

FINAL REPORT: Year 4
for the period 1 January to 30 June 2007
Submitted: 15 June 2007
FDACS# 12274

Verification Monitoring of the Ridge Citrus Nitrogen BMP

by

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Ridge Citrus Nitrogen BMP Verification Project

Introduction

This final report was requested to coincide with the end of a funding period and consequently does not reflect the effort of a full 12 months of research. As established in the beginning of this study, there are nine different grove sites involved in the BMP Verification study. All of the groves are representative of a typical grove on the Lake Wales Ridge region of central Florida. The most important feature when selecting the groves to be used was the type of soil present. The highly-drainable soil, typical in most ridge groves, is what makes them more vulnerable to excessive leaching of nitrates through the soil profile. There has been no change in the sites being used, and data is continuously being collected from these nine sites. Data collected this year by the University of Florida Citrus Research and Education Center (CREC) team includes leachate samples from the lysimeters, as well as the real time data collected by the data loggers stationed in each grove. Horticultural data is also being compiled through communication with the various growers and their caretakers, as well as through observation when visiting the different groves involved in this study. The main source of information provided to the growers is the regularly updated Ridge Citrus Nitrogen BMP verification web site, which contains all data collected by the CREC as well as the monitoring well results collected by Jim Stidham & Associates, Inc. (JSA).

Progress during January to June 2007

Groundwater nitrate-N trends

In general, the average groundwater nitrate concentrations have been declining since the Fall of 2005 (Fig. 1). In order to explain this trend, we attempted to correlate various site factors to the declining nitrate levels, including the presence of denitrifying anaerobic soil layers, rainfall, irrigation, missing tree counts, fruit yield, and fertilizer rates used in each year. The only factor which could be strongly linked to the trend in groundwater nitrate concentrations was rainfall. Figure 2, shows monthly averages of rainfall for each site since the start of the study. This graph, as was expected, clearly shows the increase in rainfall during the summer months (May – October) with two peaks, the larger one over the 2005 summer season (totaling 61.73 inches) and then the smaller peak over the 2006 summer season (totaling 53.06 inches). Rainfall during the 2004 summer season (68.13 inches) was even greater across all nine sites. The rainfall data used for these calculations came from the Florida Automated Weather Network (FAWN)

rather than the 9 data stations. Due to some periodic interruptions in data logged at the nine sites and interference with rain gauges from neighboring trees, we feel that the FAWN sensors are likely more accurate. The decrease in summer rainfall from 2004 to 2006 seems to correspond with the decrease in groundwater nitrate concentration. The rainfall amount was also much higher in Highlands County than in Polk County, and also decreased over time from the hurricane years 2004/2005 to 2006. Based on what was observed about the rainfall during the summer wet period we expected it to correlate best with nitrate concentrations, so the total rainy season rainfall from May to October for each year was separately accumulated for each county and plotted against the average groundwater nitrate concentrations for the same data groups (Fig. 3). Table 1, shows the rainfall totals for the Polk County sites (2, 3, 7, and 9) vs. the Highlands County sites (1, 4, 5, 6, and 8). Table 2 shows the decrease in Nitrates since the start of the study in both the Polk County sites and the Highlands County sites. These figures were calculated using the Monitoring Well Nitrate concentration results gathered by Jim Stidham and Associates. The nitrate totals for Polk County were calculated using only sites 2, 3 and 9. Site 7, the fourth Polk county site, was omitted because it was converted to organic production in 2004, at the beginning of the study, and consequently had exceptionally low nitrate levels. The aggregate nitrate calculated is the grand mean for that year, using every channel from every well at the three Polk County sites mentioned above. Likewise, the aggregates for the Highlands County sites were calculated using the grand mean from every channel at every well sampled at the five Highlands County sites mentioned above. Figure 3, shows this relationship between the summer rainfall and the averaged nitrate data across the two counties. The significant correlation achieved ($R^2 = 0.97$) illustrates the importance of rainfall in regulating the groundwater nitrate levels. It appears that the increased leaching events during extremely wet years causes additional nitrate accumulation in the groundwater, and is in agreement with similar results from our controlled release fertilizer experiment at Lake Placid where 48 wells are being sampled every month. More data for at least the remainder of 2007 should be collected in order to verify this relationship and to see whether it is reversible. If that is the case, we expect the groundwater nitrate concentrations in all the monitoring sites to increase again if we experience a much wetter summer season than 2006.

