Trout Brook

Spring Nitrate Monitoring Program

June 2017

North Cannon River
Watershed Management Organization

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Report prepared for the North Cannon River Watershed Management Organization
by the Dakota County Soil and Water Conservation District

Introduction

Trout Brook is a designated trout stream located in southeastern Dakota County, Minnesota. This stream has a historical data record that dates back to 1985 and is of particular interest for nitrate monitoring because it has some of the highest stream baseflow nitrate concentrations found in southeastern Minnesota (Minnesota Pollution Control Agency (MPCA)).

Analysis of several water samples collected from Trout Brook indicate that the baseflow nitrate concentrations consistently exceed the state water quality standard, which applies to public drinking water sources (in Minnesota, all trout streams are protected as potential drinking water sources). The state standard dictates that the maximum contaminant level allowed is 10 mg/L nitrate-nitrogen as consuming water with elevated nitrate could cause serious health problems, particularly for infants (National Primary Drinking Water Regulations, United States Environmental Protection Agency). Nitrate one of several different forms of nitrogen, but is of particular concern due to the high rate at which nitrate can leach through the soil profile, potentially contaminating local groundwater.

For decades, pollution from surface runoff has been at the forefront of water conservation efforts throughout the state of Minnesota; however, nitrogen pollution is quite different in that nearly all of it enters streams, lakes, and wells from a groundwater pathway. As nitrate moves vertically through the soil, the MPCA states that there are two possible ways in which groundwater contamination may occur; 1) leaching into groundwater through soils or bedrock fracturing, which then moves to a stream, lake, or well or enter by 2) leaching into subsurface drainage systems (tile lines) which then discharge directly into surface waters (streams or ditches). According to the MPCA "Nitrogen in Minnesota Surface Waters" report (2013), only 9% of nitrogen pollution in lakes, streams, and wells comes from surface runoff, with the majority of the pollution coming from groundwater pathways.

Trout Brook is found in a karst landscape, a geologic system that is characterized by underground drainage systems such as caves and sinkholes, and dotted with springs. Bedrock fracturing and thin layers of soil have a profound impact on the rate of infiltration and the flow path of water, which can be very different from what the surface topography might suggest. As a result, these systems tend to be more susceptible to contamination. Additionally, due to the unique nature of karst systems, understanding contaminant sources and movement in a karst system can be quite challenging.

Several springs have been identified in the Trout Brook watershed, four of which have become sentinel nitrate monitoring sites in that they have been monitored on a regular basis over the last three decades. In addition to the springs, three stream sites also have a relatively long period of record and are routinely monitored. These seven monitoring sites are shown in Figure 1.

The North Cannon River Watershed Management Organization (NCRWMO) recognizes that nitrate contamination is a concern, particularly in Trout Brook. As outlined in the Watershed Plan (adopted in 2013), the WMO has prioritized a water monitoring program that incorporates both spring and stream sites in order to better understand how nitrate moves through this subwatershed.

