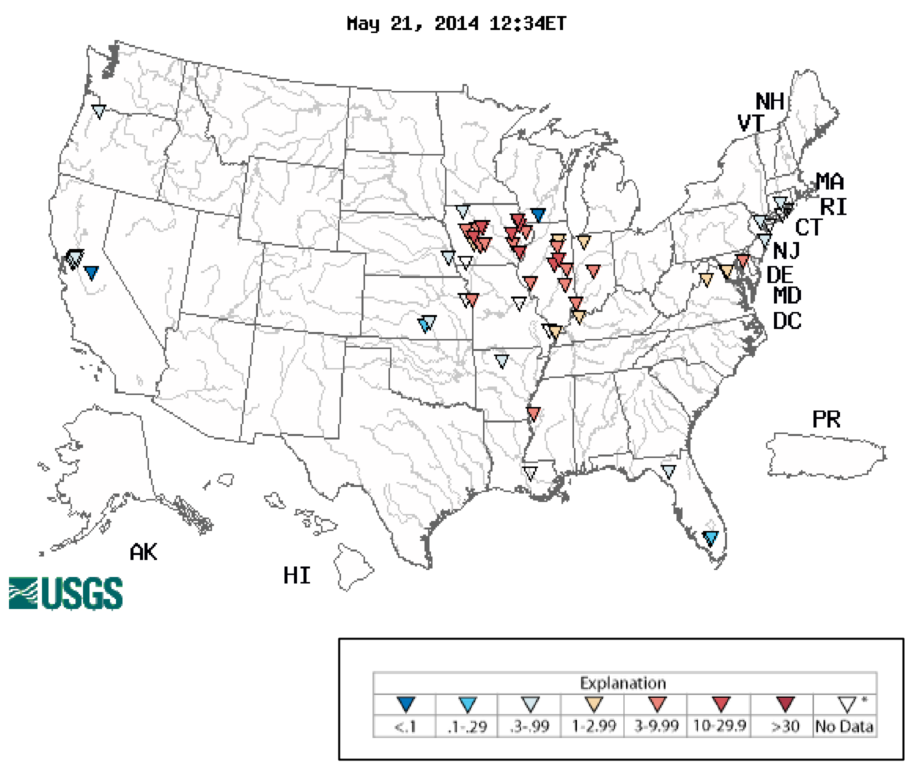
CONTINUOUS MONITORING FOR NITRATE IN USGS WATER SCIENCE CENTERS ACROSS THE U.S.

USGS scientists, in cooperation with local, State, Tribal, and other Federal partners, are implementing innovative real-time monitoring approaches to allow for continuous nitrate information available in real-time. Currently, USGS and its partners monitor nitrate continuously at nearly 80 locations. (Access *WaterQualityWatch website* for updates on locations)

Water quality conditions are complex, and ever increasing in complexity with shifts in population, land use, and climate that continue to alter our hydrologic systems and ecosystem functions. Effects are interconnected and often occur at timeframes of minutes (e.g., flash floods) to decades (e.g., implementation of management practices). Historically we have relied on discrete samples collected weekly or monthly, and laboratory analyses that can take weeks to complete. Such low-frequency data can hamper a timely response and decisions relative to rapid changes in nitrate concentrations and loads that can affect human and ecosystem health. Recent advancements in commercially available in situ sensors, data platforms, and new techniques for data analysis now provide an opportunity to monitor in real time, capturing the variability , such as in seasonal runoff, changes in precipitation intensity, and natural disturbances (such as fire) that can affect the storage, production, and transport of nitrogen in watersheds. Transmitting these data in real time can help in many ways, including in the management of water supplies and wastewater; regulation and permitting; and recreation; as well as to track trends and spatial and temporal variability of nitrate transport and contributions to key receiving waters (including seasonally, daily, and event-driven fluctuations). In addition, sensor information allows for a high degree of temporal and (or) spatial resolution; the denser data sets are useful to better understand or model hydrologic systems. Overall, the sensor information improves our understanding of how hydrology and water quality vary over short periods and can lead to more effective water management and conservation practices that improve the quality of the environment and human life. (Pellerin and Bergamaschi, Lakeline, Spring 2014).

Reliable and Readily Available

Continuous monitoring for nitrate concentrations allows for observations at a high temporal frequency, which are stored and transmitted to the USGS National Water Information System via satellite telemetry (uploaded every 1-4 hours) and available on the ***WaterQualityWatch website.*** Data can be displayed in tables, graphs, and maps and are retrievable in common spreadsheet formats. All data are quality assured with published protocols and validated with periodic laboratory analyses.



Continuous nitrate data are currently available at nearly 80 locations across the U.S. This "Real-time map" tracks short-term changes (over several hours) of water quality. Although the general appearance of the map changes very little from one hour to the next, individual sites may change rapidly in response to major rain events or to reservoir releases. The colors on the map represent ranges in concentrations, in milligrams per liter as nitrogen. "No data" refers to data that are collected but not available on the website. The data used to produce this map are provisional.

Nitrate sensor information is also available in real time through other USGS applications, such as WaterAlert and Water Now . Simply type in a station number followed by "99137" in the subject line of a text or email; retrieve "on-demand" information, as demonstrated for a small urban stream in northern Virginia, with a nitrate concentration of 1.86 milligrams per liter as nitrogen on May 21, 2014 at 12:15 p.m.

USGS Water Now

01646000 12:15EDT DIFFICULT RUN NEAR GREAT FALLS, VA
99137 Nitrate, water, in situ, milligrams per liter as nitrogen = 1.86

For Realtime Data at this station:
http://waterdata.usgs.gov/nwis/uv/?site_no=01646000

Technology

A nitrate sensor operates on the principle that nitrate ions absorb ultra-violet (UV) light at wavelengths less than 220 nanometers (nm) (Pellerin and others, 2013). The sensor is designed to convert spectral absorption properties measured to a nitrate concentration by using laboratory calibrations and integrated algorithms that also account for interferences from other absorbing ions and organic matter. This allows for real-time nitrate measurements without the need for chemical reagents. The sensors demonstrate good in-stream accuracy, typically within 3 to 5 percent of laboratory data.

*Real-time nitrate monitoring on the Potomac River at Little Falls near Washington D.C. (Station number **01646500**)*

Nitrate sensor technology is discussed in a USGS Techniques and Methods Report (TM 1-D5). The report presents guidelines for instrument selection, operation, deployment, maintenance, quality assurance, and data reporting. There are a variety of UV nitrate sensors currently available that differ in several important ways related to instrument design that affect the accuracy of their nitrate concentration measurements in different types of natural waters. The report provides information about the selection and use of UV nitrate sensors by the USGS and the collection of high-quality data across studies, sites, and instrument types. The report discusses technology complexities, including for example, how suspended sediment, highly colored water, and temperature may affect the optical sensors; how to consistently account for these factors for successful deployment; and how to interpret results in different settings. (USGS typically cleans and calibrates the nitrate sensors monthly or as needed to clean sediment, biological growth, and lime scale).

