2.f. Two Parameter Comparisons

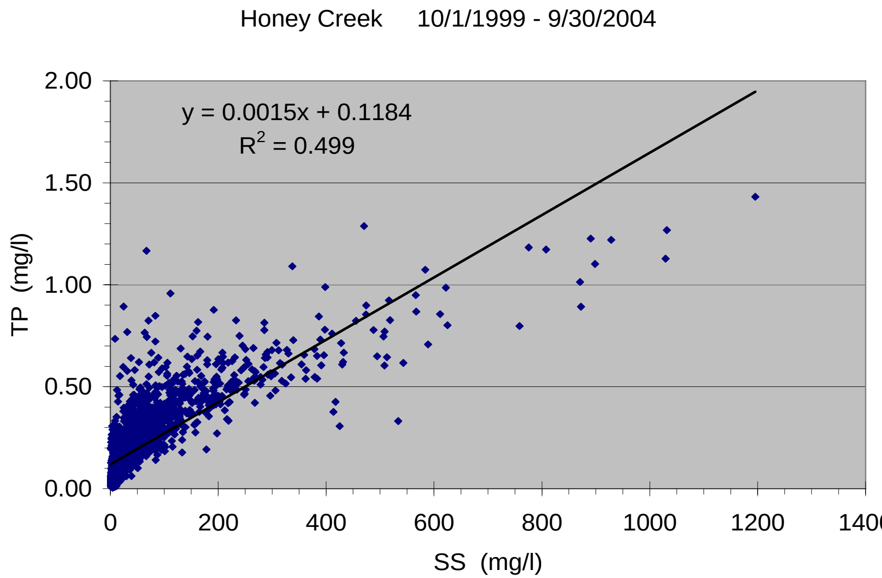
Introduction

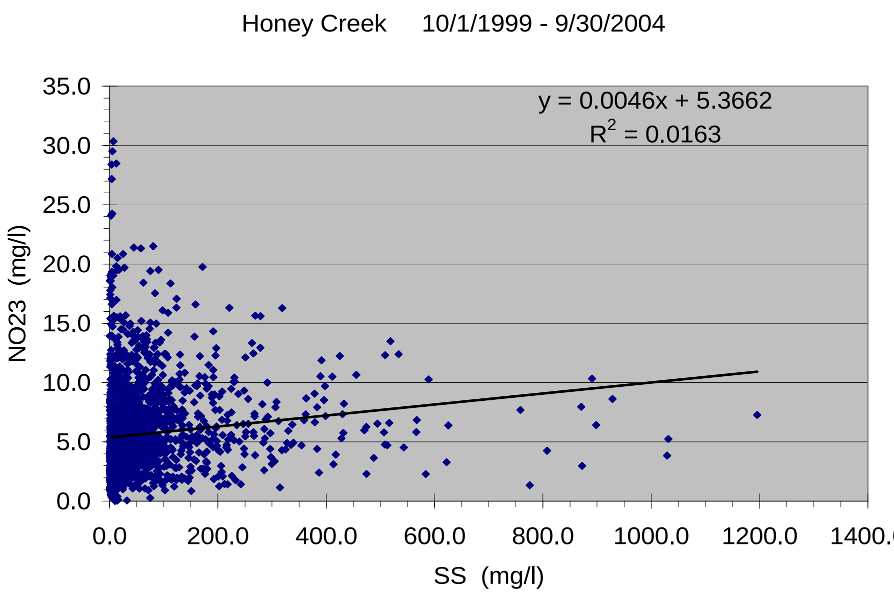
Sometimes it is useful to study the relationships between two parameters in a stream. For example the relationships between sediment concentration and nutrient concentrations may be of interest. The adjacent graphs show the relationship between Total Phosphorus and Suspended Sediment and between Nitrate and Suspended Solids in Honey Creek for the 5-year period from 10/01/99 to 09/30/04.

These data show that total phosphorus (TP) concentrations increase as suspended solids (SS) concentrations increase, although there is considerable variability in TP concentrations at a particular SS concentration. It is also evident from the data that, as suspended solids concentrations increase, the amount of increase in TP per increase in SS decreases. A curved line would likely fit the data points better than the linear regression shown on the graph. The R^2 for the linear regression is 0.499.

Some of the scatter in the TP-SS relationship may be due to differences in the TP/SS ratios on the rising and falling sides of the hydrograph. Seasonal differences may also be affecting the relationship, with higher TP/SS ratios in winter months. These differing ratios may be related to differing particle size composition in the suspended solids at the same suspended solids concentration. The data sets can support investigations of some of these relationships, but such exploration is beyond the scope of this presentation.

