

## Appendix 2. Field Comparison between StablCal and Polymer Turbidity Standards at Kansas River at De Soto, Kansas (U.S. Geological Survey Station Number 06892350), May 16 to June 24, 2017

### Comparison Description

**Station name:** Kansas River at De Soto, Kansas (U.S. Geological Survey [USGS] station number 06892350).

**Equipment:** A Yellow Springs Instrument (YSI) EXO water-quality monitor equipped with two YSI EXO turbidity sensors calibrated with different turbidity standards were deployed at the site for comparison between the two standards. The sensors were on the same monitor opposite each other with the central wiper in the middle. The monitor was set to log data every 15 minutes. No datum corrections were applied to either dataset.

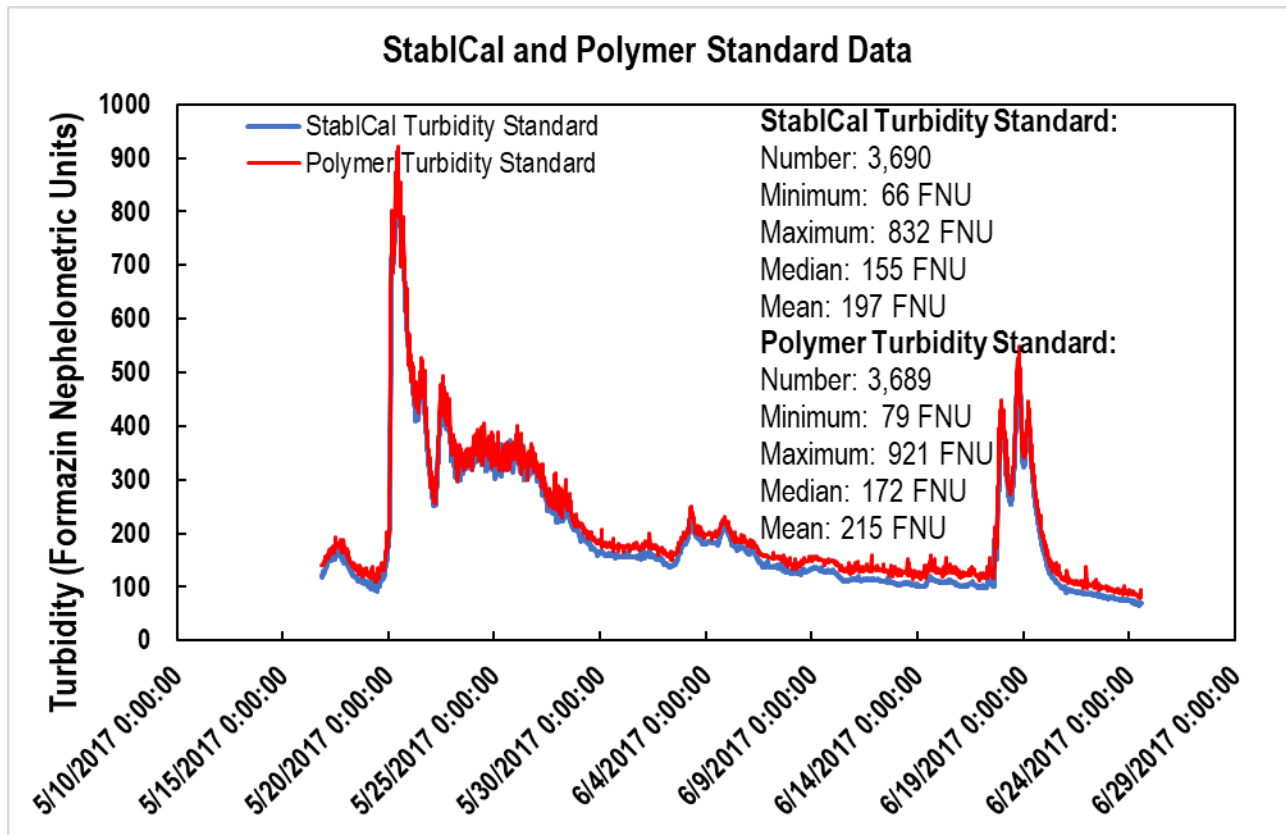
**Calibration standard used:** One sensor was calibrated with Hach StablCal turbidity standard and one sensor was calibrated with YSI polymer standard.

