Water Quality in Arthur R. Marshall Loxahatchee National Wildlife Refuge—Trends and Spatial Characteristics of Selected Constituents

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Water has historically entered Florida's Arthur R. Marshall Loxahatchee National Wildlife Refuge from rainfall and from two large pumping stations, S-5A and S-6. Water from the two pumping stations drains agricultural lands and often has relatively high concentrations of dissolved solids, nutrients, and pesticides. Water from the pump stations flows into perimeter canals and marshes of the Refuge. Water quality in the Refuge is affected by water from the nearby canals and by natural seasonal processes. The influences of canal waters extend up to 5 km or more into the marshes, depending on location in the Refuge and on water levels in the canals. The greatest influence from the canals occurs in the west and southwest parts of the Refuge, where conservative constituents such as specific conductance, chloride, and sulfate are elevated compared with background levels of the interior marshes. Nutrient concentrations are an order of magnitude higher in canal waters than in marsh waters, but, unlike conservative ions, the high concentrations are much more restricted to the marshes near the canals. Water quality of the interior marshes is affected primarily by seasonal processes such as evapotranspiration, rainfall, and biological activity.

Our analysis of water-quality data focused on a comprehensive review of all water-quality data collected in Loxahatchee National Wildlife Refuge. Data were primarily from the South Florida Water Management District (SFWMD) DBHYDRO database. Other sources of water-quality data, such as early data from the USGS, were reviewed and integrated into the analysis. Data related to water quality, such as water levels and flow, also were compiled.

We used the uncensored seasonal Kendall test and Tobit regression procedures, provided with the S-ESTREND program, to analyze historical water-quality data for trends. A 95-percent confidence level ($p = 0.05$) was used for all of the statistical tests. Generally, the interior marsh sites had few significant long-term trends, because of their isolation from agricultural and urban impacts. The interior site, LOX8, had a significant upward trend for 1978-2003 for specific conductance and for total phosphorus for 1993-2003; however, the phosphorus trend was done using Tobit regression that is not stage adjusted and could give trends caused by long-term wet and dry periods. Major canal inflow sites such as S-5A and S-6 had several significant long-term trends. S-5A, for example, had a significant downward trend in specific conductance, chloride, and total nitrogen for 1974-2003. Total phosphorus and sulfate showed no significant trend for this period. For the same period, S-6 had a significant downward trend for specific conductance, chloride, total phosphorus, and total nitrogen. Sulfate had no trend. Trend analysis for all five parameters were done using uncensored seasonal Kendall tests and were stage adjusted

Concentrations of pesticides and other organic compounds in waters and sediments have been measured at inflow pumping stations more frequently and over a longer time span than at Refuge marsh sites. Pesticides in water have been measured at pump stations S5A an S-6 from the early 1980's. Most determinations are reported as less than values (nondetects). At S-5A, the most commonly detected pesticides in water were atrazine, total ametryn, metachlor, and simazine. Atrazine (unfiltered) was detected in 57 out of 75 samples (1987-2002), with a maximum concentration of 12.3 μg/L. At S-6, the most commonly detected pesticides were atrazine, total ametryn, and dieldrin. Atrazine (filtered) was detected in 83 out of 84 samples between 1996 and 2004, with a maximum concentration of 7.8 μg/L. Only a few water samples for pesticide analysis have been collected from the Refuge marshes, and none contained detectable

concentrations. Bed sediment samples for pesticide analyses were collected annually at S-6 and S-5A, beginning as early as 1976 at S-6, and at two marsh sites, LOX8 and LOX16. Samples were analyzed for many pesticide compounds; but most did not contain measurable amounts of pesticides.

A number of detections were reported, especially for p,p' -DDD, p,p' -DDE, p.p' -DDT, and ametryn. The highest concentrations of DDT compounds were at the pumping stations (the maximum concentration was 300 μg/kg for p,p' -DDE at S-5A; most pesticide concentrations were less than 100 μg/kg)

Proposed increases in canal inflow to the Refuge associated with Everglades Restoration could adversely affect water quality over greater expanses of marsh. Even inflow of water with relatively low nutrient concentrations could adversely affect water quality of interior marshes if this additional water has high concentrations of pesticides and common ions such as chloride or sulfate that are not easily removed in Stormwater Treatment Areas. Increased sulfate concentrations could result in higher concentrations of methylmercury.