Trout Brook Watershed Nitrate Monitoring Sites

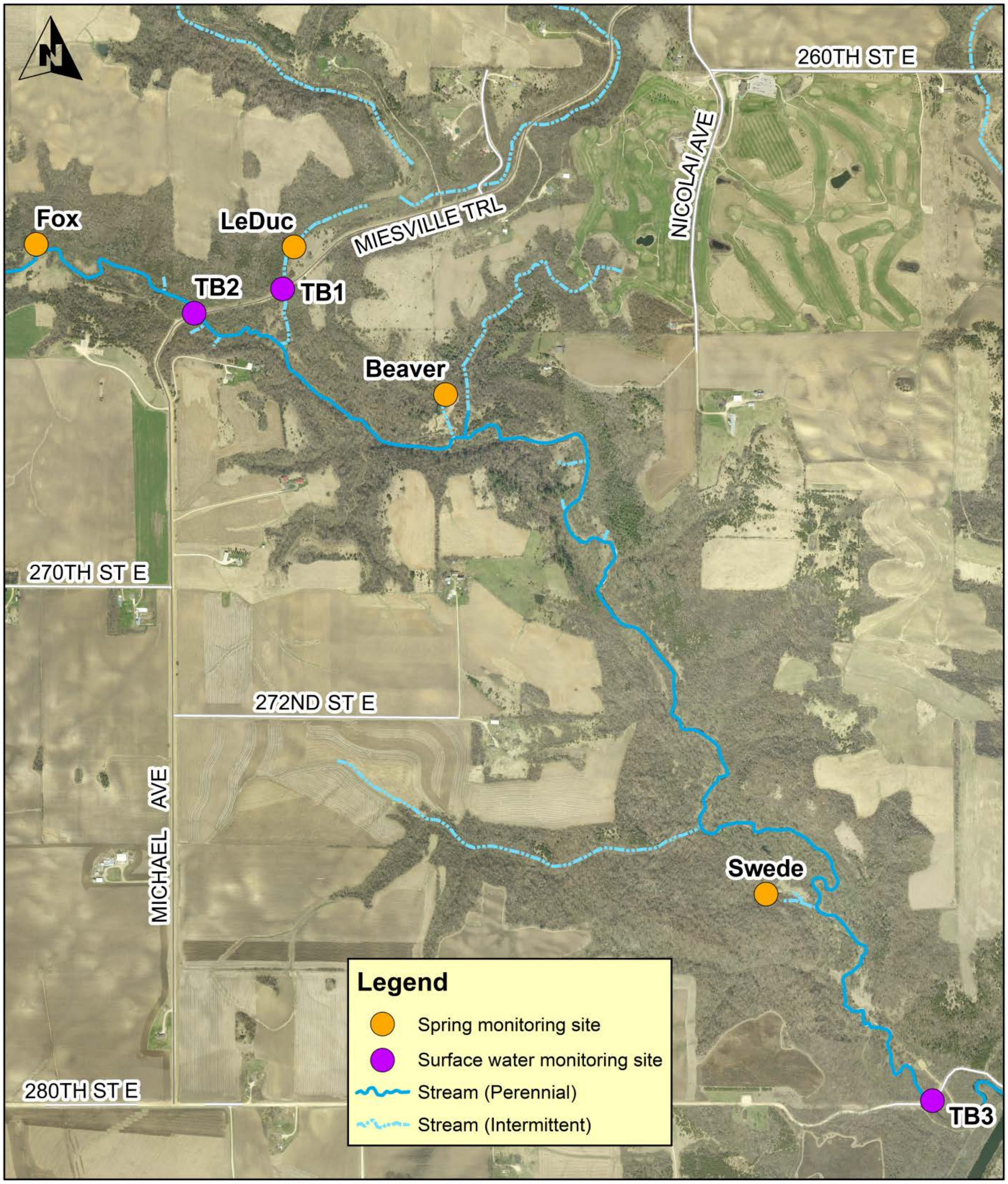

Figure 1. Map of spring and surface water monitoring sites for Trout Brook, Dakota County, Minnesota.

Methods

On February 13, 2017, with funding from the NCRWMO, baseflow water samples were collected from three streams sites and four contributing springs along Trout Brook. These data were analyzed and interpreted along with historical samples collected at these same sites. Groten and Alexander (2013) collected samples in 2011 and 2012, Dakota County Soil and Water Conservation District collected samples in 2001, 2002, 2006, and 2010. Lastly, Spong (1995) collected data in 1985 at the four sentinel spring sites and at the Swede and LeDuc springs in 1995. This monitoring record, spanning almost thirty years, is unique in its temporal extensiveness and extremely valuable in understanding nitrate movement in a complicated karst landscape.

It should be emphasized here that these samples represent baseflow conditions; when springs and distributed groundwater inputs have the largest contribution to surface stream flow.

Results

Nitrate data for surface monitoring sites and for spring monitoring sites are shown in Figures 2 and 3, respectively.

