Land Application Sites
in the LUBGWMA

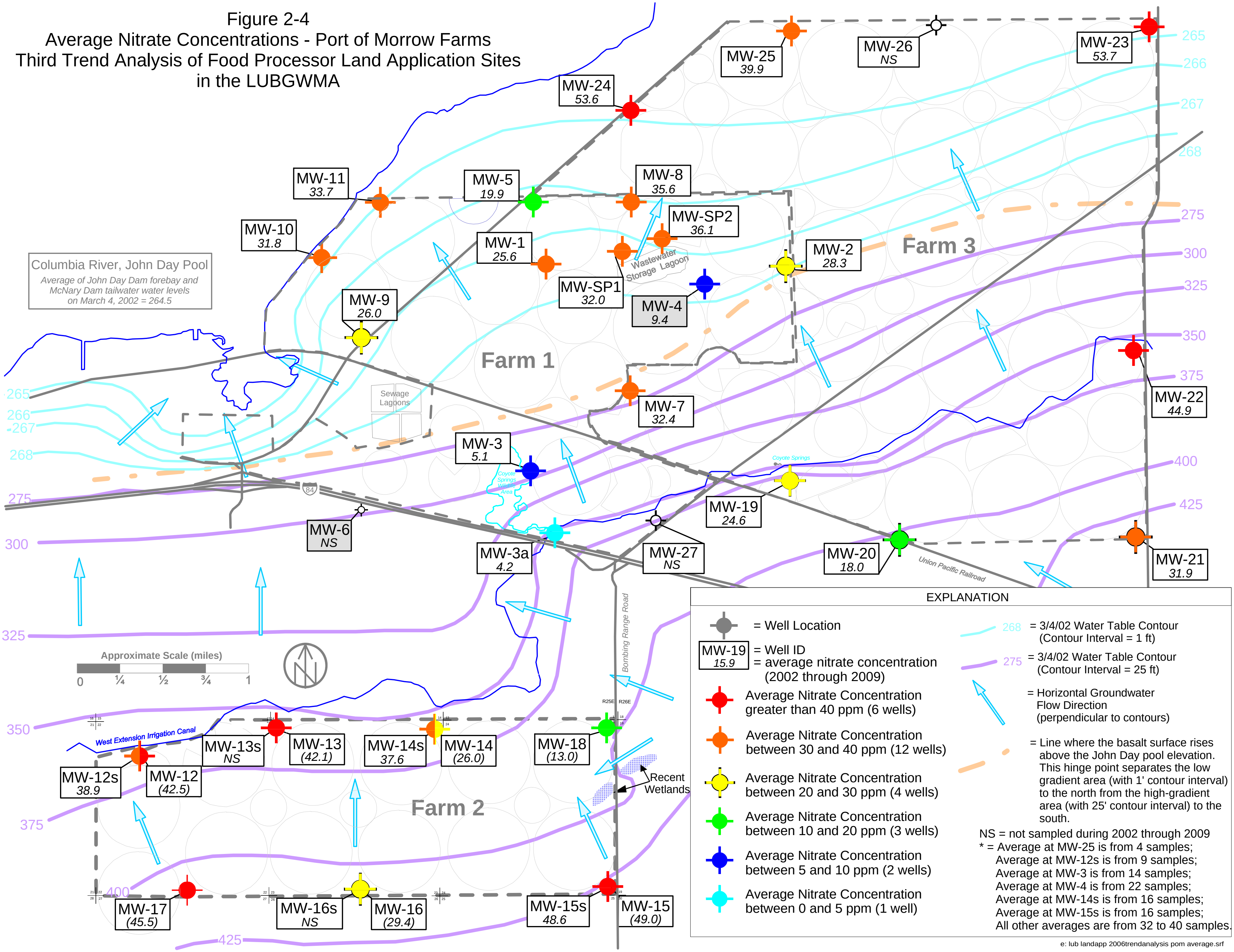
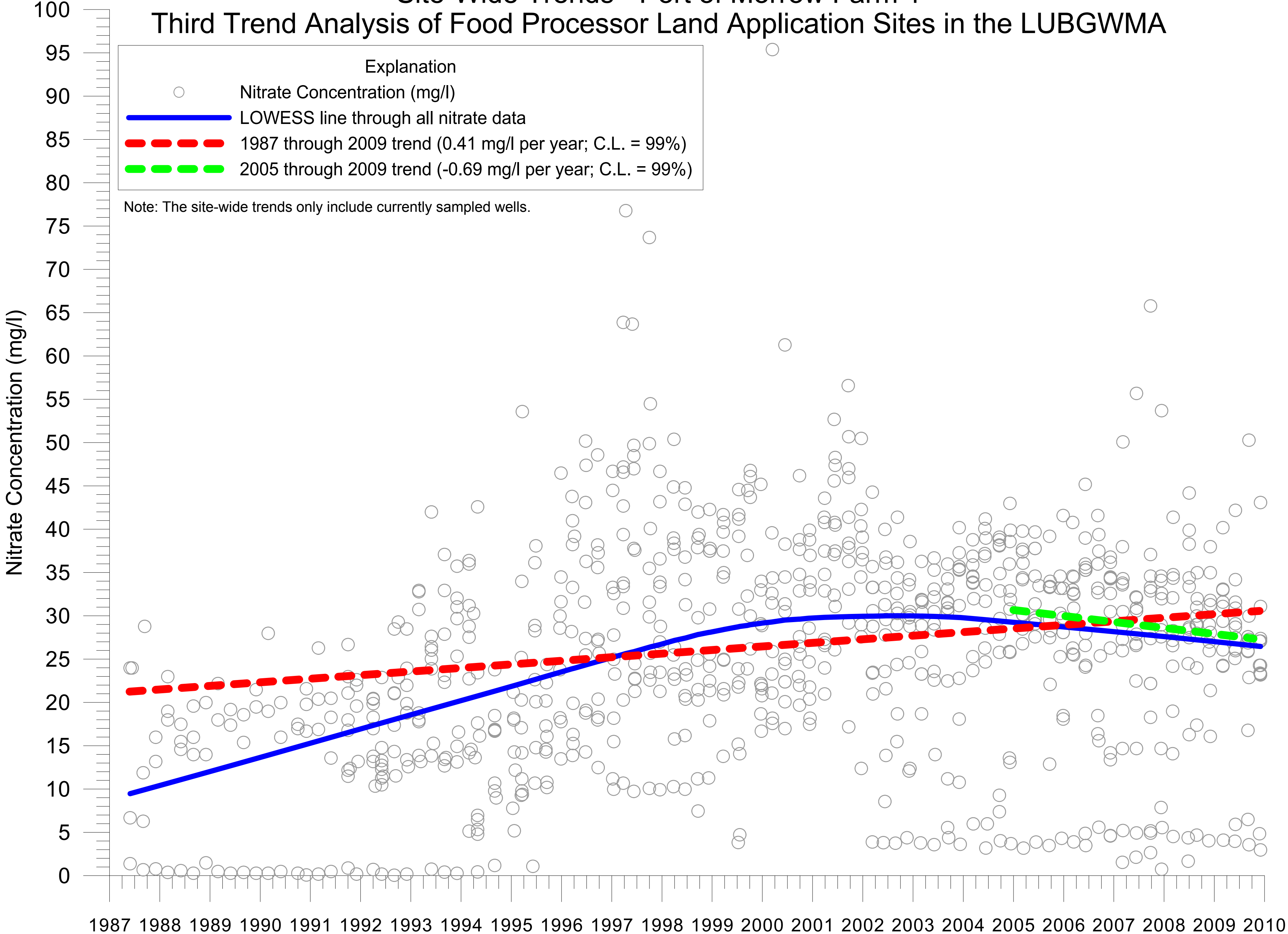
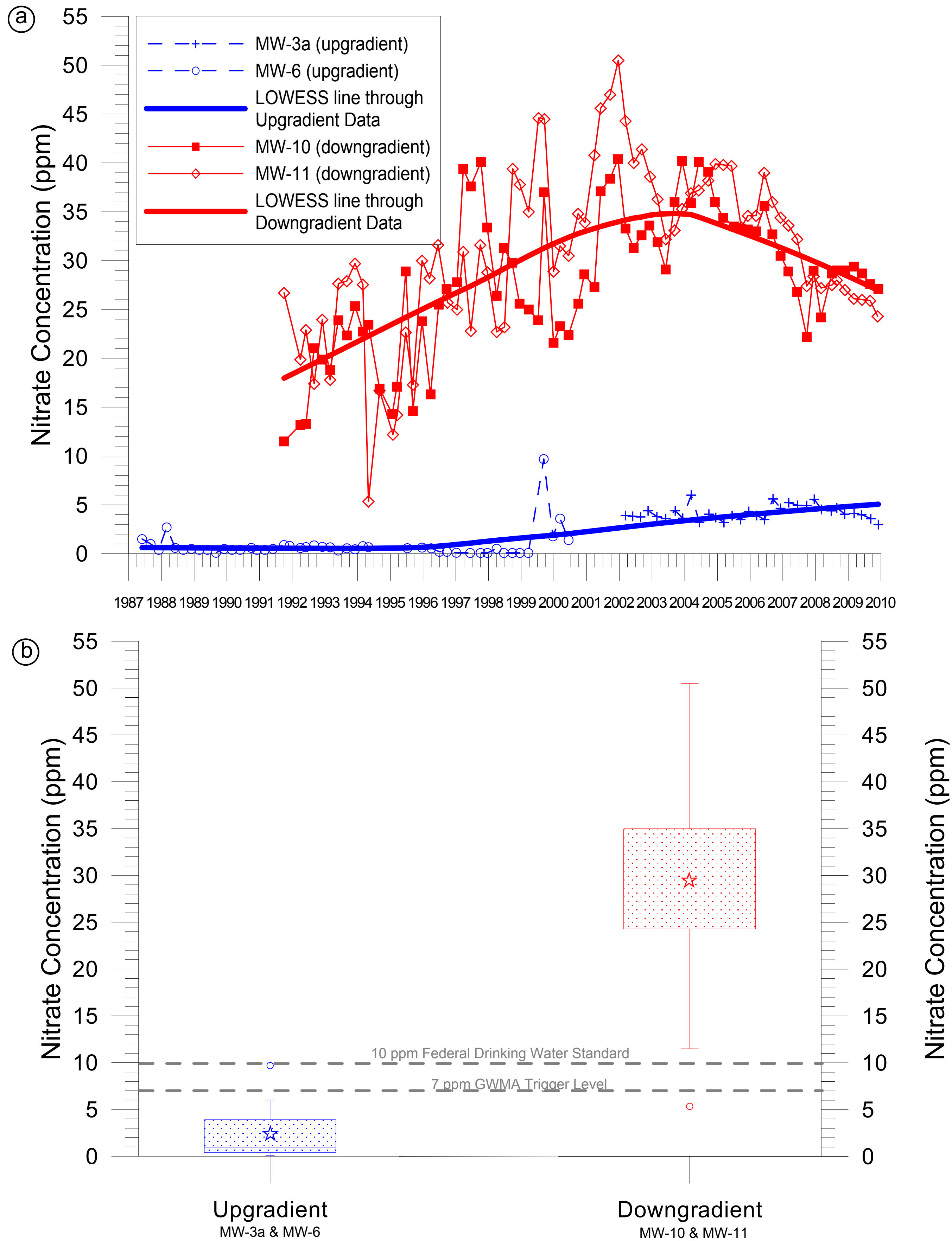


Figure 2-5
Site-Wide Trends - Port of Morrow Farm 1
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



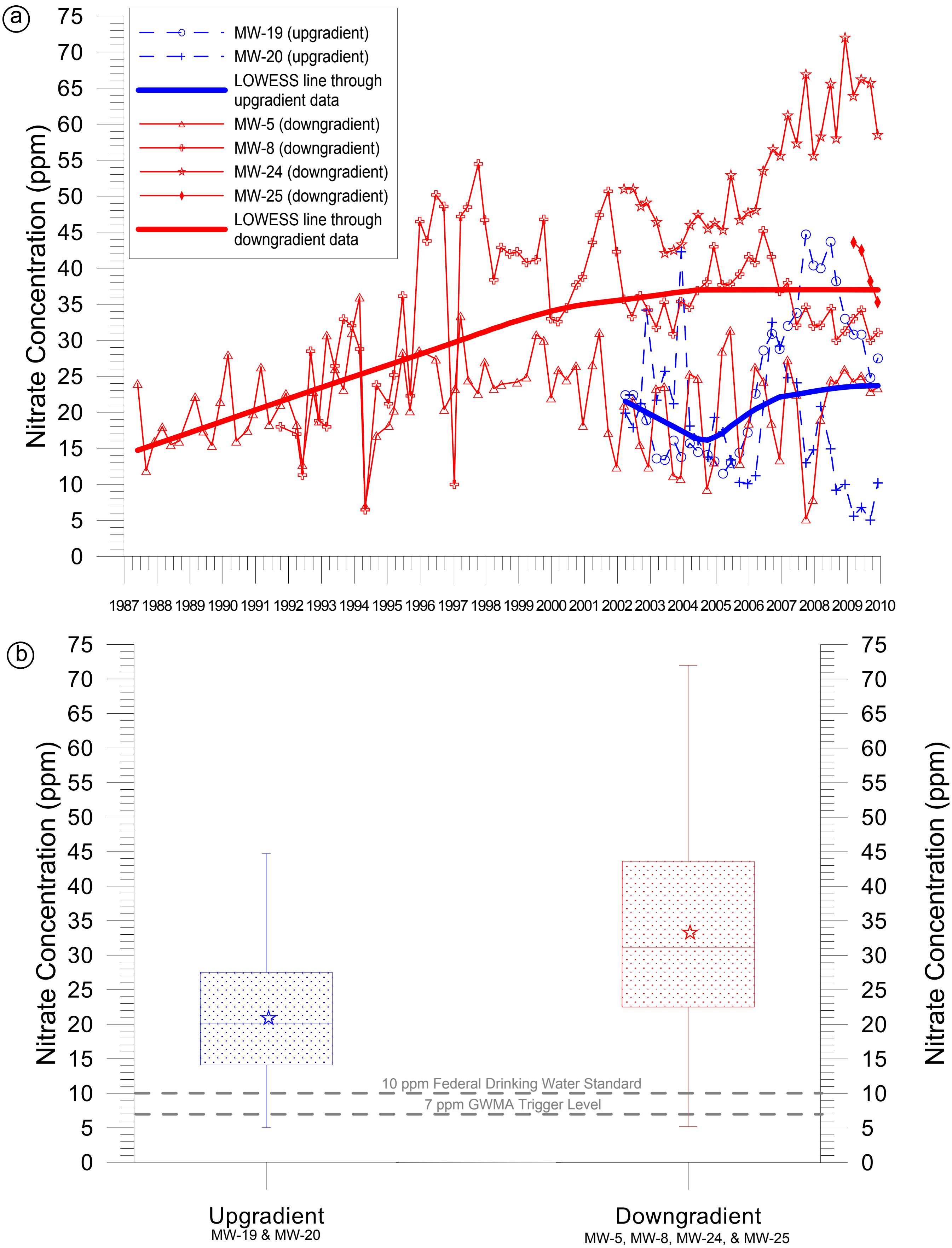
e: lub landapp thirdtrendanalysis pom alldatafarm1.grf

Figure 2-6
Upgradient vs. Downgradient Nitrate Comparisons
Western Portion of Port of Morrow Farm 1
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



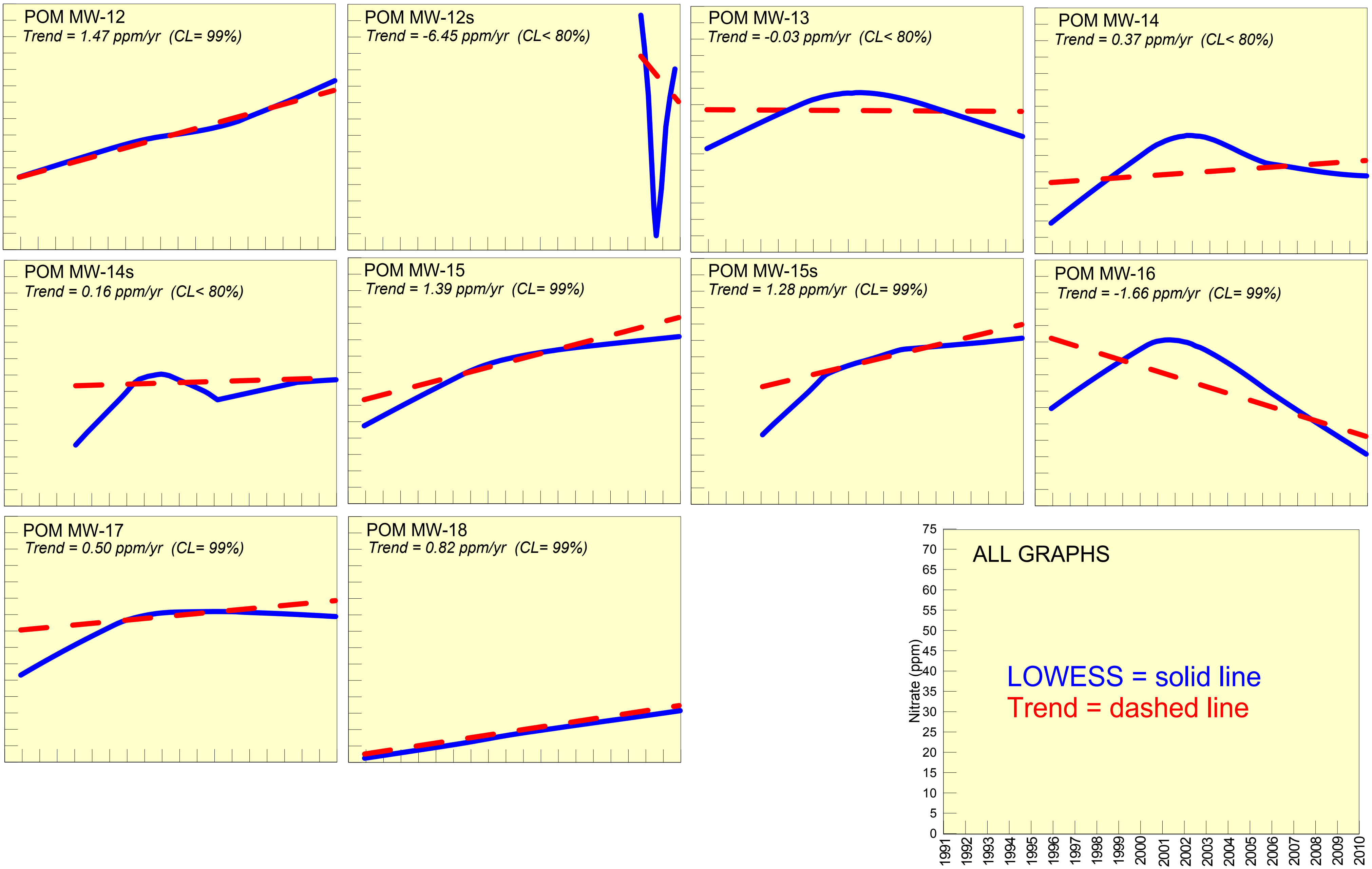
e: lub landapp 2006trendanalysis pom upvsdnFm1W.grf

Figure 2-7
Upgradient vs. Downgradient Nitrate Comparisons
Eastern Portion of Port of Morrow Farm 1 & Western Portion of Farm 3
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



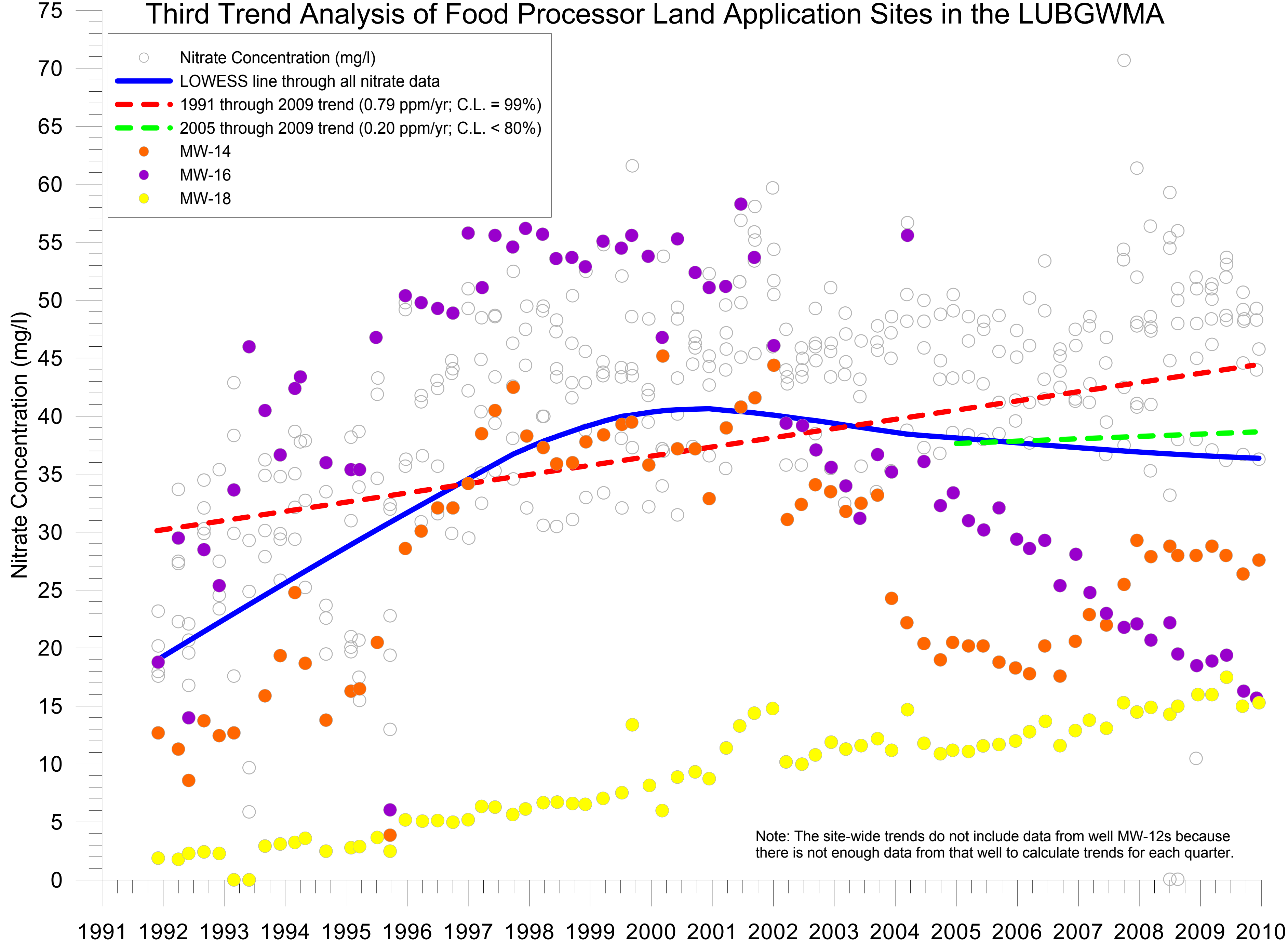
e: lub landapp thirdtrendanalysis pom up vs dn Fm1 E & Fm 3 W.grf

Figure 2-8
LOWESS Lines and Trend Lines Through Nitrate Data - Port of Morrow Farm 2
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp thirdtrendanalysis pom trends&lowess_2.grf

Figure 2-9
Site-Wide Trends - Port of Morrow Farm 2
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp thirdtrendanalysis pom alldatafarm2.grf

Figure 2-10
LOWESS Lines and Trend Lines Through Nitrate Data - Port of Morrow Farm 3
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

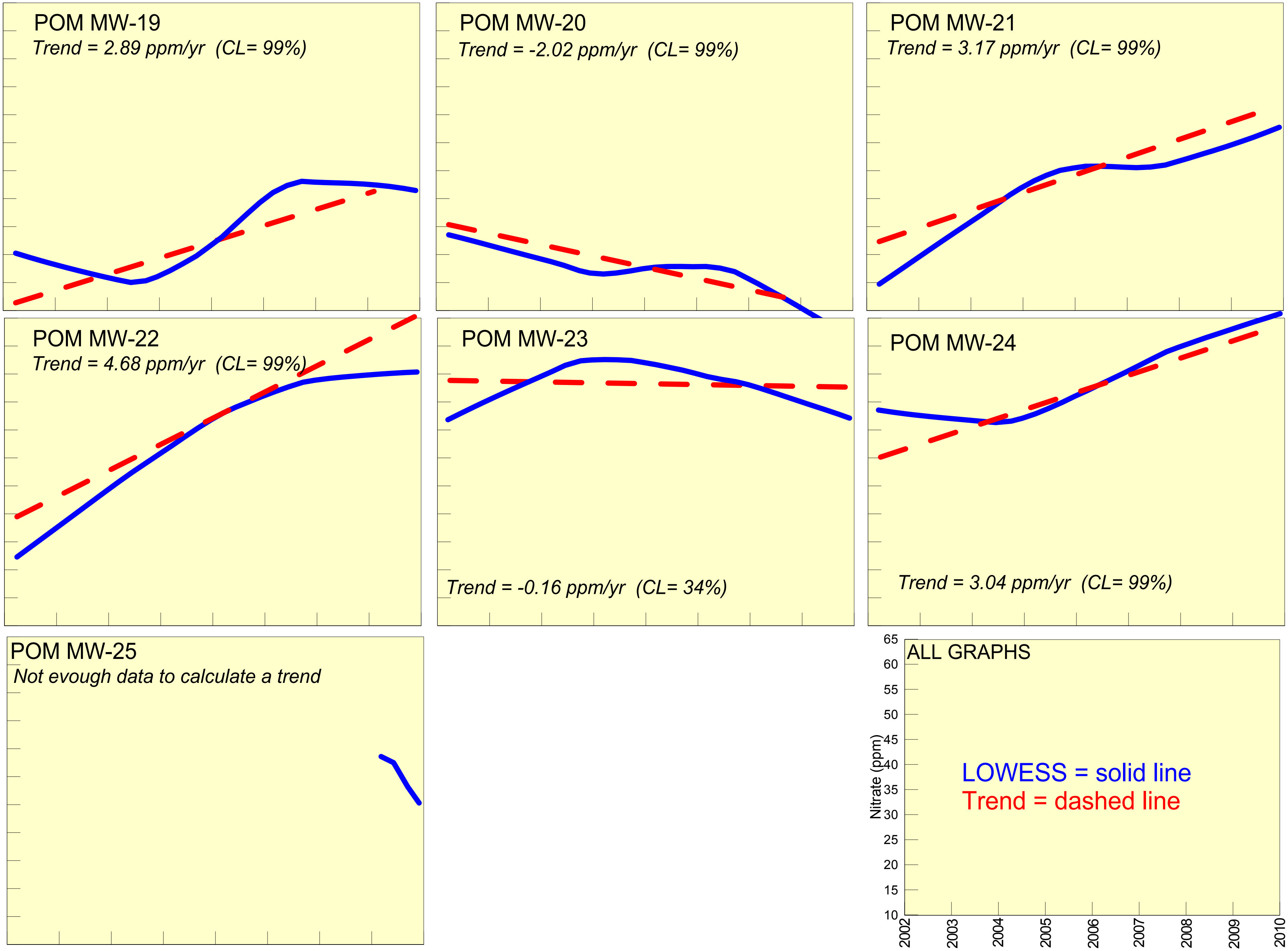
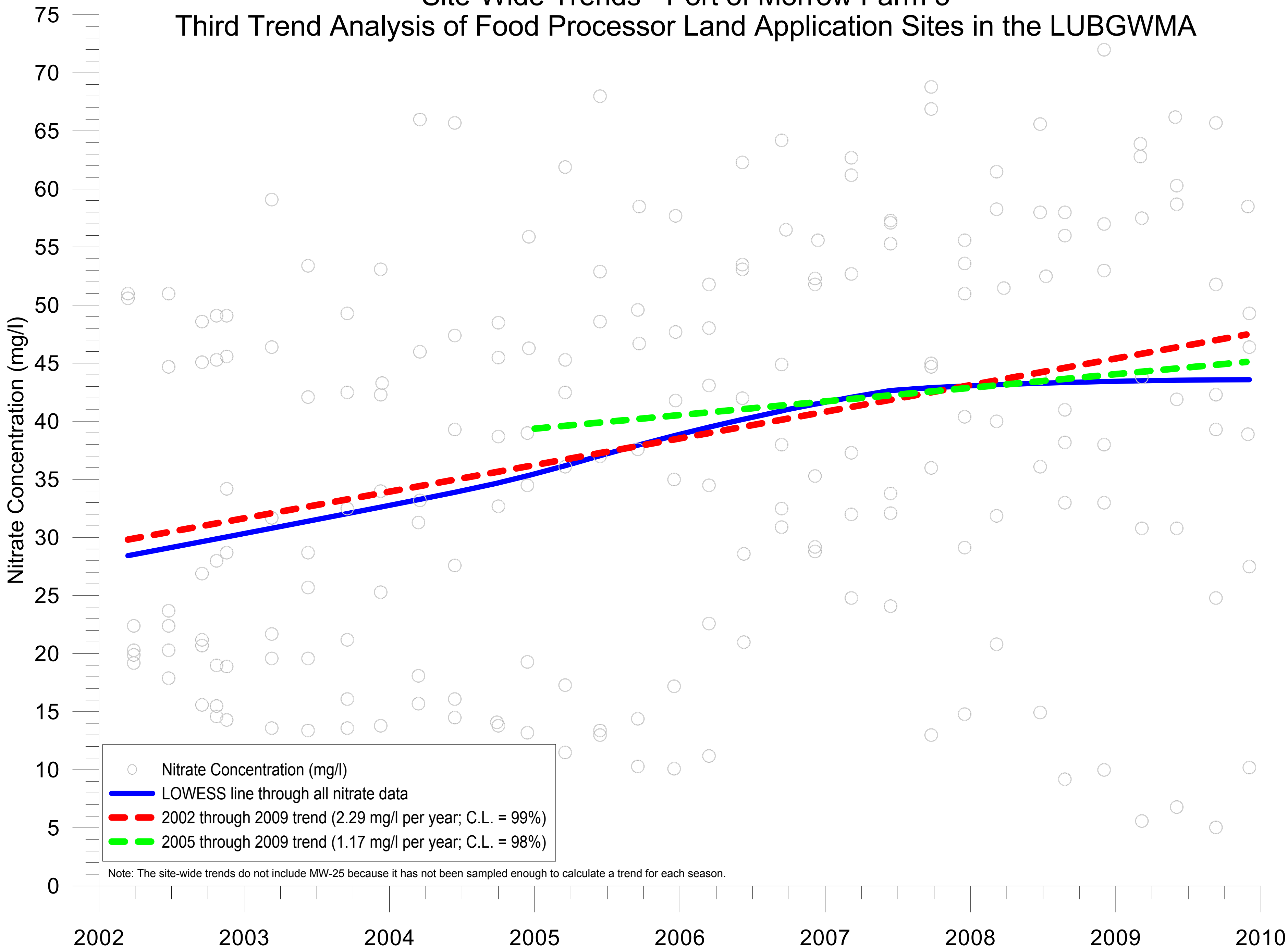
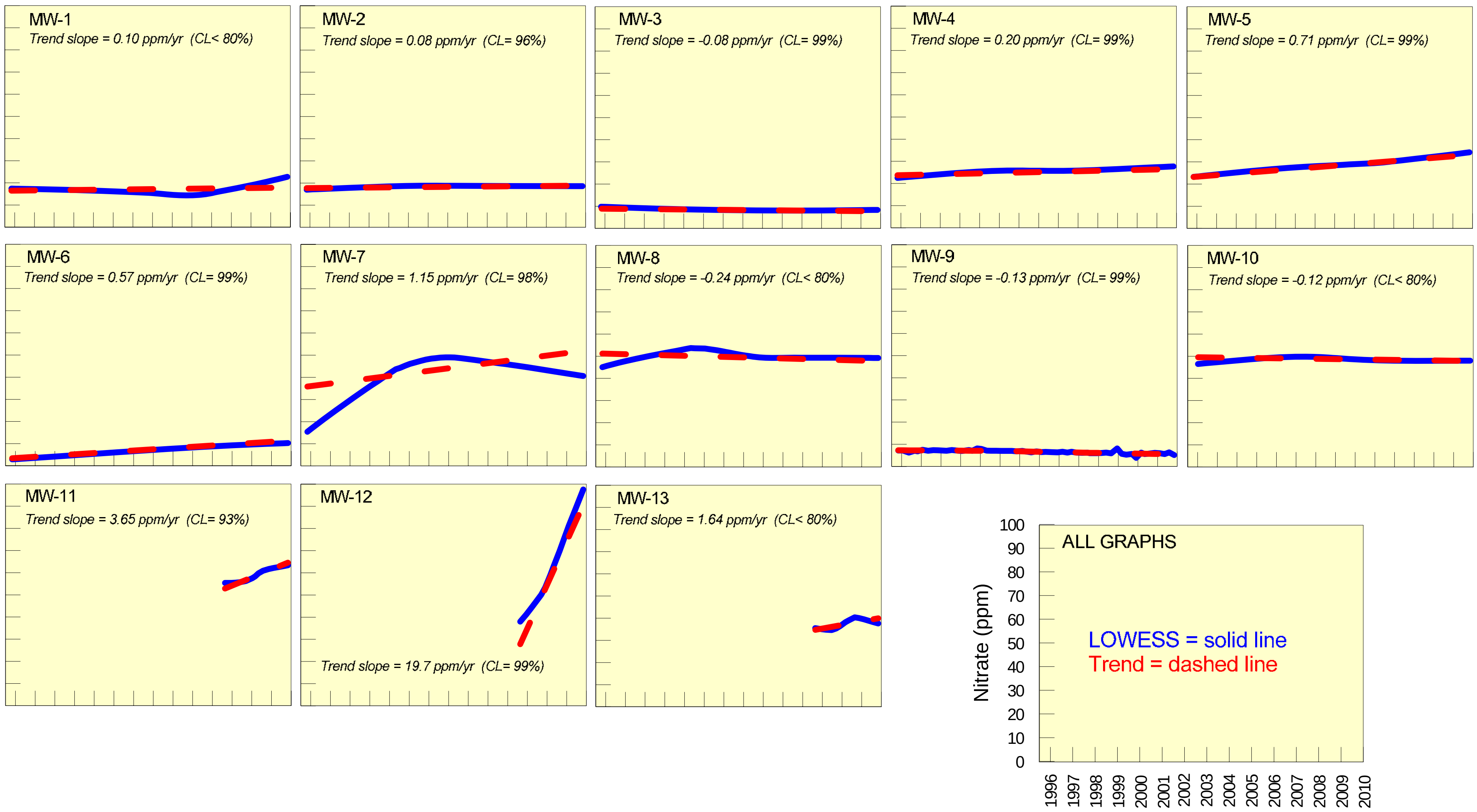


Figure 2-11
Site-Wide Trends - Port of Morrow Farm 3
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp thirdtrendanalysis pom alldatafarm3.grf

Figure 3-1
LOWESS Lines and Trend Lines Through Nitrate Data - ConAgra North Farm
Second Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalysis lw alltrend&lowess_nf.grf

Figure 3-2
Nitrate Trends - ConAgra North Farm
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

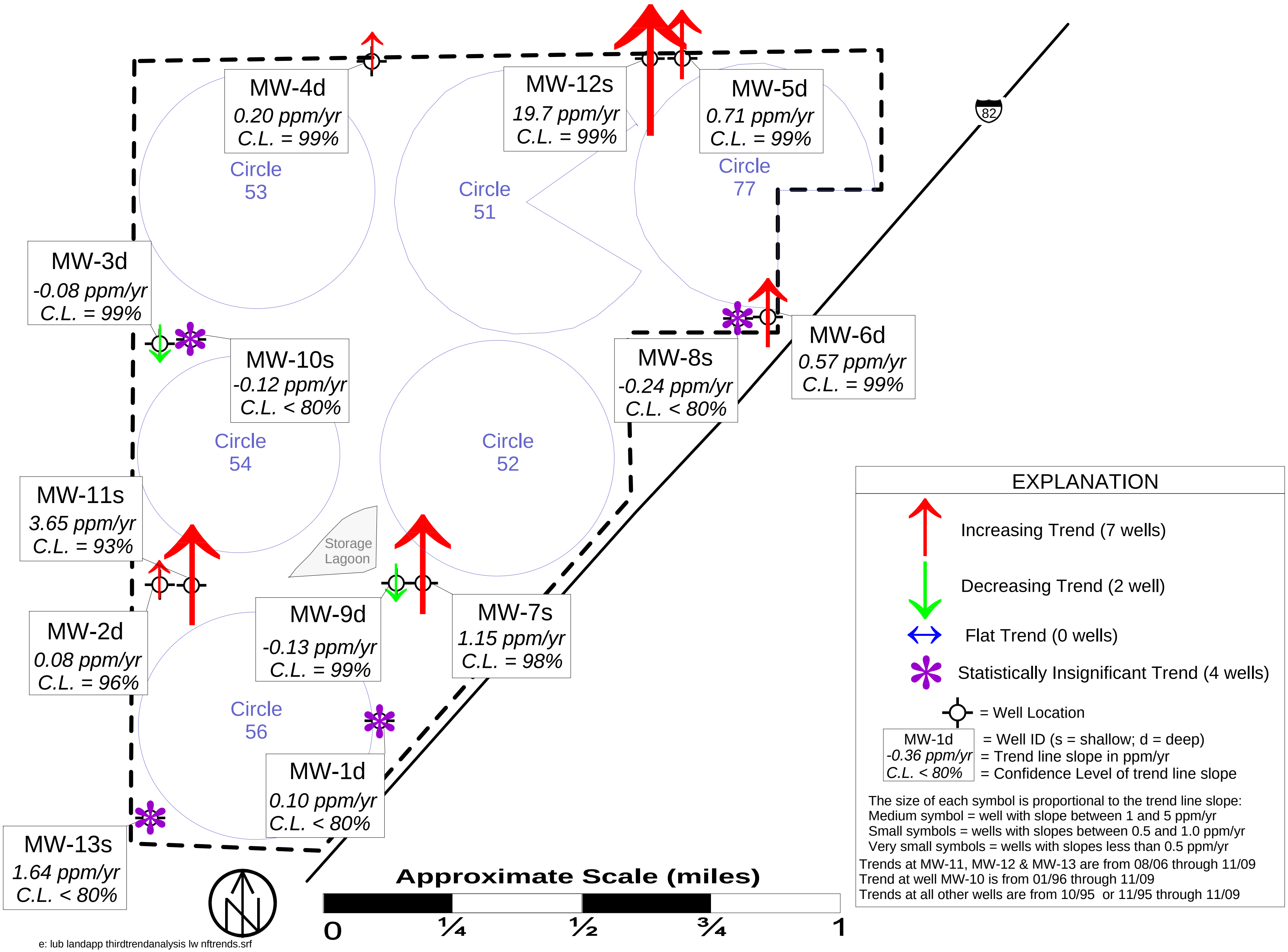


Figure 3-3
Average Nitrate Concentrations - ConAgra North Farm
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

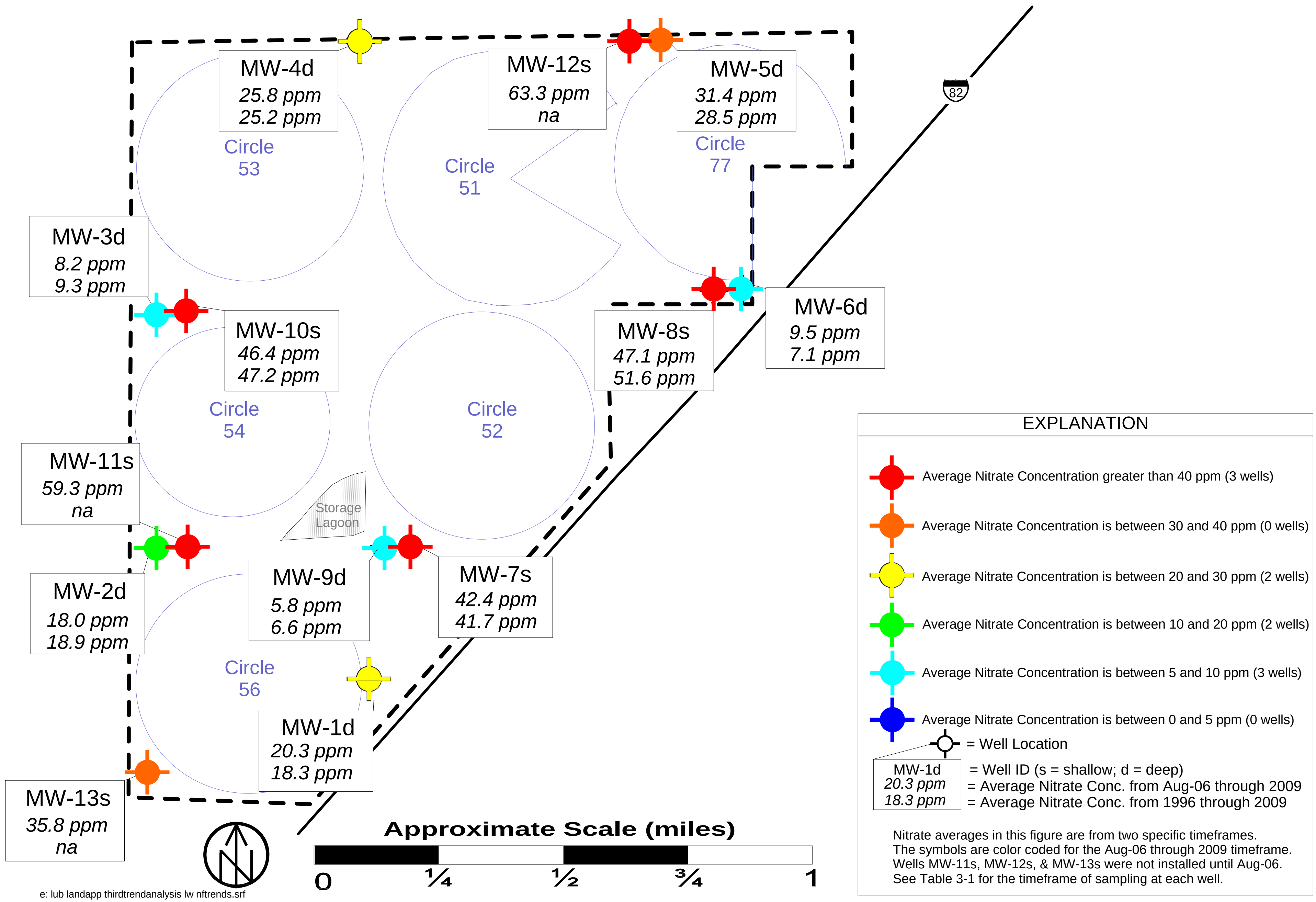


Figure 3-4
Site-Wide Trends - ConAgra North Farm
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

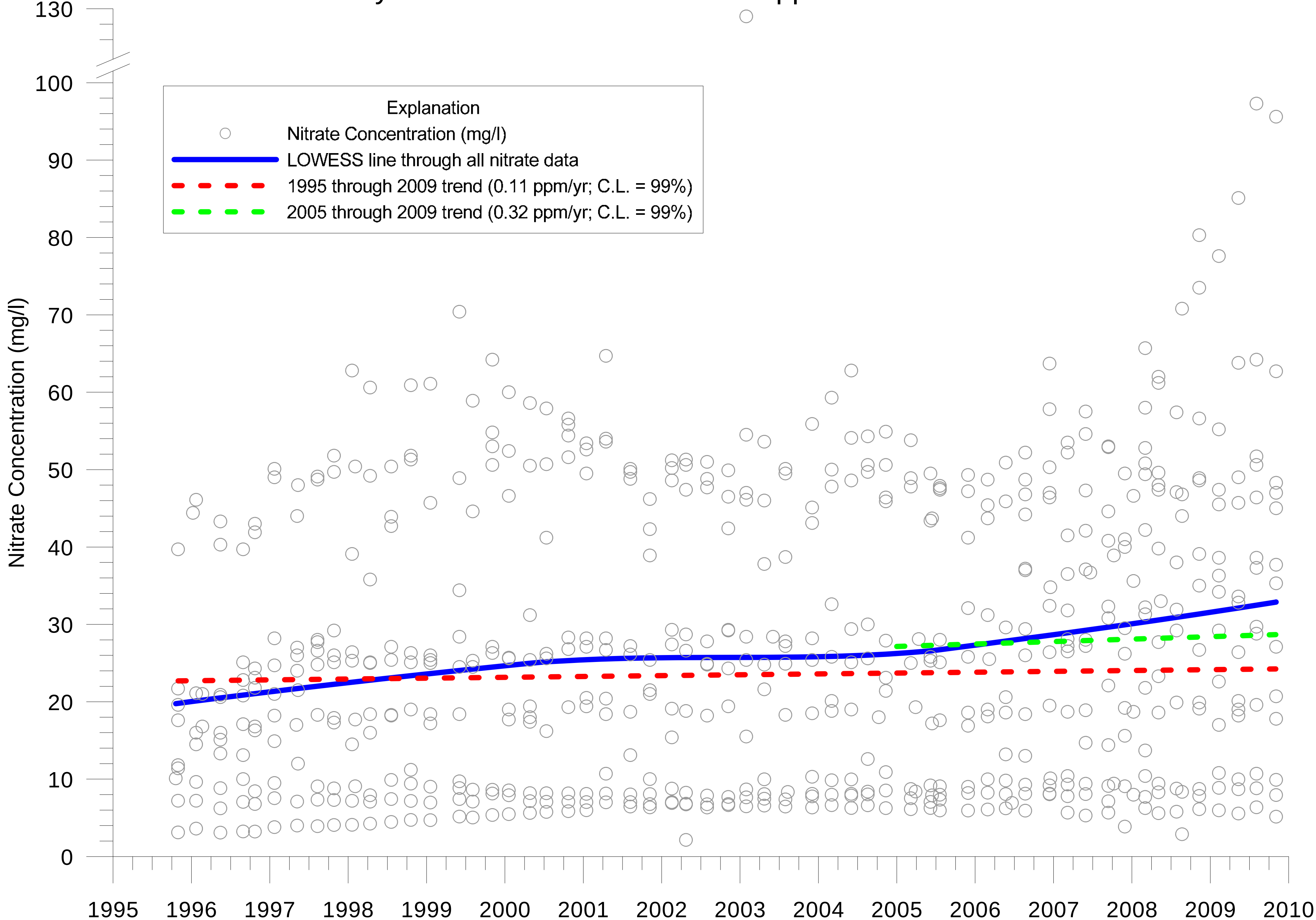
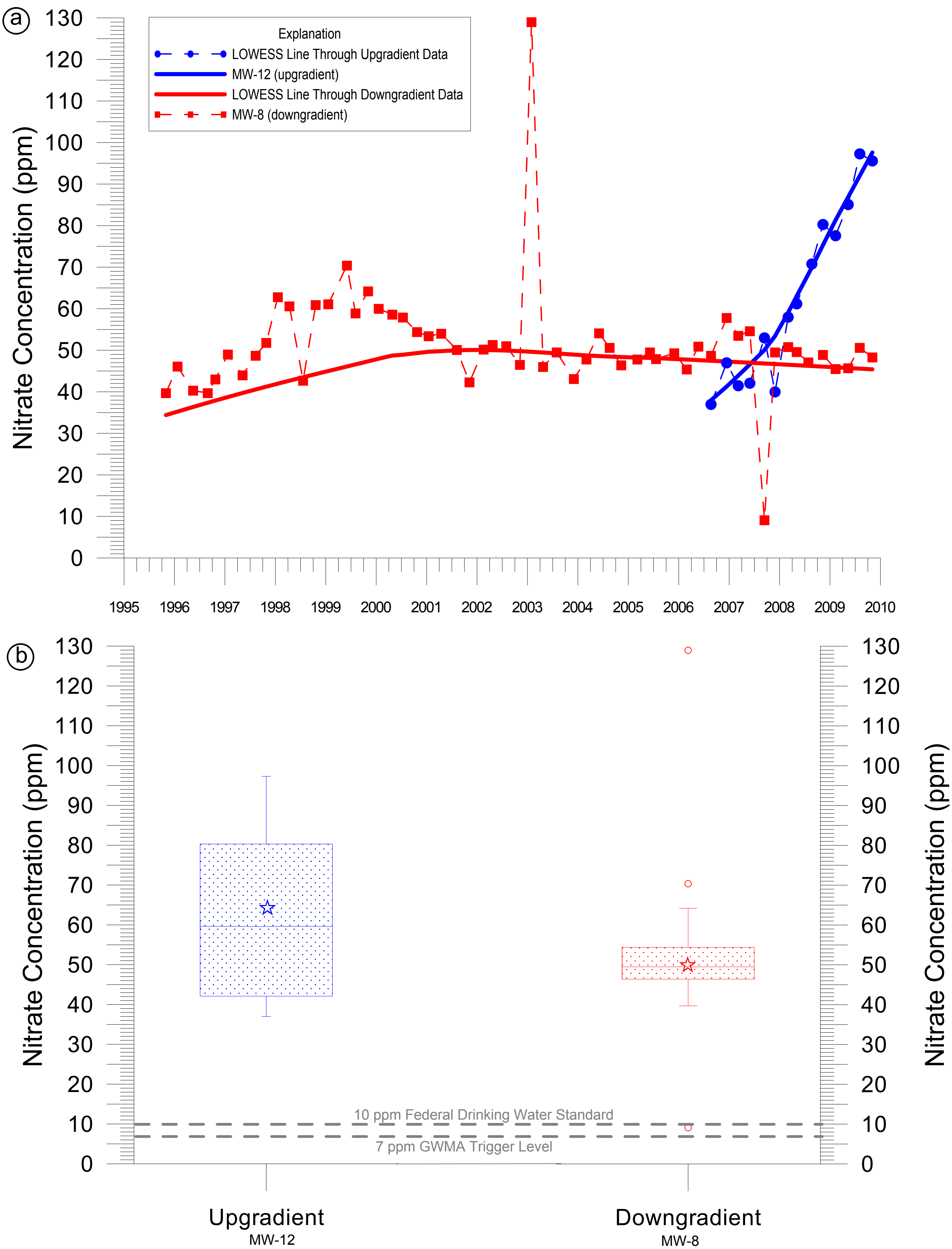


Figure 3-5
Upgradient vs. Downgradient Nitrate Comparisons - ConAgra North Farm Shallow Wells
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp thirdtrendanalysis lw up vs dn NFshallow.grf

Figure 3-6
LOWESS Lines and Trend Lines Through Nitrate Data - ConAgra Madison Ranch
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

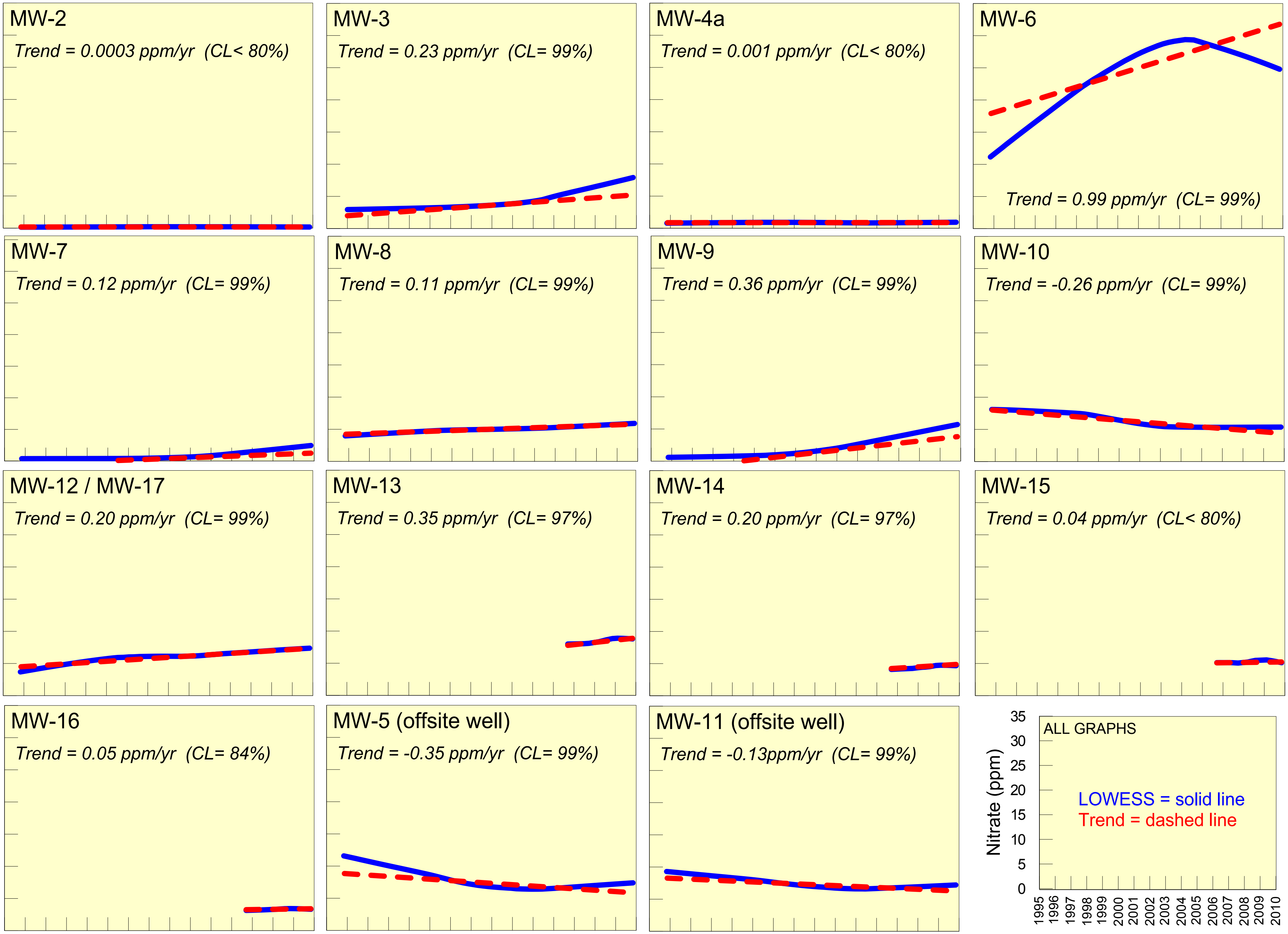


Figure 3-7
Nitrate Trends - ConAgra Madison Ranch
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

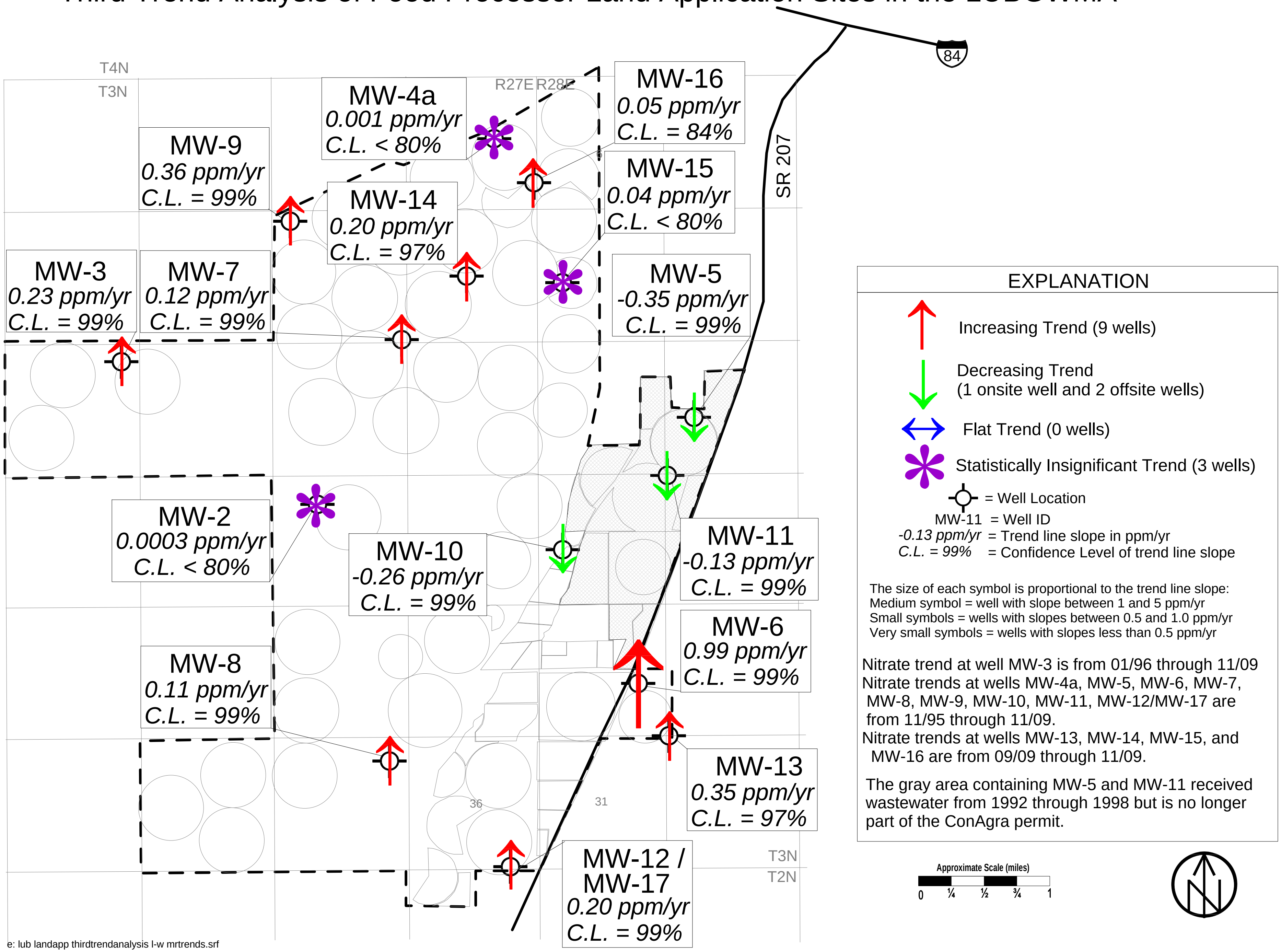


Figure 3-8
Average Nitrate Concentrations - ConAgra Madison Ranch
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

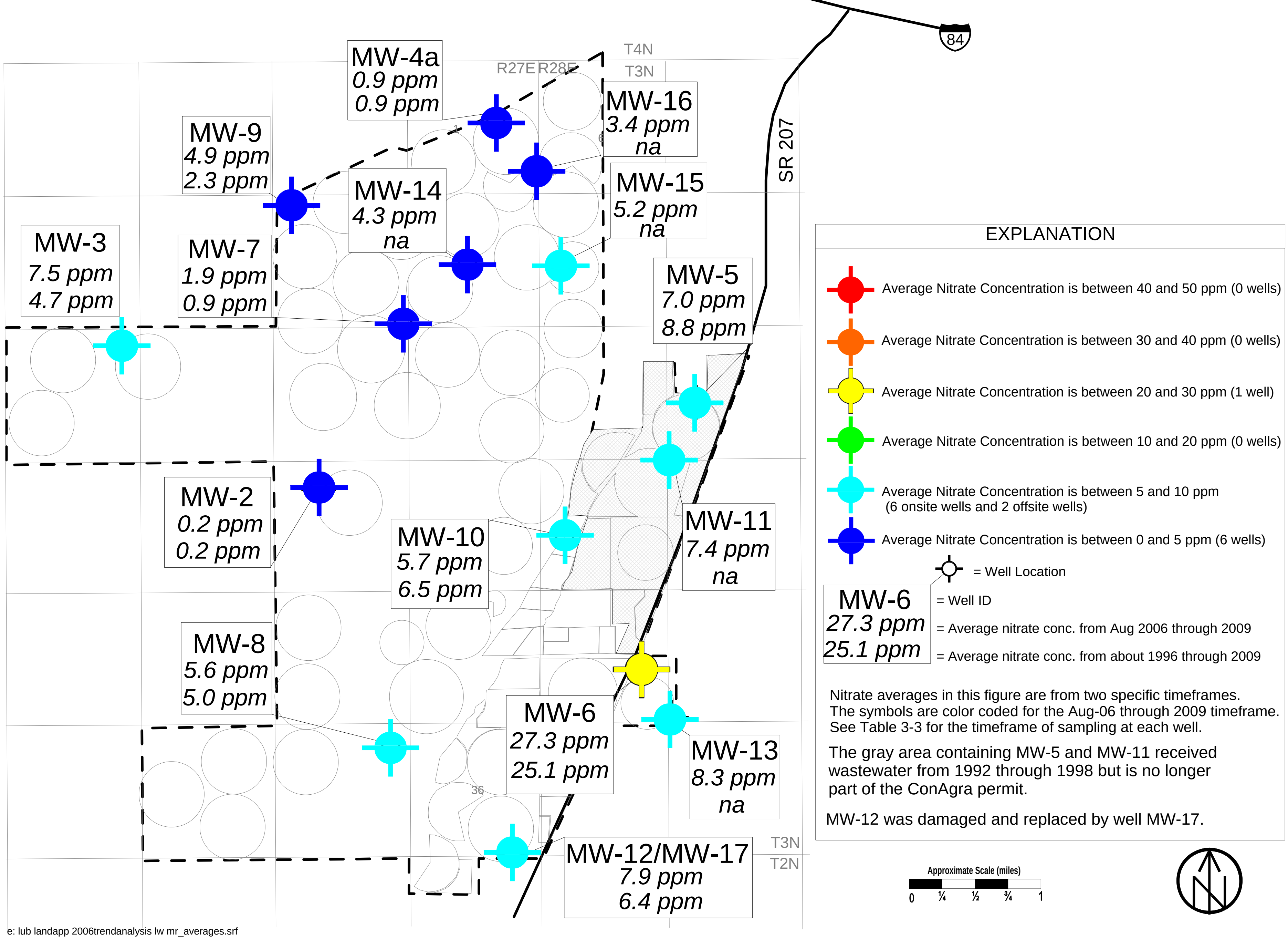
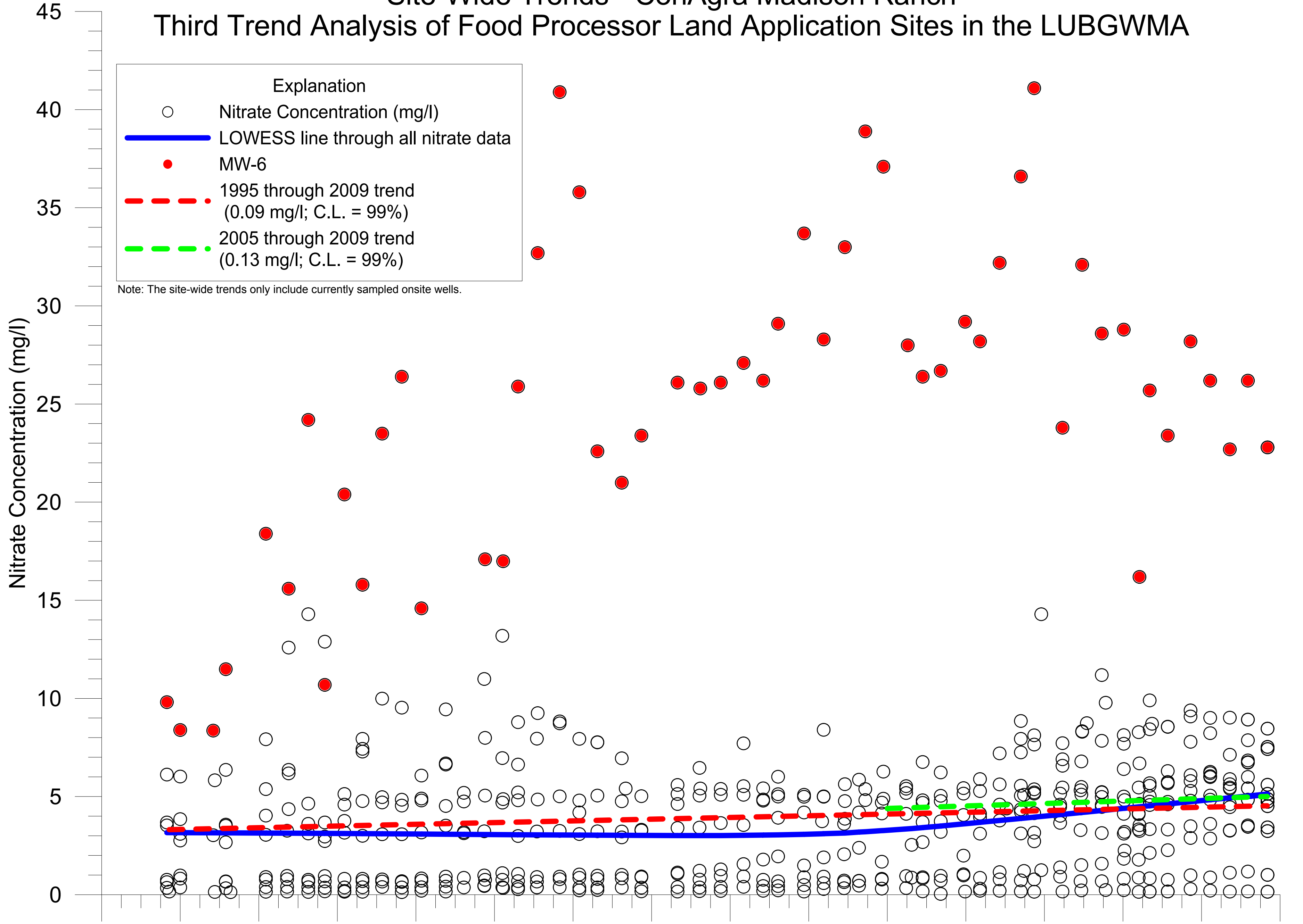


Figure 3-9
Site-Wide Trends - ConAgra Madison Ranch
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp 2006trendanalsys lw all data mr 10well.grf

Figure 4-1
LOWESS Lines and Trend Lines Through Nitrate Data - Simplot Plant Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

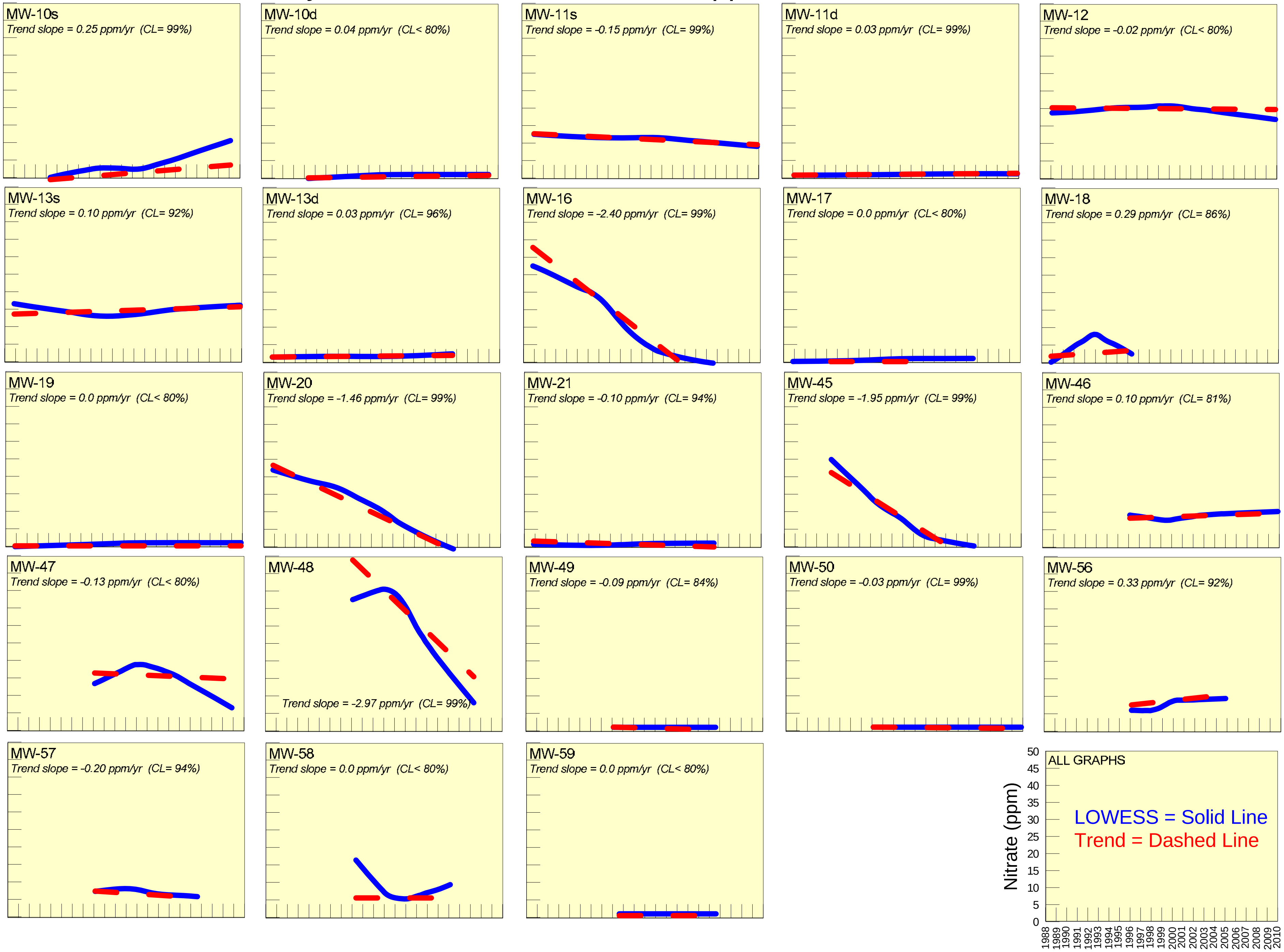
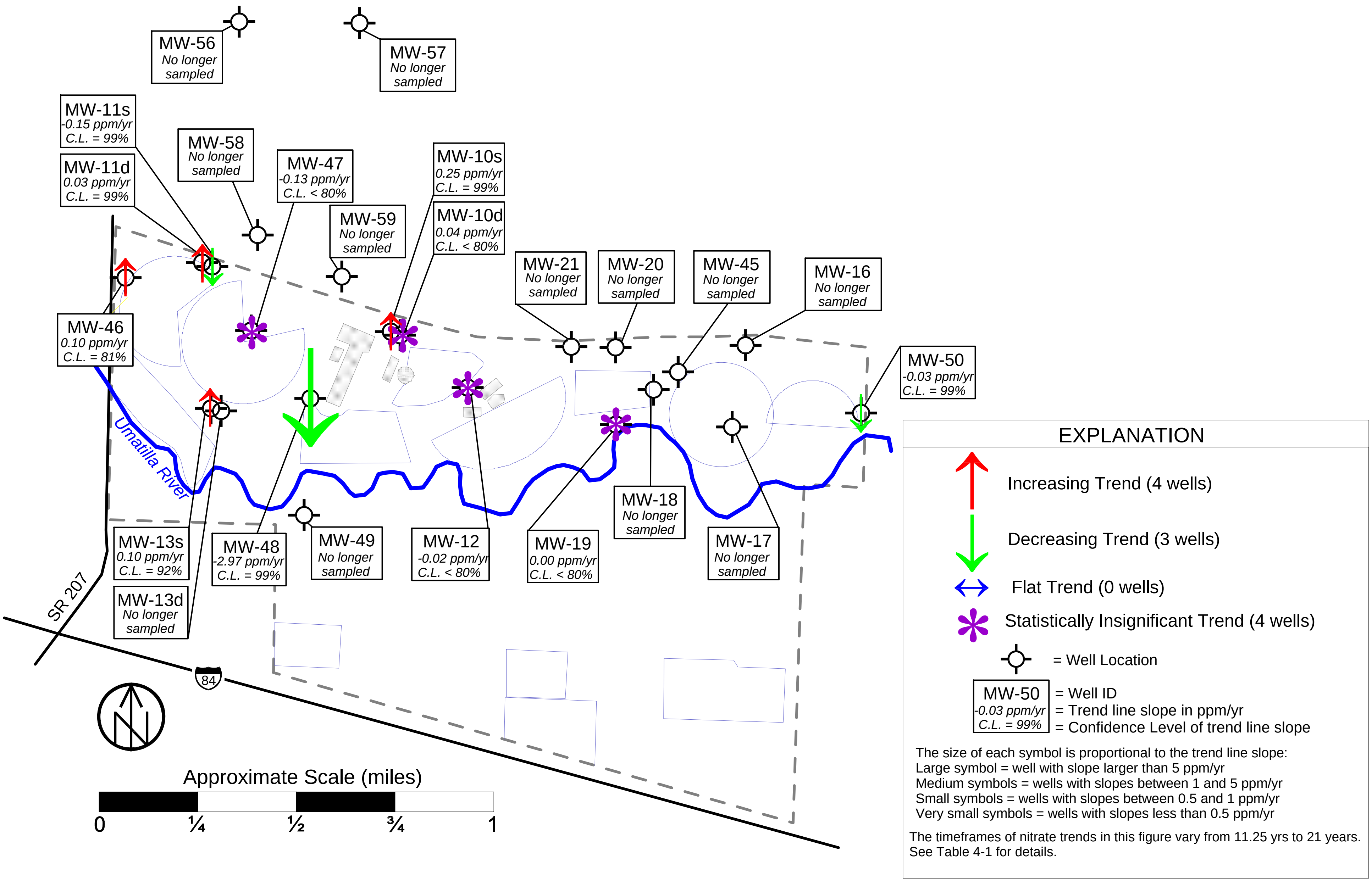
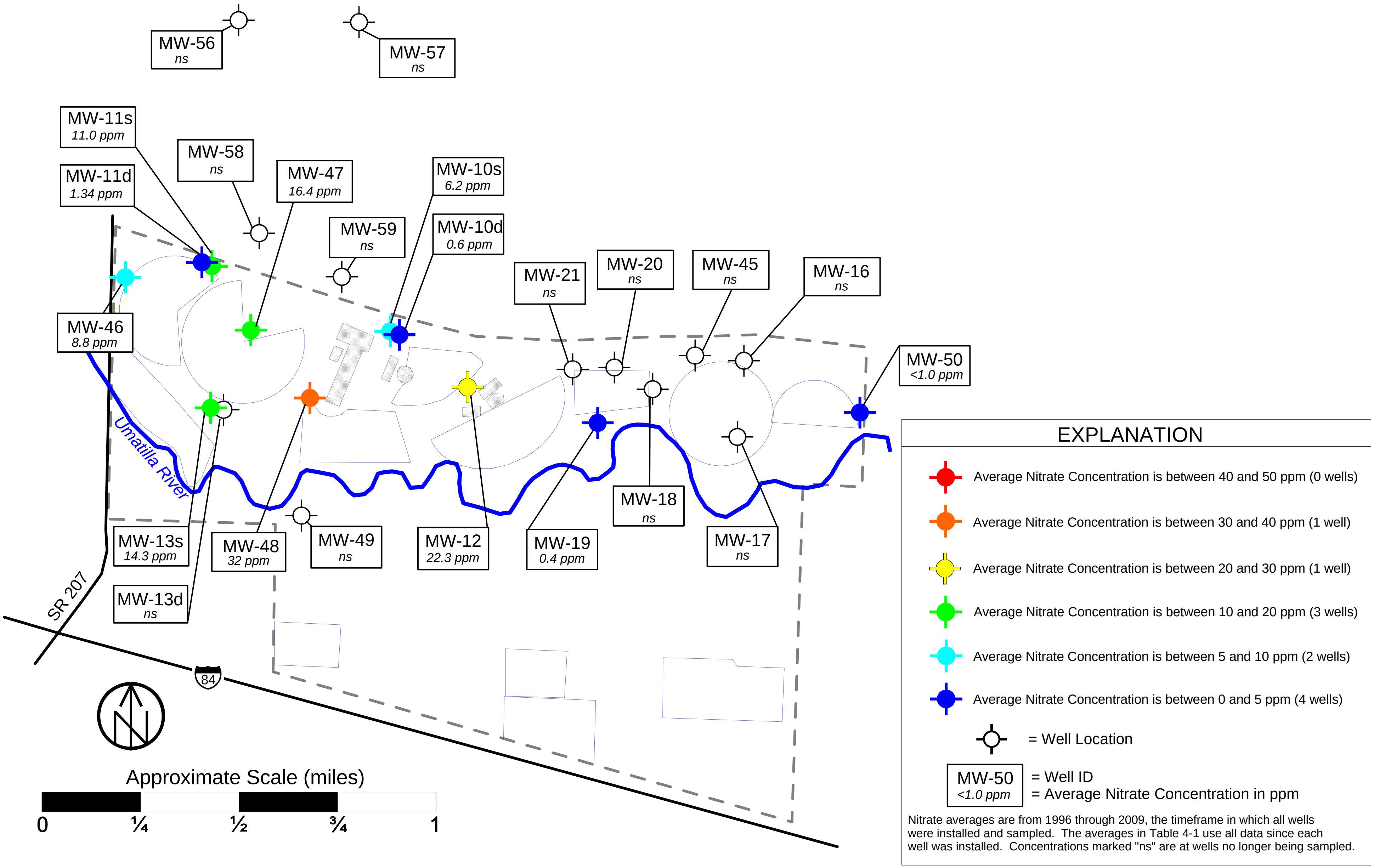


