

## Appendix K. Load Duration Curves

**1.0 Development of Load Duration Curves for the Sandusky River**

As mentioned in Chapter 4 of the upper Sandusky TMDL report, load duration curves were developed based on data collected at 3 USGS gaging stations located near the downstream boundary of the study area. Figure 26 in that chapter shows the location of the gages. Some of the dischargers located in the Bucyrus area and in other tributaries are having local impacts that are not evident when the chemical data of those 3 gages is examined. For that reason, additional load duration curves were prepared for the temporary gages that Ohio EPA set up and monitored during the 2001- 02 field work. The flow intervals (representing the 95<sup>th</sup>, 75<sup>th</sup>, 50<sup>th</sup>, 25<sup>th</sup> and 5<sup>th</sup> flow duration intervals) for the Honey Creek were converted from cfs to mm/day by dividing by the gage drainage area (149 mi<sup>2</sup>) and a conversion factor. The target phosphorus loads (or TMDLs) were also converted from lbs/day to grams/mi<sup>2</sup>/day. In this fashion, the load duration curve can be applied to any part of the stream network where samples have been collected. The unit area loads from Honey Creek were used to assess the phosphorus loads at monitoring sites in Upper and Lower Little Tymochtee Creek, Tymochtee Creek, Sycamore Creek, Honey Creek, Broken Sword Creek, Little Sandusky River and Rock Creek. Two other monitoring sites were located in parts of the watershed that are hydrologically different from Honey Creek because they are effluent dominated. For those sites (Paramour Creek and Sandusky River) a flow duration curve was developed with streamflow data from USGS gage 04196000 (Sandusky River near Bucyrus). A load duration curve was prepared to meet the target phosphorus concentration of 0.1 mg/l. The Ohio EPA gage sites are shown below.

Assessment Unit	Ohio EPA Temporary Gaging Station Description	Drainage Area (mi <sup>2</sup> )
04100011-020	Paramour Creek at Nazor Road, RM 1.5	26
04100011-020	Sandusky River at TR 13/Lower Leesville Road, RM 127.8	35
04100011-030	Broken Sword Creek at Schwemley Road/TR41, RM 25.5	32
04100011-040	Little Sandusky River at CR 113, RM 1.5	37
04100011-050	Tymochtee Creek at CR 30/Osbum Rd, RM 47.2	35
04100011-050	Tymochtee Creek at Fail Rd, RM 42.8 (backup site)	64
04100011-050	Upper Little Tymochtee Creek at CR 93, RM 4.0	35
04100011-060	Lower Little Tymochtee @ CR 29, RM 0.9	31
04100011-070	Sycamore Creek at SR 103, RM 14.3	30
04100011-080	Honey Creek at TR 85/Bigham Road, RM 34.1	28
04100011-090	Rock Ck at TR 201, Old Attica Road, RM 4.0	31