The lower graph shows the relationship or, more realistically, the lack of relationship, between suspended solids and nitrate concentrations. The R^2 for the relationship is 0.0163. As is evident from comparing the nitrate chemographs and sedigraphs (see section on Hydrographs, Sedigraphs and Chemographs), nitrate and suspended sediments have different concentration patterns during runoff events. These differences are derived from the different routes of movement to streams during runoff events.





Comparison of the Unit Area Loads and Concentrations of Total Phosphorus and Suspended Solids in the Sandusky and Cuyahoga Rivers, 10/01/94 – 09/30/04

	Annualized Unit Area Load kg/ha	Flow Weighted Mean Conc. mg/L	Time Weighted Mean Conc. mg/L	Ratio FWMC/TWMC
Sandusky, SS	674.3	195.5	65.1	3.00
Cuyahoga, SS	1,184.2	252.4	108.2	2.33
Sandusky, TP	1.38	0.400	0.175	2.29
Cuyahoga, TP	1.34	0.286	0.217	1.32

The Concentrations and Export of Suspended Solids and Total Phosphorus: A Comparison of the Sandusky and Cuyahoga Rivers

The above table shows summary data for the flow- and time-weighted average concentrations of suspended sediment (SS) and total phosphorus (TP) for the Sandusky and Cuyahoga rivers over a 10-year period. It also shows the annualized unit area exports. All of the above data are derived from the Summary Report AnalysisTemplatev3.

The Cuyahoga River, which contains large urban areas and drains a different geological setting than the intensely cultivated watershed of the Sandusky River, has a unit-area suspended sediment export rate 76% higher than the Sandusky River. The unit area export rate of total phosphorus for the Sandusky River is, however, slightly higher than that of the Cuyahoga Watershed.

The flow-weighted mean concentration (FWMC) of SS is higher in the Cuyahoga River while the FWMC of TP is higher in the Sandusky.

The time-weighted mean concentration (TWMC) for both SS and TP are higher in the Cuyahoga River.

As noted in the section on Time-Weighted and Flow-Weighted Mean Concentrations, the ratio of flow-weighted to time-weighted can be used to determine the relative importance of nonpoint to point sources of pollutants, with higher ratios indicating nonpoint source derivation.

The low ratio of FWMC to TWMC of TP in the Cuyahoga River suggests that the Cuyahoga River receives much larger point source inputs of TP than the Sandusky and/or much lower nonpoint source inputs.

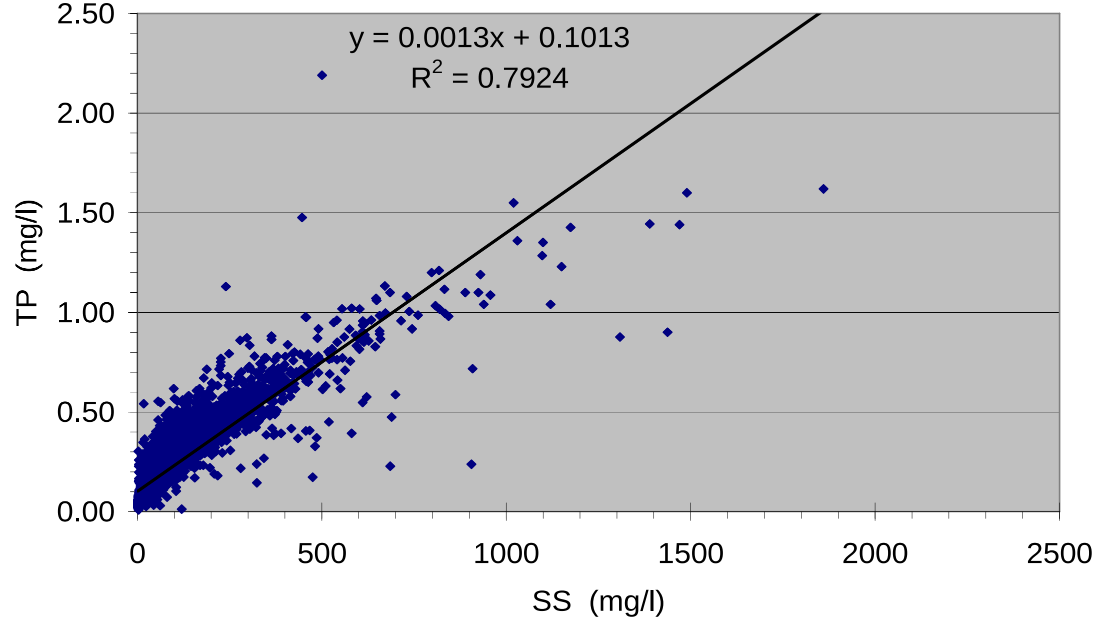
Analysis of point source loading data for the Cuyahoga confirms that it has much higher point source loading than the Sandusky River. Since the Sandusky has a higher unit area TP export rate, and a lower SS export rate, the relation between SS and TP must be very different between the two rivers. We have examined this using comparative two parameter plots.