USGS continues to work with scientists and managers from universities, government agencies, and the private sector to develop standards and applications for optical sensors, and improve handling, storing, and analyzing the continuous data they produce (access collaborative workshop summary report, 2012) (Contact: Brian Pellerin, bpeller@usgs.gov)

Reference: *Pellerin, B.A., Bergamaschi, B.A., Downing, B.D., Saraceno, J.F., Garrett, J.D., and Olsen, L.D., 2013, Optical techniques for the determination of nitrate in environmental waters—Guidelines for instrument selection, operation, deployment, maintenance, quality assurance, and data reporting: U.S. Geological Survey Techniques and Methods 1–D5, http://pubs.er.usgs.gov/publication/tm1D5, 37 p.*

Management Questions and Benefits

Nitrate sensors allow real-time information on nitrate concentrations that can help to answer many science and management questions related to drinking water, wastewater discharge, sources of nitrate to streams and estuaries, transport of nitrate in major watersheds, and effectiveness of land-management practices on water quality. In addition, the sensors provide a high degree of temporal and (or) spatial resolution to understand or model hydrologic systems. Specific benefits include, for example:

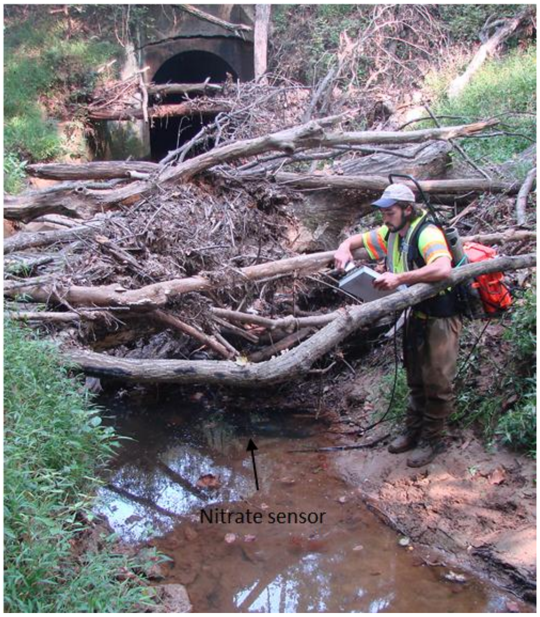
- Real-time nitrate data can inform water managers about operations of public water supplies, indicating when nitrate levels are too high for the water to be used without additional treatment steps or blending with higher quality water.
- Continuous nitrate data can provide more accurate information (as compared to weekly or monthly sampled data) about concentrations and loads of nitrate at drinking-water intakes or into sensitive receiving water bodies.
- Continuous nitrate data can provide more accurate information about trends in concentration or loading and about the efficacy of various management practices being used in a watershed to control nitrate contamination.
- Nitrate sensors can be used in a synoptic mode to help identify sources (sub-watersheds or groundwater seeps) making it easier to focus investigations and control activities on the highest priority source of nitrate in the watershed.
- Continuous nitrate data can provide new insights on the processes controlling the sources and transformations of nitrate in a watershed, leading to better watershed nutrient management plans.
- Continuous nitrate data can be used to assess the accuracy of statistical models for characterizing nitrate conditions. This can be very helpful in placing realistic uncertainty estimates around concentrations, loads and trends that are determined by methods designed for use with discrete time-series information. They can also be used to enhance the accuracy of these methods even though continuous data may never be collected.

Selected Highlights and Applications

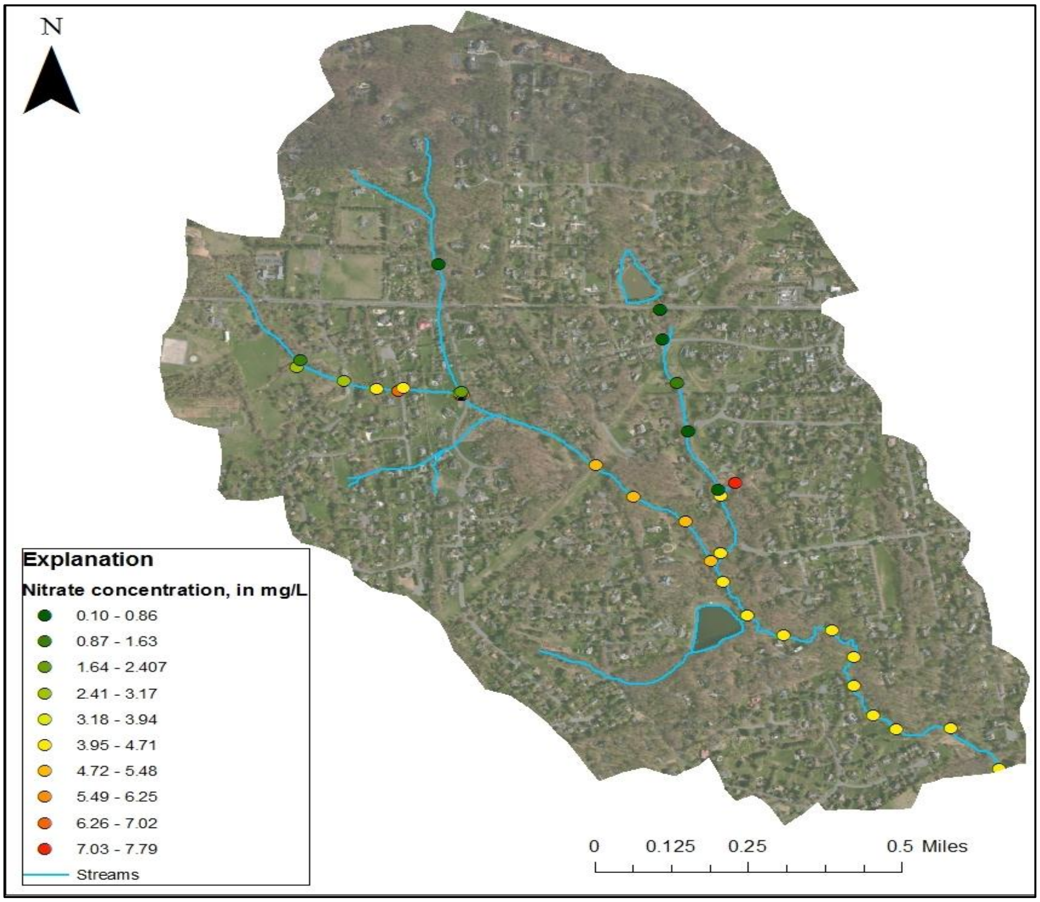
Identification of Nitrate Sources in Virginia

Nitrate sensors are being used in a synoptic mode to help identify nitrate sources in a watershed in northern Virginia. Specifically, USGS has adapted instrumentation used to log and telemeter continuous data from monitoring stations into a backpack-mounted data collection platform enabling mobile use of continuous nitrate and other water-quality sensors for forensic hydrology.

This platform supports “on-the-fly” exploration of nitrate patterns throughout entire watersheds to determine source areas or “hot spots” of increased nitrate concentrations, making it easier to focus investigations and assist managers in implementing effective monitoring strategies. Traditional sampling approaches relying on laboratory analyses would require multiple sampling efforts with considerable lag-time. (Contact: John Jastram, jdjastra@usgs.gov, (804) 261-2648)



A mobile nitrate sensor platform was used throughout an urban watershed in northern Virginia to identify potential nitrate sources associated with urban and agricultural activities.



In this synoptic study using mobile nitrate sensors, a nitrate laden groundwater seep (indicated by the red circle) was identified as a major source of elevated nitrate concentrations in the stream. Nitrate concentrations are reported in milligrams per liter, as nitrogen.