## 2.0 Duration Curves for Sandusky River Subwatersheds

### 2.1 Sandusky-Bucyrus Assessment Unit (HUC 04100011- 020)

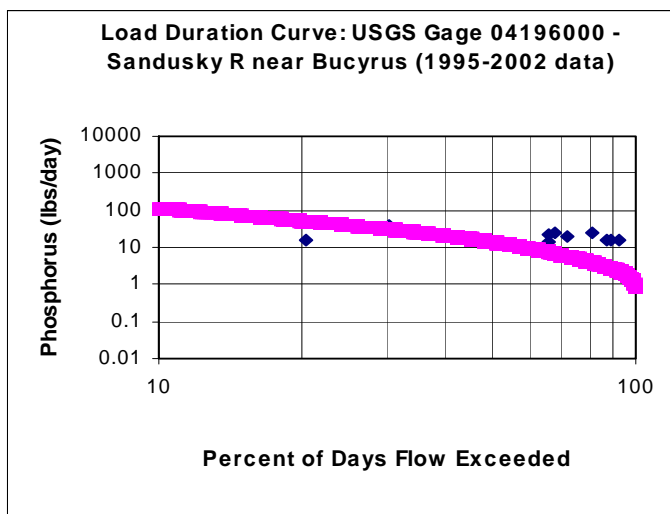
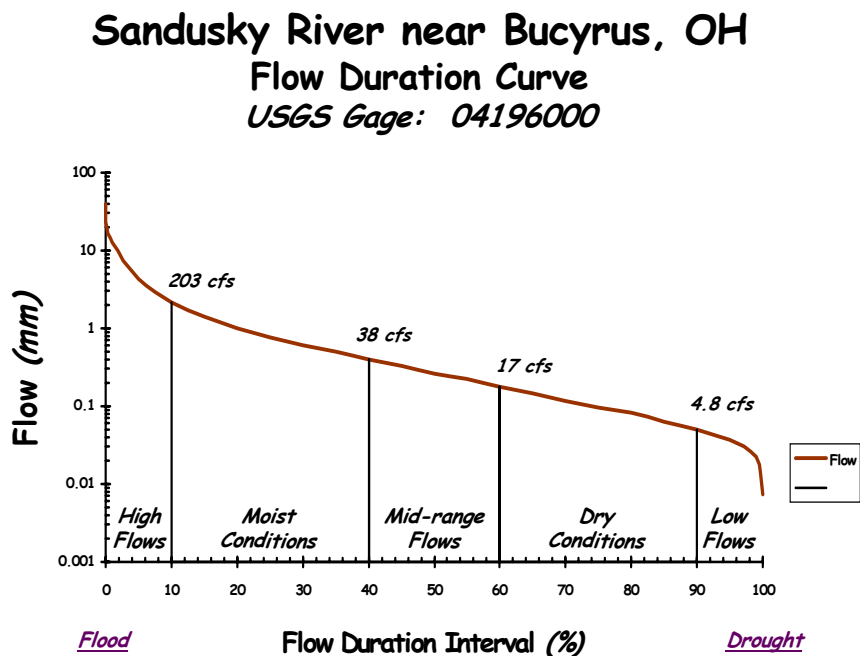


Figure 1. Total P load duration curve: Sandusky River near Bucyrus, river mile 110.4

higher than 14 cfs, although they all seem to be at or below the TMDL target (3 of those data points are obscured by the TMDL line).

Figure 1 shows the load duration curve for Sandusky River near Bucyrus. The location of the data points relative to the TMDL curve indicates that the stream is enriched with phosphorus between the flow duration intervals of 95<sup>th</sup> percentile (exceeded 95% of the time) and 50<sup>th</sup> percentile. In essence, it shows that this is an effluent dominated stream, and the target load for phosphorus is regularly exceeded when the streamflow is low (approximately 14 cfs or lower). The limitation of the data set at this site is that only 4 data points were collected at flows

Figure 2 shows the flow duration curve for the Bucyrus gage, including the boundaries that define the various flow range conditions, from low flows to high flows. Compared to



USGS Flow Data

Figure 2. Flow duration curve for the Sandusky River near Bucyrus gage

Figure 1, the phosphorus loads are exceeded during flow regimes labeled as "Low Flows" and "Dry Conditions" in Figure 2. The flow interval values (representing the 95<sup>th</sup>, 75<sup>th</sup>, 50<sup>th</sup>, 25<sup>th</sup> and 5<sup>th</sup> flow duration intervals) from this gage were used to prepare load duration curves for two other sites in the area: Paramour Creek at Nazor Road, river mile 1.5 (drainage area: 26 mi<sup>2</sup>) and Sandusky River at Lower Leesville Rd, river mile

127.8 (drainage area = 35 mi<sup>2</sup>). The first site is about 0.5 mile downstream from the tributary that carries the Crestline WWTP effluent. The Sandusky River site is located about 3.5 miles downstream from the Paramour Creek site. (An impounded area and a small tributary between both sites warranted the installation of the second gaging site,

to assess the water quality and loads upstream of Bucyrus). The effect of the impounded area is noticed when the load duration curves prepared for both sites are compared.

