Nitrates and Lake Havasu City's Wastewater Expansion Program

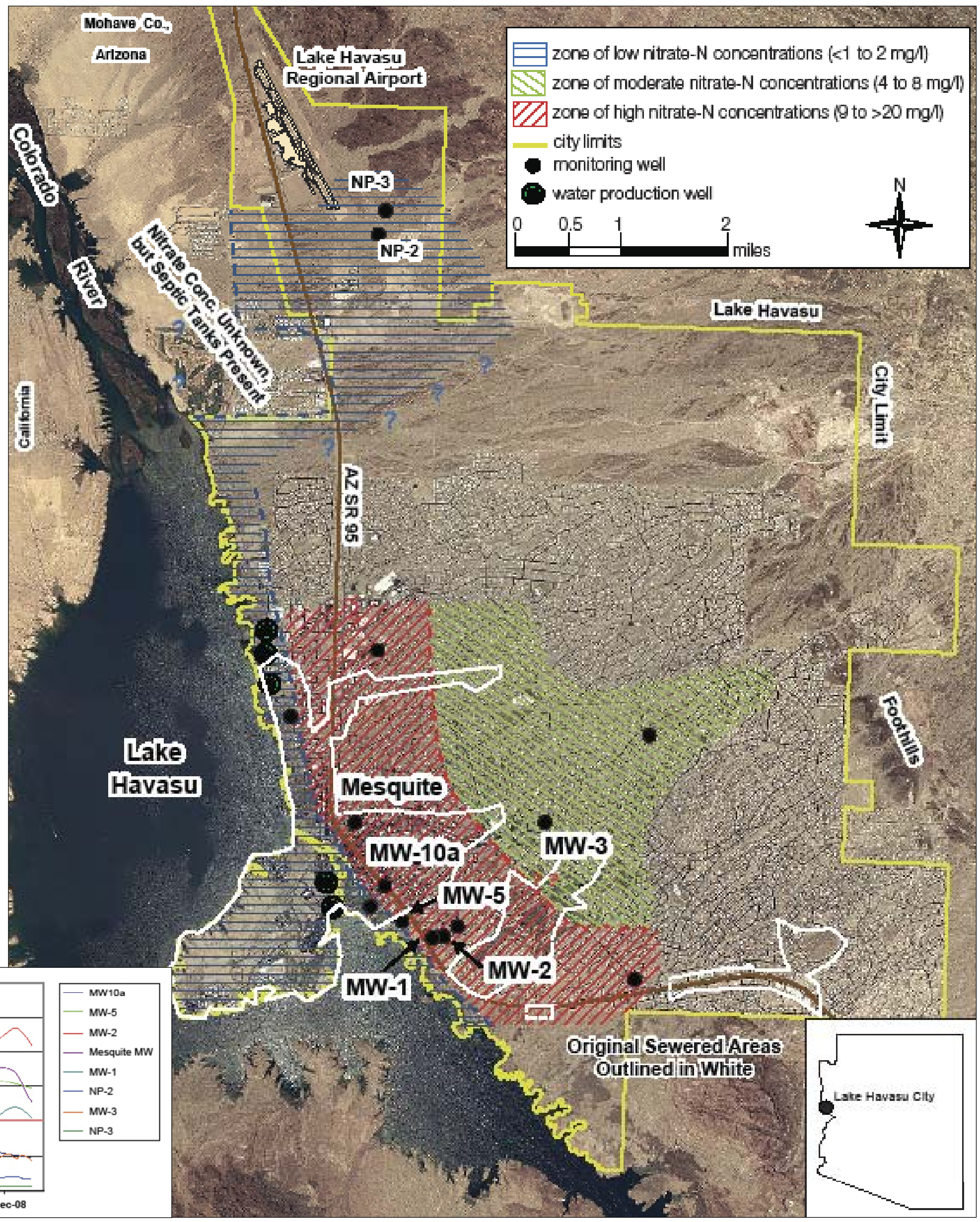
Doyle C. Wilson – Lake Havasu City, Arizona

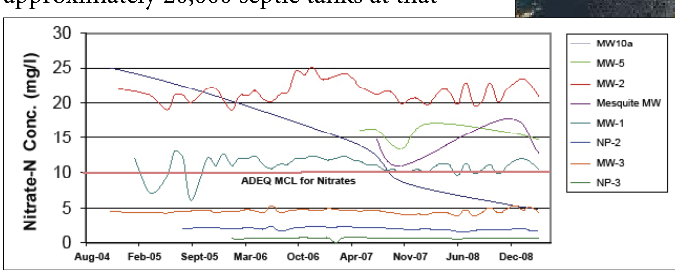
Lake Havasu City (pop. 56,000) in Mohave County, Arizona, sits on the banks of Lake Havasu, a 70-year old reservoir on the Lower Colorado River below Lake Mead. The city is in a topographic trough and nearly surrounded by mountains, where it receives low average annual precipitation (3.5 inches) and extreme summer heat. When the city was first planned, the central sewer was confined largely to residential and commercial/industrial areas closest to the lake. Residences away from the lake had individual septic tanks, whose numbers grew, ultimately to 28,000, with the city's population.