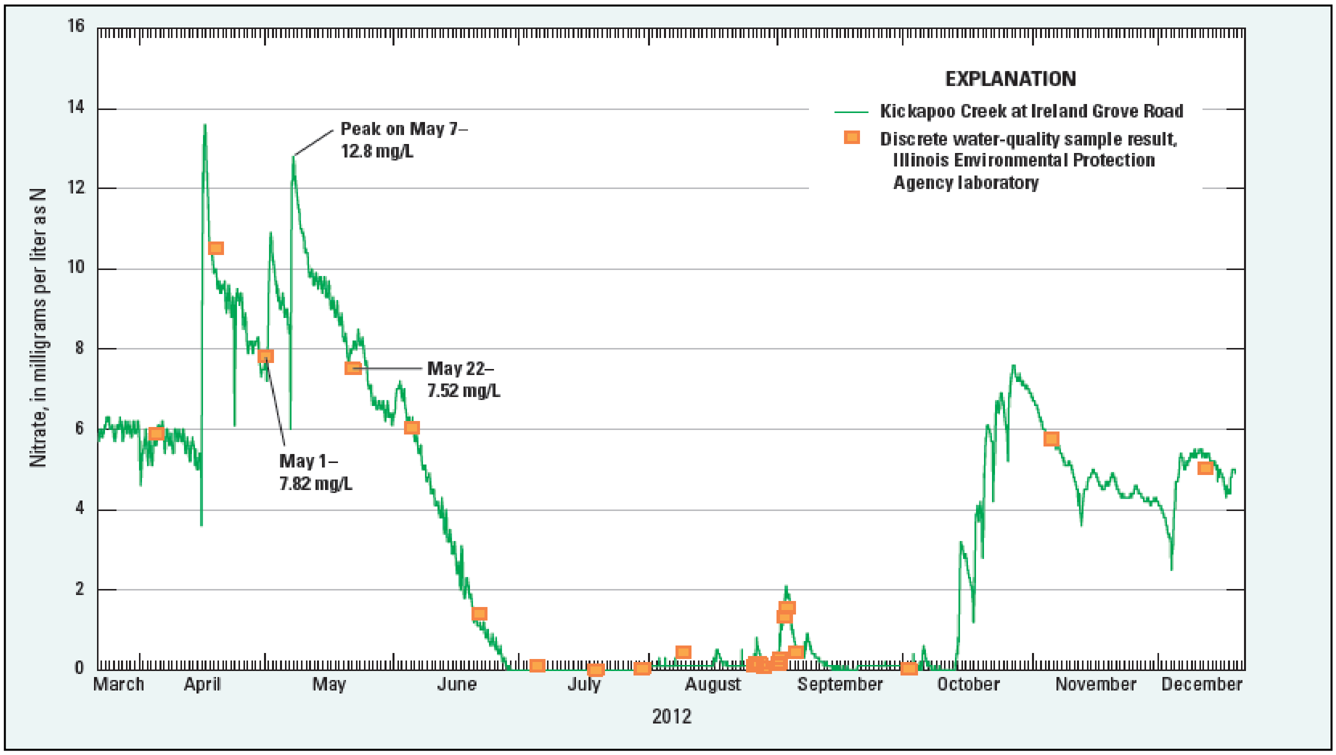
Management of Wastewater and Drinking Water in Kansas

USGS, in collaboration with Johnson County Wastewater and Stormwater Management Programs, monitors and assesses nitrate in real time in Indian Creek, an urban stream that receives discharge from two wastewater treatment facilities. The nitrate sensors in Indian Creek provide reliable estimates of nitrate concentrations in the stream at a greater frequency than discretely-collected data and with less error than estimates by USGS surrogate models. Continuous nitrate measurements are used to quantify among-site differences, diurnal and seasonal variability, and loads from point and non-point sources and can be related to in-stream processes such as primary production and respiration. Understanding the dynamics, fate, and transport of nitrate in Indian Creek helps to document the efficacy of wastewater treatment processes and the development of effective nutrient reduction strategies, watershed management plans, and best management practices. (Contact: Jennifer Graham, jlgraham@usgs.gov, (785) 832-3511)

USGS also monitors real-time nitrate for improved management of drinking water in collaboration with the Kansas Water Office, City of Wichita, and a consortium of water suppliers. One site on the Little Arkansas River near Sedgwick site is part of a USGS study on *Equus* Beds Groundwater Recharge; the nitrate data are used to help evaluate surface water quality for treatment prior to recharge. The other study sites on the Kansas River and Cheney Reservoir are part of cyanobacteria studies; nitrate is of interest in these studies from a basic drinking-water quality perspective and potential relations with cyanobacterial occurrence.

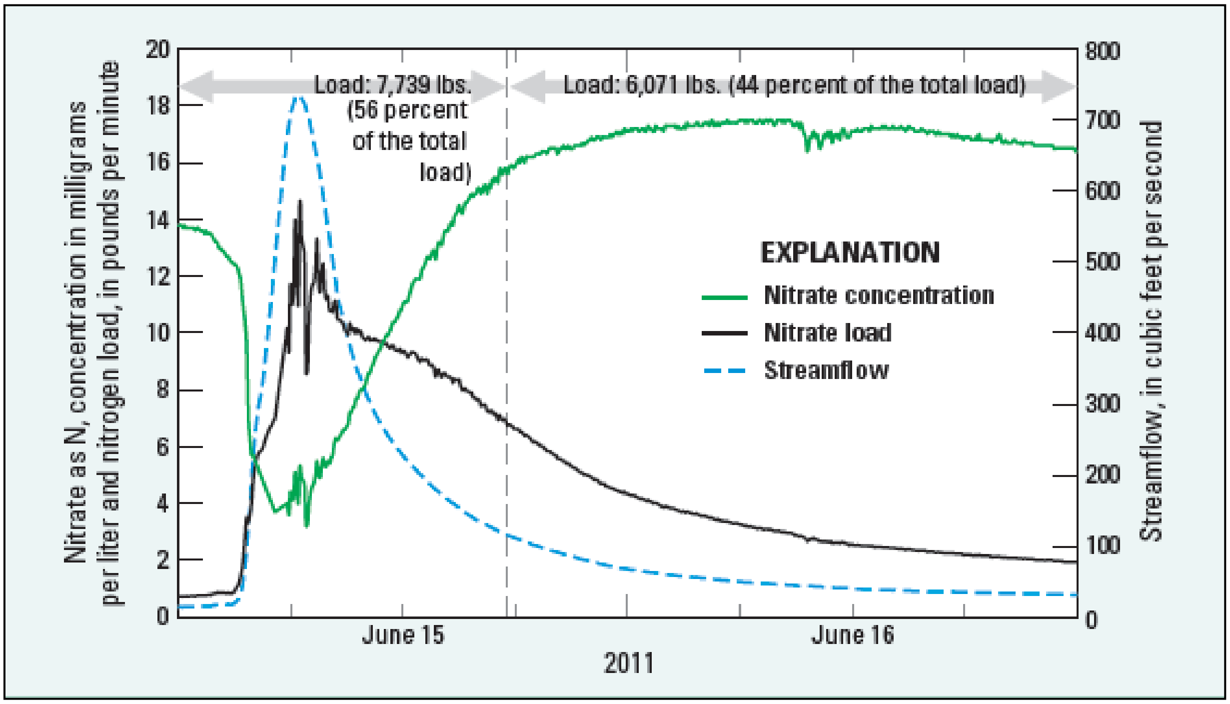
Capturing Peaks in Nitrate Concentrations in Kickapoo Creek near Bloomington, Illinois

Continuous nitrate data on Kickapoo Creek near Bloomington, Illinois show that sampling seasonally or even monthly may not often capture the variability of nitrate in riverine environments. As indicated in the graph below, peaks in continuous nitrate concentrations are not evident in discrete samples. A peak of 12.8 milligrams per liter (mg/L) as nitrogen (N) captured by continuous monitoring on May 7, 2012 is substantially higher than nitrate samples collected on May 1, 2012 (7.82 mg/L), and May 22, 2012 (7.52 mg/L). When nitrate is a concern in drinking water or an accurate calculation of load is needed, the identification of the peak concentration is important for managing the water quality. (Warner, K.L., Terrio, P.J., Straub, T.D., Roseboom, Don and Johnson, G.P., 2013, Real-Time Continuous Nitrate Monitoring in Illinois in 2013: U.S. Geological Survey Fact Sheet 2013-3109, 4 p.)



