# Appendix 15. Field Comparison between YSI EXO and YSI 6136 Turbidity Sensors at Neosho River at Burlington, Kansas (U.S. Geological Survey [USGS] Station Number 07182510), May 9 to May 16, 2017

## Comparison Description

**Station name**: Neosho River at Burlington, Kansas (U.S. Geological Survey [USGS] station number 07182510).

**Equipment**: A Yellow Springs Instrument (YSI) EXO water-quality monitor equipped with a YSI EXO turbidity sensor and a YSI 6 series equipped with a YSI 6136 turbidity sensor were deployed at the site for comparison between the sensors. The monitors were set to log data every 15 minutes. The monitors were suspended in the stream in pipes that were attached to each other. No datum corrections were applied to either dataset. Turbidity at the site did not go above 100 FNU, therefore the data cannot be separated into low- and high-turbidity conditions.

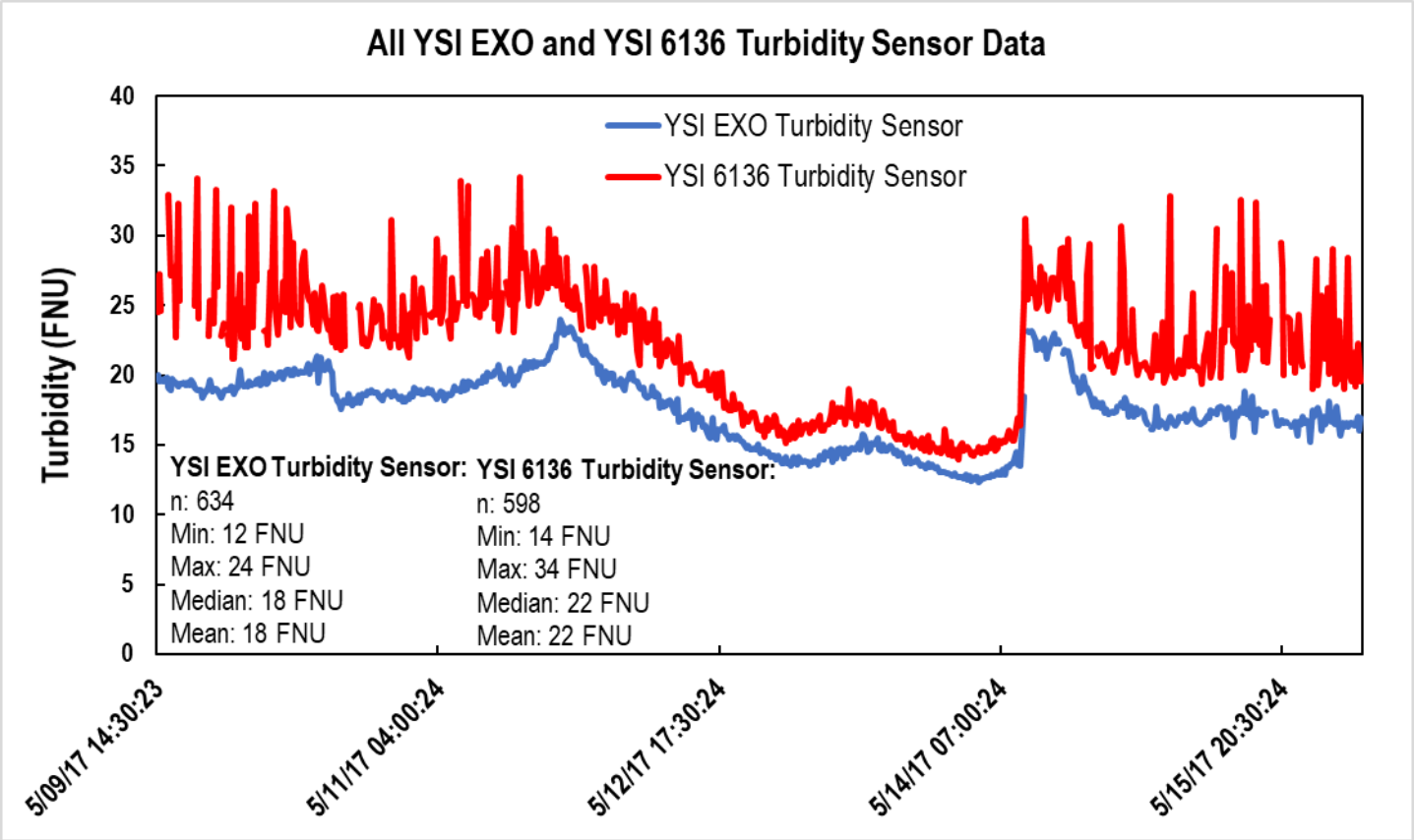
**Calibration standard used:** Hach StablCal standard.