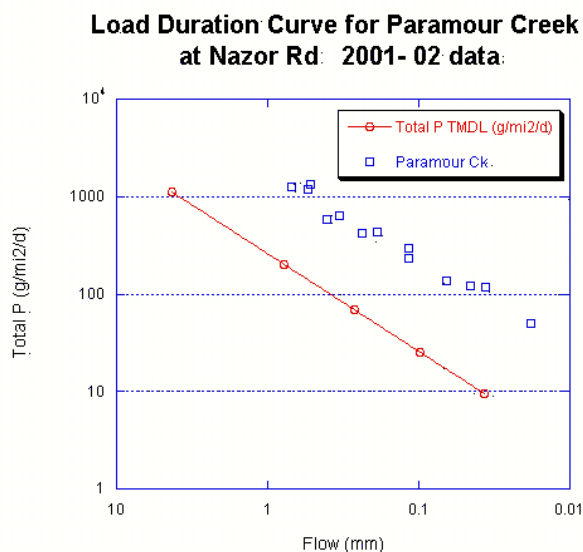


Figure 3. Total phosphorus load duration curve for Paramour Creek, river mile 1.5

Figure 3 shows the load duration curve for Paramour Creek downstream of the Crestline WWTP. The phosphorus target load is uniformly exceeded under all the flow conditions that were monitored between 2001 and 2002. The data was collected during all seasons (about half during Summer/Fall and half during Winter/Spring). The TMDL curve is based on flow data from the Bucyrus USGS gage.

**The uniformity of the load exceedance under low flow through moist conditions indicates that phosphorus load reductions are needed under all flow conditions.** The Crestline WWTP currently has a total phosphorus effluent limit of 1 mg/l, which evidently exceeds the assimilative capacity at this particular location. The impact of CSO loads may also be reflected in the data. The habitat score at this site was slightly below target, but

was about 50% below target in the two sites upstream. Refer to appendix D for more details about the habitat scores for Paramour Creek. Paramour Creek is hindered by an excessive point source nutrient load in combination with very low upstream flows.

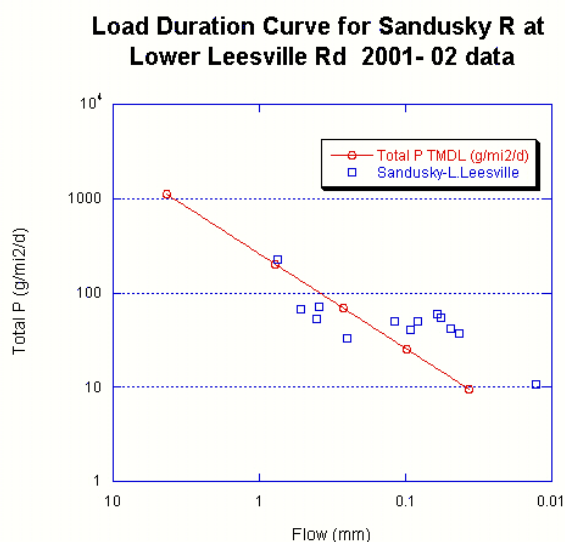


Figure 4. Total phosphorus load duration curve for Sandusky River upstream of Bucyrus, RM 127.8

Figure 4 shows the load duration curve for the Sandusky River at Lower Leesville road. The phosphorus target loads are being exceeded under low flows and dry conditions, but are usually being met under higher flow conditions. It is believed that part of the phosphorus load settles in the impounded area between both sites, and another portion of the load is assimilated by the stream's biological community. The stream habitat at the

Lower Leesville road site had one of the highest scores recorded in the mainstem, hence is more conducive to efficient assimilation of nutrients. Although part of the phosphorus load is assimilated, the stream remains enriched relative to the target phosphorus load. **Based on the measured phosphorus concentrations at the headwater sites in this assessment unit, a 49% reduction in phosphorus was recommended** (rounded to 50% in Table 19). The instream loads downstream of this site were already shown in figure 1, which depicts the phosphorus loads in the Sandusky River downstream of the Bucyrus WWTP, and how the target load was exceeded for those samples that were collected when the streamflow value was approximately 65<sup>th</sup> percentile or higher. The TMDL curve is based on flow data from the Bucyrus USGS gage.