Yield trends

Along with the monitoring of groundwater nitrates, horticultural data was also being collected. Yield data has been part of this collected data set. Figure 4 shows the yield data averaged by the two counties (Polk and Highlands) and a grand mean of the sites. This data was

calculated using 8 mature sites, the ninth site, site 9, was not used in this data set due to the young age of the grove and the steady increase in the production during the 3 growing seasons of the study as the trees matured. All other sites were mature groves at the start of the study, and therefore used in the yield analysis. Over the course of the study the yield at the 8 sites has seemed to drop, however, when compared with earlier years before the start of the study, the yield has remained relatively steady with both increases and decreases in yield over time.

Leaf N trends

Results from the leaf tissue analysis over the course of the study include two complete sampling events (2005 and 2006) and one incomplete sampling event (2004). Table 3 shows the average percent nitrogen concentration across all nine sites for 2005 and 2006 as well as across the sites included in the study in July of 2004 (sites 1, 2, 5, 6, 7, 8, and 9). There has been no significant change in the leaf nitrogen concentrations through out the duration of the study. The procedure for taking leaf samples also changed from the first sampling event (2004) and the last two sampling events (2005 and 2006). For the first event only two samples were taken at each site, with the exception of site 9, where one sample was taken for each of the five blocks. For all other sites, one sample was taken from an area of the grove characterized as the “best,” or healthiest area, and the other sample came from an area characterized as the “weakest,” or least healthy area. The analysis completed for the leaf sampling in the 2005 and 2006 required extra samples to be taken from “best” and “weakest” areas of the grove for estimation of statistical significance. Site nine was sampled differently based on the location of the two rootstocks used at that site, as well as, site three, where there are two different varieties of oranges being grown. The same procedure used in 2005 was repeated in 2006. Exact leaf sample locations can be found on the interactive maps web page located on the Ridge Citrus Nitrate BMP verification web site at http://128.227.177.113/bmp/BMP_Map.html.

Soil water trends

Regular sampling of the vacuum lysimeters has occurred since the Fall of 2004. Figure 5, shows the grand mean of the lysimeter results for each sampling event, which is the average of all the samples taken on a sampling event. In general, increases in the lysimeter nitrate concentration occurs after high rainfall or long irrigation events, especially when one such event occurs shortly after an application of fertilizer. Figure 6, is a graph of the lysimeter results from site 2, in this graph, increases in lysimeter nitrate concentration can be seen after long irrigation events (i.e. over night cold protection irrigation applications), and after heavy rainfall events (i.e.

hurricanes and tropical storms, or strong afternoon thunderstorms). In this figure several occurrences of elevated lysimeter nitrate concentrations can be seen shortly after fertilizer applications, either as a result of several rainfall or irrigation events.

Compilation and maintenance of the comprehensive Citrus N-BMP web site

The Ridge Citrus Nitrate BMP Verification web site continues to be a useful tool for both grower/cooperators and researchers. The real-time data page is where the automatically updated data can be found, which includes the weather station data, rainfall, and grove temperature, as well as the three soil moisture sensors data to help aid in irrigation scheduling. All real-time data is updated every six hours and can be viewed on the data logger results web page which is located at http://128.227.177.113/bmp/data%20_logger.html. The web page also serves as a constantly updated results report to the grower/cooperators, as well as to interested parties wanting to obtain the most recent results. The sample analysis page includes data from the lysimeter, monitoring well, and leaf tissue sampling events, which is located on the web site at http://128.227.177.113/bmp/sample_analysis.html. As well as data logger and sample analysis, there is also a section on the web site for the horticultural data such as the most recent fertilizer applications, yield data, and water budget tables.

Table 1 - Summer Season Rainfall (inches)

Summer Rainfall	Polk County	Highlands County
2004	25.71	42.42
2005	24.21	37.52
2006	22.07	30.99

Table 2 - Groundwater Nitrate concentration (mg/L)

Year	Polk County	Highlands County
2004	8.679	12.151
2005	8.187	12.088
2006	7.441	9.148

