Use of Acoustic Instruments for Estimating Total Suspended Solids Concentrations in Streams -- The South Florida Experience

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An acoustic velocity meter (AVM) and an acoustic Doppler velocity meter (ADVM) were used in a study to estimate total suspended solids (TSS) concentrations in southern Florida streams. The AVM system provides information on automatic gain control (AGC), an index of the acoustic signal strength recorded by the instrument as the acoustic pulse travels across a stream. The ADVM system provides information on acoustic backscatter strength (ABS), an index of the strength of return acoustic signals recorded by the instrument. Both AGC and ABS values increase with corresponding increases in the concentration of suspended material.

The study was conducted at two sites in southern Florida (fig. 1). An AVM was installed in 1993 in L-4 Canal (below structure G-88), a narrow manmade channel in northwestern Broward used to drain excess runoff from agricultural fields. Water velocities in this freshwater canal, which is about 40 feet wide and averages between 7 and 8 feet in depth, range from –0.5 to 2.5 feet per second. An ADVM system was installed in 1997 in North Fork stream (in Veterans Park), a tidal channel that discharges into the St. Lucie River Estuary along the southeastern coast of Florida. Water velocities in this tidal stream, which is about 280 feet wide and averages about 8 feet in depth, range from about –1.5 to 1.5 feet per second; salinity varies from fresh to brackish (0.2 to about 15 milligrams per liter). In addition to the acoustic instruments, water-quality sensors were installed at both sites to record specific conductance (or salinity) and temperature data. These data were used to monitor the potential effects that density changes could have on the AGC/ABS to TSS relations.

Depth-integrated samples for TSS analysis were collected at the L-4 Canal site using a DH-59 sampler and the equal discharge increment (EDI) methodology. Samples at the North Fork site were collected using a point sampler at the depth of the ADVM system and about 9 feet away from the transducer faces (near the start of the sampling volume). Samples for determining TSS and volatile suspended solids (VSS) concentrations were analyzed at the U.S. Geological Survey Laboratory in Ocala, Florida.

TSS concentrations ranged from 22 to 1,058 milligrams per liter at the L-4 Canal site and from 3 to 25 milligrams per liter at the North Fork site. The organic content of samples used in the analysis varied from 30 to 93 percent at the L-4 Canal site and from about 50 to 75 percent at the North Fork site. No sand splits or particle-size distribution analyses were performed for samples at either site.

Regression analysis techniques were used to develop empirical and site-specific relations between AGC and ABS to TSS concentration at the L-4 Canal and North Fork sites. The general form of the equation used to determine the AGC/ABS to TSS concentration relation at the study sites is:

$$TSS = 10^{\{A * [a + b * \log(salinity) + c * \log(temperature)] + d * \log(velocity) + e\}} \quad (1)$$

where A represents AGC or ABS; a, b, c, and d are regression coefficients; and e is the intercept. The relations obtained using site-specific forms of equation 1 produced good

correlation as shown in figures 2 and 3. Correlation coefficients of 0.91 and 0.87 were obtained at the L-4 Canal and North Fork sites, respectively. The results suggest that this technique is feasible for estimating TSS concentrations in streams using information from acoustic instruments.