## 2.2 Broken Sword Creek Assessment Unit (HUC 04100011- 030)

Figure 5 shows the phosphorus load duration curve for Broken Sword Creek at river mile 25.5. The data indicates that the phosphorus load targets are met under all flow conditions that were sampled. No phosphorus load reductions are recommended for this assessment unit. However, this site was classified as modified warmwater habitat (MWH) and had the lowest habitat score among the Broken Sword Creek sites. The sites located downstream showed improved habitat and attainment status as the drainage area increased. The impairment in the headwaters of this assessment unit is due to poor habitat and low flows during the summer. Refer to appendix D for more details about the habitat scores for Broken Sword Creek.

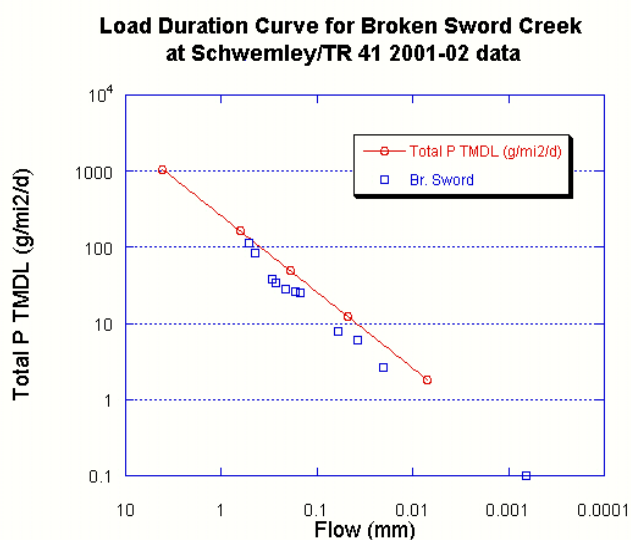


Figure 5. Total phosphorus load duration curve for Broken Sword creek at RM 25.5

## 2.3 Sandusky-Upper Sandusky Assessment Unit (HUC 04100011- 040)

The Sandusky River mainstem sites located in this assessment unit were for the most part in full attainment of the WWH use designation. However, most tributaries were affected by nutrient enrichment and poor habitat. An Ohio EPA gaging station located in the Little Sandusky river was used to estimate the phosphorus loads. Figure 6 shows the loading curve prepared based on that data, and indicates that phosphorus loads in excess of the recommended target were measured under low flow through moist conditions. **Based on the measured phosphorus concentrations at the headwater sites in this assessment unit, a 34% reduction in phosphorus was recommended.**

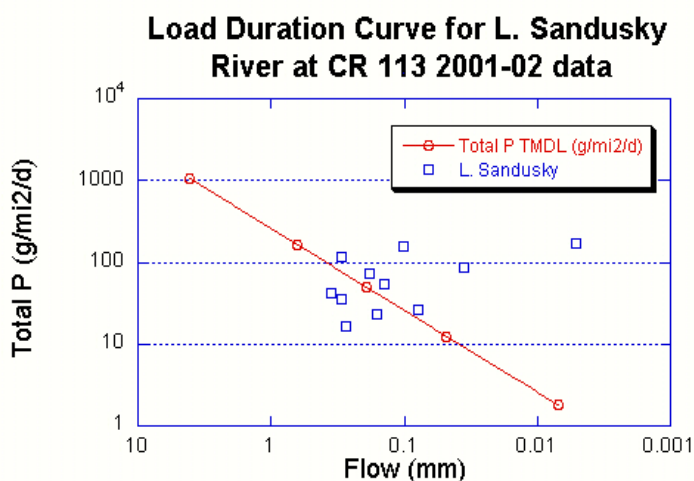


Figure 6. Total phosphorus load duration curve for Little Sandusky river at river mile 1.5.