Surface water

In the surface monitoring sites, baseflow nitrate concentrations have historically exceeded the 10 mg/L standard at all three sites. In 2017, monitoring results showed lower nitrate concentrations at all sites which had an impact on the trend at both TB1 and TB2. The East Branch (TB1) had increased at a rate of about 0.11 mg/L/year from 2001 to 2006, and then decreased from 2006 through 2014 at a rate of about -0.33 mg/L/year (slowed from -0.37 mg/L in 2014). The West Branch (TB2) monitoring site had the highest concentration of the surface monitoring sites and increased at a rate of about 0.22 mg/L/year from 2001 to 2017 (slowed from 0.37 mg/L in 2014). At the Main Branch (TB3) monitoring site, the nitrate concentration increased at a rate of about 0.11 mg/L/year from 2001 to 2017.

The reason for the recent decreasing trend at the East Branch (TB1) has not been thoroughly investigated. Groten and Alexander (2013) have compared the changes in flow regime between 1985 and 2011 and concluded that the East Branch contributed more flow to Trout Brook than the West Branch in 1985, but that by 2011 that had shifted and the West Branch was contributing more flow than the East Branch. The authors further suggest that these changes in flow regime could be attributed to 'climate, anthropogenic activities such as irrigation, changes in land use, or from changes in the steam channel itself by major floods.'

Springs

All four spring monitoring sites show increasing nitrate concentration trends over time. Similar to what was found at the stream sites, monitoring results from 2017 have lower nitrate concentrations than previous years, but this did not have an impact on the overall trend for most springs.

The Fox Spring, which feeds the West Branch of Trout Brook had the highest concentrations of nitrate and is increasing at the fastest rate, about 0.40 mg/L/year. The LeDuc Spring, upstream of the East Branch surface monitoring site is increasing at the slowest rate, about 0.11 mg/L/year. The Beaver and Swede springs, both of which enter the Main Branch of Trout Brook upstream of the Main Branch surface monitoring site are increasing at rates of about 0.22 mg/L/year (slowed from 0.26 mg/L in 2014) and 0.18 mg/L/year, respectively. Swede Spring has the lowest nitrate values, which may be because it is lower in the stratigraphic section and has a greater proportion of deeper, regional water input to dilute the nitrate-polluted water. Runkel et al. (2013) point out that this less contaminated deep water is finite and diminishing, and that the buffering capacity may be lost in the future as water is used up and contaminated water infiltrates from above.

Conclusions

Trout Brook is of great interest for nitrate monitoring because it has some of the highest measured nitrate in southeastern Minnesota; it has an established historical record, and the karst landscape in which it is found increases its susceptibility to pollution.

Nitrate concentrations in springs contributing to Trout Brook have been increasing at rates of 0.11 to 0.40 mg/L/year from 1985 to 2017. The surface water monitoring sites also show increasing trends of nitrate concentrations at the Main Branch and West Branch from 2001 to 2017, with the nitrate concentrations decreasing at the East Branch since about 2006. Concentrations in 2017 at both the spring and stream monitoring sites were much lower than in previous years.

Land use in the Trout Brook watershed is dominated by agriculture practices and is estimated to have close to 66,000 acres of row crops across the landscape. Groten and Alexander (2013) suggest that row crop agriculture and animal feedlots are the likely sources of nitrate contamination in Trout Brook, although the proportion attributed to each source is difficult to determine. In addition to monitoring nitrate, Groten and Alexander had measured other anions and the data were indicative of animal waste sources. Lastly, Watkins (2011) showed that nitrate concentrations in Southeastern Minnesota trout streams are strongly correlated with the percentage of row crop acres in a watershed; a conclusion which Trout Brook data supports.

Recommendations

- Long historical records of water quality data are rare. Continued monitoring of the springs and stream monitoring sites will be important to increase understanding of nitrate sources and movement in Trout Brook.
- Understanding pollution movement and susceptibility in karst landscapes is complicated. The rate and direction of water movement underground can be very different than what surface topography suggests. Continued work to delineate springsheds would help to determine the types and percentages of land use that may be impacting Trout Brook. This information could then be used to determine groundwater management areas, which may be quite different than surface watersheds.


Fox Spring, February 13, 2017

- Continued education and assistance to local land owners and land users. Provide technical assistance and cost sharing for Best Management Practices which reduce nitrate pollution, targeting identified sources including row crop agriculture and animal feedlot operations.