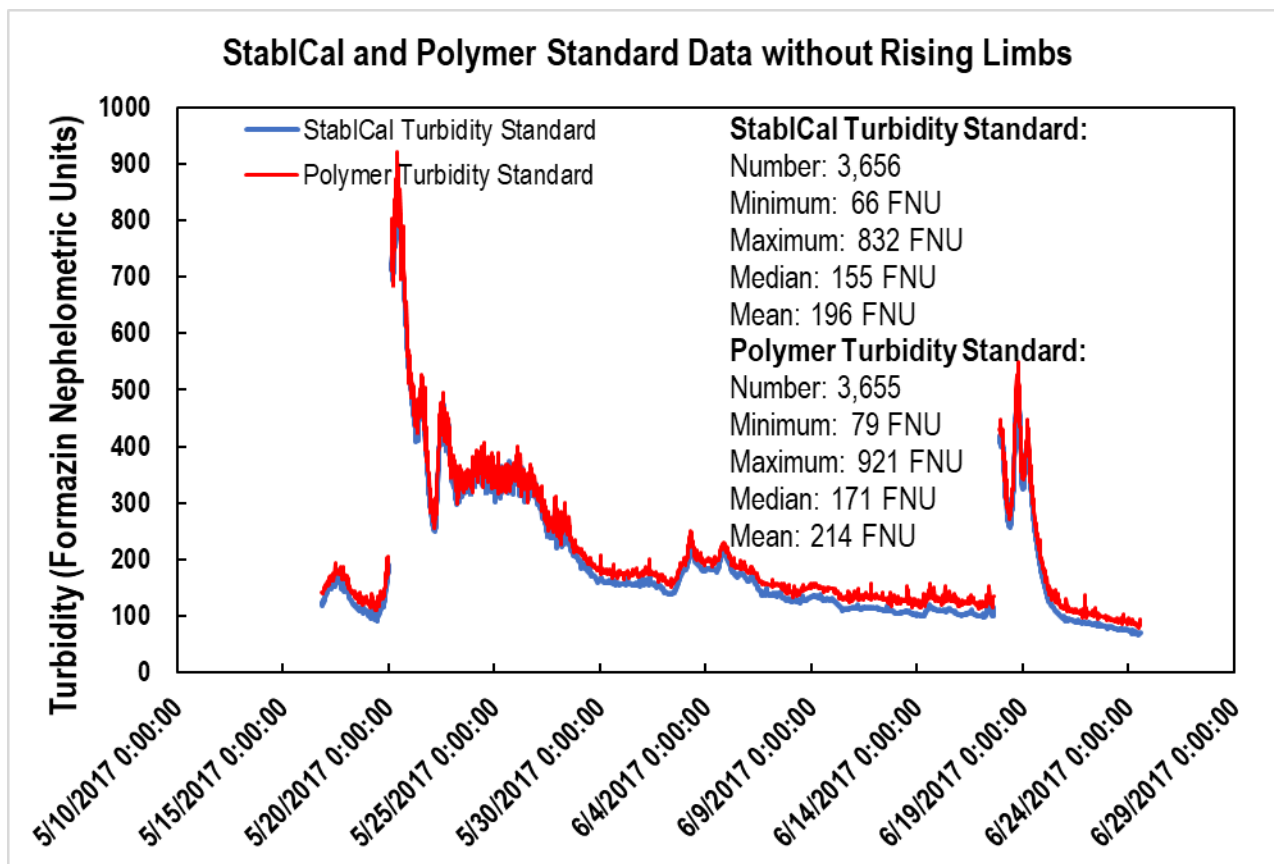
**Side-by-side comparison data period:** May 16 to June 24, 2017.