Table 3 - Leaf Tissue Averages

Year	%N	Comments
2004	2.72	Optimum
2005	2.67	Optimum
2006	2.78	Optimum

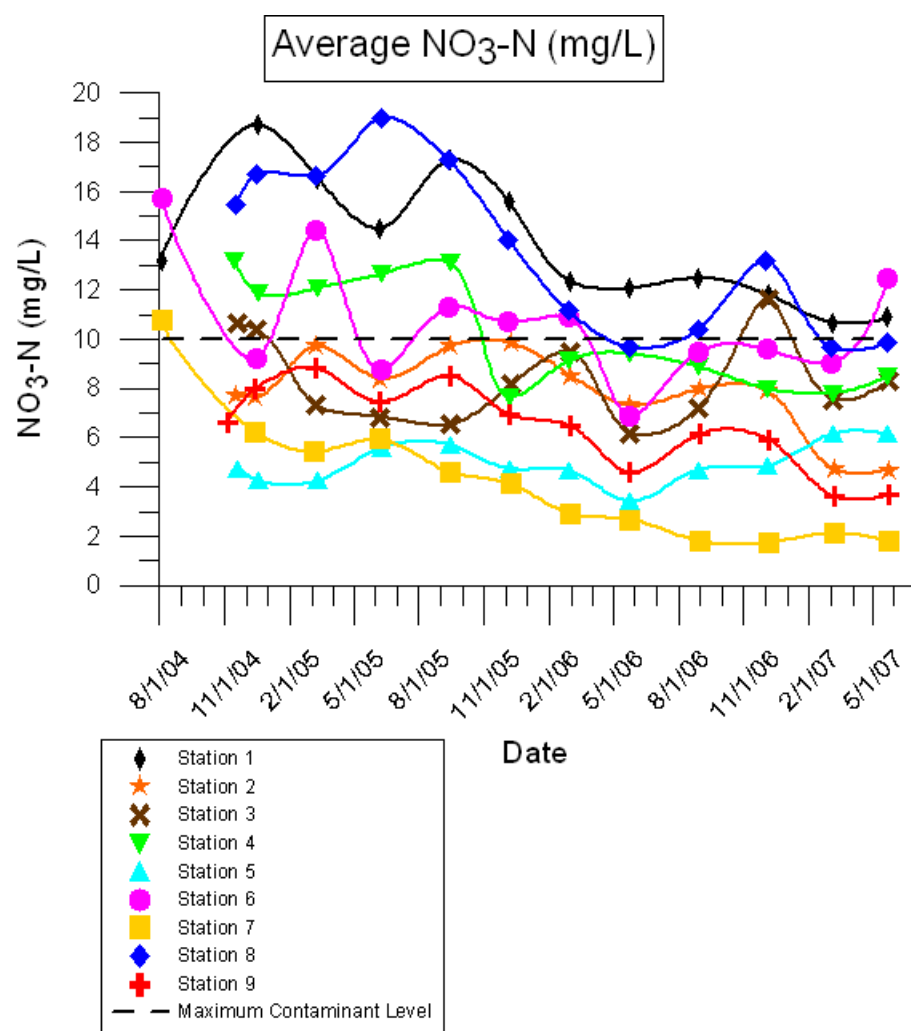


Figure 1 - Groundwater nitrate-N averages from all nine sites

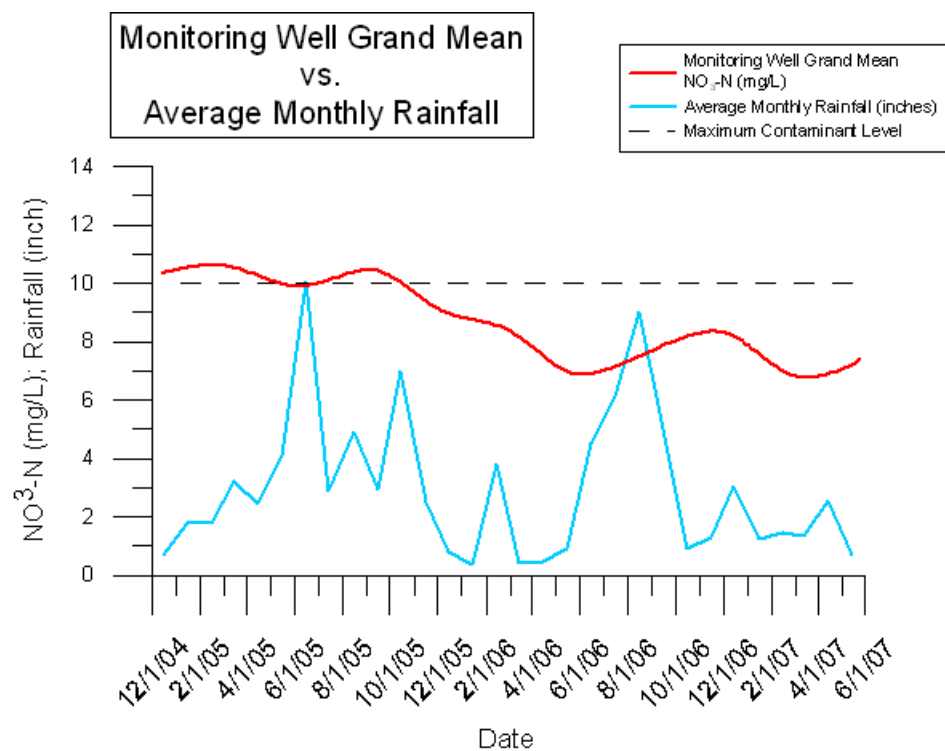