Figure 4-2
Nitrate Trends - Simplot Plant Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



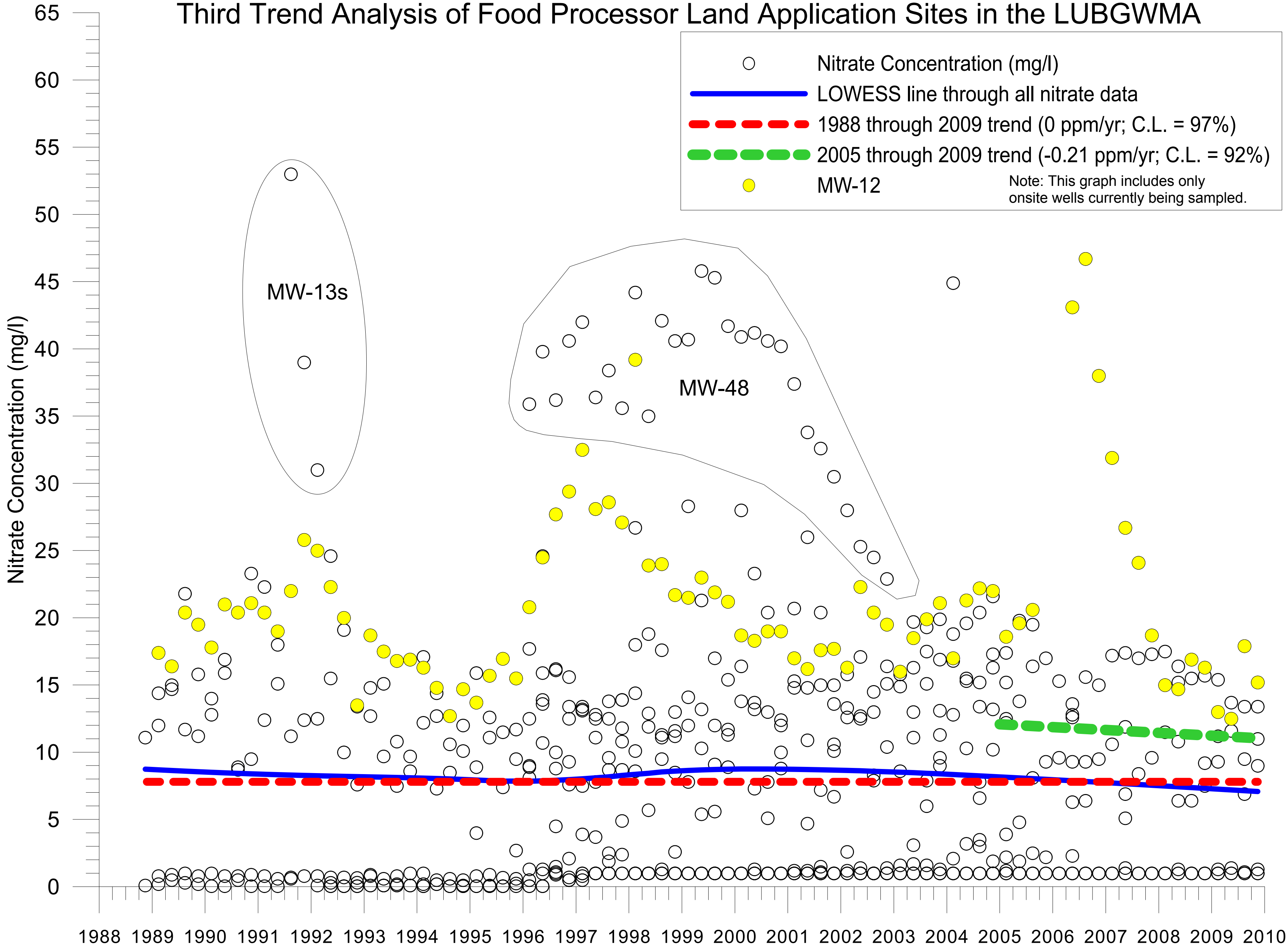
e: lub landapp thirdtrendanalysis simplot plt_trends.srf

Figure 4-3
Average Nitrate Concentrations - Simplot Plant Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



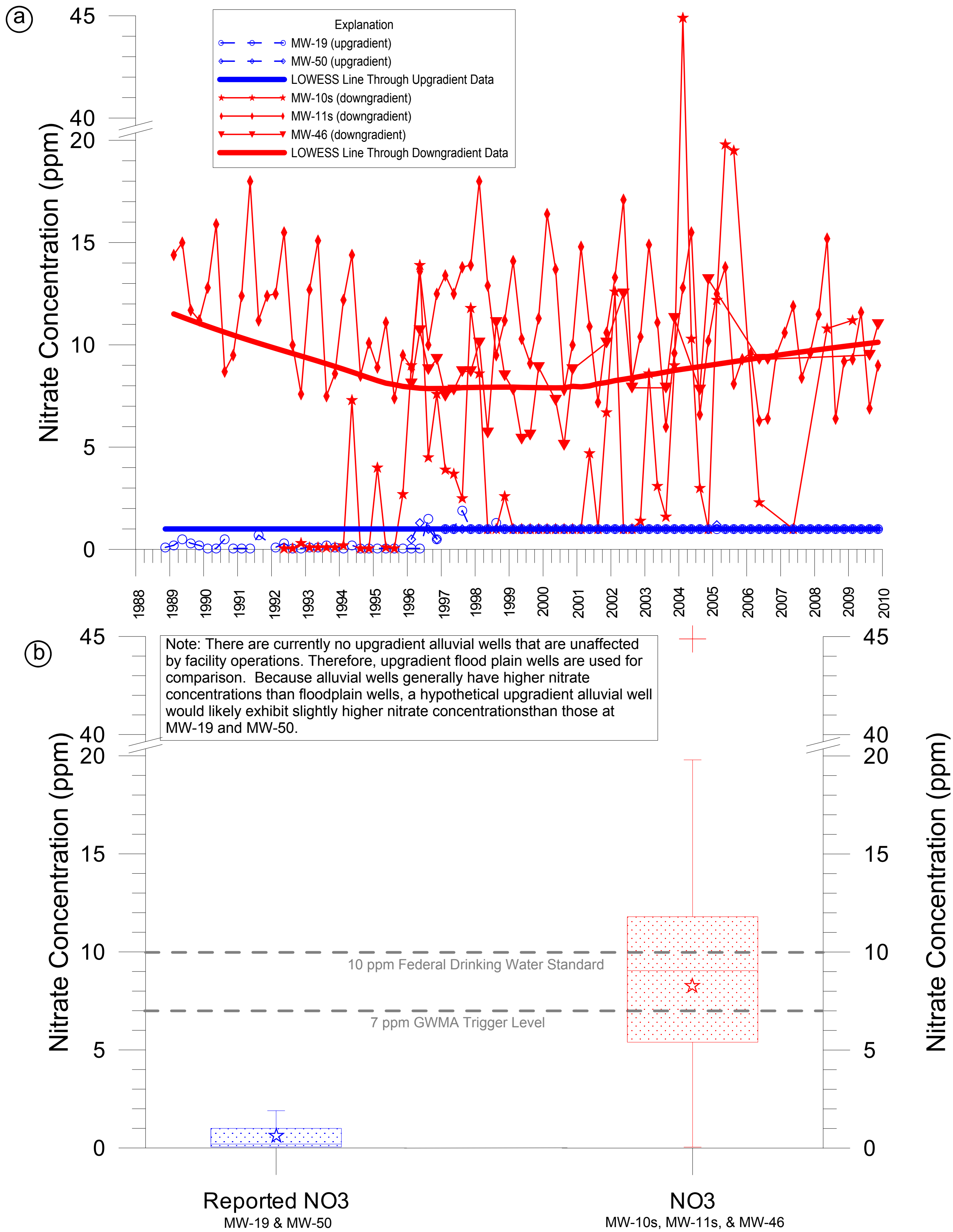
e: lub landapp thirdtrendanalysis simplot plt_averages.srf

Figure 4-4
Site-Wide Trends - Simplot Plant Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



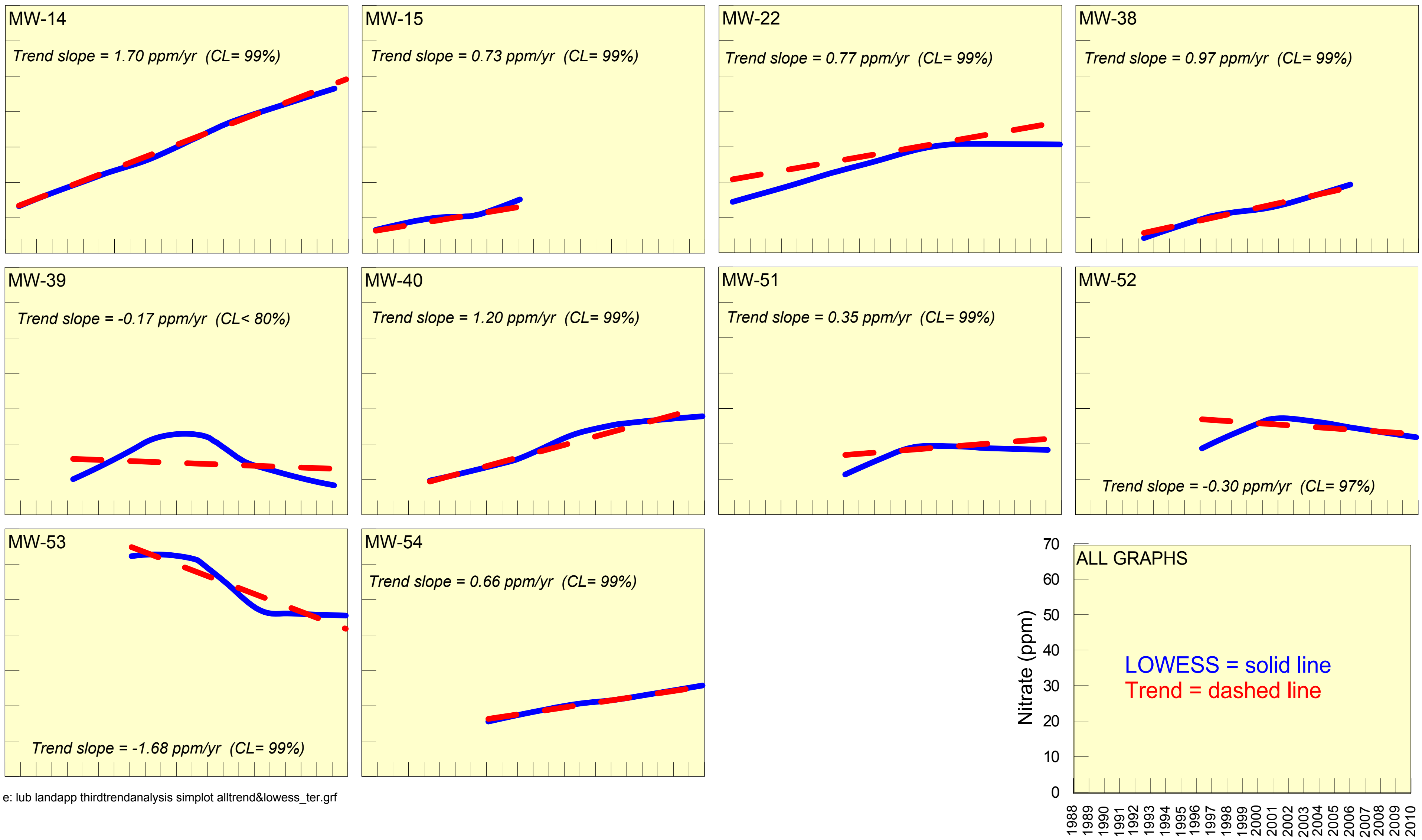
e: lub landapp thirdtrendanalysis simplot alldataplantsite.grf

Figure 4-5
Upgradient vs. Downgradient Nitrate Comparisons - Simplot Plant Site Alluvial Wells
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



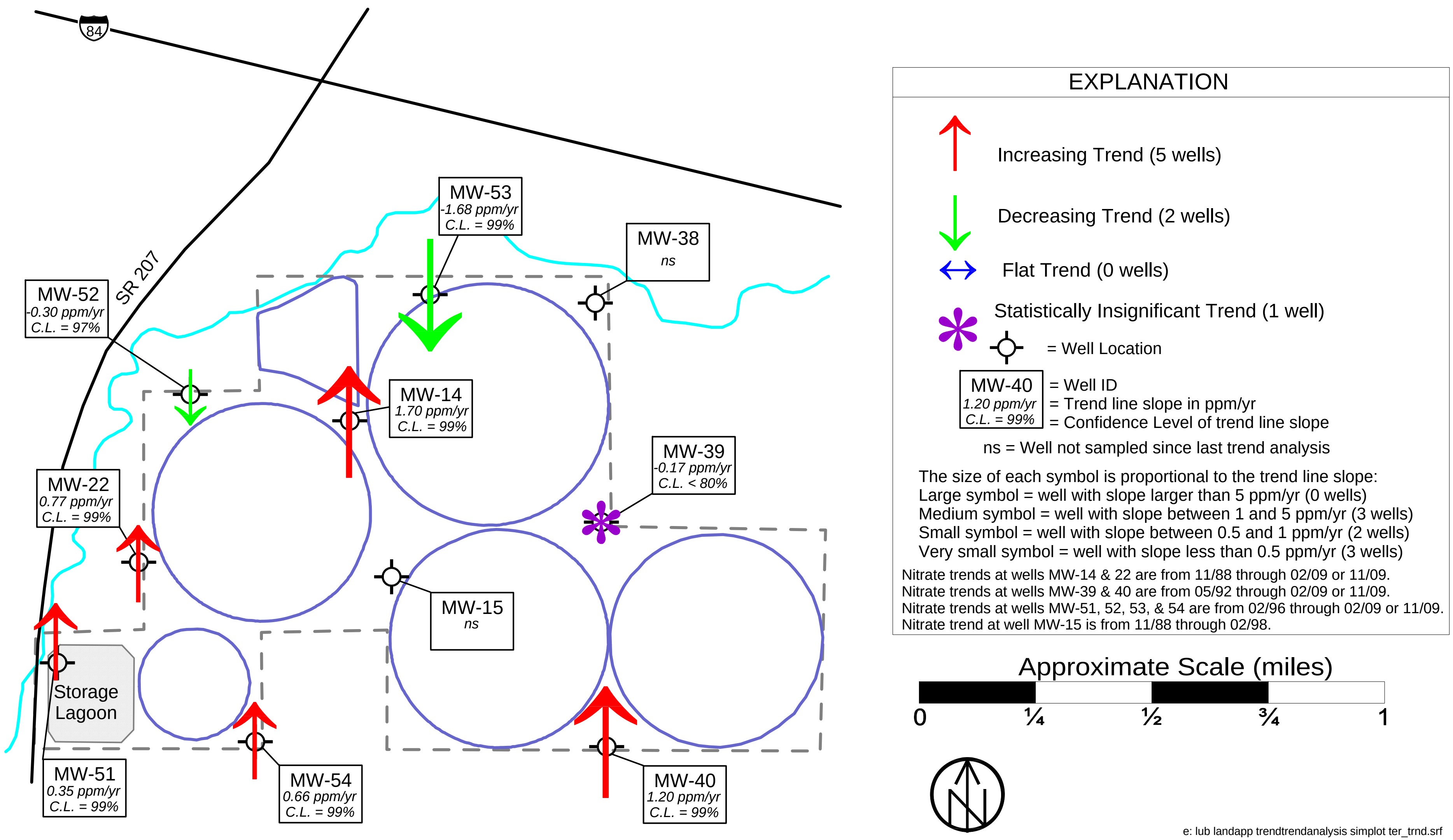
e: lub landapp 2006trendanalysis simplot up vs dn plant al.grf

Figure 4-6
LOWESS Lines and Trend Lines Through Nitrate Data - Simplot Terrace Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



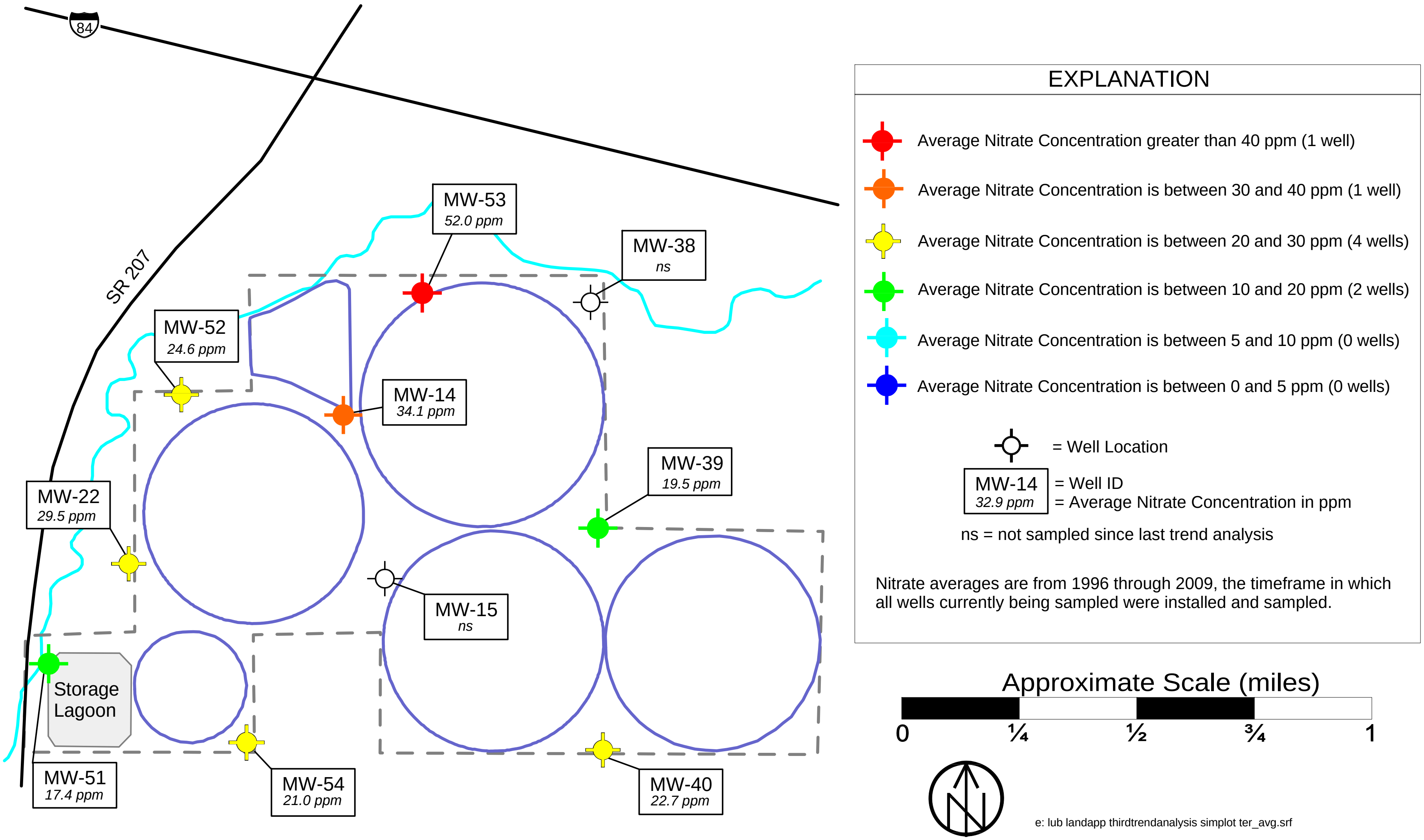
e: lub landapp thirdtrendanalysis simplot alltrend&lowess_ter.grf

Figure 4-7
Nitrate Trends - Simplot Terrace Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp trendtrendanalysis simplot ter_trnd.srf

Figure 4-8
Average Nitrate Concentrations - Simplot Terrace Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



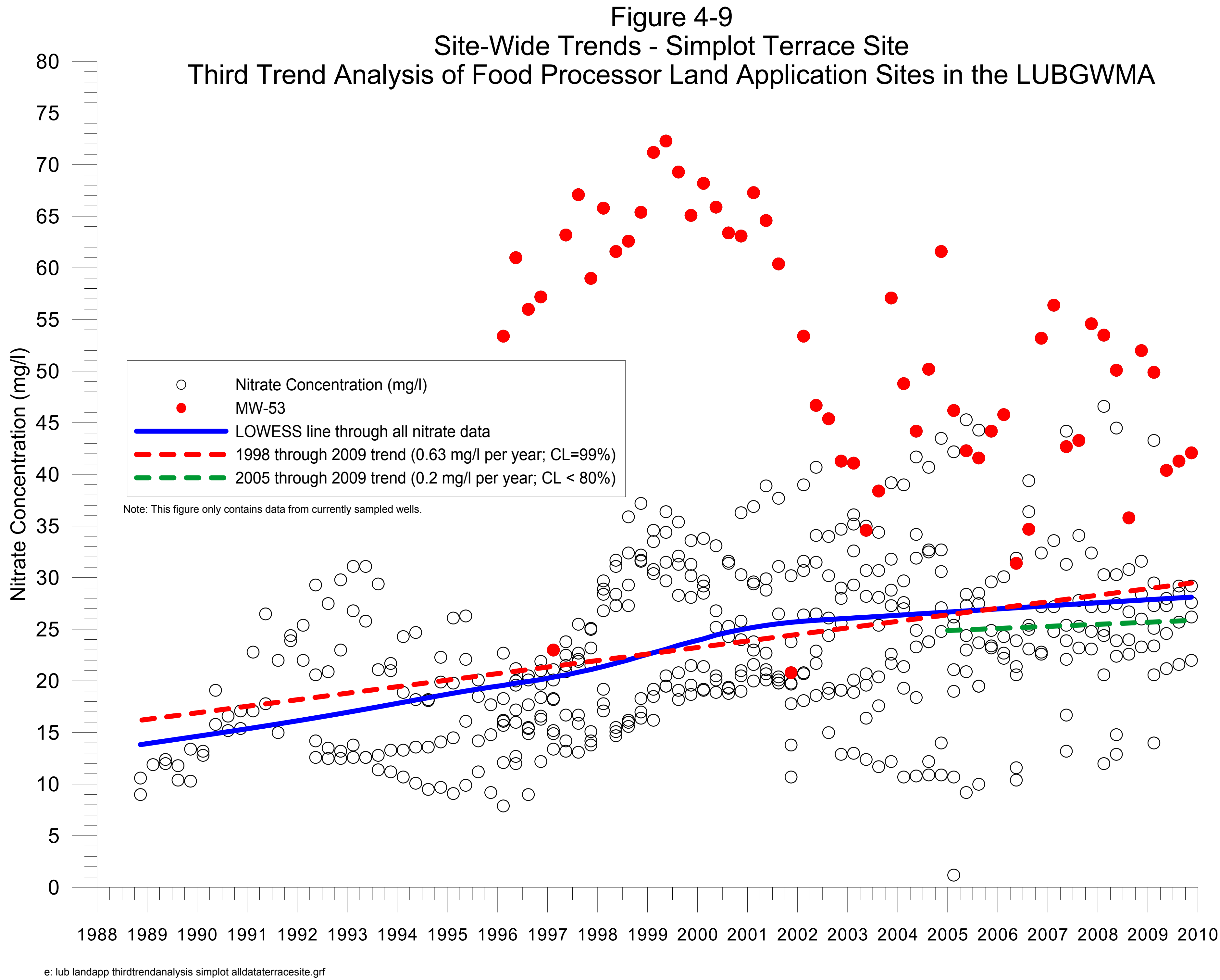
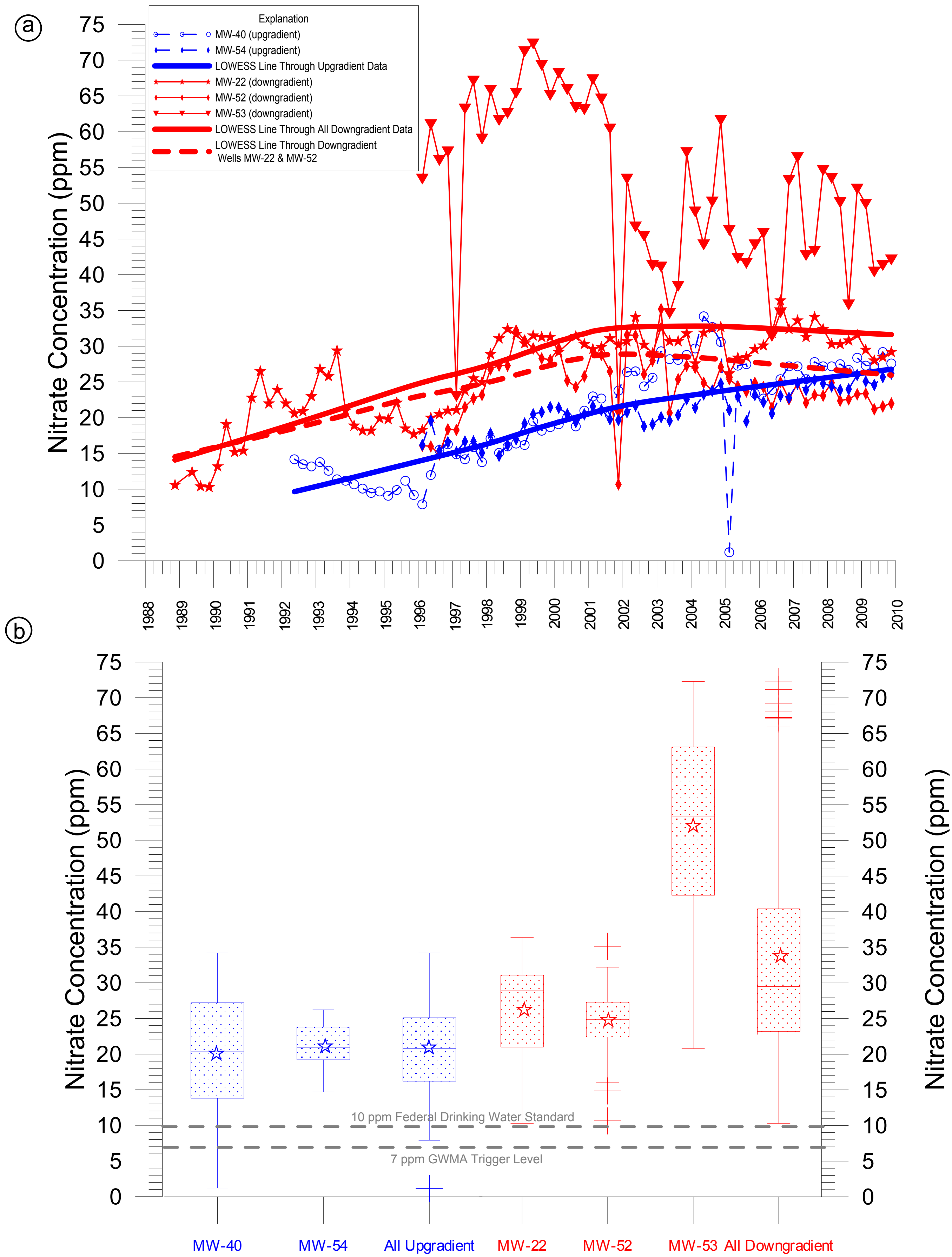


Figure 4-9
Site-Wide Trends - Simplot Terrace Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA
Nitrate Concentration (mg/l)
Nitrate Concentration (mg/l)
MW-53
LOWESS line through all nitrate data
1998 through 2009 trend (0.63 mg/l per year; CL=99%)
2005 through 2009 trend (0.2 mg/l per year; CL < 80%)
Note: This figure only contains data from currently sampled wells.
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
e: lub landapp thirdtrendanalysis simplot alldataterracesite.grf

Figure 4-10
Upgradient vs. Downgradient Nitrate Comparisons - Simplot Terrace Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp thirdtrendanalysis simplot up vs dn terrace.grf

Figure 4-11
LOWESS Lines and Trend Lines Through Nitrate Data - Simplot Expansion Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

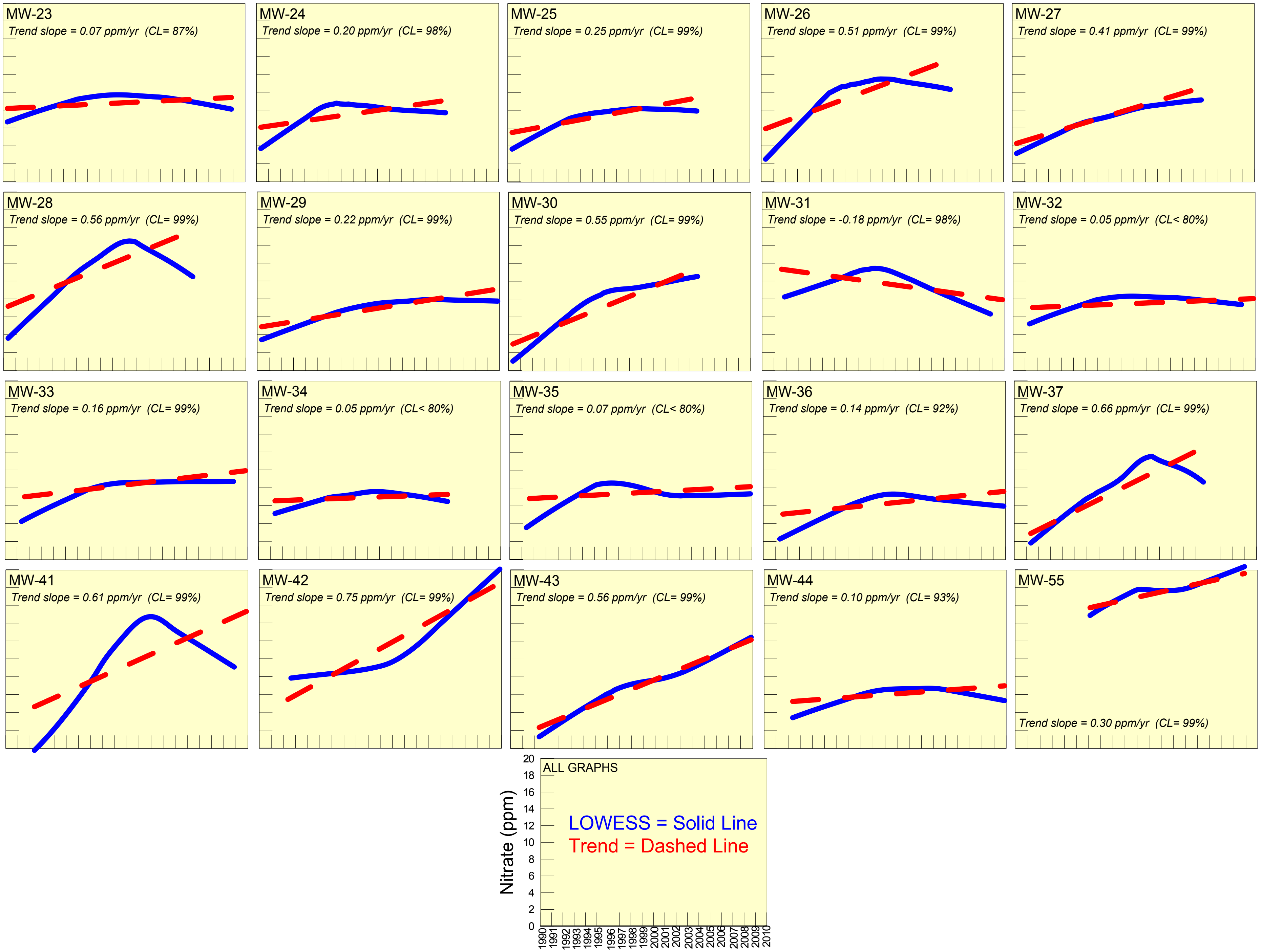


Figure 4-12
Nitrate Trends - Simplot Expansion Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

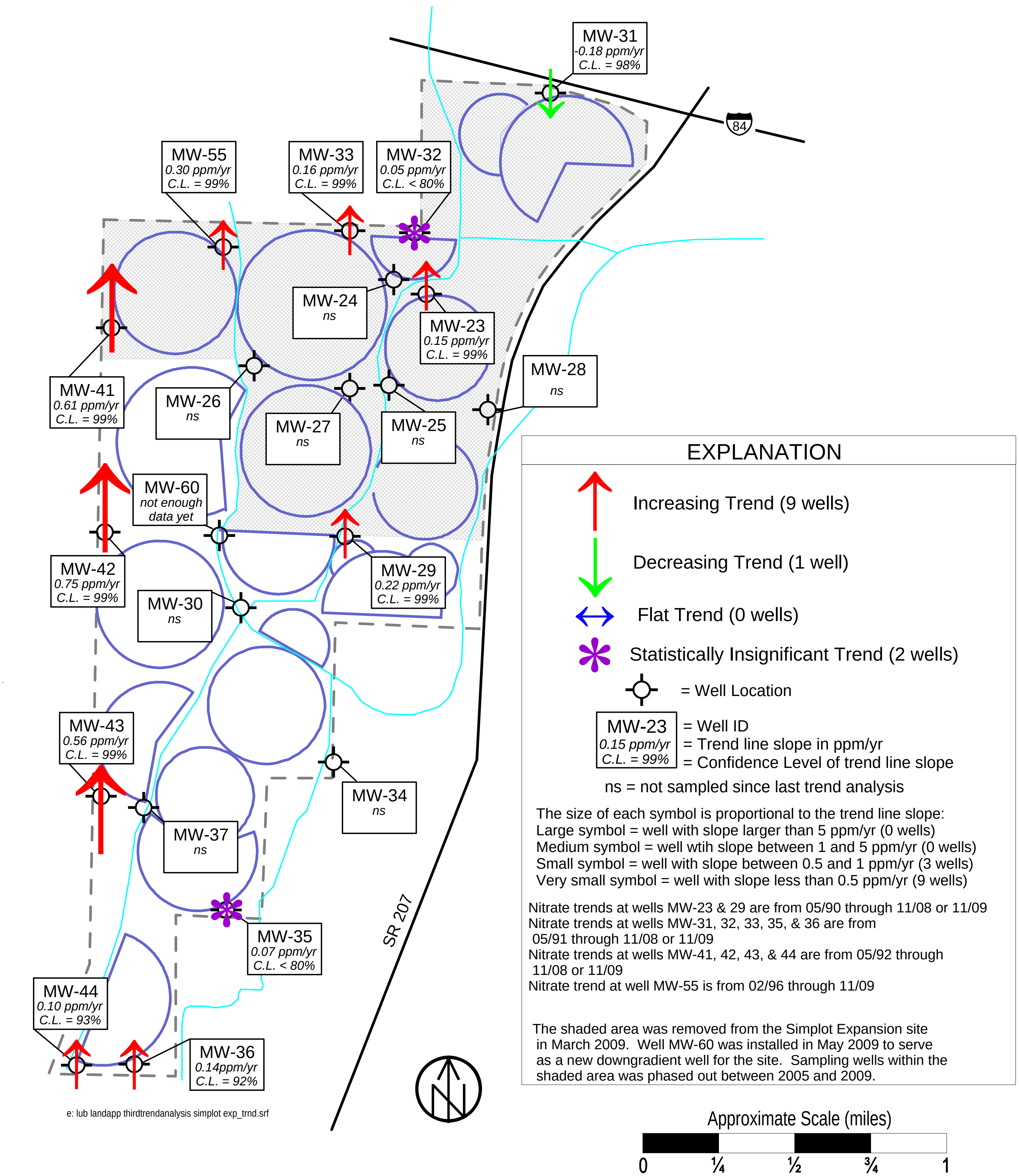


Figure 4-13
Average Nitrate Concentrations - Simplot Expansion Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

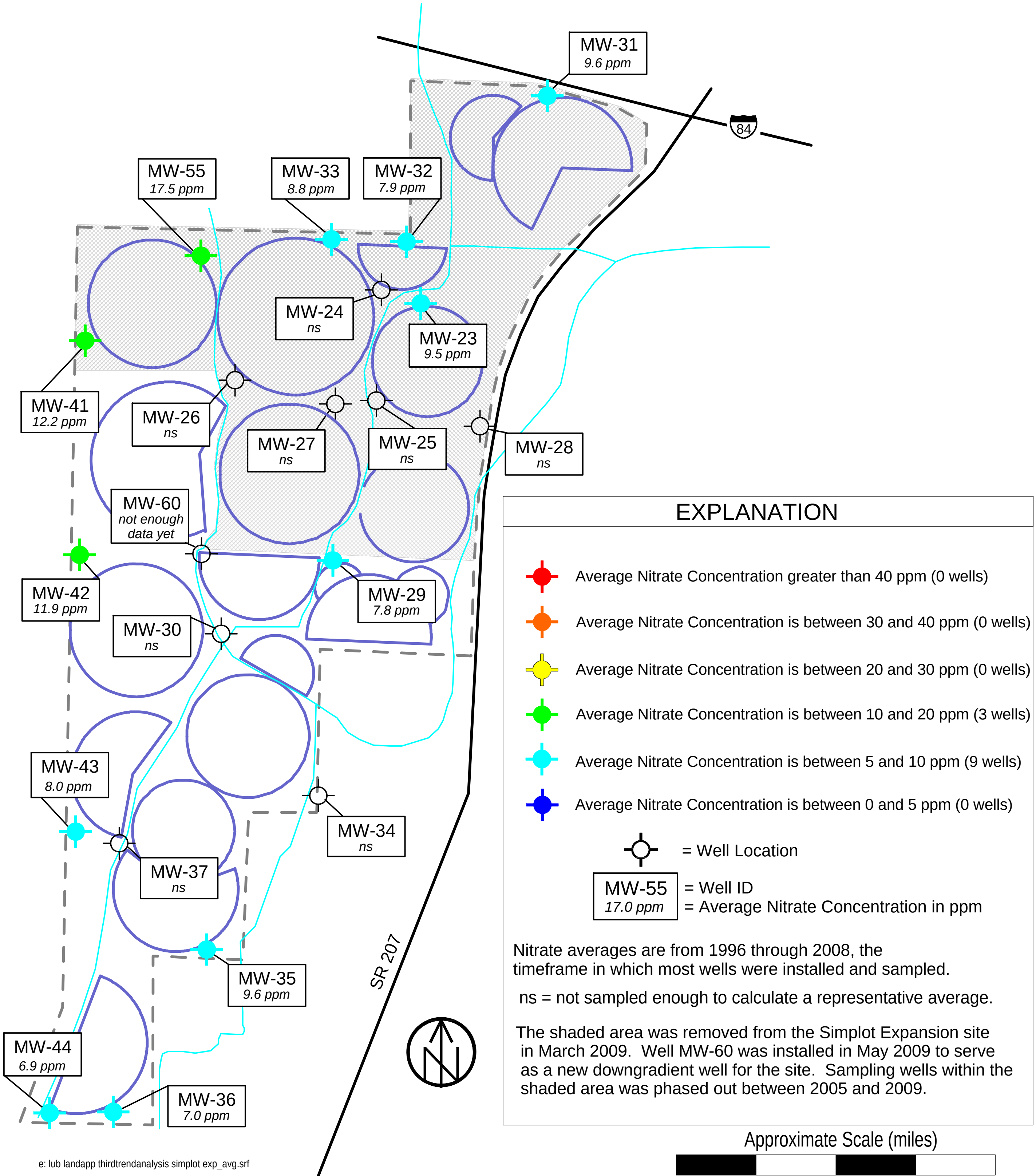
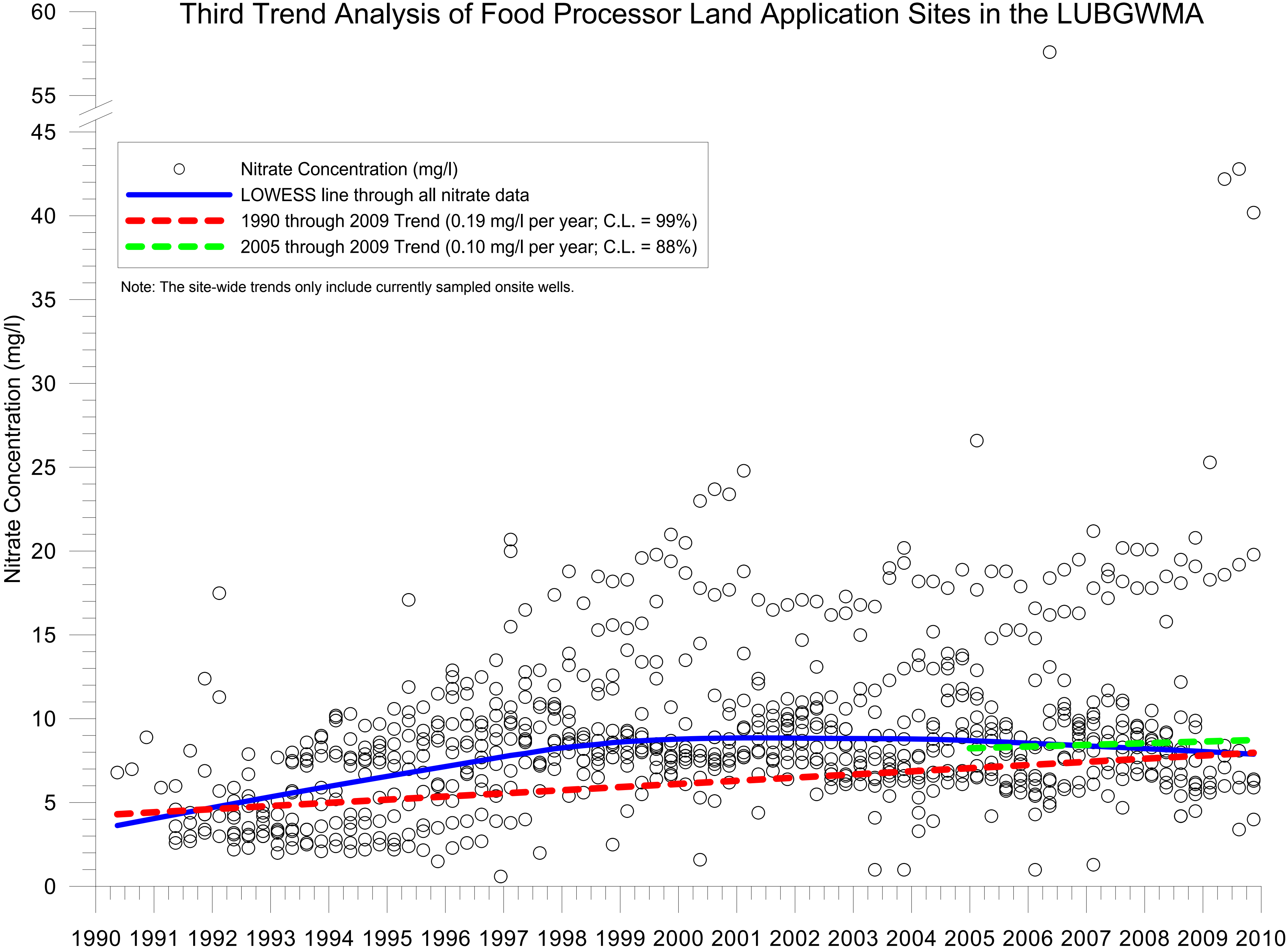


Figure 4-14
Site-Wide Trends - Simplot Expansion Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp thirdtrendanalysis simplot alldataexpansionsite.grf

Figure 4-15
Upgradient vs. Downgradient Nitrate Comparisons - Simplot Expansion Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

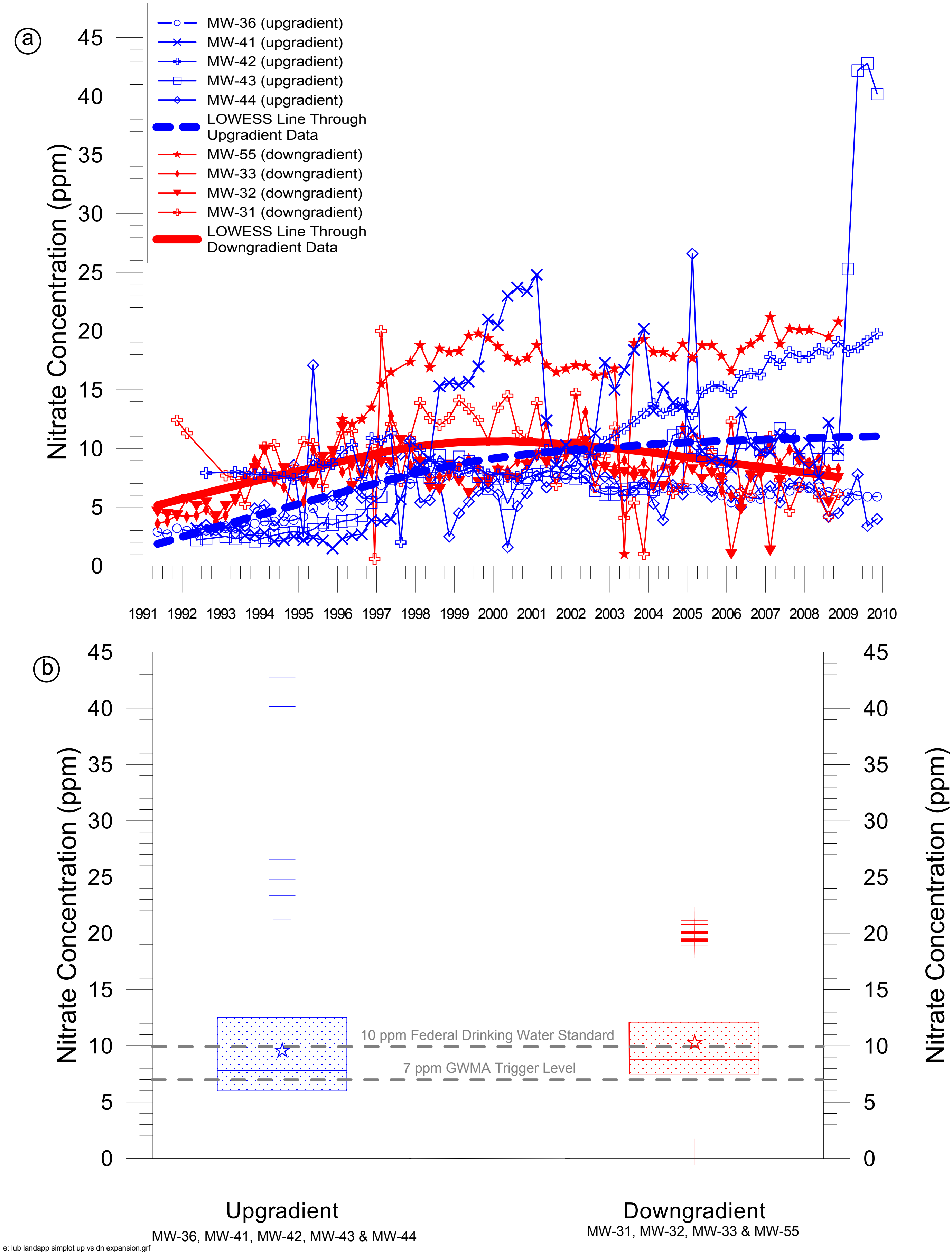
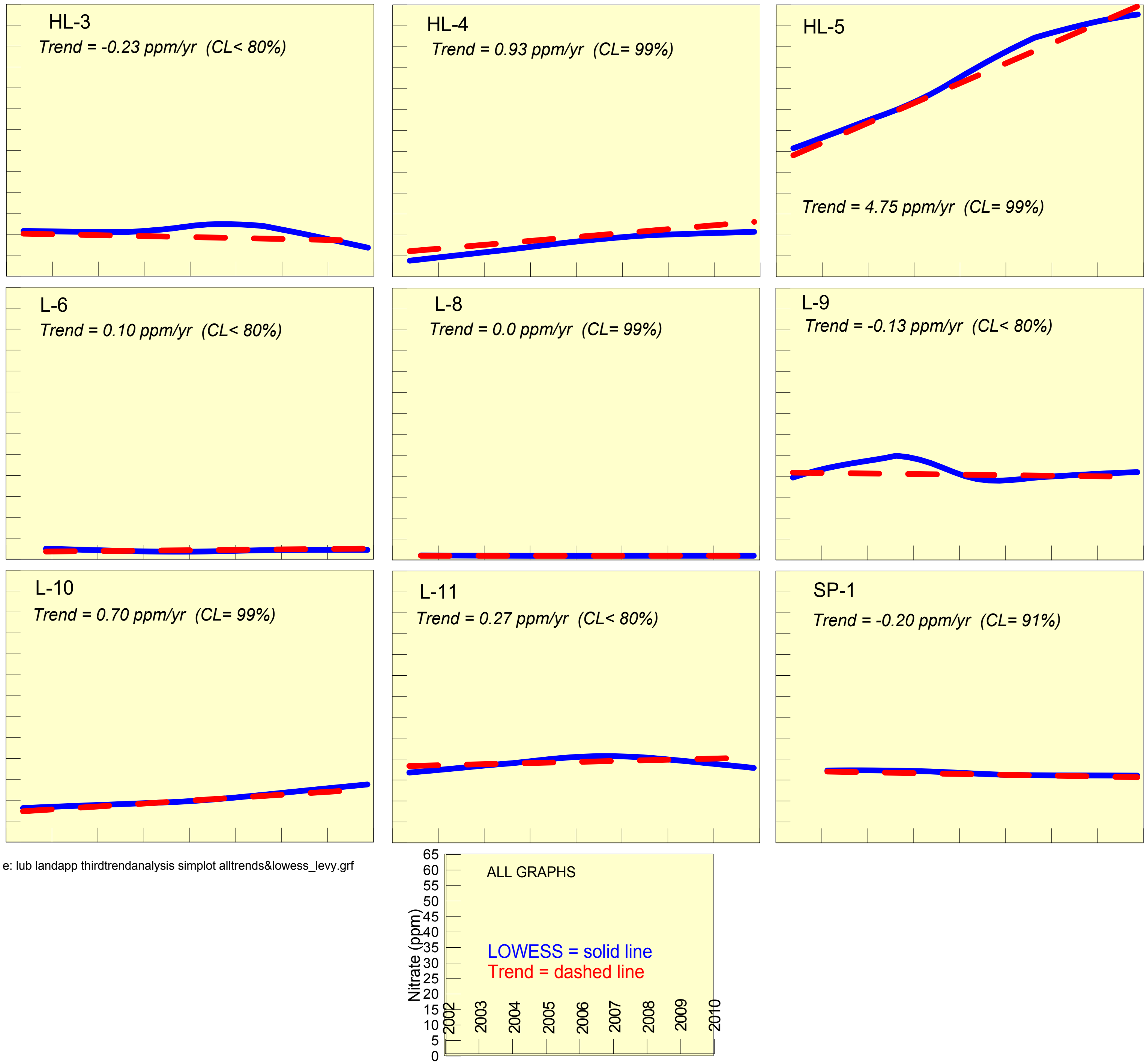


Figure 4-16
LOWESS Lines and Trend Lines Through Nitrate Data - Simplot Levy Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp thirdtrendanalysis simplot alltrends&lowess_levy.grf

Figure 4-17
Nitrate Trends - Simplot Levy Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

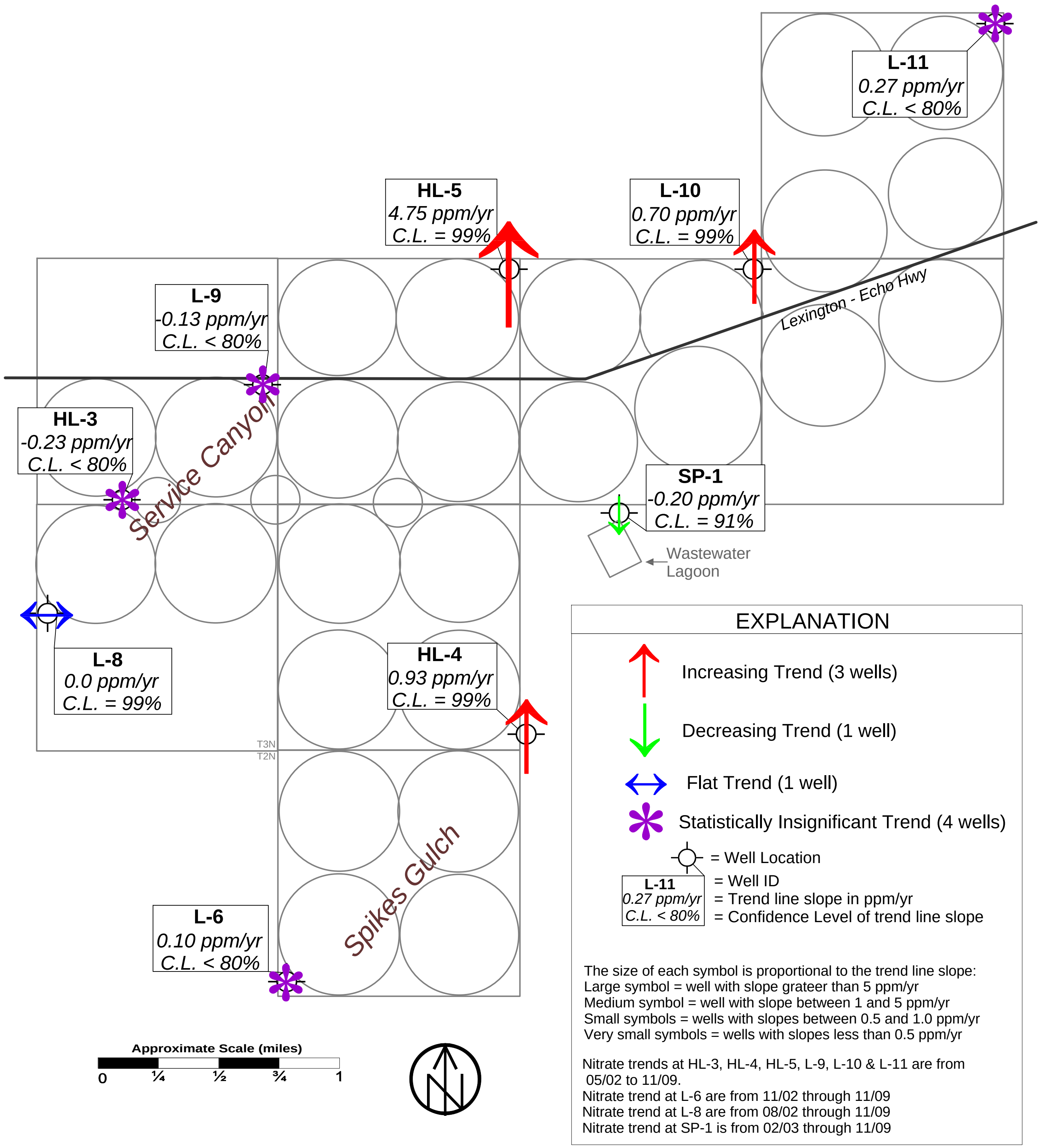
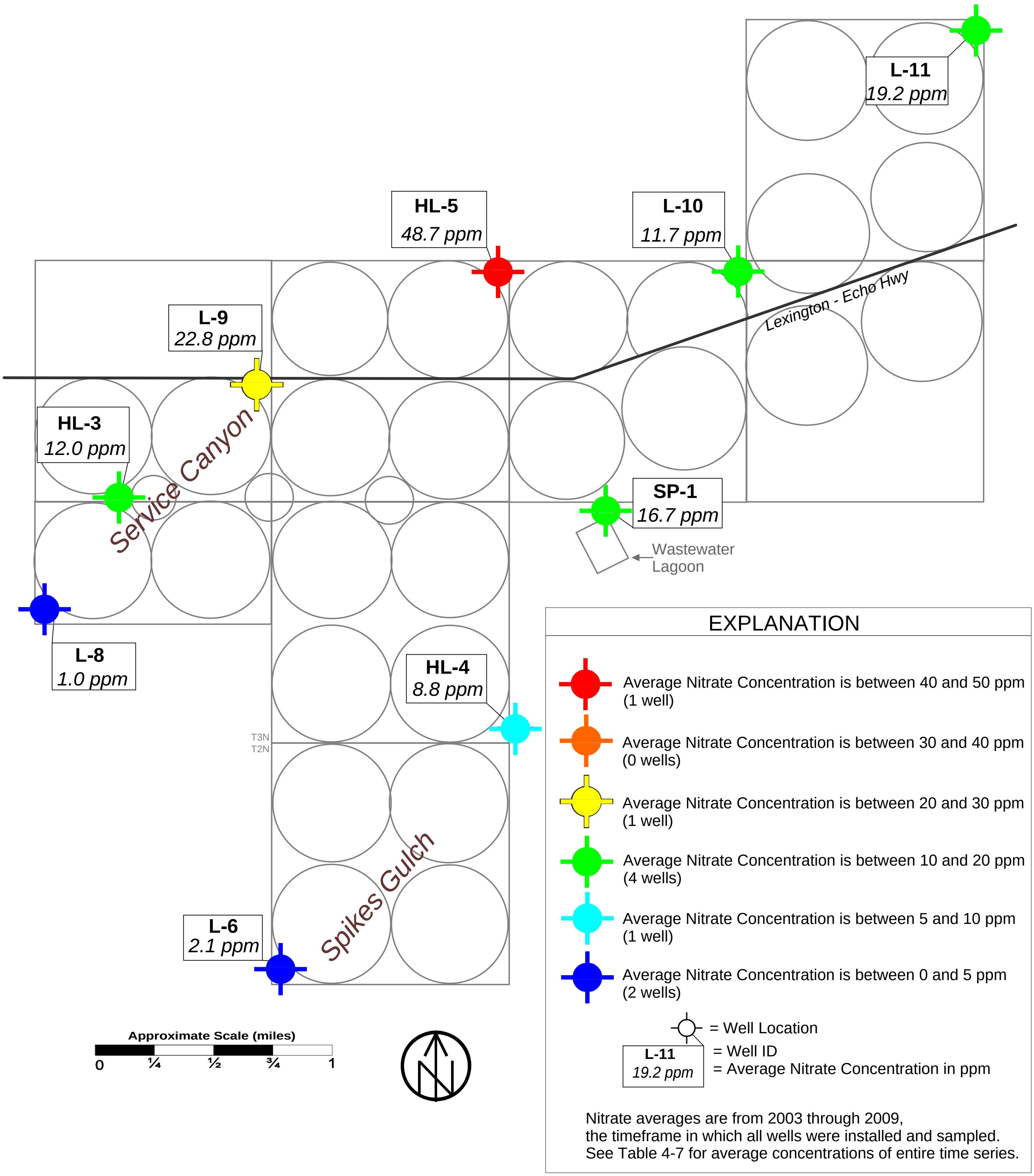


Figure 4-18
Average Nitrate Concentrations - Simplot Levy Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



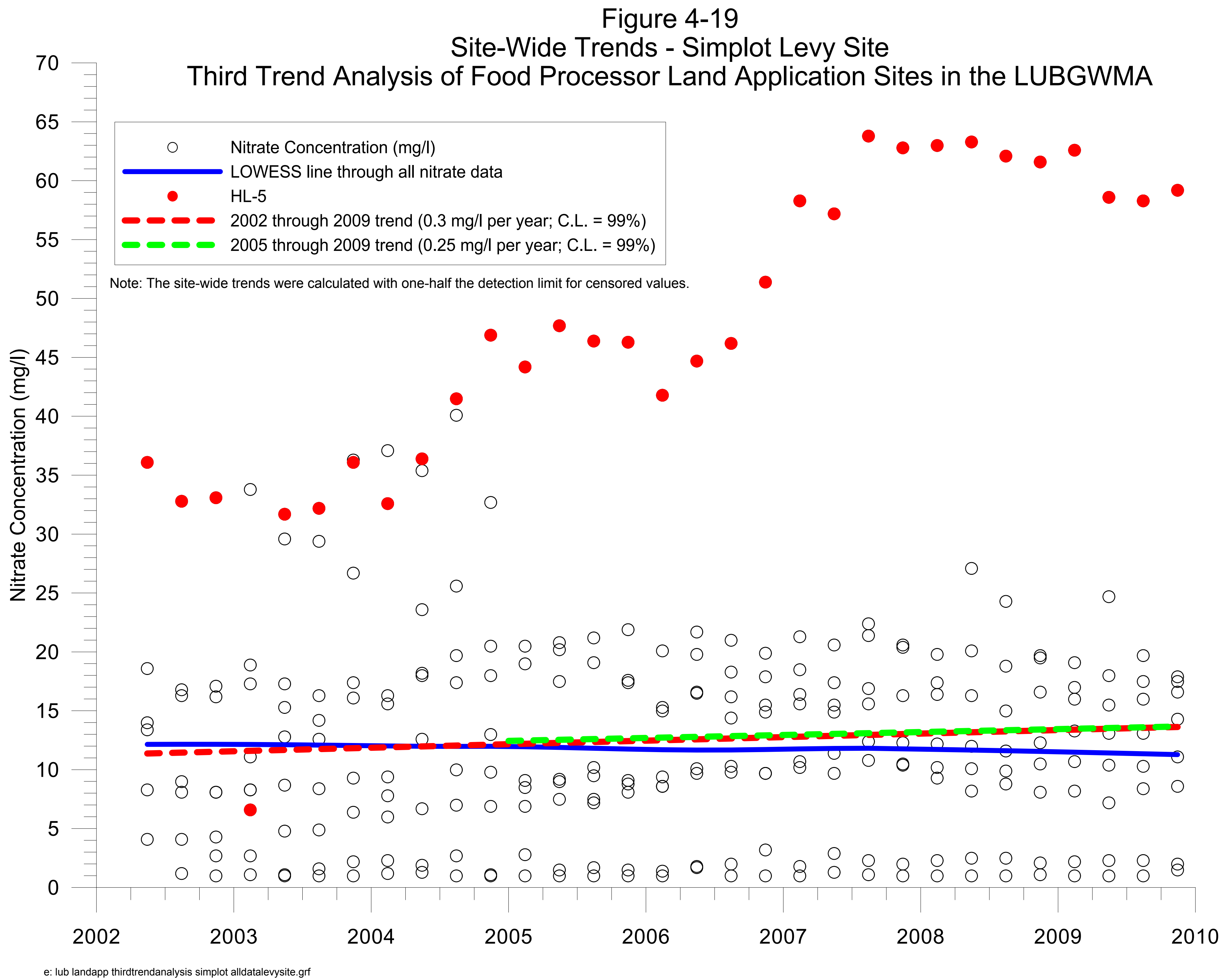
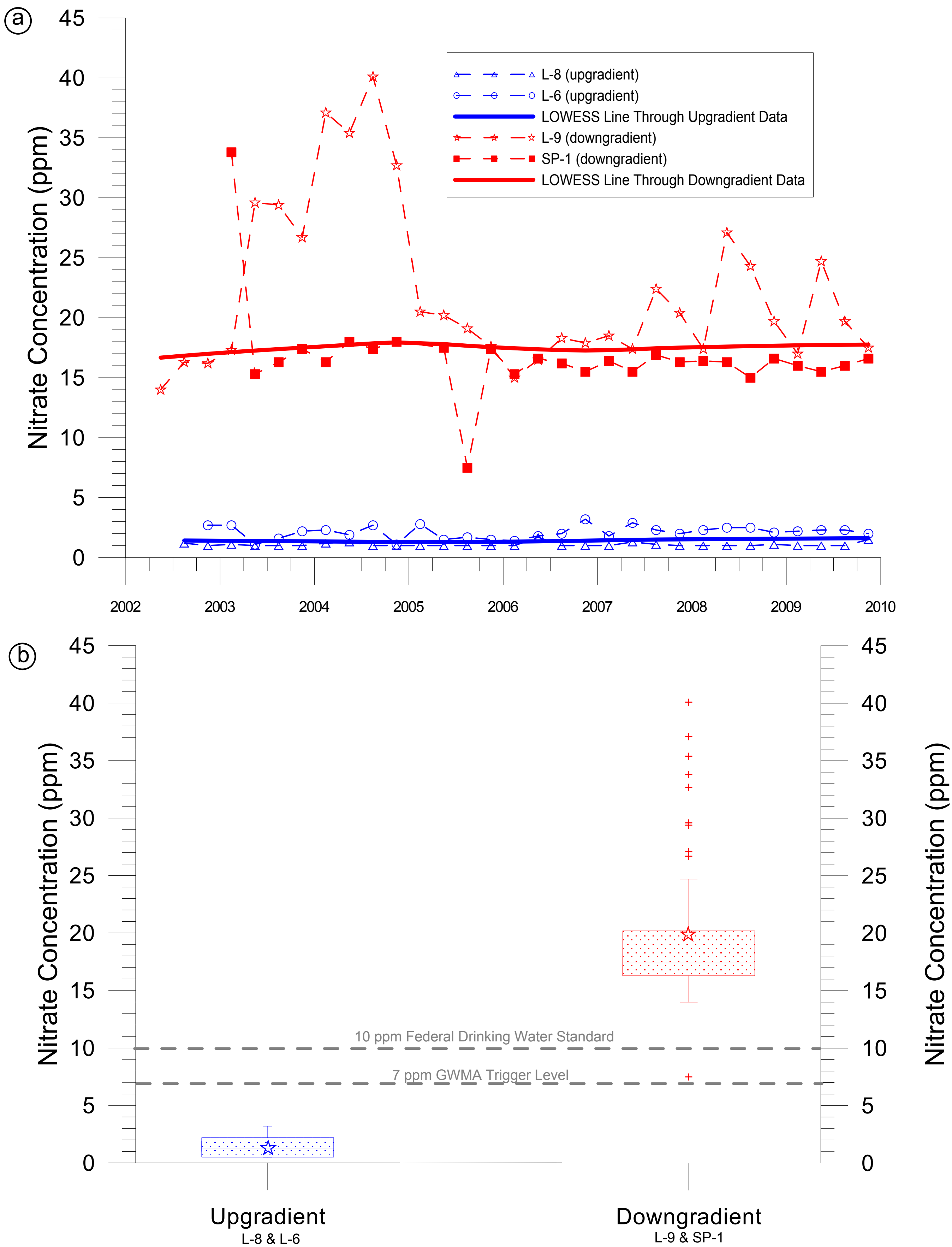


Figure 4-19
Site-Wide Trends - Simplot Levy Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA
Nitrate Concentration (mg/l)
LOWESS line through all nitrate data
HL-5
2002 through 2009 trend (0.3 mg/l per year; C.L. = 99%)
2005 through 2009 trend (0.25 mg/l per year; C.L. = 99%)
Note: The site-wide trends were calculated with one-half the detection limit for censored values.
Nitrate Concentration (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
2002
2003
2004
2005
2006
2007
2008
2009
2010
e: lub landapp thirdtrendanalysis simplot alldatalevysite.grf

Figure 4-20
Upgradient vs. Downgradient Nitrate Comparisons - Simplot Levy Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp thirdtrendanalysis simplot upvsdnLevy.grf

Figure 5-1
LOWESS Lines and Trend Lines Through Nitrate Data - Hermiston Foods Site
Third Trend Analysis of Food Processor Land Application Sites in the LUB GWMA

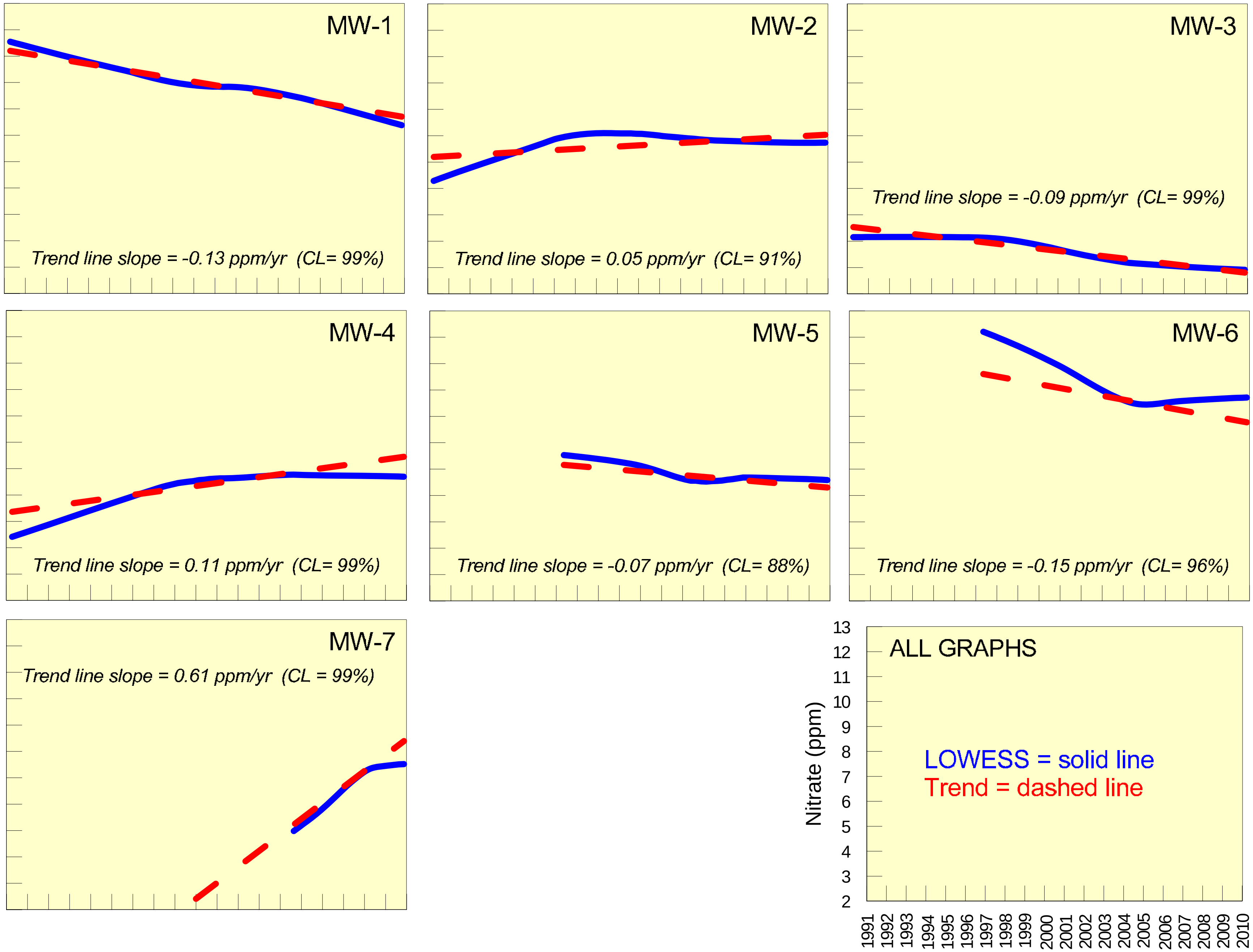
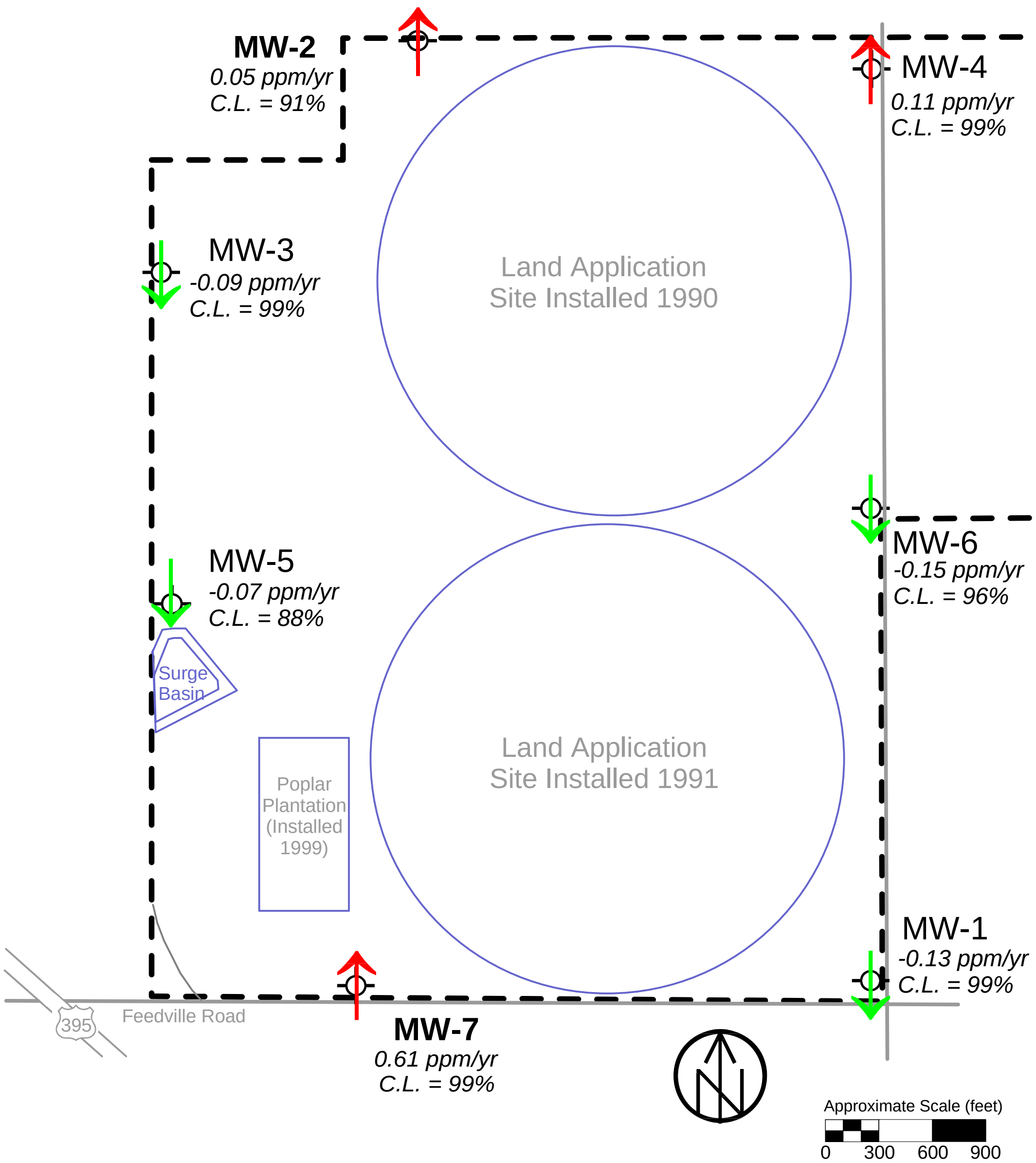


Figure 5-2
Nitrate Trends - Hermiston Foods Site
Third Trend Analysis of Food Processor Land Application Sites in the LUB GWMA



EXPLANATION

Increasing Trend (3 wells)

Decreasing Trend (4 wells)

Flat Trend (0 wells)

Statistically Insignificant Trend (0 wells)

= Well Location

MW-1 = Well ID

-0.13 ppm/yr = Trend line slope in ppm/yr

C.L. = 99% = Confidence Level of trend line slope

The size of each symbol is proportional to the trend line slope:
Large symbol = well with slope larger than 5 ppm/yr (0 wells)
Medium symbol = well wtih slope between 1 and 5 ppm/yr (0 wells)
Small symbol = well with slope between 0.5 and 1 ppm/yr (0 wells)
Very small symbol = well with slope less than 0.5 ppm/yr (7 wells)

Nitrate trends at wells MW-1 through MW-4 are from 04/91 through 11/09
Nitrate trends at wells MW-5 through MW-6 are from 05/97 through 11/09

e: lub landapp thirdtrendanalysis hf trends.srf

Figure 5-3
Average Nitrate Concentrations - Hermiston Foods Site
Third Trend Analysis of Food Processor Land Application Sites in the LUB GWMA