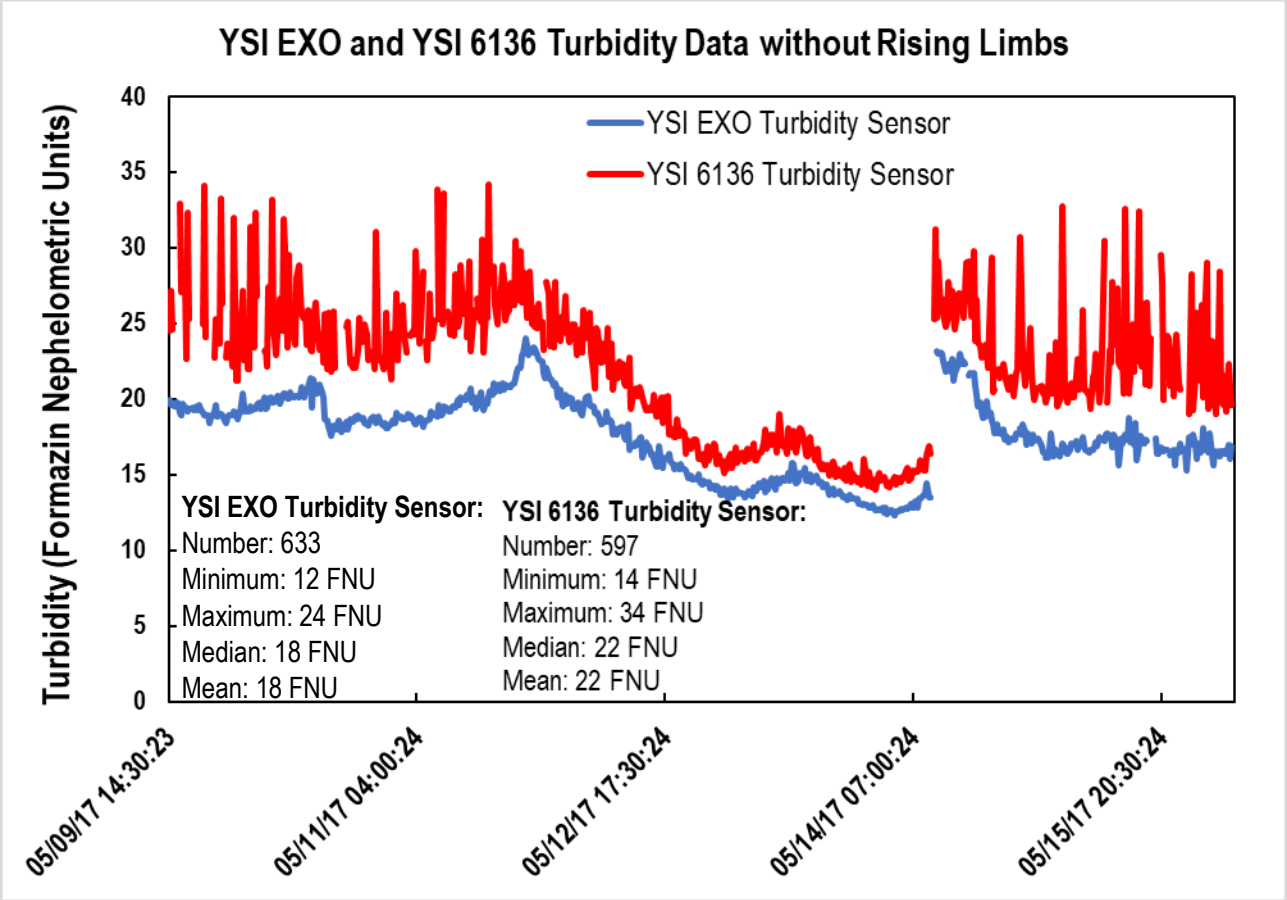
**Side-by-side comparison data period:** May 9 to May 16, 2017.

## Datasets

All data were collected using USGS protocols (U.S. Geological Survey, variously dated) and are published in King (2021). Data were analyzed in three ways: (1) the entire dataset (0–1,000 formazin nephelometric units [FNU]) with only clearly erroneous data edited out, (2) 0–99 FNU with the rising limbs removed, and (3) 100–1,000 FNU with the rising limbs removed. Rising limbs were removed (on the basis of visual inspection, when the hydrograph became vertical to near vertical) to eliminate the effect of the highly variable turbidity readings commonly observed during this part of the hydrograph.