References

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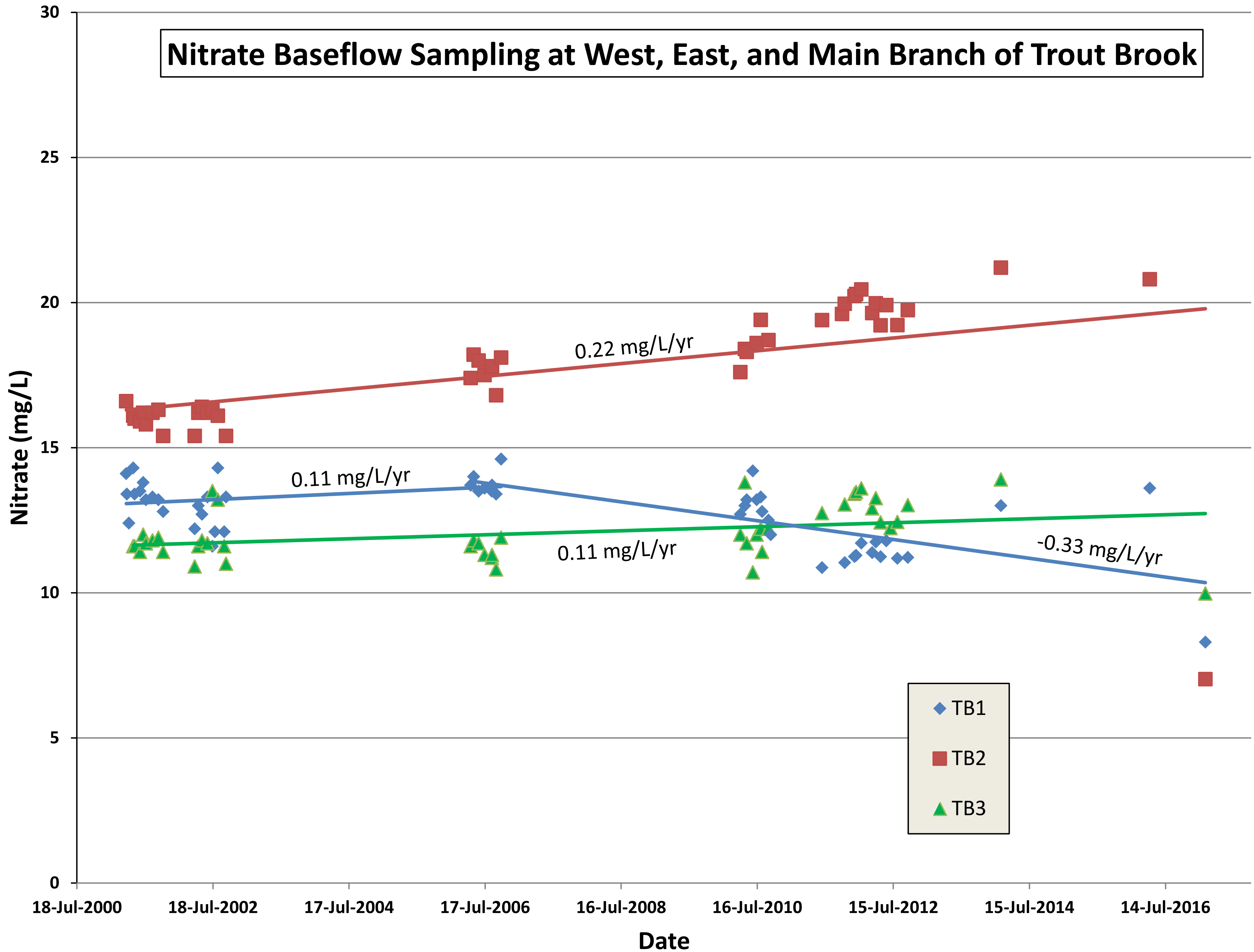

Figure 2. Baseflow nitrate data from surface monitoring sites, Trout Brook's West (TB2), East (TB1), and Main (TB3) branches.