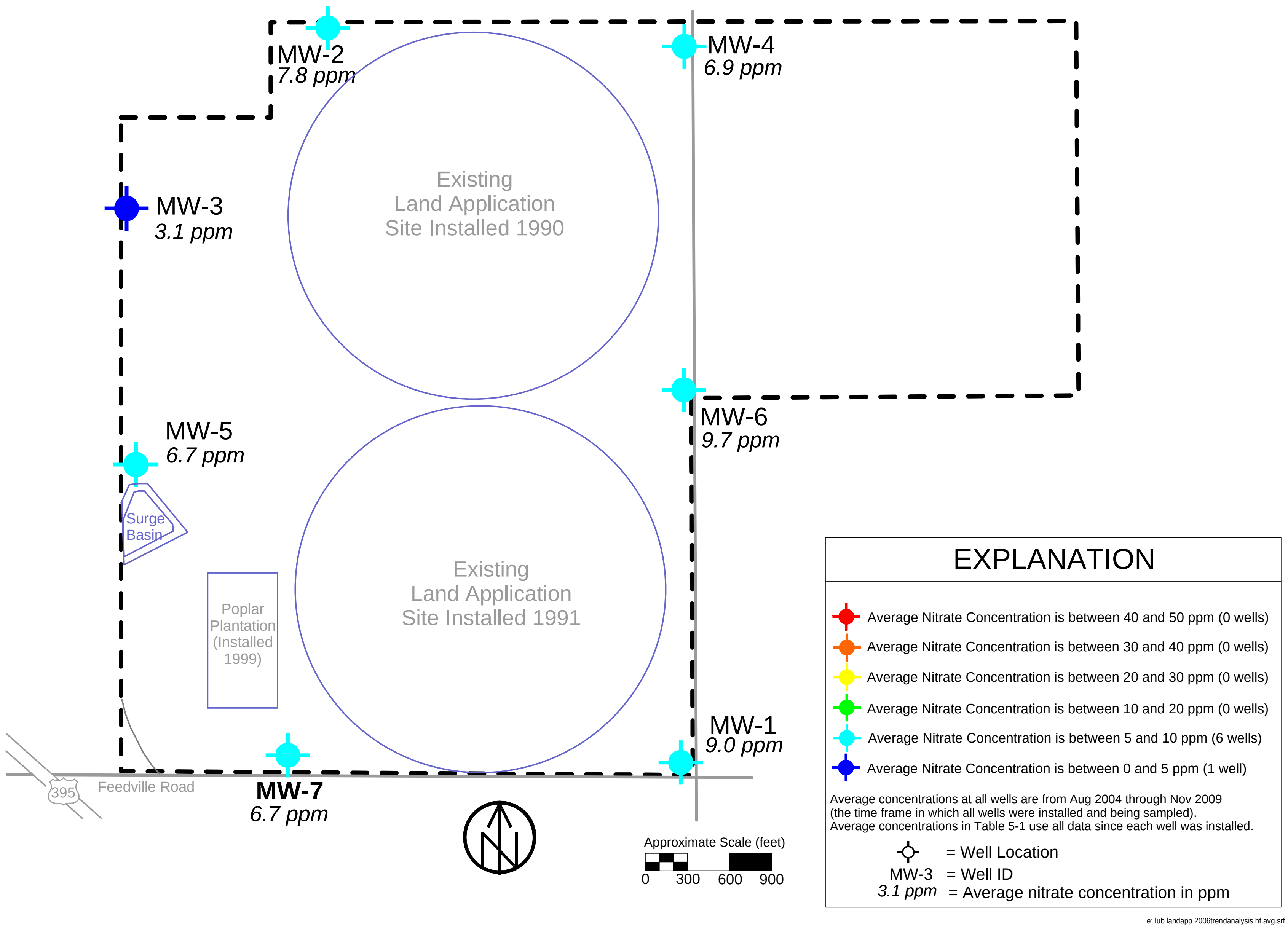
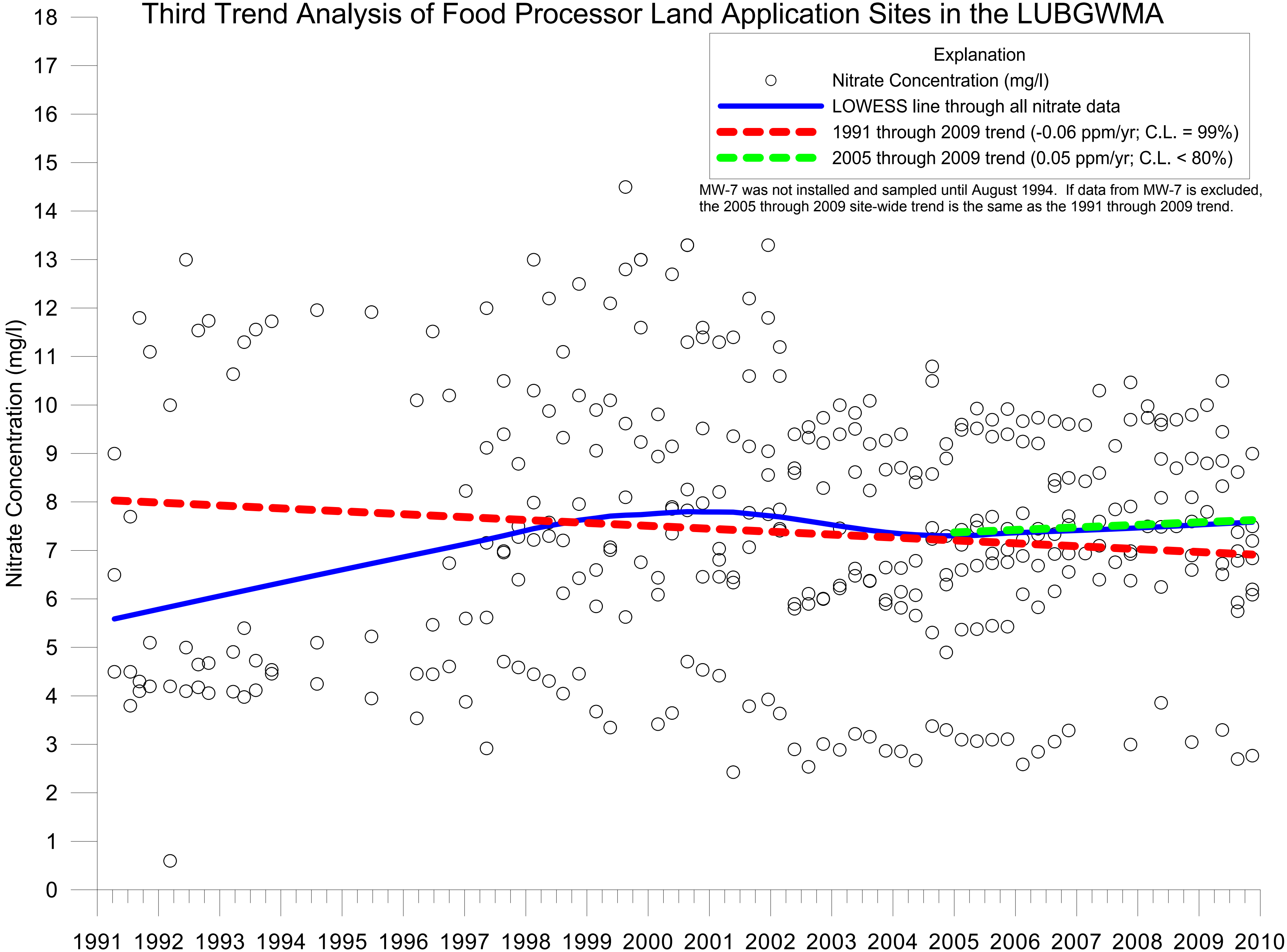
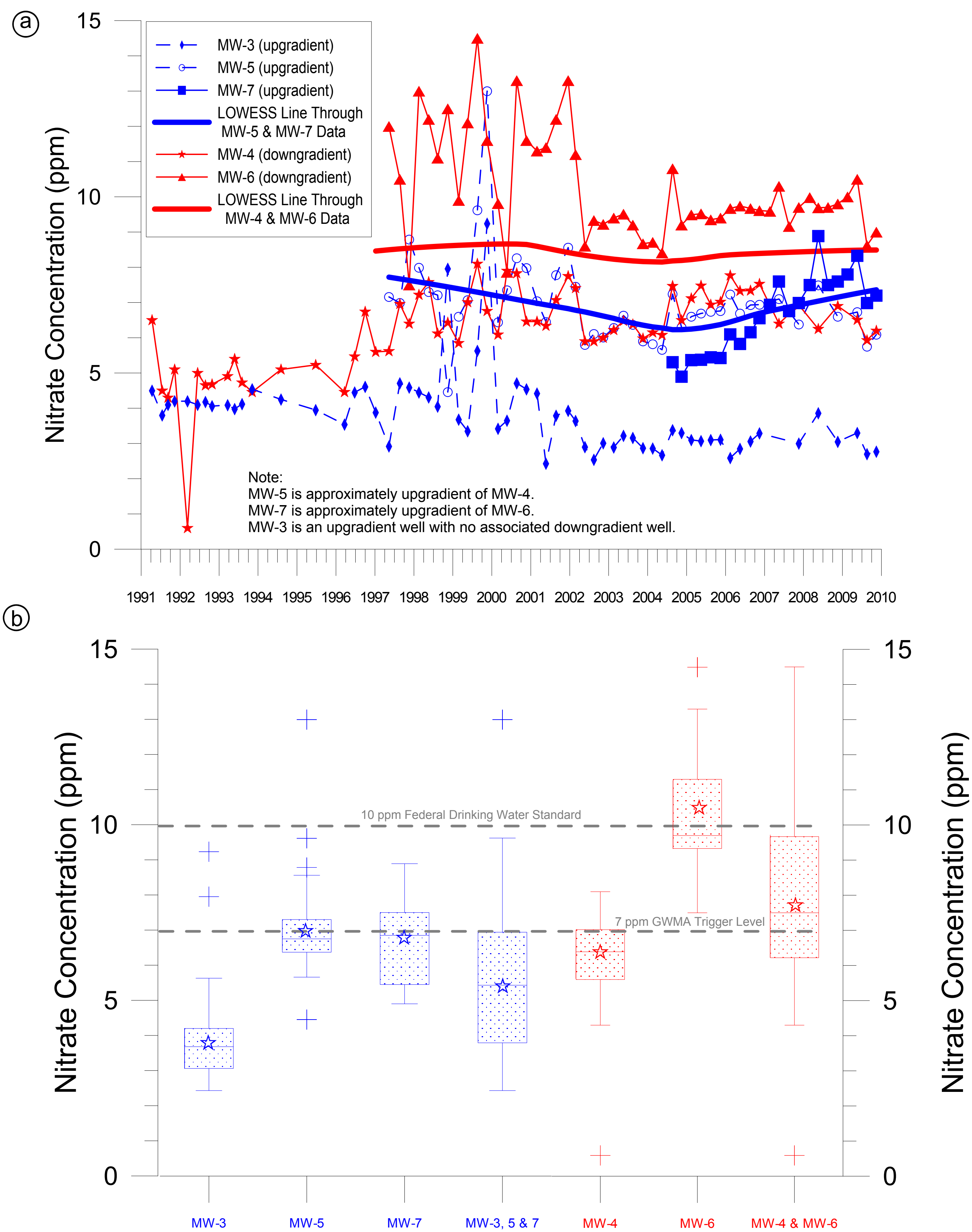


Figure 5-4
Site-Wide Trends - Hermiston Foods Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp thirdtrendanalysis hermiston foods all data.grf

Figure 5-5
Upgradient vs. Downgradient Nitrate Comparisons - Hermiston Foods
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp thirdtrendanalysis hf up vs dn 3.grf

Figure 6-1
LOWESS Lines and Trend Lines Through Nitrate Data - MorStarch Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

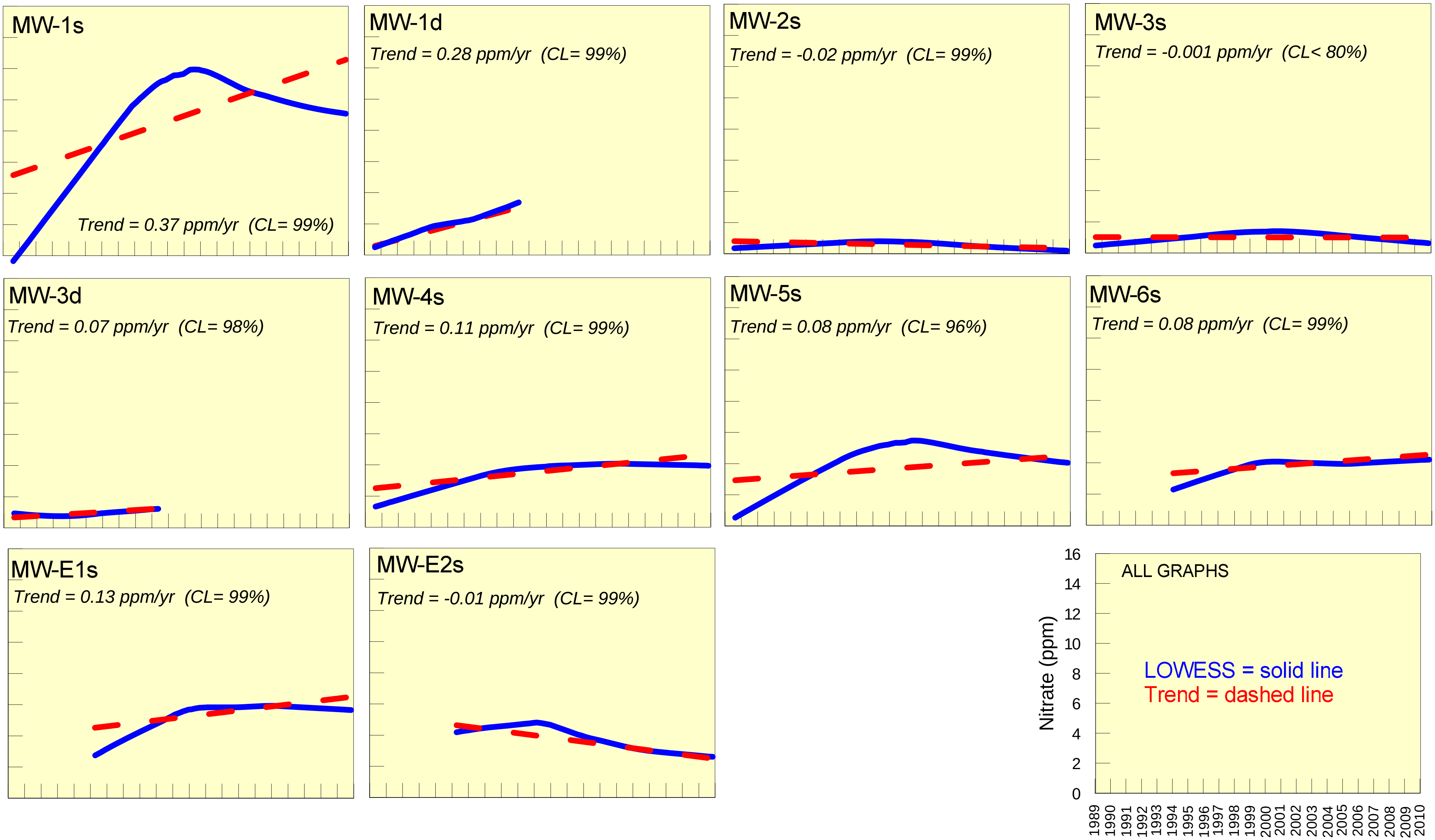


Figure 6-2
Nitrate Trends - MorStarch Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

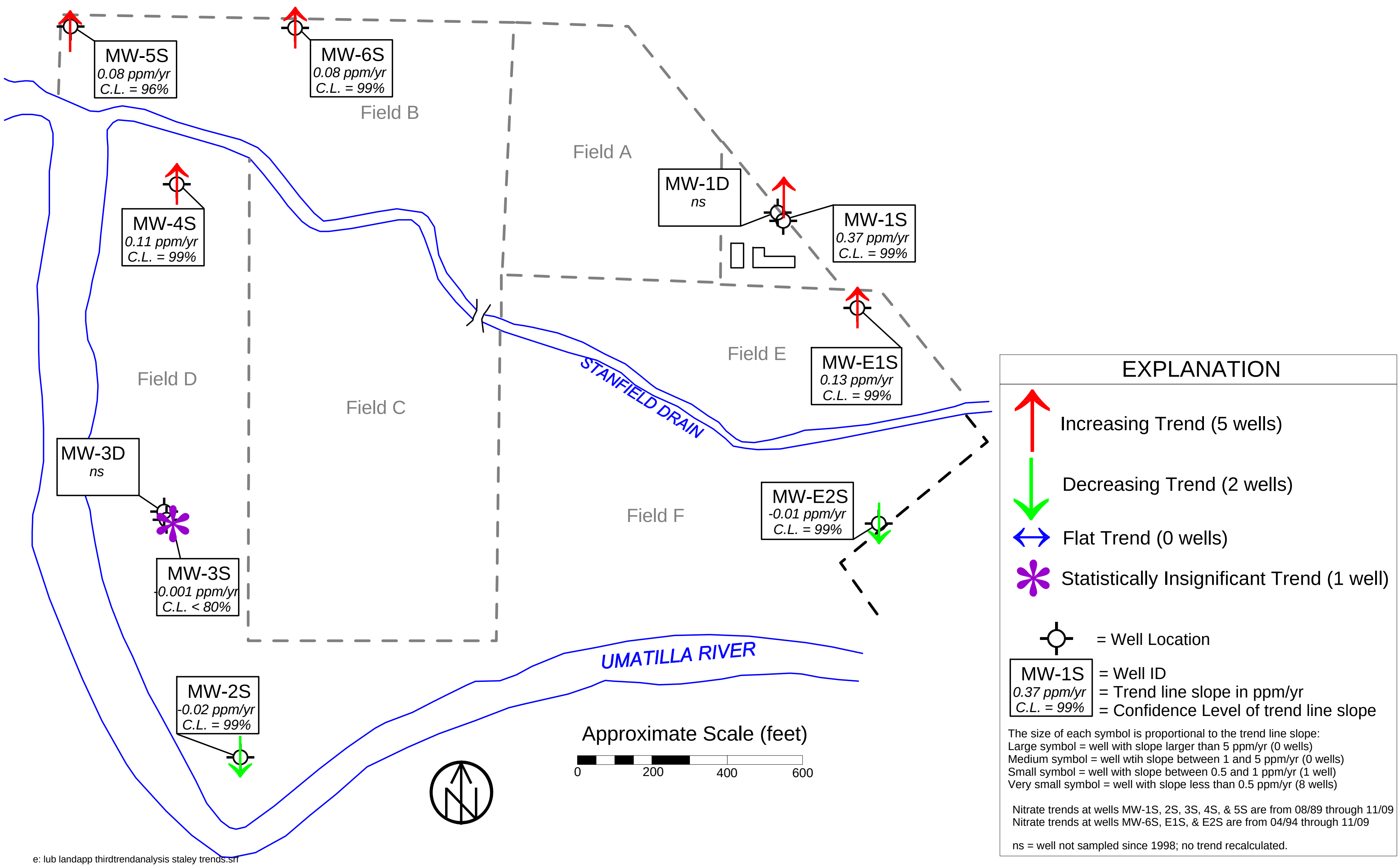
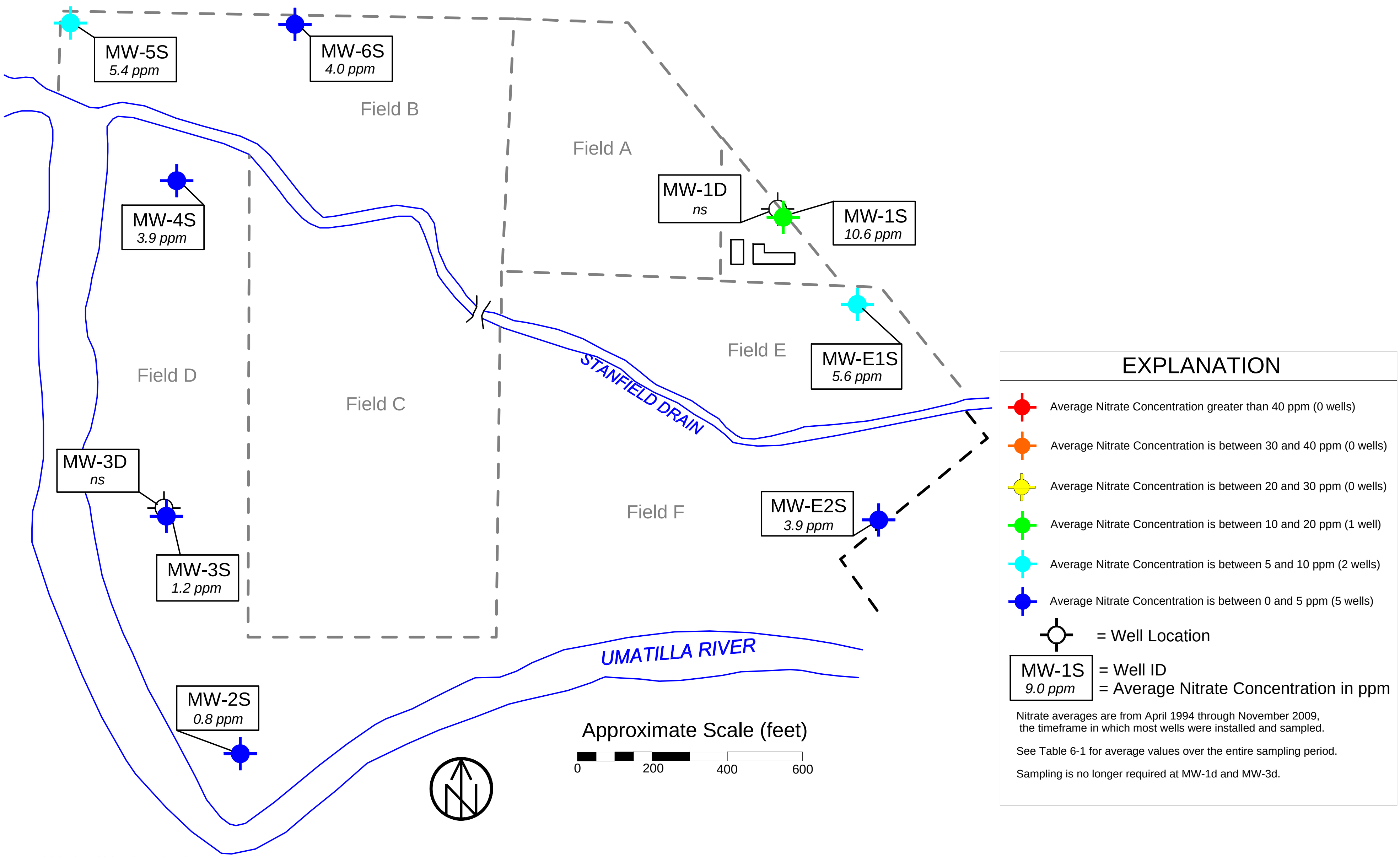
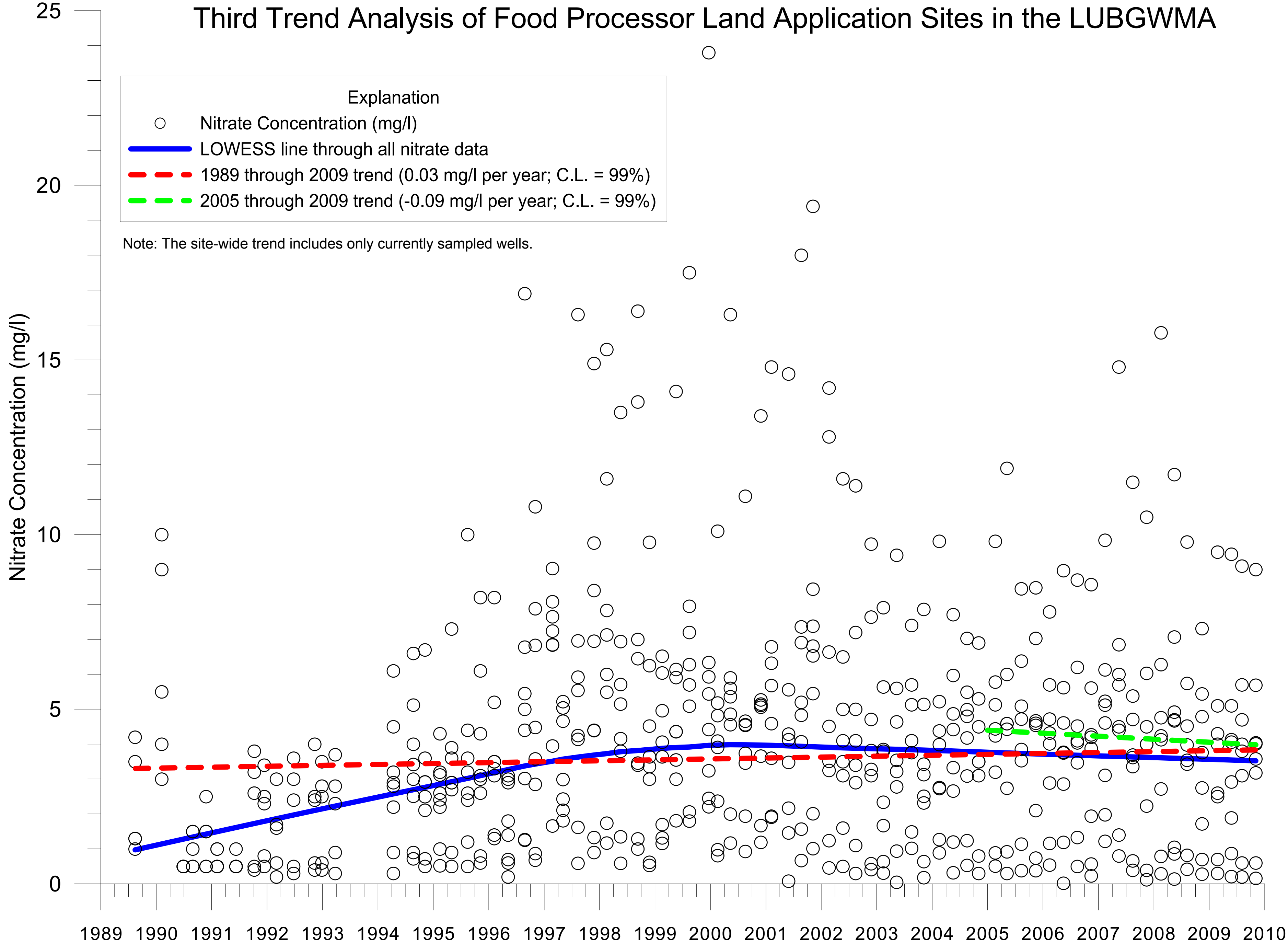


Figure 6-3
Average Nitrate Concentrations - MorStarch Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



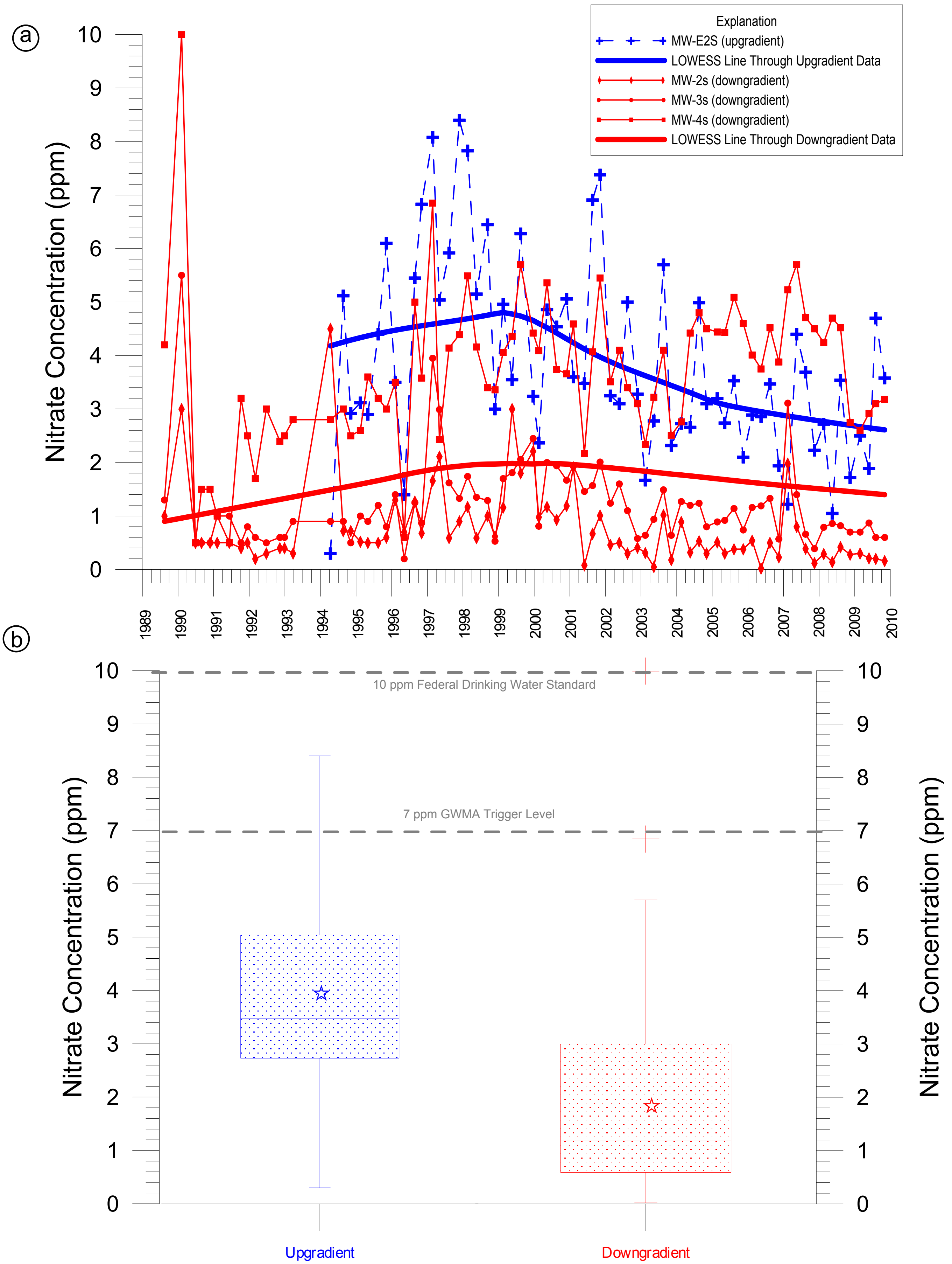
e: lub landapp thirdtrendanalysis staley averages.srf

Figure 6-4
Site-Wide Trends - MorStarch Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp thirdtrendanalysis staley all data.grf

Figure 6-5
Upgradient vs. Downgradient Nitrate Comparisons - MorStarch Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp thirdtrendanalysis staley up vs dn southside.grf

Figure 7-1
LOWESS Lines and Trend Lines Through Nitrate Data - Snack Alliance Site
Third Trend Analysis of Food Processor Land Application Sites in the LUB GWMA

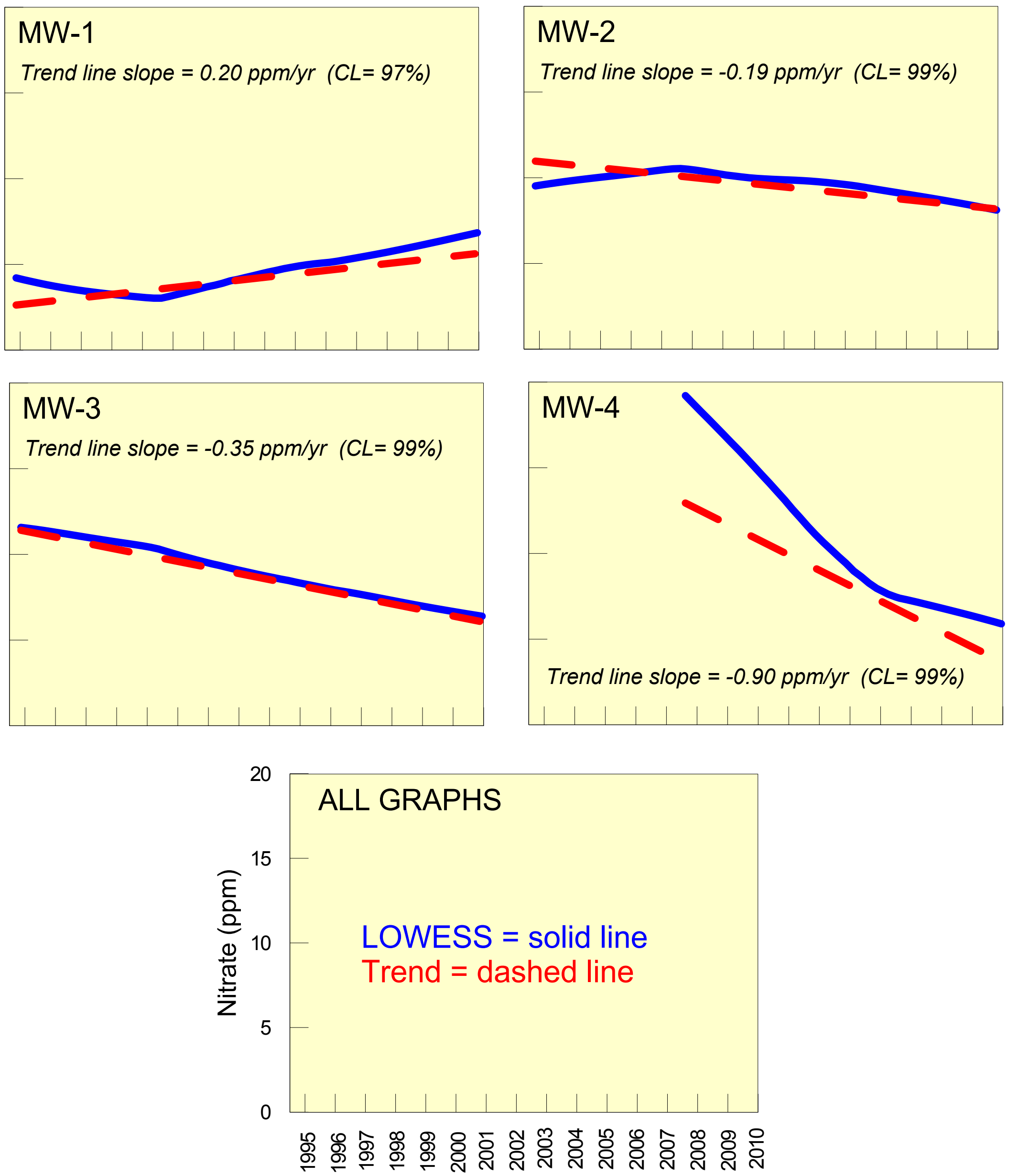
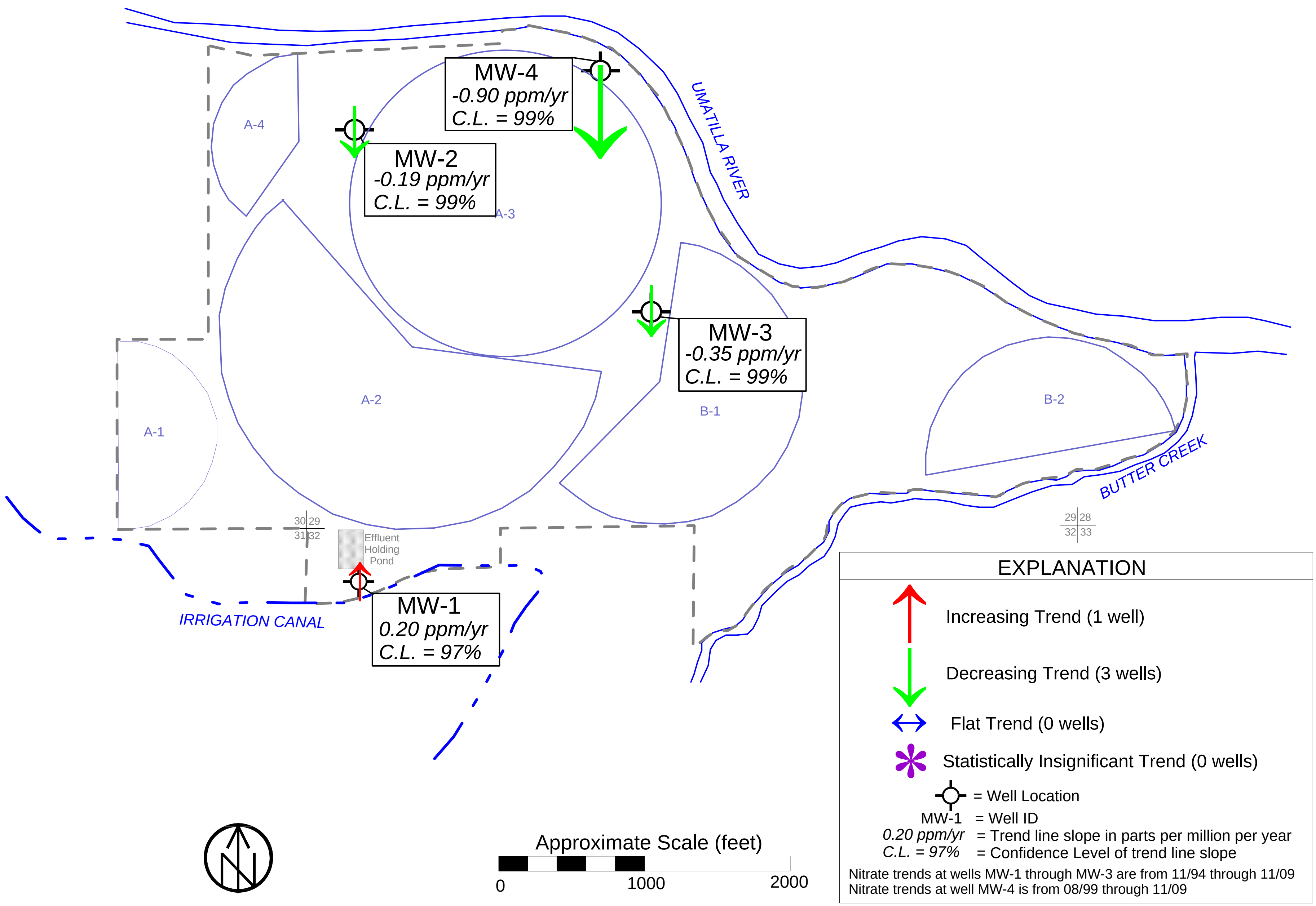
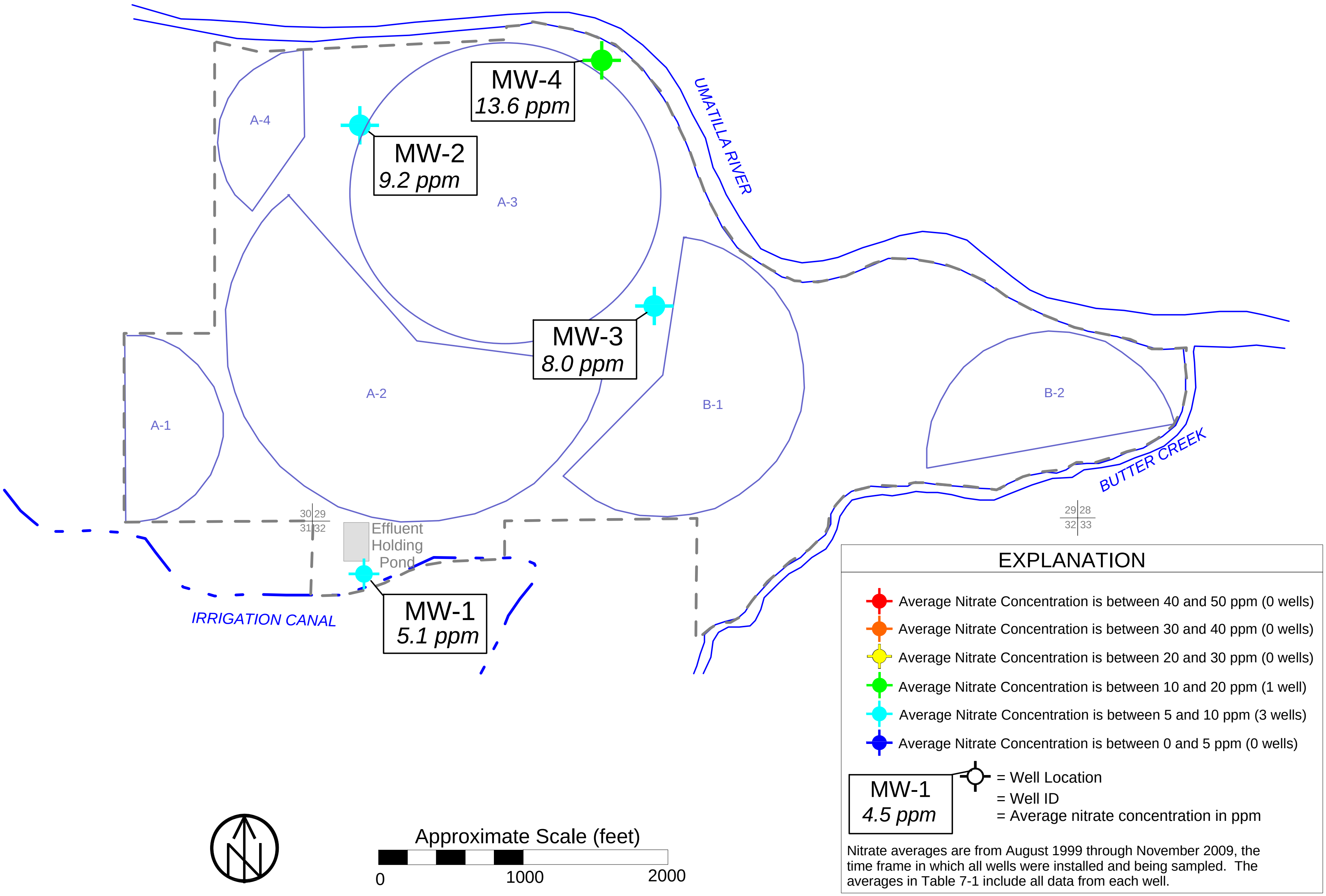


Figure 7-2
Nitrate Trends - Snack Alliance Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



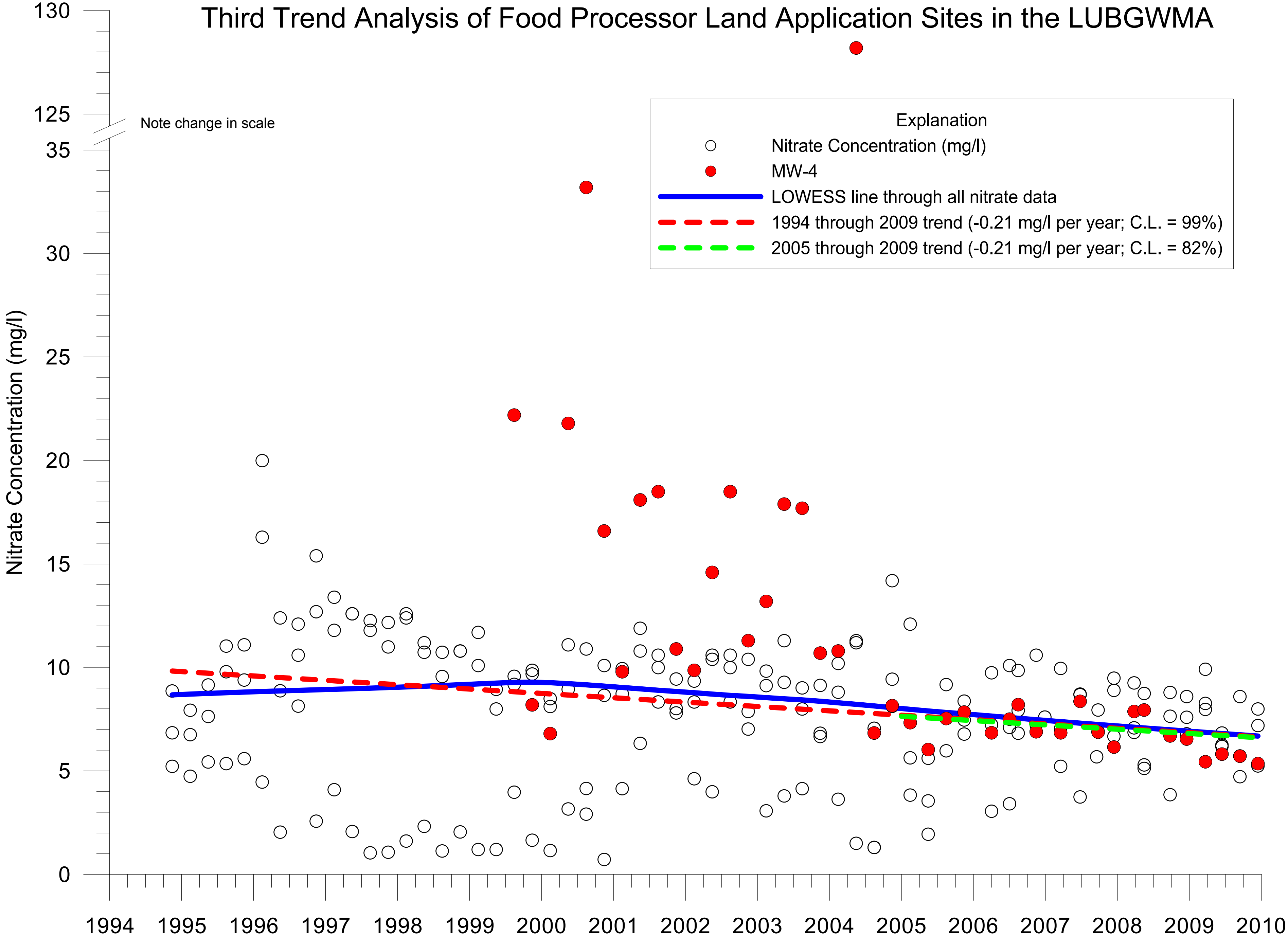
e: lub landapp thirdtrendanalysis snakcorp trends.srf

Figure 7-3
Average Nitrate Concentrations - Snack Alliance Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



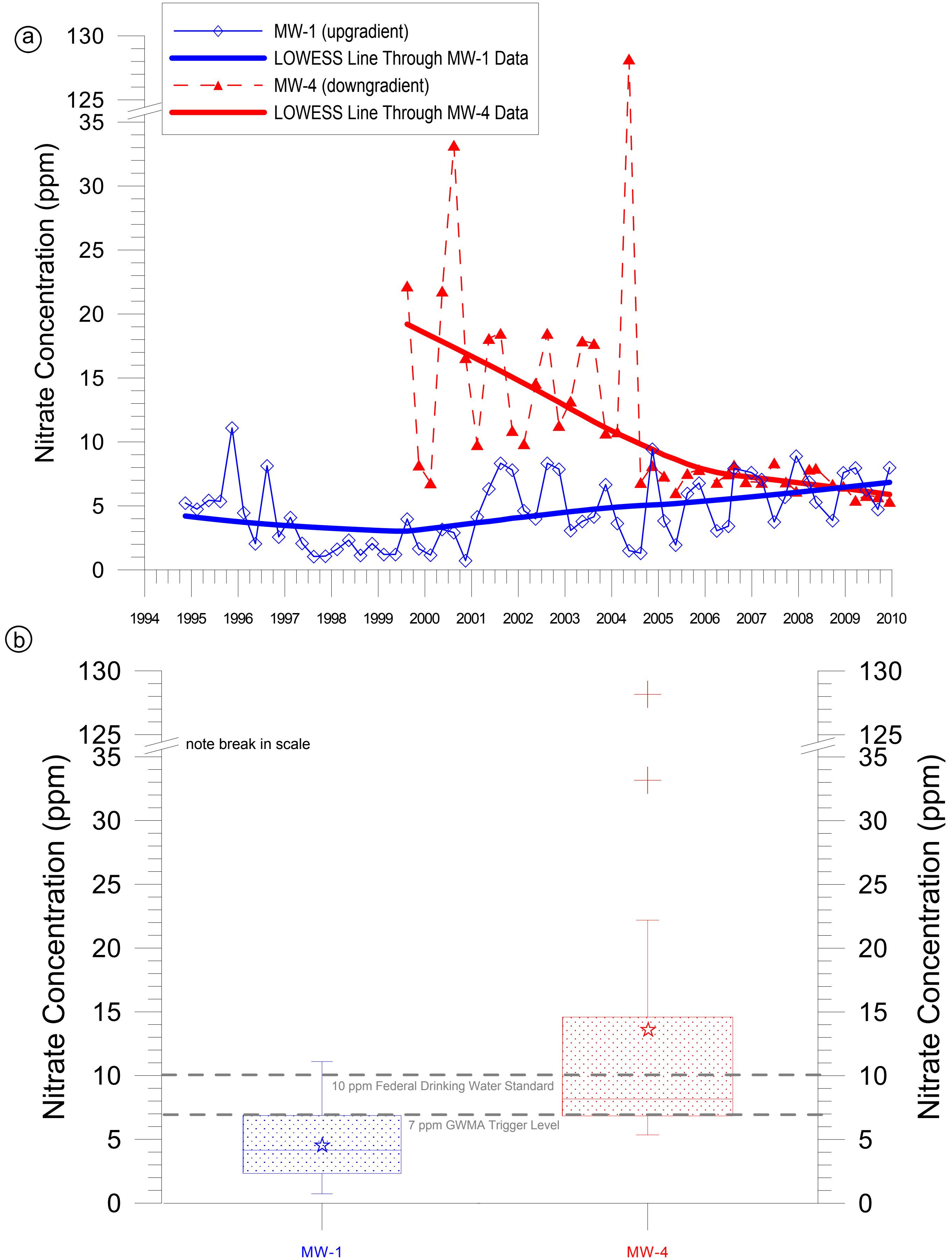
e: lub landapp thirdtrendanalysis snakcorp avg.srf

Figure 7-4
Site-Wide Trends - Snack Alliance Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp thirdtrendanalysis snackcorp all data.grf

Figure 7-5
Upgradient vs. Downgradient Nitrate Comparisons - Snack Alliance Site
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



e: lub landapp thirdtrendanalysis snakcorp up v dn.grf

Figure 8-1
Summary of All Trends
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA

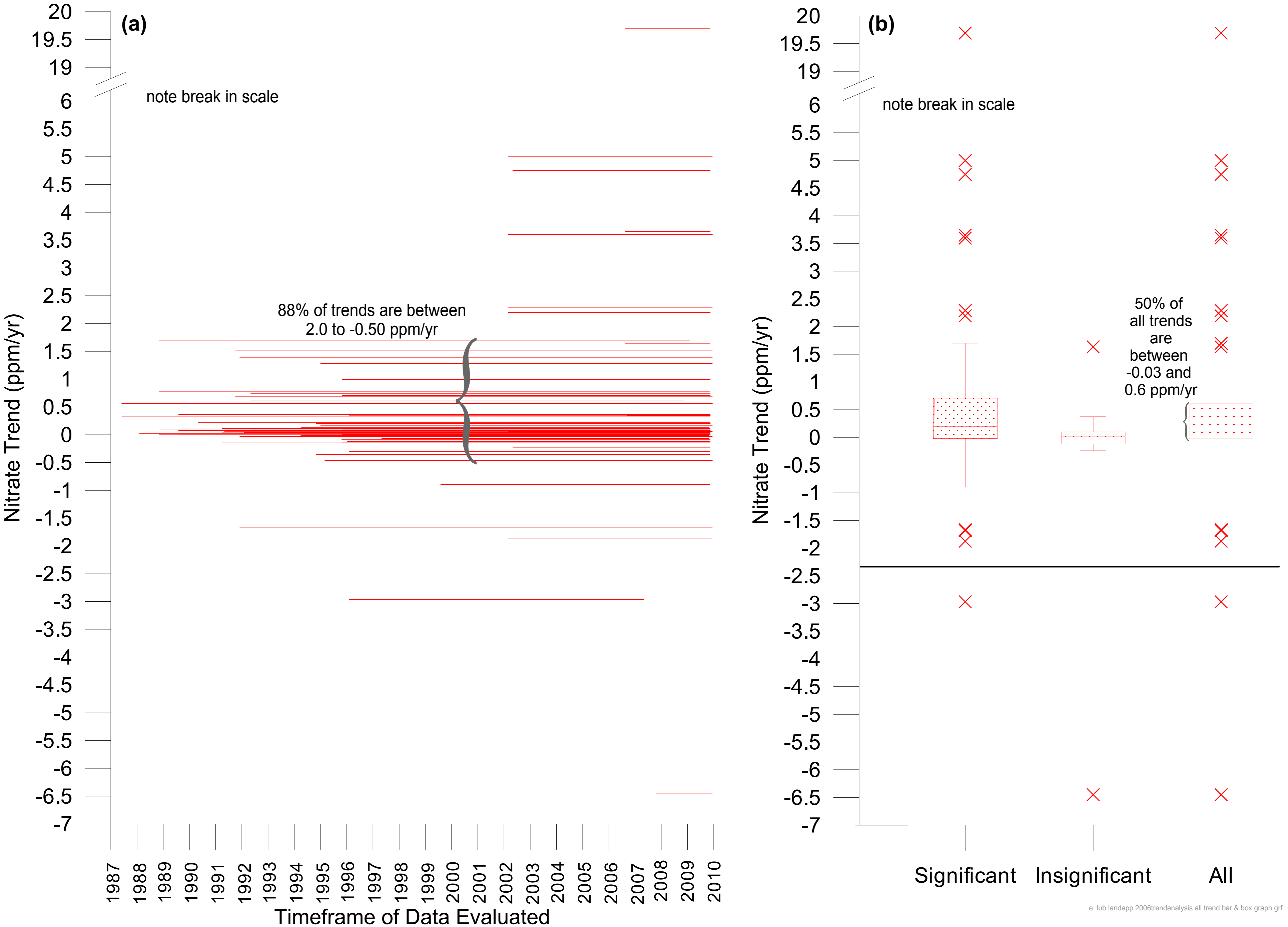
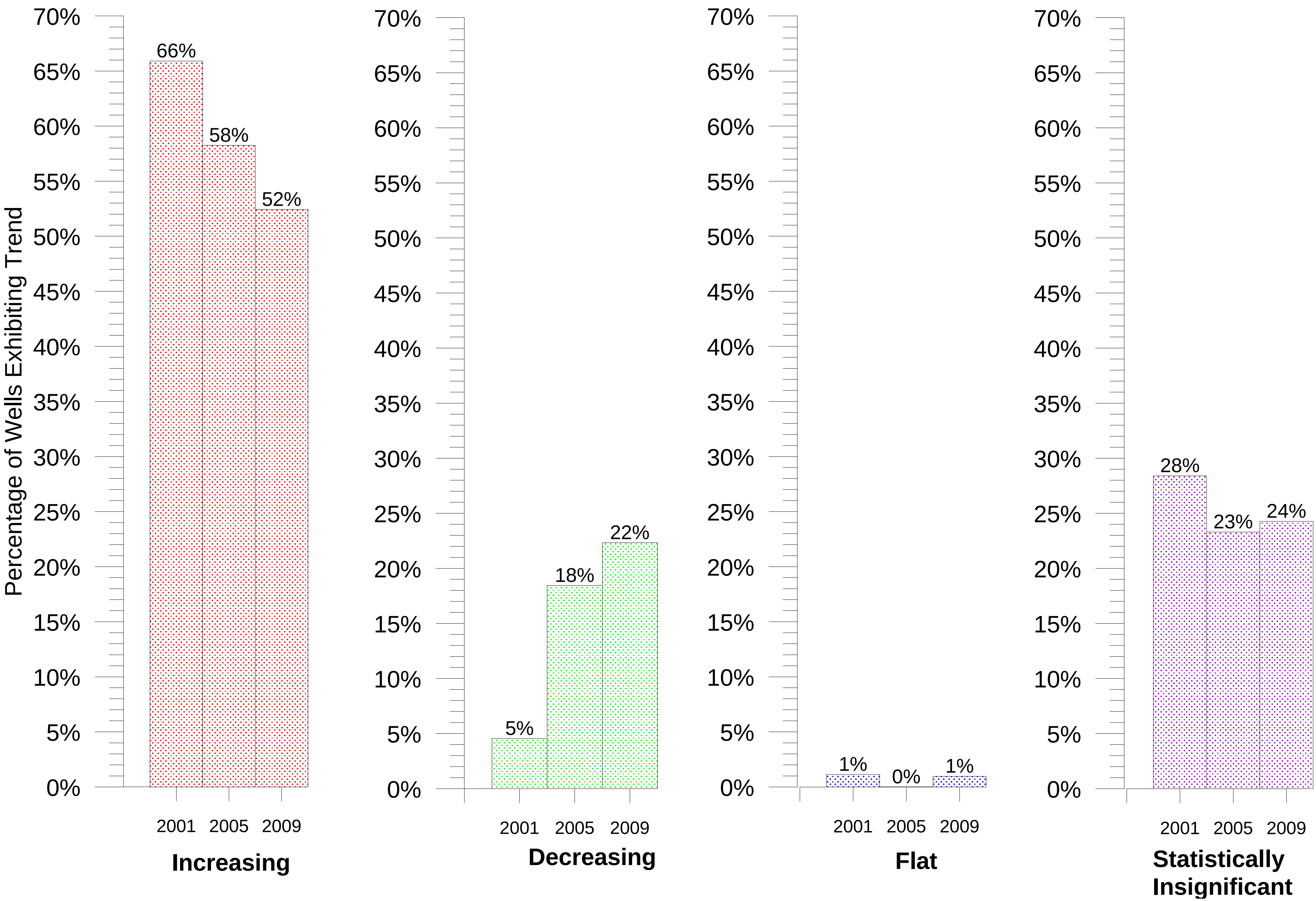
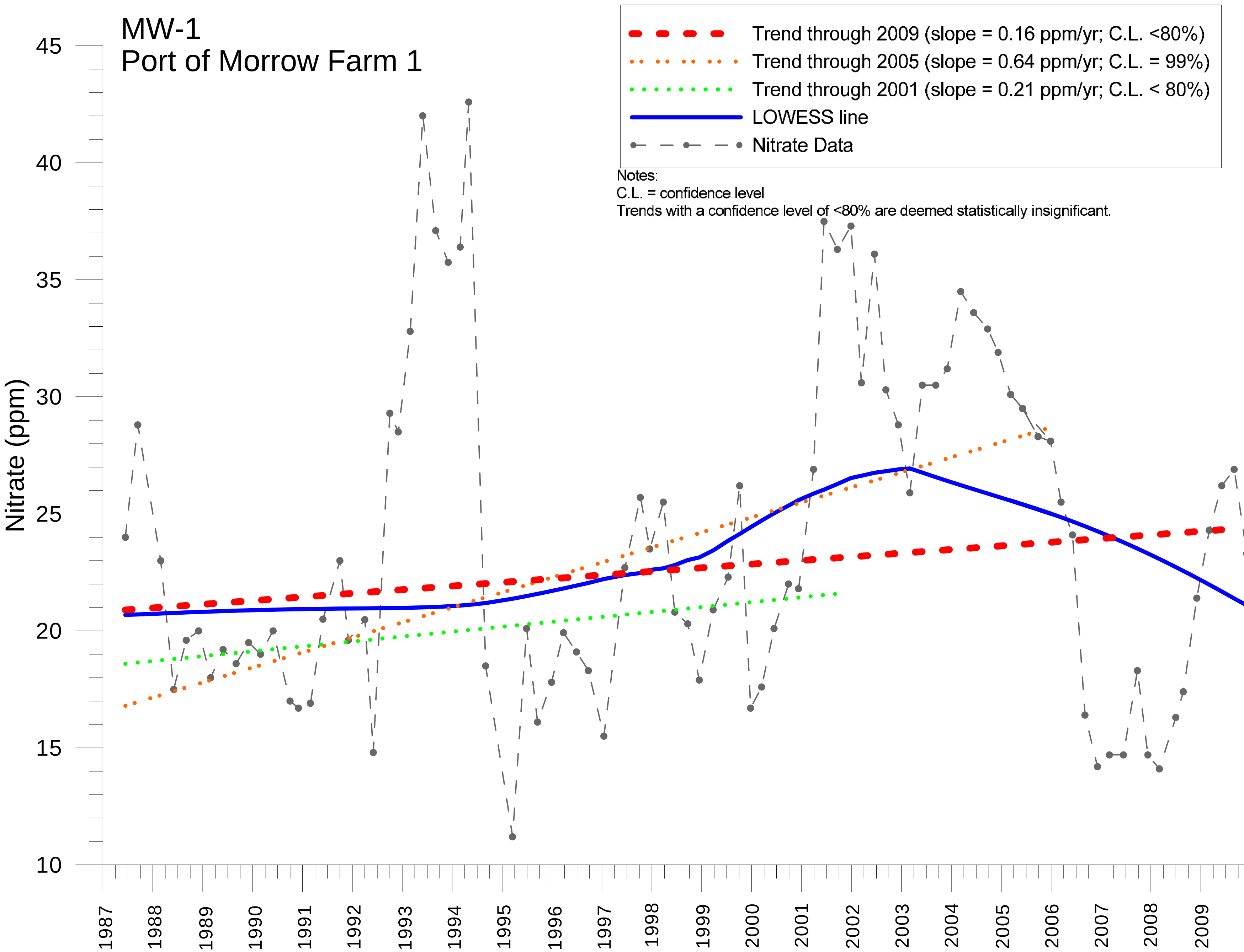
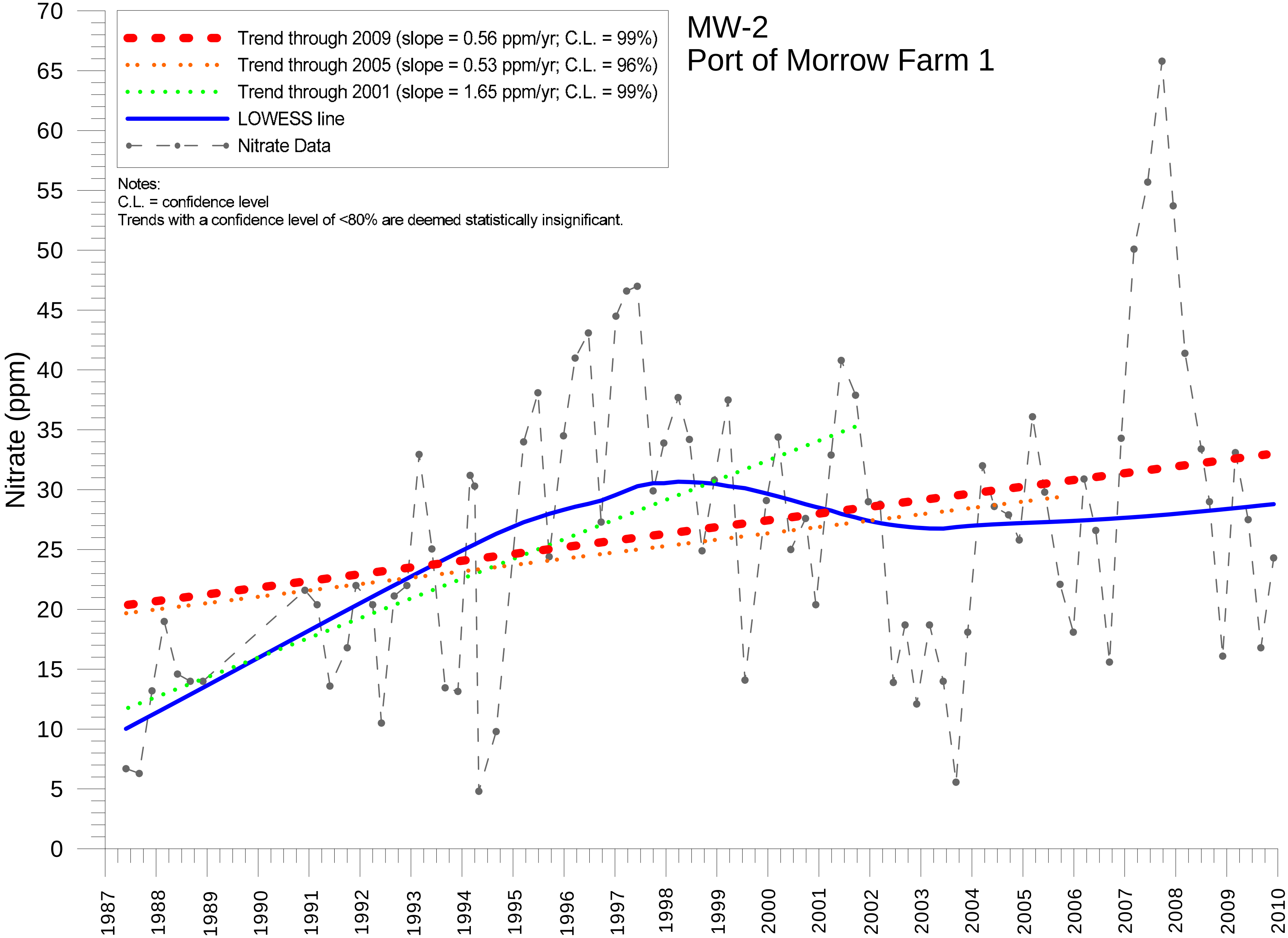


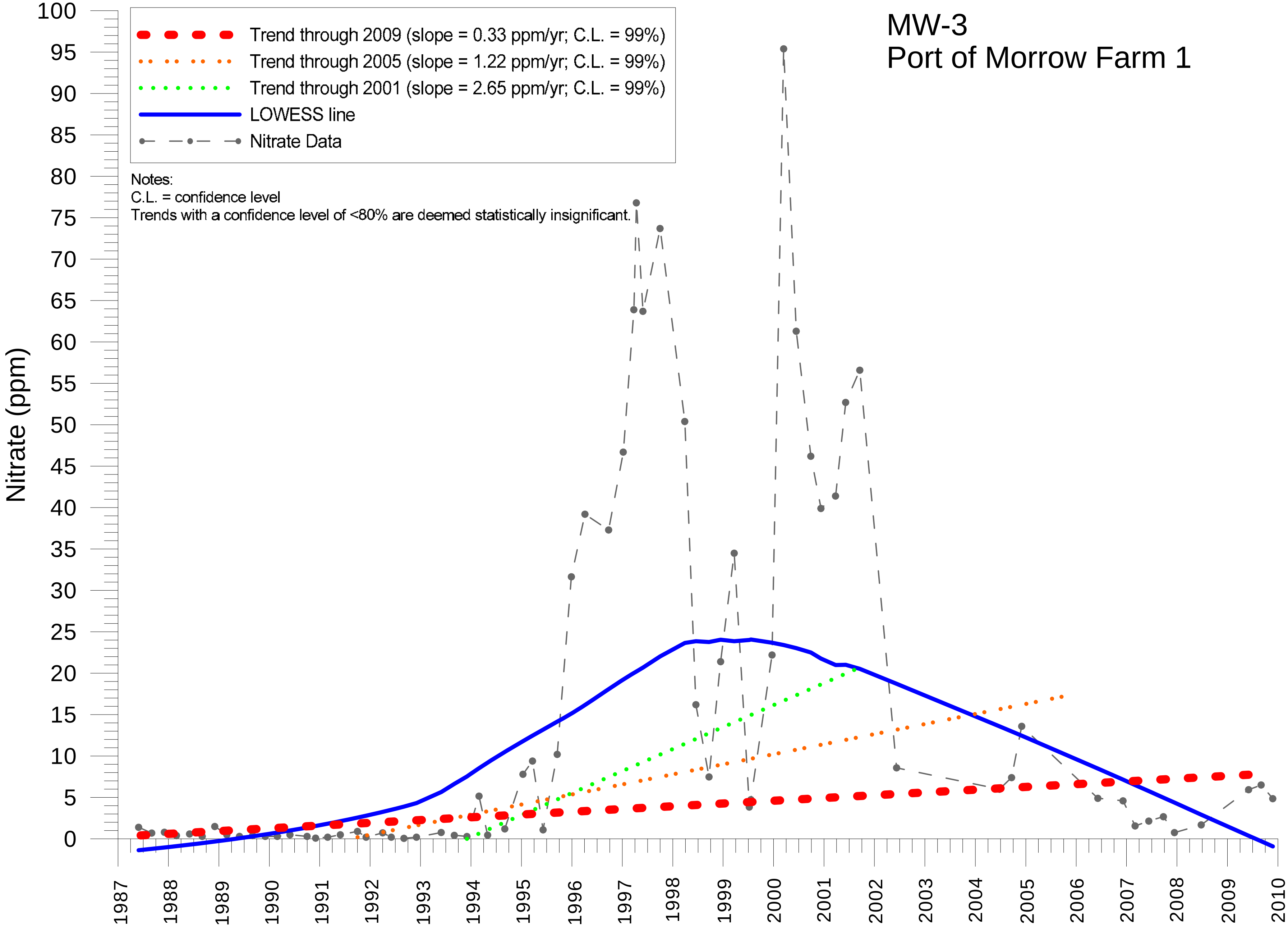
Figure 8-2
Trends at Wells Analyzed Three Times
Third Trend Analysis of Food Processor Land Application Sites in the LUBGWMA



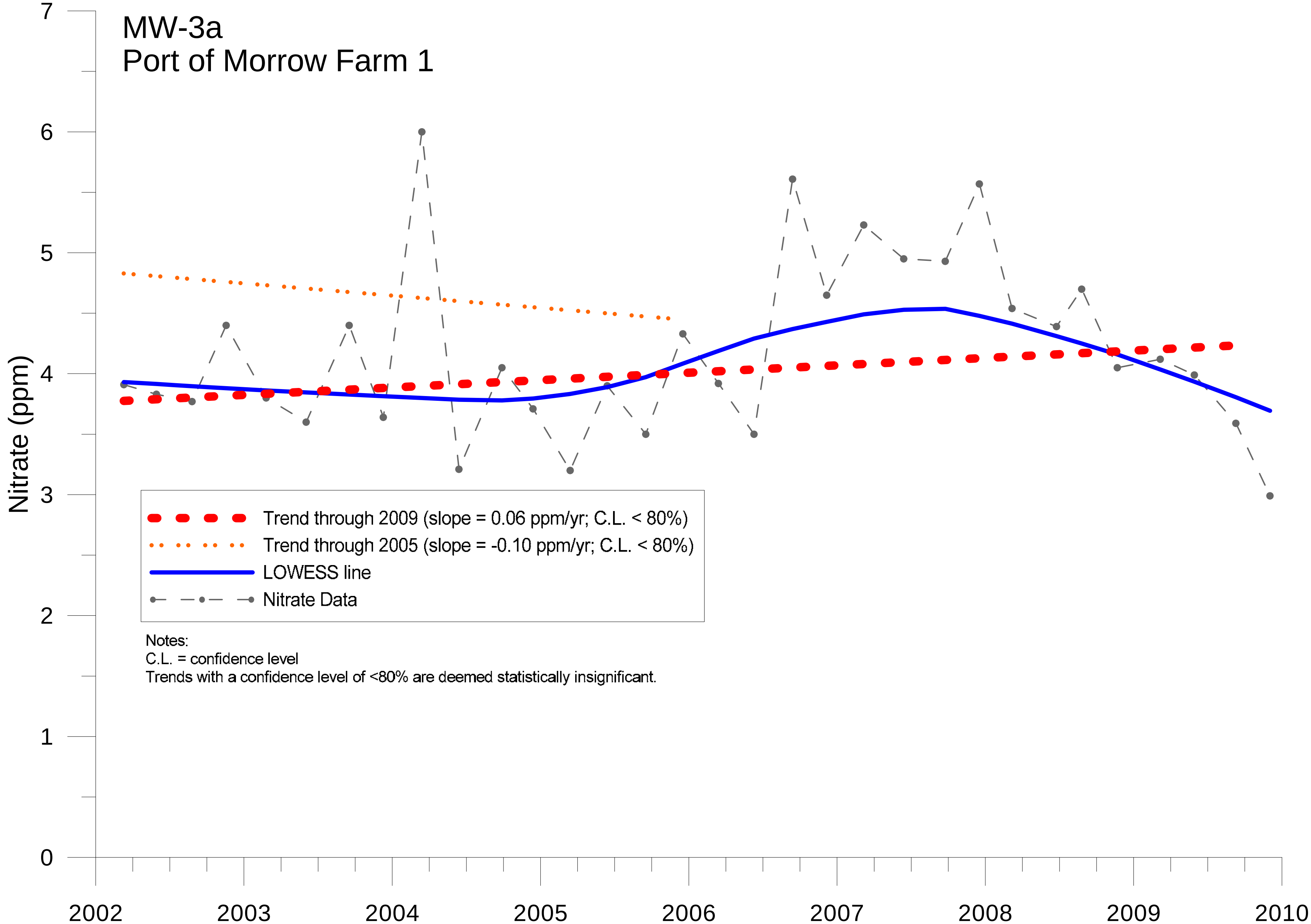

MW-1
Port of Morrow Farm 1
Trend through 2009 (slope = 0.16 ppm/yr; C.L. <80%)
Trend through 2005 (slope = 0.64 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.21 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
45
40
35
30
25
20
15
10
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010



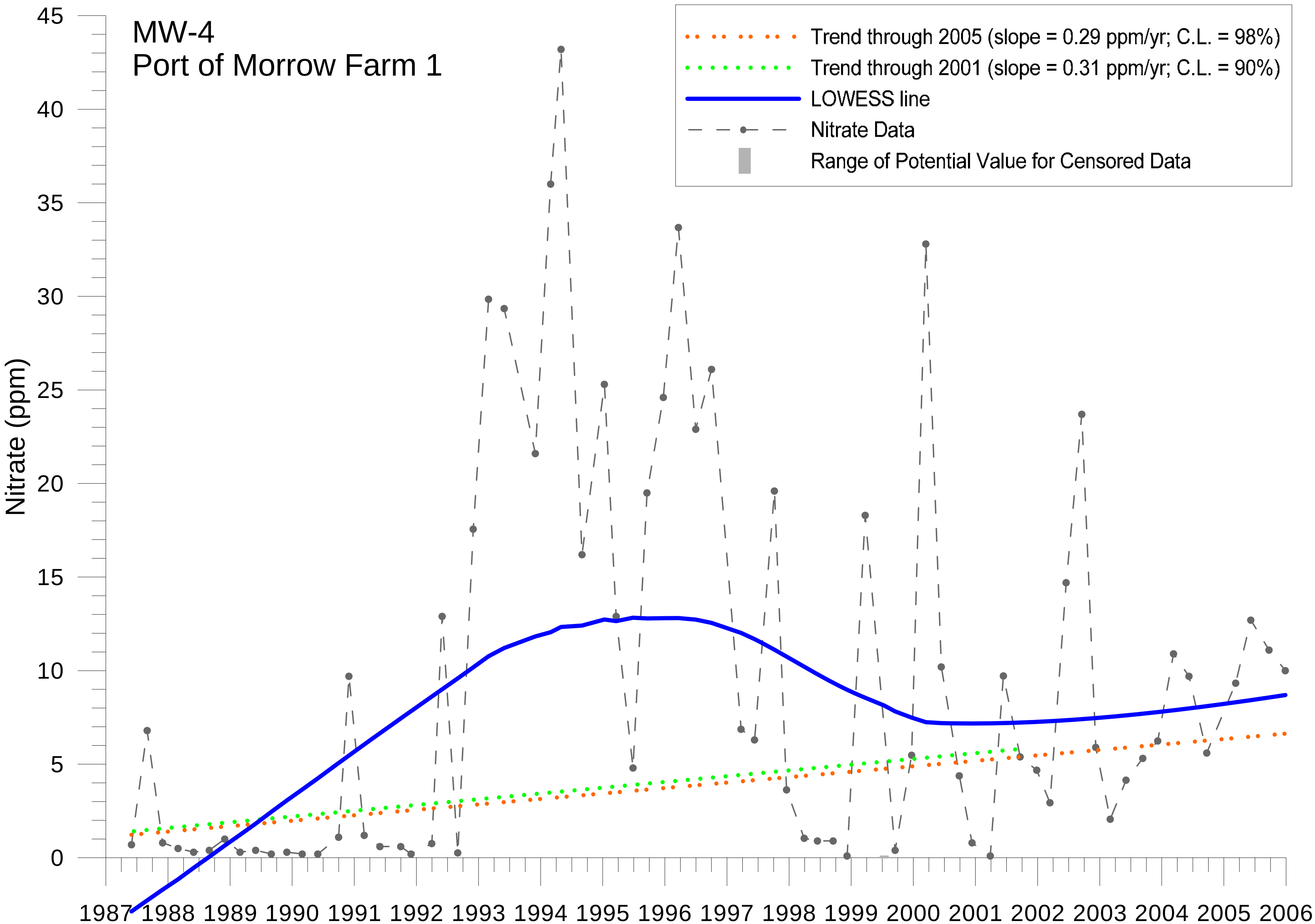
MW-2
Port of Morrow Farm 1
Trend through 2009 (slope = 0.56 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 0.53 ppm/yr; C.L. = 96%)
Trend through 2001 (slope = 1.65 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