Figure 2 - Mean groundwater nitrate-N and rainfall graph

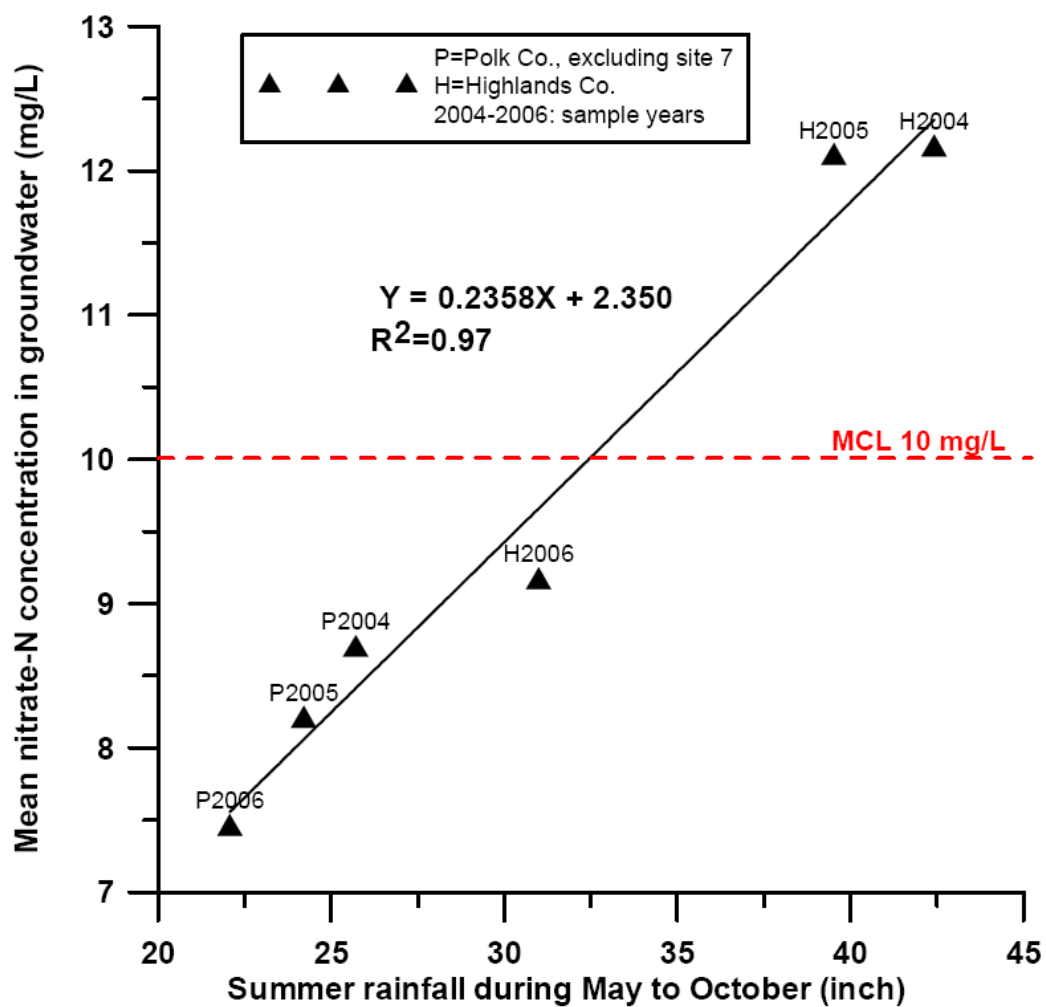


Figure 3 - Relationship between summer rainfall and groundwater nitrate concentrations in 8 sites grouped by two counties.