## 2.4 Upper Tymochtee Creek Assessment Unit (HUC 04100011- 050)

This assessment unit includes the headwaters of Tymochtee Creek and extends to the confluence with Warpole Creek. This unit was most affected by the low water levels during the year (2001) when the biological survey was conducted. The median value of total phosphorus concentrations measured in the assessment unit indicate that the wadeable streams are meeting the target phosphorus value, while the headwater streams need a 19% reduction in concentration to meet the phosphorus target. The load duration curve shown in figure 7 for Tymochtee Creek at Fail Road indicates that total phosphorus loads slightly exceed the target under low flows and dry conditions. Water from Tymochtee Creek is diverted into Killdeer Reservoir, and the storage is available for low flow augmentation. According to the USGS, a mean annual release of 2.2 cfs is returned to the stream from the reservoir.

A second temporary gaging station was located in a tributary (Upper Little Tymochtee) to this assessment unit. The loading curve for this tributary is shown in figure 8. The phosphorus load trends are similar, with slight exceedance of the target phosphorus load only under low flows and dry conditions.

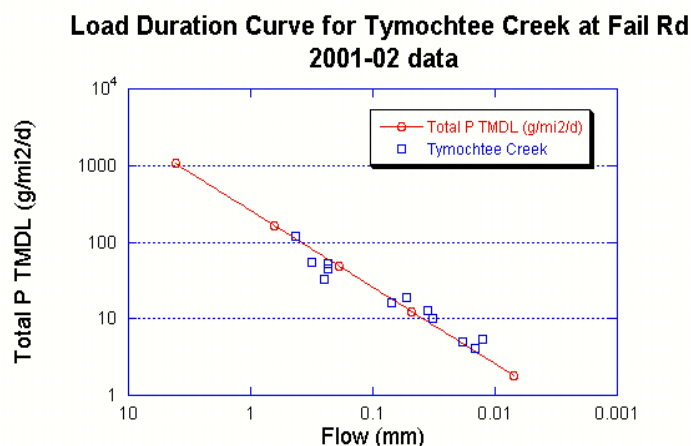


Figure 7. Total phosphorus load duration curve for Tymochtee Ck at river mile 42.8

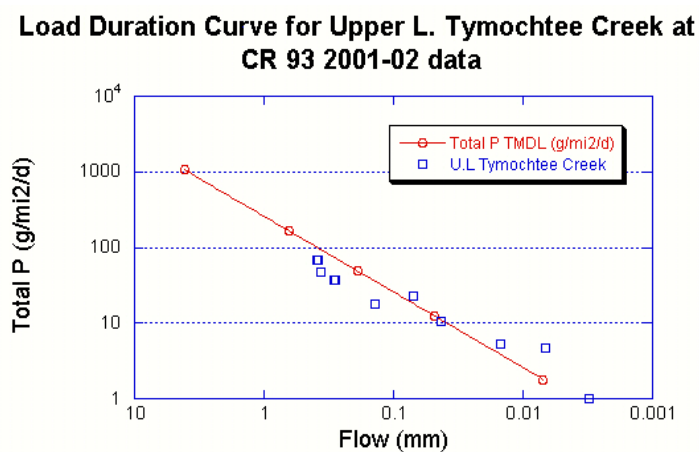


Figure 8. Total phosphorus load duration curve for Upper Little Tymochtee creek at river mile 4.0

## 2.5 Lower Tymochtee Creek Assessment Unit (HUC 04100011- 060)

This assessment unit extends from downstream of Warpole Creek to the mouth of Tymochtee Creek. The median value of total phosphorus concentrations measured in this assessment unit indicate that the wadeable streams (drainage area 20 - 200 mi<sup>2</sup>) and large rivers (drainage area 200 - 999 mi<sup>2</sup>) are meeting the target phosphorus value, but headwater streams (drainage area <20 mi<sup>2</sup>) show signs of organic enrichment problems that warrant a nutrient load reduction. **Based on the measured phosphorus concentrations at the headwater sites in this assessment unit, a 60% reduction in phosphorus is recommended.** The load duration curve shown in figure 9 for Lower Little Tymochtee Creek at river mile 0.9 indicates that total phosphorus loads occasionally exceed the target under various flow conditions.