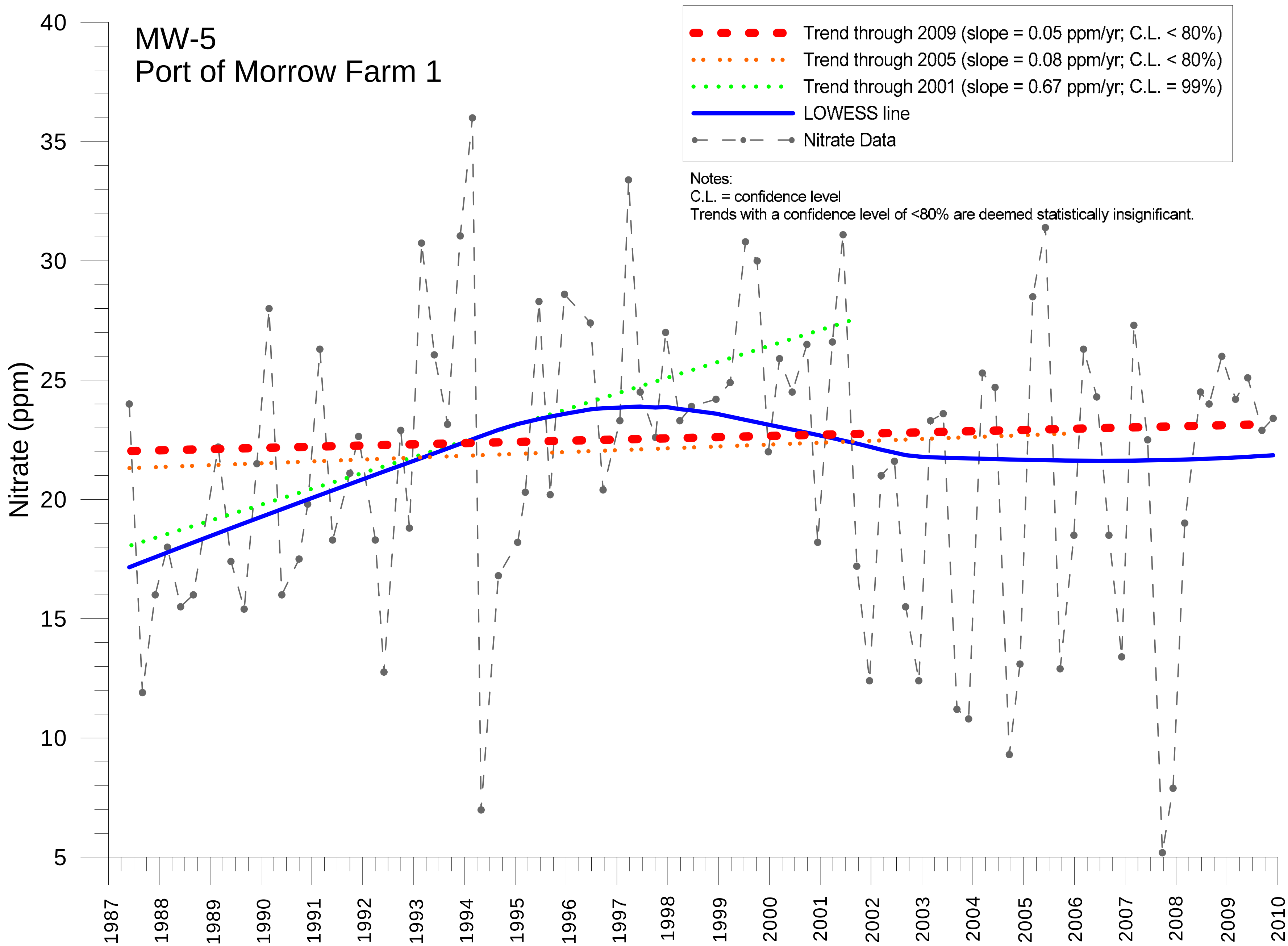


MW-3
Port of Morrow Farm 1
Trend through 2009 (slope = 0.33 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 1.22 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 2.65 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

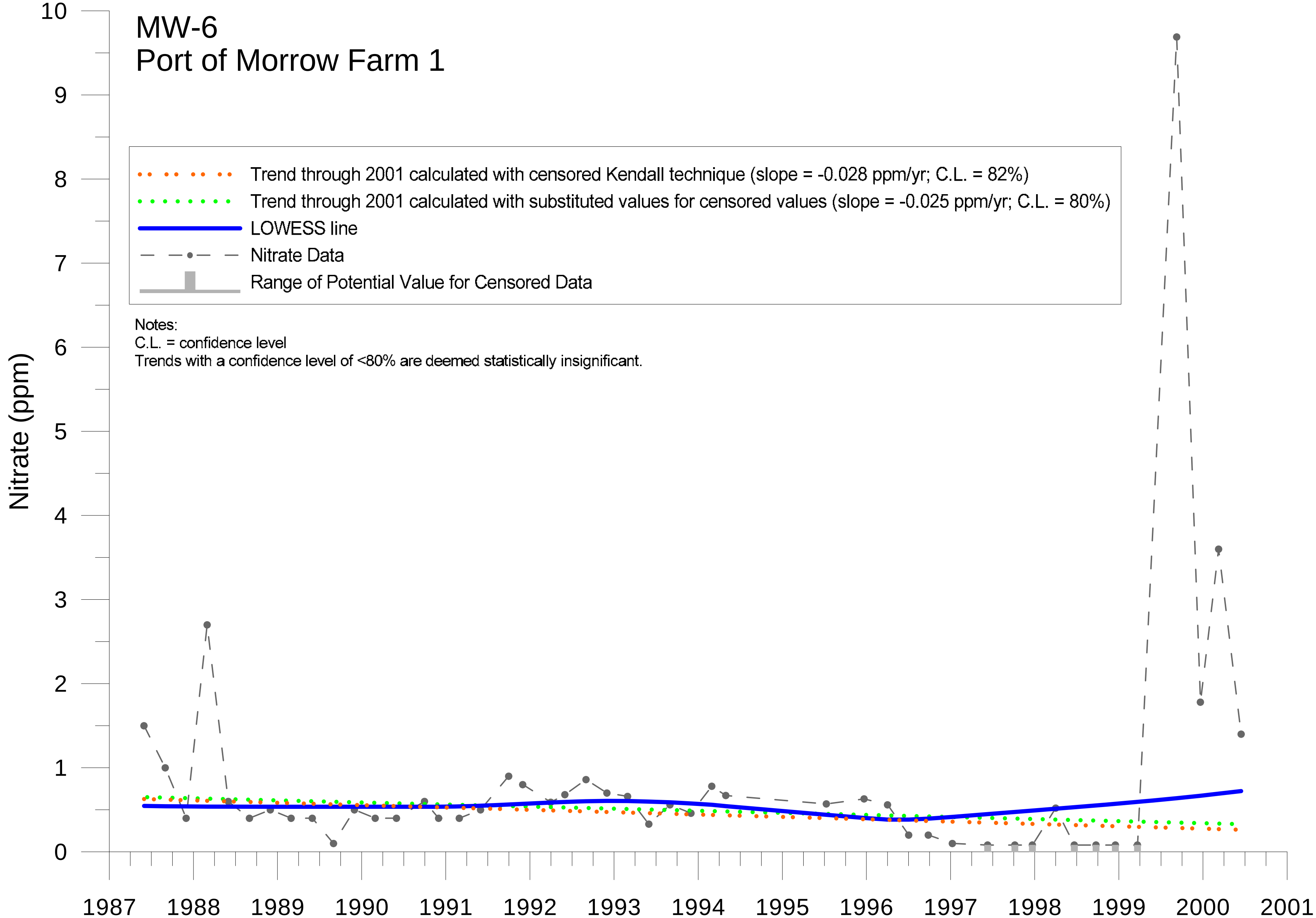


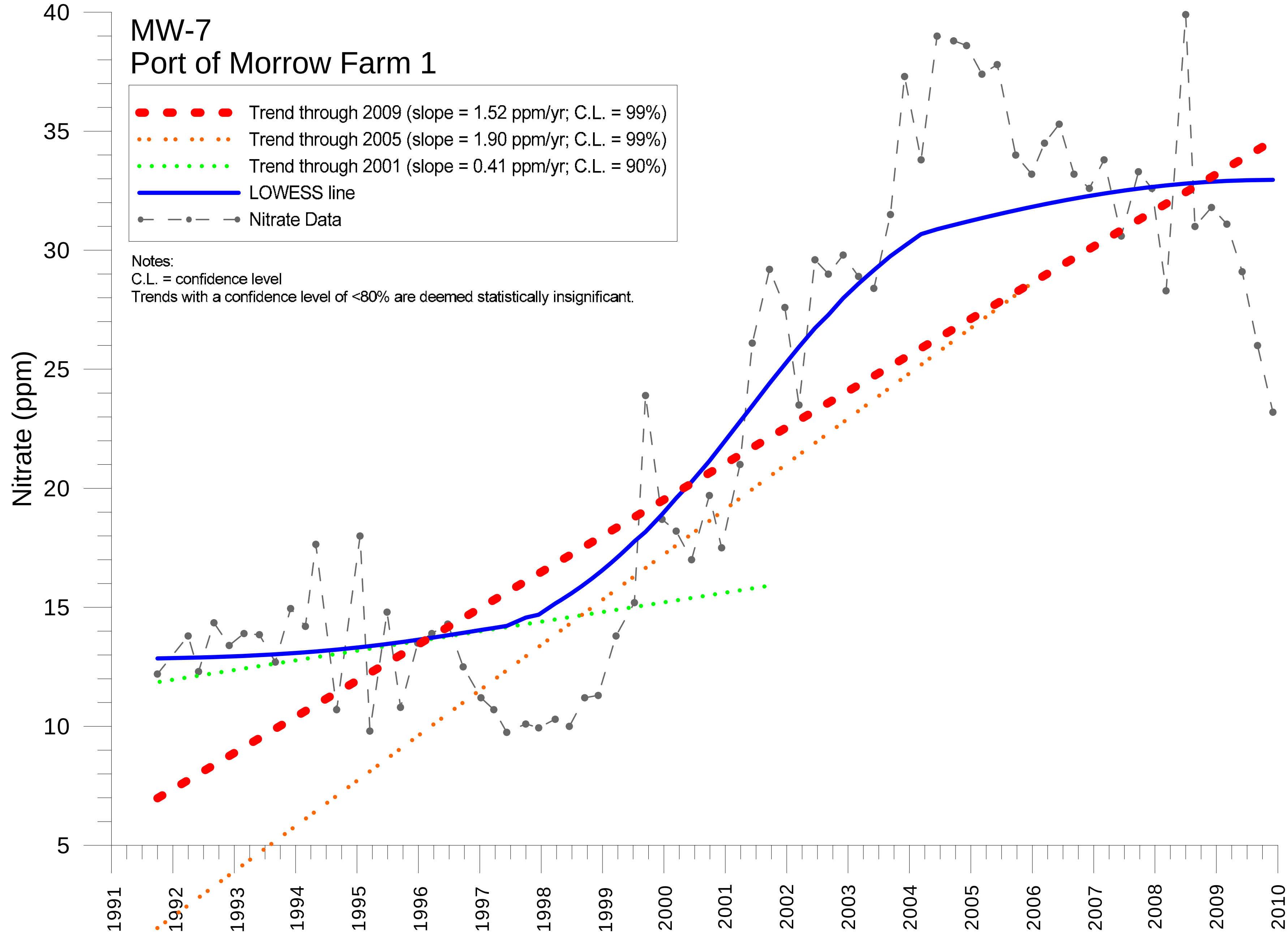
MW-3a
Port of Morrow Farm 1
Nitrate (ppm)
0
1
2
3
4
5
6
7
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 0.06 ppm/yr; C.L. < 80%)
Trend through 2005 (slope = -0.10 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

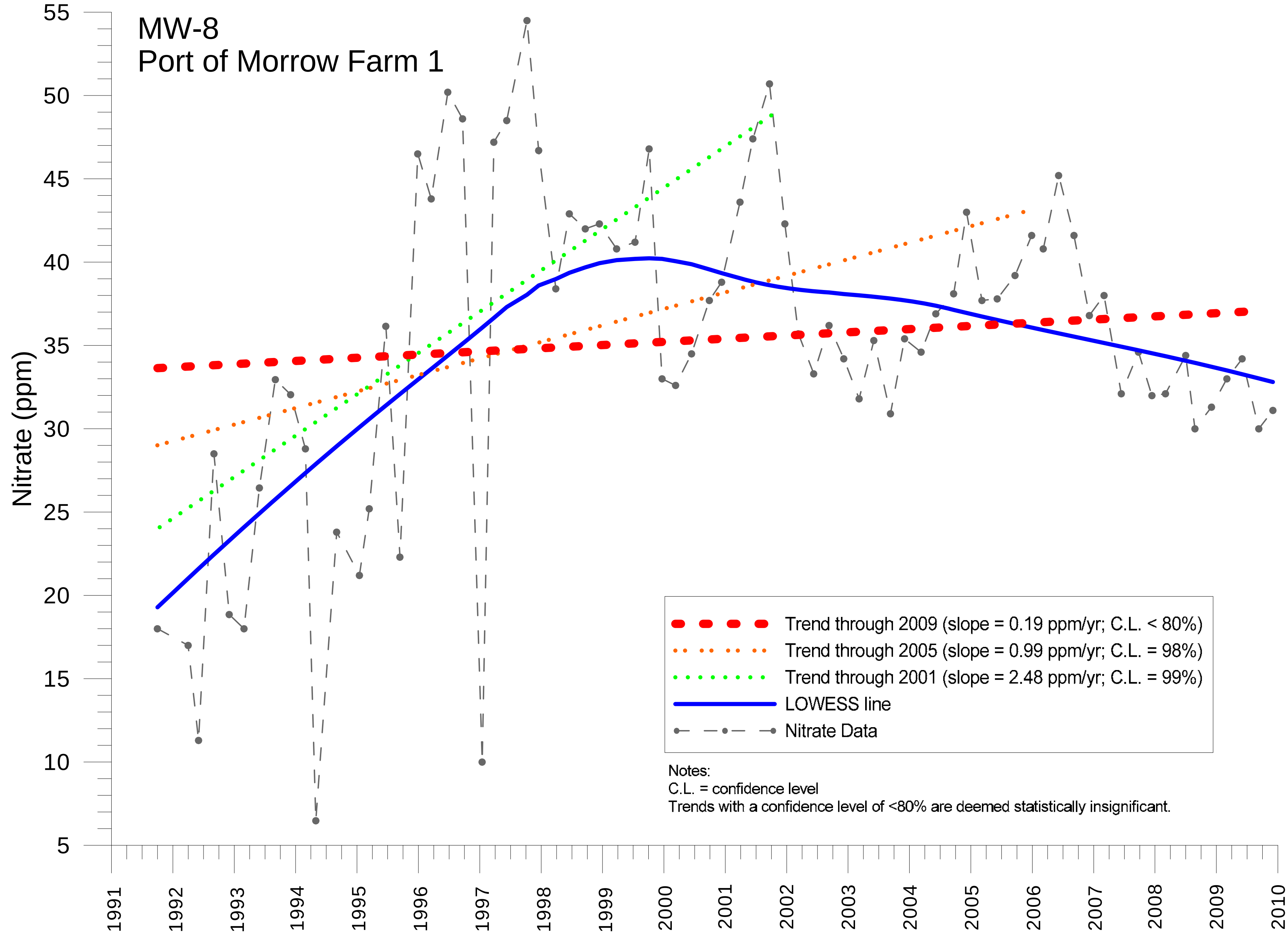

MW-4
Port of Morrow Farm 1
Trend through 2005 (slope = 0.29 ppm/yr; C.L. = 98%)
Trend through 2001 (slope = 0.31 ppm/yr; C.L. = 90%)
LOWESS line
Nitrate Data
Range of Potential Value for Censored Data
Nitrate (ppm)
0
5
10
15
20
25
30
35
40
45
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006



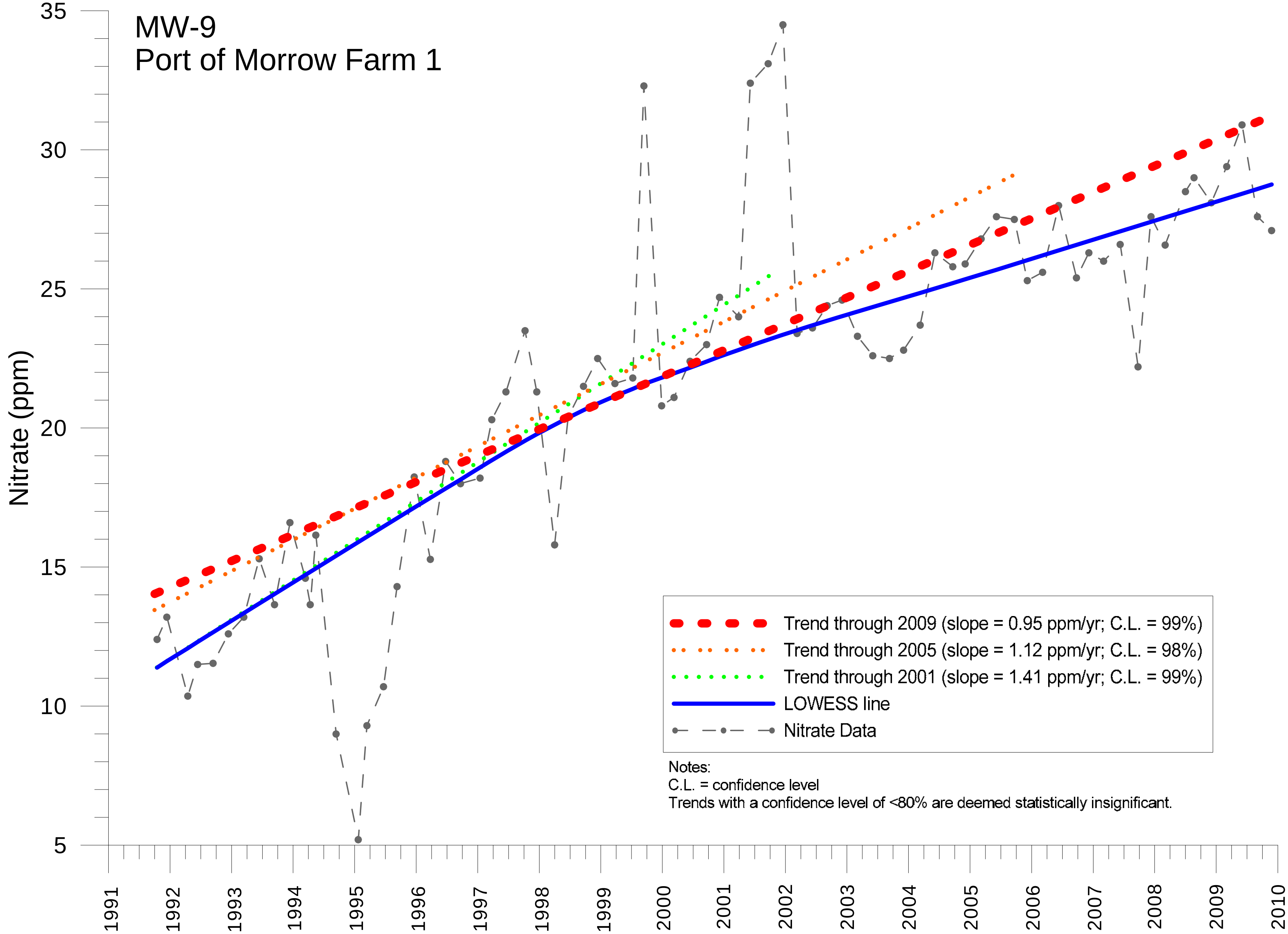
MW-5
Port of Morrow Farm 1
Trend through 2009 (slope = 0.05 ppm/yr; C.L. < 80%)
Trend through 2005 (slope = 0.08 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 0.67 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
40
35
30
25
20
15
10
5
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

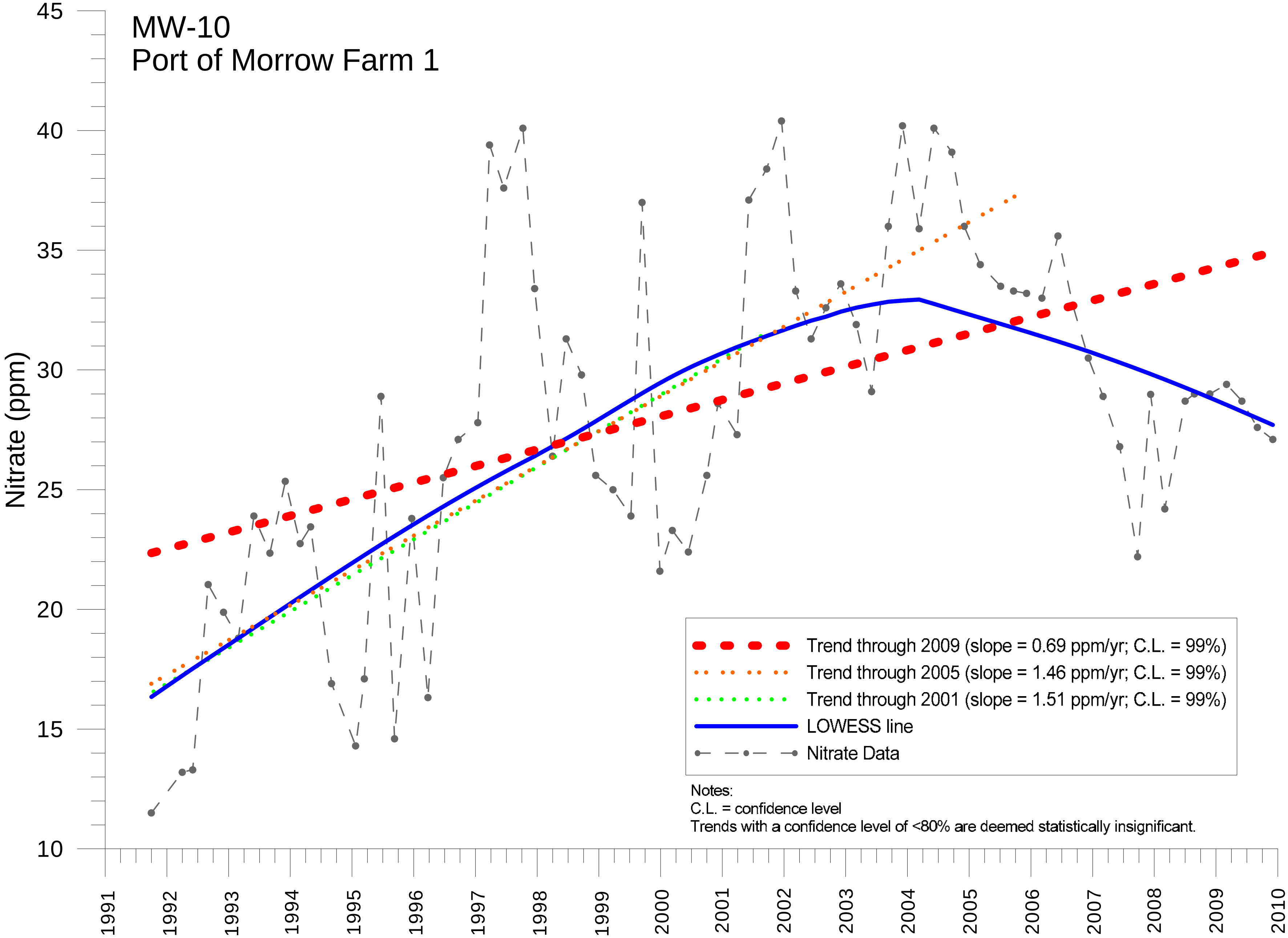

MW-6
Port of Morrow Farm 1
Trend through 2001 calculated with censored Kendall technique (slope = -0.028 ppm/yr; C.L. = 82%)
Trend through 2001 calculated with substituted values for censored values (slope = -0.025 ppm/yr; C.L. = 80%)
LOWESS line
Nitrate Data
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0
1
2
3
4
5
6
7
8
9
10
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001


MW-7
Port of Morrow Farm 1
Trend through 2009 (slope = 1.52 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 1.90 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.41 ppm/yr; C.L. = 90%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
40
35
30
25
20
15
10
5
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

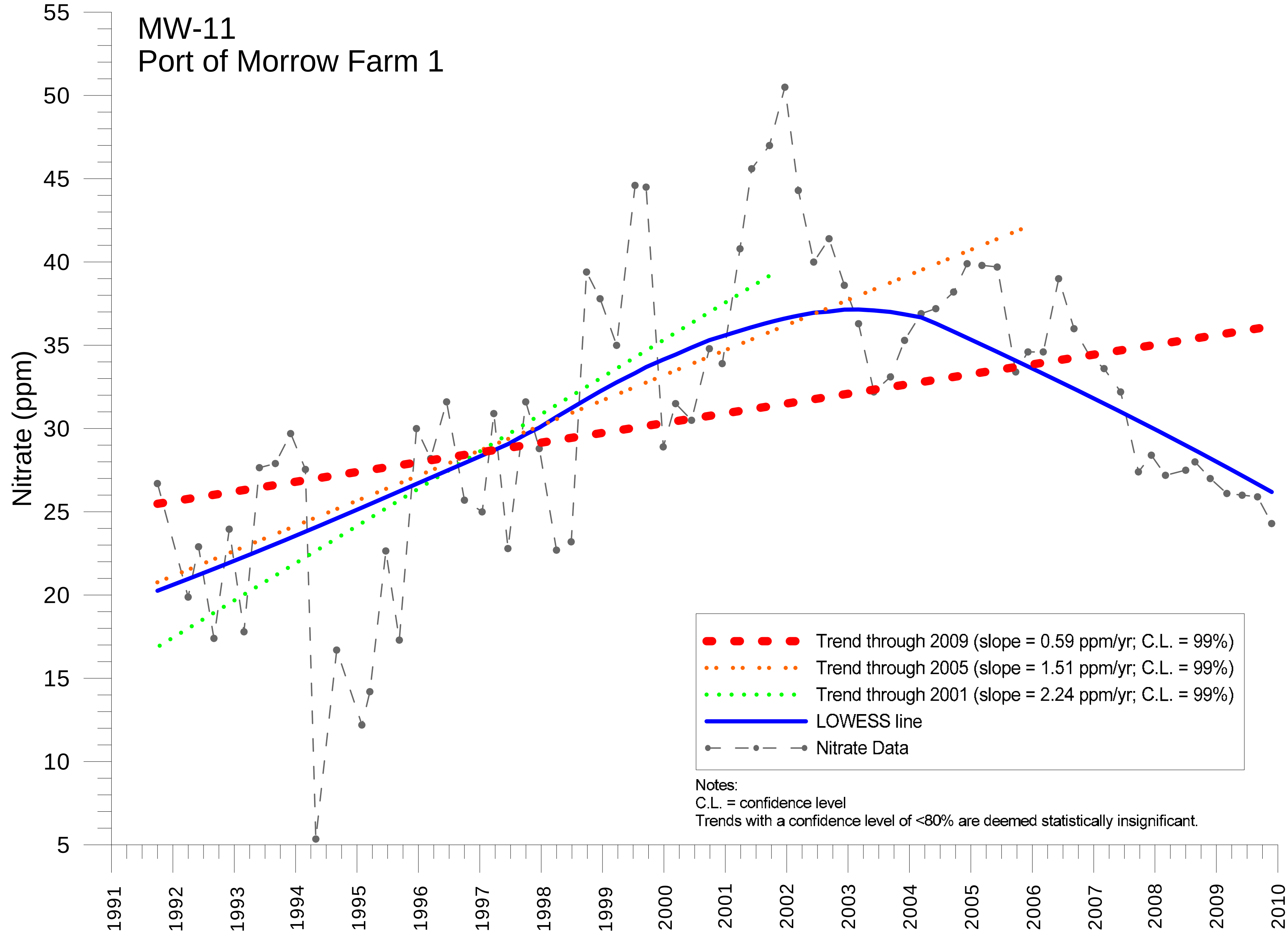


Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

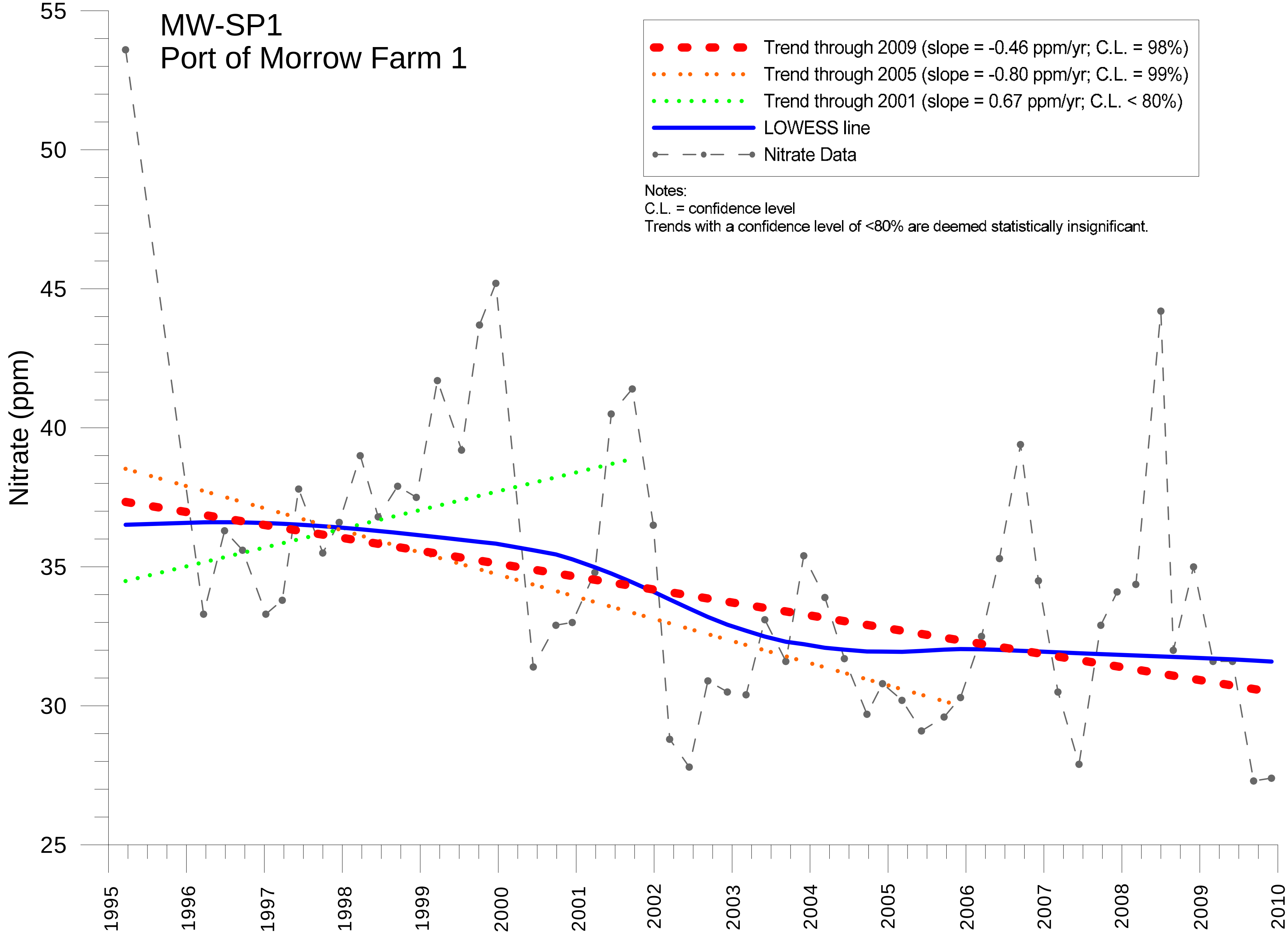

MW-9
Port of Morrow Farm 1
Nitrate (ppm)
35
30
25
20
15
10
5
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 0.95 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 1.12 ppm/yr; C.L. = 98%)
Trend through 2001 (slope = 1.41 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



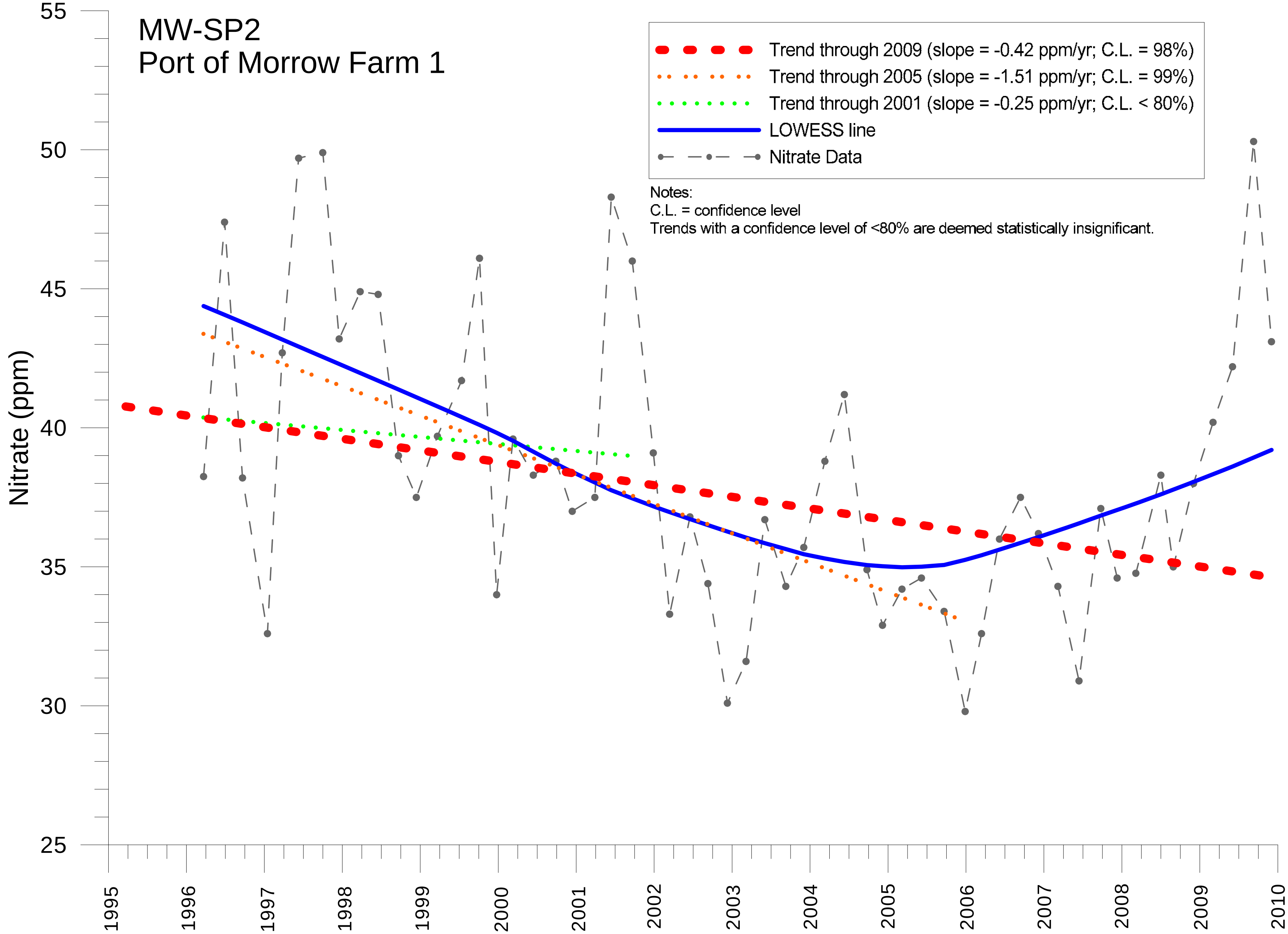
MW-10
Port of Morrow Farm 1
Nitrate (ppm)
45
40
35
30
25
20
15
10
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 0.69 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 1.46 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 1.51 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

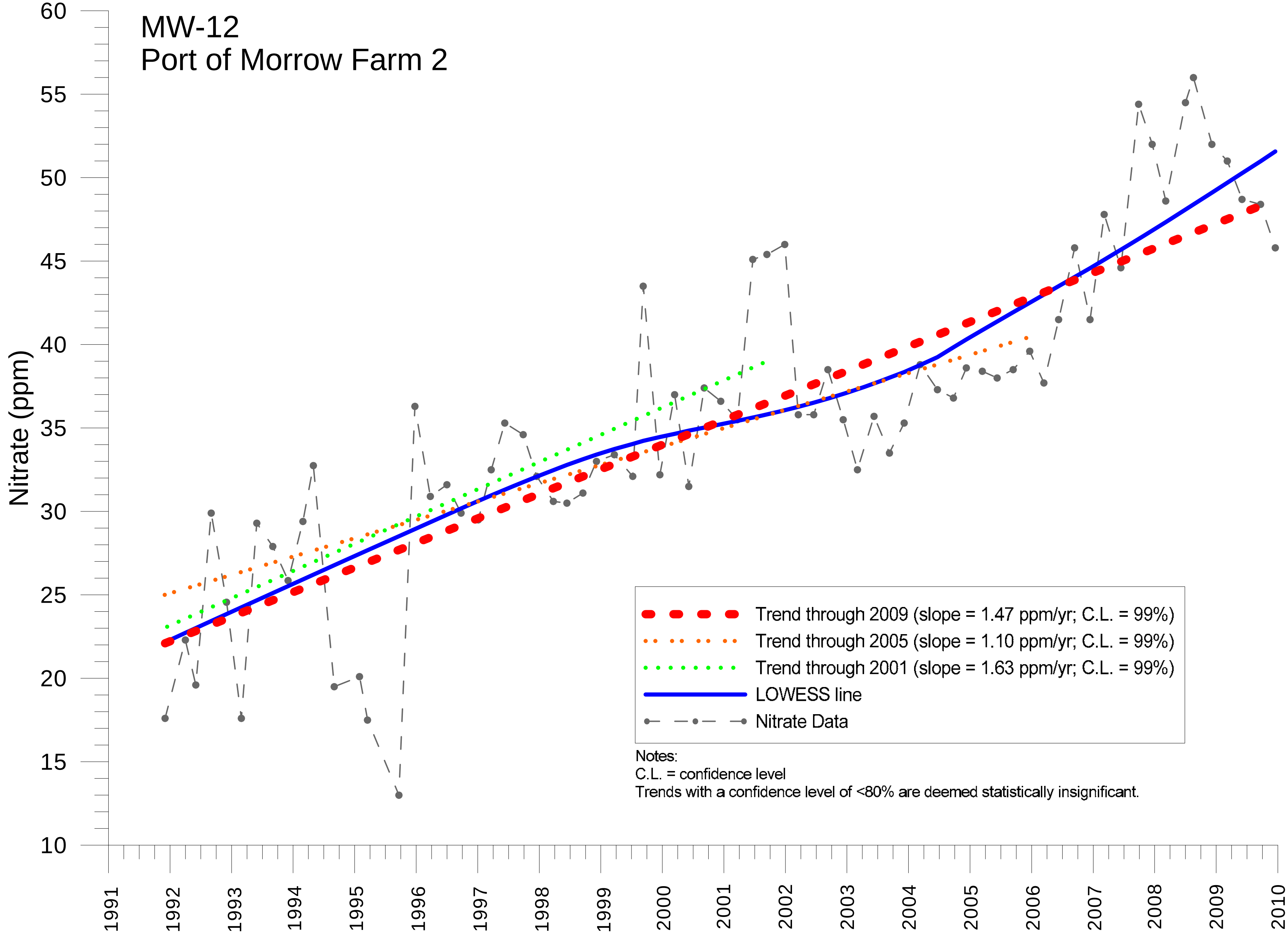


MW-11
Port of Morrow Farm 1
Nitrate (ppm)
55
50
45
40
35
30
25
20
15
10
5
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 0.59 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 1.51 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 2.24 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

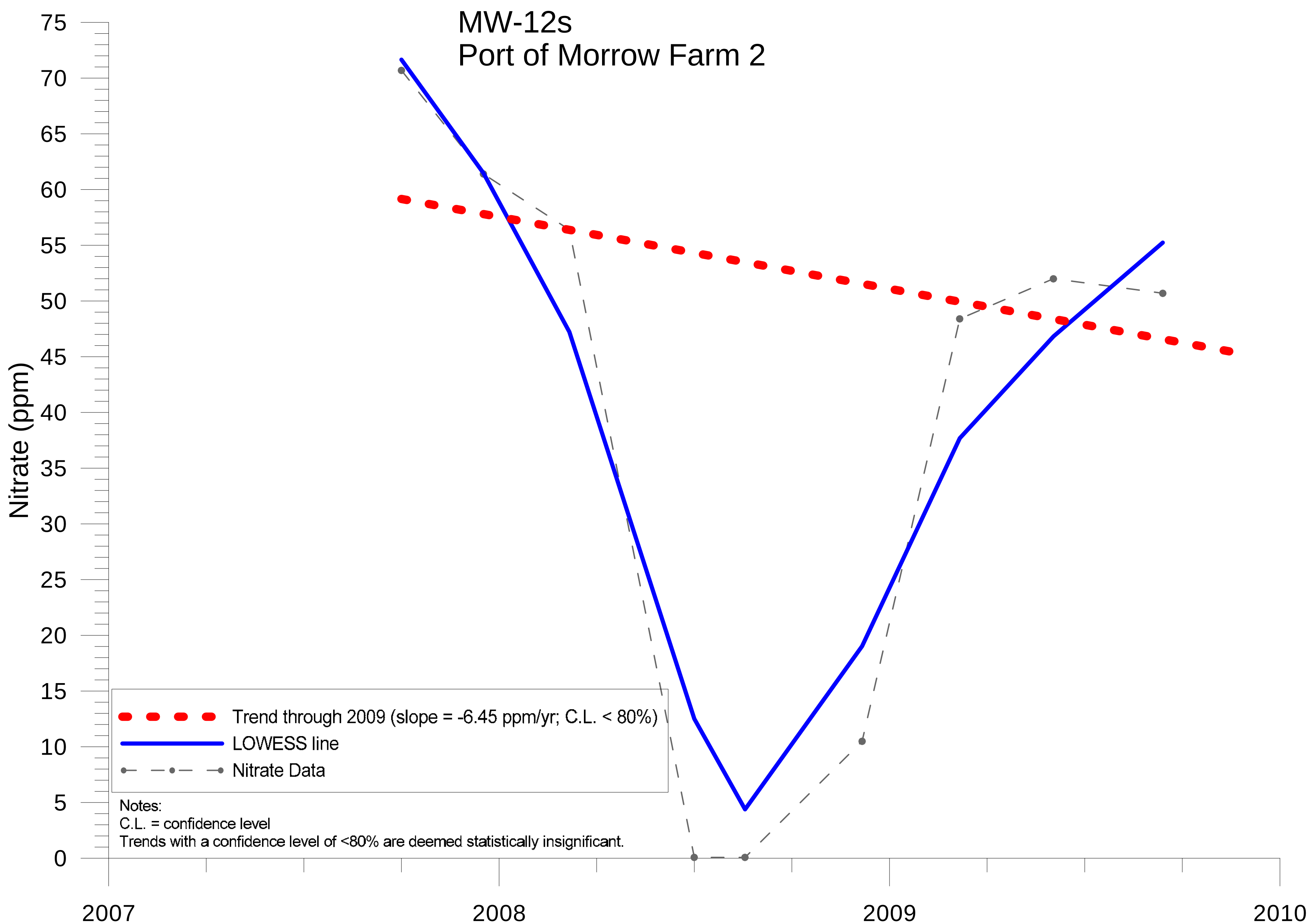


MW-SP1
Port of Morrow Farm 1
Trend through 2009 (slope = -0.46 ppm/yr; C.L. = 98%)
Trend through 2005 (slope = -0.80 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.67 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
55
50
45
40
35
30
25
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

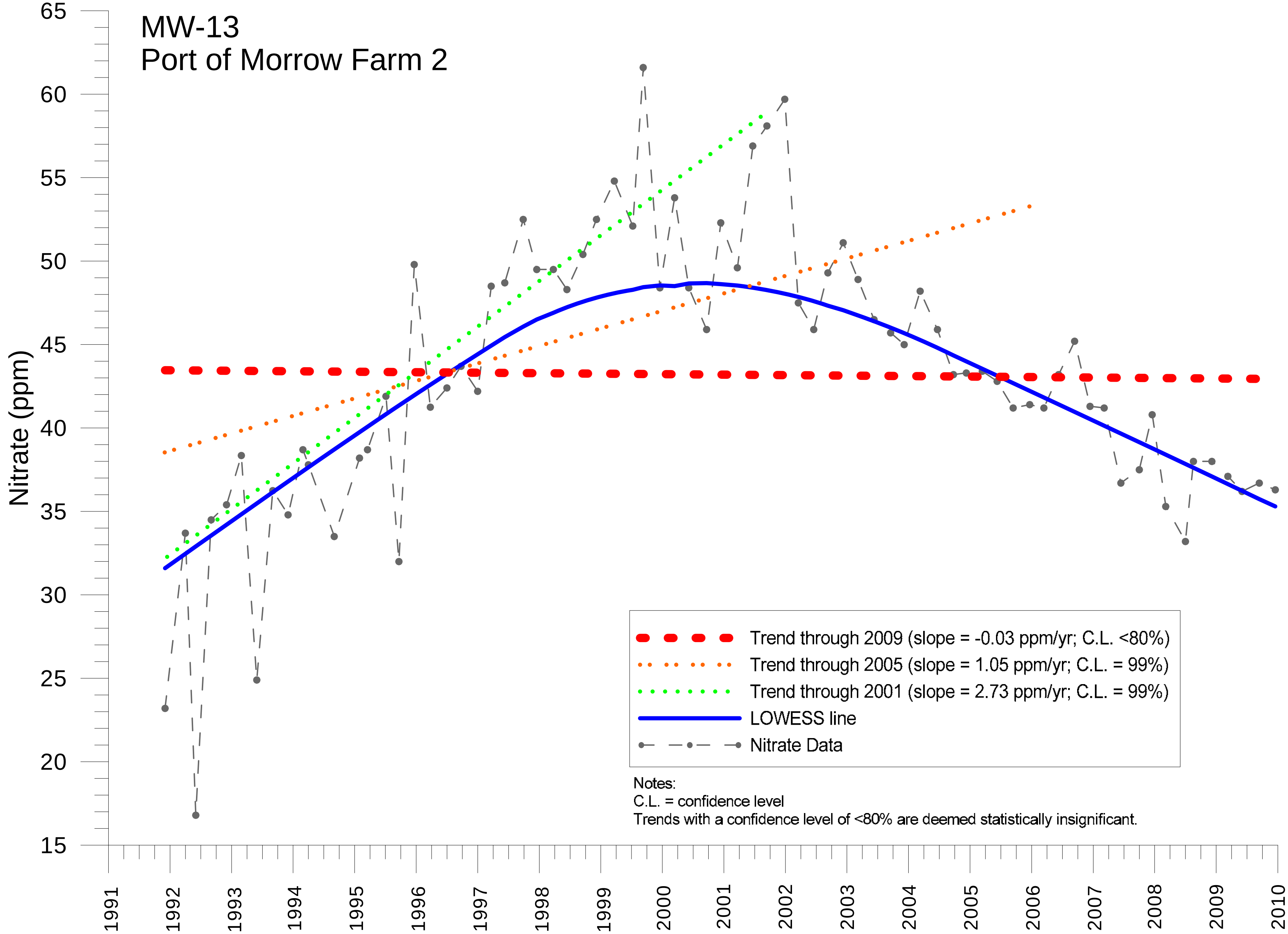

MW-SP2
Port of Morrow Farm 1
Trend through 2009 (slope = -0.42 ppm/yr; C.L. = 98%)
Trend through 2005 (slope = -1.51 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = -0.25 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
55
50
45
40
35
30
25
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

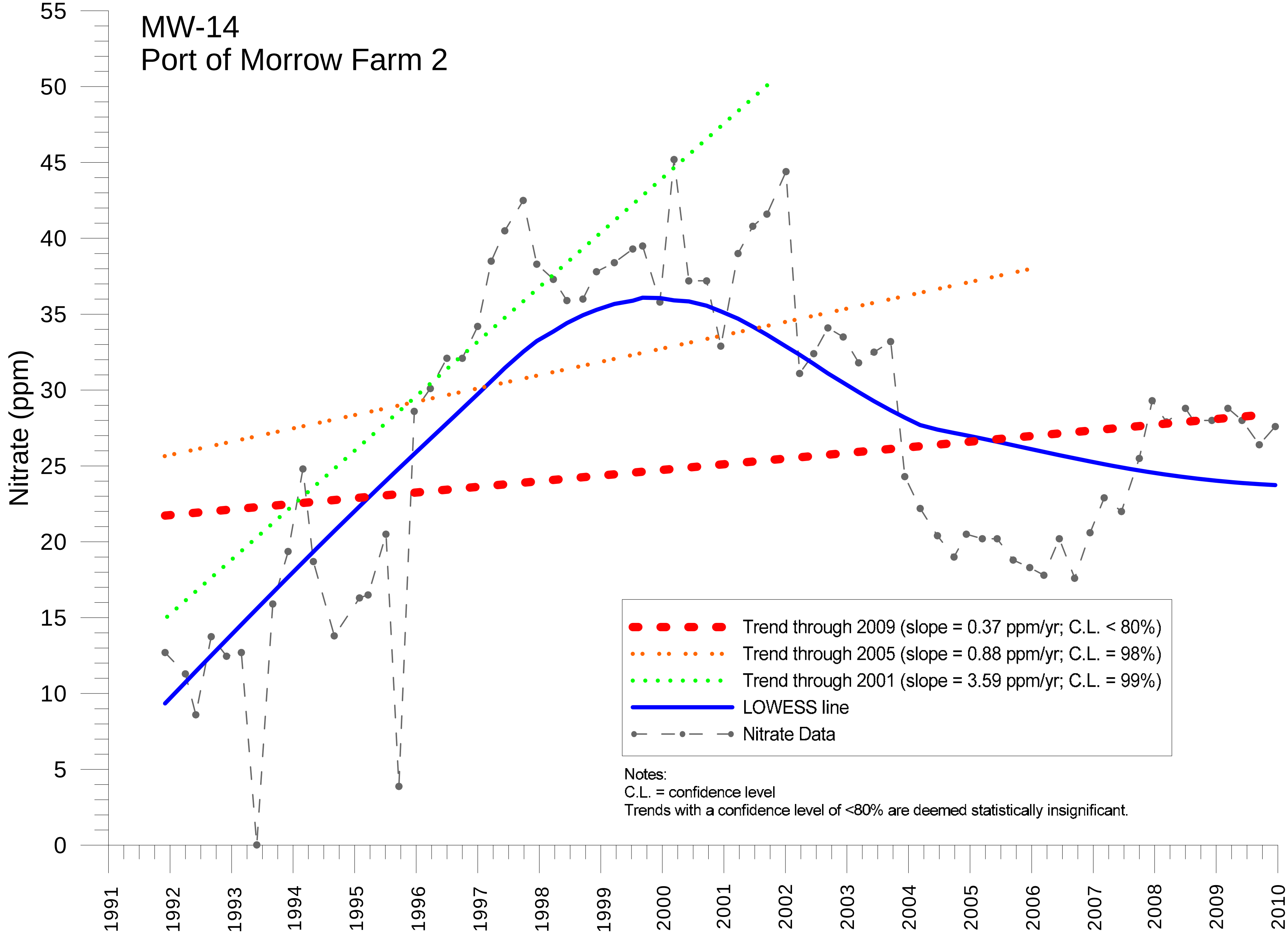


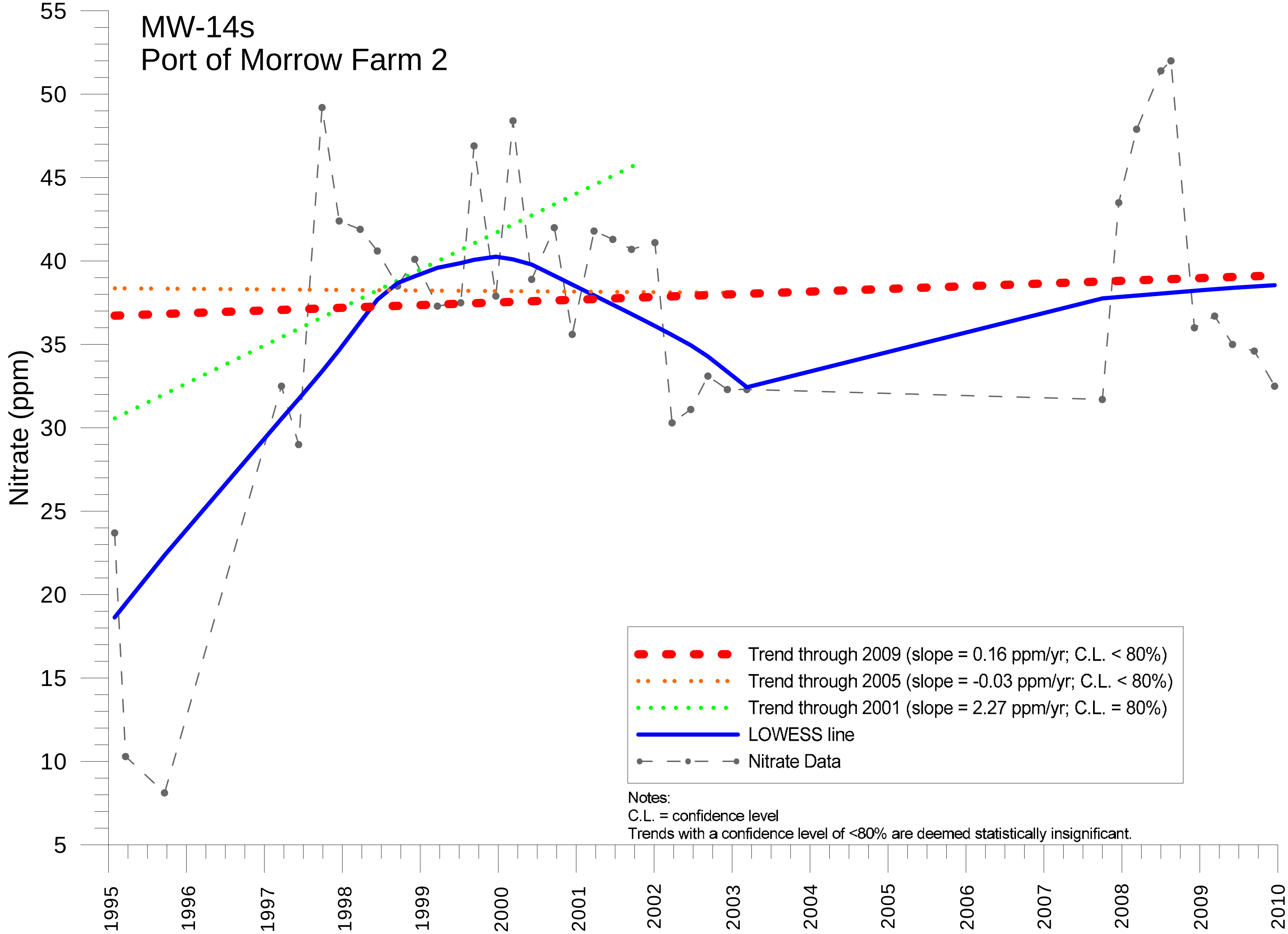
MW-12
Port of Morrow Farm 2
Nitrate (ppm)
60
55
50
45
40
35
30
25
20
15
10
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 1.47 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 1.10 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 1.63 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



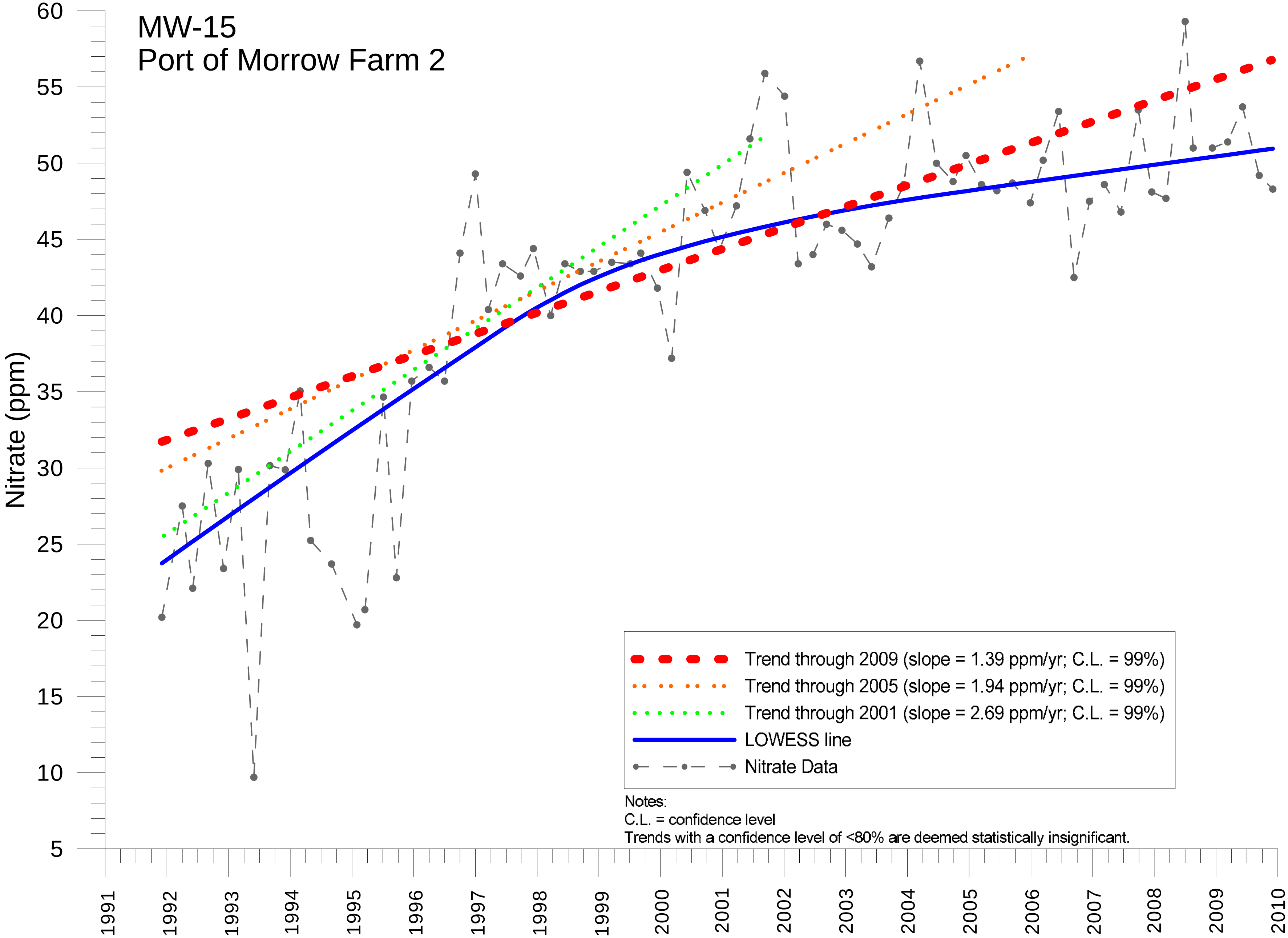
MW-12s
Port of Morrow Farm 2
Nitrate (ppm)
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
2007
2008
2009
2010
Trend through 2009 (slope = -6.45 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

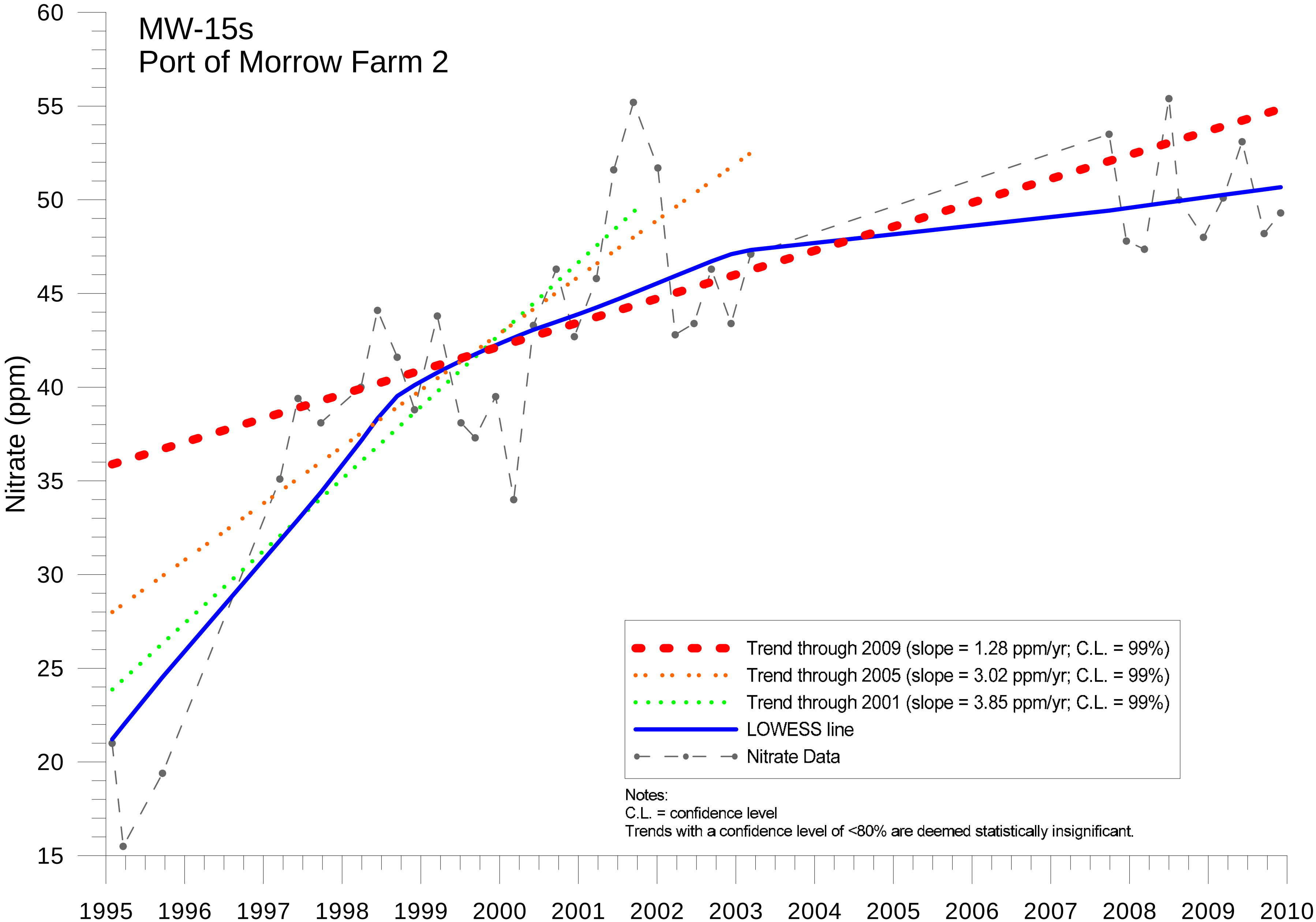

MW-13
Port of Morrow Farm 2
Nitrate (ppm)
65
60
55
50
45
40
35
30
25
20
15
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = -0.03 ppm/yr; C.L. <80%)
Trend through 2005 (slope = 1.05 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 2.73 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.


MW-14
Port of Morrow Farm 2
Nitrate (ppm)
0
5
10
15
20
25
30
35
40
45
50
55
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 0.37 ppm/yr; C.L. < 80%)
Trend through 2005 (slope = 0.88 ppm/yr; C.L. = 98%)
Trend through 2001 (slope = 3.59 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

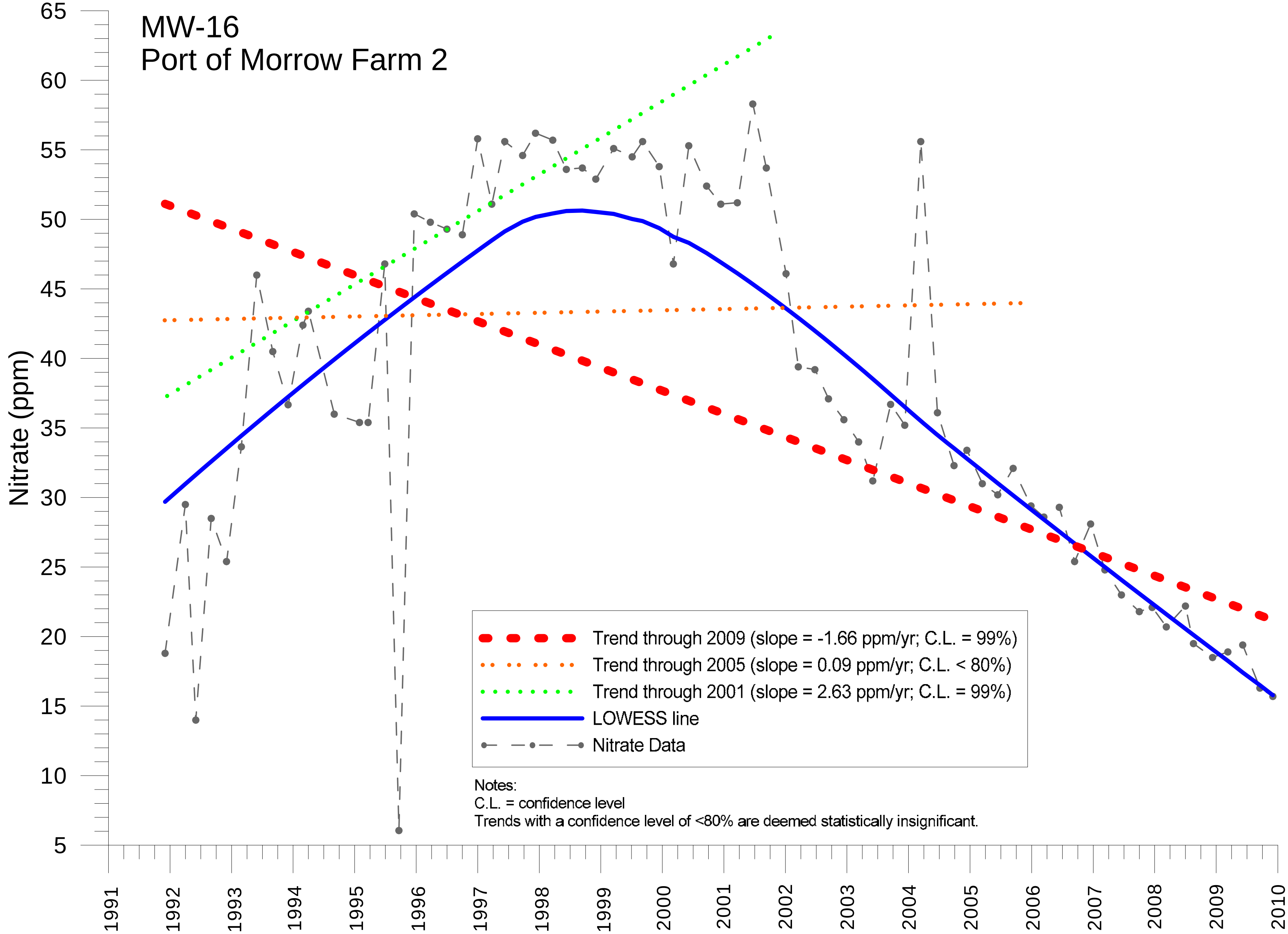


Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

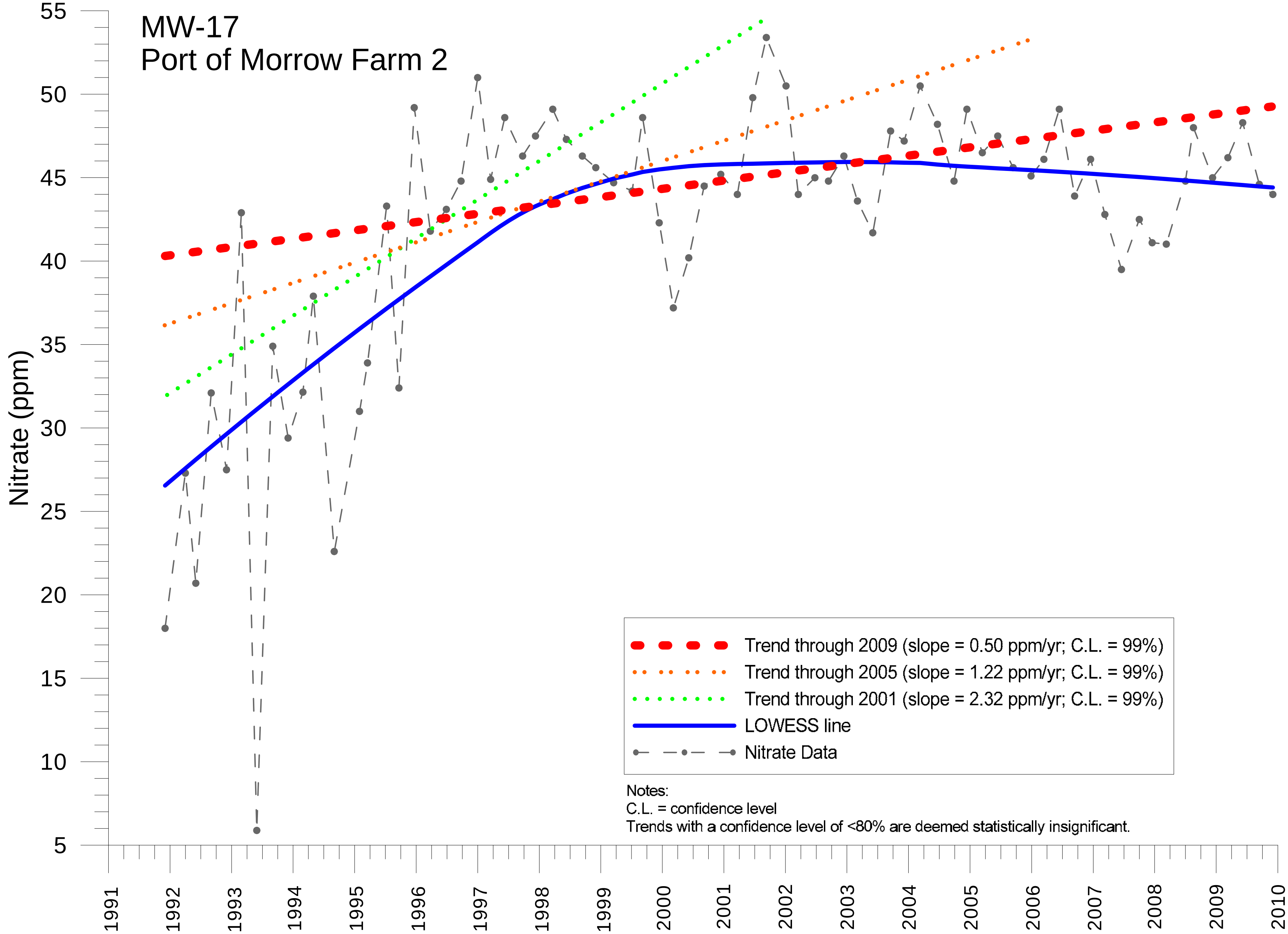

MW-15
Port of Morrow Farm 2
Nitrate (ppm)
60
55
50
45
40
35
30
25
20
15
10
5
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 1.39 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 1.94 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 2.69 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



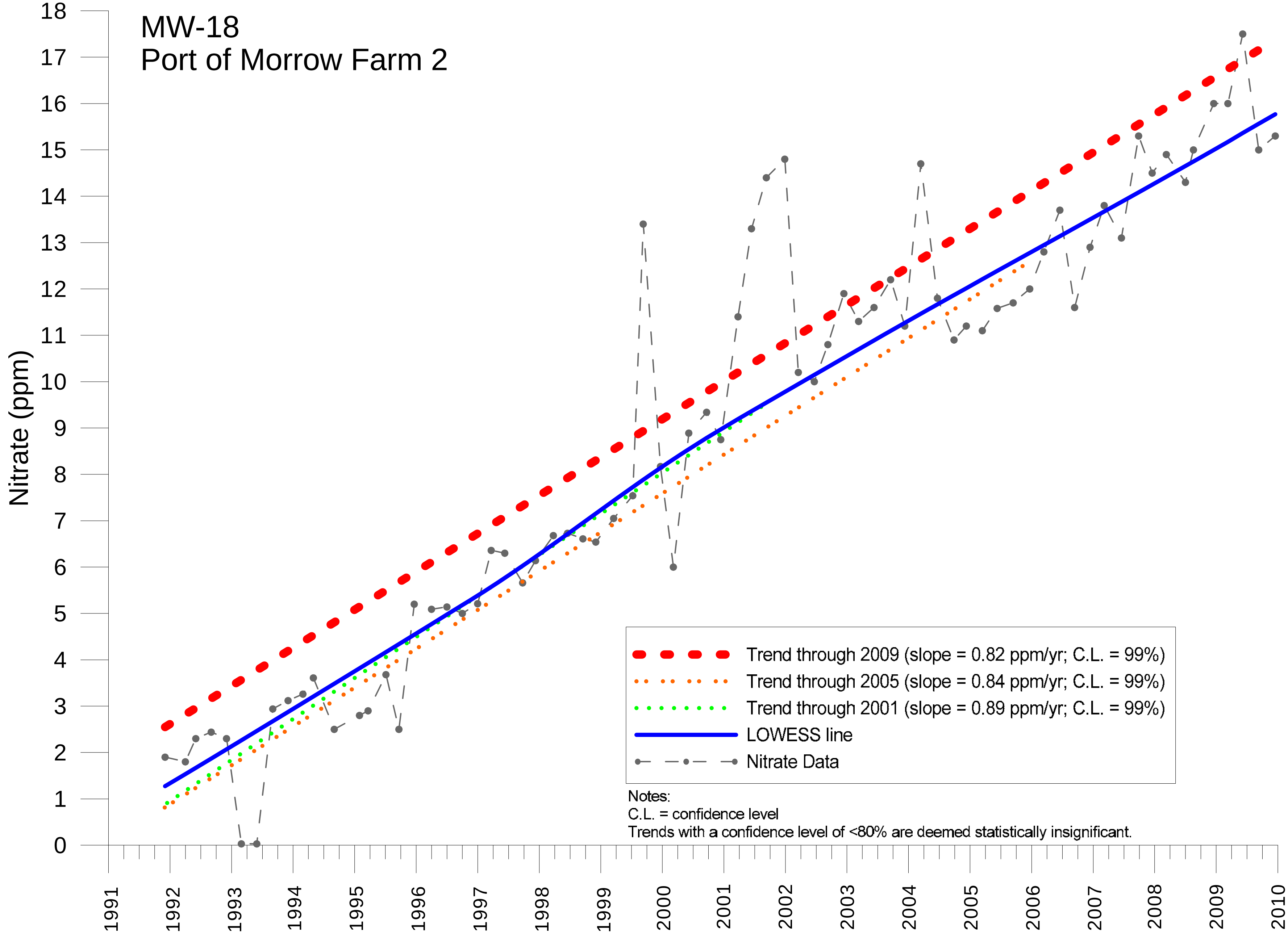
MW-15s
Port of Morrow Farm 2
Nitrate (ppm)
60
55
50
45
40
35
30
25
20
15
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 1.28 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 3.02 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 3.85 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



