THE ADVANTAGE OF CONTINUOUS TURBIDITY MONITORING: A LESSON FROM THE NORTH SANTIAM RIVER BASIN, OREGON, 1998-2002

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Background

The North Santiam River Basin in Oregon drains the western Cascade Range and has a drainage area of 690 mi^2 upstream from the City of Salem Water Treatment Plant. Most river channelsin the basin are steep sloped with high stream velocities, especially during the high flow period from November to March. Normal summer to fall turbidity at base flow, as well as steady-state flow during other times of the year, ranges from 0 to around 3 Nephelometric Turbidity Units (NTU). Turbidity during winter highflow and storms approachs 300 NTU, and can peak at 1,400 NTU or higher for brief periods during landslide and glacial events. Most high turbidity (median daily turbidity greater than 10 NTU) occurs less than 10 percent of the time. There is little algal or organic growth in the North Santiam system.

Equipment

Selection of turbidity equipment depends on the objectives of the study. The North Santiam study required monitoring additional water quality parameters, so a multi-parameter datasonde device was used. The North Santiam study uses eight continuously monitoring datasondes, connected by either a hard-line or cellular phone system and are interrogated every 3 to 4 hours, providing data in 30-minute increments. Other stand-alone turbidity probes are available, although most datasondes provide internal logging, which is an advantage over single turbidity probes, since the datasonde logger can serve as a backup to the gaging station data logger. Also, additional parameters can help verify turbidity spikes that occur from land disturbances or glacial activity, as their adjoining readings usually change in conjunction with the turbidity values during these events.

The North Santiam project uses wiper-type turbidity probes, which rotate before each reading in two directions to clean the lens. Proper wiper rotation depends on wiper quality. If the wiper becomes dirty, corroded or torn it will affect the parking of the wiper and subsequently the turbidity readings, as the wiper will interfere with the lens and the infrared reflectance, causing erroneous readings. Wiper maintenance is critical to proper turbidity monitoring, although there are stand-alone probes that alleviate this problem by parking the wiper magnetically.

Installation

Because the high stream velocities in the North Santiam River Basin can damage or impede the stability of the datasonde, the units were housed inside 4-inch, schedule 80 PVC pipe, which in-turn was housed inside 6-inch cast-iron well casing. Both were securely mounted to permanent structures along the stream bank, such as gaging station houses, large rocks or trees. The PVC pipe was perforated on the end to allow for water flow and extended out from the well casing by about 2 feet, with a stainless steel bolt through the end, to provide both a resting place for the datasonde and to prevent it from passing through the pipe bottom.

Probes should be placed away from any channel obstruction, such as large rocks, bridge piers or abutments, and at least 1-2 feet from the river bottom to prevent bed material and other obstacles from affecting the readings. For best performance, the probe should be located in moving water, but the velocities should not be so turbulent as to cause air bubbles surrounding the probe.

Calibration

The North Santiam project developed protocols to calibrate turbidity and other water-quality probes that use a backup datasonde to compare readings to the station datasonde. Calibrations are conducted routinely on a 2-3 week basis or more if readings indicate a problem. All calibrations are conducted at each site with standards at stream temperatures. Each turbidity probe is initially calibrated to 0 (dionized water, DI), 10, and 100 NTU stabilized formazin (Sadar, 1999), after which the probe calibration is checked using a polymer-bead standard.

Initial readings are collected from the station probe and backup probe, after the backup probe has equilibrated in the stream at close proximity to the station probe. The station probe is then cleaned and another set of duplicate readings are recorded from both probes. These cleaning corrections are applied in ADAPS similar to datum corrections in working discharge record, although very few cleaning corrections are necessary, due to the wiper cleansing process. Next the station probe calibration is checked in 0 (DI), 10, 100, and 1000 NTU polymer-bead standards. If the readings vary by more than 5 percent from the previous calibration, the instrument is recalibrated using formazin, otherwise the discrepancies less than 5 percent are handled as regular ADAPS variable-shift corrections adjusted to the turbidity calibration points.

Cross-sectional measurements, either from a bridge or cableway, also are collected and correlated to the instream turbidity readings. This is especially important for large stream widths where the streambank turbidity may not represent the entire cross-section turbidity. Also correlated to the instream station readings are samples collected for turbidity. These cross-sectional equal-width-increment, and/or dip samples collected near the datasonde pipe, are measured on site directly after the sampling.

Standards

Formazin is a suspected carcinogen and experimental mutagen with a short shelf life; the polymer-bead standard is less toxic and has a longer shelf life. For this reason the polymer-bead standard is used more frequently, but is considered the secondary standard and is used only for checking calibration. The U.S. Environmental Protection Agency recognizes formazin as a primary standard for calibration, at least until instream turbidity probe standard methods are developed.