### 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





## Statistical Analyses – All Data

### Slope Comparison

The following is a summary of final regression analysis for sensor-measured turbidity from two identical YSI EXO turbidity sensors calibrated by using two different turbidity standards at Kansas River at De Soto, Kansas, May 16 to June 24, 2017:

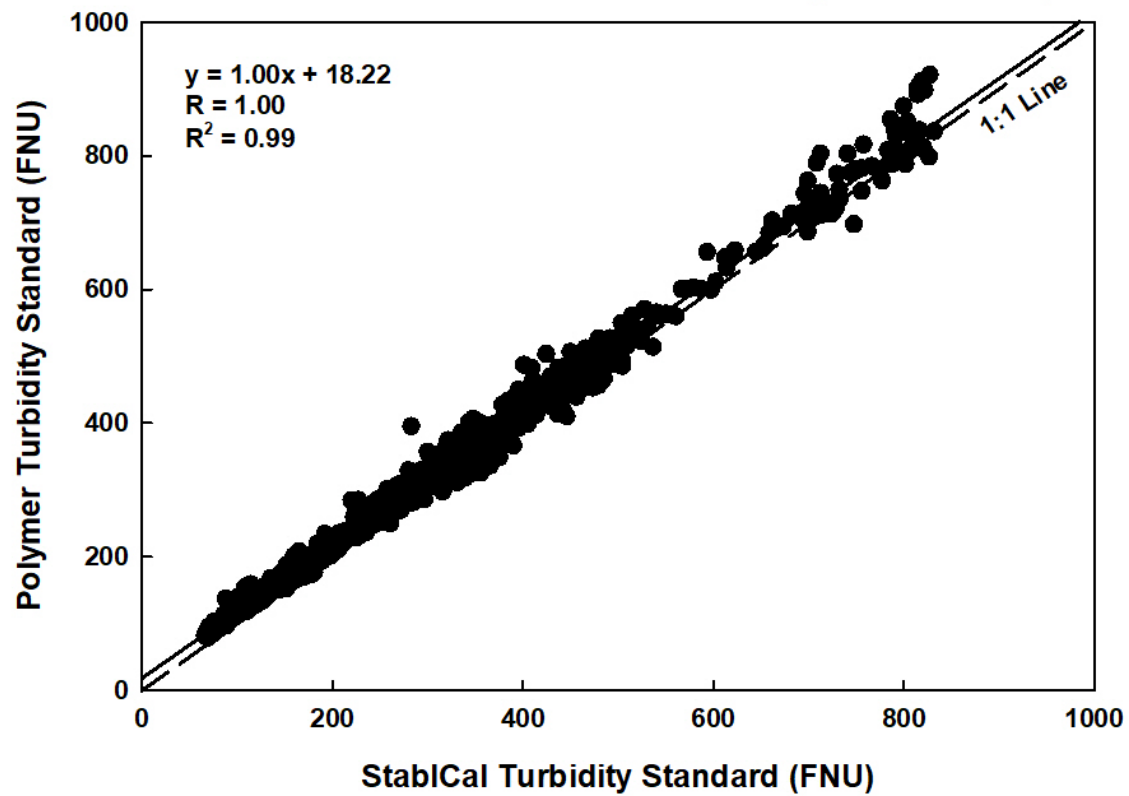
$$y = 1.00x + 18.22$$

where

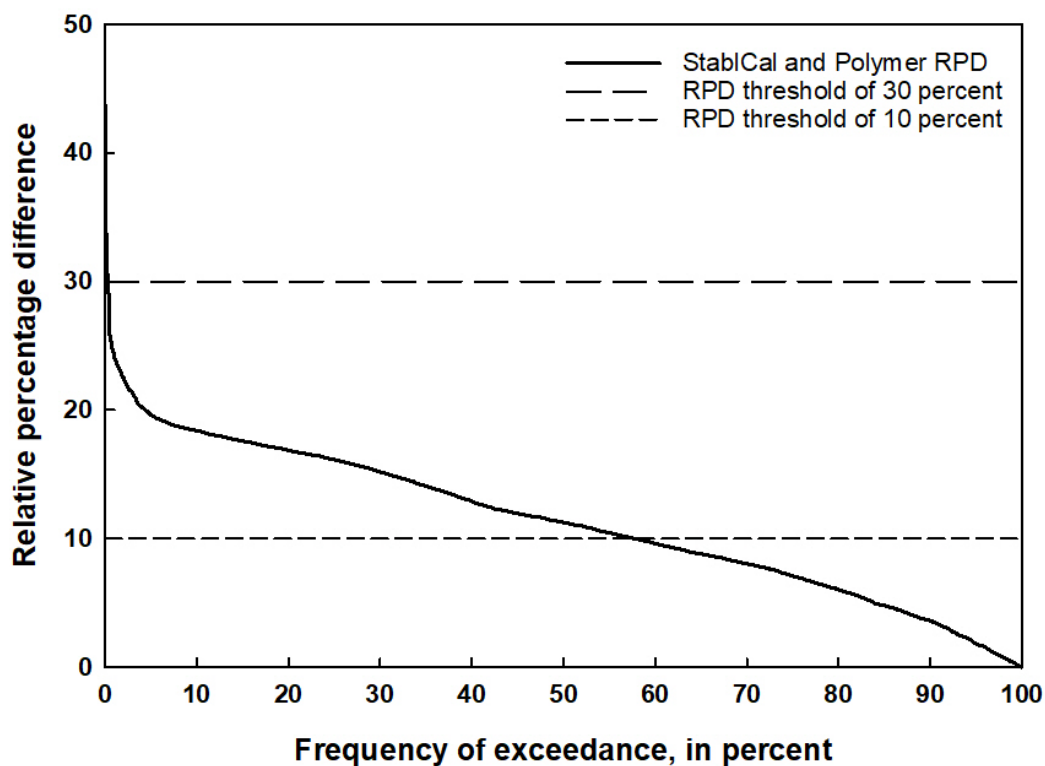
y = turbidity measured with polymer turbidity standard (FNU)