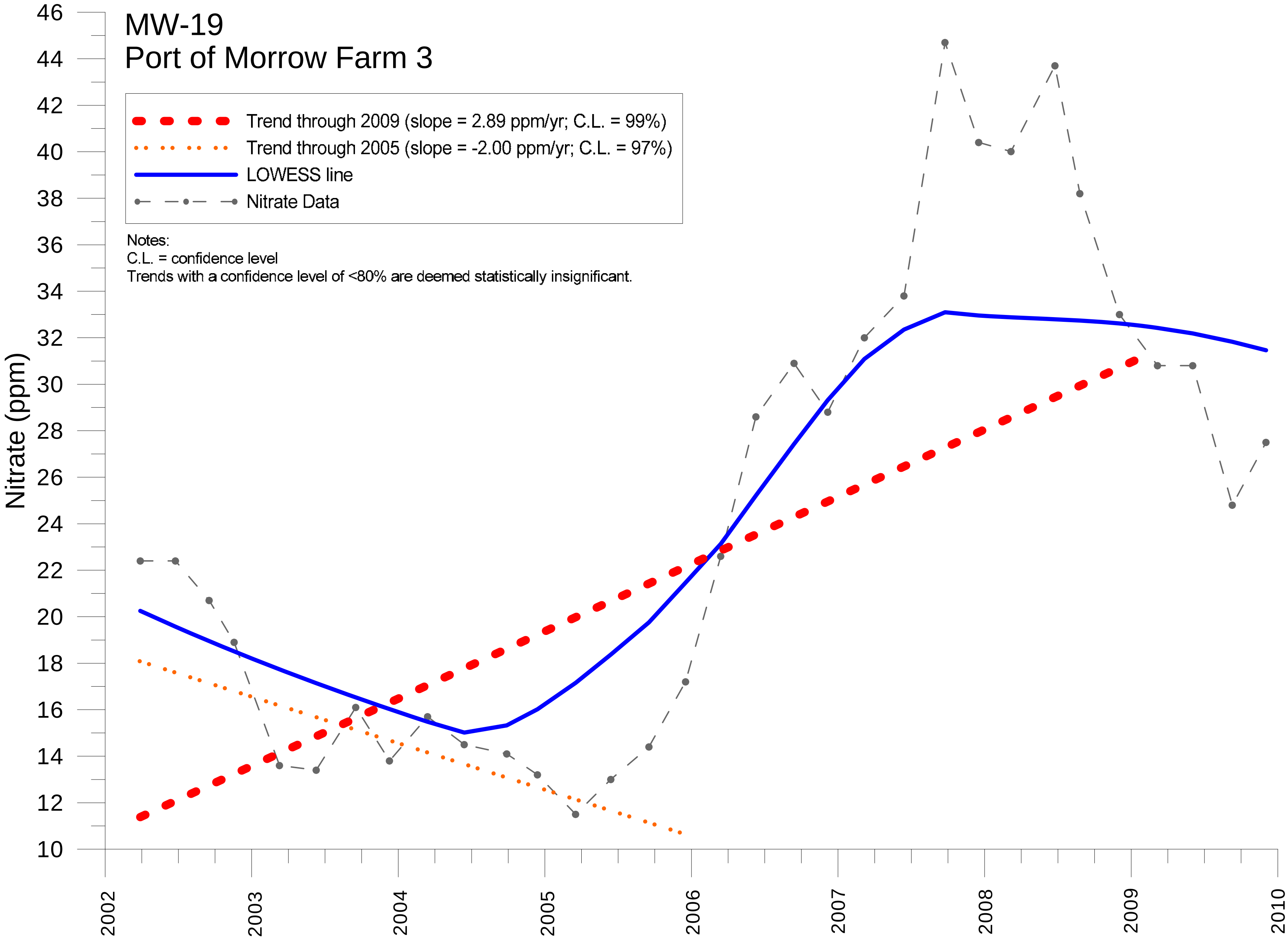
MW-16
Port of Morrow Farm 2
Nitrate (ppm)
65
60
55
50
45
40
35
30
25
20
15
10
5
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = -1.66 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 0.09 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 2.63 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

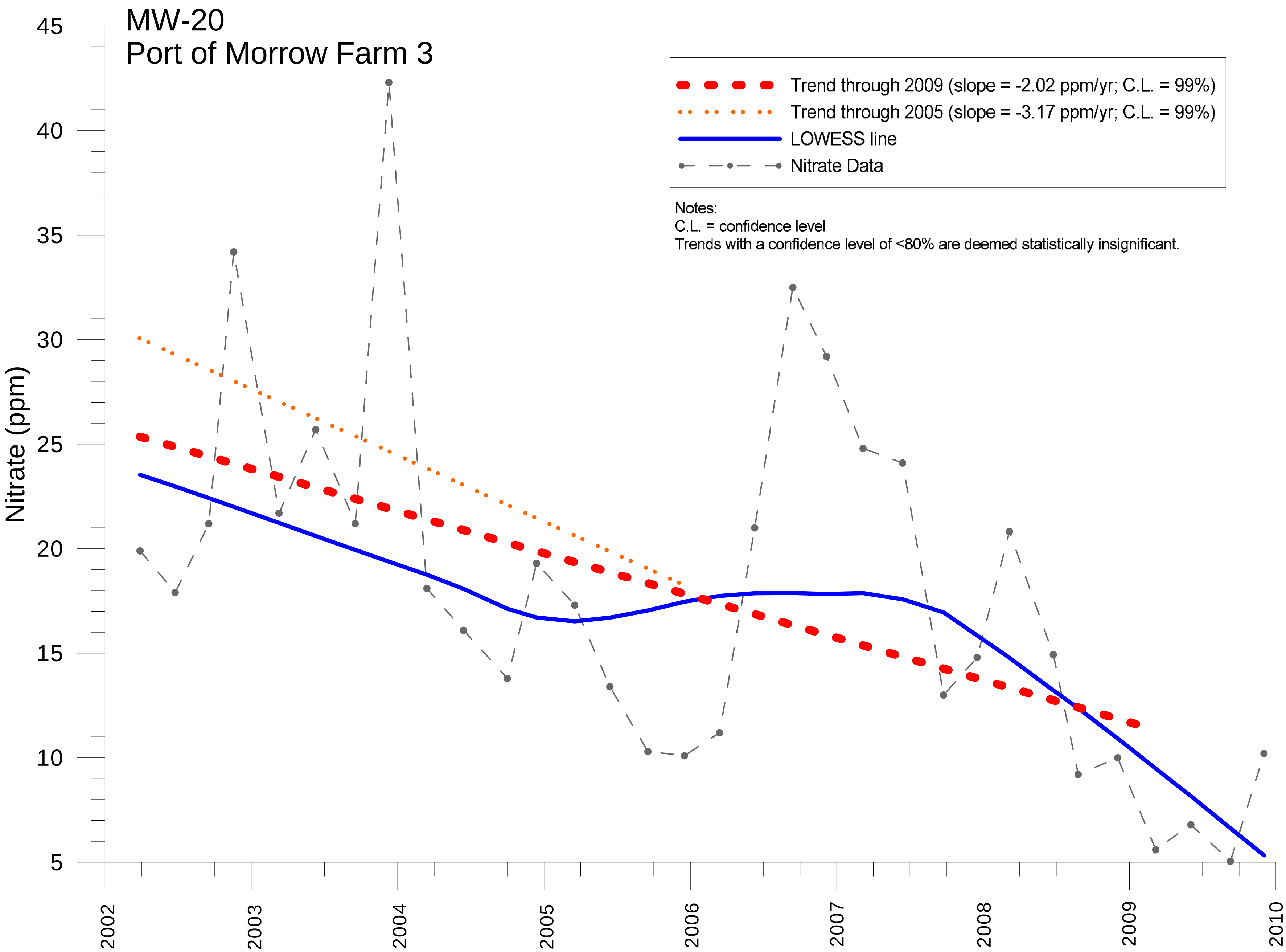


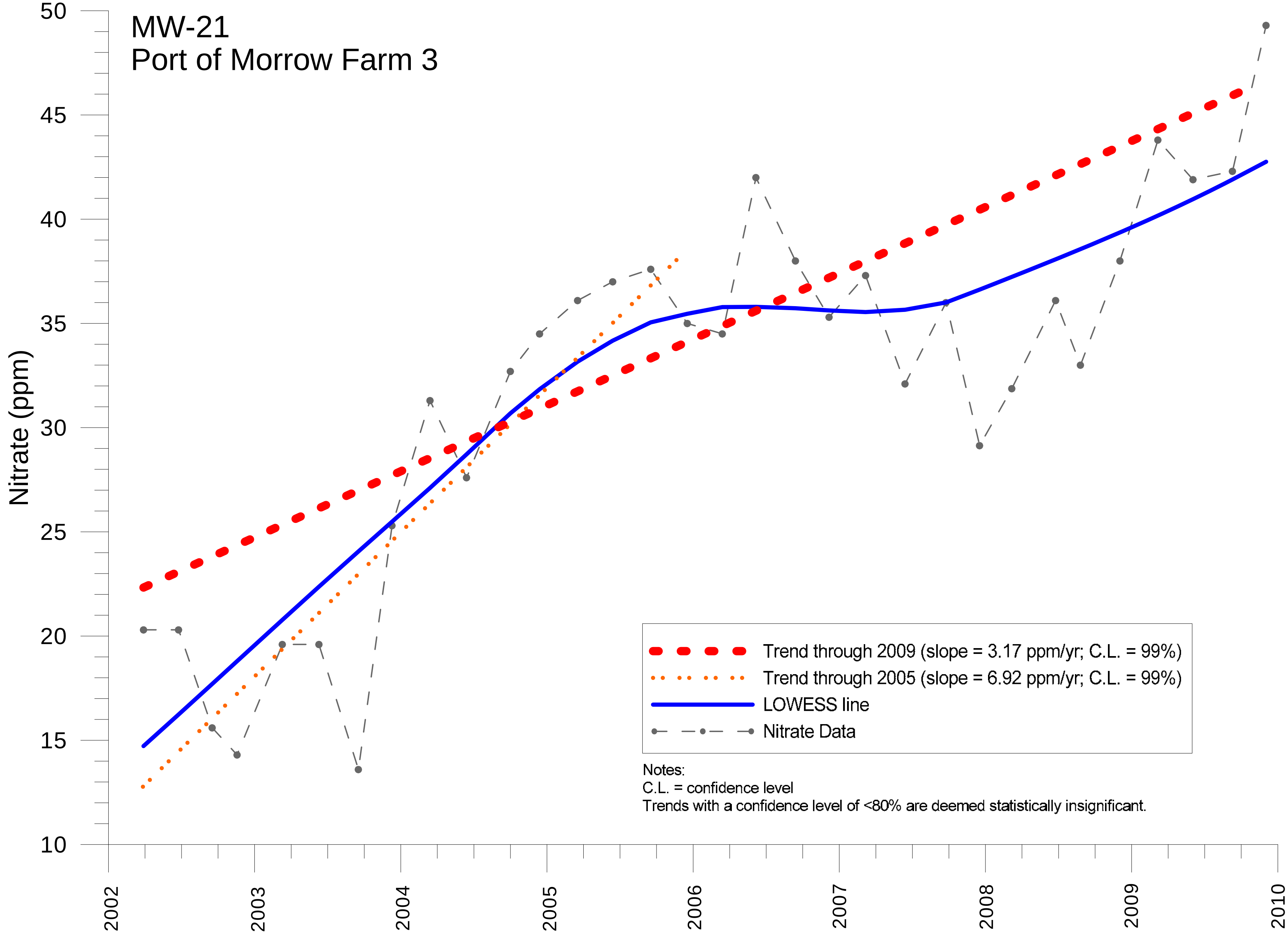
MW-17
Port of Morrow Farm 2
Nitrate (ppm)
55
50
45
40
35
30
25
20
15
10
5
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 0.50 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 1.22 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 2.32 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

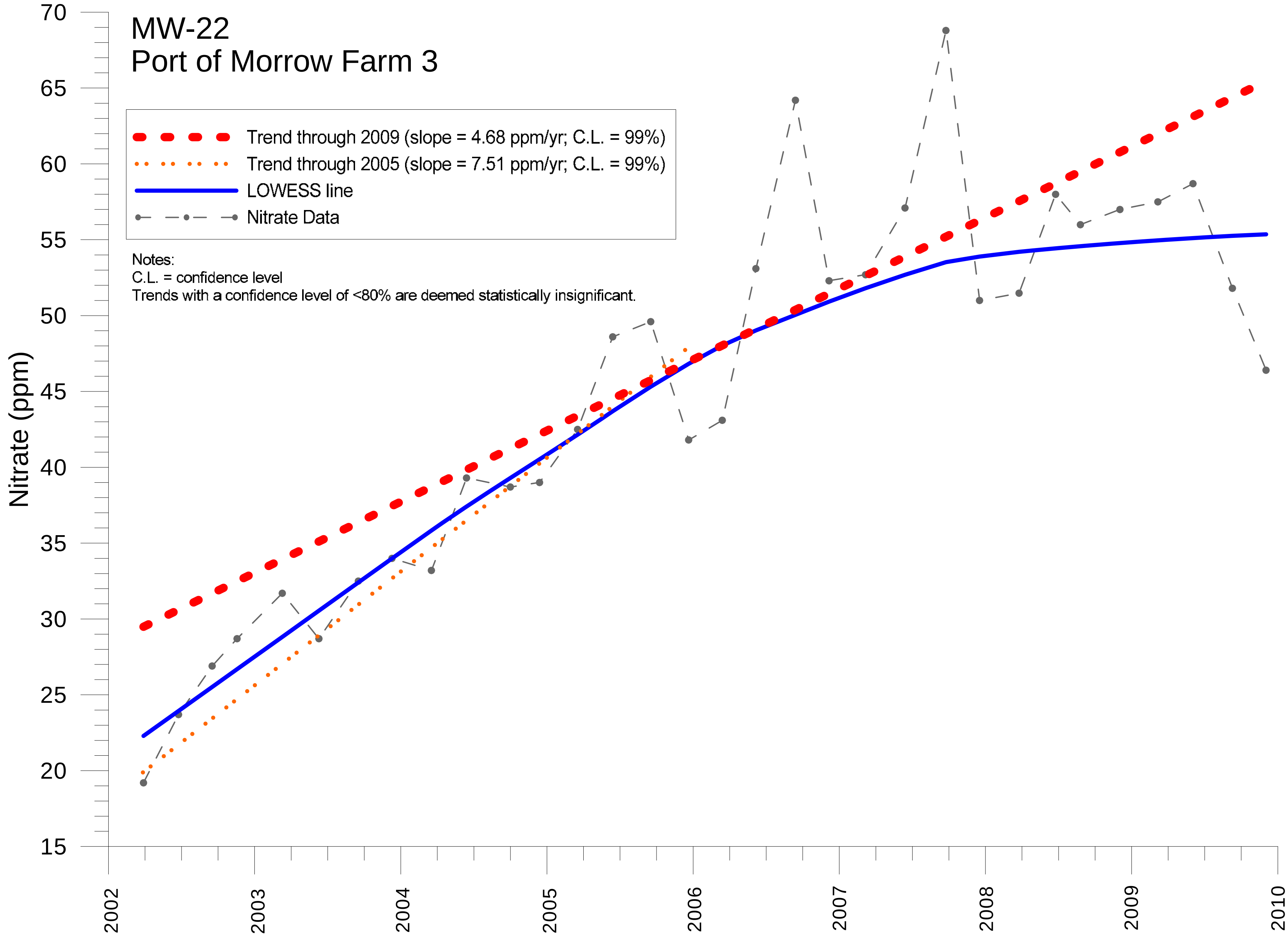


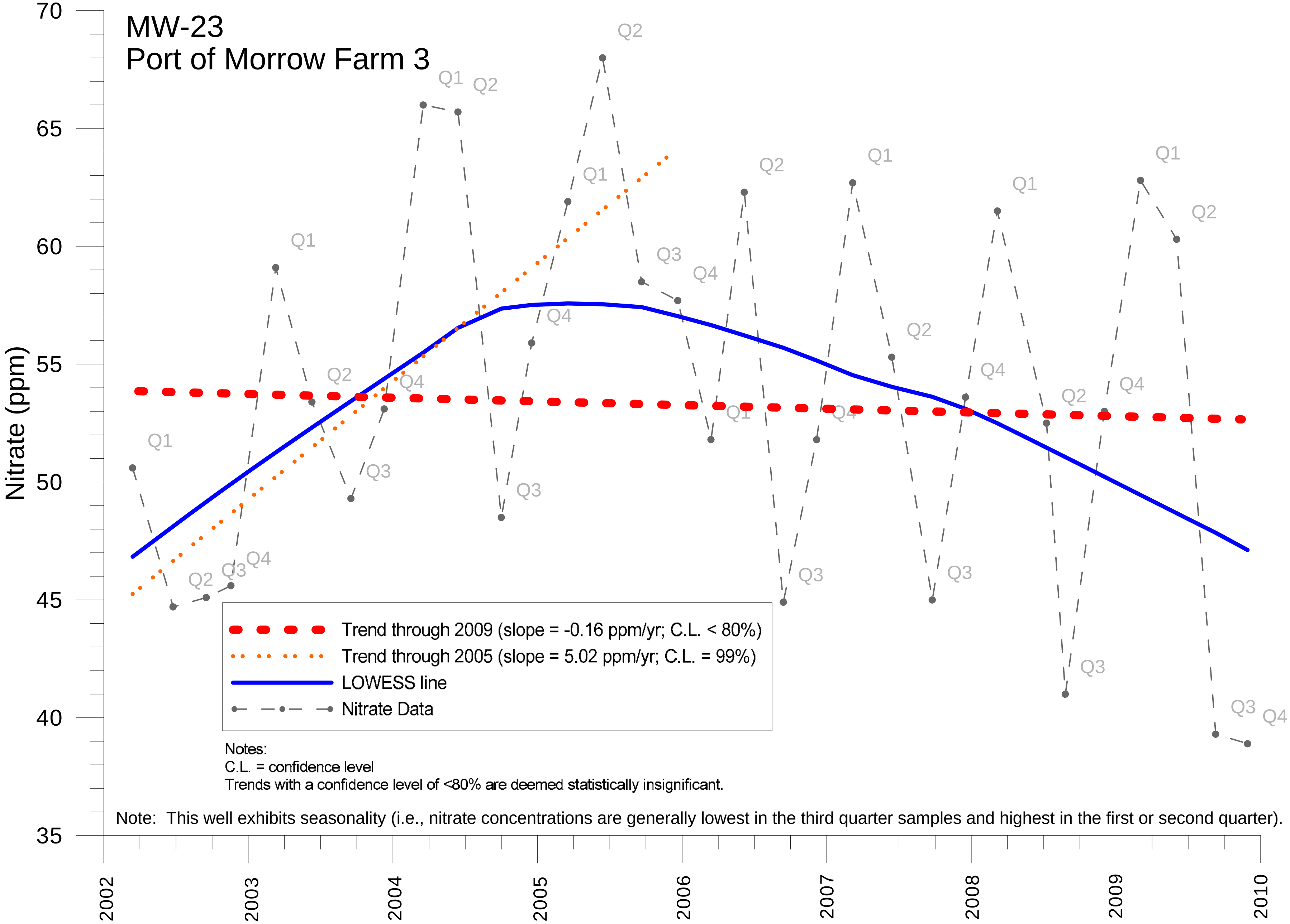
MW-18
Port of Morrow Farm 2
Nitrate (ppm)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 0.82 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 0.84 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.89 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.


MW-19
Port of Morrow Farm 3
Trend through 2009 (slope = 2.89 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = -2.00 ppm/yr; C.L. = 97%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
2002
2003
2004
2005
2006
2007
2008
2009
2010

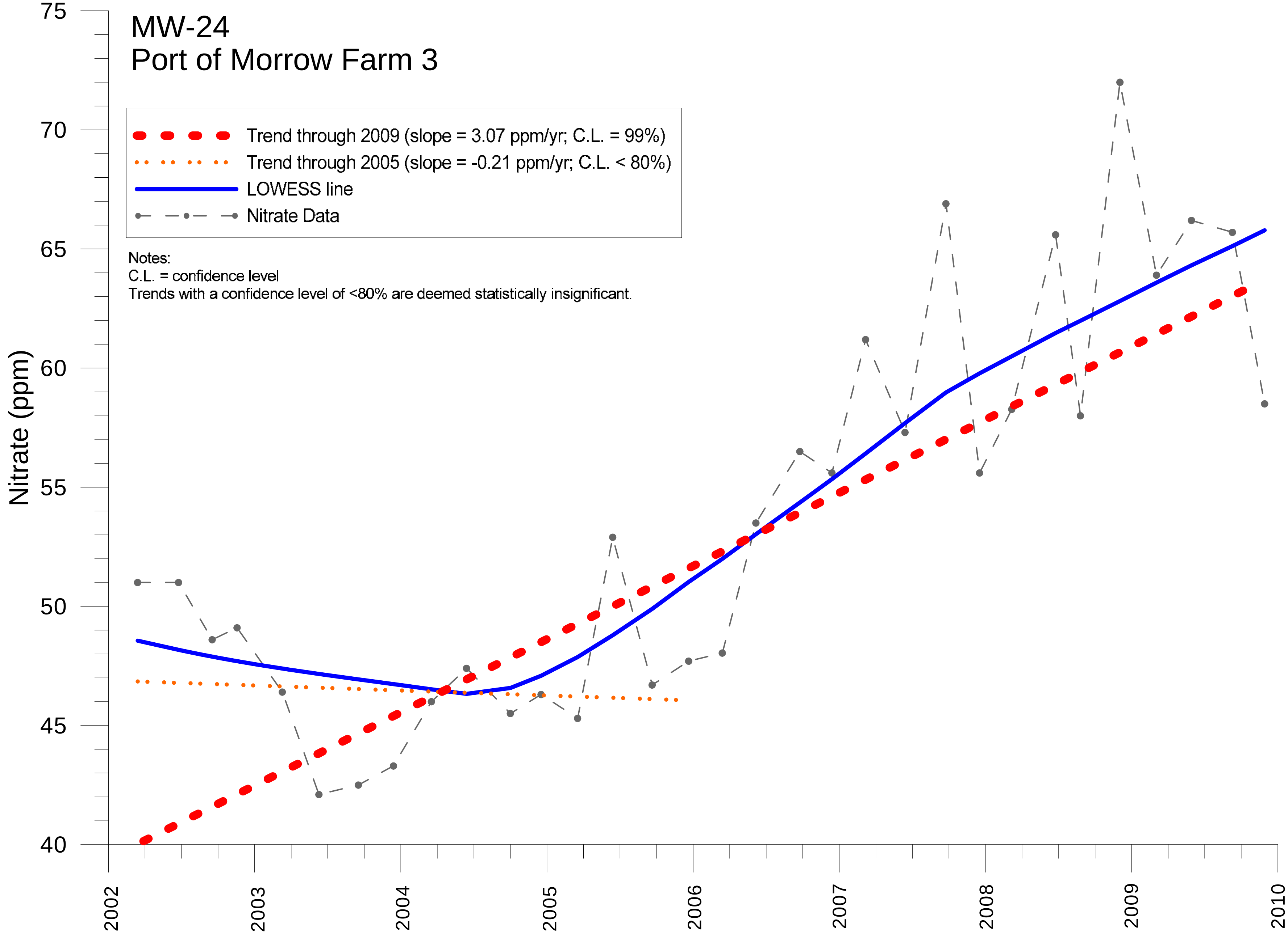

MW-20
Port of Morrow Farm 3
Trend through 2009 (slope = -2.02 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = -3.17 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
45
40
35
30
25
20
15
10
5
2002
2003
2004
2005
2006
2007
2008
2009
2010


MW-21
Port of Morrow Farm 3
Nitrate (ppm)
50
45
40
35
30
25
20
15
10
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 3.17 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 6.92 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

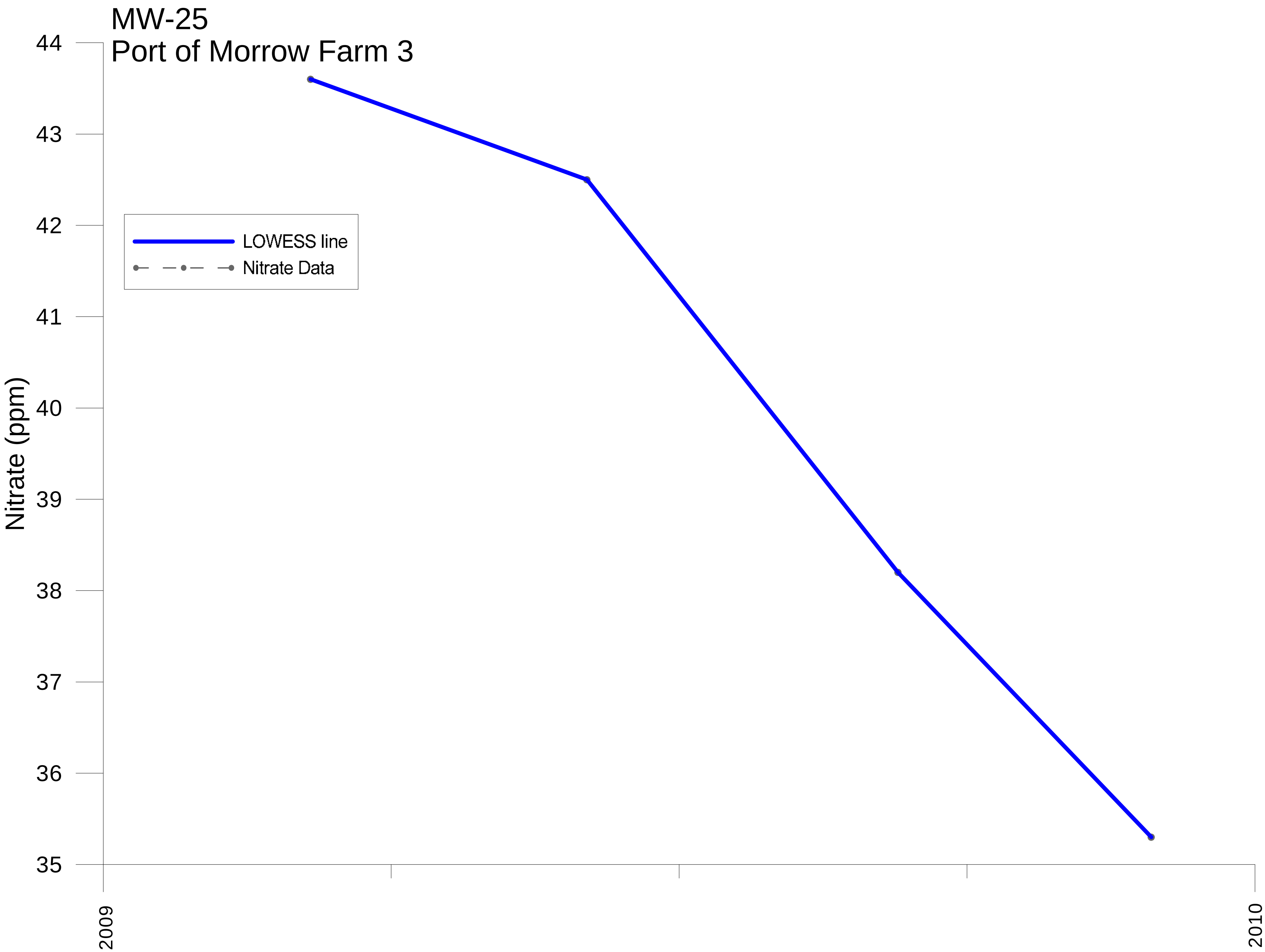

MW-22
Port of Morrow Farm 3
Trend through 2009 (slope = 4.68 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 7.51 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
70
65
60
55
50
45
40
35
30
25
20
15
2002
2003
2004
2005
2006
2007
2008
2009
2010

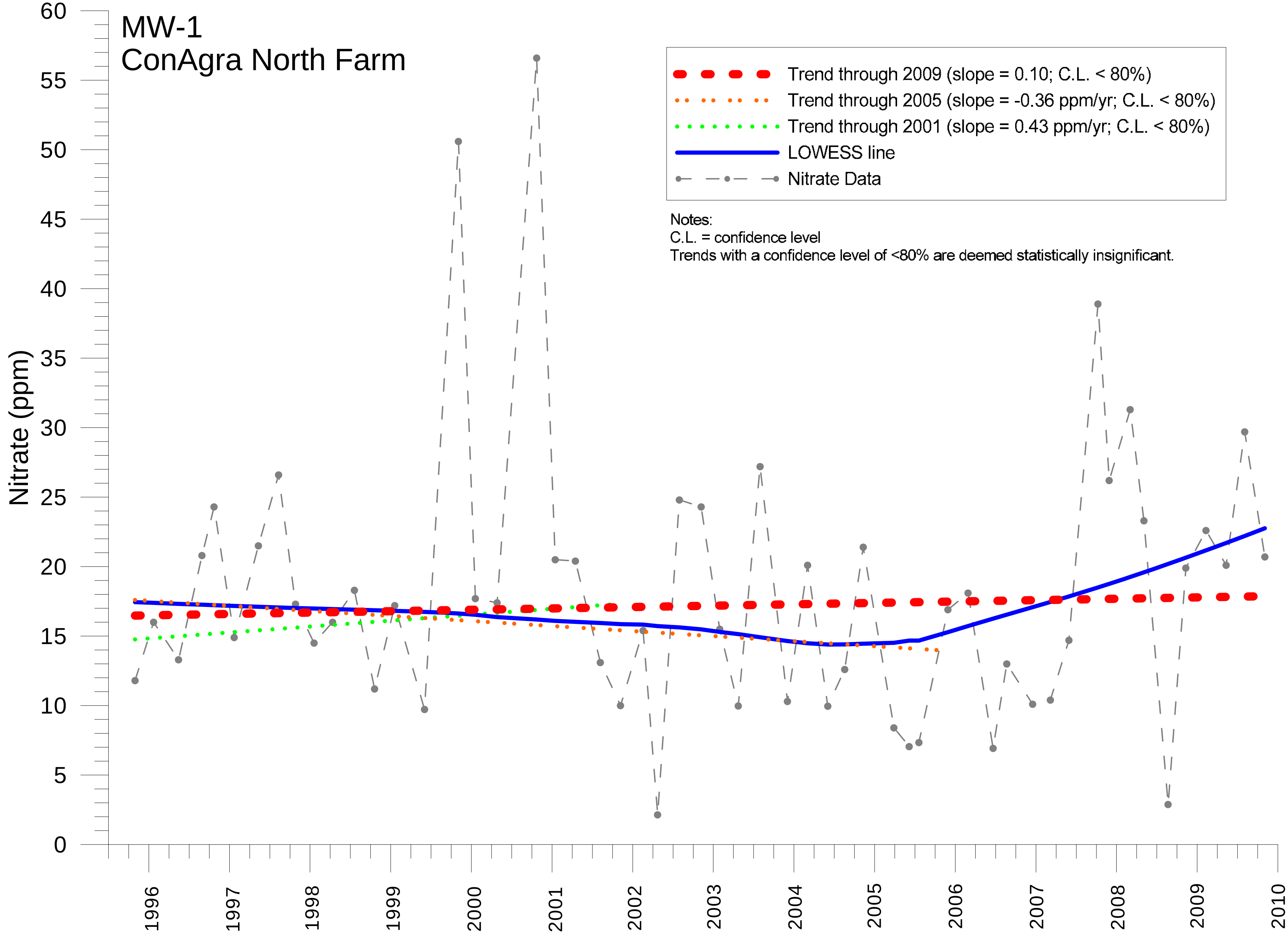


MW-23
Port of Morrow Farm 3
Nitrate (ppm)
70
65
60
55
50
45
40
35
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = -0.16 ppm/yr; C.L. < 80%)
Trend through 2005 (slope = 5.02 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Note: This well exhibits seasonality (i.e., nitrate concentrations are generally lowest in the third quarter samples and highest in the first or second quarter).

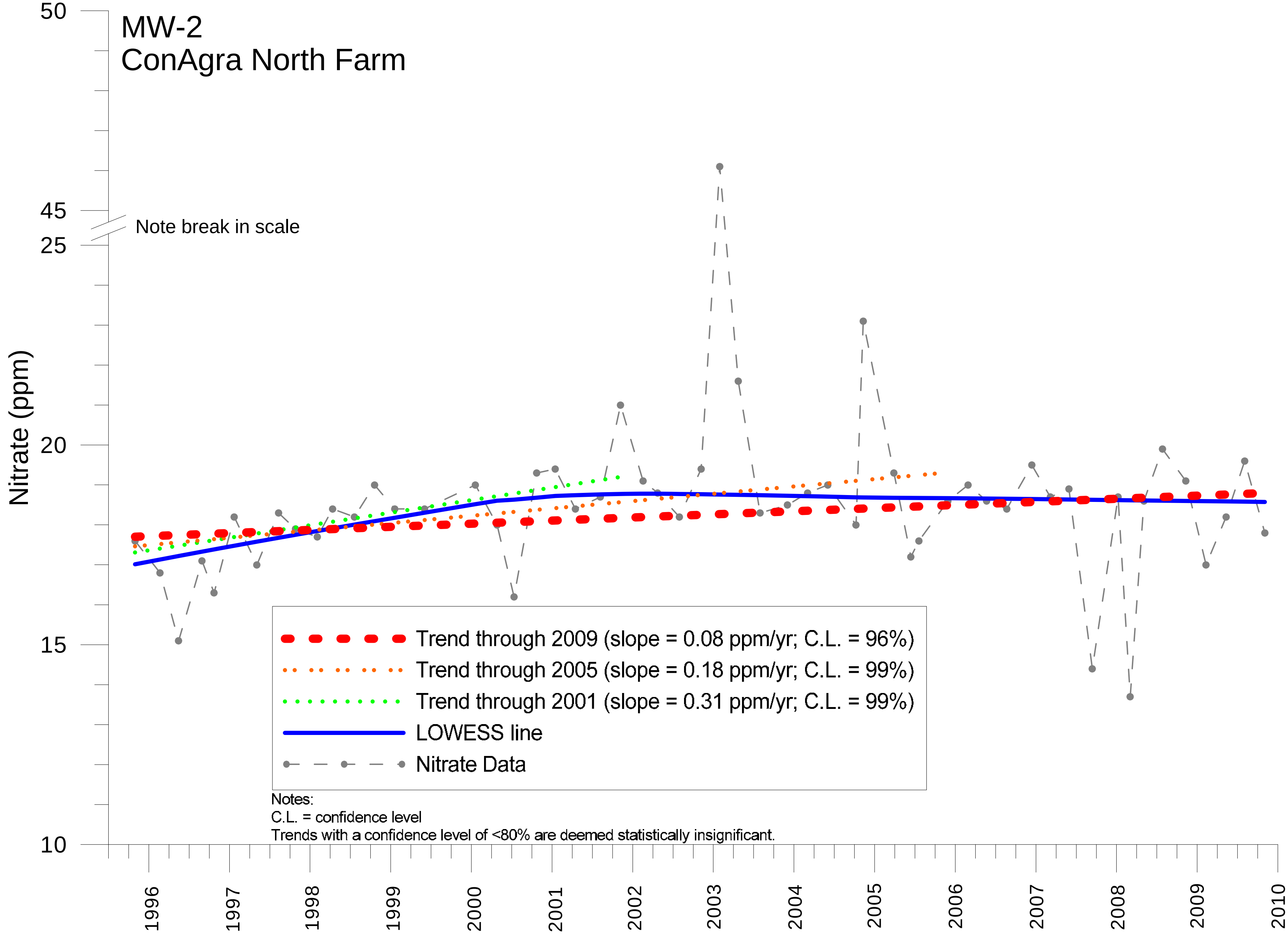


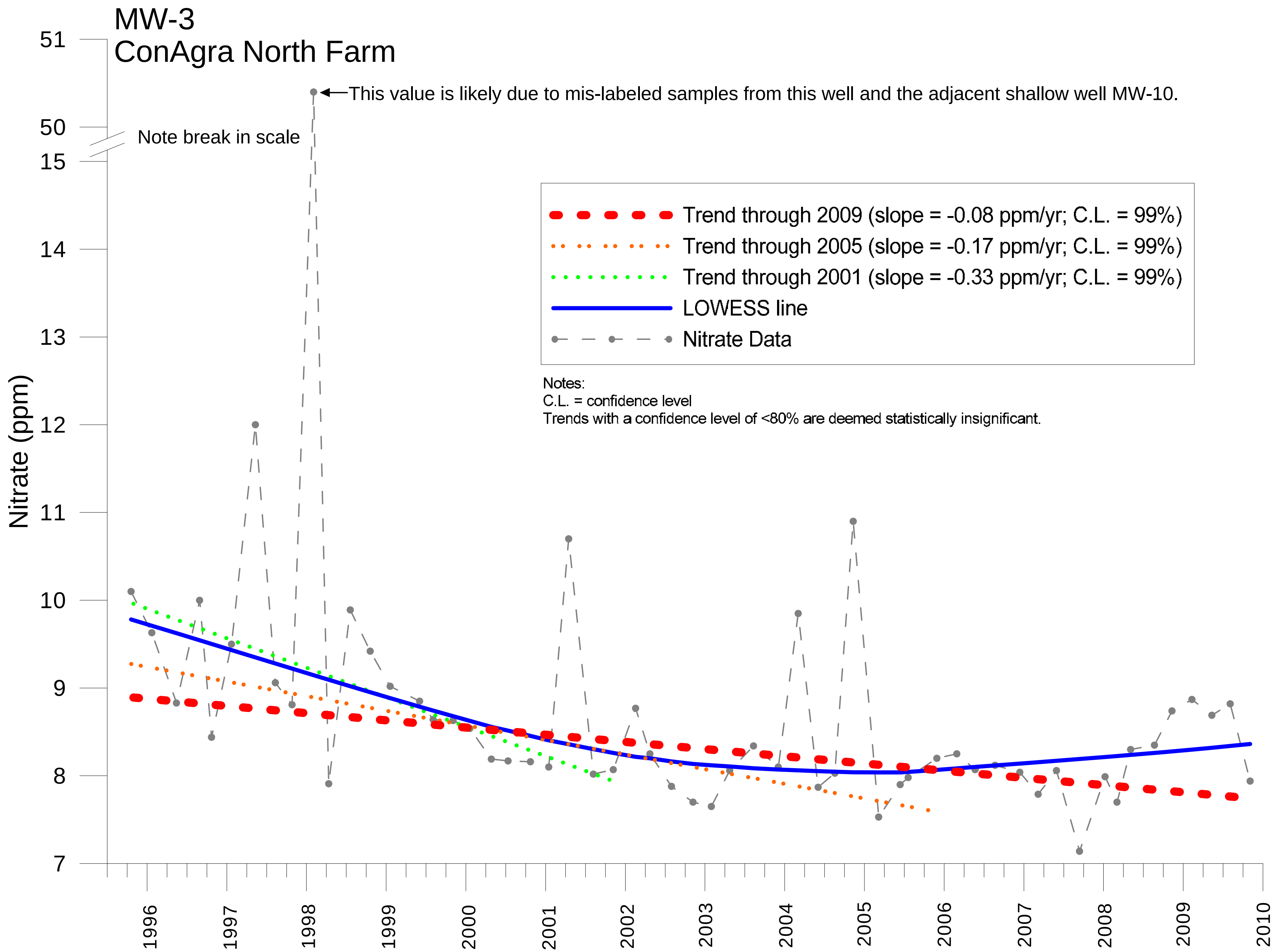
MW-24
Port of Morrow Farm 3
Trend through 2009 (slope = 3.07 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = -0.21 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
75
70
65
60
55
50
45
40
2002
2003
2004
2005
2006
2007
2008
2009
2010

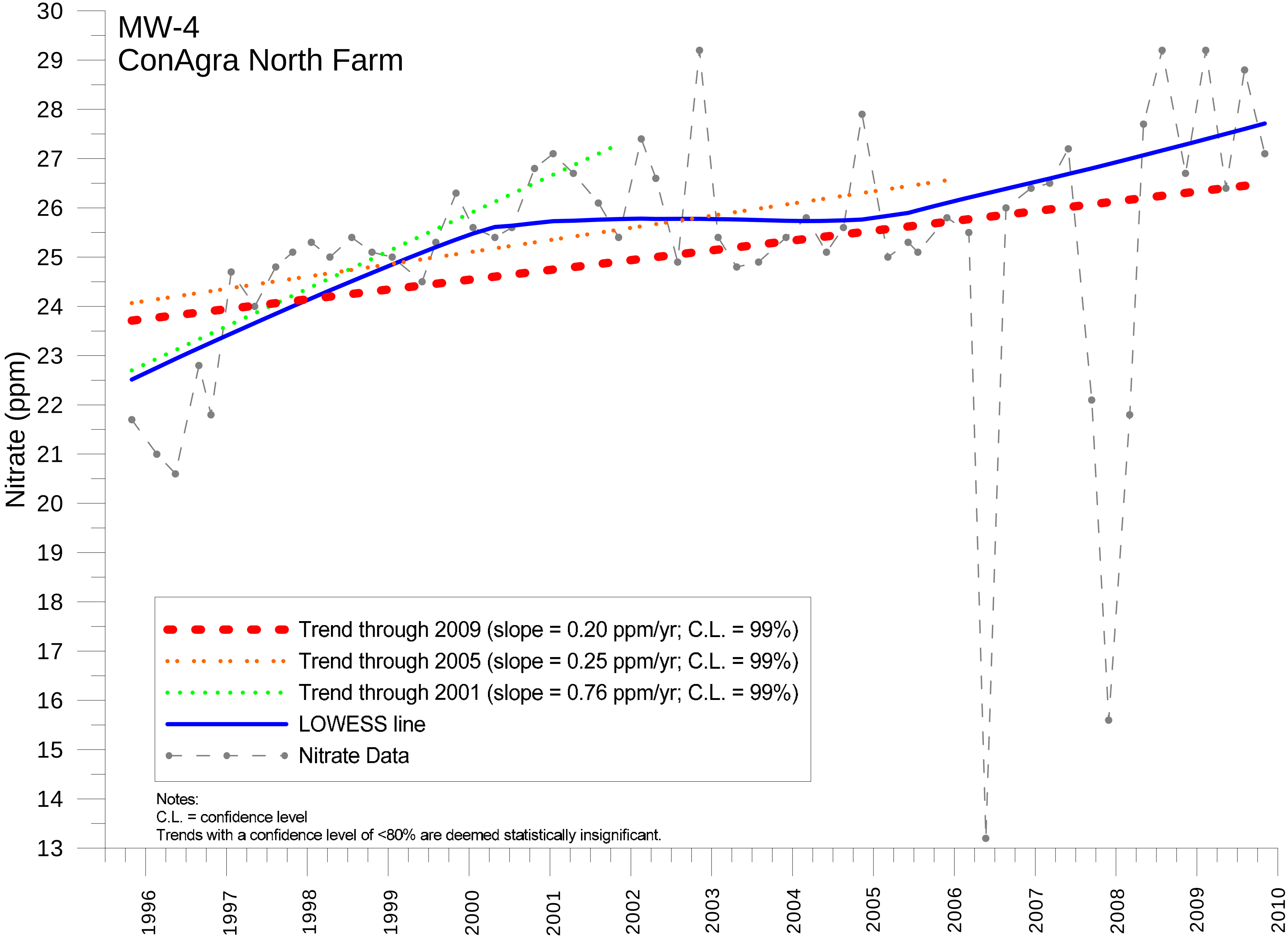

MW-25
Port of Morrow Farm 3
Nitrate (ppm)
44
43
42
41
40
39
38
37
36
35
LOWESS line
Nitrate Data
2009
2010



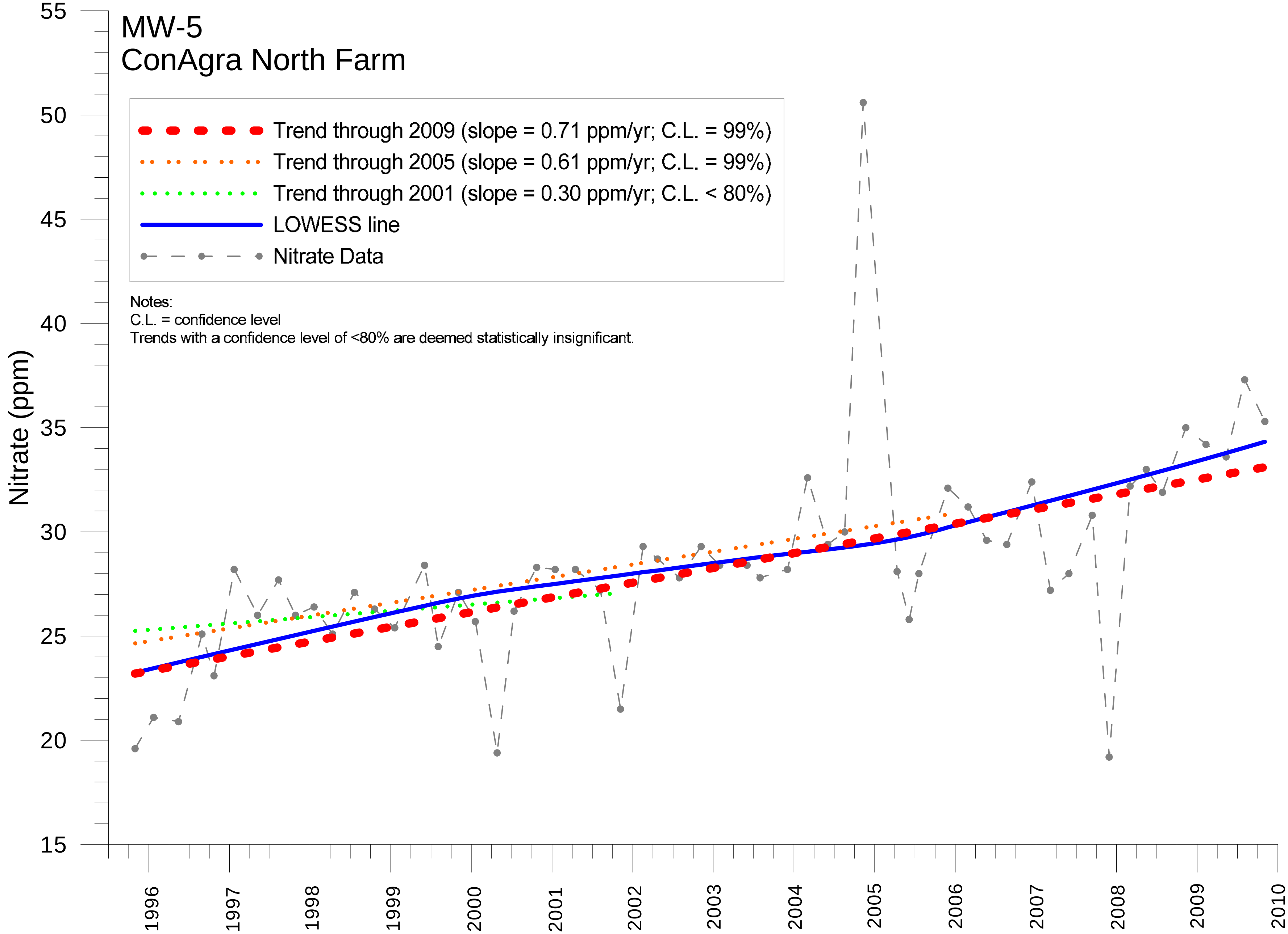
MW-1
ConAgra North Farm
Trend through 2009 (slope = 0.10; C.L. < 80%)
Trend through 2005 (slope = -0.36 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 0.43 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0
5
10
15
20
25
30
35
40
45
50
55
60
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

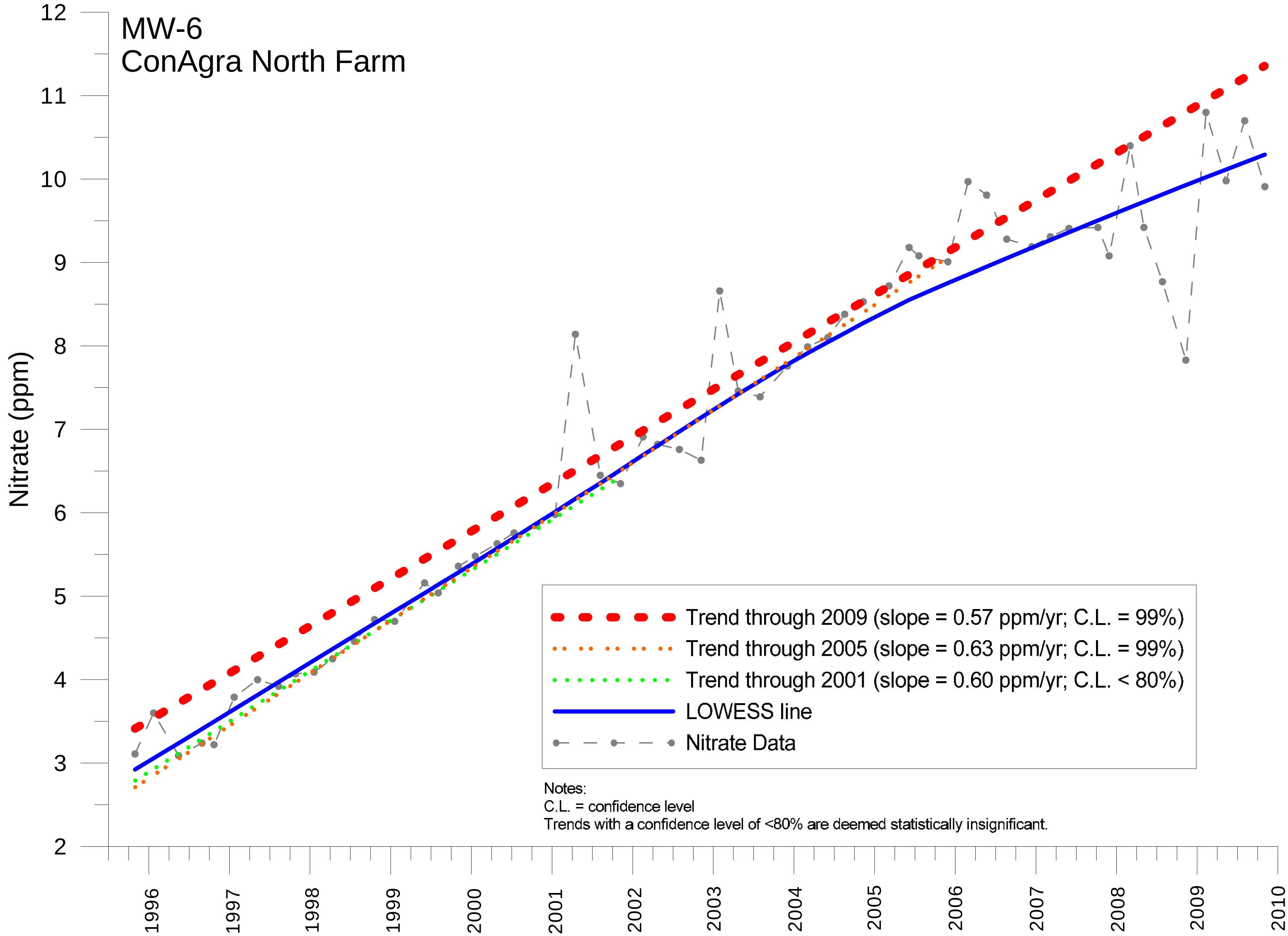

MW-2
ConAgra North Farm
Nitrate (ppm)
50
45
25
20
15
10
Note break in scale
Trend through 2009 (slope = 0.08 ppm/yr; C.L. = 96%)
Trend through 2005 (slope = 0.18 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.31 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010


MW-3
ConAgra North Farm
This value is likely due to mis-labeled samples from this well and the adjacent shallow well MW-10.
Note break in scale
Trend through 2009 (slope = -0.08 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = -0.17 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = -0.33 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
51
50
15
14
13
12
11
10
9
8
7
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

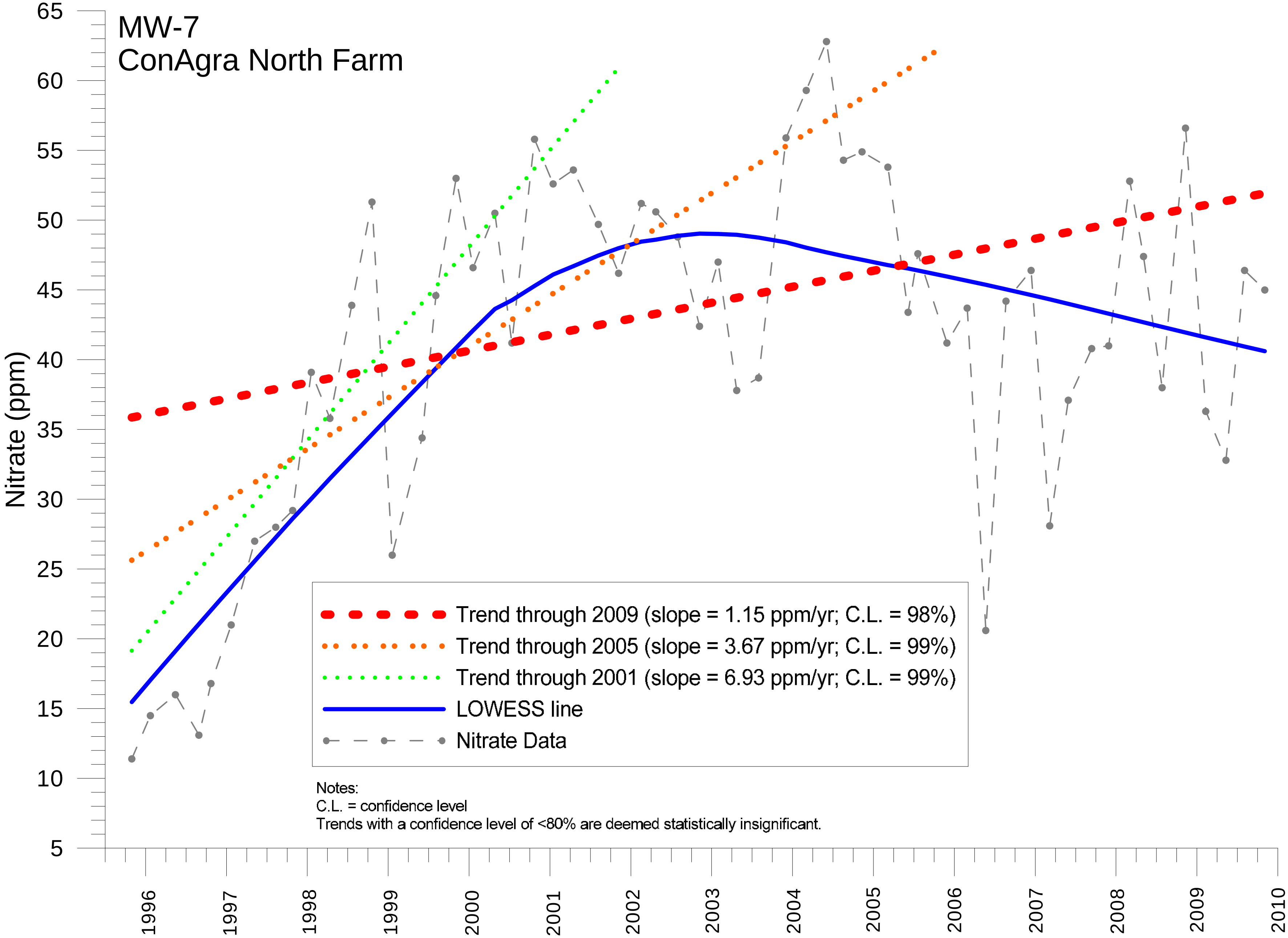


MW-4
ConAgra North Farm
Nitrate (ppm)
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 0.20 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 0.25 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.76 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

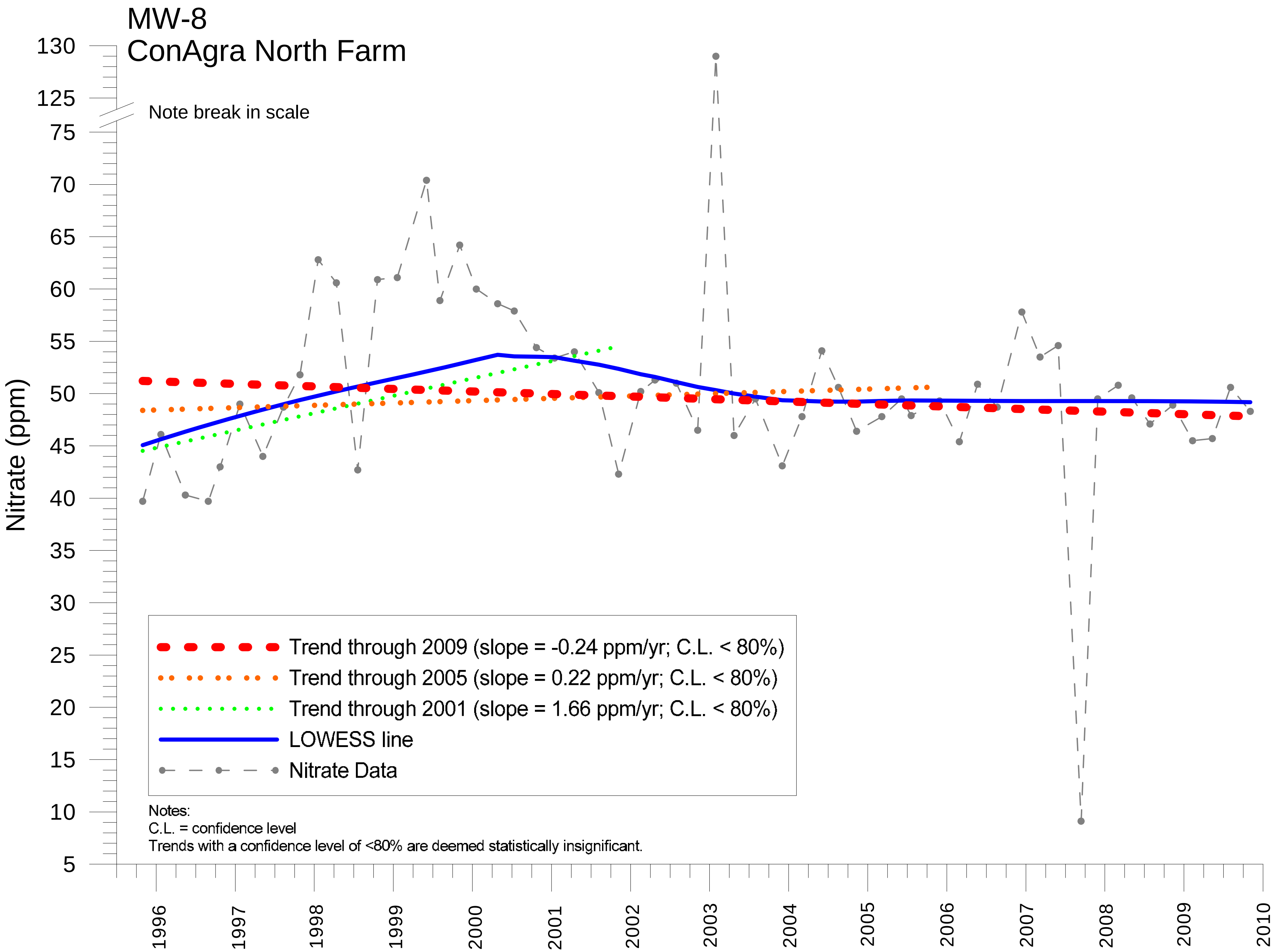

MW-5
ConAgra North Farm
Trend through 2009 (slope = 0.71 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 0.61 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.30 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
55
50
45
40
35
30
25
20
15
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010



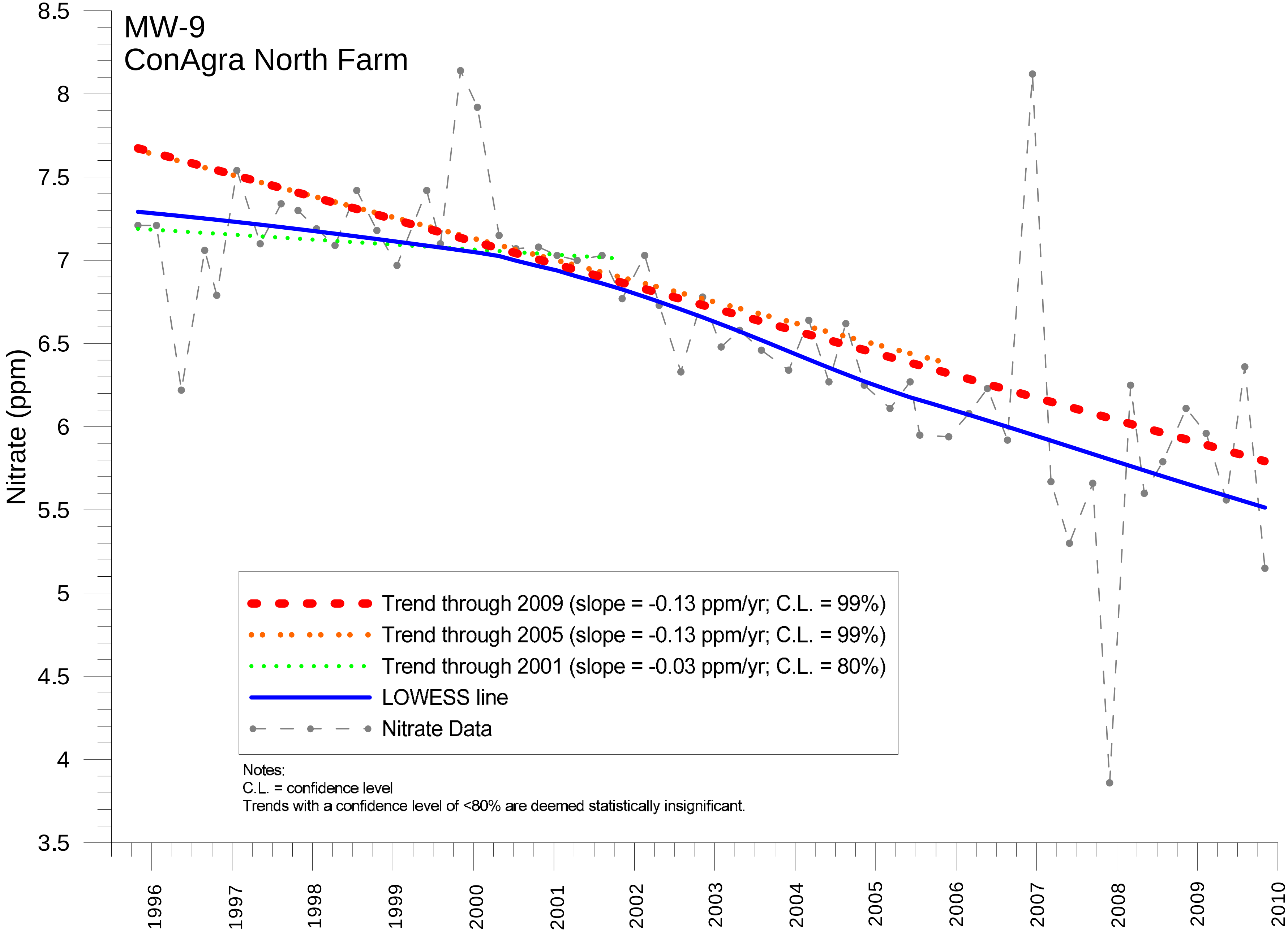
MW-6
ConAgra North Farm
Nitrate (ppm)
12
11
10
9
8
7
6
5
4
3
2
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 0.57 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 0.63 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.60 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

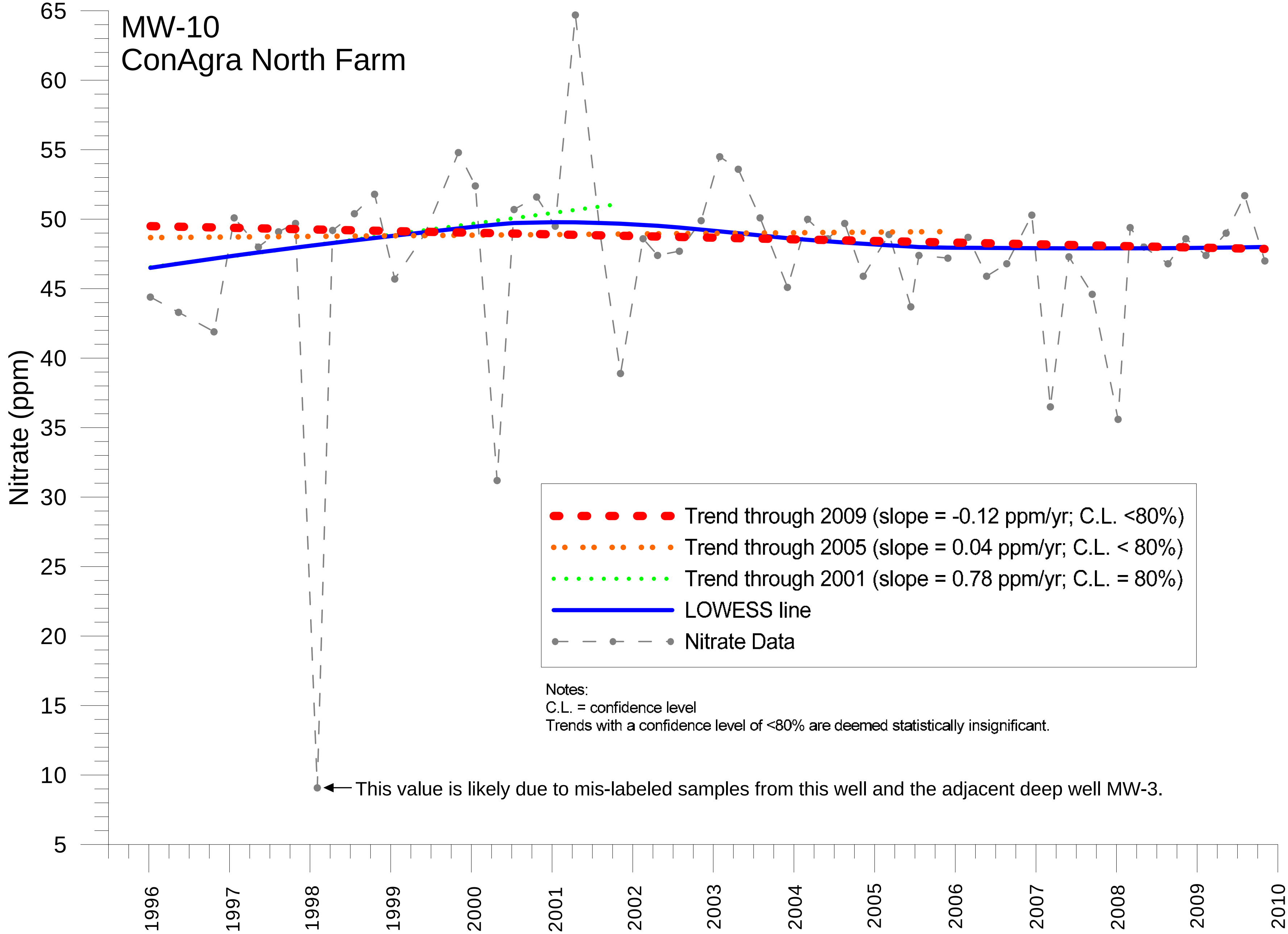


MW-7
ConAgra North Farm
Nitrate (ppm)
65
60
55
50
45
40
35
30
25
20
15
10
5
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 1.15 ppm/yr; C.L. = 98%)
Trend through 2005 (slope = 3.67 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 6.93 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

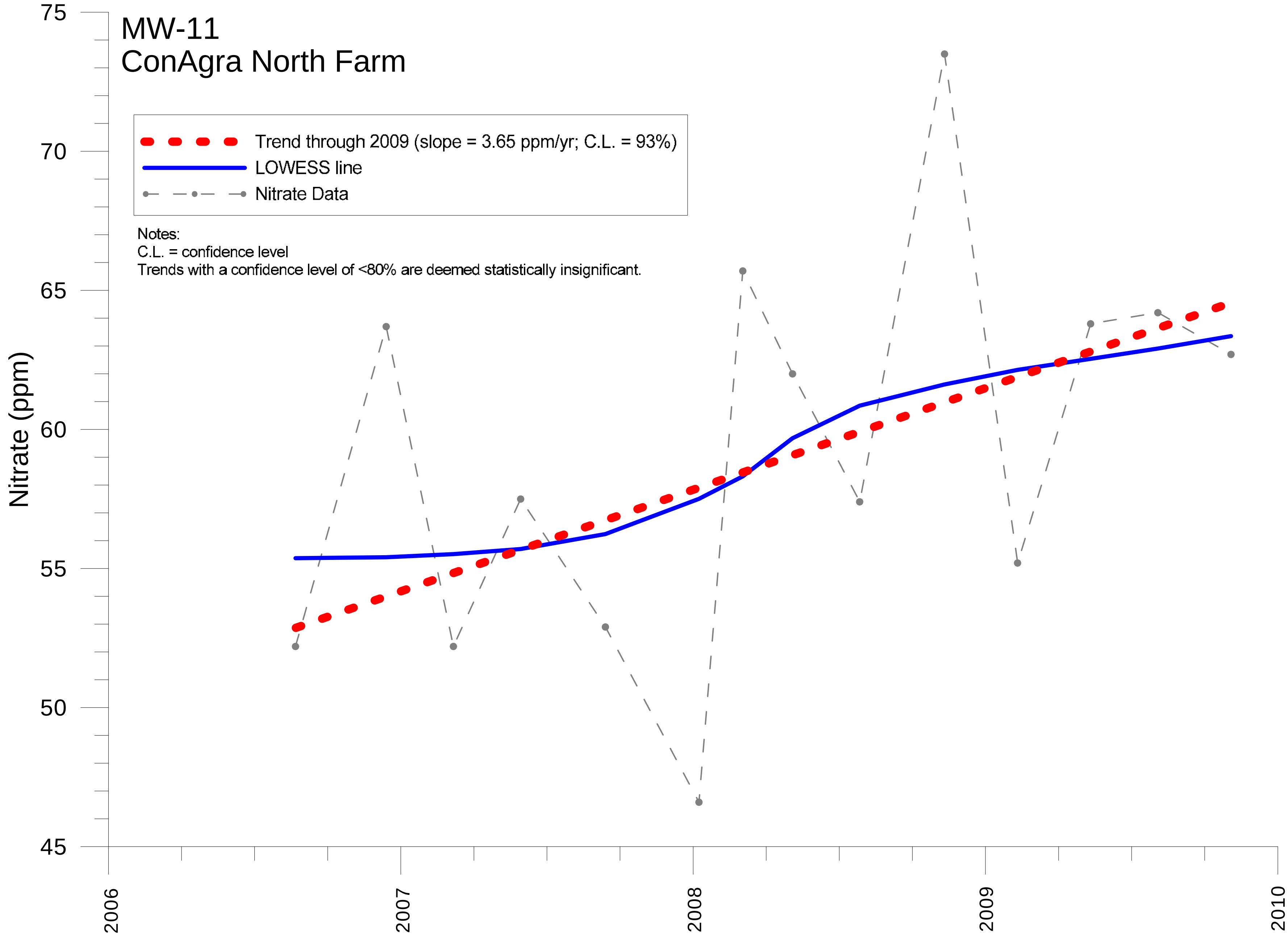


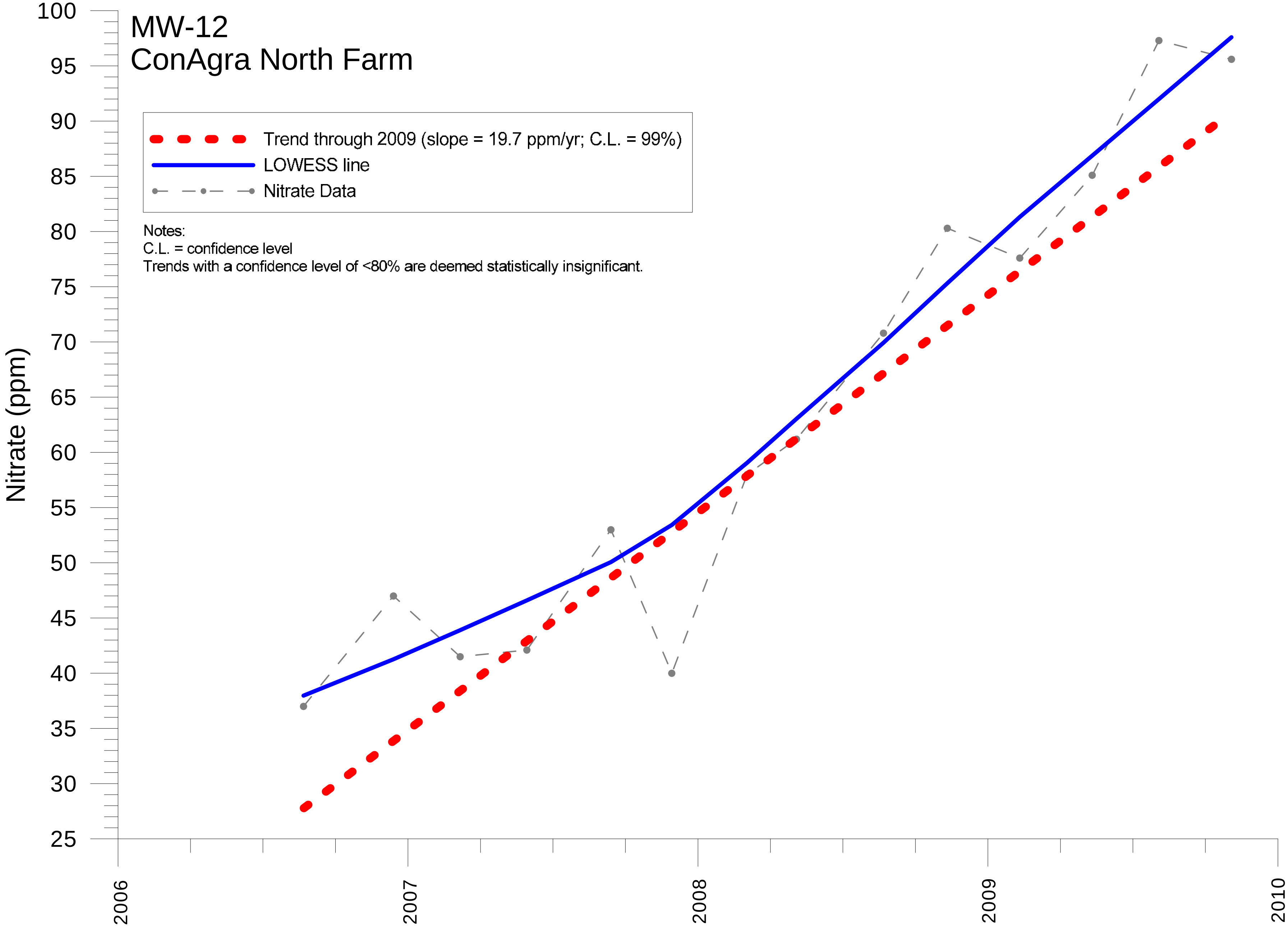
MW-8
ConAgra North Farm
Note break in scale
Nitrate (ppm)
130
125
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = -0.24 ppm/yr; C.L. < 80%)
Trend through 2005 (slope = 0.22 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 1.66 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

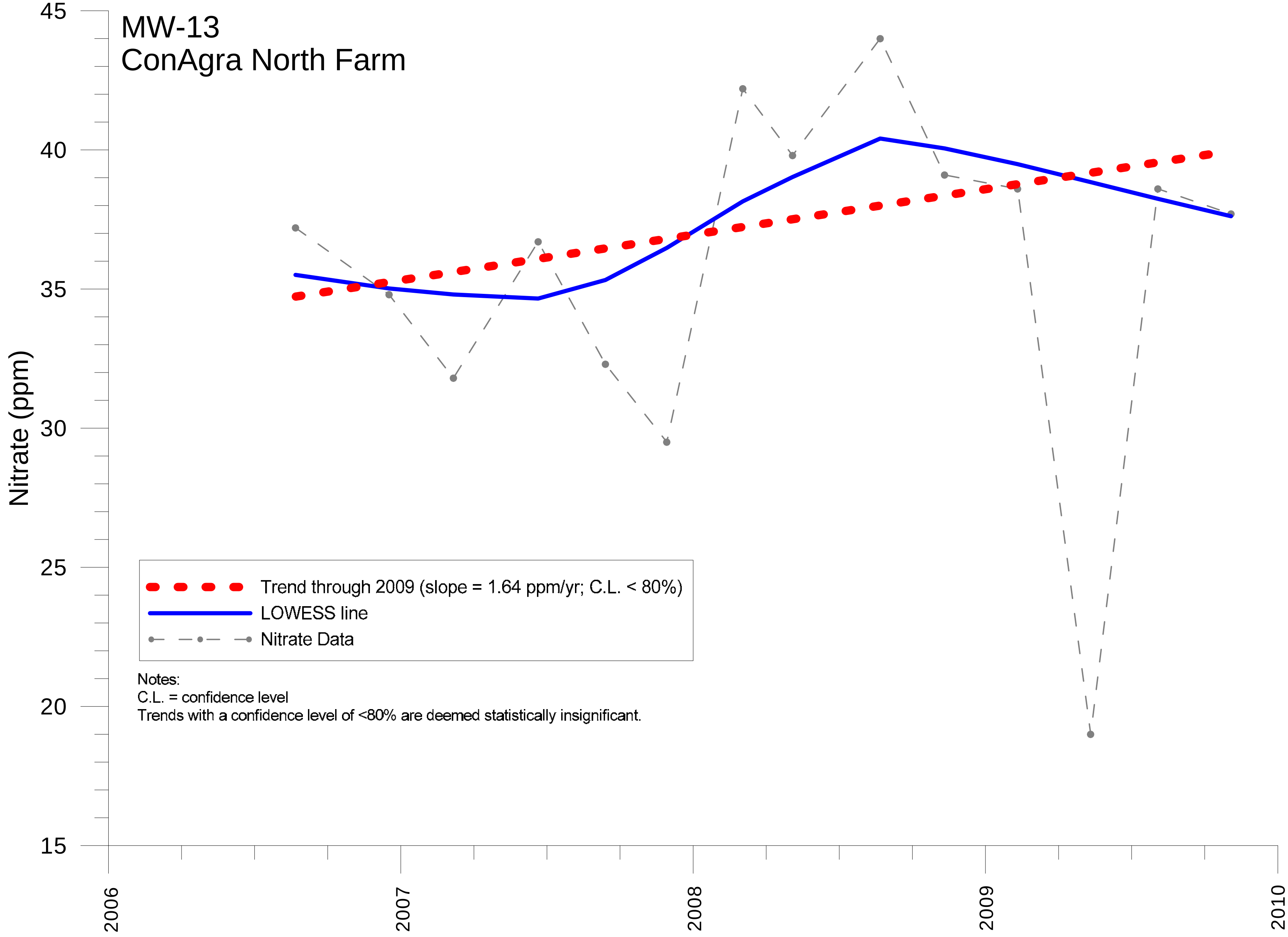

MW-9
ConAgra North Farm
Nitrate (ppm)
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = -0.13 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = -0.13 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = -0.03 ppm/yr; C.L. = 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

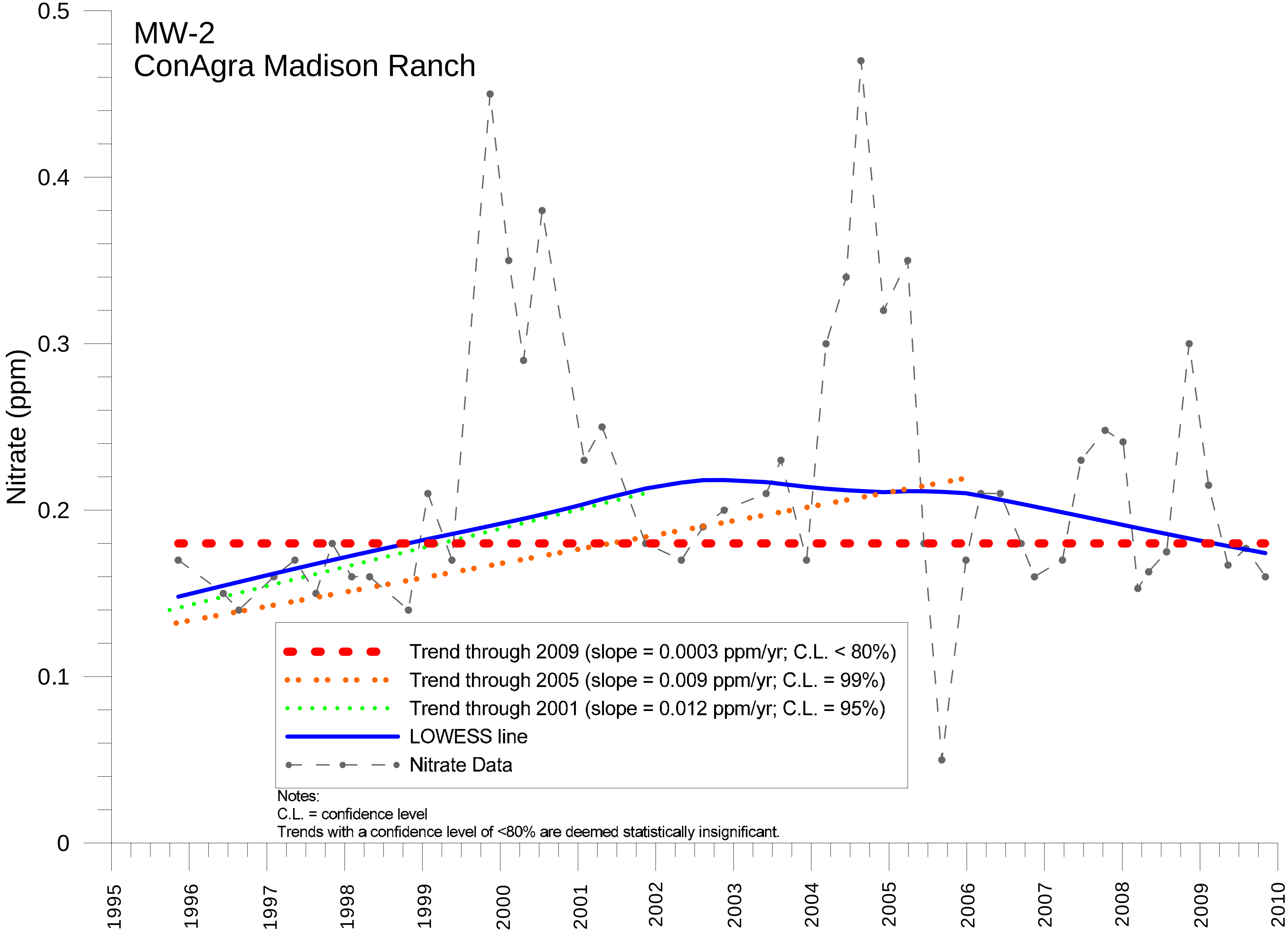


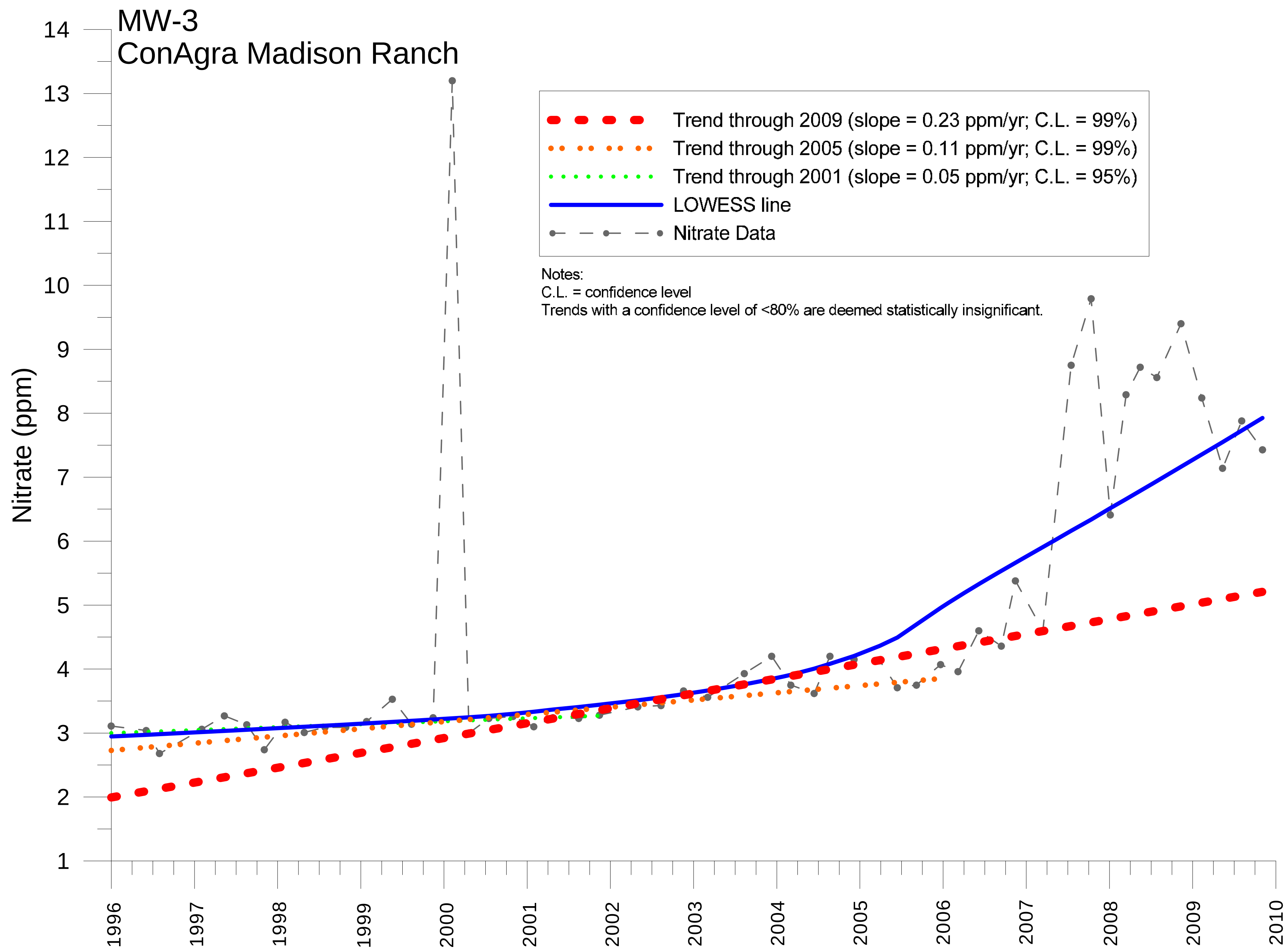
MW-10
ConAgra North Farm
Nitrate (ppm)
65
60
55
50
45
40
35
30
25
20
15
10
5
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = -0.12 ppm/yr; C.L. <80%)
Trend through 2005 (slope = 0.04 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 0.78 ppm/yr; C.L. = 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
This value is likely due to mis-labeled samples from this well and the adjacent deep well MW-3.