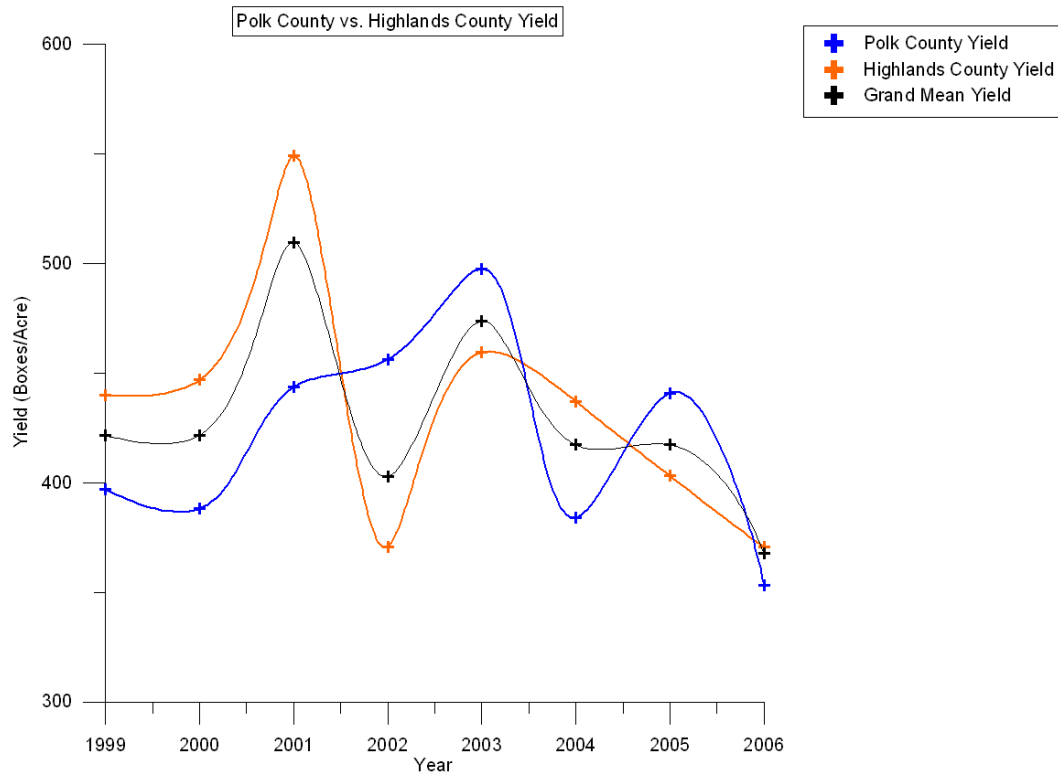


Figure 4 - Average Yield Data for Polk and Highlands Counties

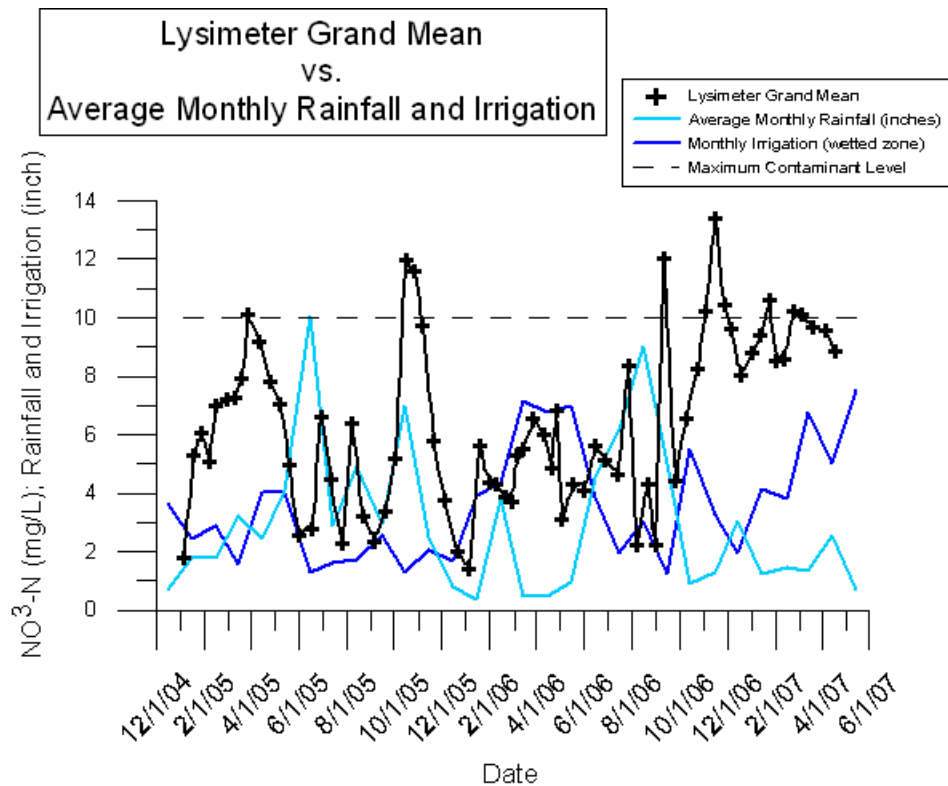


Figure 5 - Final Lysimeter Grand Mean Graph vs. Monthly Rainfall and Irrigation