x = turbidity measured with StablCal turbidity standard (FNU).

### Linear Association of All StablCal and Polymer Turbidity Data



### Relative Percentage Difference (RPD) of StablCal and Polymer Turbidity Standard



#### Wilcoxon Signed-Rank Test for All Data

SigmaPlot Statistical Output:

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

| Group    | N    | Missing | Median  | 25%     | 75%     |
|----------|------|---------|---------|---------|---------|
| StablCal | 3683 | 0       | 155.370 | 111.060 | 248.260 |
| Polymer  | 3683 | 0       | 171.910 | 131.520 | 264.840 |

W= 6573391.000 T+ = 6678738.500 T- = -105347.500

Z-Statistic (based on positive ranks) = 50.928

( $P = < 0.001$ )

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: Polymer and StablCal
v = 6678739, p-value < 2.2e-16
alternative hypothesis: true location shift is not equal to 0
95 percent confidence interval:
 17.59999 17.92496
sample estimates:
(pseudo)median
 17.76007
```

### Summary of Results

There is a strong linear association between measurements made with the two sensors ( $R = 1.00$ ). Less than one 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 StablCal and polymer turbidity standards was statistically significant ( $P < 0.05$ ).

## Statistical Analyses - Low-Turbidity Conditions (0 to 99 FNU)

The data from the side-by-side comparison was separated into low- and high-turbidity conditions. These statistical analyses are for low-turbidity conditions between 0 and 99 FNU.