MW-11
ConAgra North Farm
Trend through 2009 (slope = 3.65 ppm/yr; C.L. = 93%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
75
70
65
60
55
50
45
2006
2007
2008
2009
2010

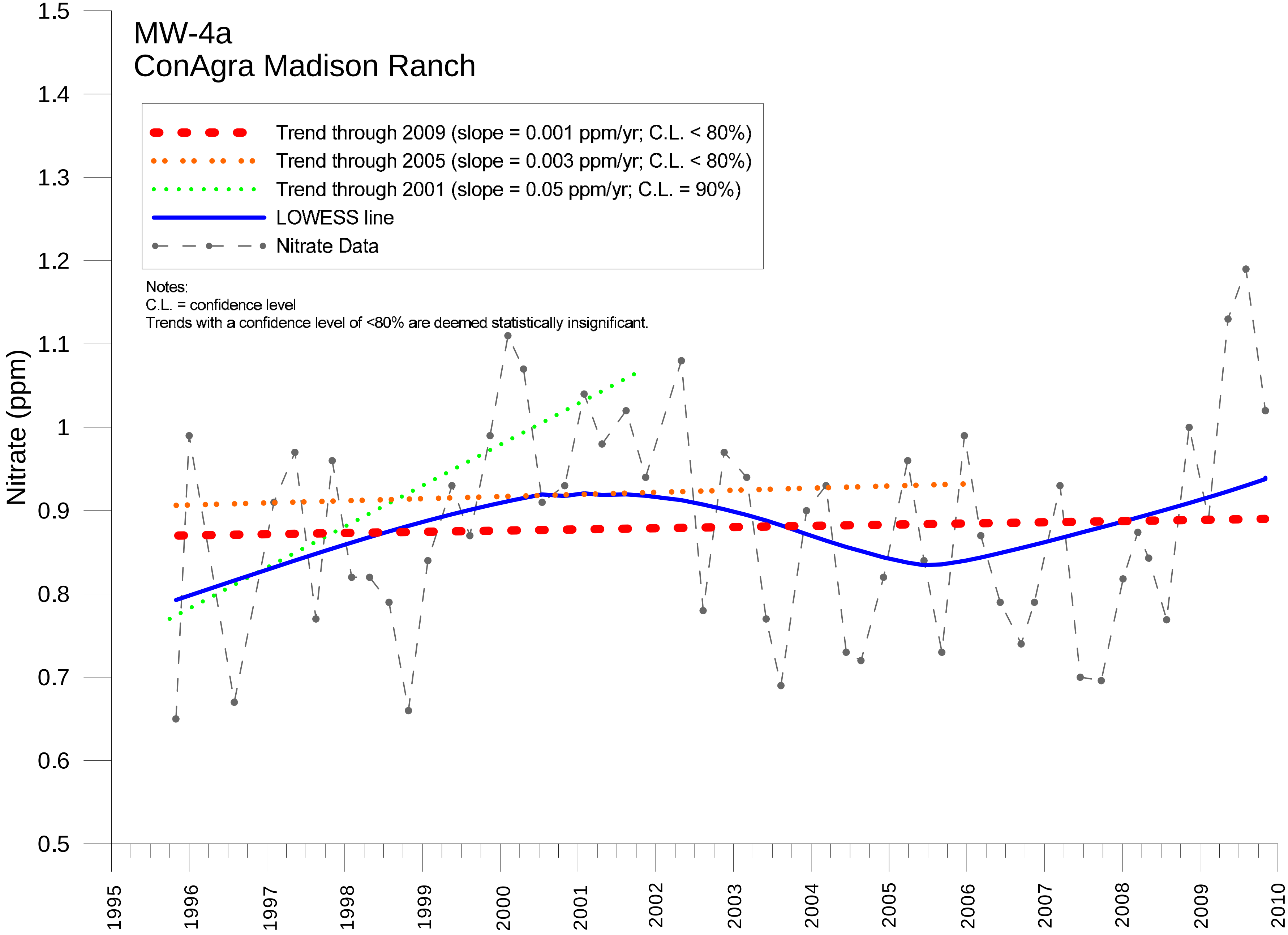

MW-12
ConAgra North Farm
Trend through 2009 (slope = 19.7 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
2006
2007
2008
2009
2010


MW-13
ConAgra North Farm
Nitrate (ppm)
45
40
35
30
25
20
15
2006
2007
2008
2009
2010
Trend through 2009 (slope = 1.64 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

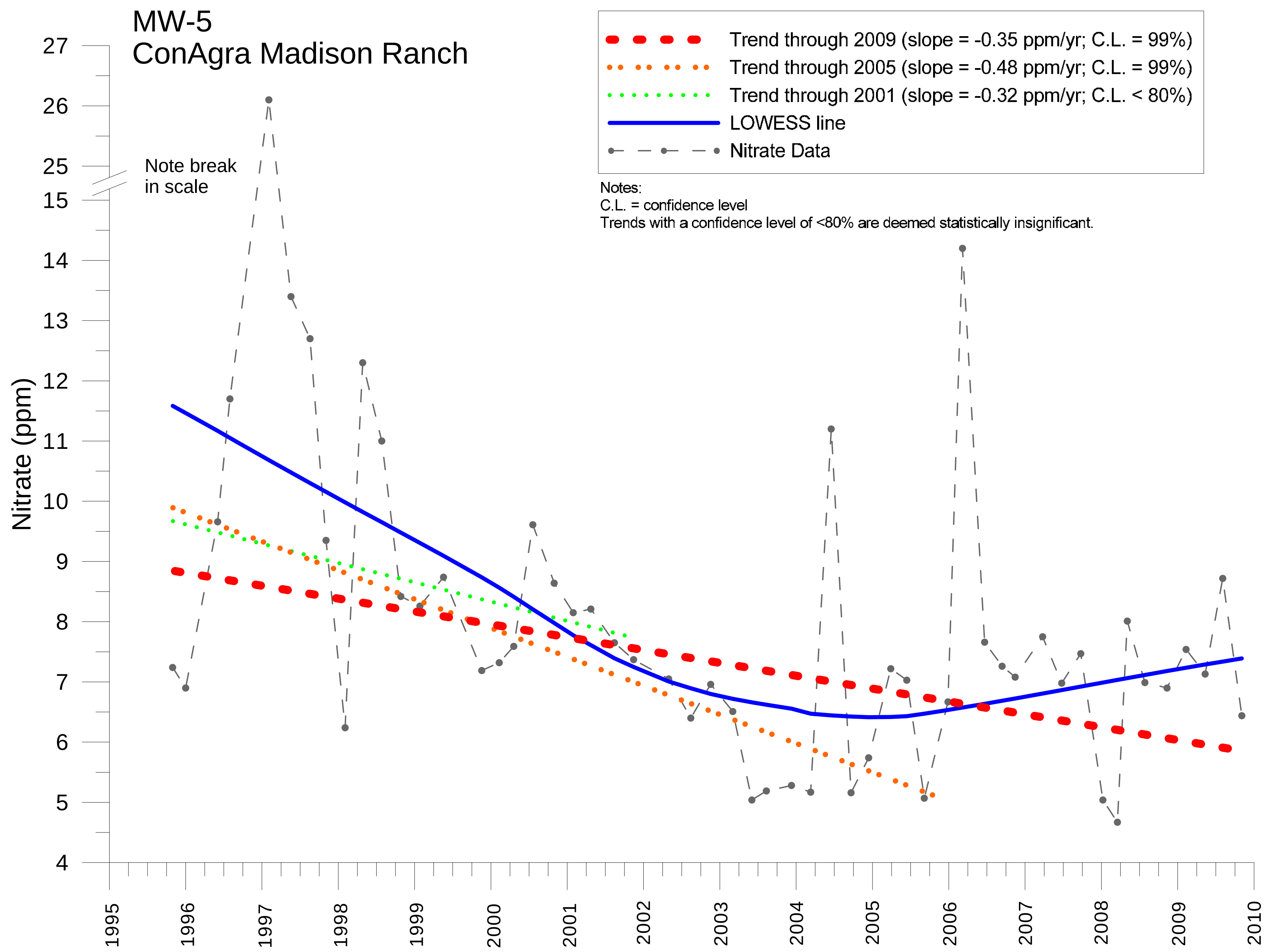

MW-2
ConAgra Madison Ranch
Nitrate (ppm)
0.5
0.4
0.3
0.2
0.1
0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 0.0003 ppm/yr; C.L. < 80%)
Trend through 2005 (slope = 0.009 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.012 ppm/yr; C.L. = 95%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



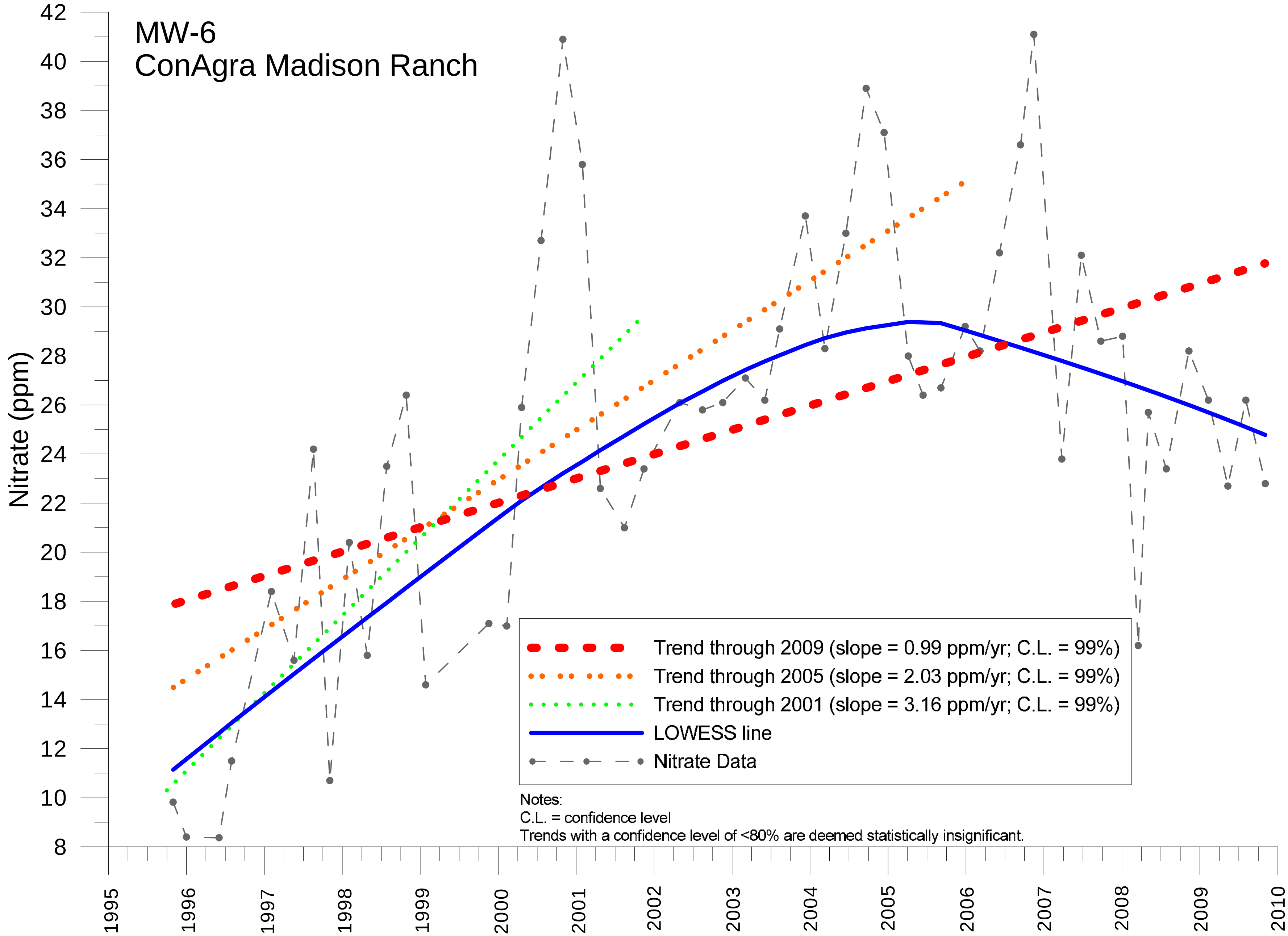
MW-3
ConAgra Madison Ranch
Trend through 2009 (slope = 0.23 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 0.11 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.05 ppm/yr; C.L. = 95%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010



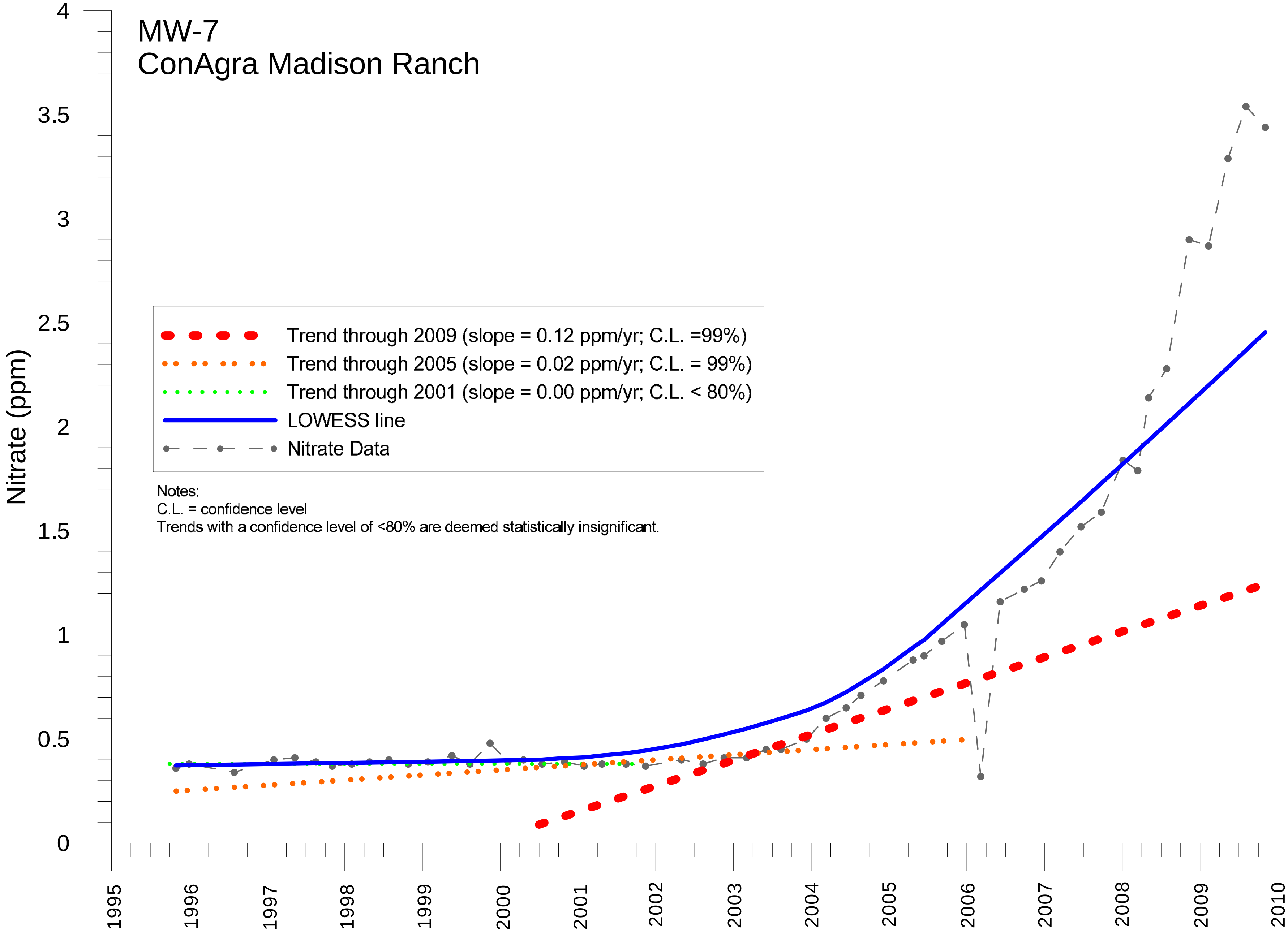
MW-4a
ConAgra Madison Ranch
Trend through 2009 (slope = 0.001 ppm/yr; C.L. < 80%)
Trend through 2005 (slope = 0.003 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 0.05 ppm/yr; C.L. = 90%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

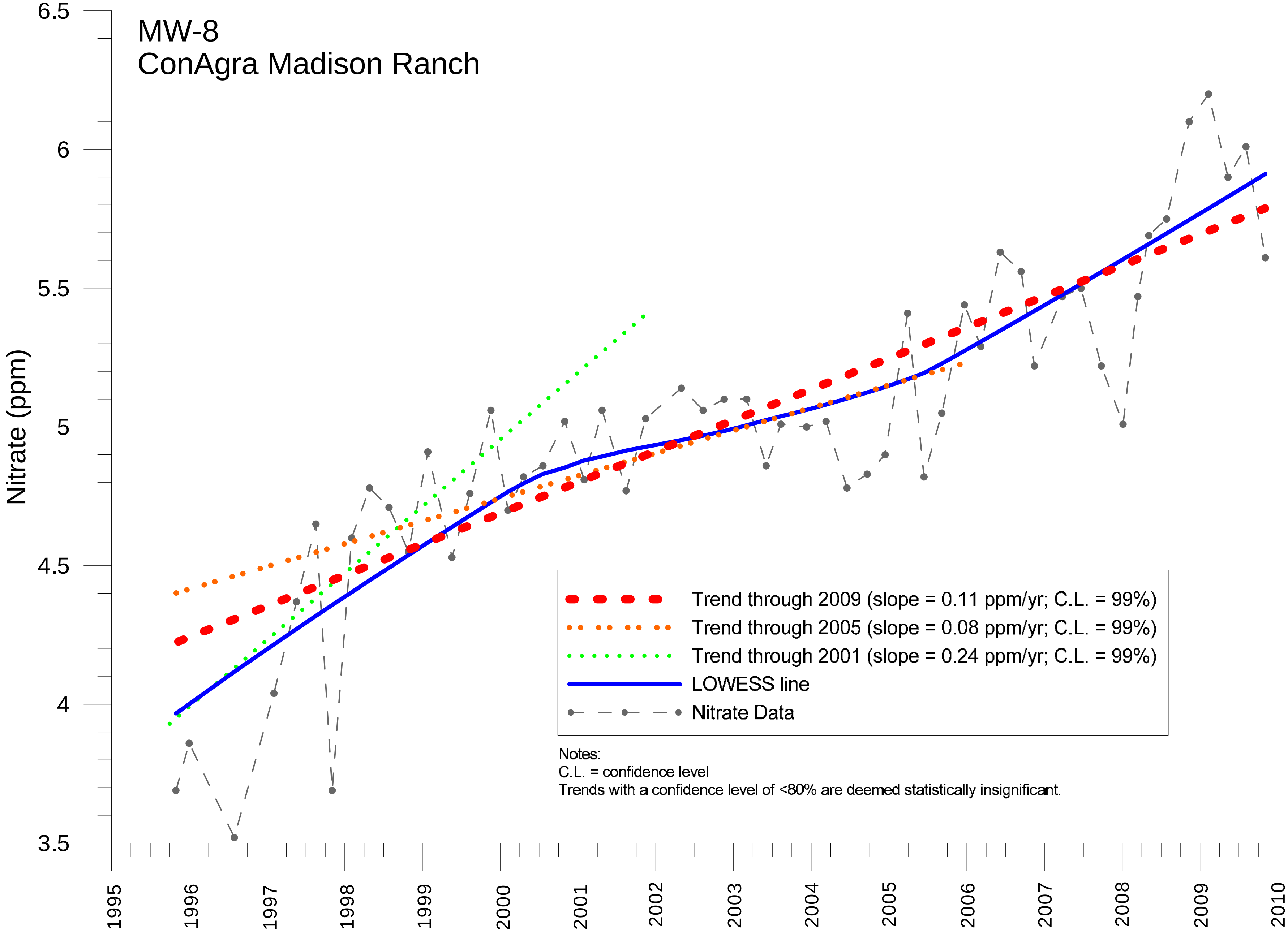


MW-5
ConAgra Madison Ranch
Trend through 2009 (slope = -0.35 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = -0.48 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = -0.32 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Note break in scale
Nitrate (ppm)
27
26
25
15
14
13
12
11
10
9
8
7
6
5
4
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

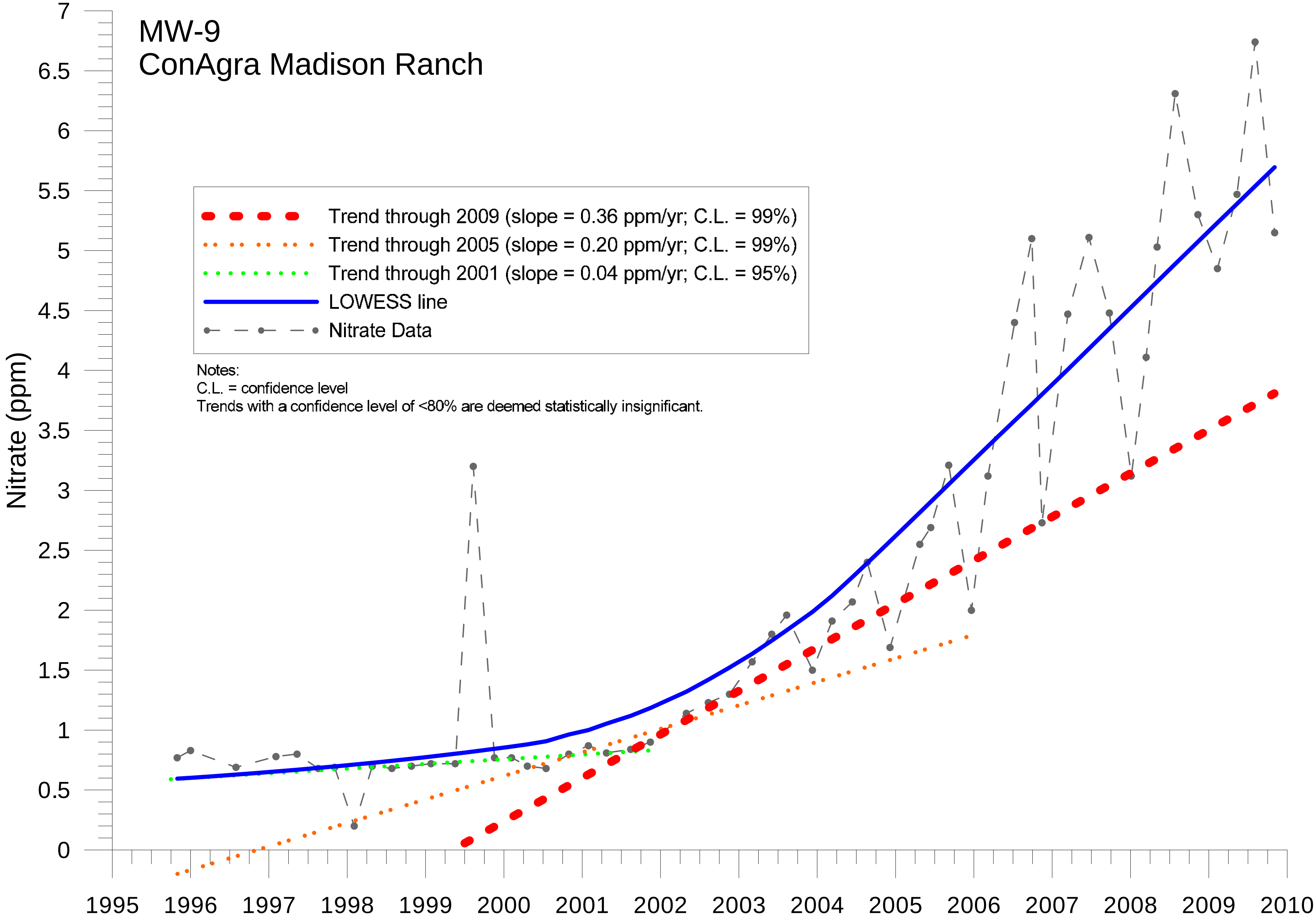


MW-6
ConAgra Madison Ranch
Nitrate (ppm)
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 0.99 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 2.03 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 3.16 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

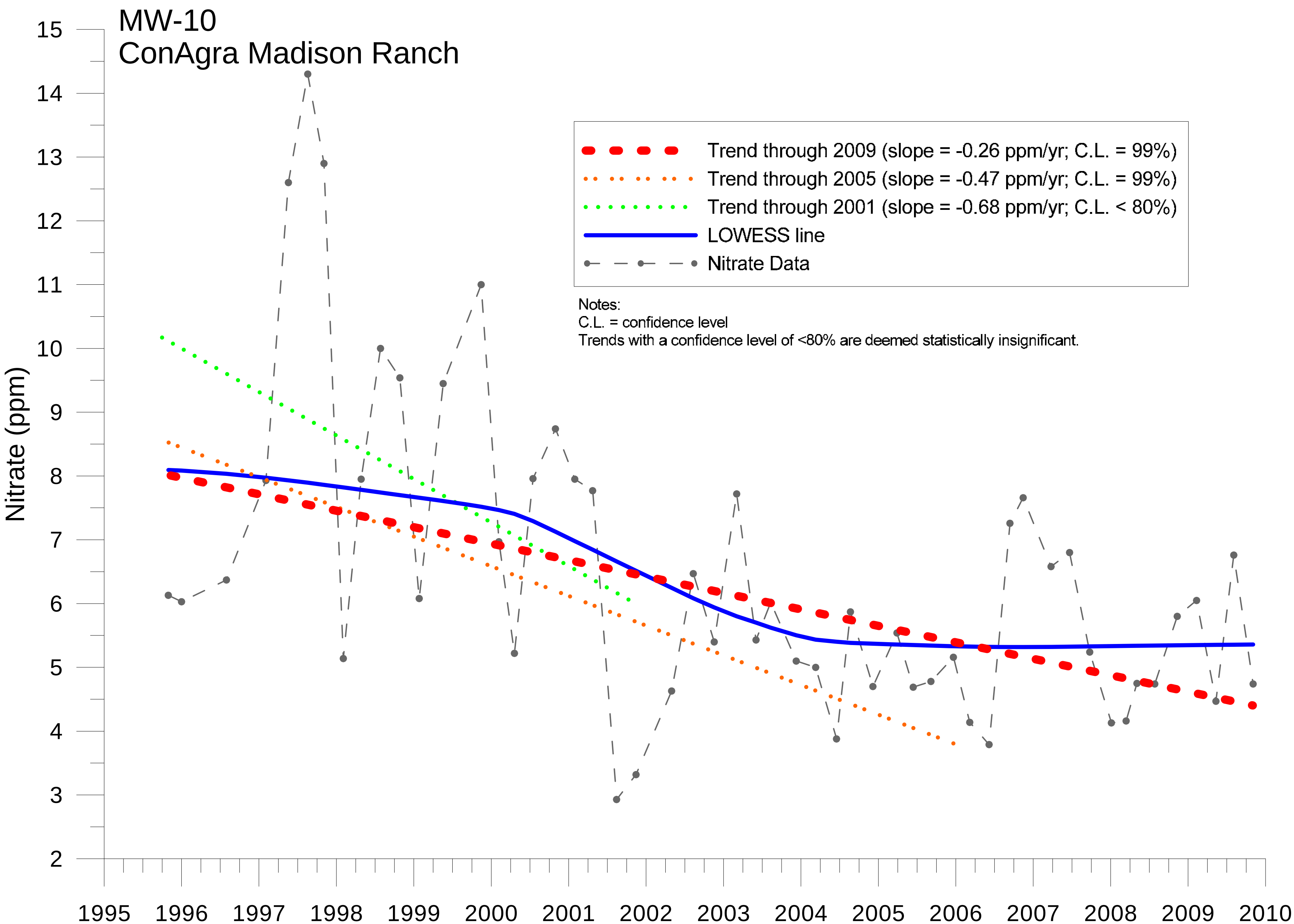

MW-7
ConAgra Madison Ranch
Nitrate (ppm)
Trend through 2009 (slope = 0.12 ppm/yr; C.L. =99%)
Trend through 2005 (slope = 0.02 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.00 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
0
0.5
1
1.5
2
2.5
3
3.5
4
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

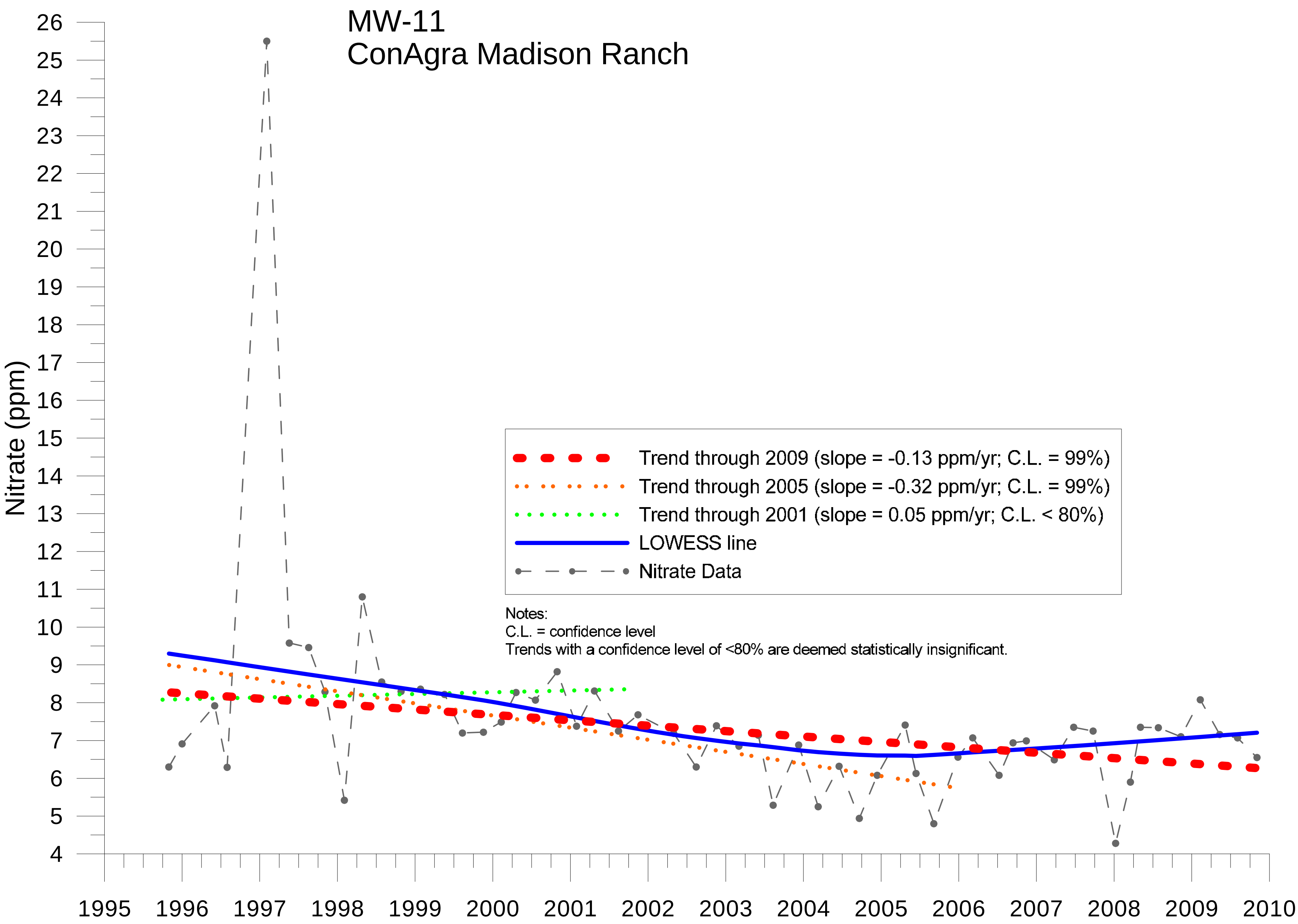


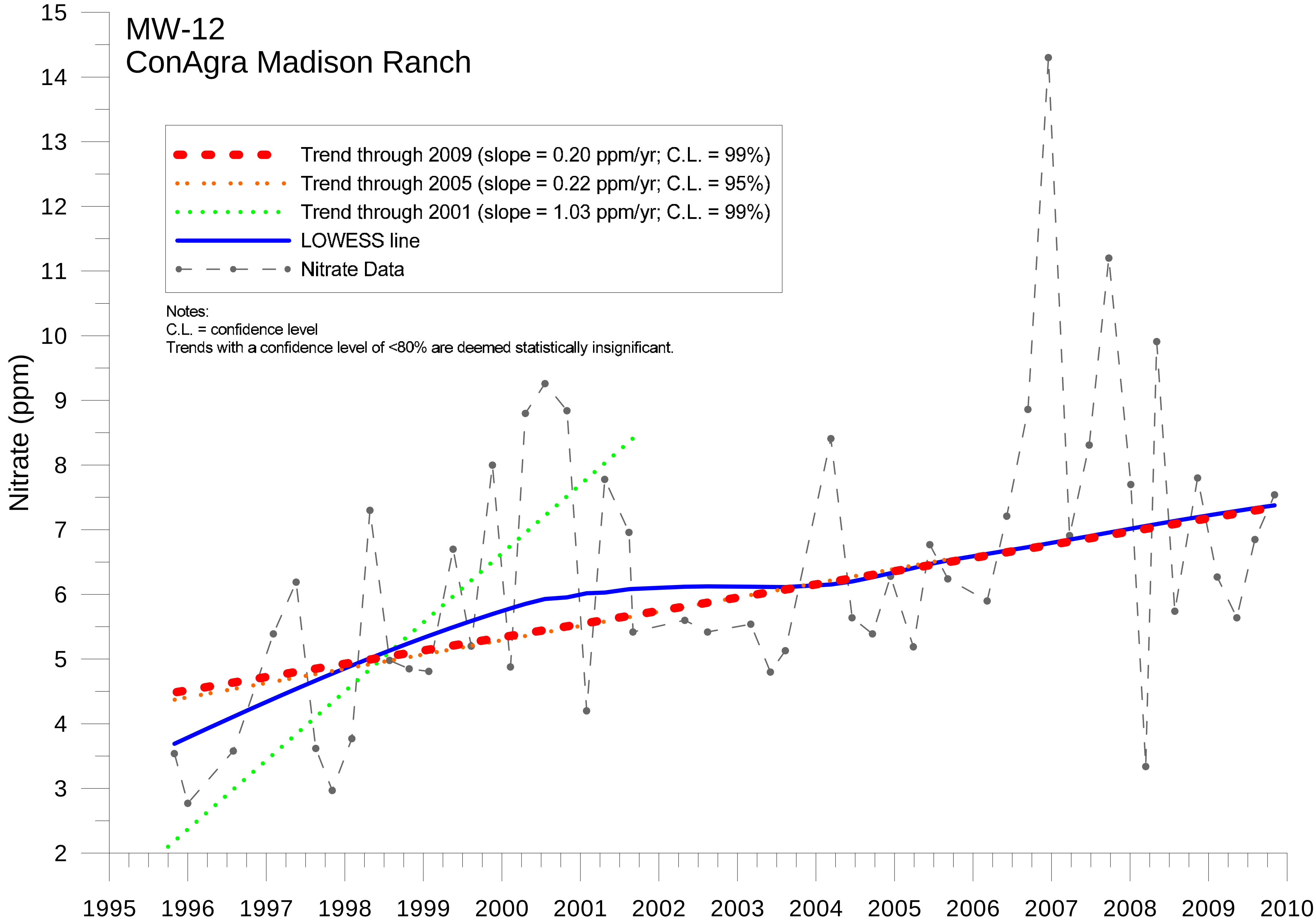
MW-8
ConAgra Madison Ranch
Nitrate (ppm)
6.5
6
5.5
5
4.5
4
3.5
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 0.11 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 0.08 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.24 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

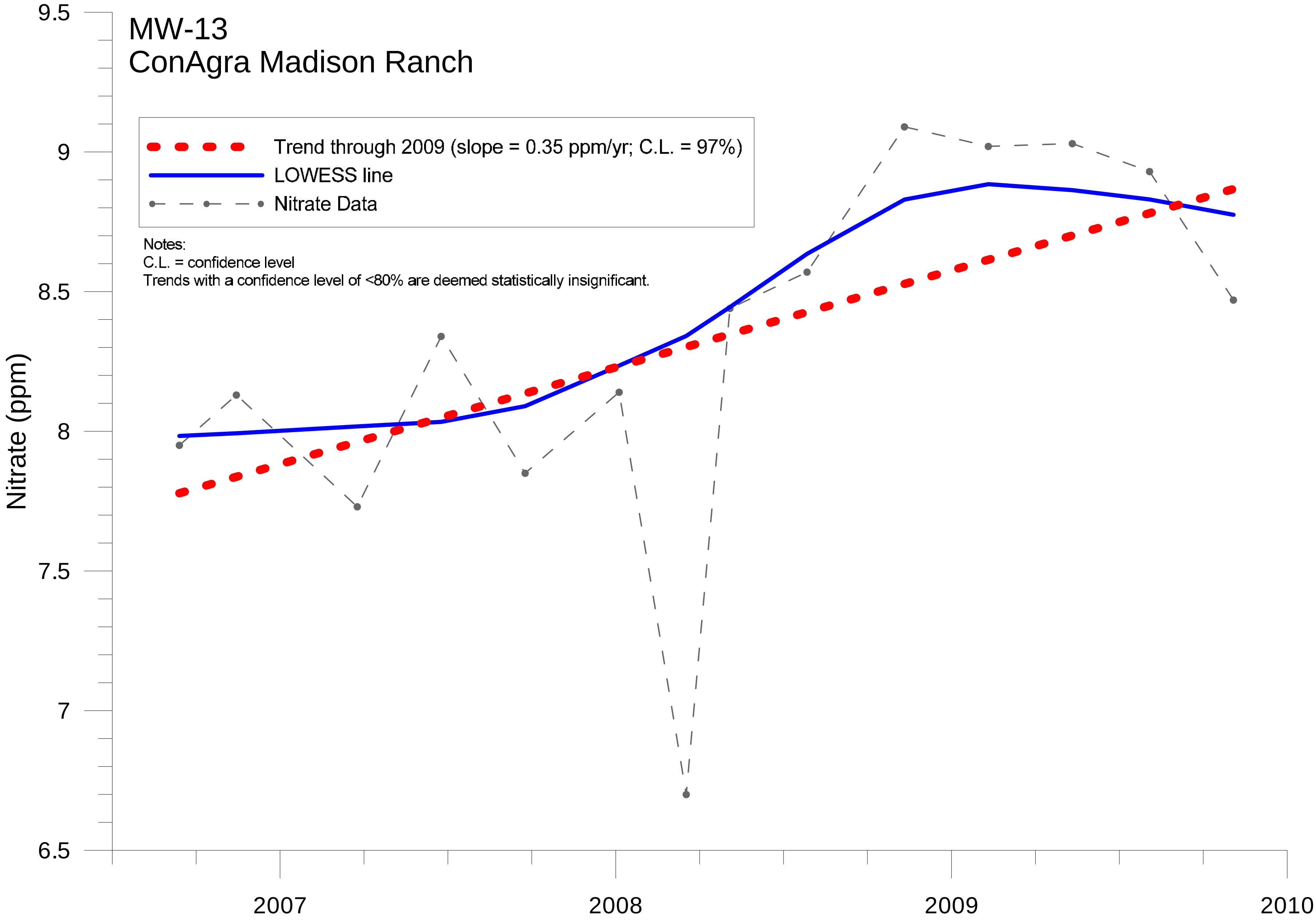


MW-9
ConAgra Madison Ranch
Trend through 2009 (slope = 0.36 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 0.20 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.04 ppm/yr; C.L. = 95%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

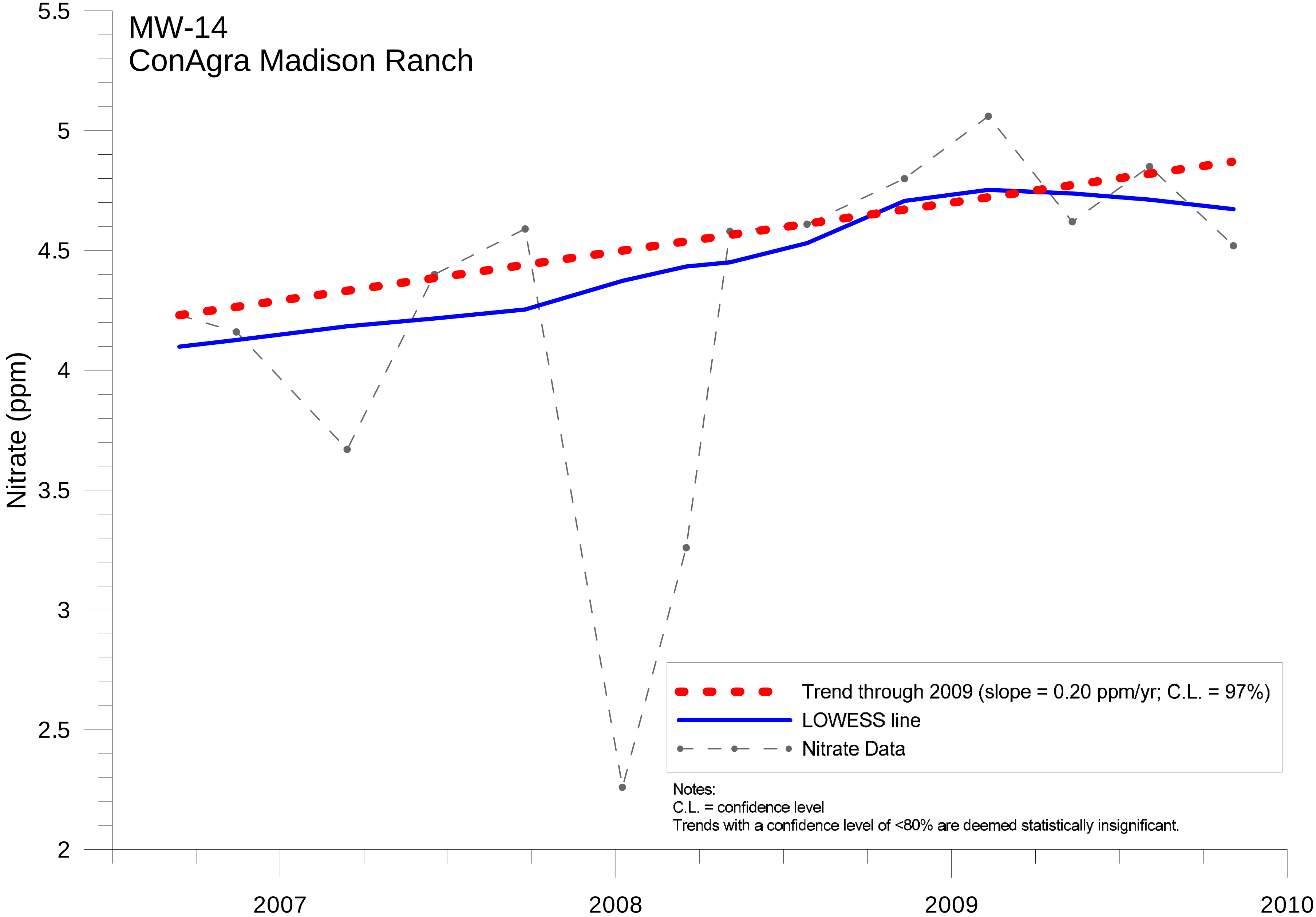

MW-10
ConAgra Madison Ranch
Trend through 2009 (slope = -0.26 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = -0.47 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = -0.68 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

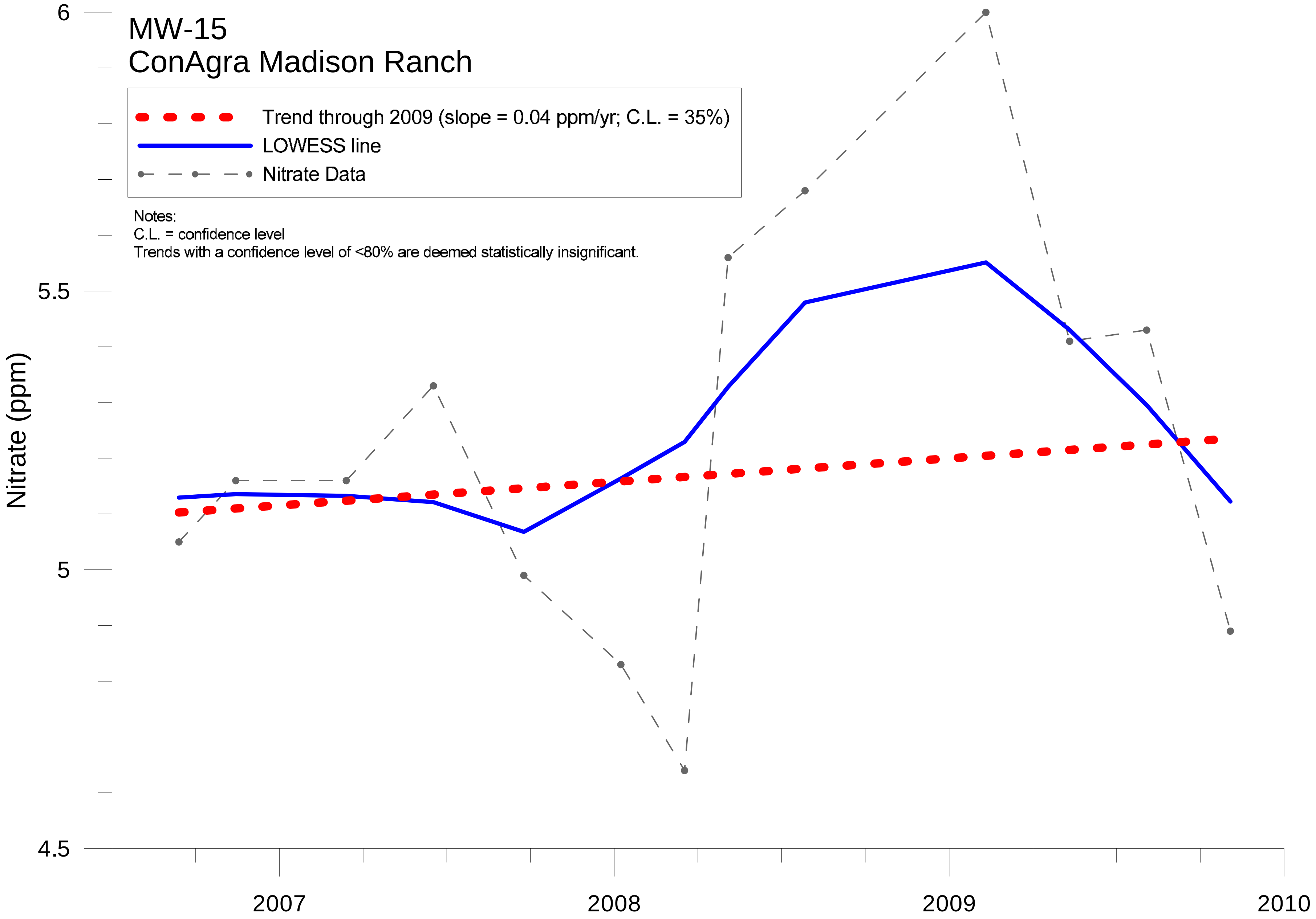

MW-11
ConAgra Madison Ranch
Nitrate (ppm)
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = -0.13 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = -0.32 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.05 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.


MW-12
ConAgra Madison Ranch
Trend through 2009 (slope = 0.20 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 0.22 ppm/yr; C.L. = 95%)
Trend through 2001 (slope = 1.03 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

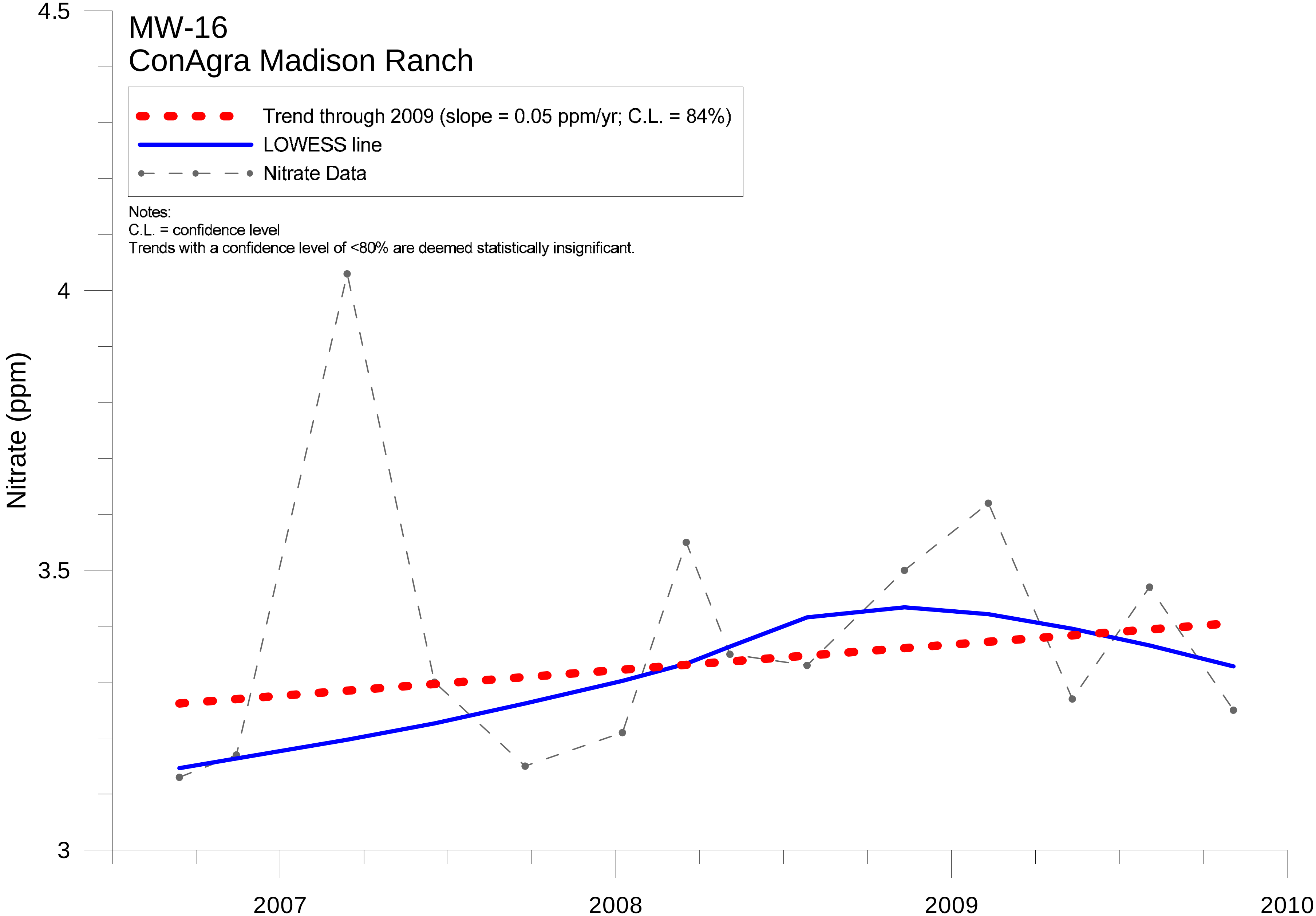


MW-13
ConAgra Madison Ranch
Trend through 2009 (slope = 0.35 ppm/yr; C.L. = 97%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
9.5
9
8.5
8
7.5
7
6.5
2007
2008
2009
2010

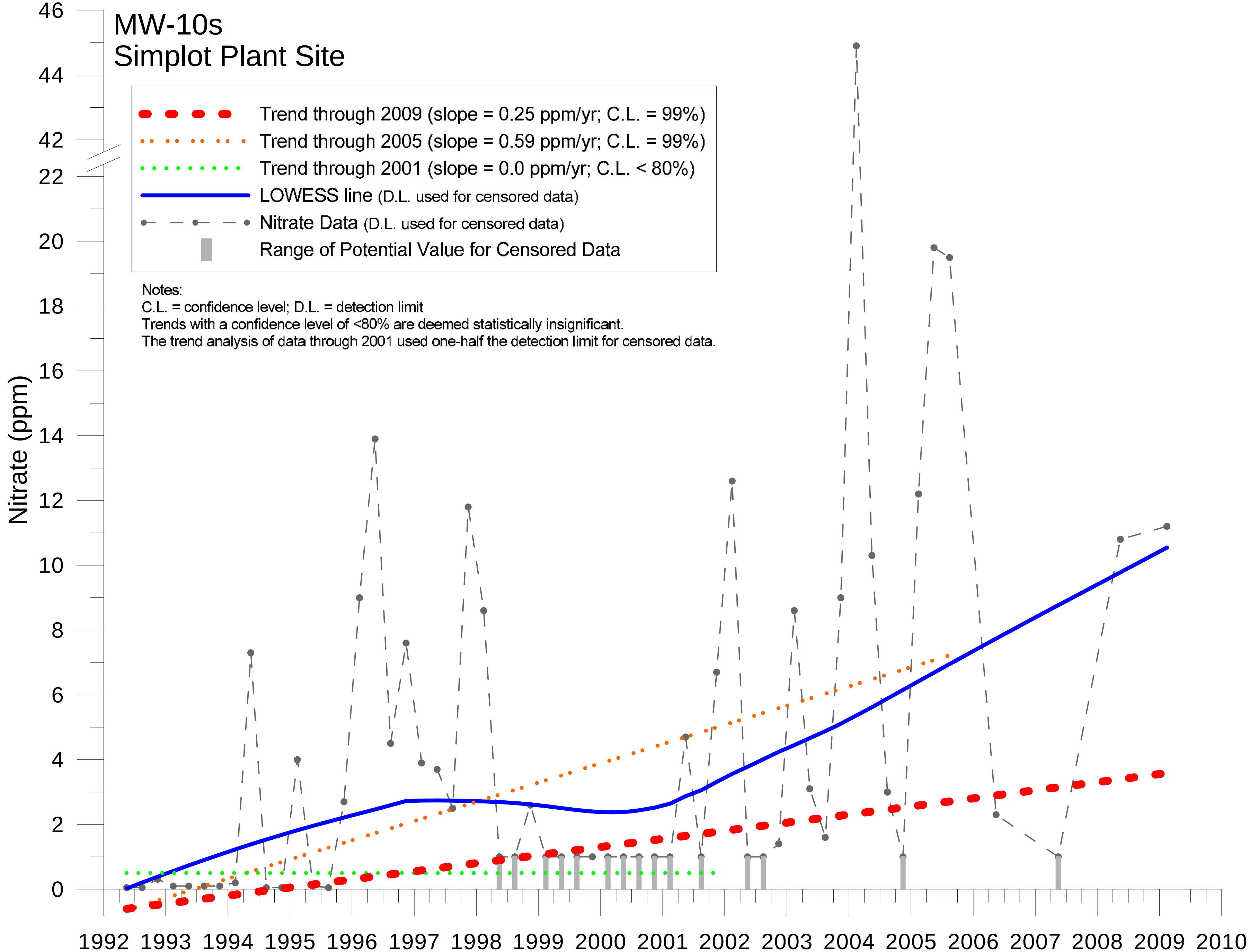

MW-14
ConAgra Madison Ranch
Nitrate (ppm)
5.5
5
4.5
4
3.5
3
2.5
2
2007
2008
2009
2010
Trend through 2009 (slope = 0.20 ppm/yr; C.L. = 97%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



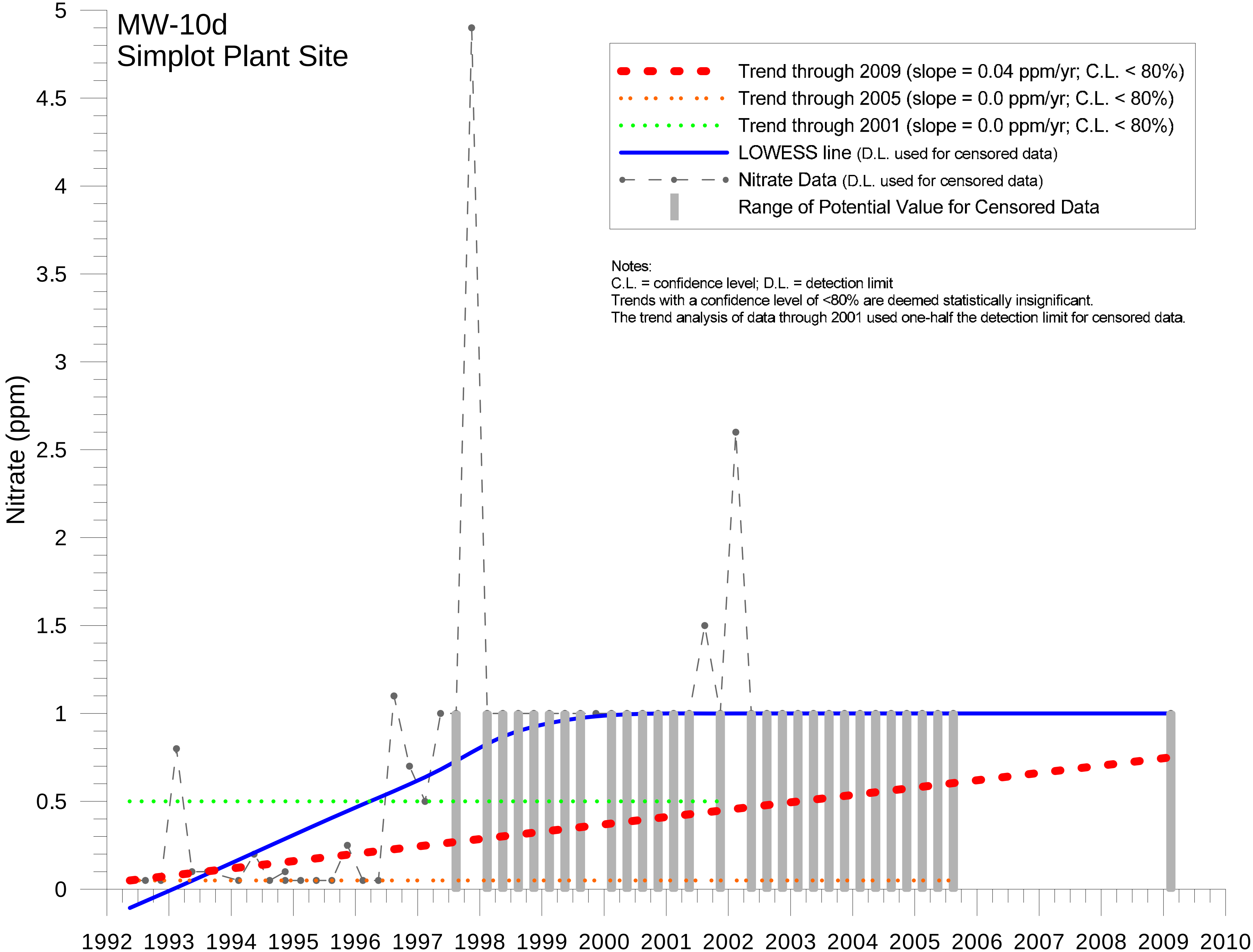
MW-15
ConAgra Madison Ranch
Trend through 2009 (slope = 0.04 ppm/yr; C.L. = 35%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
6
5.5
5
4.5
2007
2008
2009
2010

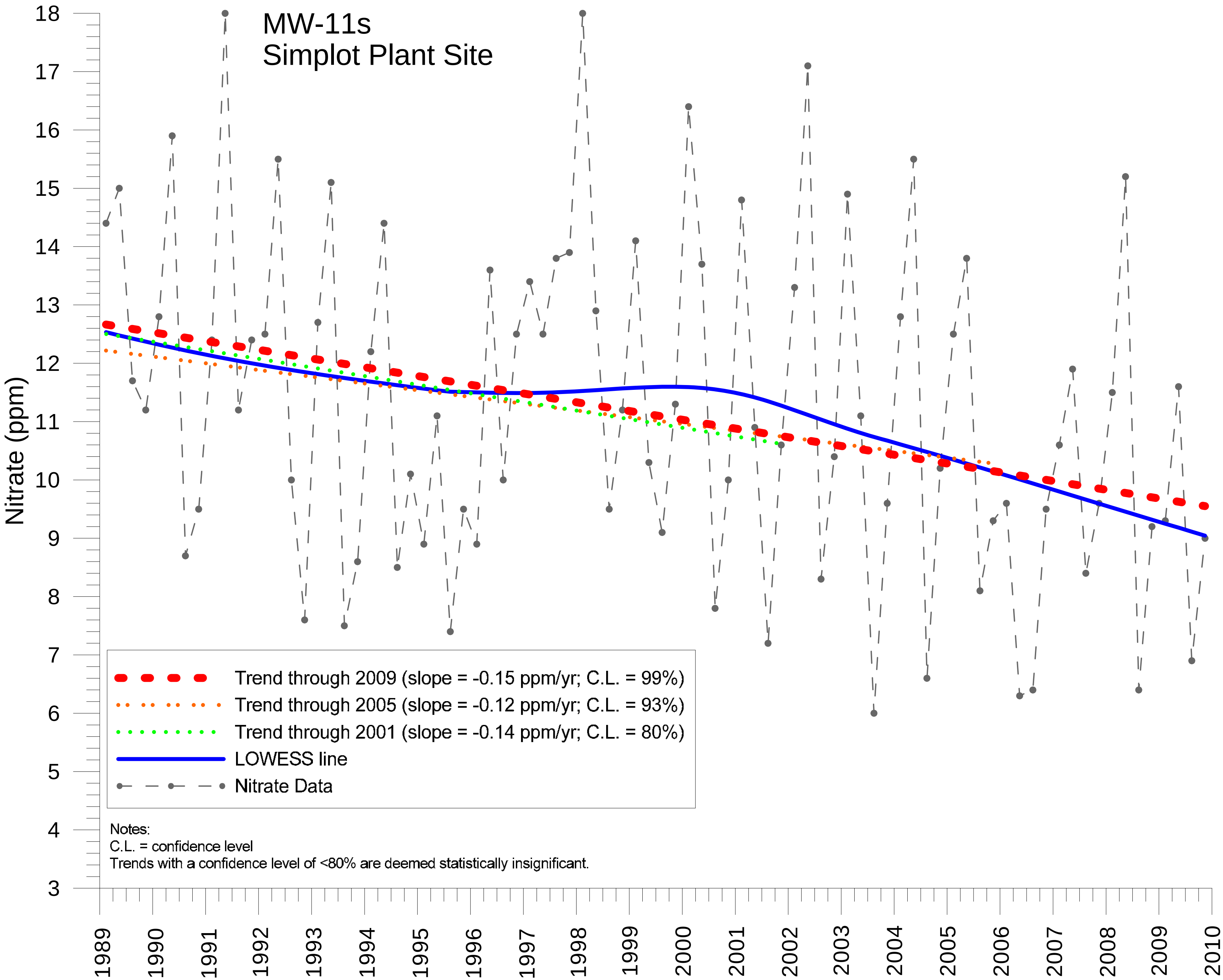


MW-16
ConAgra Madison Ranch
Trend through 2009 (slope = 0.05 ppm/yr; C.L. = 84%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
4.5
4
3.5
3
2007
2008
2009
2010

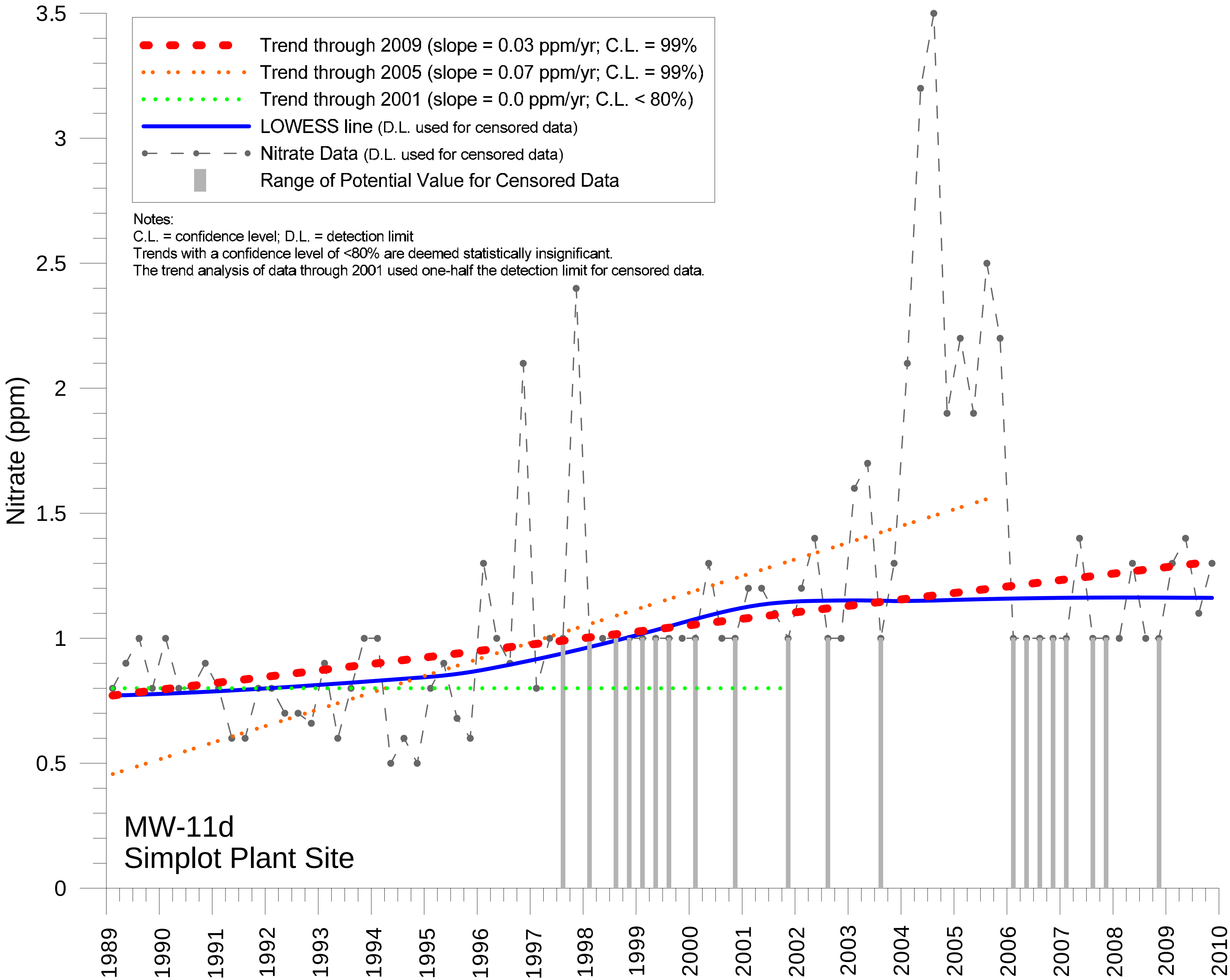


MW-10s
Simplot Plant Site
Trend through 2009 (slope = 0.25 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 0.59 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.0 ppm/yr; C.L. < 80%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.
Nitrate (ppm)
46
44
42
22
20
18
16
14
12
10
8
6
4
2
0
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