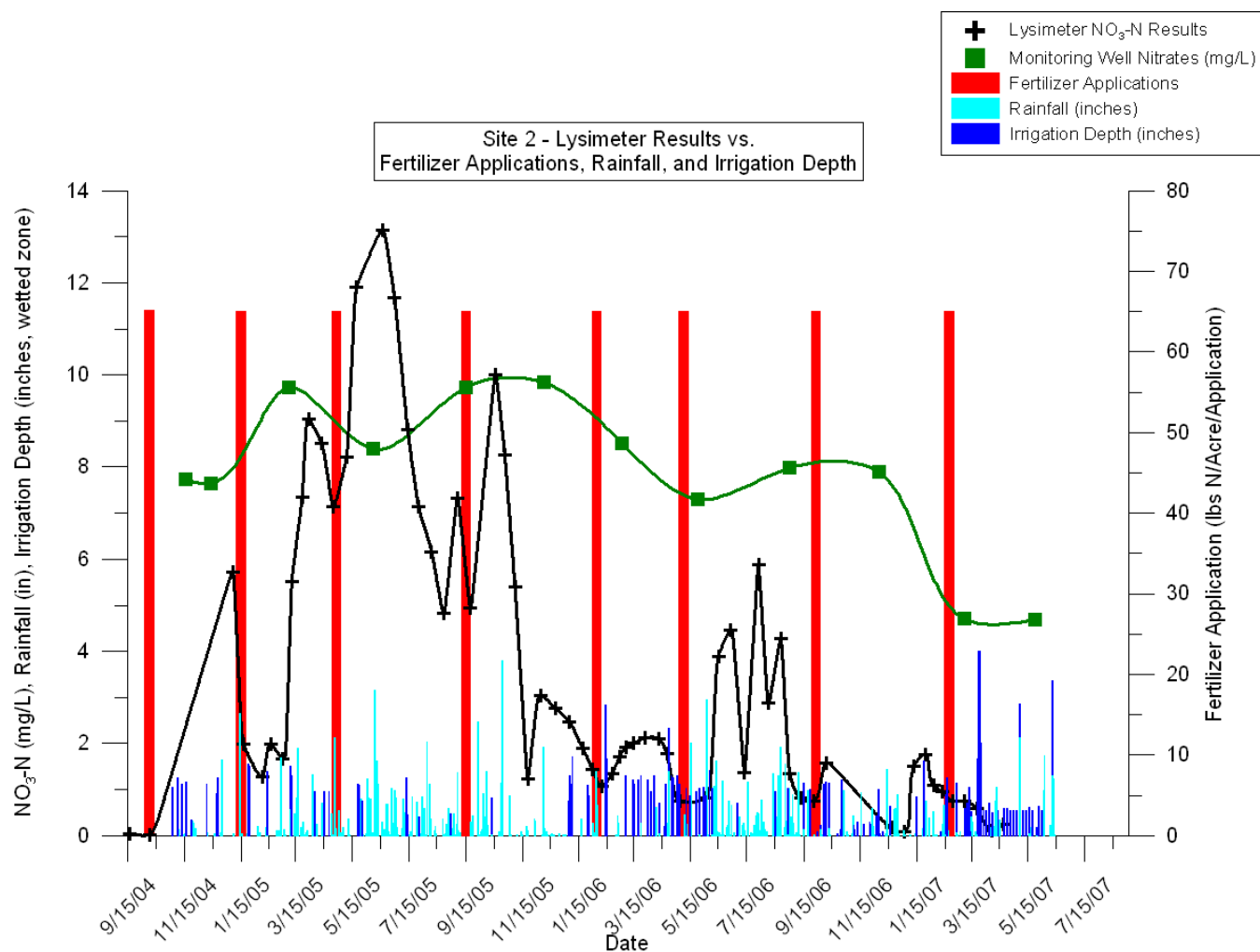


Figure 6 - Lysimeter results from Site 2 showing an increase in the lysimeter nitrate concentration after both high rainfall and irrigation events.