## Time Series


All YSI EXO and YSI 6136 Turbidity Sensor Data
YSI EXO Turbidity Sensor
YSI 6136 Turbidity Sensor
Turbidity (FNU)
40
35
30
25
20
15
10
5
0
YSI EXO Turbidity Sensor:
n: 634
Min: 12 FNU
Max: 24 FNU
Median: 18 FNU
Mean: 18 FNU
YSI 6136 Turbidity Sensor:
n: 598
Min: 14 FNU
Max: 34 FNU
Median: 22 FNU
Mean: 22 FNU
5/09/17 14:30:23
5/11/17 04:00:24
5/12/17 17:30:24
5/14/17 07:00:24
5/15/17 20:30:24




## Statistical Analyses – All Data

### Slope comparison

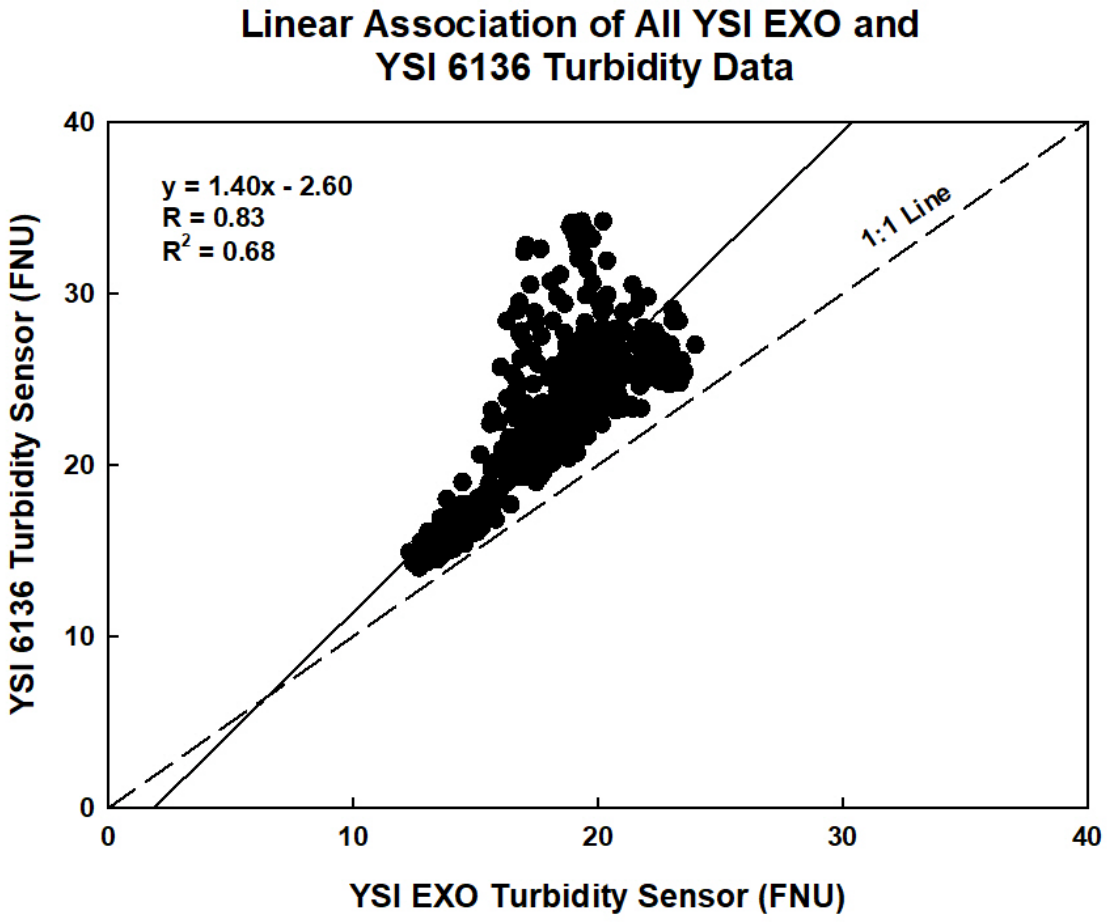
The following is a summary of final regression analysis for sensor-measured turbidity from a YSI EXO turbidity sensor and a YSI 6136 turbidity sensor at Neosho River at Burlington, Kansas, May 9 to May 16, 2017.