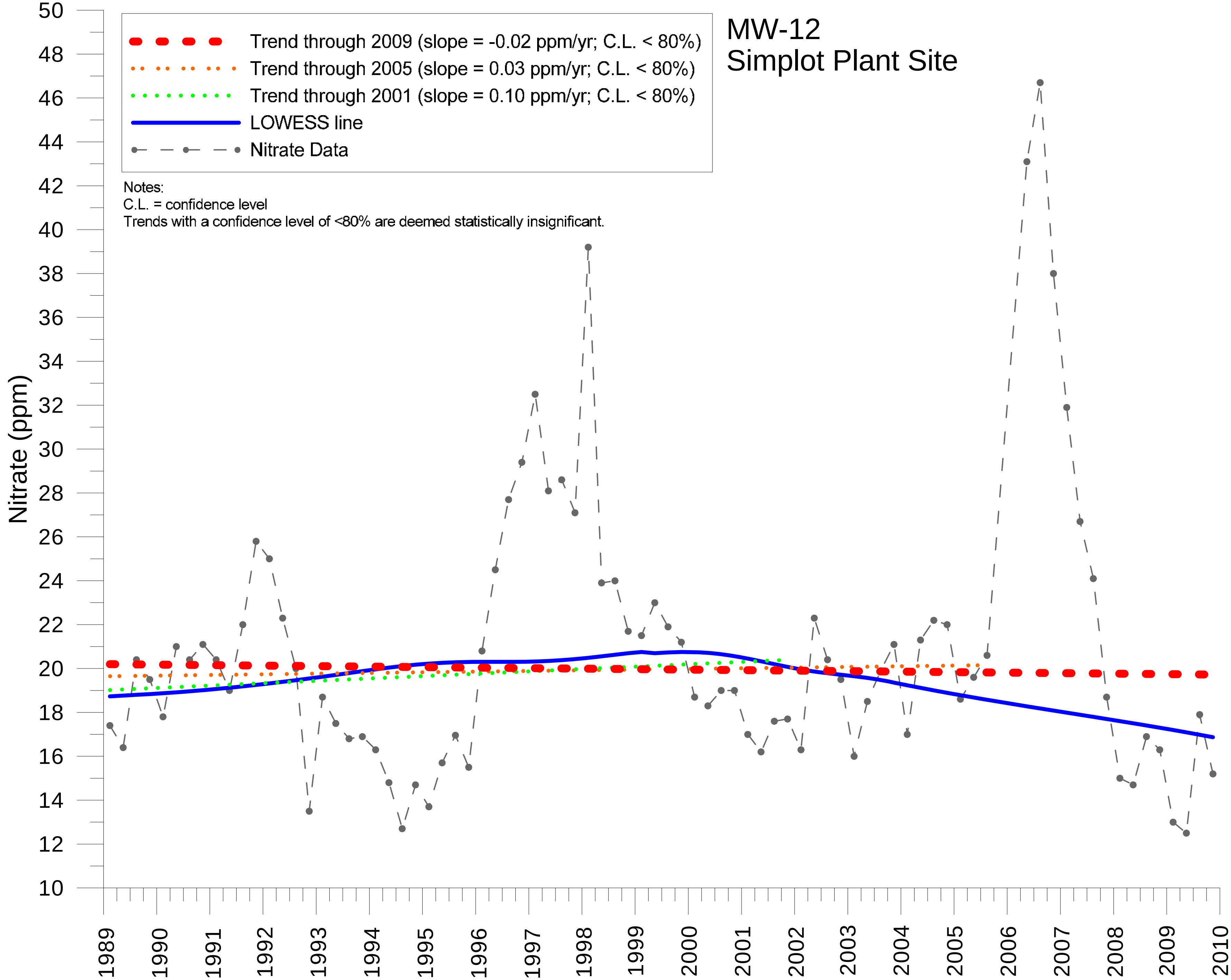

MW-10d
Simplot Plant Site
Trend through 2009 (slope = 0.04 ppm/yr; C.L. < 80%)
Trend through 2005 (slope = 0.0 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 0.0 ppm/yr; C.L. < 80%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.
Nitrate (ppm)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

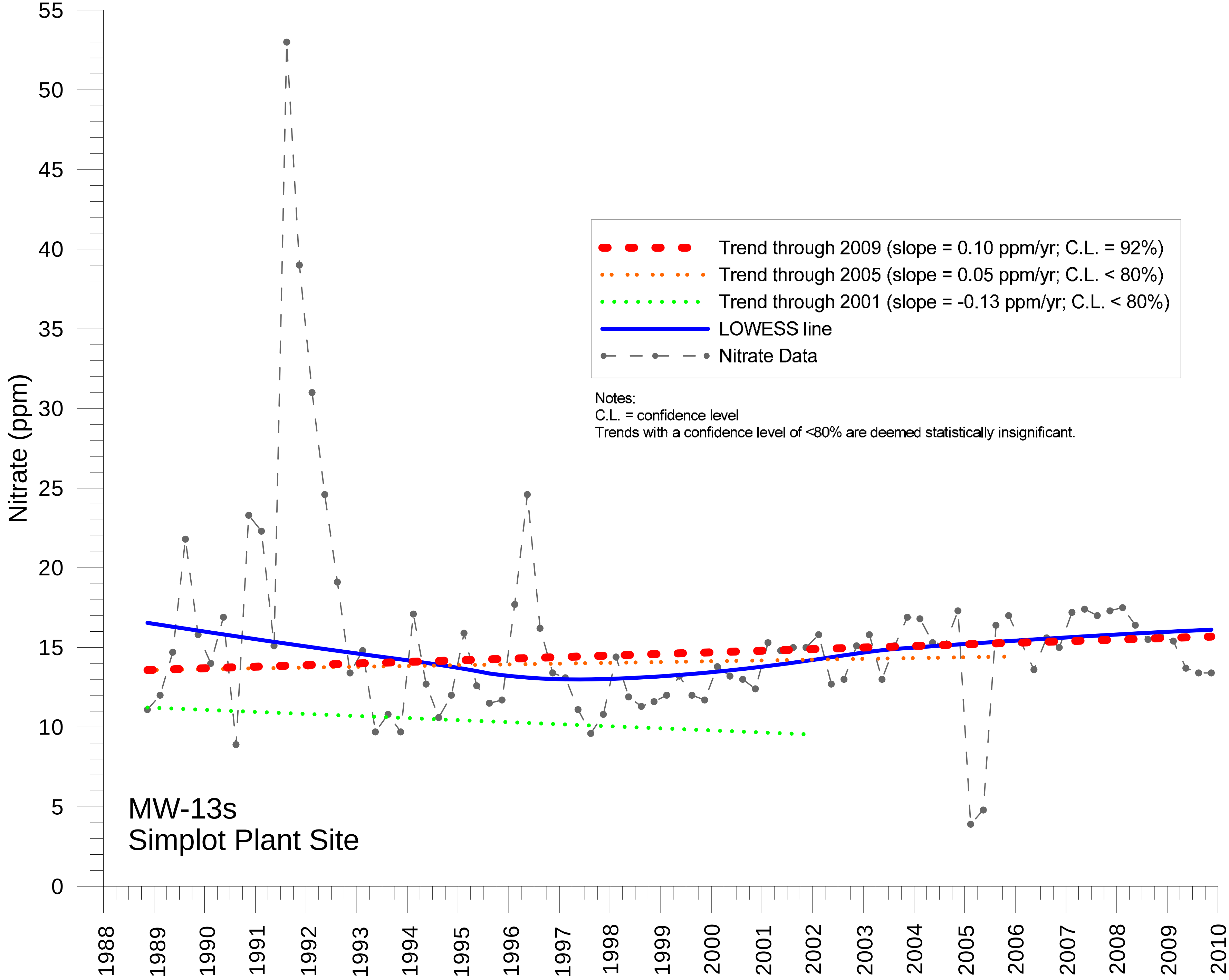


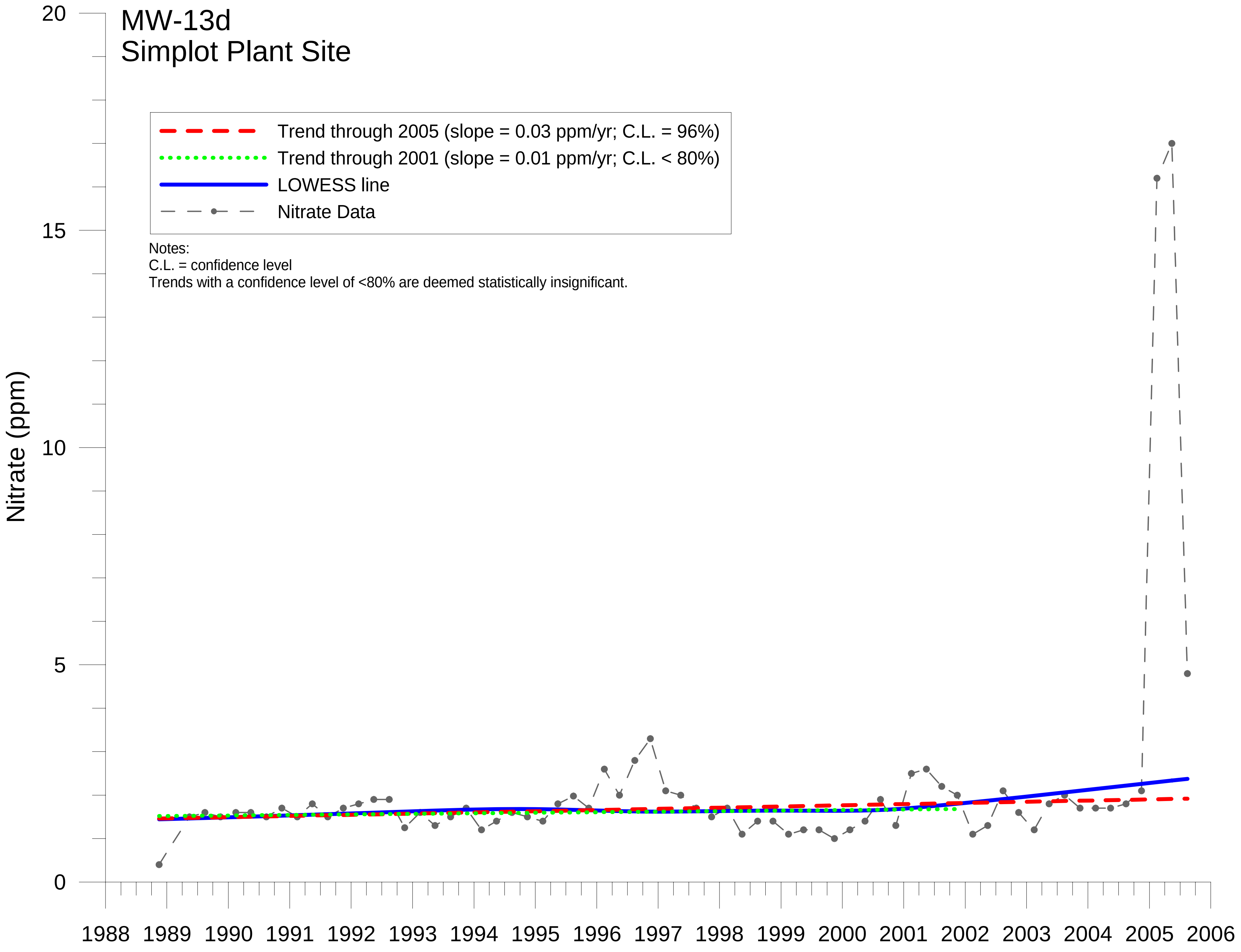
MW-11s
Simplot Plant Site
Nitrate (ppm)
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = -0.15 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = -0.12 ppm/yr; C.L. = 93%)
Trend through 2001 (slope = -0.14 ppm/yr; C.L. = 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



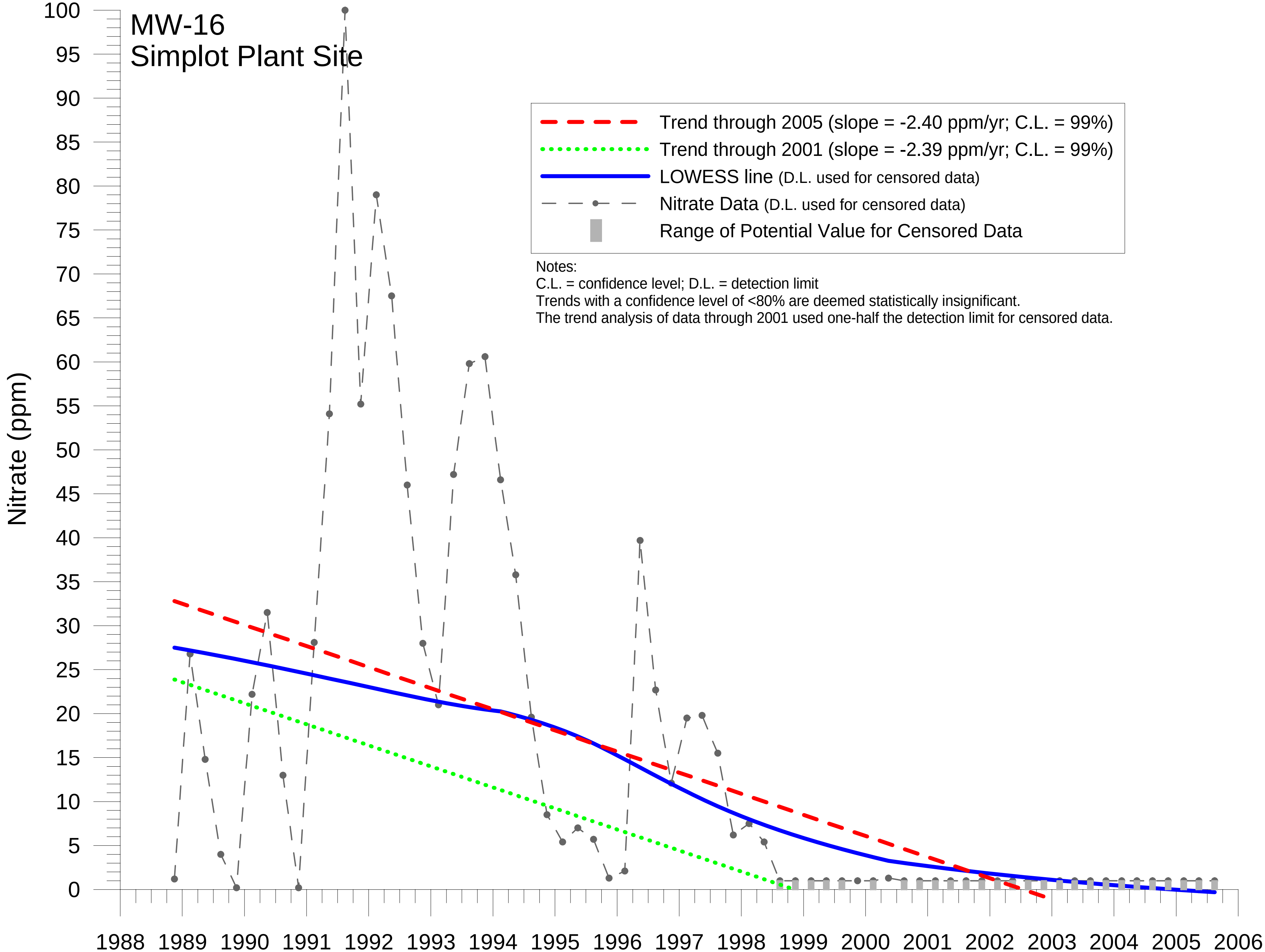
Trend through 2009 (slope = 0.03 ppm/yr; C.L. = 99%
Trend through 2005 (slope = 0.07 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.0 ppm/yr; C.L. < 80%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.
Nitrate (ppm)
MW-11d
Simplot Plant Site
3.5
3
2.5
2
1.5
1
0.5
0
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010


MW-12
Simplot Plant Site
Trend through 2009 (slope = -0.02 ppm/yr; C.L. < 80%)
Trend through 2005 (slope = 0.03 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 0.10 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

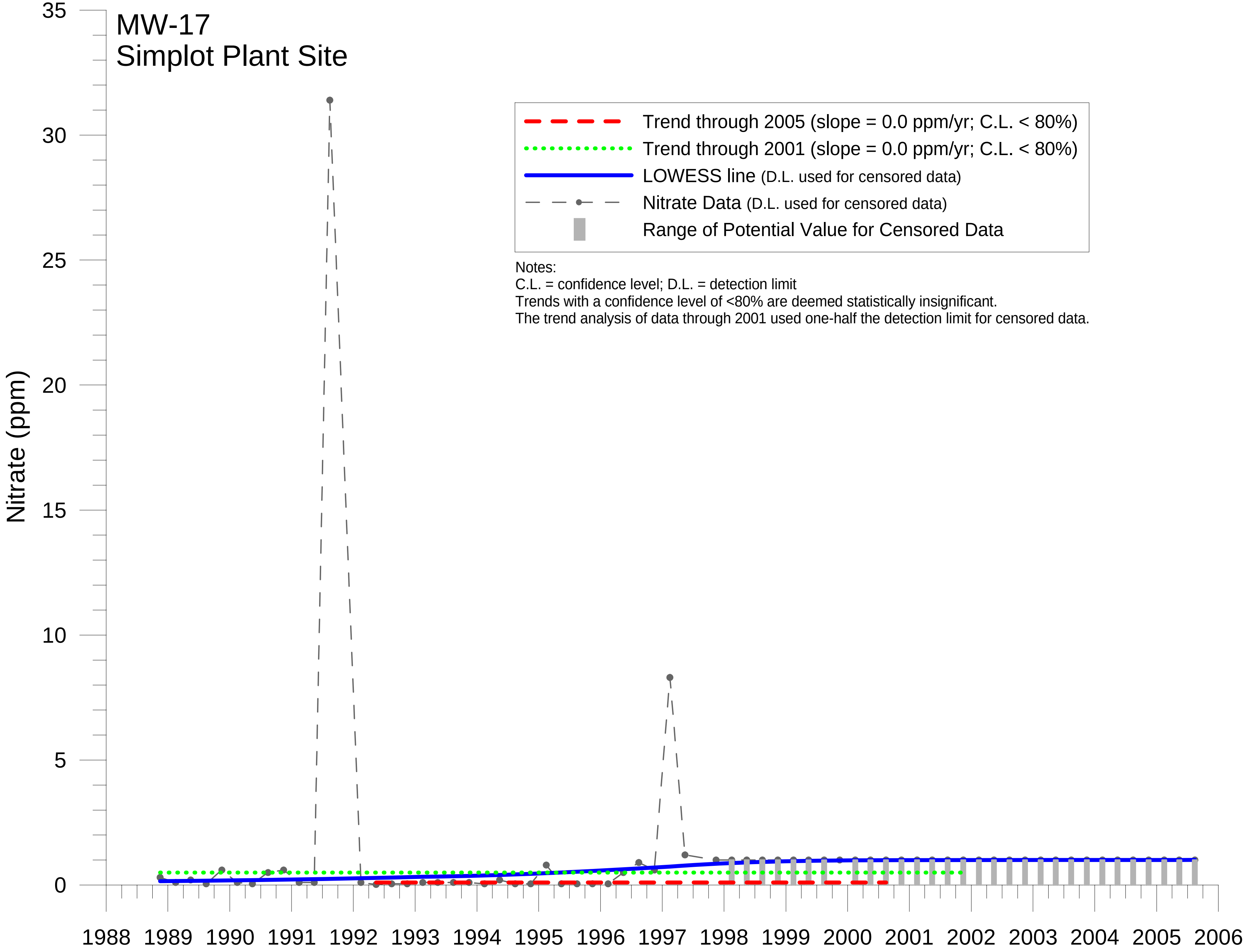

Nitrate (ppm)
55
50
45
40
35
30
25
20
15
10
5
0
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 0.10 ppm/yr; C.L. = 92%)
Trend through 2005 (slope = 0.05 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = -0.13 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
MW-13s
Simplot Plant Site



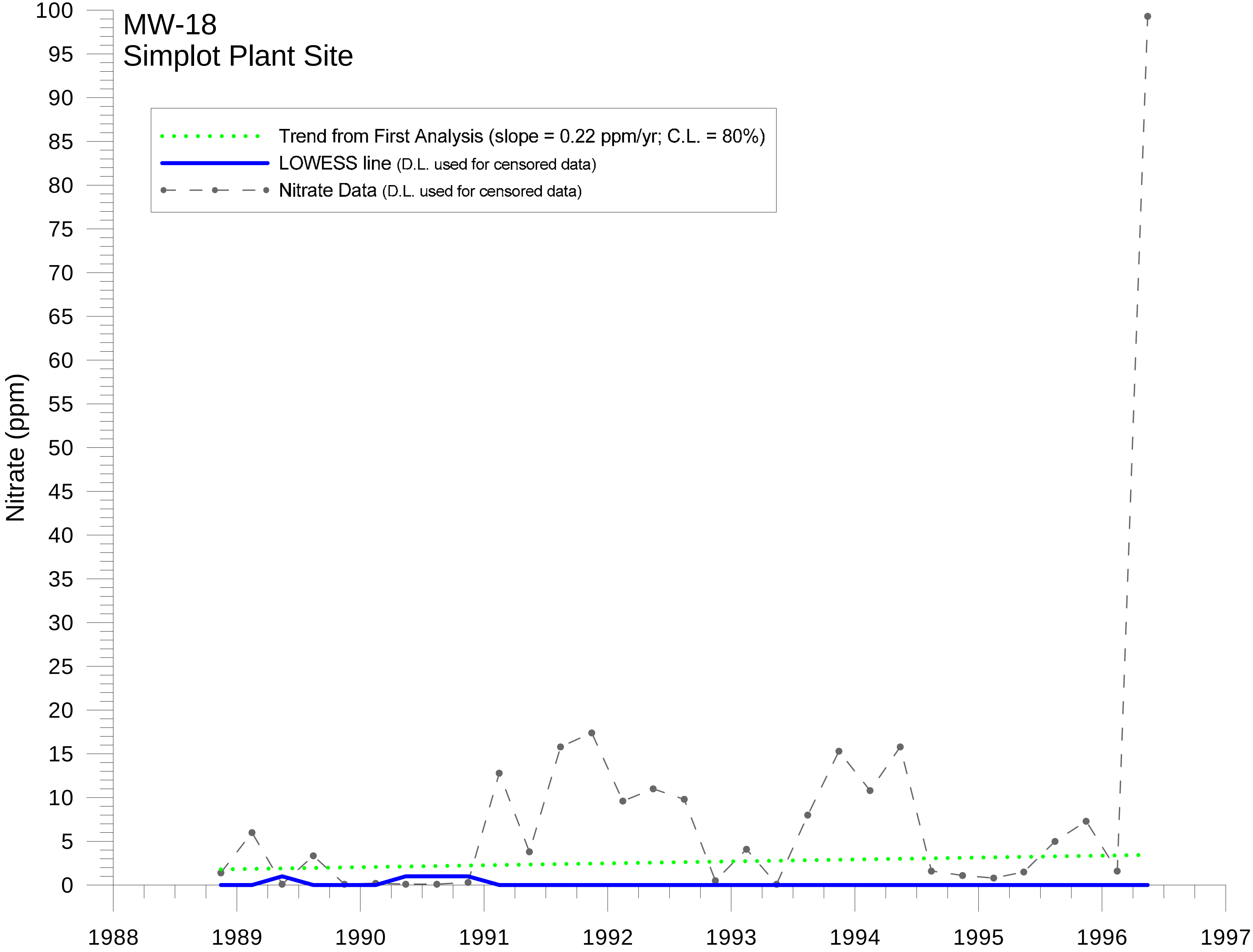
MW-13d
Simplot Plant Site
Trend through 2005 (slope = 0.03 ppm/yr; C.L. = 96%)
Trend through 2001 (slope = 0.01 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0
5
10
15
20
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006



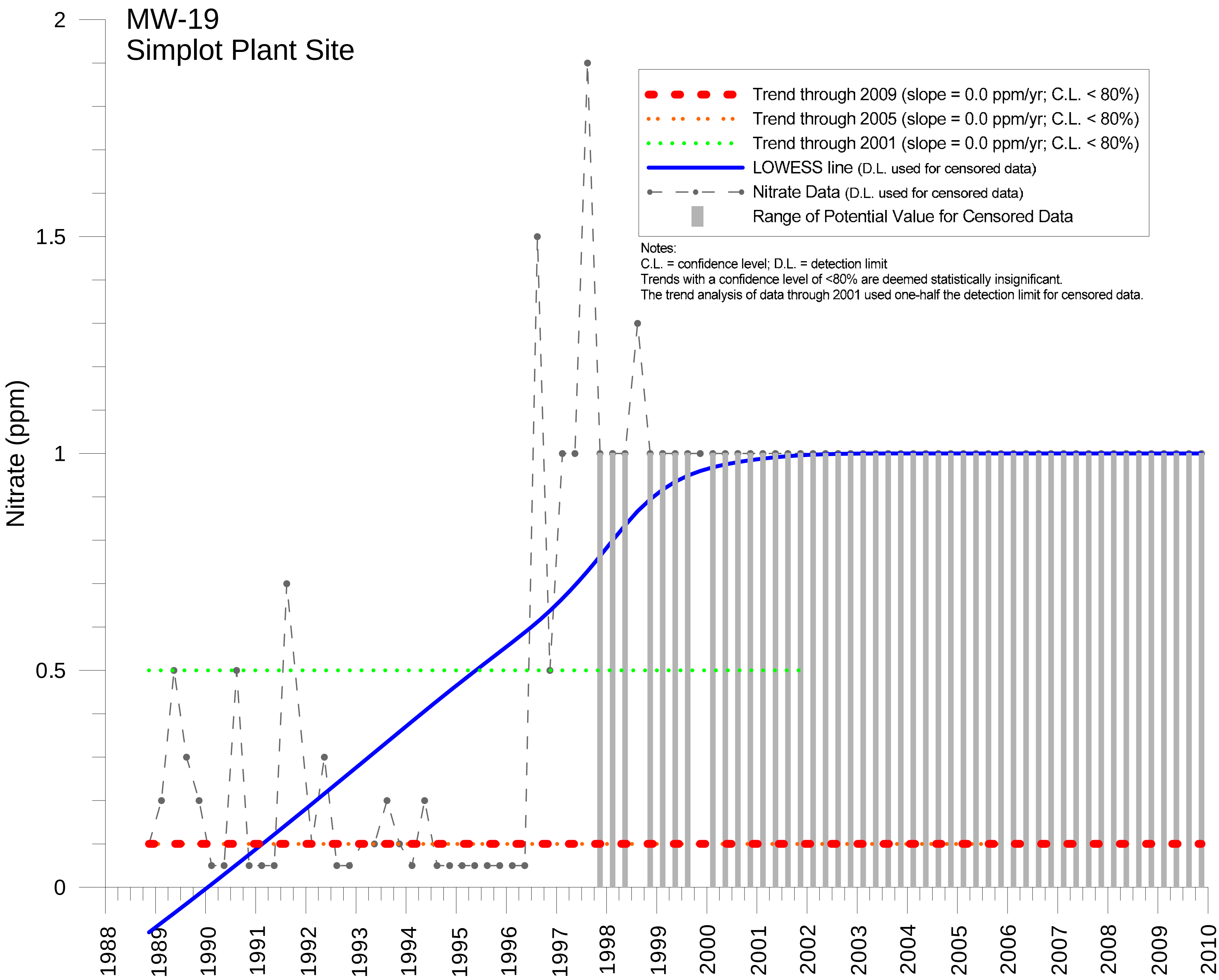
MW-16
Simplot Plant Site
Nitrate (ppm)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = -2.40 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = -2.39 ppm/yr; C.L. = 99%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.



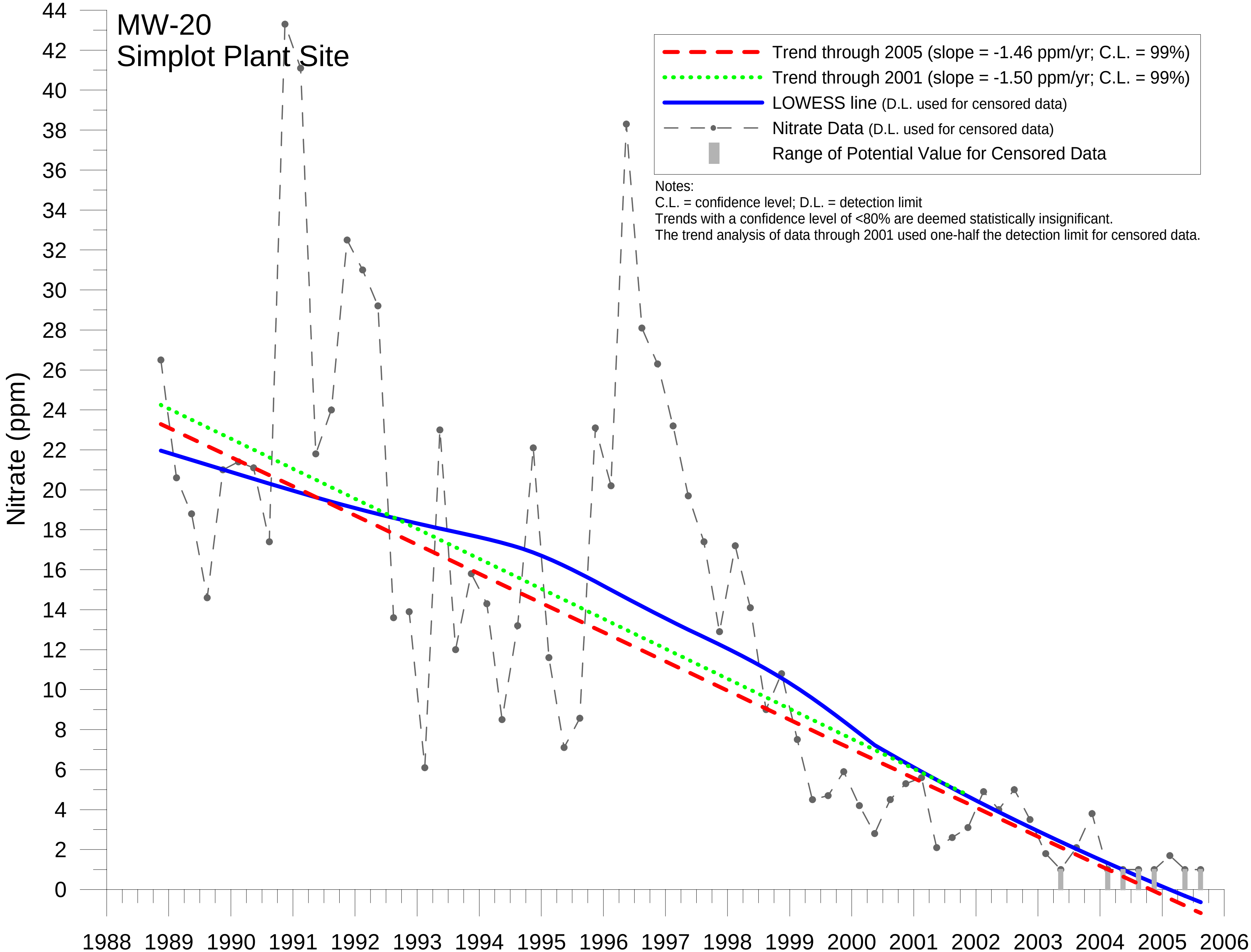
MW-17
Simplot Plant Site
Trend through 2005 (slope = 0.0 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 0.0 ppm/yr; C.L. < 80%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.
Nitrate (ppm)
0
5
10
15
20
25
30
35
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006



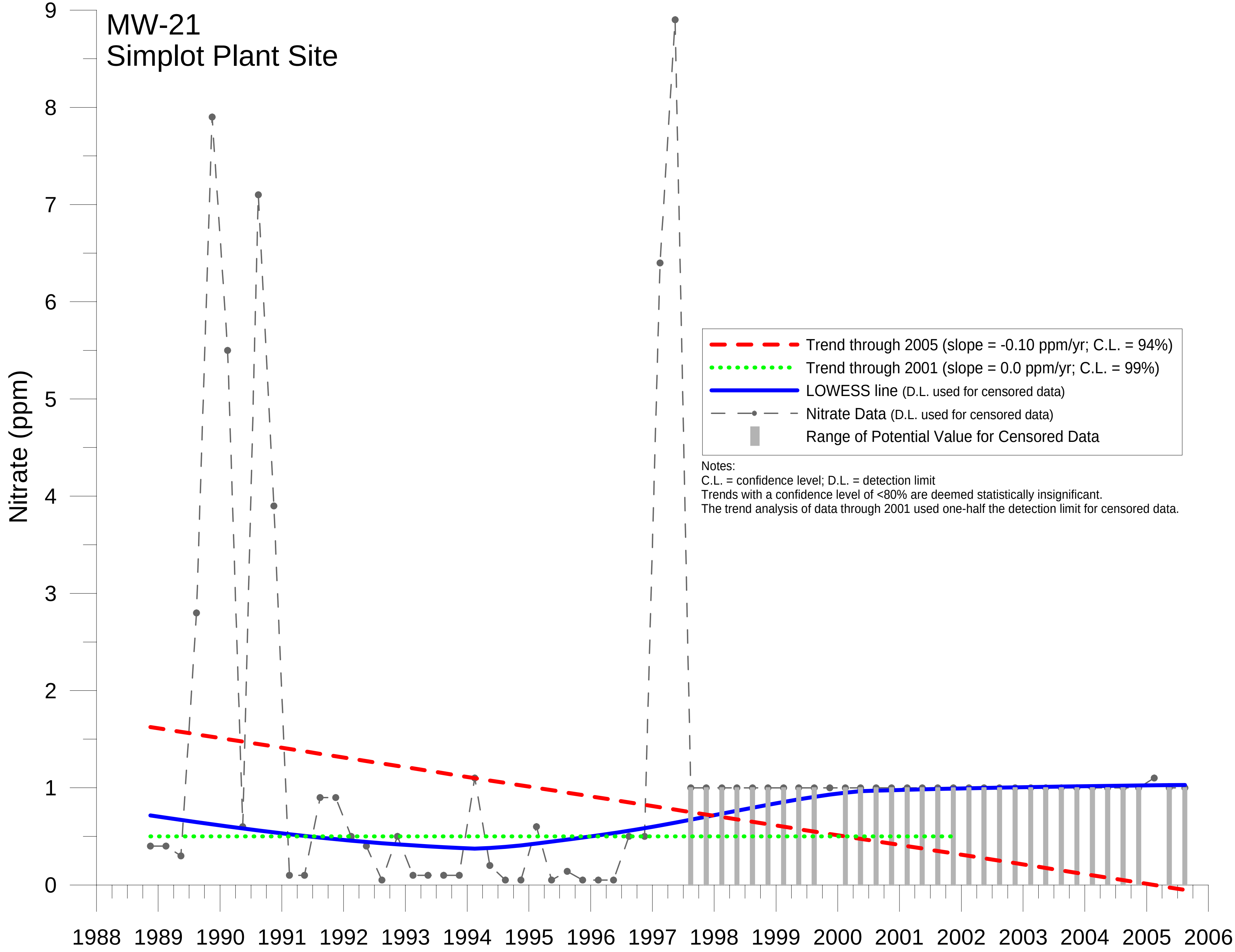
MW-18
Simplot Plant Site
Trend from First Analysis (slope = 0.22 ppm/yr; C.L. = 80%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Nitrate (ppm)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997

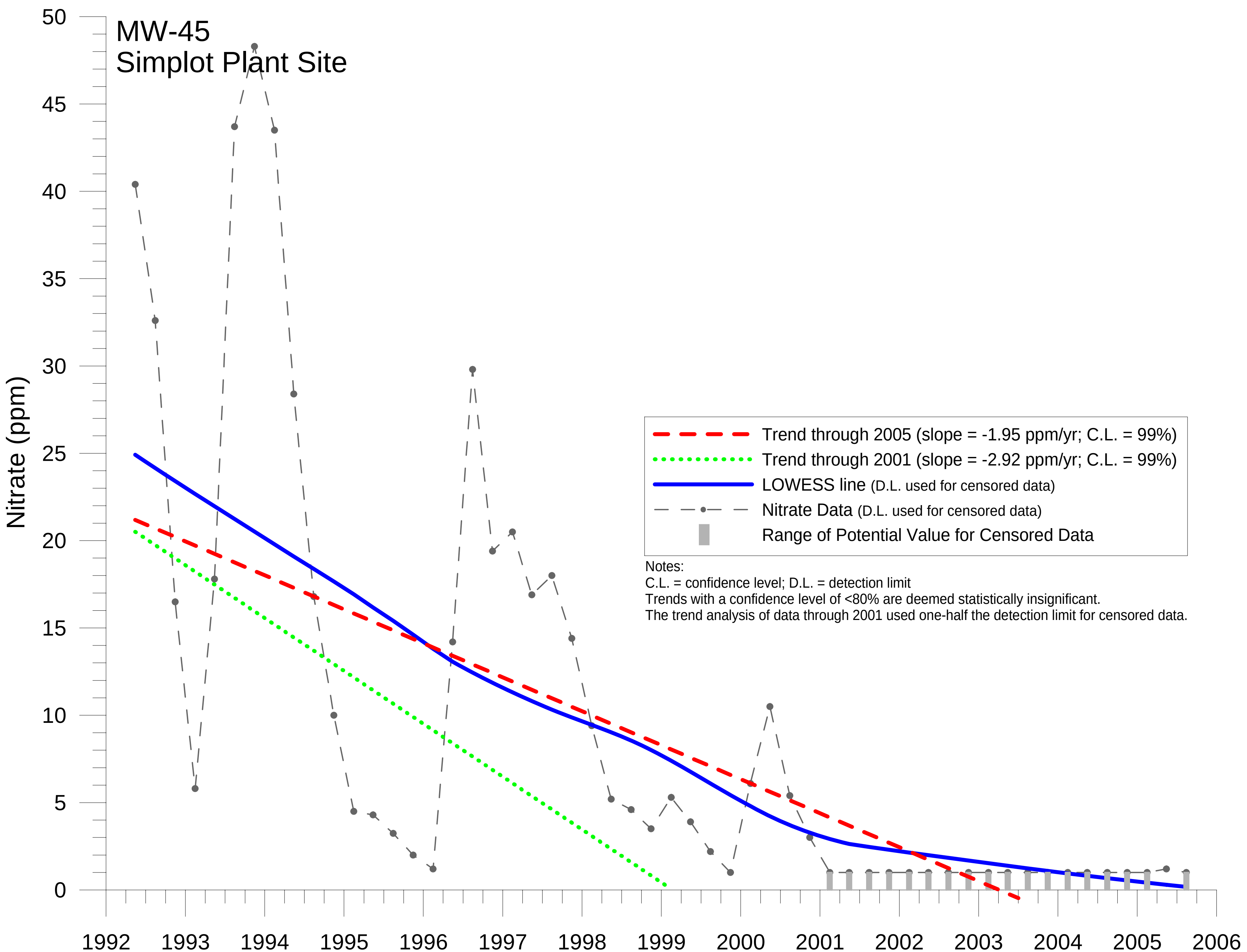


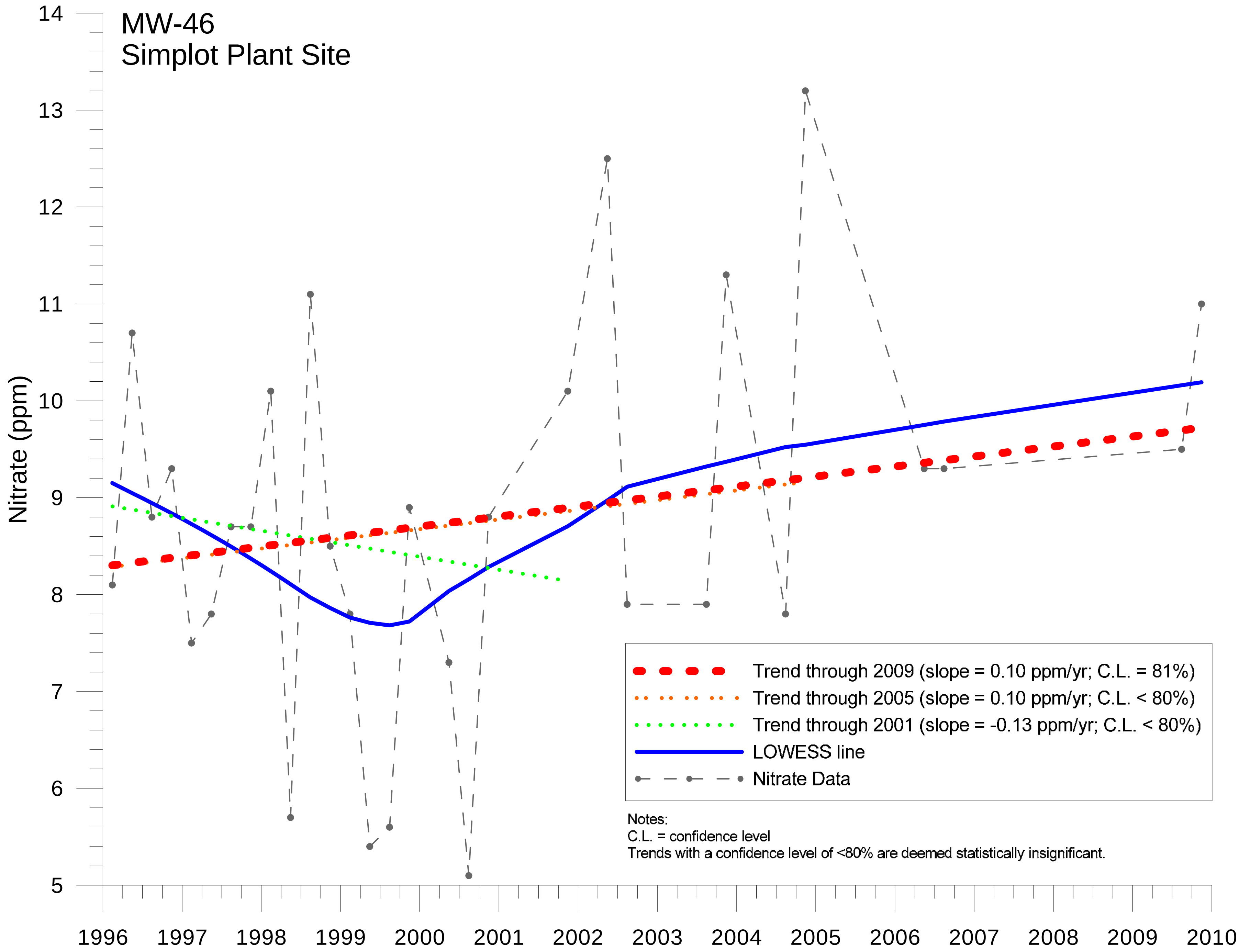
MW-19
Simplot Plant Site
Nitrate (ppm)
0
0.5
1
1.5
2
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 0.0 ppm/yr; C.L. < 80%)
Trend through 2005 (slope = 0.0 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 0.0 ppm/yr; C.L. < 80%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.

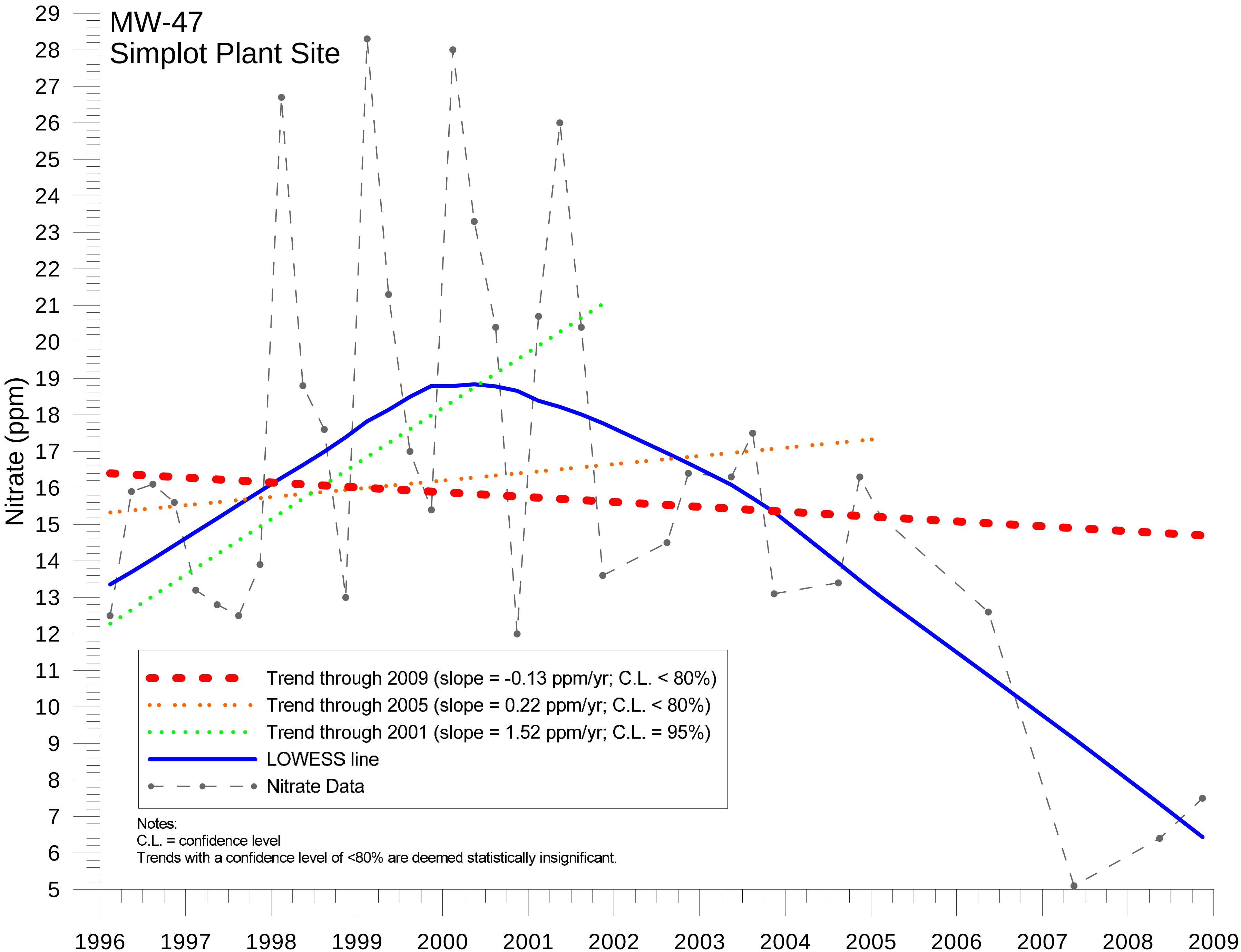


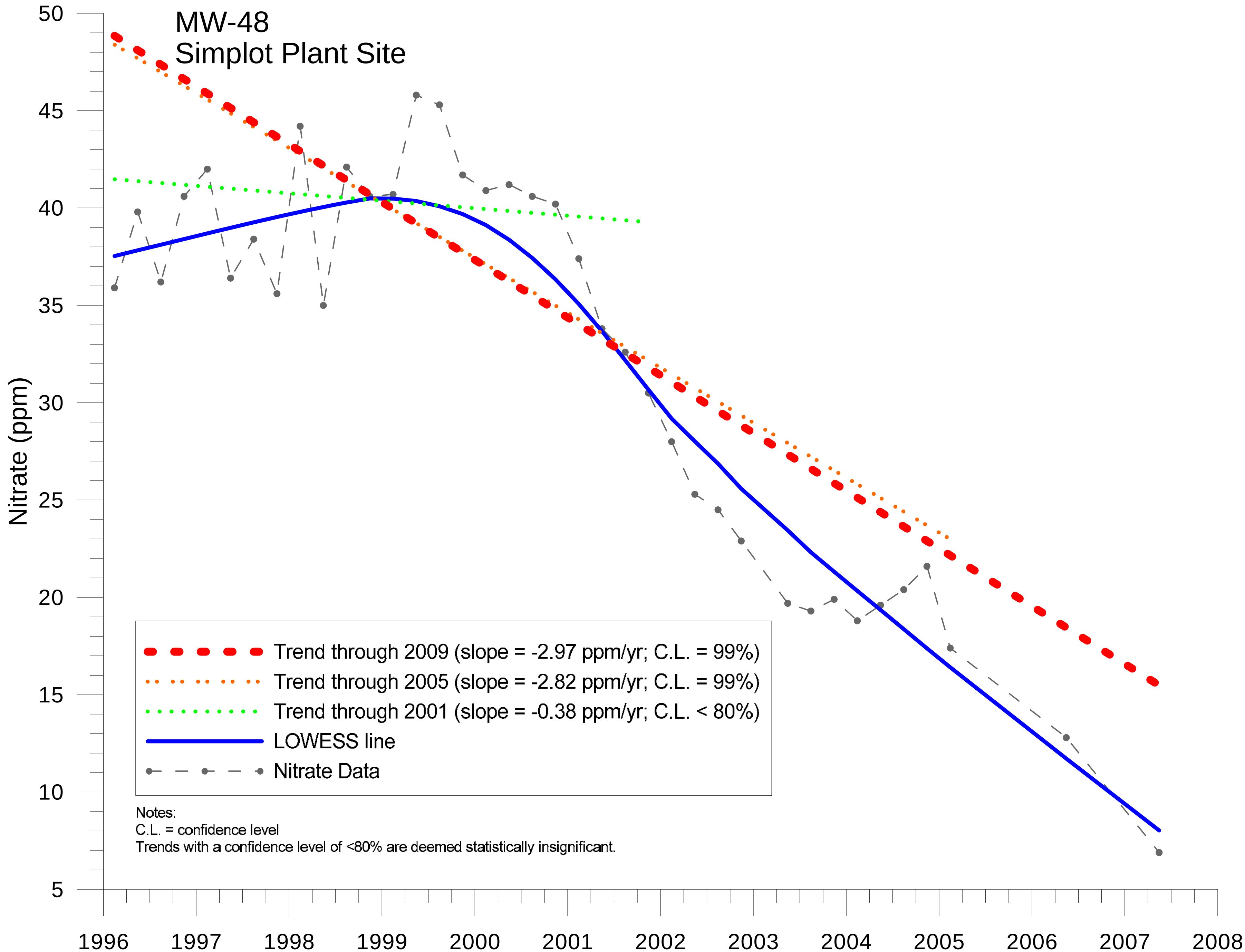
MW-20
Simplot Plant Site
Trend through 2005 (slope = -1.46 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = -1.50 ppm/yr; C.L. = 99%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.
Nitrate (ppm)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

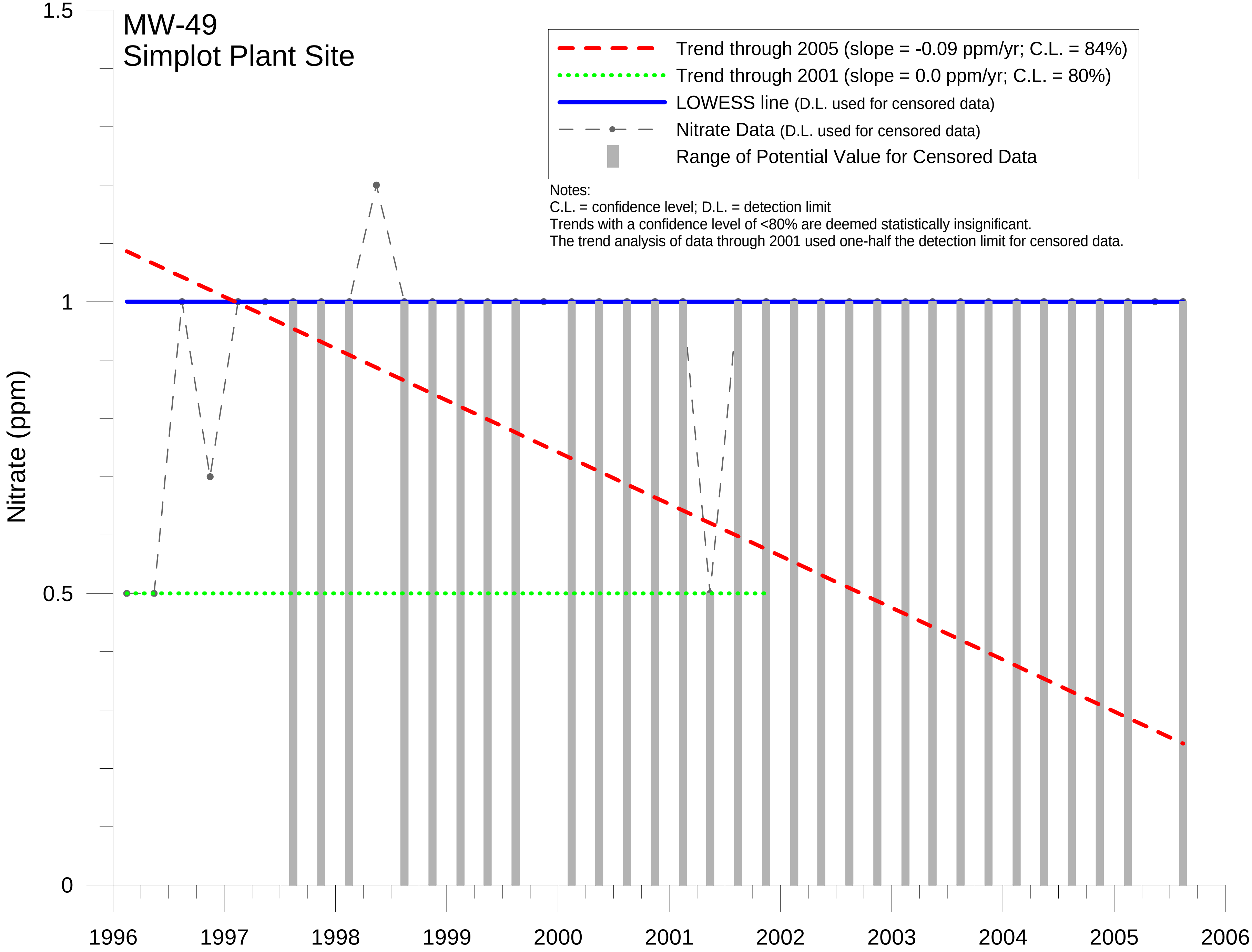

MW-21
Simplot Plant Site
Nitrate (ppm)
0
1
2
3
4
5
6
7
8
9
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = -0.10 ppm/yr; C.L. = 94%)
Trend through 2001 (slope = 0.0 ppm/yr; C.L. = 99%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.


MW-45
Simplot Plant Site
Nitrate (ppm)
0
5
10
15
20
25
30
35
40
45
50
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = -1.95 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = -2.92 ppm/yr; C.L. = 99%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.

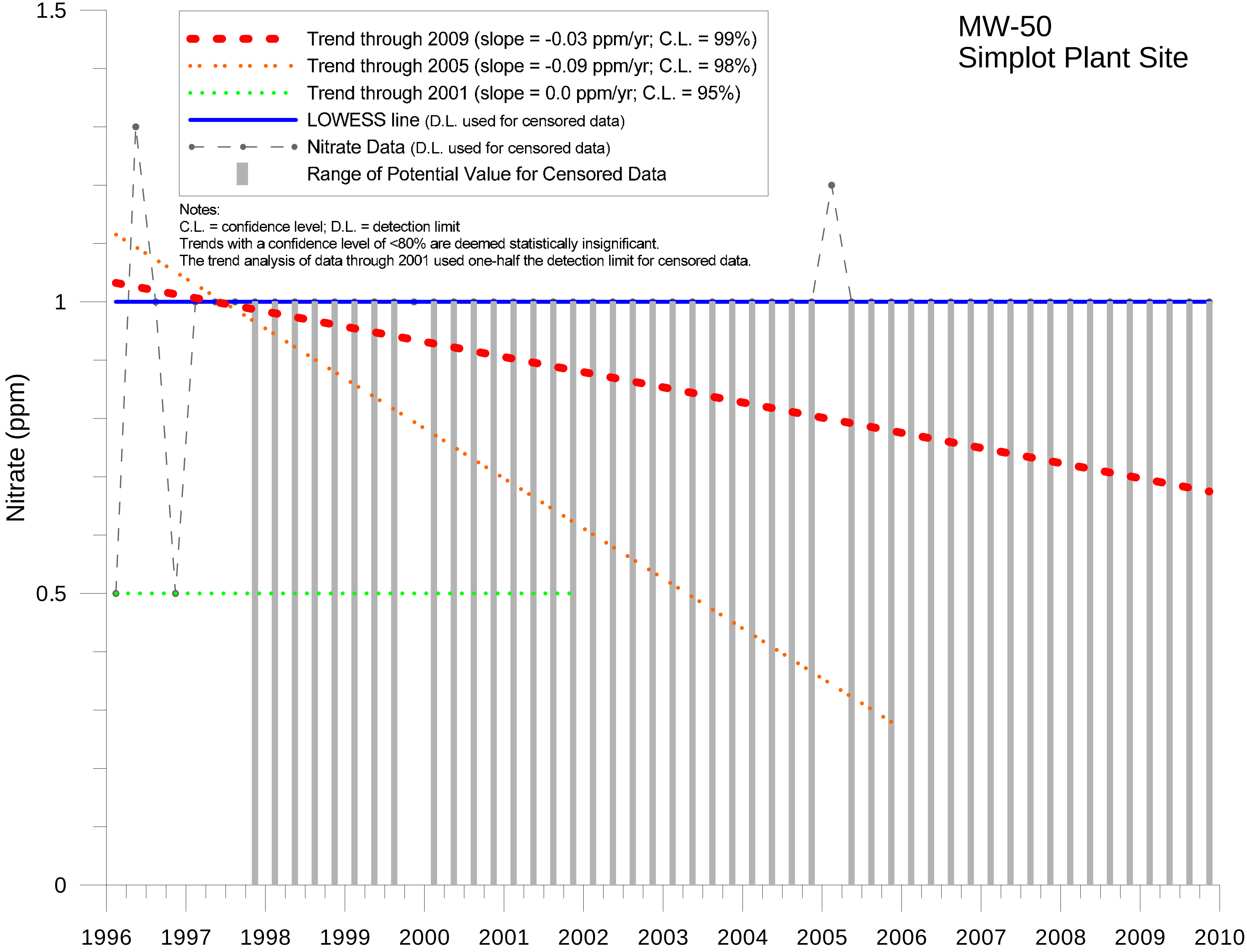

MW-46
Simplot Plant Site
Nitrate (ppm)
14
13
12
11
10
9
8
7
6
5
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 0.10 ppm/yr; C.L. = 81%)
Trend through 2005 (slope = 0.10 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = -0.13 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

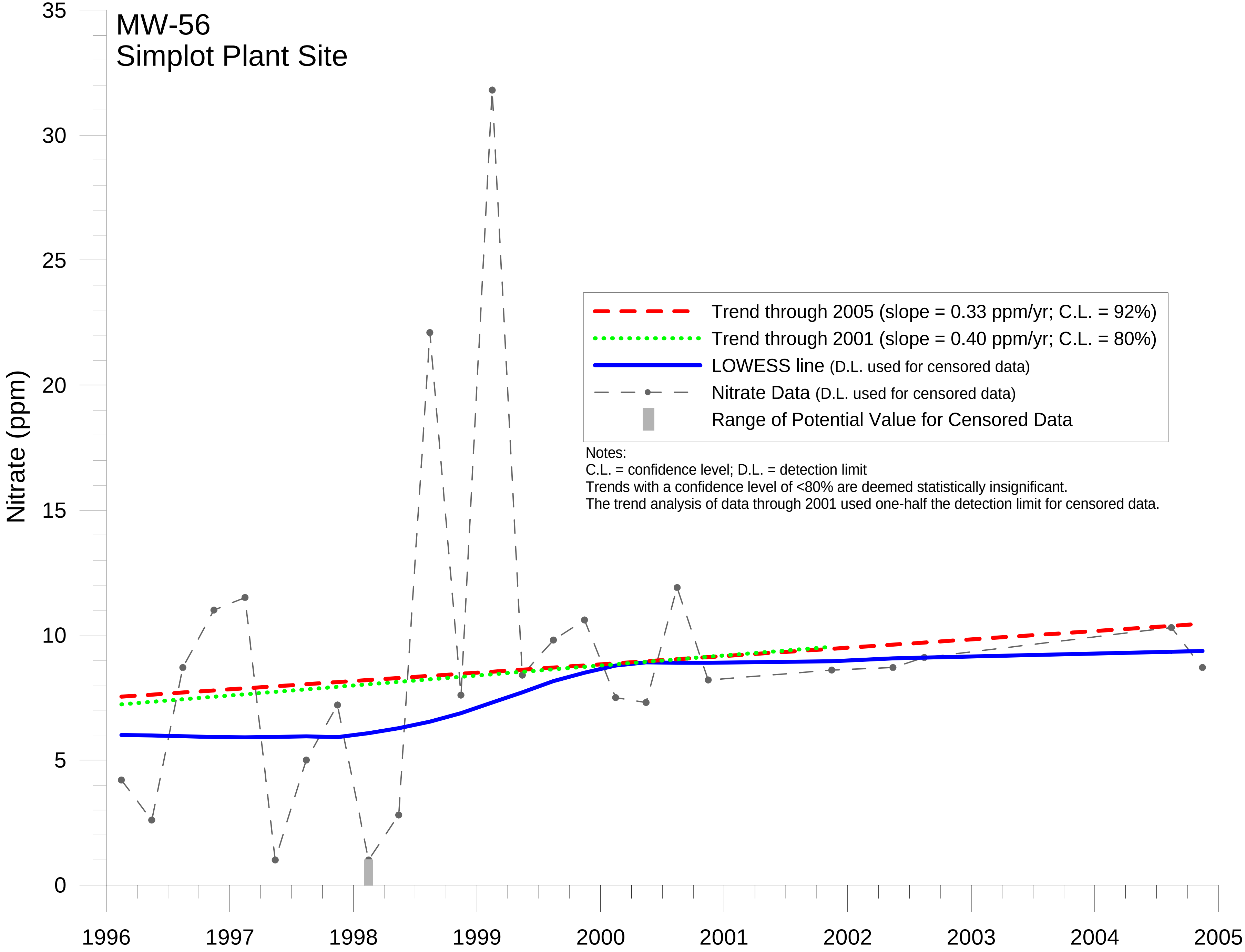

MW-47
Simplot Plant Site
Nitrate (ppm)
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Trend through 2009 (slope = -0.13 ppm/yr; C.L. < 80%)
Trend through 2005 (slope = 0.22 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 1.52 ppm/yr; C.L. = 95%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

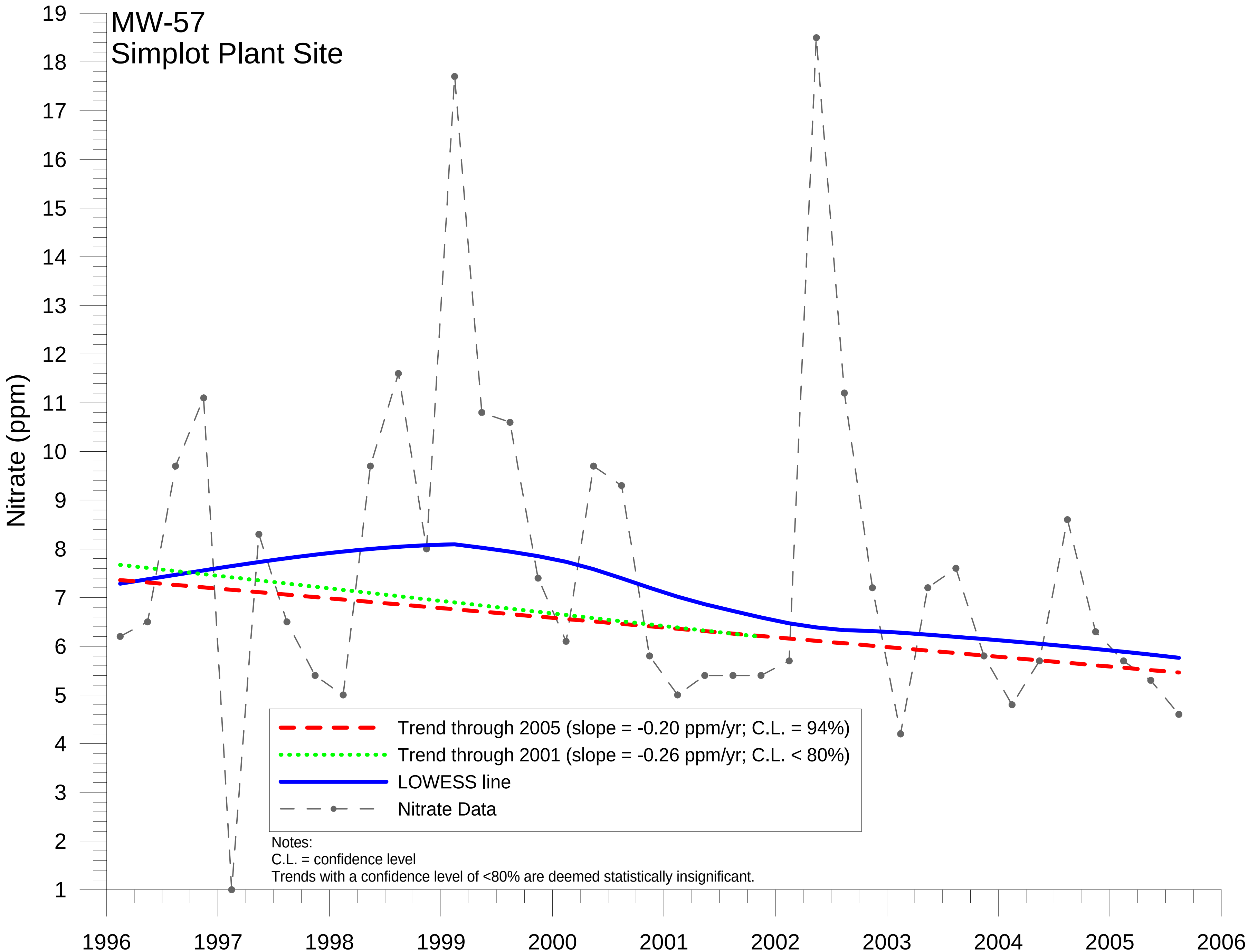

MW-48
Simplot Plant Site
Nitrate (ppm)
50
45
40
35
30
25
20
15
10
5
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Trend through 2009 (slope = -2.97 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = -2.82 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = -0.38 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

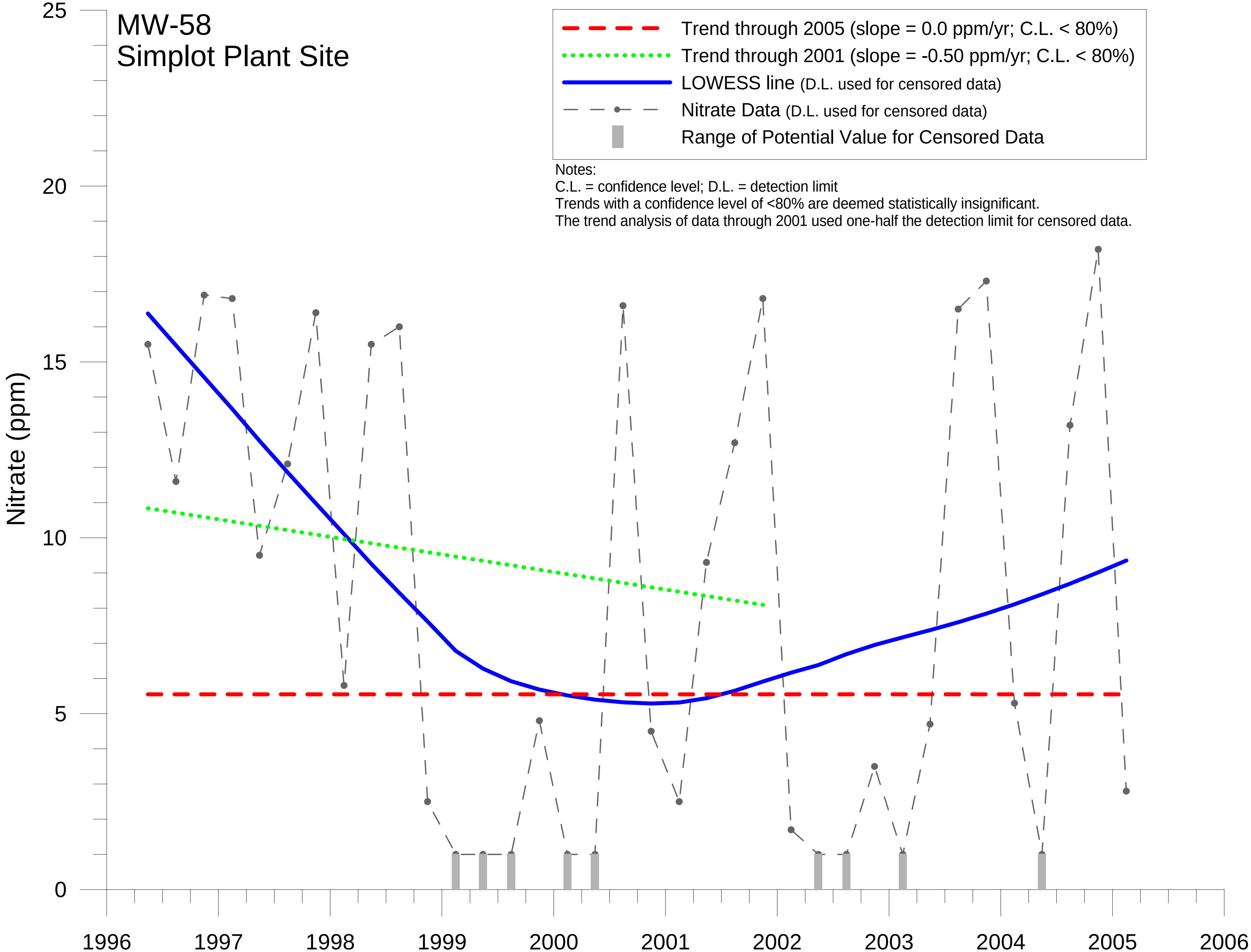


MW-49
Simplot Plant Site
Trend through 2005 (slope = -0.09 ppm/yr; C.L. = 84%)
Trend through 2001 (slope = 0.0 ppm/yr; C.L. = 80%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.
Nitrate (ppm)
1.5
1
0.5
0
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

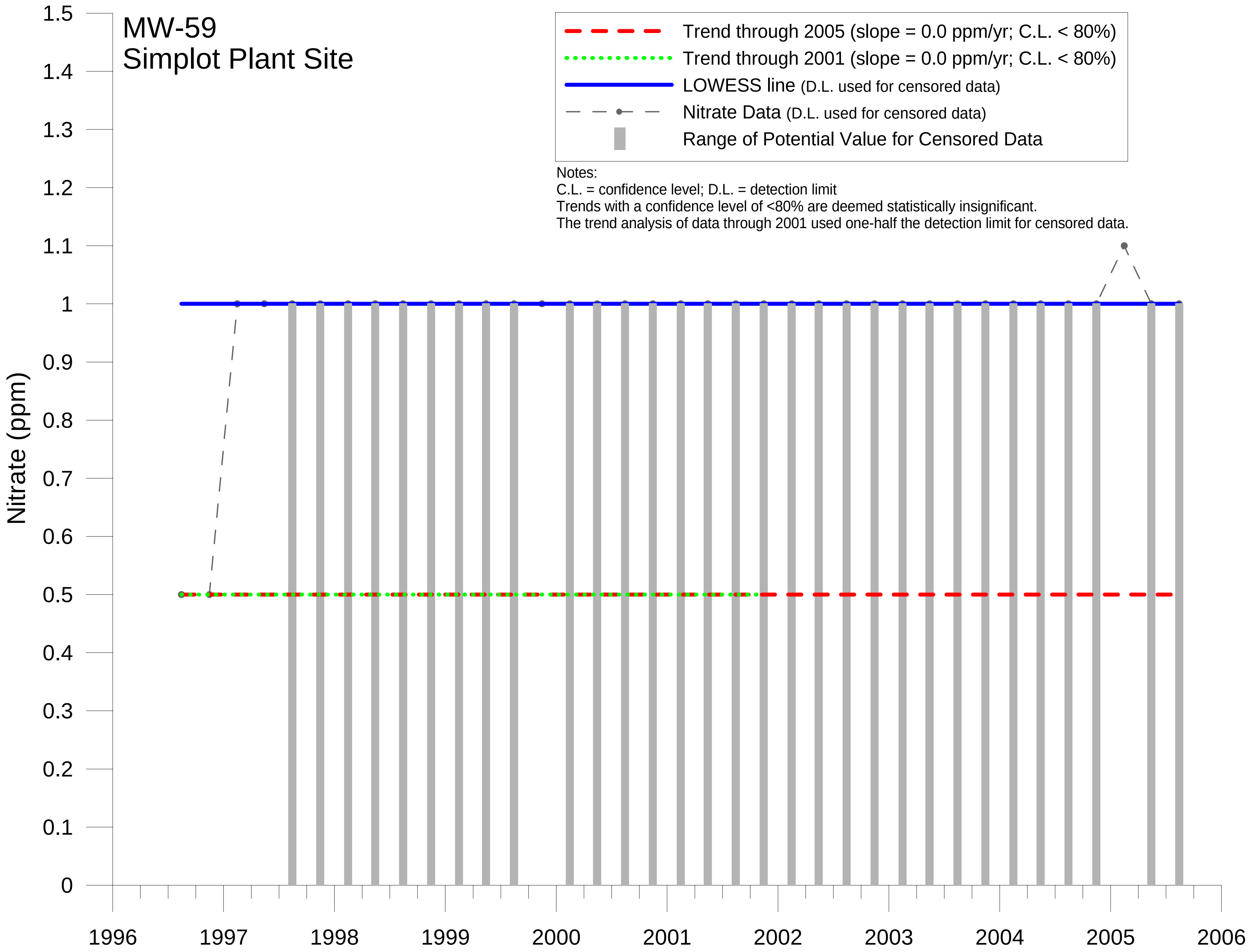

MW-50
Simplot Plant Site
Trend through 2009 (slope = -0.03 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = -0.09 ppm/yr; C.L. = 98%)
Trend through 2001 (slope = 0.0 ppm/yr; C.L. = 95%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.
Nitrate (ppm)
1.5
1
0.5
0
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010


MW-56
Simplot Plant Site
Nitrate (ppm)
0
5
10
15
20
25
30
35
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Trend through 2005 (slope = 0.33 ppm/yr; C.L. = 92%)
Trend through 2001 (slope = 0.40 ppm/yr; C.L. = 80%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.

