CONTINUOUS IN-SITU MEASUREMENT OF TURBIDITY IN KANSAS STREAMS

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ABSTRACT

Continuous, in-situ measurements of turbidity to estimate suspended-sediment concentrations are being made at stream monitoring sites throughout the United States. Considerations for selecting instrumentation, proper installation, methods for verifying sensor performance, and collection of point in-situ data that are representative of the channel cross section need to be well thought out for the data to be of acceptable quality. Experiences and specific examples for selected monitoring sites in Kansas are discussed.

Choosing an Instrument: There are many turbidity/optical backscatter probes suitable for continuous in-situ measurements. Sensors can measure turbidity values ranging from 0 to 1,000 nephelometric turbidity units (NTU), with some capable of measuring up to 4,000 NTU. Most turbidity probes conform to ISO method 7027 or GLI Method II. Currently, the only method approved for measuring turbidities > 40 NTU in stream source water is ISO method 7027. Some manufacturers offer features that help improve the quality of the data and extend the time between maintenance trips. Such probes are equipped with mechanical wipers or shutter technology that activate prior to a measurement and keep the sensor clear of interference. Probes that are SDI-12 (serial data interface at 1200 baud) compatible are easily installed at U.S. Geological Survey (USGS) stream-gaging stations that have data-collection platforms (DCPs), and the data can be displayed on the World Wide Web in real time. Daily review of real-time turbidity data is essential for timely troubleshooting of equipment malfunctions.

Installation: Several factors need to be considered prior to installation of a turbidity sensor as a surrogate for determining suspended-sediment concentrations in streams. First, a monitoring site that represents the area of interest and is located at a cross section of the stream that is well mixed needs to be selected. In Kansas, the USGS has selected mostly sites with existing stream-gaging stations. Adding a turbidity sensor to an existing stream-gaging station has several advantages: (1) continuous flow data are available for load calculations, (2) the equipment infrastructure for logging and transmitting the data is in place, and (3) sample collection is possible at all flow regimes. For ungaged installations, site selection for the turbidity sensor should be based on the same criteria for choosing the location of a stream-gaging station (that is, accessibility during all flow regimes, total flow is confined to one channel, the general course of the stream is straight within a few hundred feet of the stream, etc.. Rantz and others, 1982).

After the site is selected, the type of installation needs to be determined. In Kansas, the USGS has successfully used two types of installations, horizontal bank (or fixed) and vertical suspension. Bank installations have been limited to sites with small drainage areas. This type of installation has failed at sites with large drainage areas because, during extended periods of high flow, floating debris damages the equipment and high sediment concentrations fill the protective plastic pipe with mud and silt to the point that the turbidity probe becomes extremely difficult to retrieve. Most of the USGS turbidity monitoring sites in Kansas use a vertical suspension installation from the bridge deck to the stream. Vertical suspension is the most adaptable and convenient for installation and maintenance. The installation is made up of a turbidity probe, 10 feet of plastic pipe, a chain, a 12-volt winch, and sometimes a radio transmitter. The pipe and turbidity sensor typically are suspended behind a bridge pier so that the sensor is protected from debris. The pipe and turbidity sensor are tethered from the bridge deck using the chain. The DCP inside the gage house logs data every 15 or 30 minutes, either directly from the sensor or via radio communication from the sensor. The DCP then transmits the logged data every 4 hours via satellite for display of the data on the World Wide Web. A watertight aluminum box encloses the transmission equipment and is mounted to the bridge rail using clamps so that no holes are necessary in the bridge rail. The winch is used to raise the pipe to the bridge deck for servicing or repairing the sensor. The versatility of this type of installation is that it can be installed on any bridge and at any point along that bridge. This type of installation can be easily adjusted during high-flow conditions and relocated on meandering streams.

Continuous Measurements: The turbidity sensor is serviced several times a year. The USGS in Kansas uses a turbidity sensor equipped with a mechanical wiper that impedes the accumulation of silt and microbial growth on the optic sensor, reducing the number of cleaning visits. The transmitted turbidity data are reviewed daily to verify sensor performance. The sensors are inspected monthly to verify the most-recent calibration. Most sensors are designed to be calibrated with a formazin standard. Using standards that are not approved by the sensor's manufacturer most likely will not provide accurate readings. During these inspections, a calibrated field sensor is used to measure the turbidity at a minimum of 10 locations throughout the cross section of the stream. These data are used to verify that data from the continuous turbidity sensor are adequately representing the entire stream cross section. If the comparison differs by more than 10 percent the sensor can be relocated to a more representative location. The sensor is not relocated on the basis of temporary situations, but only as a result of long-term variations. A good check of the continuous in-situ turbidity sensor is determined by regressing the average cross-section measurements with the in-situ sensor values (fig. 1).