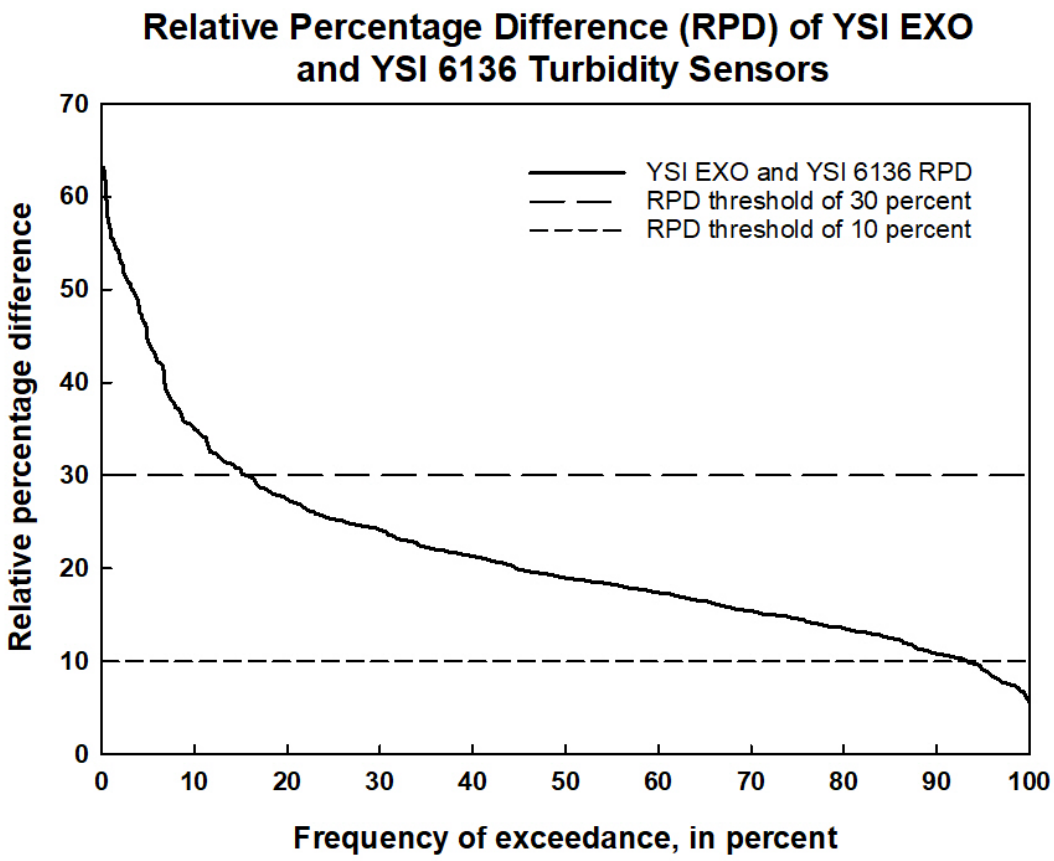
$$y = 1.40x - 2.60$$

where

y = turbidity measured with YSI 6136 turbidity sensor (FNU)

x = turbidity measured with YSI EXO turbidity sensor (FNU).


Linear Association of All YSI EXO and
YSI 6136 Turbidity Data
y = 1.40x - 2.60
R = 0.83
R2 = 0.68
1:1 Line
YSI 6136 Turbidity Sensor (FNU)
YSI EXO Turbidity Sensor (FNU)
0
10
20
30
40




## Wilcoxon Signed-Rank Test for All Data

### SigmaPlot Statistical Output:

**Normality Test (Shapiro-Wilk):** Failed (P < 0.050)

| Group | N | Missing | Median | 25% | 75% |
|---|---|---|---|---|---|
| YSI EXO | 590 | 0 | 17.645 | 15.337 | 19.480 |
| YSI 6136 | 590 | 0 | 22.300 | 17.700 | 25.025 |

W= 174345.000 T+ = 174345.000 T-= -0.000

Z-Statistic (based on positive ranks) = 21.045

(P = <0.001)

The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant difference (P = <0.001).

R Statistical Output:

```
Wilcoxon Signed-Rank test with continuity correction

data:  YSI 6136 and YSI EXO
V = 174345, p-value < 2.2e-16
alternative hypothesis: true location shift is not equal to 0
95 percent confidence interval:
 3.839990 4.225034
sample estimates:
(pseudo)median
      4.025007
```

### Summary of Results

There is a strong linear association between measurements made with the two sensors (R = 0.83). Sixteen percent of the time, the relative percentage difference in turbidity values measured with the two sensors was greater than 30 percent. The data did not pass the Shapiro-Wilk test for normality (P<0.05); therefore, a Wilcoxon signed-rank test was performed. The difference between median values for the YSI EXO and YSI 6136 turbidity sensors was statistically significant (P<0.05).

## Selected References


Cleveland, W.S., 1979, Robust locally weighted regression and smoothing scatterplots: Journal of the American Statistical Association, v. 74, no. 368, p. 829–836.

Helsel, D.R., and Hirsch, R.M., 2002, Statistical methods in water resources—Hydrologic analysis and interpretation: U.S. Geological Survey Techniques of Water-Resources Investigations, book 4, chap. A3, 522 p. [Also available at https://doi.org/10.3133/twri04A3.]

King, L.R., 2021, Laboratory and field data for selected turbidity standard and sensor comparisons, October 2014 to September 2017: U.S. Geological Survey Data Release, https://doi.org/10.5066/P9EVSDHH.

U.S. Geological Survey, variously dated, The national field manual for the collection of water-quality data: U.S. Geological Survey Techniques and Methods, book 9, chaps A1–A10. [Also available at https://water.usgs.gov/owq/FieldManual/.]