Continuous monitoring for nitrate at Kickapoo Creek near Bloomington, Illinois (USGS Site 05579610) captures concentration peaks that may not be captured by monthly discrete sampling and helps to improve management of nitrate in drinking-water supplies. (Warner and others, 2013, p. 4)

Continuous nitrate data on Kickapoo Creek also show variability in nitrate transport during storm events. Specifically, findings show that nitrate concentrations decrease with precipitation events and then gradually come back up to initial concentrations. However, the total amount of nitrogen (referred to a "load," or mass of nitrate during a given time in pounds per minute) increases during a storm event. As shown in the graph below, more than half of the nitrate load in Kickapoo Creek occurred within 15 hours from the initial storm event on June 15, 2011. Such findings have implications for managing nitrate treatment associated with drinking water intakes or for sustaining sensitive ecosystems during storm events. (***Warner and others, 2013***) (Contact: Doug Yeskis, djyeskis@usgs.gov, (217) 328-9706)

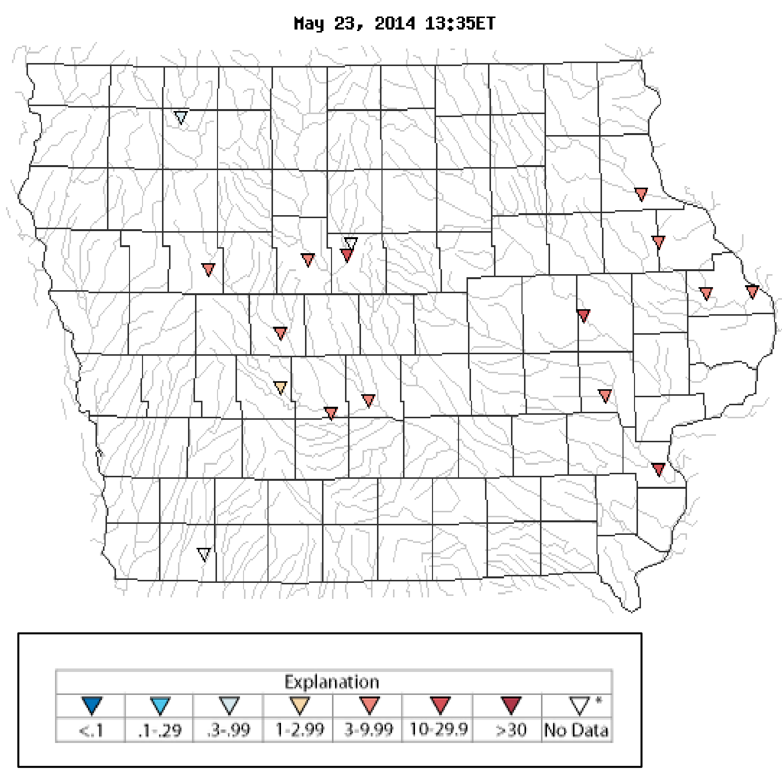


Continuous monitoring for nitrate at Kickapoo Creek near Bloomington, Illinois ([USGS Site 05579610]) shows transport of the majority of nitrate loads within 15 hours after a storm event in June 2011. ([Warner and others, 2013], p. 4)

Continuous Nitrate Monitoring in Iowa to Manage Water Supplies and Track Agricultural-Related Loads in Iowa

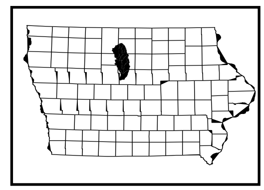
Iowa has one of the largest and fast growing real-time nitrate networks in the country, currently operational at 15 sites across the State. (Contact: Kevin Richards, krichard@usgs.gov)

Real-time nitrate is continuously monitored at 15 sites across Iowa to help stakeholders manage drinking-water supplies and discharges of wastewater. Data for May 23, 2014 show elevated nitrate concentrations, reported as nitrogen, throughout the agricultural parts of the State. The colors on the map represent ranges in concentrations, in milligrams per liter as nitrogen. "No data" refers to data that are collected but not available on the website. The data used to produce this map are provisional.



Similar to Illinois, continuous nitrate data are used to manage drinking-water supplies and discharges of wastewater. The Cities of Des Moines and Cedar Rapids, for example, use the data to determine blending strategies and day-to-day management of denitrification. Challenges can be considerable. For example, concentrations of nitrate at one continuously monitored site on Lyons Creek, a highly tiled watershed with intense poultry feeding operations near Des Moines, remained above 30 milligrams per liter in most of May through July 2013. Other sources of water and denitrification processes were used by the City of Des Moines to lower the concentration below the U.S. Environmental Protection Agency maximum contaminant level (MCL) of 10 milligrams per liter as nitrogen.

Continuous nitrate data also are used in Iowa to track effectiveness of agricultural best management practices and temporal variability in nitrate concentrations and loads. The real-time data show large temporal variability in nitrate loads that peak in the spring months because of highly tiled farms and a high intensity of poultry confined animal feeding operations (CAFOs). For example, as shown in the table below, nitrate loads from the Boone River watershed in the north-central part of Iowa peak in May 2013 represent almost 85 percent of the total annual flux. The data help state managers and producers to determine those watersheds with significant yields and track temporal performance of best management practices (BMPs) in the watershed.



Month	Average discharge (ft^3/s)	Average nitrate concentration (mg/L)	Nitrate load (tons)	Percent of total flux
March*	47.9	0.32	0.70	0.07
April	115	2.17	31.4	3.2
May	247	16.4	823	84.2
June	128	10.2	113	11.5
July	22.1	2.43	7.88	0.8
August	8.05	1.36	0.92	0.09
September	9.14	0.30	0.23	0.02
October	15.3	0.48	0.62	0.06
November *	12.8	0.43	0.21	0.02

Nitrate loads (tons) from the Boone River watershed in north-central Iowa in the Mississippi River Basin intensify in the spring, related to agricultural activities in the watershed. Nitrate loads in May 2013 (823 tons) accounted for about 84 percent of the total annual flux. (Note: Asterisks denote partial months. March and November are partial months as the instrument was deployed in March and pulled in November to protect from the ice.)