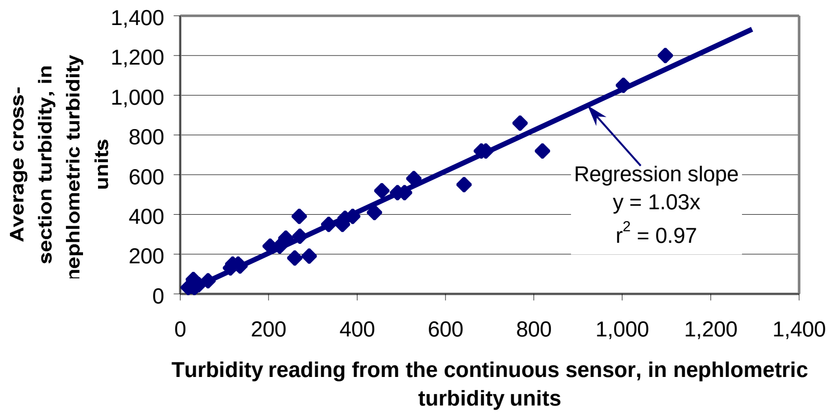

Figure 1. Comparison of continuous-sensor and cross-section turbidity values for Kansas River at Topeka, Kansas, October 2000 through January 2002.

The closer the slope is to 1.0, the more representative the data from the continuous sensor are of turbidity in the stream cross section without correction. At least 20 to 30 measurements throughout the entire range of turbidity values (0-1,500 NTU) are necessary to develop a robust relation. Regression results made on the basis of fewer measurements can lead to false conclusions. An effective method for determining at what turbidity level a cross-section measurement is necessary is to construct a turbidity duration curve (fig. 2).

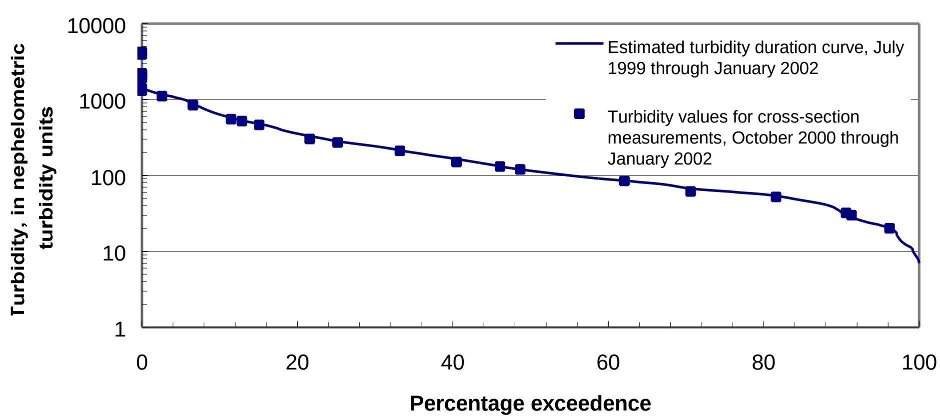

Figure 2. Turbidity duration curve for Kansas River at DeSoto, Kansas, October 2000 through January 2002.

Cross-section turbidity values plotted on the duration curve represent ranges of turbidity values for which cross-sectional measurements would be required and when samples need to be collected. The duration curve also provides an excellent summary of the turbidity conditions at a particular site.

Turbidity as a Surrogate: Continuous turbidity measurements have been shown to reliably estimate concentrations and loads of several constituents with defined uncertainty. Using methods explained in Christensen and others (2000), estimates for suspended-sediment load (fig. 3), total suspended solids, fecal coliform, *E. coli*, and total nitrogen and phosphorus can be estimated continuously and in real time

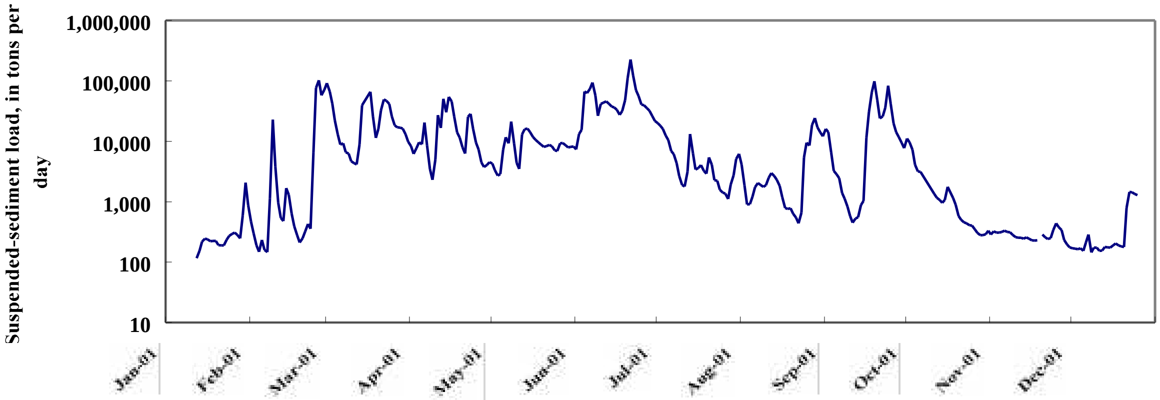

Figure 3. Turbidity-estimated suspended-sediment load for Kansas River at DeSoto, Kansas, 2001.

(http://ks.water.usgs.gov/Kansas/rtqw/). The advantage of continuous regression estimates using continuous turbidity measurements over discrete sample collection is that continuous estimates represent all flow conditions regardless of size or duration. This can be an advantage when determining total maximum daily loads or assessing resource-management practices.

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