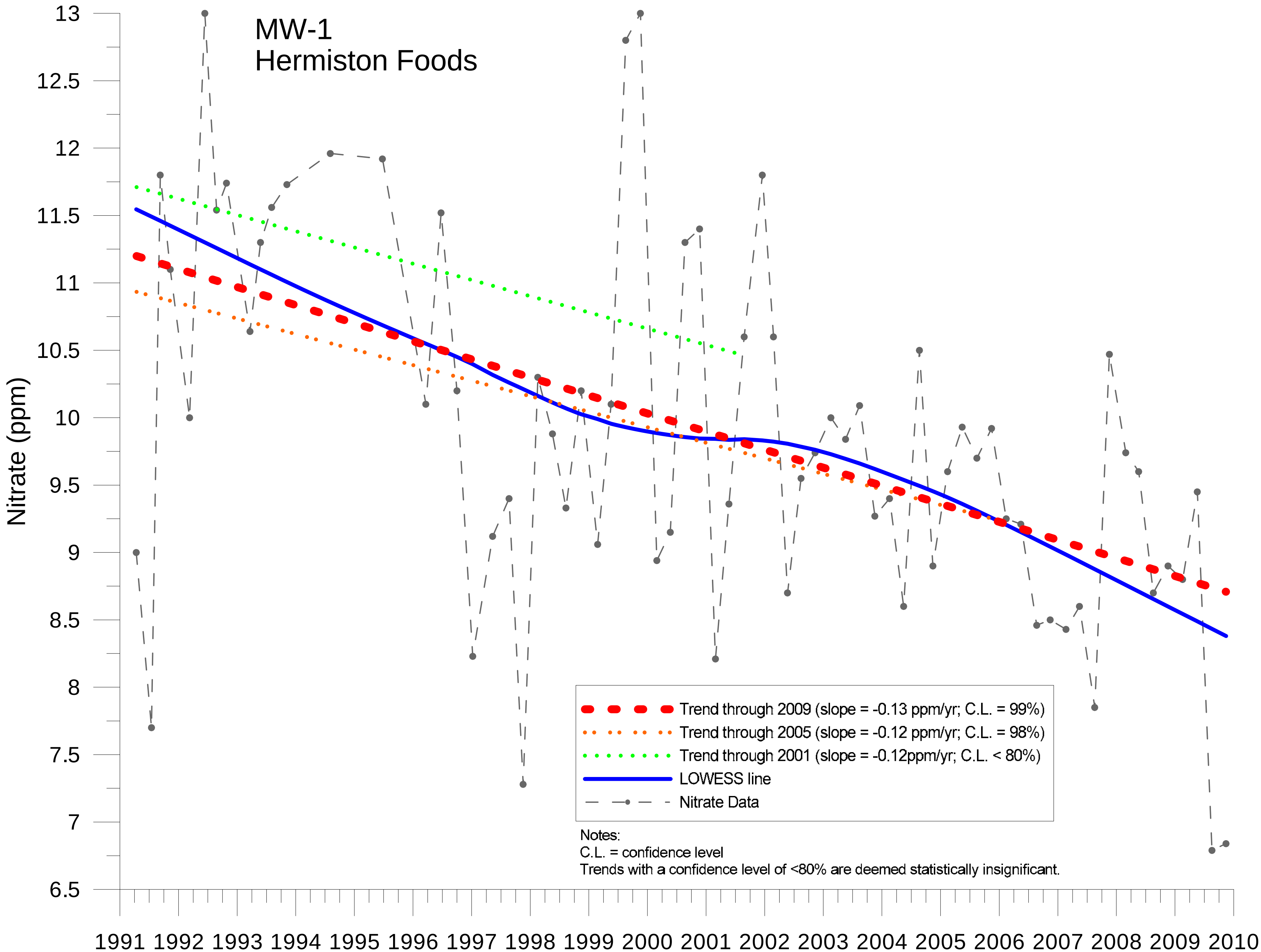

MW-57
Simplot Plant Site
Nitrate (ppm)
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Trend through 2005 (slope = -0.20 ppm/yr; C.L. = 94%)
Trend through 2001 (slope = -0.26 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

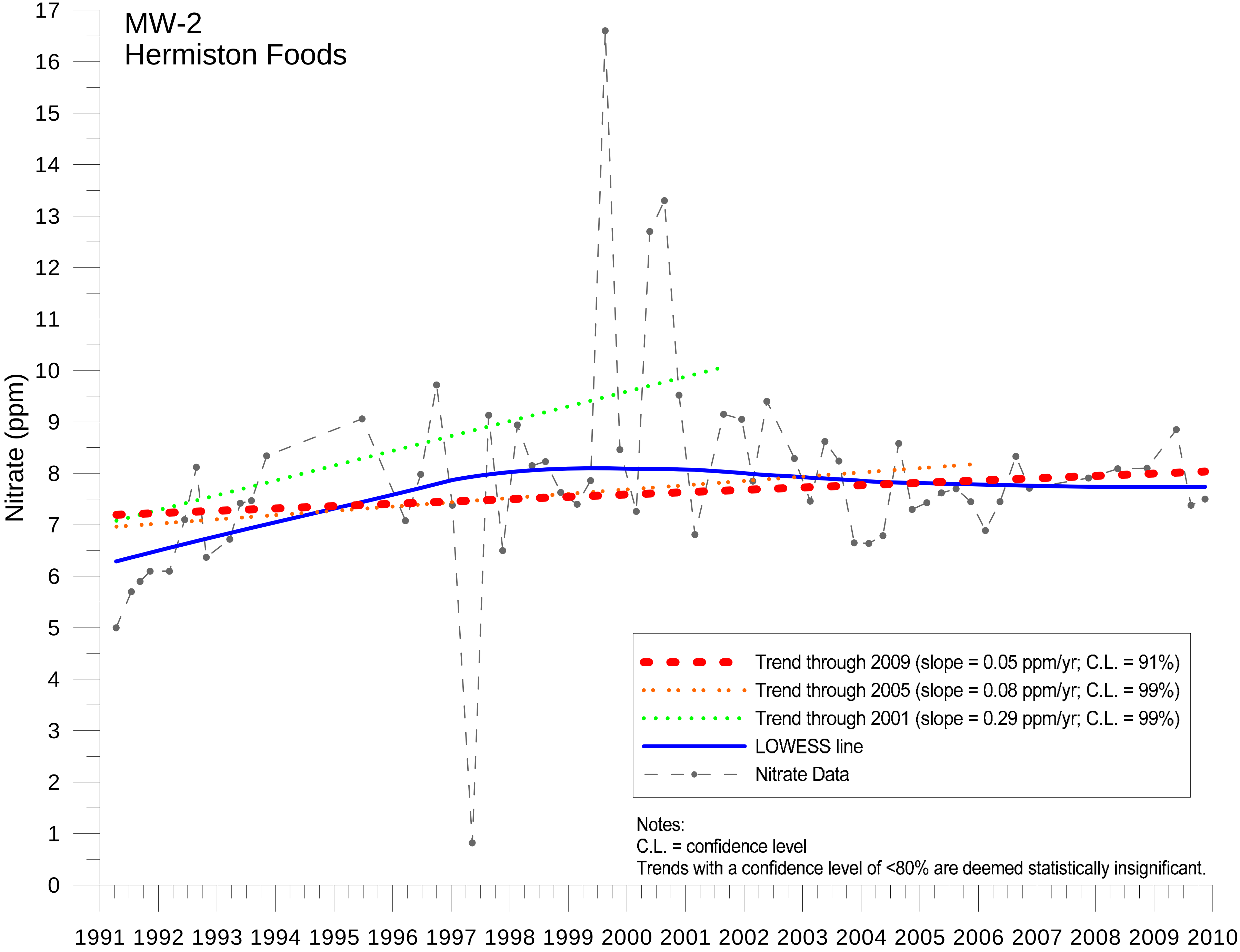


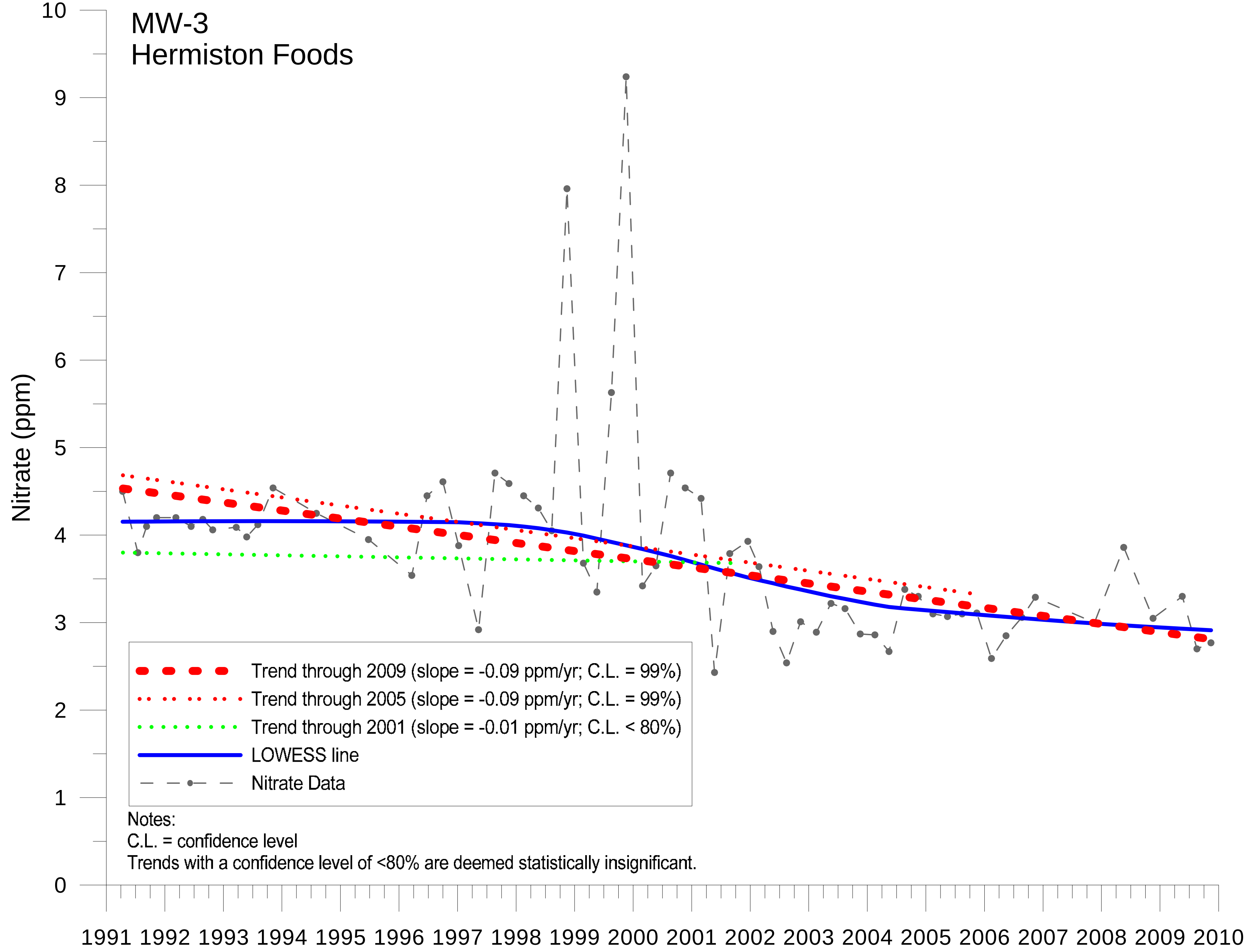
MW-58
Simplot Plant Site
Trend through 2005 (slope = 0.0 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = -0.50 ppm/yr; C.L. < 80%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.
Nitrate (ppm)
0
5
10
15
20
25
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

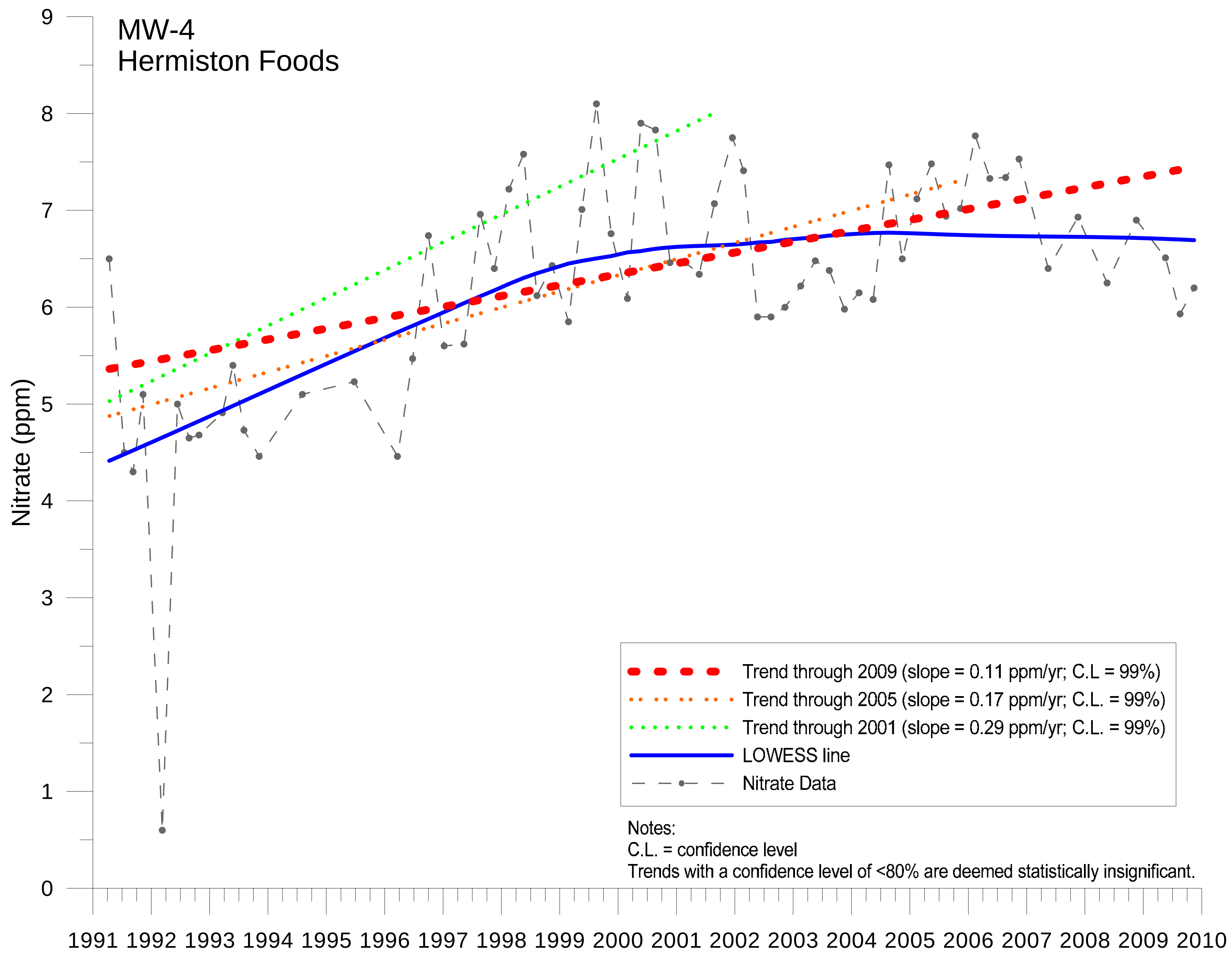


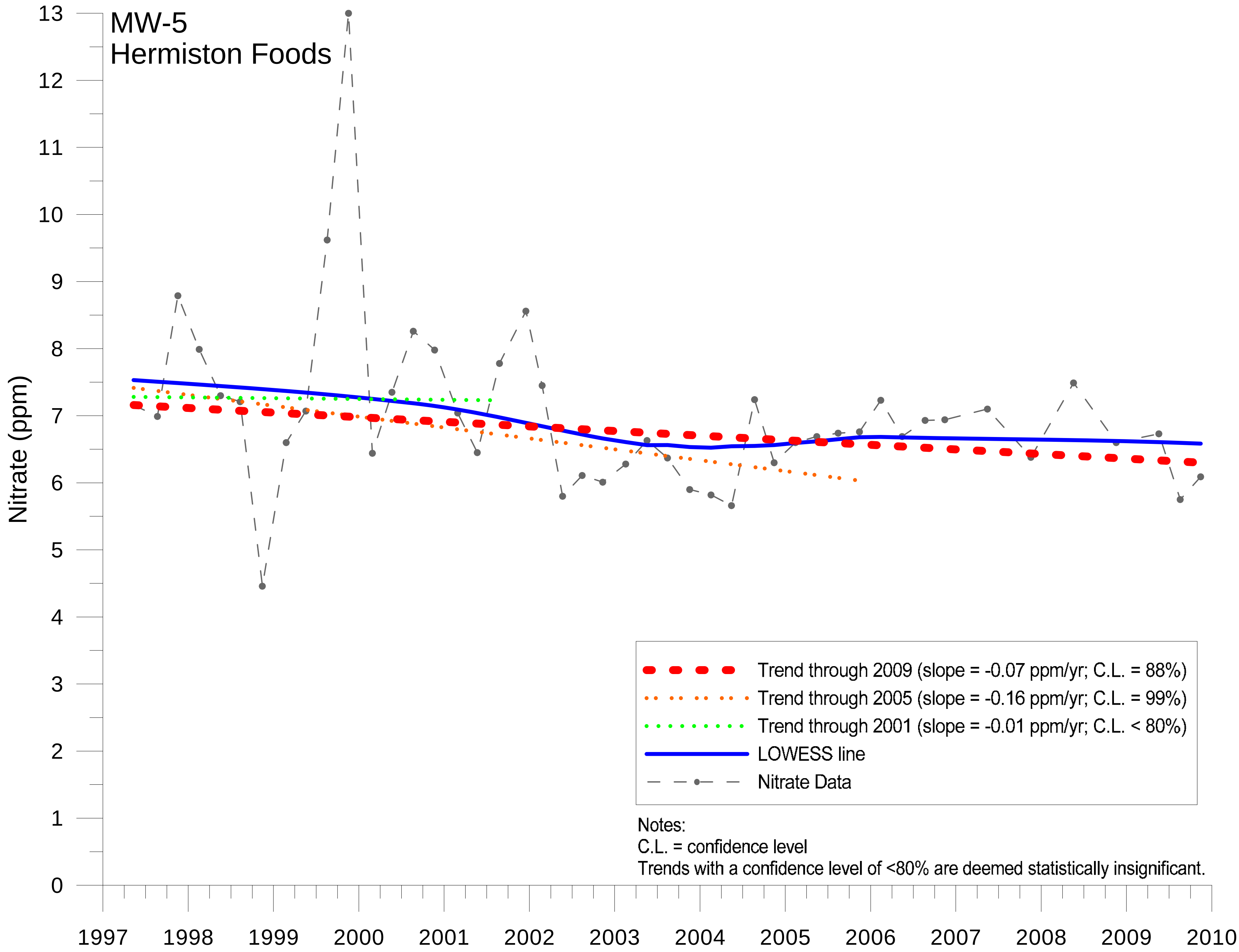
MW-59
Simplot Plant Site
Trend through 2005 (slope = 0.0 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 0.0 ppm/yr; C.L. < 80%)
LOWESS line (D.L. used for censored data)
Nitrate Data (D.L. used for censored data)
Range of Potential Value for Censored Data
Notes:
C.L. = confidence level; D.L. = detection limit
Trends with a confidence level of <80% are deemed statistically insignificant.
The trend analysis of data through 2001 used one-half the detection limit for censored data.
Nitrate (ppm)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006


MW-1
Hermiston Foods
Nitrate (ppm)
13
12.5
12
11.5
11
10.5
10
9.5
9
8.5
8
7.5
7
6.5
1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
Trend through 2009 (slope = -0.13 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = -0.12 ppm/yr; C.L. = 98%)
Trend through 2001 (slope = -0.12ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

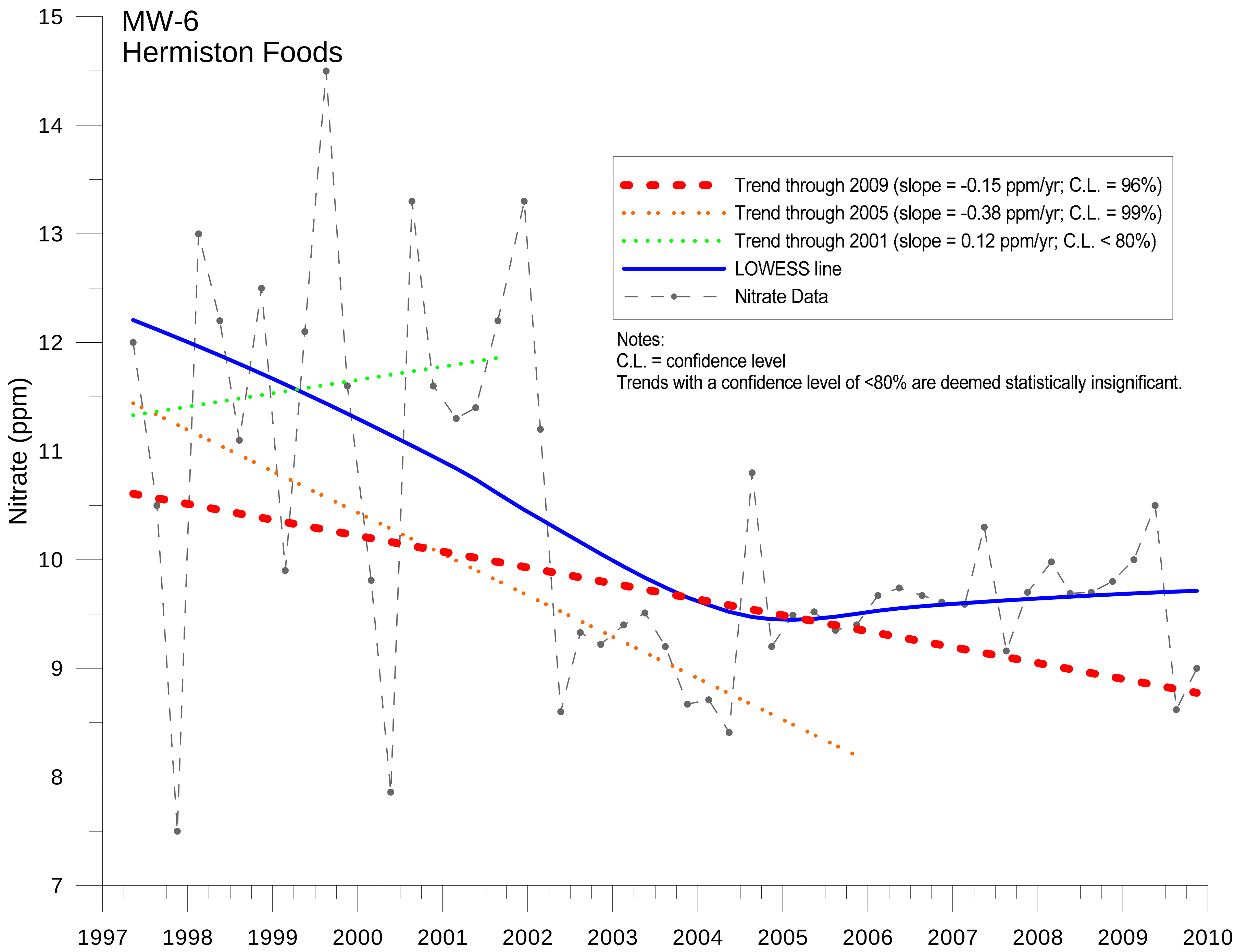

MW-2
Hermiston Foods
Nitrate (ppm)
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
Trend through 2009 (slope = 0.05 ppm/yr; C.L. = 91%)
Trend through 2005 (slope = 0.08 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.29 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.


MW-3
Hermiston Foods
Nitrate (ppm)
10
9
8
7
6
5
4
3
2
1
0
1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
Trend through 2009 (slope = -0.09 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = -0.09 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = -0.01 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

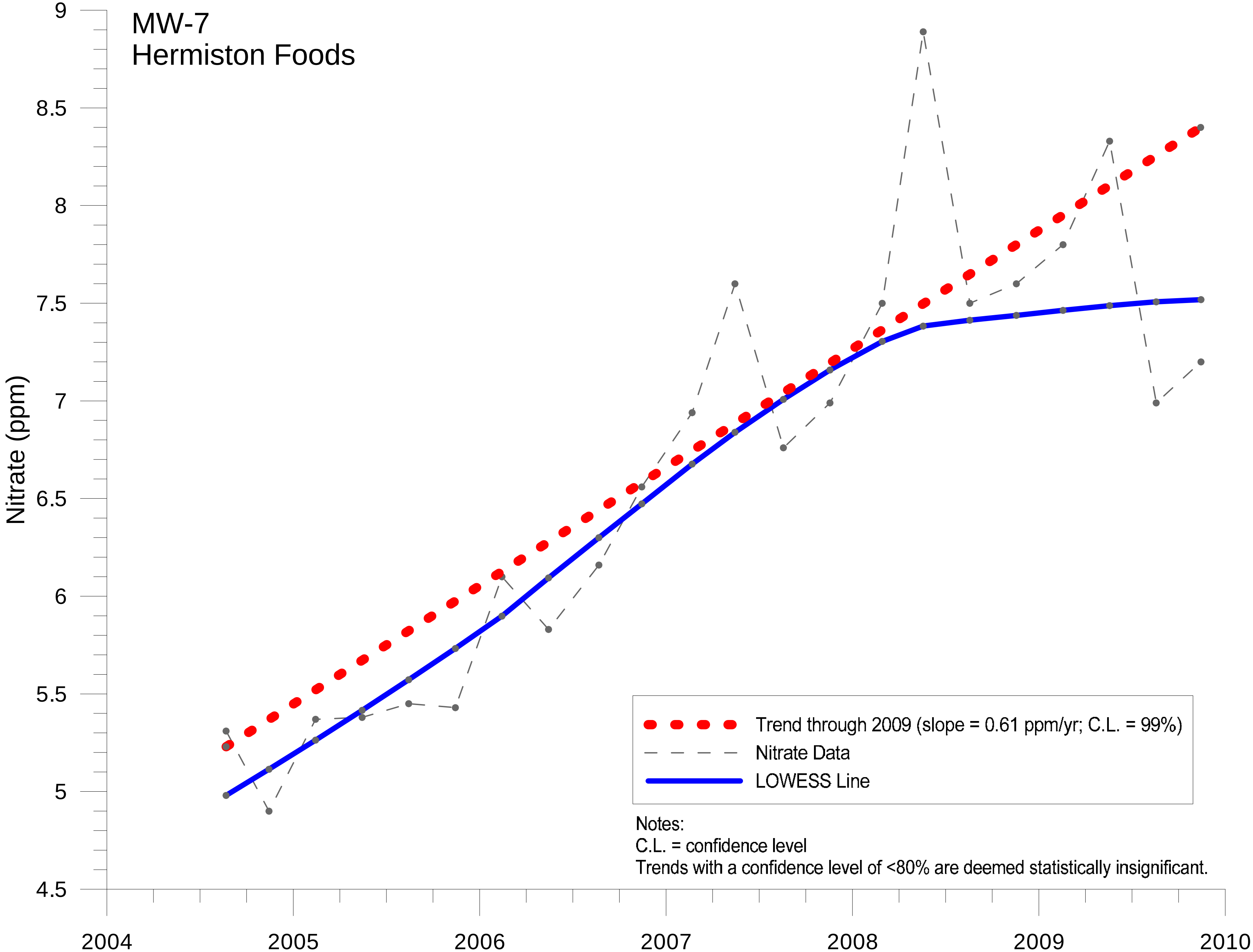

MW-4
Hermiston Foods
Nitrate (ppm)
0
1
2
3
4
5
6
7
8
9
1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
Trend through 2009 (slope = 0.11 ppm/yr; C.L = 99%)
Trend through 2005 (slope = 0.17 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.29 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

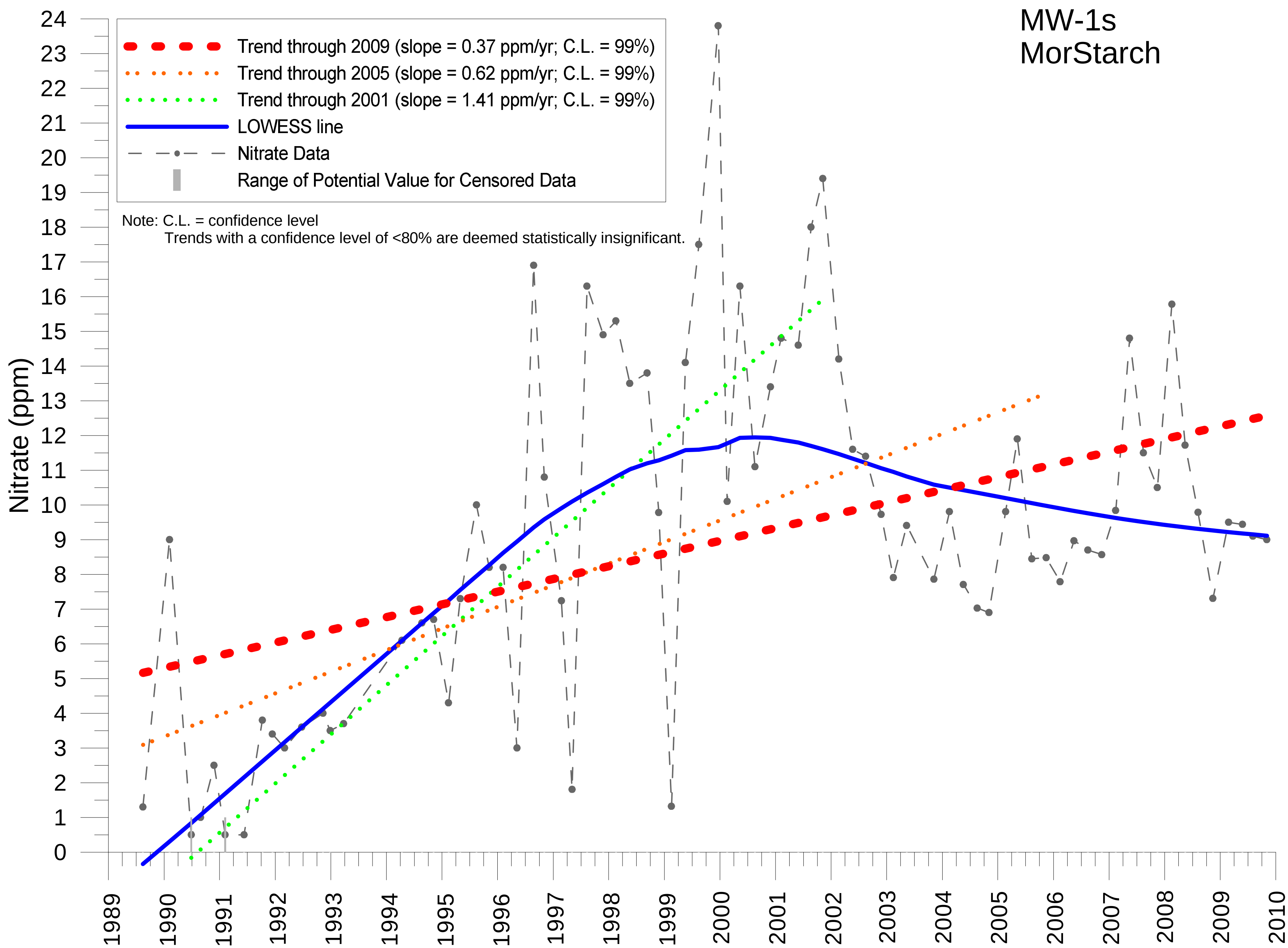


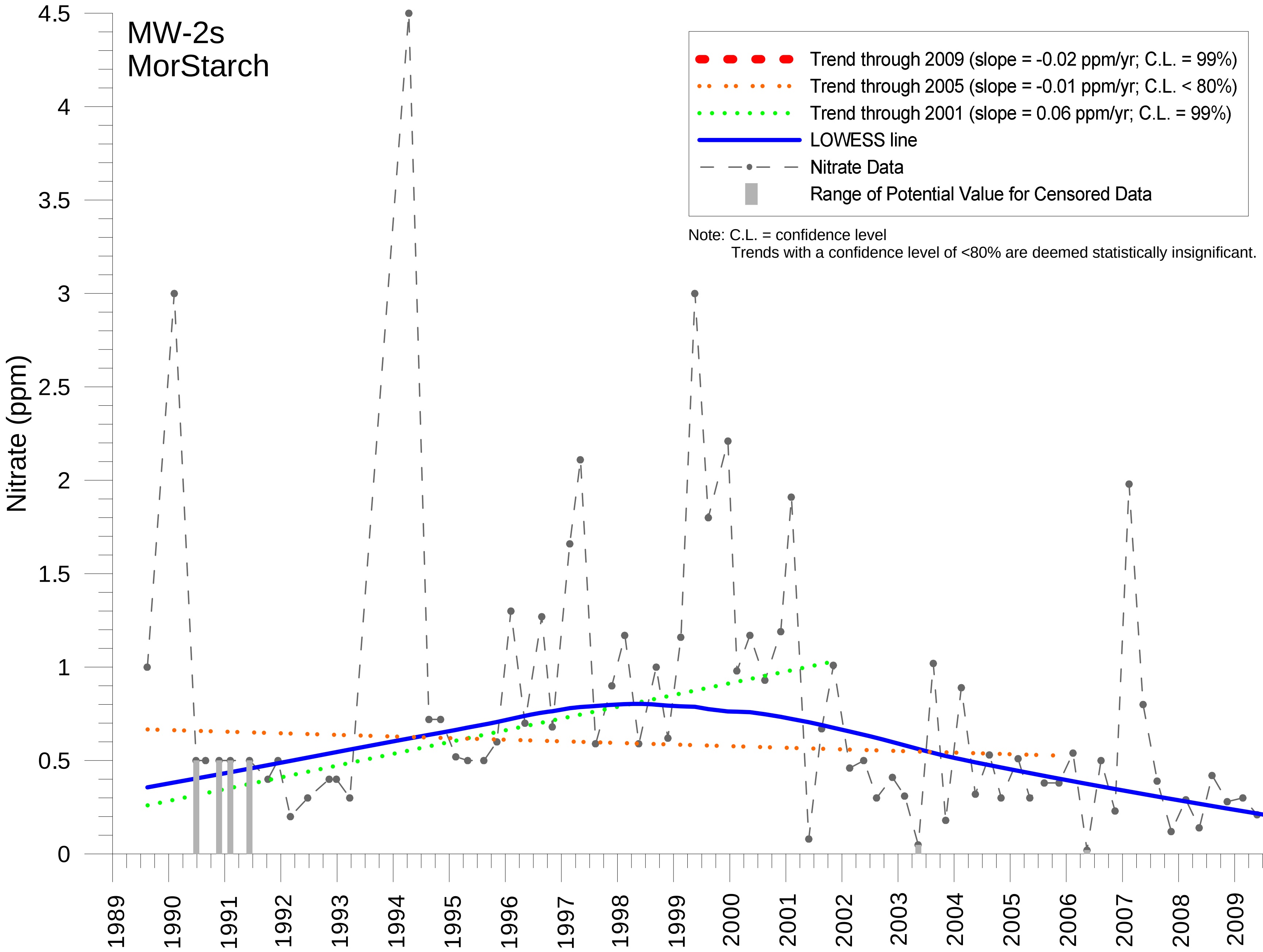
MW-5
Hermiston Foods
Nitrate (ppm)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = -0.07 ppm/yr; C.L. = 88%)
Trend through 2005 (slope = -0.16 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = -0.01 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.



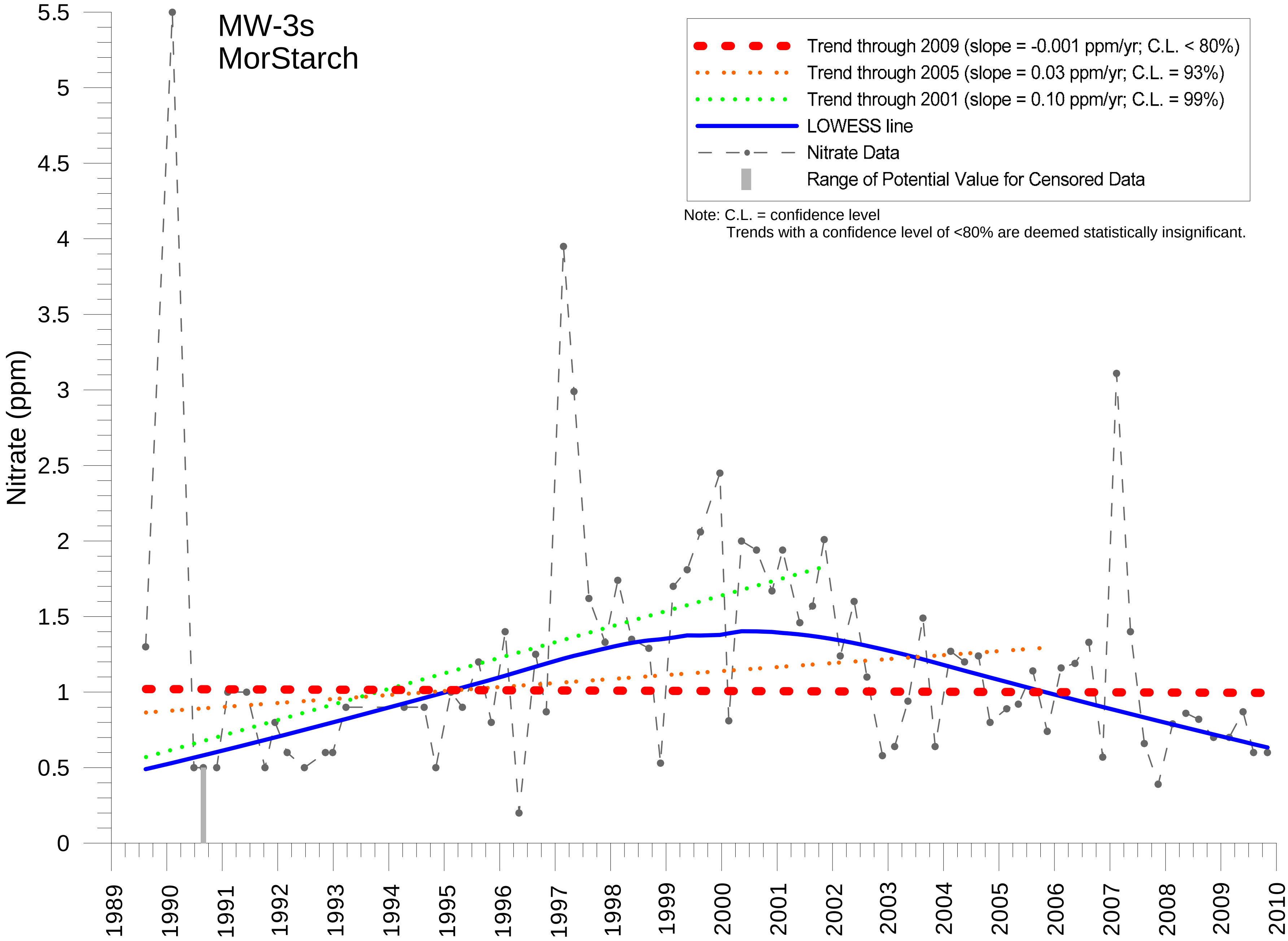
MW-6
Hermiston Foods
Trend through 2009 (slope = -0.15 ppm/yr; C.L. = 96%)
Trend through 2005 (slope = -0.38 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.12 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
15
14
13
12
11
10
9
8
7
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

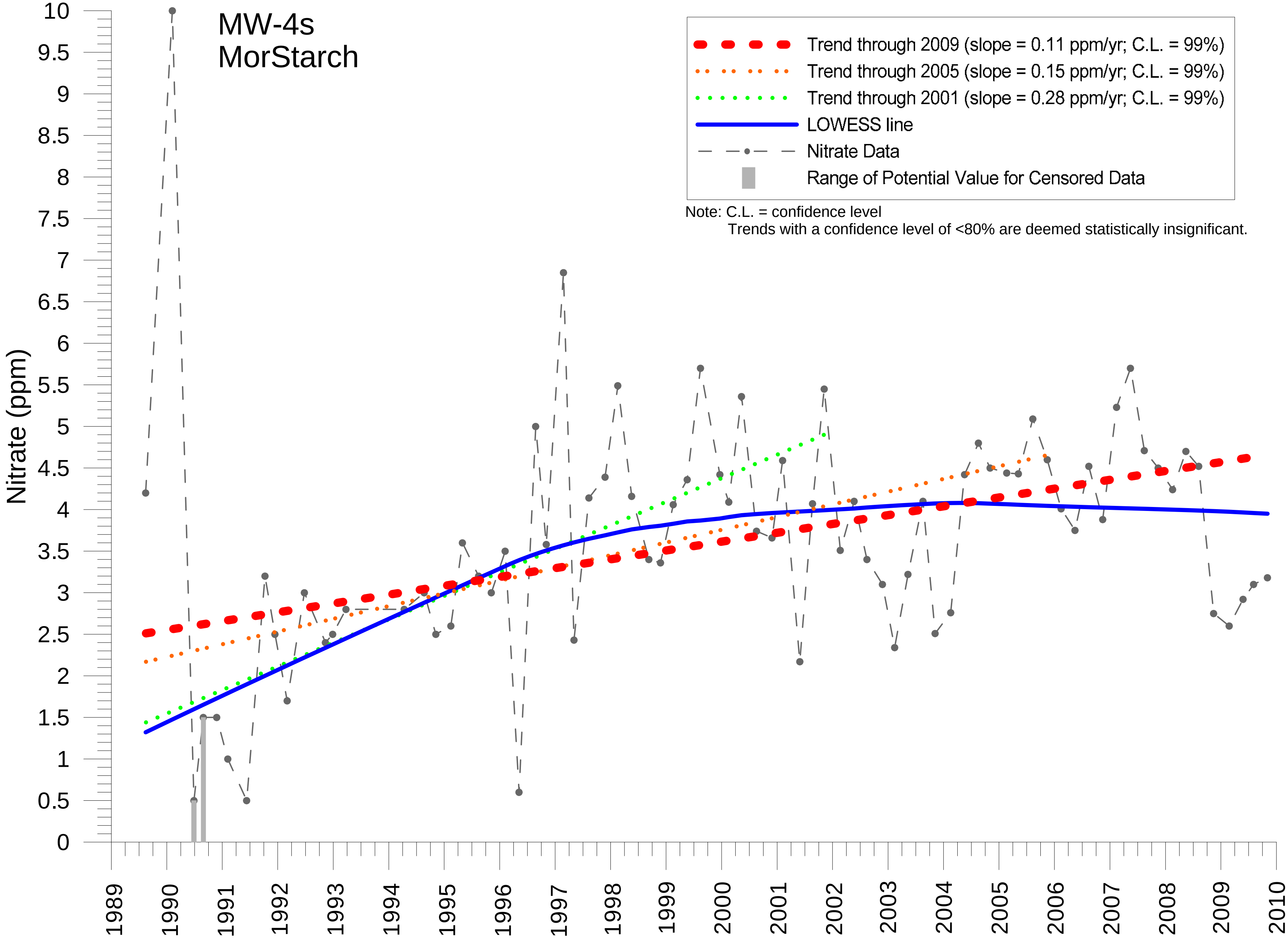

MW-7
Hermiston Foods
Nitrate (ppm)
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 0.61 ppm/yr; C.L. = 99%)
Nitrate Data
LOWESS Line
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.

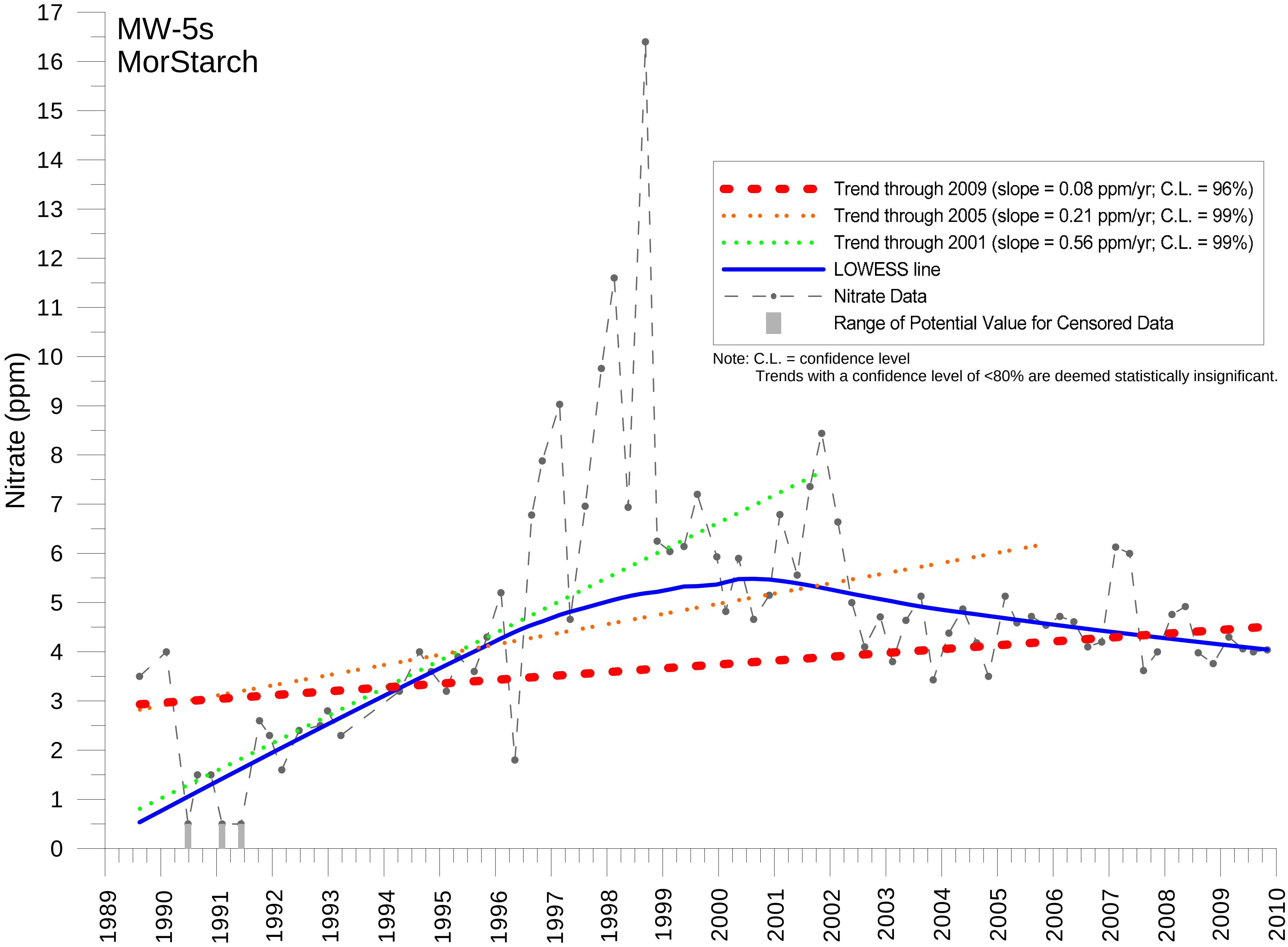

MW-1s
MorStarch
Trend through 2009 (slope = 0.37 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 0.62 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 1.41 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Range of Potential Value for Censored Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

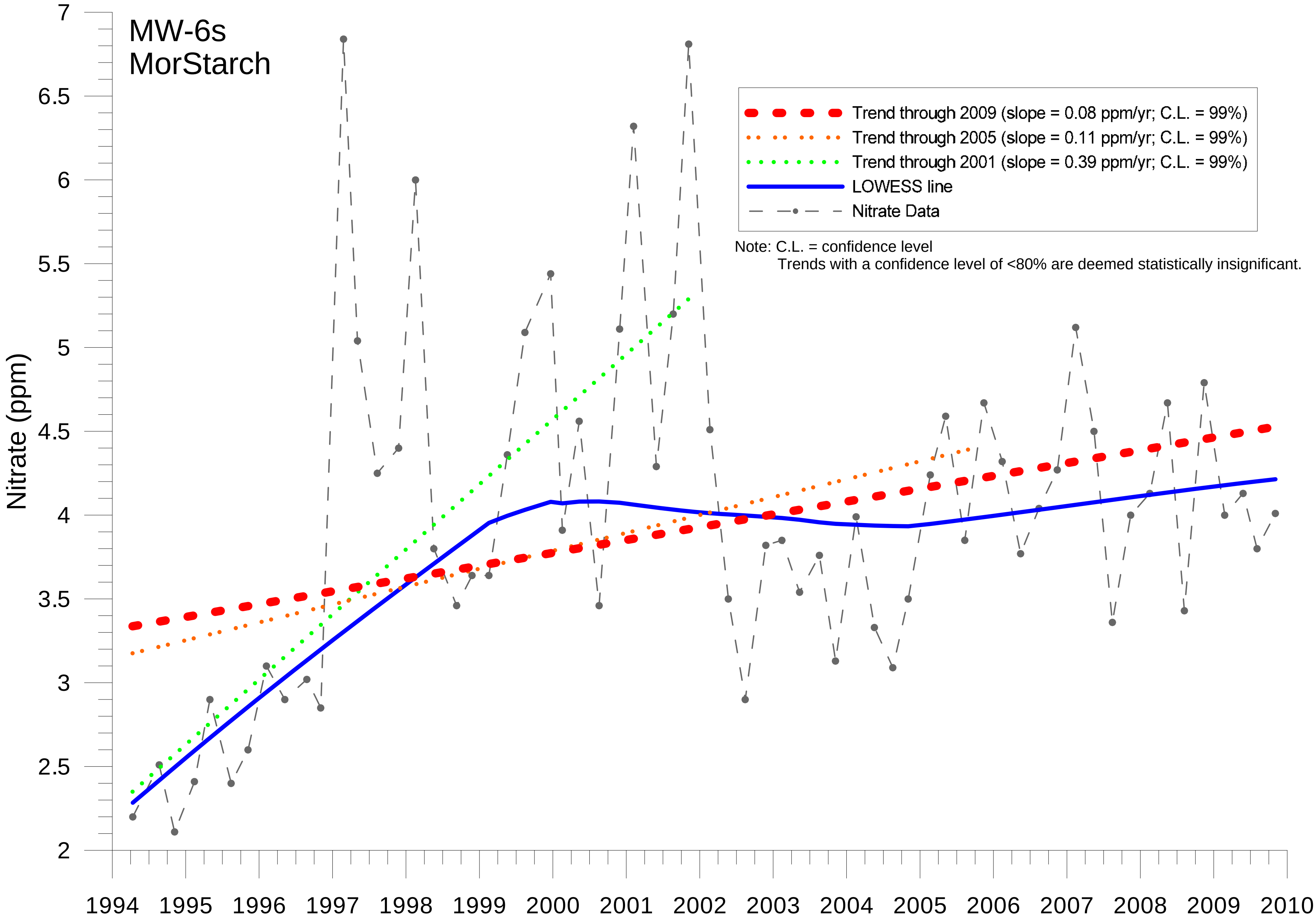


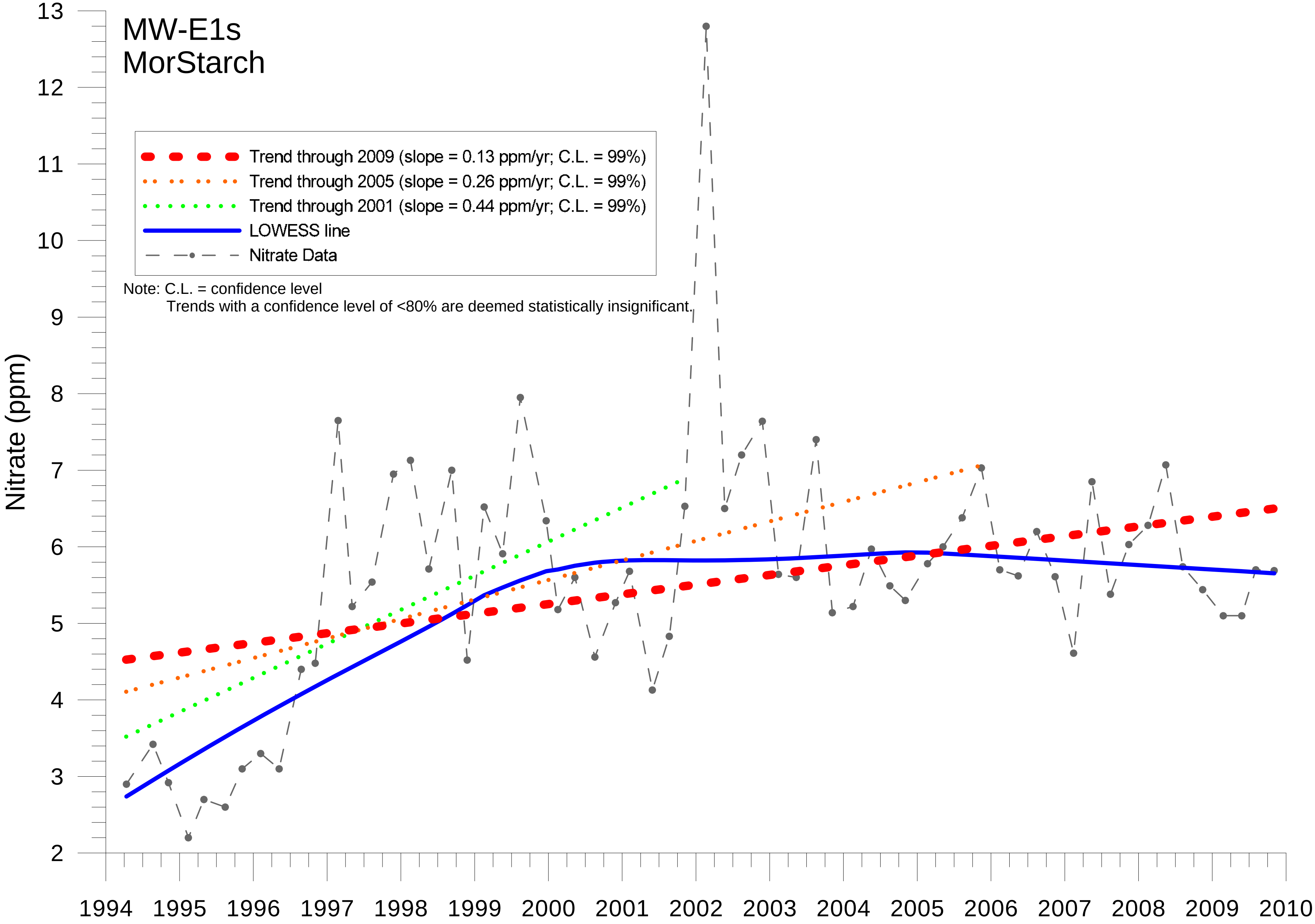
MW-2s
MorStarch
Trend through 2009 (slope = -0.02 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = -0.01 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = 0.06 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Range of Potential Value for Censored Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

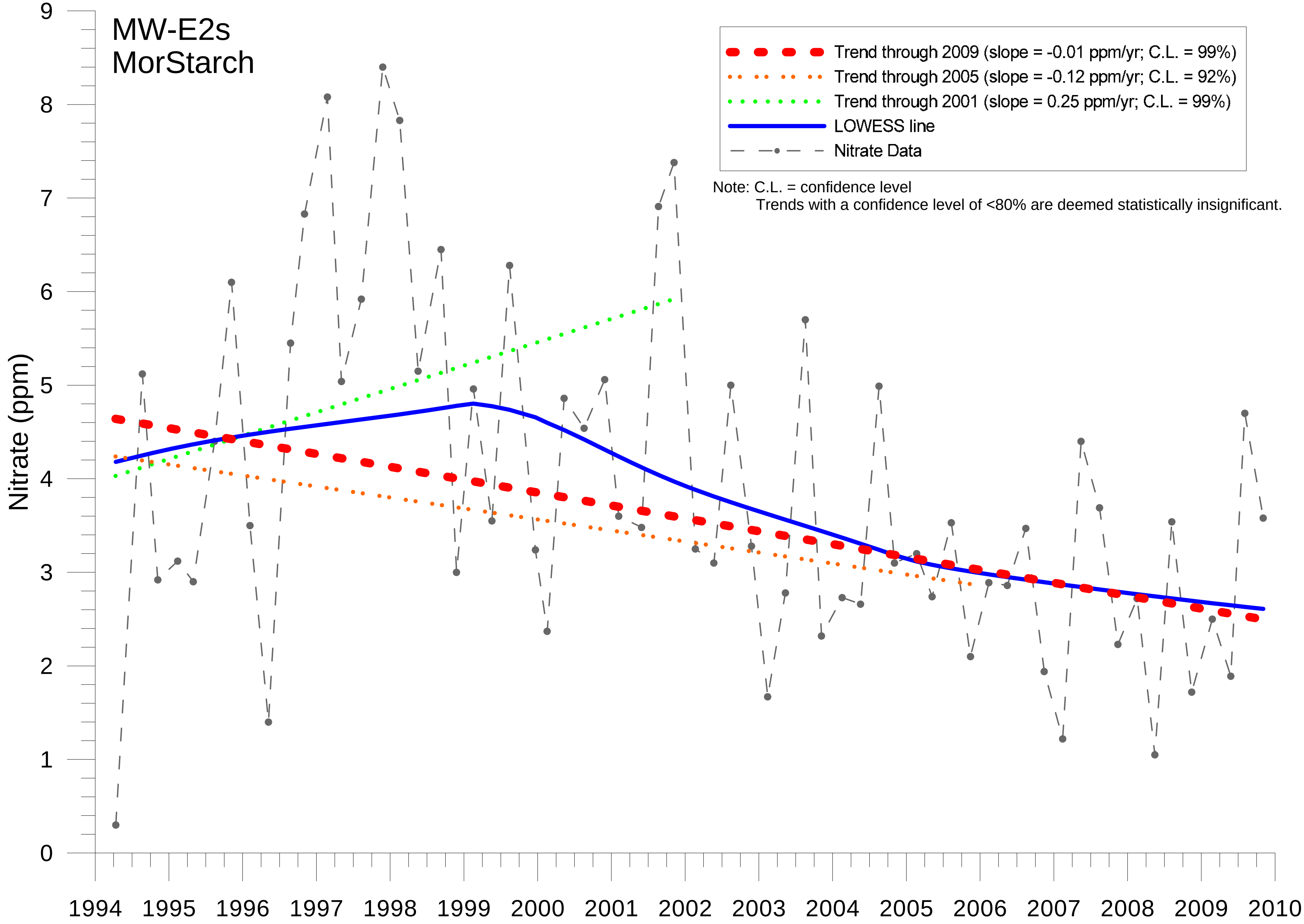

MW-3s
MorStarch
Nitrate (ppm)
Trend through 2009 (slope = -0.001 ppm/yr; C.L. < 80%)
Trend through 2005 (slope = 0.03 ppm/yr; C.L. = 93%)
Trend through 2001 (slope = 0.10 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Range of Potential Value for Censored Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

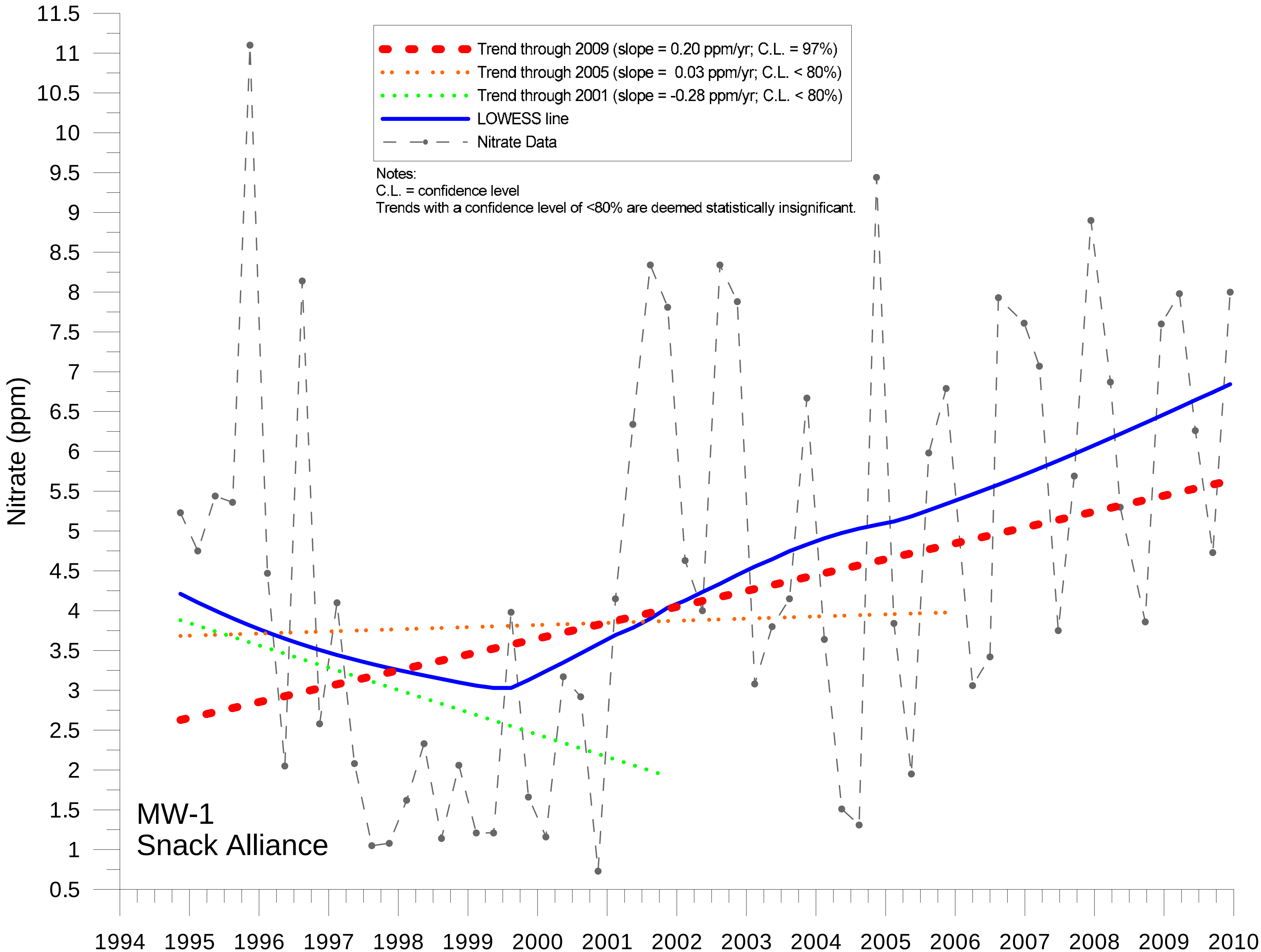

MW-4s
MorStarch
Trend through 2009 (slope = 0.11 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 0.15 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.28 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Range of Potential Value for Censored Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
10
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

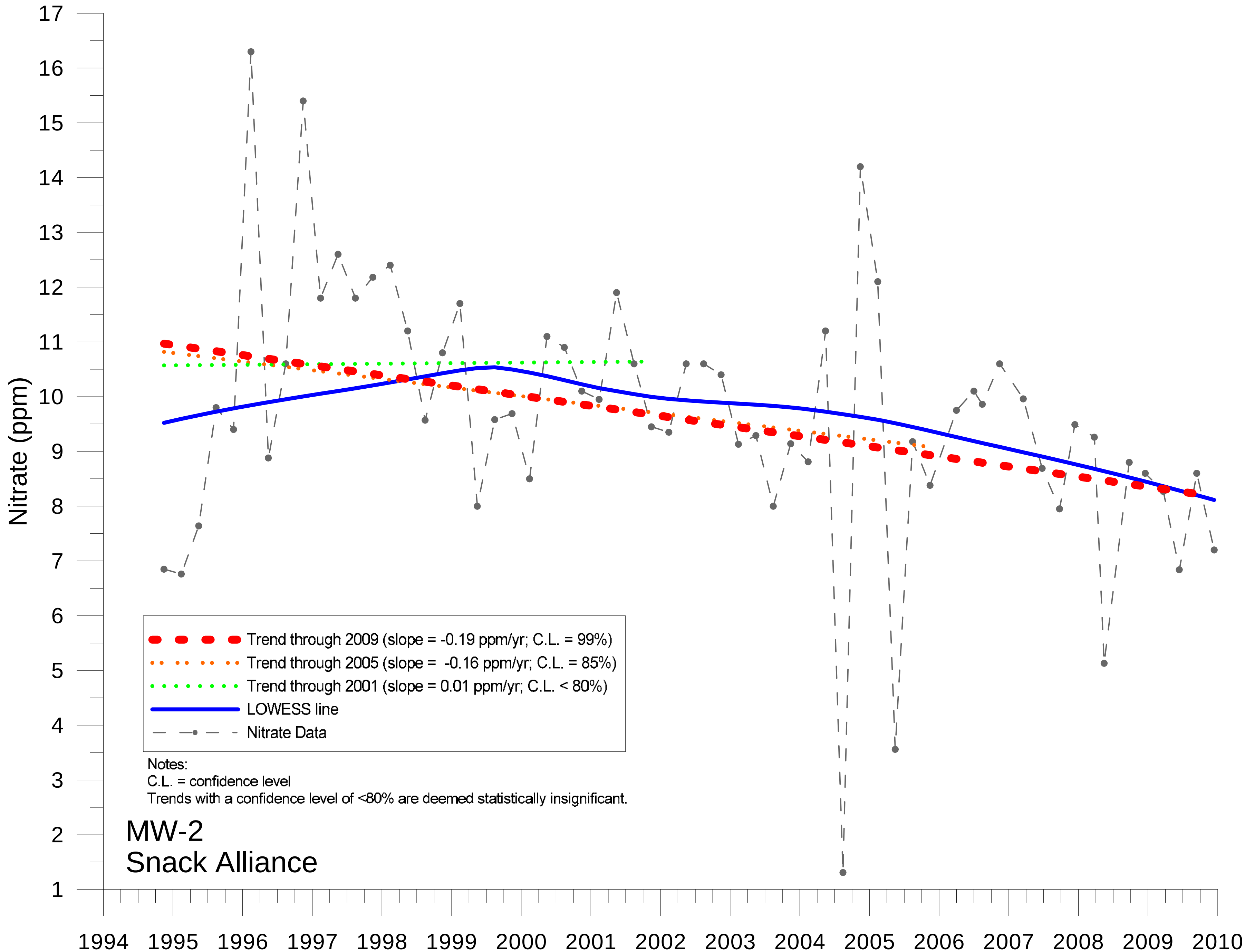

MW-5s
MorStarch
Nitrate (ppm)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = 0.08 ppm/yr; C.L. = 96%)
Trend through 2005 (slope = 0.21 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.56 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Range of Potential Value for Censored Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.


MW-6s
MorStarch
Trend through 2009 (slope = 0.08 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 0.11 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.39 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

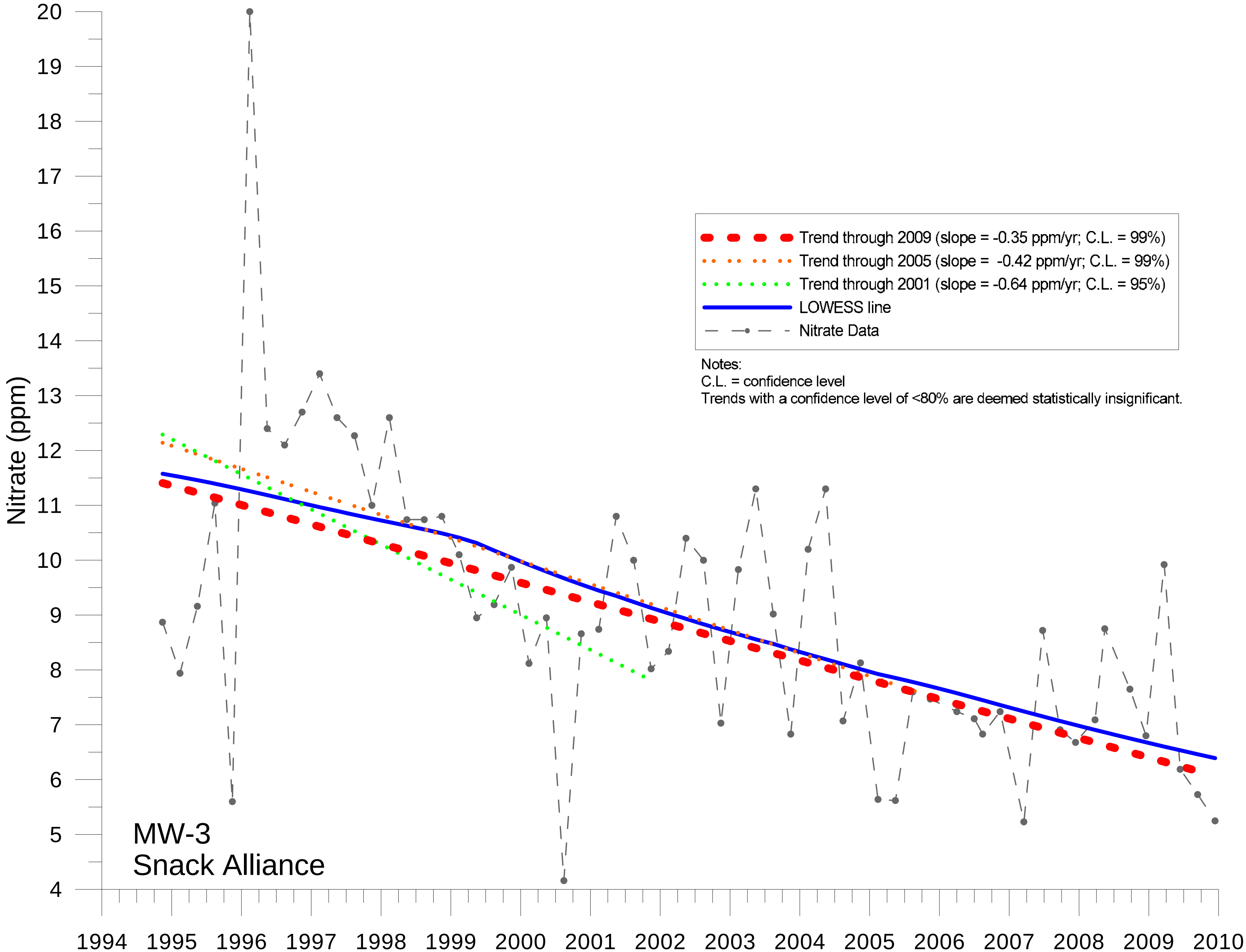

MW-E1s
MorStarch
Trend through 2009 (slope = 0.13 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = 0.26 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = 0.44 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
2
3
4
5
6
7
8
9
10
11
12
13
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

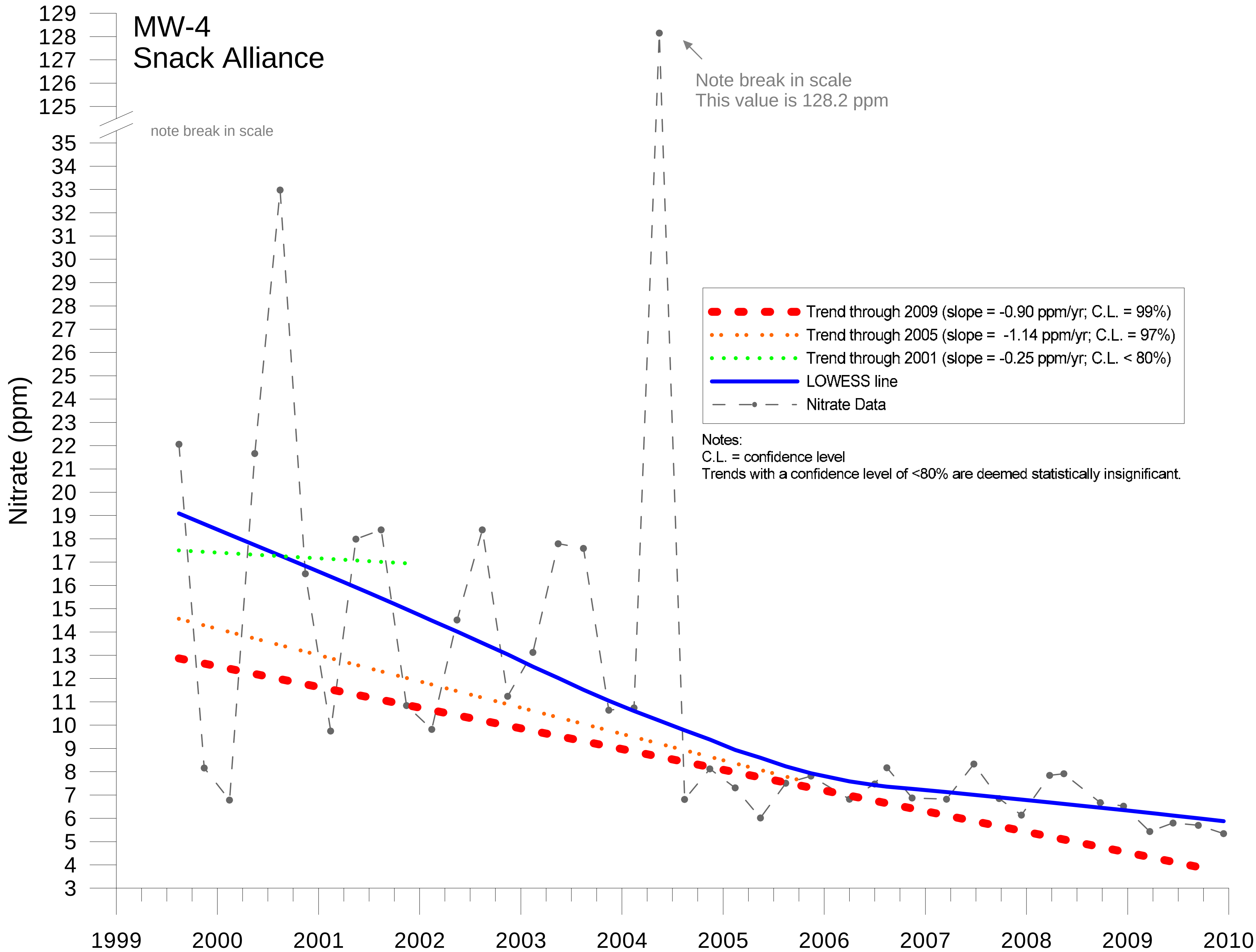

MW-E2s
MorStarch
Trend through 2009 (slope = -0.01 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = -0.12 ppm/yr; C.L. = 92%)
Trend through 2001 (slope = 0.25 ppm/yr; C.L. = 99%)
LOWESS line
Nitrate Data
Note: C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
0
1
2
3
4
5
6
7
8
9
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010


Trend through 2009 (slope = 0.20 ppm/yr; C.L. = 97%)
Trend through 2005 (slope = 0.03 ppm/yr; C.L. < 80%)
Trend through 2001 (slope = -0.28 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
Nitrate (ppm)
11.5
11
10.5
10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
MW-1
Snack Alliance
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010



Nitrate (ppm)
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = -0.19 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = -0.16 ppm/yr; C.L. = 85%)
Trend through 2001 (slope = 0.01 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
MW-2
Snack Alliance


Nitrate (ppm)
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Trend through 2009 (slope = -0.35 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = -0.42 ppm/yr; C.L. = 99%)
Trend through 2001 (slope = -0.64 ppm/yr; C.L. = 95%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
MW-3
Snack Alliance



MW-4
Snack Alliance
Nitrate (ppm)
129
128
127
126
125
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
note break in scale
Note break in scale
This value is 128.2 ppm
Trend through 2009 (slope = -0.90 ppm/yr; C.L. = 99%)
Trend through 2005 (slope = -1.14 ppm/yr; C.L. = 97%)
Trend through 2001 (slope = -0.25 ppm/yr; C.L. < 80%)
LOWESS line
Nitrate Data
Notes:
C.L. = confidence level
Trends with a confidence level of <80% are deemed statistically insignificant.
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010