Comparing Two Parameter Plots for Two Rivers

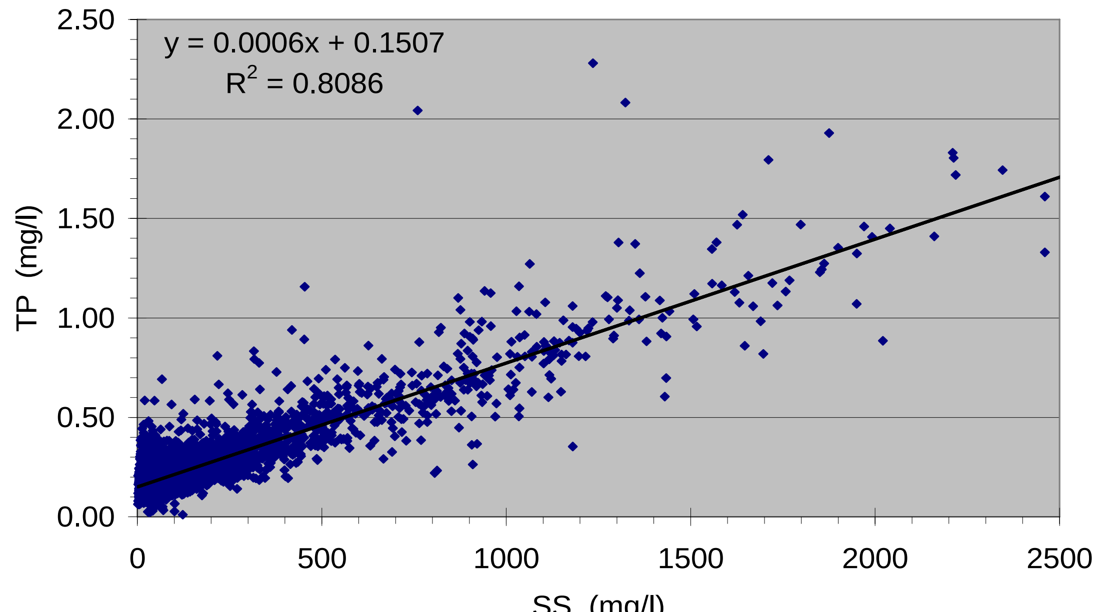
The two graphs to the right show the relationship between TP concentration and SS concentration in samples from the Sandusky River and the Cuyahoga River. The correlation between the two parameters, as reflected in the R^2 values, is similar for both rivers. However, the slope of the regression of TP on SS is much steeper in the Sandusky River than in the Cuyahoga River (see the linear equations for each river).

One disadvantage of using linear scales for both axes in these types of graphs is that many data points are "crammed" into the lower left portion of the graph. Consequently, any "fine structure" to the relationships between TP and SS at lower SS concentrations is not evident. On the next page, these same two graphs are plotted using logarithmic scales.