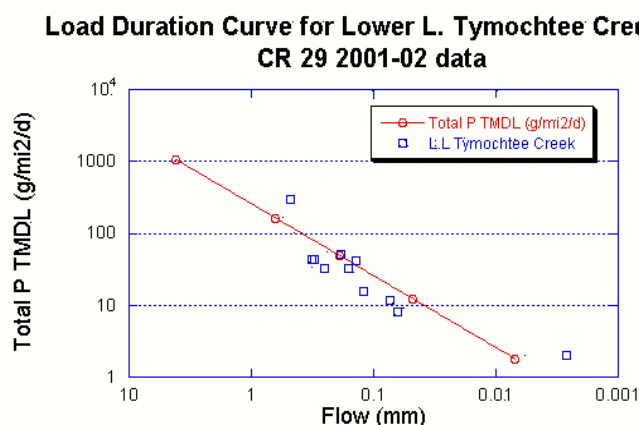


Figure 9. Total phosphorus load duration curve for Lower little Tymochtee Creek at river mile 0.9

## 2.6 Sandusky River-Mexico Assessment Unit (HUC 04100011- 070)

This assessment unit extends from downstream of Tymochtee Creek to upstream of Honey Creek. The chemistry data collected throughout this unit shows that the total phosphorus targets are being met. **Based on the measured phosphorus concentrations, this assessment unit requires no load reduction in phosphorus during low flow periods.** The load duration curve shown in figure 10 for Sycamore Creek at river mile 14.3 indicates one instance when total phosphorus loads significantly exceeded the target under high flow conditions. During periods of high flow, the eroded sediments carry phosphorus attached to soil particles. That is why there is a basin wide goal of 25% phosphorus load reduction, which applies to nonpoint sources, as recommended in section 4.4.2 of the Upper Sandusky TMDL report.

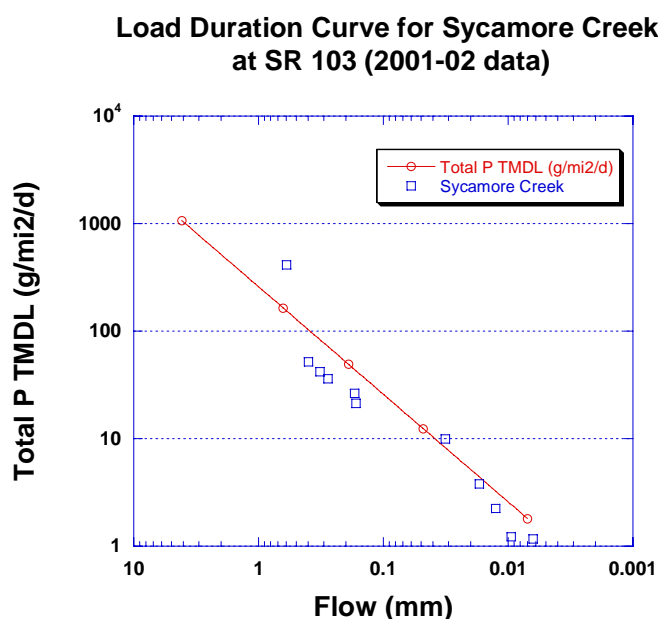


Figure 10. Total phosphorus load duration curve for Sycamore Ck at river mile 14.3