First Sign of Problems

Lake Havasu City faced beach closures in June 1994, due to elevated *E. coli* bacteria counts in Lake Havasu during a record-breaking heat wave in which temperatures reached 128°F. In response, several monitoring wells were installed near the lakeshore by the Arizona Department of Environmental Quality (ADEQ) to determine the bacteria's nutrient source. Well samples collected in the following years showed nitrate-N concentrations in four wells were up to four times higher than the 10 milligrams-per-liter (mg/l) maximum concentration level allowed by state and federal regulations. ADEQ concluded that nitrates transported in septic tank effluent could affect the city's water production wells, and in 1999 banned installation of nondenitrifying septic tanks within a one-mile radius of each monitoring well. The city had approximately 20,000 septic tanks at that time. Further testing indicated that nitrate levels were not diminishing and ADEQ urged the city to take mitigating measures or they would mandate a citywide ban on septic tank installations. Bullhead City, Arizona, about 60 miles to the north, earlier received such a mandate from ADEQ and implemented a centralized wastewater collection expansion program.

Lake Havasu City voters overwhelmingly passed a bond election in 2001 for centralized wastewater collection and treatment expansion at an estimated cost of $463 million, one of the largest infrastructure projects in the state. This 11-year program calls for decommissioning 90 percent of the city's septic tanks, installing 400 miles of sewer lines, building





The original sewered area of Lake Havasu City is outlined in dashed white. Three zones of varying CRA nitrate concentrations are identified with hachures: red shows the urban core, with the highest nitrate levels; green has moderate nitrate concentrations; blue has the lowest, but is where the city's water production wells are sited.

a new wastewater treatment facility and expanding two existing ones, upgrading water connection service lines, and repaving roads affected by sewer line installation. Funding for the program was to come from 20- to 30-year, low-interest loans provided by the Water Infrastructure and Financing Authority and later by the Greater Arizona Development Authority, both Arizona state agencies. The burden of loan repayment has fallen on the citizens through installation fees and sewer charges based on domestic water consumption. The only outside funding received to date has been a $1.4-million federal appropriation earmark in 2006 sponsored by Senator Jon Kyl. City staff worked hard to reduce the overall cost of the program to approximately $425 million through innovative strategies without compromising infrastructure quality.

Prior to construction, the city joined the Colorado River Regional Sewer Coalition (CRRSCo), consisting of local, county, and special district wastewater service providers and Native American tribes. This group, which has since added the Southern Nevada Water Authority, Metropolitan Water District of Southern California, and the Central Arizona Project as members, aims to improve water quality on the Lower Colorado River by establishing centralized sewer collection systems and eliminating effluent seepage that migrates to the river from septic tanks.

Hydrogeology and Water Quality

After Parker Dam was constructed, the formation of Lake Havasu behind it caused the aquifer in the adjacent uncemented alluvial-fan gravels and sands to expand considerably. The unconfined aquifer, known as the Colorado River Aquifer (CRA), initially dips slightly away from the lake then slowly rises inland at a rate of two to four feet per mile, increasing water depths to several hundred feet below ground surface (bgs). This nearly flat water table and recharging warm groundwater (100°F or more) from buried volcanic rocks adjacent to the Mohave Mountains are responsible for very slow water movement toward the lake.

Monitoring wells that intercept the CRA outside the urban core show average nitrate-N concentrations of less than 1 mg/l to about 2 mg/l. Groundwater from wells in the developed city has concentrations ranging from less than 1 mg/l to 22 mg/l and can be roughly subdivided into three zones (see map, left).

The zone with highest nitrate-N levels (9 mg/l to 22 mg/l) occurs within the urban core, from around 1,000 feet to almost one mile upslope from the lake, representing the progressive accumulation of upslope septic effluent. Groundwater levels in monitoring wells within this zone are between 50 and 100 feet bgs. From the lakeshore to 1,000 feet upslope is a transition zone where groundwater apparently mixes with lake water as the lake surface rises and falls in response to upstream and downstream dam operations. Incremental lake-level fluctuations drive nitrate-poor lake water into and away from the aquifer, slowing the recharge process and diluting nitrate-laden groundwater. Although nitrate-N concentrations average below 3 mg/l in this zone, bulk nitrate loads provide a nutrient supply to the lake. The city's water production wells are in this zone, drawing nitrate-poor water close to and beneath the lake. The third zone, containing moderate nitrate-N concentrations (4 mg/l to 8 mg/l), occurs east and upslope of the middle zone. Two monitoring wells in this zone and in the heart of residential development have water levels in excess of 200 and 400 feet bgs, respectively.

Gradual Progress

Dedicated monitoring of nitrate concentrations in the two zones farthest from the lake began in late 2004 to determine the mitigating effects of decommissioning thousands of septic tanks. Pre-sewer nitrate concentrations have dropped dramatically in some wells, yet concentrations in most wells, while fluctuating from sample to sample, have had consistent long-term trends (see chart). Slow migrating groundwater will take years to flush all of the aquifer to acceptable nitrate concentrations after the sources are eliminated.

This time lag implies that nitrate and other nutrient loading in the lake will continue, but at decreasing rates. The extra nutrients bolster aquatic plant and phytoplankton populations, with negative consequences. Aquatic plants have become a navigational hazard for boats in areas of the lake and elevated phytoplankton numbers are supporting the rapid expansion of filter-feeding quagga mussels. The measures taken by Lake Havasu City and Bullhead City to mitigate and eliminate septic nutrient sources will need to be followed by many other entities with septic sources along the river; CRRSCo will assist in realizing these efforts.

Although Lake Havasu City's sewer expansion program won overwhelming voter approval, community support has been mixed since the program was implemented, due to its cost and how it is financed. In addition to improved groundwater quality, positive outcomes of the program include reduced residential water consumption and an expanded water source: effluent for irrigation. But base sewer charges increase annually to keep pace with loan repayment, and since the overall sewer charge per customer is based on water consumption averaged over three winter months, many residents pay more than the base charge. Monthly sewer charges over $100 are not uncommon and will continue to rise if no federal funding materializes. ■

Contact Doyle Wilson at wilsond@lhcaz.gov.