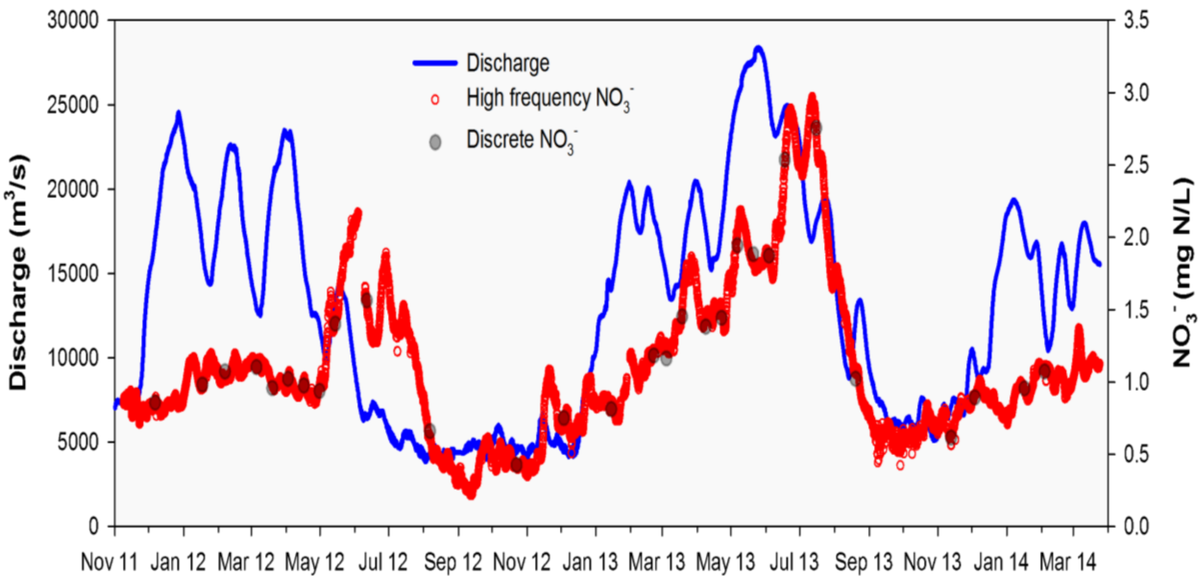
Tracking Nitrate Transport in Large Watersheds and Major Estuaries

Mississippi River Basin and the Gulf of Mexico

Improved Understanding of Variable Concentrations During Storms and Seasons in the Mississippi River Basin – Nitrate is the largest component of total nitrogen in most freshwater systems and, in many locations, represents the most significant concern for algal blooms. One such example is in the Mississippi River Basin, where the addition of nitrate sensors at key USGS stations is providing new information about the sources and processes that deliver nitrogen to the Gulf. USGS tracks continuous nitrate at several sites on the main stem and tributaries of the Mississippi River, including several on the lower Mississippi River (at Vicksburg, Mississippi and Baton Rouge, Louisiana); one on the upper Mississippi River at Cape Girardeau, Missouri; one on the Missouri River at Hermann, Missouri; and one on the Ohio River at Omsted, Illinois. In addition, USGS and partners support continuous monitoring at more than 30 locations in the Mississippi River basin. These sites are not only helping stakeholders manage drinking-water supplies, wastewater, and management practices (as described above), but also serve to enhance the network of real-time nitrate monitoring in the Basin, which helps to explain geographic variability in nitrate across watersheds and temporal variability over rainfall events and seasons. Together the information provides enhanced understanding throughout the region on sources of nitrate and transport timing – basically the "when" and "where" nitrate is moving through the system.

Preliminary USGS findings show that considerable variability in nitrate concentrations at the mouth of the Mississippi River can occur over relatively short time-periods (days to weeks) and is dependent on short- and long-term variability in precipitation patterns in different parts of the Basin. Nitrate concentrations measured in situ in the Mississippi River at Baton Rouge ranged from 0.22 to 2.97 milligrams per liter as nitrogen over the two year study period (2011-2013). Concentrations typically were lowest in September and highest in June or July, reflecting the seasonality in precipitation and snowmelt runoff, fertilizer applications and relative groundwater contributions to the Mississippi River. The lowest concentrations were measured during the 2012 drought, suggesting that lower water depths and longer water residence times associated with droughts may have increased the in-stream nitrogen retention in Basin streams and tributaries. Higher concentrations in 2013 suggest that nitrogen accumulated in soils during the 2012 drought period may have subsequently flushed during the 2013 spring flooding (Pellerin, written communication, 2014, bpeller@usgs.gov).