Polymer-bead standards are instrument specific, particularly for instream turbidity probes, and will not calibrate correctly if they are not referenced to formazin using the same turbidity instrument. The North Santiam project worked with the standard and probe manufacturers, to prepare a polymer-bead standard referenced to formazin, using an identical instream turbidity probe.

Turbidity Records

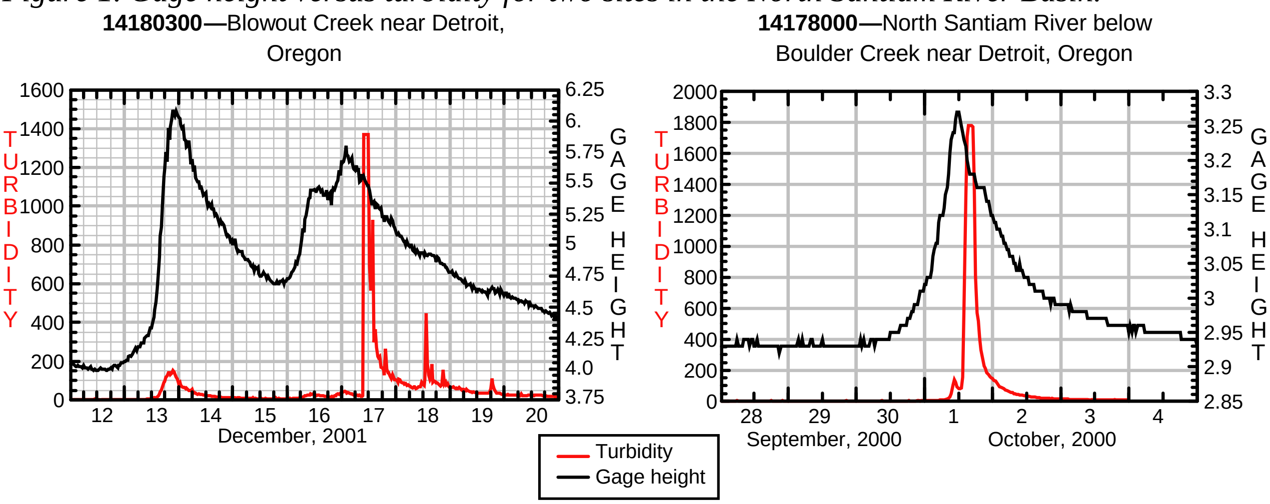
Instream turbidity is highly variable, especially in moving, dynamic river systems; even during normal base flow conditions. Most probes provide some data filtering, but occasional spikes will always occur in the turbidity record. If the spikes occur during high-flow storm conditions they are usually left as is; if they occur during quiescent conditions they are scrutinized carefully and removed if they vary by 10 percent or more from the previous value. For other periods of unexplained turbidity, the data are compared to the station streamflow and any local precipitation record, along with other neighboring continuous turbidity stations. Appropriate corrections are applied and probe operation is checked and/or recalibrated. Turbidity is published in whole numbers as the maximum, minimum and median daily value; turbidity from 0 to 1 is published as less than 1.

Turbidity versus Discharge as a Surrogate for Suspended-Sediment Concentration: Figure 1 illustrates two examples of why continuous turbidity monitoring is a more accurate and reliable surrogate for suspended-sediment concentration than discharge. The Blowout Creek Basin experienced a large landslide on December 17, 2001, after a 2-day, 2.5 inch precipitation event, causing abnormally high turbidity spikes. Turbidity values reached the high threshold of the probe at near 1,400 NTU, following an approximate 1-foot rise in gage height. Prior to that, on December 13 and 14th, a 3-day, 3.5 inch precipitation event occurred that caused a 2-foot rise in gage height, causing the turbidity to peak near 180 NTU. This later turbidity peak was the normal response to storm events for this basin. Conversely, the December 17th peak was caused by massive slope failure, undetectable using discharge correlated to suspended-sediment concentrations. Suspended-sediment loads calculated using discharge as a surrogate would not have provided accurate data in this instance.

On October 1, 2000, a glacial outburst episode occurred on Mt. Jefferson, a volcano in the upper-most basin of the North Santiam River. In this case, turbidity spiked again at the probe threshold (near 1,800 NTU). The stage rise was only 0.3 feet, almost imperceptible, yet the river turned into a muddy-brown slurry. Again, discharge correlated to suspended-sediment concentration would not have computed an accurate rise in suspended-sediment load through this period.

Continuous turbidity monitoring is basin specific. Relationships developed between one basin are usually not directly compared to other basins, especially between areas of dissimilar topography and geology. A diligent calibration routine coupled with proper probe placement will yield good turbidity record with little missing data.

Figure 1. Gage height versus turbidity for two sites in the North Santiam River Basin.



References

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