## 2.7 Honey Creek Assessment Unit (HUC 04100011- 080)

This assessment unit is limited to the Honey Creek subwatershed. The chemistry data collected throughout this unit indicates that the headwater streams are significantly exceeding the recommended total phosphorus target. **Based on the measured phosphorus concentrations, this assessment unit requires a 65% load reduction in phosphorus during low flow periods.** The load duration curve shown in figure 11 for Honey Creek at river mile 34.1 indicates that total phosphorus loads exceeded the target very infrequently. The explanation for this discrepancy with the recommended load reduction is that this temporary gage was located upstream of the wastewater treatment plants for New Washington, Attica and Bloomville. New Washington has a controlled discharge lagoon, and should not have a significant impact during low flows. Although the Attica and Bloomville WWTPs are minor dischargers, their existing effluent concentration of phosphorus exceeds what Honey Creek can assimilate under low flow periods. Chapter 6 of the Upper Sandusky TMDL specifies load limits for both dischargers that incorporate the recommended load reductions.

Load Duration Curve for Honey Creek at TR 85/Bigham  
Rd 2001-2002 data

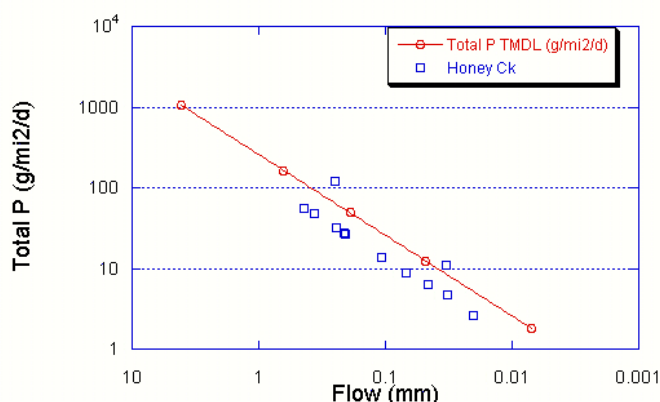


Figure 11. Total phosphorus load duration curve for Honey Creek at river mile 34.1

## 2.8 Sandusky-Tiffin Assessment Unit (HUC 04100011- 090)

This assessment unit extends from downstream of Honey Creek to upstream of Wolf Creek (excluding the mainstem). The chemistry data collected throughout this unit shows that the total phosphorus targets are being met at the wading sites, but not at the headwater sites. Based on the measured phosphorus concentrations, this assessment unit requires a 21% load reduction in phosphorus during low flow periods. However, since there are no point sources in those headwater streams, all the phosphorus is coming from nonpoint sources. The load duration curve shown in figure 12 for Rock Creek at river mile 4.0 indicates just one instance when total phosphorus loads significantly exceeded the target (under dry conditions). For this reason, **the TMDL report recommended that this assessment unit requires no load reduction in phosphorus during low flow periods**. The basin wide goal of 25% phosphorus load reduction, which applies to nonpoint sources, should control the phosphorus loads in this unit.

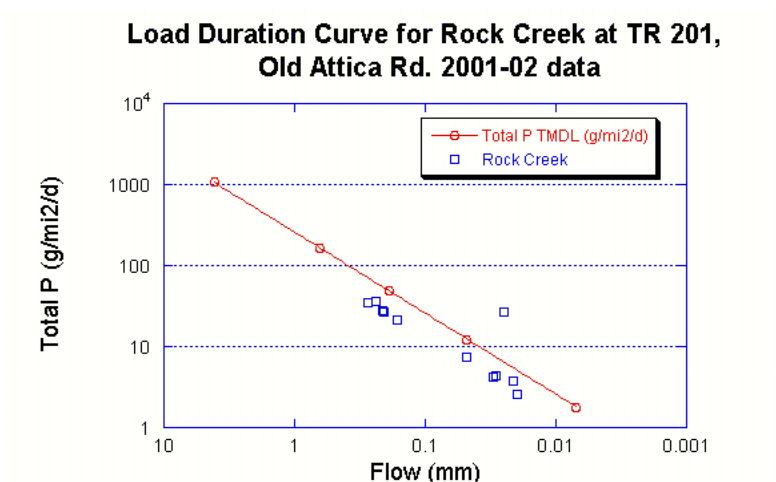


Figure 12. Total phosphorus load duration curve for Rock Creek at river mile 4.0