Mississippi River at Baton Rouge

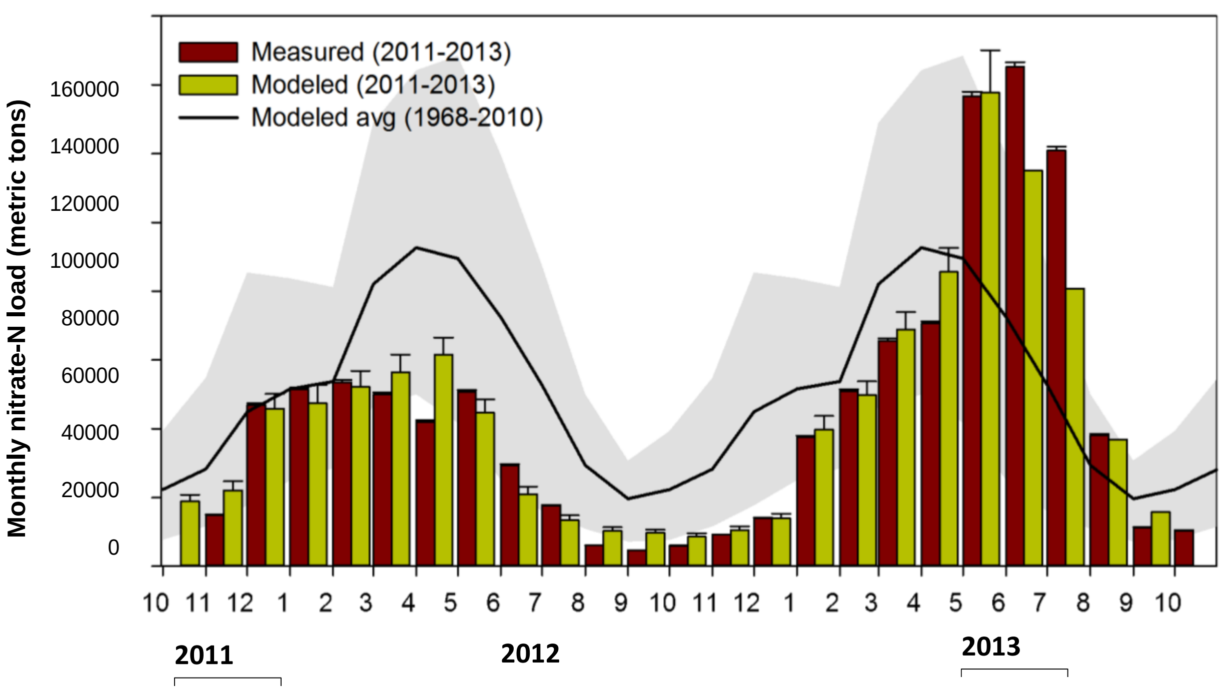


Time, represented in months and year

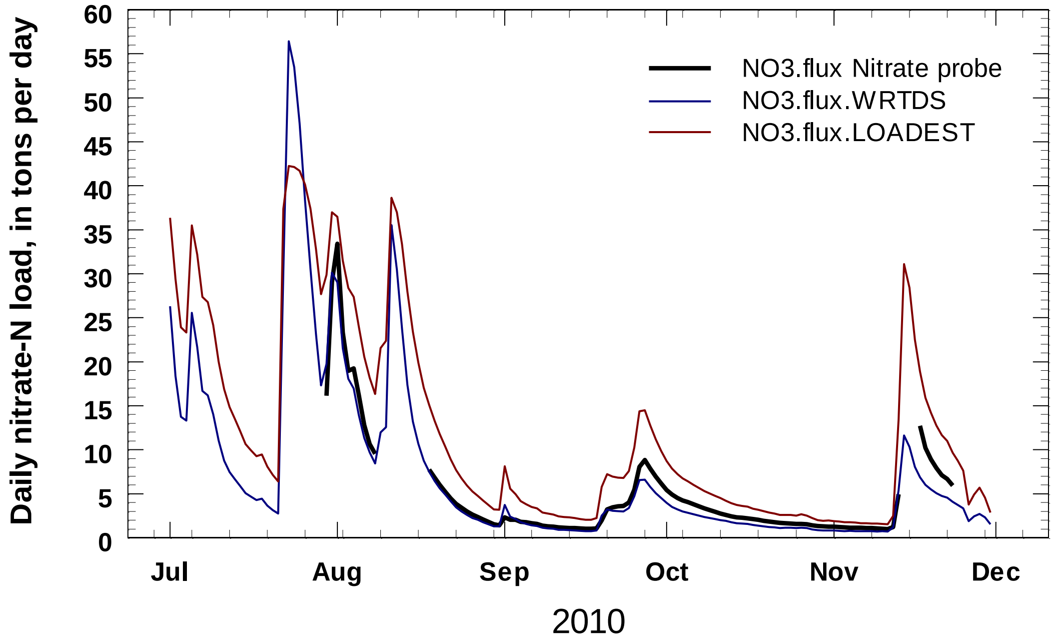
Nitrate sensors capture nitrate concentrations during all hydrologic events, and demonstrate variability in concentrations over relatively short periods (days to weeks) in the Mississippi River (site shown is the Mississippi River at Baton Rouge, Site Number 07374000). Continued nitrate data show considerable complexities in the relationship between nitrate concentrations and discharge, which reflects storm pulses, seasonality in precipitation and snowmelt runoff, sources of nitrate within the basin, and accumulation of nitrate in soils prior to flushing. Specifically, nitrate concentrations (reported as nitrogen) typically peaked later than the peak of discharge, and showed virtually no relationship with streamflow during colder months of the year. The data show that nitrate concentrations were particularly high in the aftermath of heavy precipitation in Spring 2013 which followed the long dry period in 2012. These high discharges helped to flush significant amounts of nitrogen that was in storage in soils and groundwater from the preceding dry year.

Improved Modeled Estimates of Loads in the Mississippi River Basin – Recent deployment of nitrate sensors at key locations on the Mississippi River allows for monthly loading estimates to be refined while reducing the uncertainty in those estimates, leading to a better understanding of the timing and magnitude of nitrate transport within the basin. Real-time nitrate data provide a more accurate measure of loads than can be produced using statistical models that rely on discrete sample data, such as LOADEST, a FORTRAN based regression model used to estimate monthly loads in streams and rivers, and WRTDS, Weighted Regressions on Time, Discharge, and Seasons) (https://github.com/USGS-R/EGRET/wiki). Efforts are underway to develop hybrid methods of loads in watersheds in which sensor data are available for part of the year and discrete sample data are available throughout the year.

The availability of continuous nitrate data at some sites provides researchers with the data needed to evaluate the statistical methods that are designed for sites with only discrete samples. For example, the figure below shows monthly nitrate loads to the Gulf of Mexico using a regression-based estimation model (LOADEST) and biweekly to bimonthly discrete nitrate samples and compares them to the much more accurate record developed from the continuous data. As shown in the graph below, LOADEST-modeled monthly nitrate loads differed from measured loads by – 40 percent to +53 percent, with no consistent bias across the study period. Mass differences in the two monthly load estimates were greatest during critical spring months, with modeled nitrate loads +32 percent in April 2012 and -23 percent in May 2013. Comparisons of measured and modeled nitrate loads based on sensor data differed by only 2 percent for the entire two year study period. Measured monthly loads based on sensor measurements also showed lower error estimates, ranging from 1 to 2.3 percent. The continuous data can be used by researchers to refine methods for estimating the uncertainty in load computations and in long-term trend estimates derived from discrete data. Increasing the certainty will improve understanding of spring nitrate loading, which is a key factor in the formation of summer hypoxia in the Gulf of Mexico. (Pellerin, written communication, 2014, bpeller@usgs.gov)



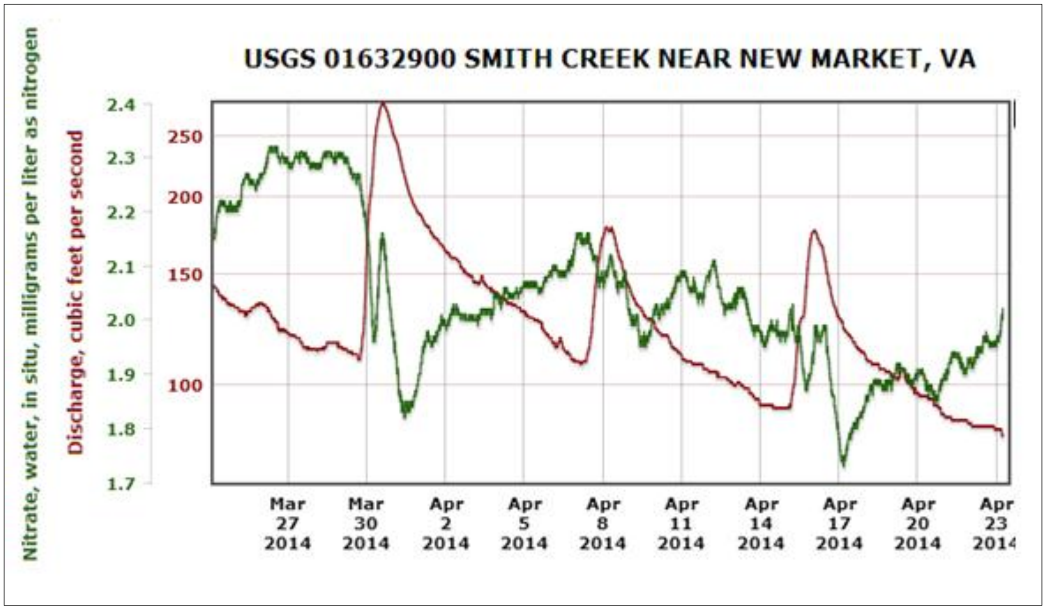
Monthly loads to the Gulf of Mexico based on sensor measured values and modeled values (LOADEST) from October 2011 to October 2013 vary considerably, particularly during the spring months. The solid line is the monthly LOADEST average from 1968 to 2010, and the shaded area represents the 10 and 90 percentiles. Months (represented by numbers 1-12) are shown on the x-axis.



Comparisons on smaller watersheds in the Mississippi River Basin also show differences in continuous measured loads from statistically modeled loads that are designed for discrete data. For example, in the South Fork Iowa River near New Providence, Iowa, the LOADEST method overestimated nitrate loads by 64 percent for the four month period where continuous records exist. In contrast, the WRTDS (aka "Weighted Regressions on Time, Discharge, and Seasons") underestimated loads by 16 percent. Specifically, the estimated total nitrate load in the South Fork Iowa River was 487 tons based on sensor nitrate data, versus 410 tons using the USGS WRTDs model and 802 tons using the LOADEST model.