Sandusky River 10/1/1994 - 9/30/2004



Cuyahoga River 10/1/1994 - 9/30/2004



Comparing Two Parameter Plots for Two Rivers, continued

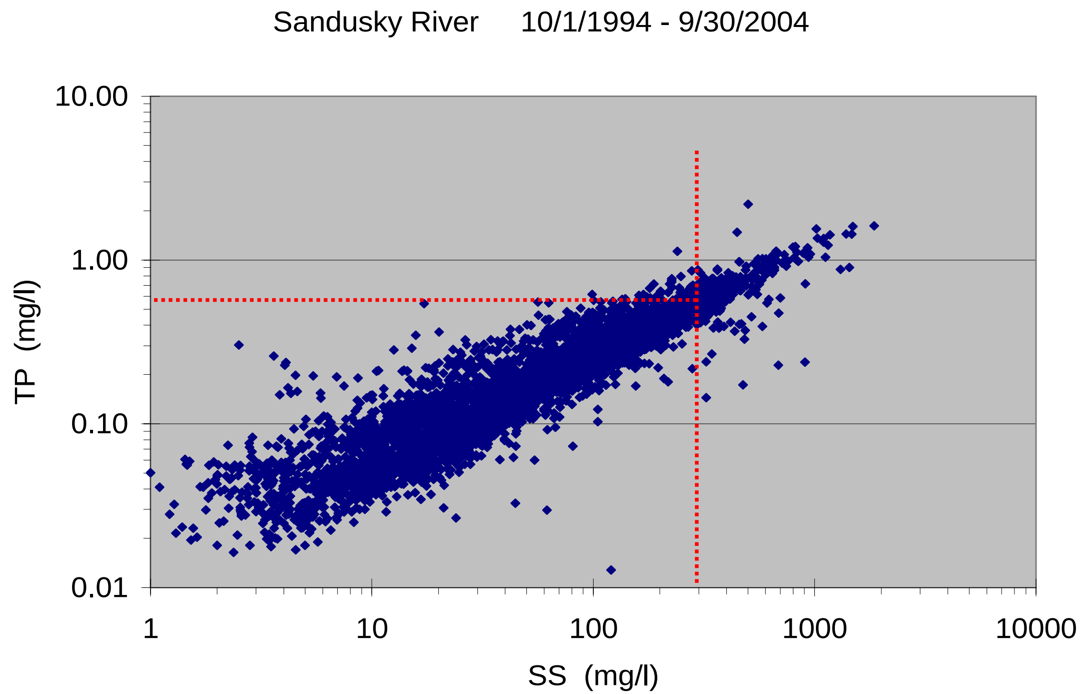
When log scales are used to plot TP-SS relationships, major differences become apparent between the Sandusky and Cuyahoga rivers. In the case of the Sandusky River, the relationship between log SS and log TP appears "linear" over the entire range of the SS concentration values. For the Cuyahoga River, a "linear" relationship between log SS and log TP is limited to SS concentrations above 100 mg/L. Below that concentration of SS, there appears to be minimal relationship between log TP and log SS concentrations.

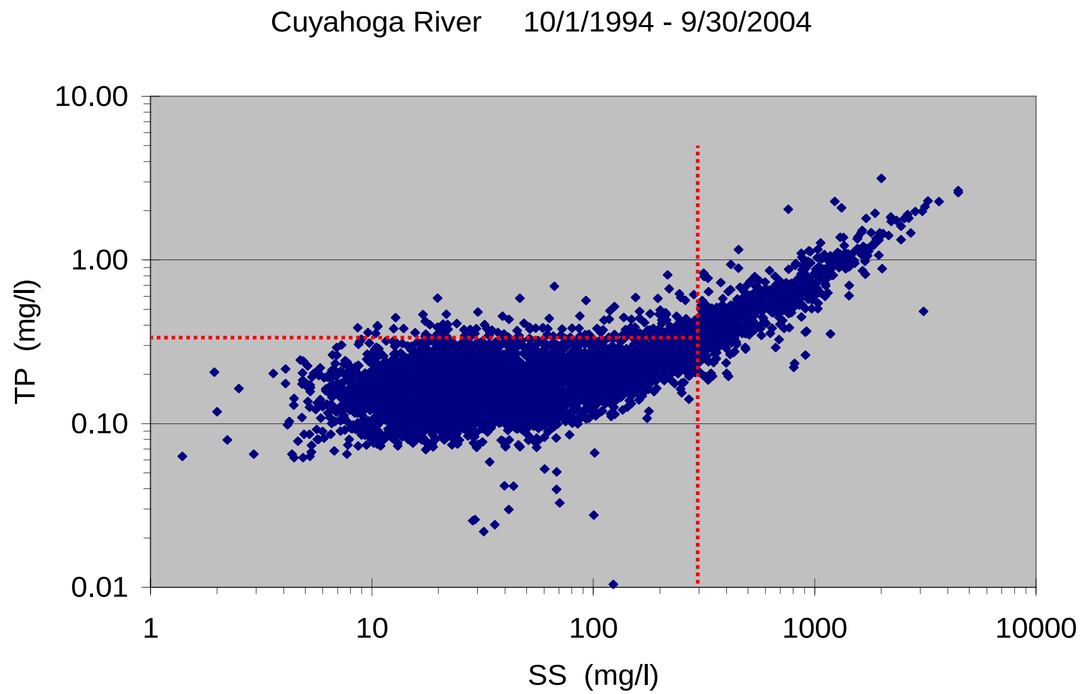
Low sediment concentrations generally occur during periods of low stream flow. Point sources of phosphorus, if present, will produce relatively high TP concentrations under low flow. In the case of the Sandusky River, which lacks major point sources of TP, the linkage of TP and SS is evident down to low SS concentrations and, by inference, to low flow conditions..

