REVISIONS AND UPDATES OF REGRESSION MODELS RELATING TURBIDITY AND SUSPENDED-SEDIMENT CONCENTRATION, NORTH SANTIAM RIVER, OREGON

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Abstract The dynamic sediment-transport conditions of the upper North Santiam River indicated the need to evaluate and update regression models used to estimate suspended-sediment concentration (SSC) from turbidity. Most sediment transport in the basin occurs as a result of precipitation-driven high streamflow during the winter months. However, Mount Jefferson's melting glaciers and snowfields increase sediment transport with little or no increase of streamflow during the warm daytime temperatures of summer and early fall. These two distinct streamflow and turbidity conditions necessitated the creation of two separate models for estimating SSC from turbidity. Several years after the development of the two models, a major debris flow on the mountain altered the sediment-transport conditions. This change was identified by a statistically significant change in one of the annually updated models.

Continuous turbidity data collection began in water year (WY) 1999 at the USGS monitoring station on the upper North Santiam River. In addition, cross-sectional, depth-integrated suspended-sediment samples were collected over a range of hydrologic conditions during water years 1999-2004. The SSC of each sample and the corresponding instream turbidity provided the calibration data for a regression model. An ordinary least square regression analysis was completed with the base-10 logarithmic transformations of the dataset. A single model was developed to estimate continuous SSC and compute annual suspended-sediment loads for all sediment-source and hydrologic conditions during WY 1999-2004 (table 1).

Table 1 Regression models for differing sediment-transport and hydrologic conditions for water years 1999-2004 at the upper North Santiam River monitoring station

Sediment-source and hydrologic conditions	Regression model equation	Number of samples
All	$\log_{10}(\text{SSC}) = 1.04 \log_{10}(\text{turbidity}) + 0.188$	121
Precipitation-driven	$\log_{10}(\text{SSC}) = 1.07 \log_{10}(\text{turbidity}) + 0.243$	116
Meltwater-driven	$\log_{10}(\text{SSC}) = 0.907 \log_{10}(\text{turbidity}) + 0.0651$	32

Further analysis of the turbidity-SSC model revealed that the relationship between turbidity and SSC during meltwater-driven sediment transport was distinct from precipitation-driven events. For the revised analysis, the model calibration dataset was categorized on the basis of sediment-transport conditions and two separate regressions were developed (table 1). The revised models were not used to modify the estimated SSC for WY 1999-2004, but both were updated as described below and used beginning in WY 2005.

Instream turbidity monitoring and suspended-sediment sample collection continued through WY 2008 at the monitoring station on the upper North Santiam River in order to update and verify the regression models. The USGS method for annually updating the models required adding the samples collected during each subsequent water year to the model calibration dataset and repeating the regression analysis (Rasmussen and others, 2009). Analysis of covariance, in the form of a nested F-test, was performed to determine whether the coefficients of a new regression equation had changed significantly from those of the previous equation (Helsel and Hirsch, 2002). Additionally, the root mean squared error of each regression was calculated and converted to upper and lower model standard percent errors (MSPE). The magnitudes of the MSPE values indicated the amount of uncertainty in the predicted values and were used to compare models.

Statistical analysis of the regression equations for precipitation-driven sediment transport at the monitoring station indicated a significant shift between the models for WY 2006 and 2007. The MSPE values increased for the WY 2007 model after they had steadily decreased for the two preceding annual updates in WY 2005 and 2006. The analysis of covariance (nested F-test, α = 0.10) indicated a significant difference between the coefficients of the two equations (table 2). This change was attributed to the increase of sediment available for transport during precipitation events following the massive debris flow that occurred on Mount Jefferson during WY 2007. The WY 2008 model shifted slightly in the opposite direction of the WY 2007 model shift, indicating that the effect of the debris flow sediment was likely temporary.

Table 2 Statistical analysis results for precipitation-driven regression models at the upper North Santiam River monitoring station

Water year (WY)	Upper MSPE	Lower MSPE	Analysis of Covariance, compared to previous WY regression model		
			F statistic (nested)	F distribution (α = 0.10)	F test result
2004	60.2	37.6	-	-	-
2005	58.8	37.0	1.68	2.75	pass
2006	56.8	36.2	0.52	1.56	pass
2007	60.6	37.7	2.08	1.59	fail
2008	60.0	37.5	0.30	2.12	pass

References

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