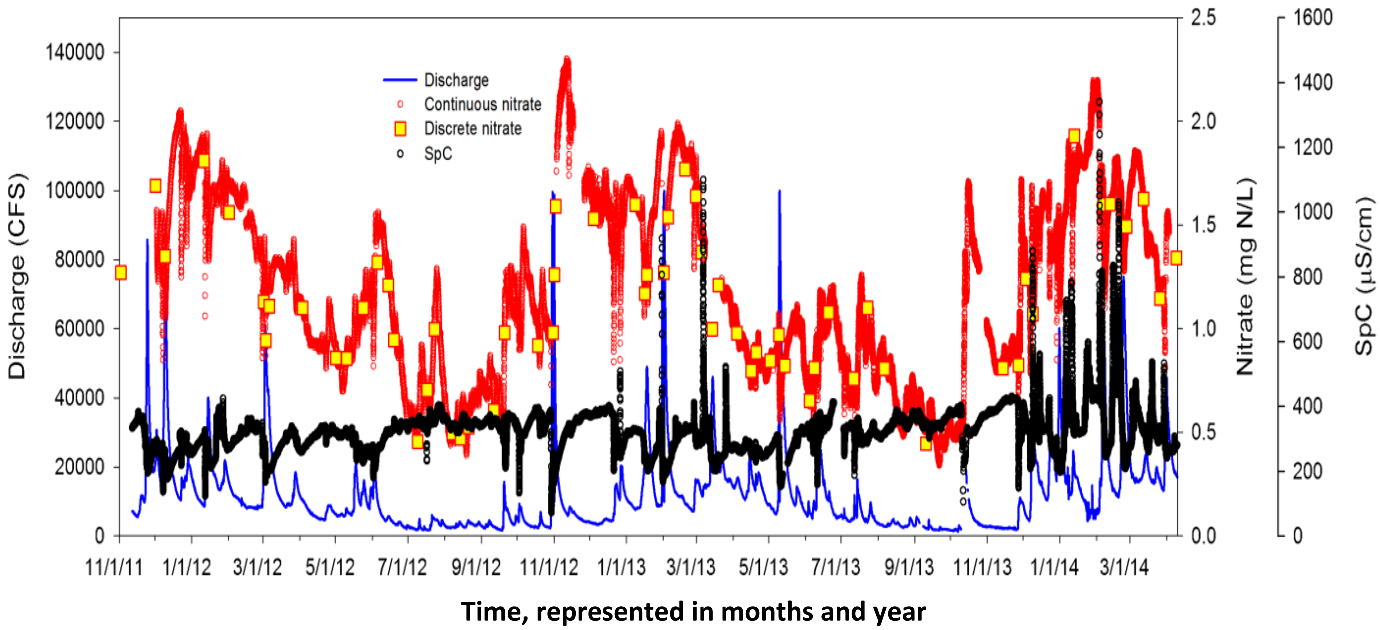
Chesapeake Bay Tributaries –

Improved Understanding of Variable Concentrations During Storms and Seasons in Chesapeake Bay - USGS monitors real-time nitrate concentrations on multiple tributaries of Chesapeake Bay to improve the understanding of processes controlling nitrate transport in agricultural- and suburban watersheds and to capture the variability in nitrate concentrations that are observed during storm events and between storm events. Continuous nitrate data are paired with other hydrologic indicators (or "tracers" such as other nutrients, major ions, metals, and isotopes) to better understand nitrogen sources, sinks, and transport pathways. Additionally, the continuous nitrate data are used to improve estimates of total nitrogen loading from these watersheds where nitrate transport is highly variable and not well represented by traditional modeling techniques. (Contact: Ken Hyer, kenhyer@usgs.gov, (804)261-2636)



Sensor nitrate concentrations (reported as nitrogen) and streamflow (discharge) in Smith Creek near New Market, Virginia (USGS site 01632900) during Spring 2014 show temporal variability during stormflows. The sensor nitrate information is needed to better predict nitrate responses from this agricultural watershed in the Chesapeake Bay region, ultimately leading to improved tracking and prediction of nitrogen sources to the Bay.

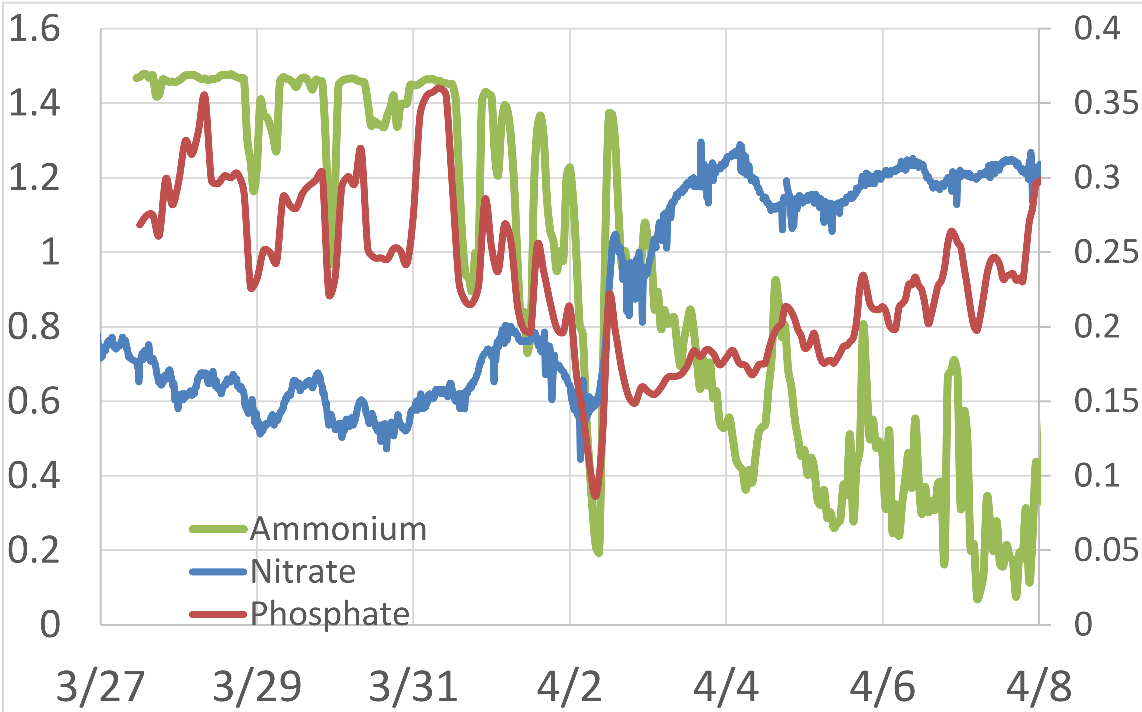
Improved Understanding and Models of Hydrologic Processes in Chesapeake Bay - In addition to improving load estimates, such as to the Gulf of Mexico described above, continuous nitrate sensor data are also being used for understanding and modeling processes such as water flow paths and in-stream nitrogen retention in rivers and streams. For example, USGS scientists are evaluating the use of continuous nitrate data and specific conductance in the Potomac River to better understand the role of groundwater delivery and in-stream processing in nitrate loads to Chesapeake Bay. In particular, the comparison of continuous nitrate data with specific conductance data (which can serve as a chemical tracer of water flow paths) suggests changes in water sources and/or biological activity in the river, such as, for example, increasing and decreasing seasonal contributions of groundwater to streams. These data are being used to evaluate parameters in the USGS SPARROW model for Chesapeake Bay (USGS publication), which tracks annual nitrate loads to Chesapeake Bay, with the intent of supporting a dynamic (e.g. seasonal) model that more directly incorporates groundwater nitrate loading. (Pellerin, written communication, 2014, bpeller@usgs.gov)



Continuous sensor data for streamflow (or "discharge"), nitrate as nitrogen, and specific conductance at the Potomac River at Little Falls (USGS site 01646500) show variability over time during the 3-year study period (November 2011 to March 2014) (above). Differences in the behavior of nitrate and specific conductance may be indicative of changes in water flow paths such as increasing and decreasing seasonal contributions of groundwater to streams and/or in-stream nitrogen retention. (Red line indicates nitrate; black line indicates specific conductance; blue line indicates stream discharge).