### Slope Comparison

The following is a summary of final regression analysis for sensor-measured turbidity from two identical YSI EXO turbidity sensors was calibrated by using two different turbidity standards at low-turbidity conditions (0-99 FNU) at Kansas River at De Soto, Kansas, May 16 to June 24, 2017:

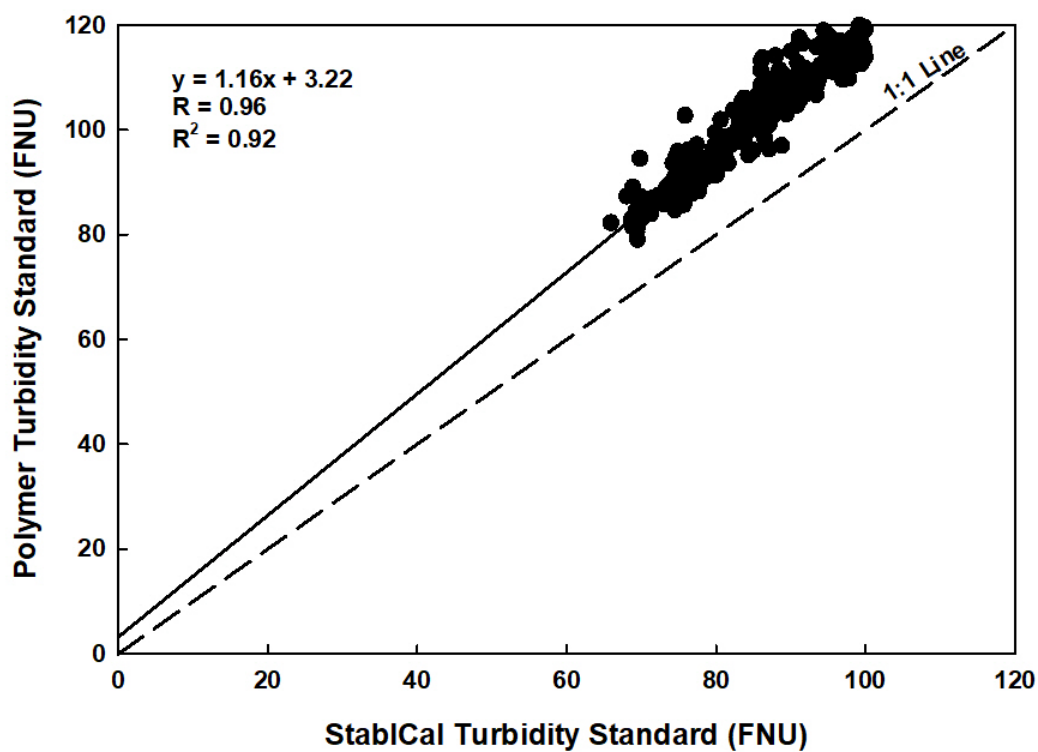
$$y = 1.16x + 3.22$$

where

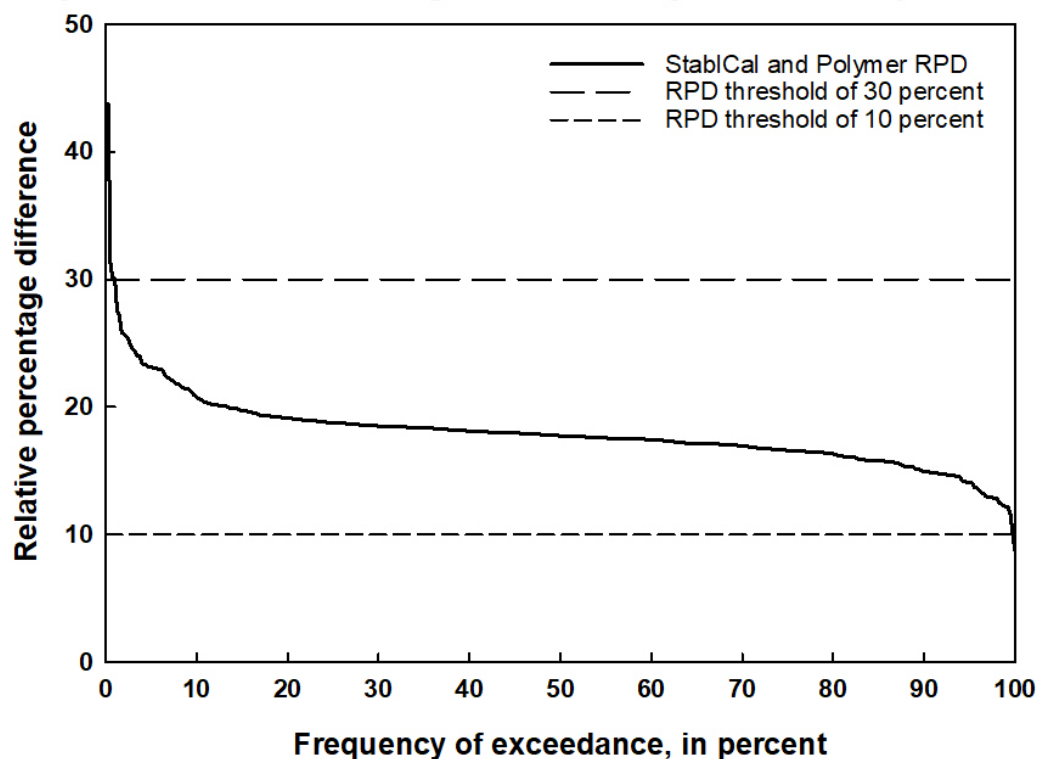
$y$  = turbidity measured with polymer turbidity standard (FNU)

$x$  = turbidity measured with StablCal turbidity standard (FNU).

**Linear Association of StablCal and Polymer Standard  
Low-Turbidity Data (0 to 99 FNU)**



### Relative Percentage Difference (RPD) of StablCal and Polymer Standards During Low-Turbidity Conditions (0 to 99 FNU)



### Wilcoxon Signed-Rank Test for Low-Turbidity Data

SigmaPlot Statistical Output:

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

| Group    | N   | Missing | Median  | 25%    | 75%     |
|----------|-----|---------|---------|--------|---------|
| StablCal | 403 | 0       | 85.510  | 76.890 | 92.000  |
| Polymer  | 403 | 0       | 102.320 | 92.220 | 109.820 |

W= 81406.000 T+ = 81406.000 T- = -0.000

Z-Statistic (based on positive ranks) = 17.396

(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: Polymer and StablCal
v = 81406, p-value < 2.2e-16
alternative hypothesis: true location shift is not equal to 0
95 percent confidence interval:
 16.18996 16.73501
sample estimates:
(pseudo)median
 16.45505
```