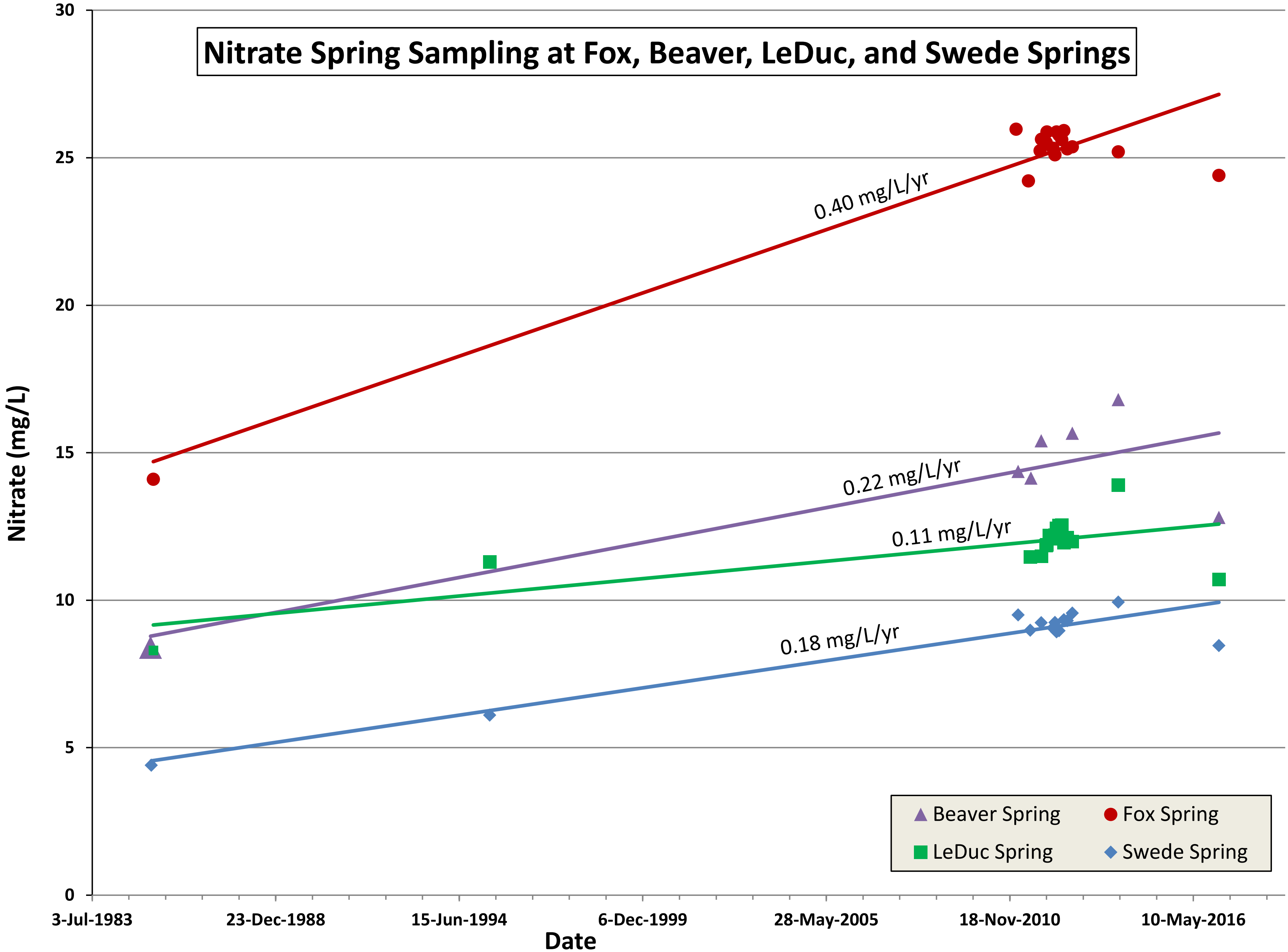

Figure 3. Baseflow nitrate data from spring monitoring sites; Fox, Beaver, LeDuc, and Swede