Nitrate Dynamics in the San Francisco Estuary -

USGS monitors real-time nitrate at six stations in the San Francisco Estuary and on the Sacramento River for the purpose of characterizing and quantifying in-estuary dynamics, particularly those involving interaction with tidal wetlands. Characterizing how nutrient dynamics in estuaries are affected by interaction with adjacent tidal marshes is essential for developing accurate nutrient budgets, assessing the impacts of eutrophication, and planning wetland restorations to help mitigate effects of rising population. The difficulty is that water quality and nutrient supply in estuaries change continuously as river flows, tidal- and wind-driven currents, and other physical processes move new water parcels across comparatively static geomorphic settings. The USGS uses high frequency, in situ measurements of nitrate together with simultaneous measurements of phosphate and ammonium to assess nutrient dynamics. Bi-directional discharge is continuously monitored acoustically. USGS scientists have observed large variability in dynamics, from tidal to seasonal time scales, and found substantial seasonal and episodic variation in the magnitude and direction of net nutrient fluxes, suggesting that long-term, high-frequency observations are necessary in order to evaluate nutrient retention in wetlands. (Contact: Brian Bergamaschi: bbergama@usgs.gov, (916) 278-3053)



Time, in days, March 27 – April 8, 2013

Concurrent measurements of nitrate, phosphate and ammonium in the Sacramento River at Walnut Grove in the tidal reaches of the San Francisco estuary show large tidal dynamics in concentrations, from tidal to seasonal time scales. USGS scientists report substantial seasonal and episodic variation in the magnitude and direction of net nutrient fluxes, suggesting that long-term, high-frequency observations are necessary in order to evaluate nutrient retention in wetlands.

Assessment of System-Wide Nitrate Loads in the Columbia River Basin, Oregon –

USGS monitors real-time nitrate concentrations in the Willamette River at Portland, Oregon in collaboration with Portland State University and other partners. The nitrate data are useful because the Willamette River drains one of the most important basins in Oregon-- one that is critical to the State's economic success, home to the vast majority of its population and a wide variety of agriculture. In addition, the nitrate data serve as a useful contrast to the seasonal patterns, concentrations, and loads of nitrate measured in other parts of the USA; typically, nitrate concentrations are far lower than those in the Mississippi/Missouri/Ohio River basins.

USGS also collaborates with Oregon Health & Science University to monitor nitrate continuously in the Columbia River, both upstream and downstream of the mouth of the Willamette River. Together, the three sites provide excellent data for assessing system-wide loads and mass balances, as well as data to assess primary productivity and other stream-health metrics.

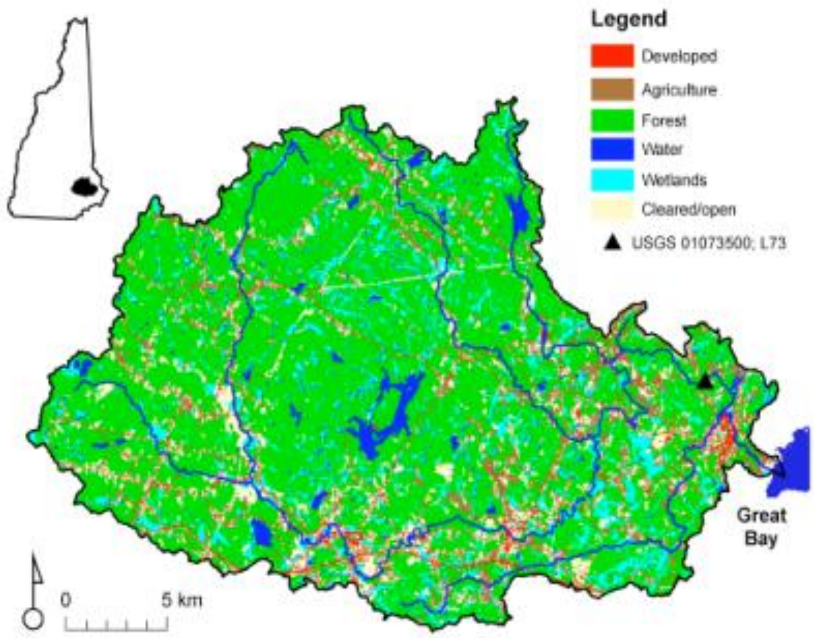
The Willamette River nitrate data are collected along with discharge, stage, velocity, and eight other continuous water-quality constituents (see http://or.water.usgs.gov/will_morrison/monitors/). The data are useful as indicators of upstream sources and for assessing the relative importance of processes that control water quality. For example, In February of 2014, a large regional storm caused the river’s discharge to increase rapidly, including localized inundation of upstream agricultural fields and high runoff in tributaries from forested, agricultural, and urbanized areas around western Oregon. The nitrate sensor in the Willamette River at Portland, which had been in operation for about a year, recorded its highest nitrate value to date (1.22 mg/L as N), and one of the highest concentrations ever measured by USGS at this long-term sampling location. This response is different from what is observed at some other locations in the nation where high discharge from storms appears to dilute nitrate concentrations, and suggests that nitrate concentrations were enhanced by nonpoint runoff during this event. Another sensor measuring the fluorescence response of dissolved organic material in the water column, or FDOM, responded similarly to the nitrate sensor. Smaller variations in both nitrate and FDOM could represent water reaching the Portland site from other tributaries in the Portland area, with different travel times and nutrient and organic-material characteristics. Together these data suggest that the nitrate and organic matter had been mobilized from upstream soils, including in the predominantly agricultural lands of the Willamette Valley’s lowlands, and provide new insights into the hydrologic response of the regions streams to rainfall. (Contact: Stewart Rounds, sarounds@usgs.gov, (503) 251-3280, and Chauncey Anderson, chauncey@usgs.gov, (503) 251-3206)

Assessment of Nitrate Concentrations and Sources to Great Bay Estuary, New Hampshire –

Real-time nitrate data are collected on the Lamprey River near Wiswall, New Hampshire (USGS site number 01073495) to better understand nutrient transport to the Great Bay estuary. (Contact: Ken Toppin, ktoppin@usgs.gov, (603) 226-7808).

The Great Bay was classified as nitrogen-impaired by the Environmental Protection Agency due to both point and non-point sources. The Lamprey River is the largest tributary to Great Bay and nitrate levels in the watershed are increasing, in large part due to land-use development, including suburbanization; human population density in the watershed has increased substantially over the past 10 years. Recent research has shown that nitrogen loads are greatest during storm flows and therefore may have a relatively large influence on the downstream Great Bay (Doyle, 2005, "*Incorporating hydrologic variability into nutrient spiraling."* Journal of Geophysical Research 110:GO1003).

A nitrate sensor was installed near the mouth of the Lamprey River near Wiswall, New Hampshire to track nutrient transport across a range of flow conditions and storm events and to help to quantify nonpoint sources of nitrate during storm events. The information is used by managers to prioritize management actions for controlling sources of nutrients to the estuary.



The Lamprey River (USGS site number 01073495) is the largest tributary to the Great Bay and contributes significant nitrate, particularly during storm events, because of increasing urbanization and agriculture.