### Summary of Results

There is a strong linear association between measurements made with the two sensors ( $R = 0.96$ ). One 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 StablCal and polymer turbidity standards was statistically significant ( $P < 0.05$ ).

### Statistical Analyses - High-Turbidity Conditions (100 to 1,000 FNU)

The data from the side-by-side comparison was separated into low- and high-turbidity conditions. These statistical analyses are for high-turbidity conditions between 100 and 1,000 FNU.

#### Slope Comparison

The following is a summary of final regression analysis for sensor-measured turbidity from two identical YSI EXO turbidity sensors calibrated by using two different turbidity standards at high-turbidity conditions (100 to 1,000 FNU) at Kansas River at De Soto, KS, May 16 to June 24, 2017:

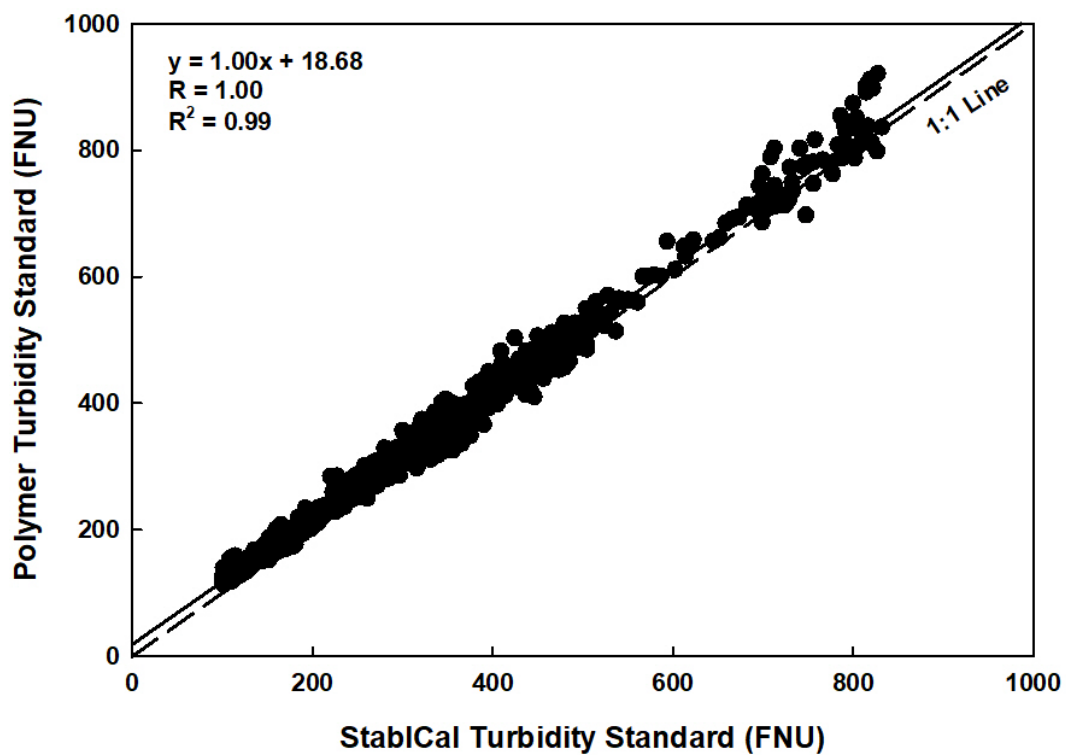
$$y = 1.00x + 18.68$$

where

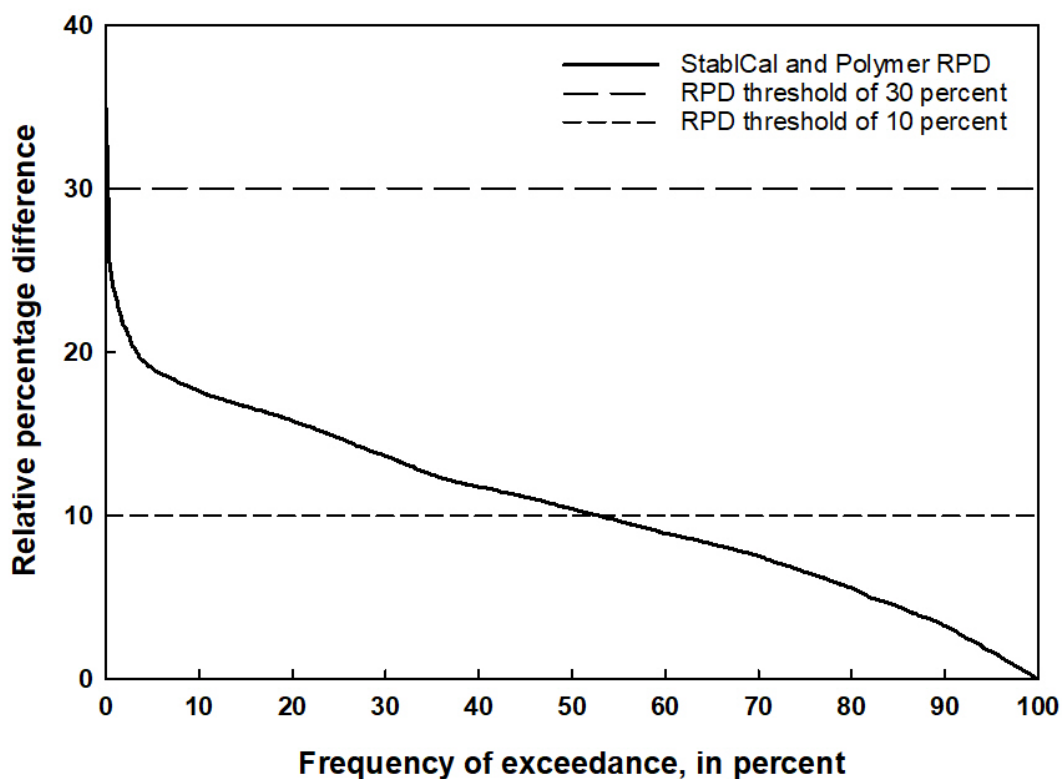
$y$  = turbidity measured with polymer turbidity standard (FNU)

$x$  = turbidity measured with StablCal turbidity standard (FNU).

**Linear Association of StablCal and Polymer  
High-Turbidity Data (100 to 1,000 FNU)**



## Relative Percentage Difference (RPD) of StablCal and Polymer Standards During High-Turbidity Conditions (100 to 1,000 FNU)



### Wilcoxon Signed-Rank Test for High-Turbidity Data

SigmaPlot Statistical Output:

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

| Group    | N    | Missing | Median  | 25%     | 75%     |
|----------|------|---------|---------|---------|---------|
| StablCal | 3246 | 0       | 159.145 | 119.068 | 274.463 |
| Polymer  | 3246 | 0       | 176.300 | 139.980 | 292.465 |

W= 5083712.000 T+ = 5176796.500 T- = -93084.500

Z-Statistic (based on positive ranks) = 47.601

( $P = < 0.001$ )

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: Polymer and StablCal
V = 5176797, p-value < 2.2e-16
alternative hypothesis: true location shift is not equal to 0
95 percent confidence interval:
 17.74496 18.11008
sample estimates:
(pseudo)median
 17.93004
```

## Summary of Results

There is a strong linear association between measurements made with the two sensors ( $R = 1.00$ ). Less than one 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 StablCal and polymer turbidity standards 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/>.]