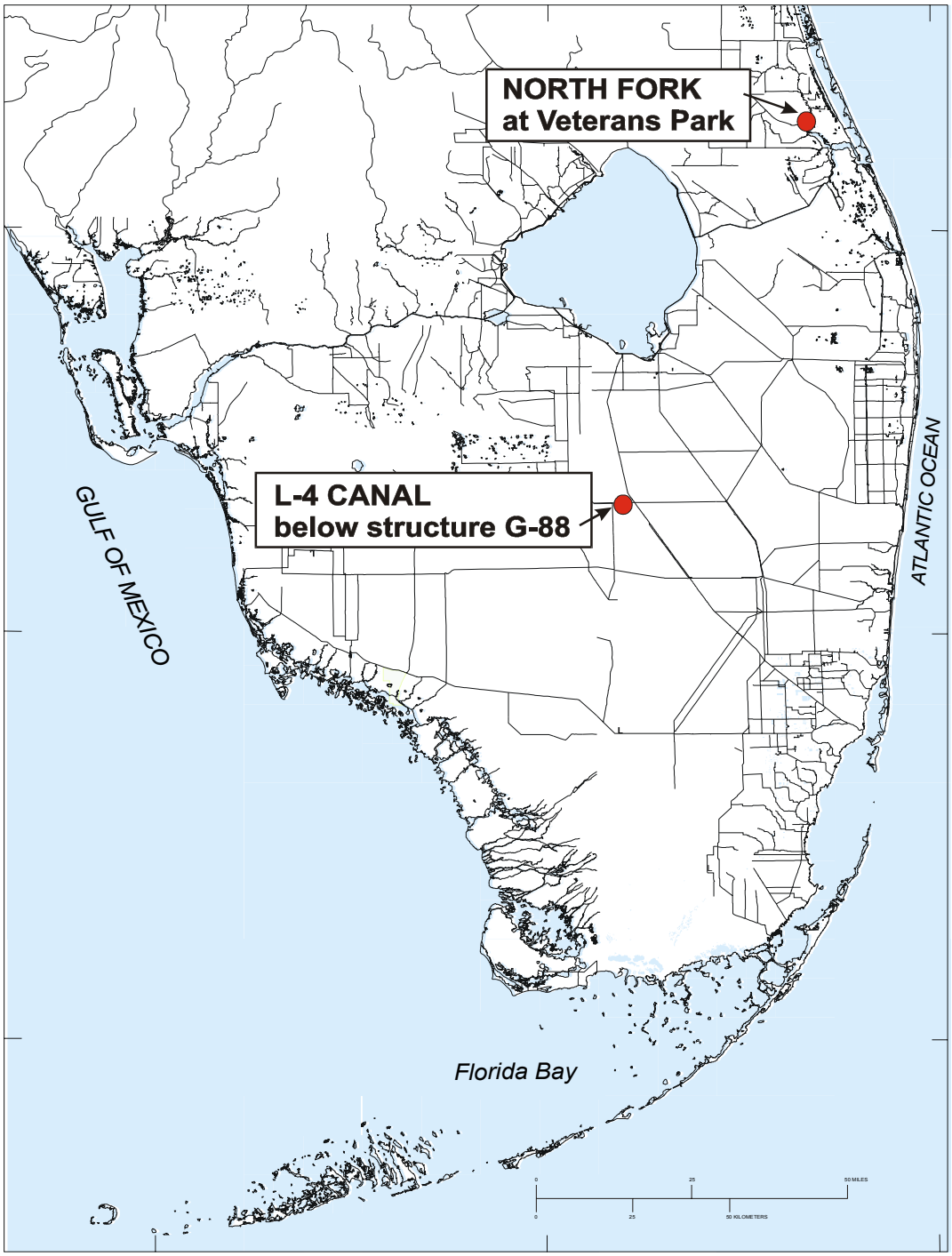

Figure 1. Location of the L-4 Canal and North Fork monitoring sites.

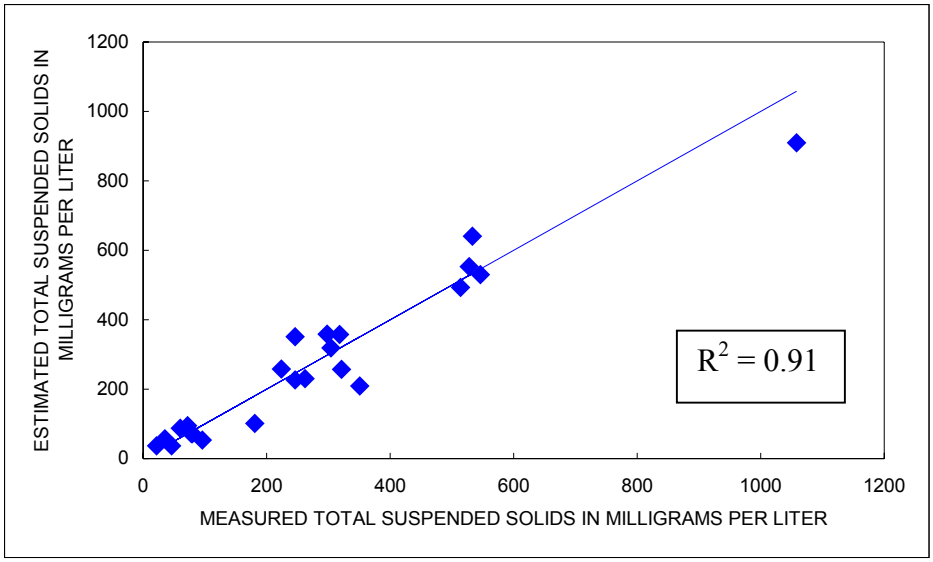

Figure 2. Estimated total suspended solids (TSS) concentrations for the L-4 Canal site. Relation developed using $TSS = 10^{\{AGC * [0.1968 - 0.017 * log(temperature)] + 0.7096 * log(velocity) - 4.4561\}}$

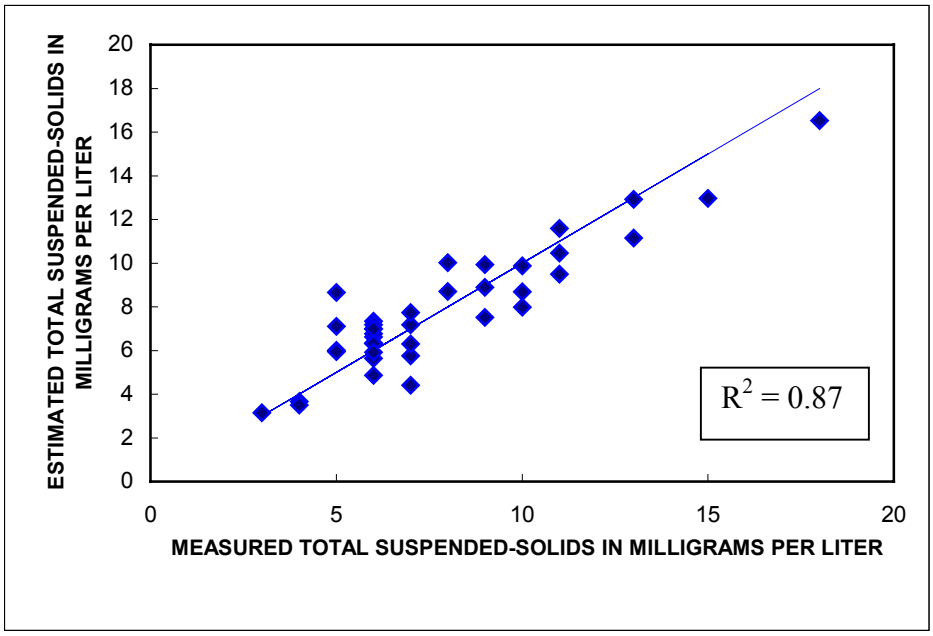

Figure 3. Estimated total suspended solids (TSS) concentrations for the North Fork site. Relation developed using $TSS = 10^{\{ABS * [0.07462 + 0.00084 * log(salinity) - 0.02957 * log(temperature)] - 1.4615\}}$