In the case of the Cuyahoga River, during the low flow conditions accompanying low sediment concentrations, point source phosphorus has significant impacts on TP concentrations. This accounts for the "flattening" of the data cloud at SS concentrations below 100 mg/L SS in the Cuyahoga River.

For both graphs, vertical lines have been placed at 300 mg/L SS. These fall within the SS concentration range that is "linear" for each river. It is evident that the vertical line intersects the data cloud at different concentration ranges of TP. For the Sandusky, the data cloud appears to be centered at about 0.57mg/L TP, while for the Cuyahoga, the data cloud appears centered at about 0.31 mg/L.

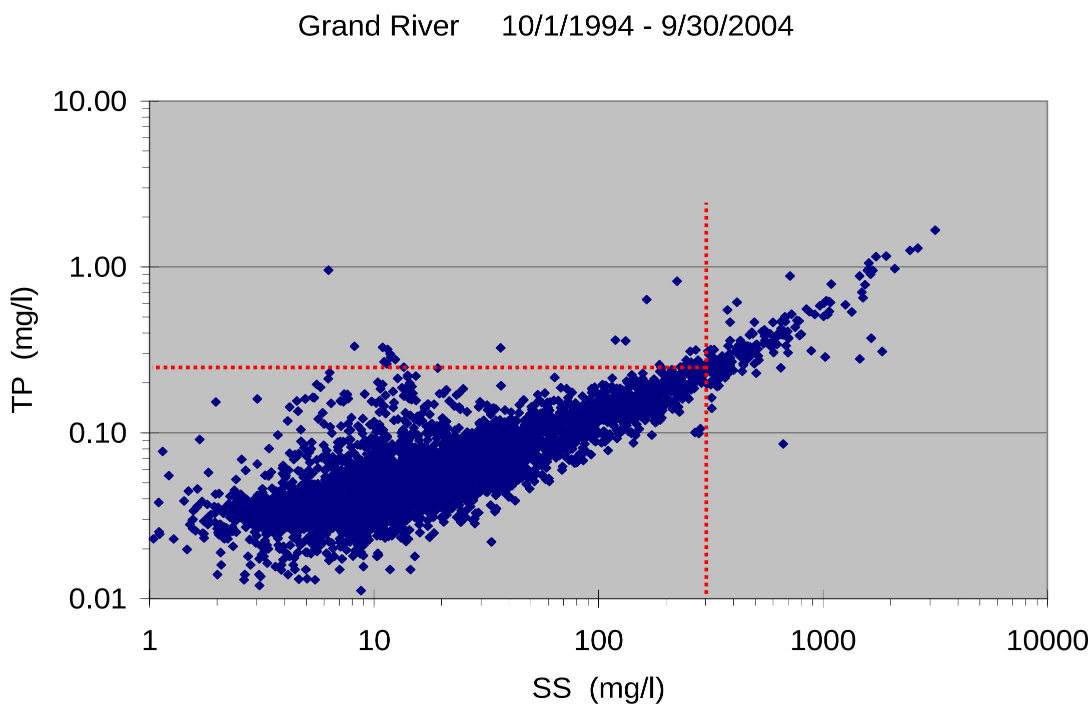
These data indicate that the phosphorus content of sediment in the Sandusky River is much higher than that in the Cuyahoga. Other studies by the WQL indicate that the particle size composition of suspended sediment in the Cuyahoga River is much larger than that of the Sandusky River.





Comparing Two-Parameter Plots for Two Rivers, continued

The adjacent graph shows the TP/SS relationships on log scales for the Grand River. The Grand River has a similar geology to that of the Cuyahoga, but has much smaller point source inputs. For the Grand, the links between TP and SS extend to much lower SS concentrations than for the Cuyahoga. Also, the TP concentration at an SS concentration of 300 mg/L is even lower than for the Cuyahoga. Thus the suspended sediment composition in the Grand River, relative to phosphorus content, is very different from the Sandusky River.



Plotting Two Parameter Graphs

Plotting two parameter graphs is straight forward, provided you are familiar with Excel plot routines. Copy the parameters of interest for the selected time interval from the RiverData files, paste them into a new Excel workbook, and proceed to use the Excel graphing procedures for constructing the plot.

The AnalysisTemplatev3 contains a routine for plotting two parameter graphs. In that routine, you can select linear or logarithmic scales for either axis.