Pine River Watershed and Van Etten Lake
2018 Phosphorous and Suspended Solids Monitoring

SUMMARY

A shift in the focus of the annual sampling was initiated in 2017 as a variation to the sampling started in 2009. The Pine River at the county line and the Van Etten River (Lower Van Etten Creek) where it leaves the lake continued to be monitored to determine the relative impact of upstream and lake shore nutrients and solids. Sampling was started in 2017 on the South and West Branches and the Pine River (E/W) at F-30. Van Etten Creek at the corner of Barlow Road and Pine River Trail was also sampled in 2018 as water levels had returned to normal as the blockage downstream of the sampling point seemed to have gone away.

Based on the first two years of estimates, it appears that the percentage contribution of TSS from each tributary is close to the percent estimated flow. However, the contributions of phosphorus from Van Etten Creek and the East Branch, both of which pass through agricultural areas are higher than would be indicated by their flows.

The estimated amount of phosphorus - P (14.9 lbs/day) entering the lake from the Pine River for the year was about 49 percent of the estimated nine year mean amount. This reduction in P load was unexpected because of the wetter conditions. The estimated amount of total suspended solids - TSS (5.41 tons/day) entering the lake was about 77 percent of the nine year mean. This was also unexpected based on the wetter conditions. Both estimates are based on the regression method approach.

However, unexpected higher P concentrations were measured at the outlet from Van Etten Lake at the dam. The late summer samples were reanalyzed by the laboratory using an alternate procedure and the resulting concentrations were lower possibly because of interference with the first procedure. If the higher values and the higher than expected flows continue in 2019, some explanation for these elevated values will have to be sought.

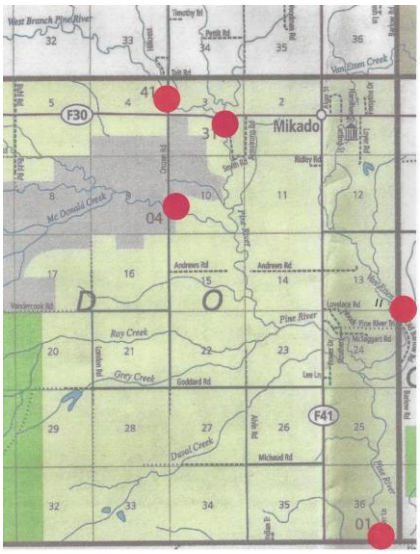
Flow/stage measurements were made on the South and West Branches of the Pine, the Pine at the county line and on Van Etten Creek in 2018 following the installation of Crowd-Hydrology gauges. More measurements are planned for 2019 there and on Lower Van Etten Creek at F-41 as a flow meter remains available for use.

TRIBUTARY STREAM SAMPLING PROGRAM OVERVIEW

Sampling was started in 2017 and continued in 2018 on the South and West branches and the Pine River (E/W) at F-30. Van Etten Creek at the corner of Barlow Road and Pine River Trail was also sampled in 2018. The Pine River at the county line and the Van Etten River (Lower Van Etten Creek) where it leaves the lake continued to be monitored to determine the relative impact of upstream and lake shore nutrients and solids.

Samples were collected from the five locations shown in Figure 1 and from immediately downstream of the Van Etten Lake dam and analyzed for total phosphorous (P) and total suspended solids (TSS). Water level (stage) measurements were taken at the time of sampling to obtain an estimate of the flow. Samples were collected during both high flow and low flow conditions from April through October in an attempt to characterize the quantity and quality of inflows in the system.

Figure 1 - Sampling Locations



RESULTS

The results of this sampling are summarized in table 1, below and in Appendix A. The TSS results reported by the University of Michigan Laboratory for all locations sampled continued to be higher than those reported by the Central Michigan University Laboratory. This should not be a problem in future years as the intent of this sampling is to estimate the relative contribution of each tributary to the total loading at the county line. Gauge measurements taken and recorded at the Crowd Hydrology web sites were also converted to estimated flow rates for purposes of estimating P and TSS loads at these Crowd Hydrology sites. Regression analyses were used to estimate the P and TSS loadings for those dates that gauge and flow readings were taken over the sampling period.

Table 1
Pine River Tributary Sampling Results

	Flow Q		Phosphorus P			Solids TSS		
	cfs	%	#/day	%	Regression #/day	tons /day	%	Regression tons/day
So Branch (04)	100	47%	8.0	35%		5.9	38%	
East Br by difference	59	27%	9.4	41%		5.8	38%	
West Branch (41)	46	21%	3.3	15%		2.8	18%	
Van Etten Creek (11)	10	5%	2.0	9%		0.9	6%	
Pine River @ Co Line (01)	173		17.2		14.9	11.7		5.41
			% of mean		43%	% of mean		77%
Tributary estimate for balance (not including Duvall)								
	214	124%	22.6	132%		15.3	131%	
Van Etten River below Dam	235		45.2		30.8	5.1		1.48
			% of mean		158%	% of mean		131%
E/W Pine @ F-30 (31)	105		12.7			8.6		

Although 2018 saw a continuation of wetter and cooler conditions than experienced in previous years, the flow rates did not reflect this. The results of the first two years of tributary sampling in the watershed continued to show an imbalance of unknown origin. The combined estimated flow from the tributaries was approximately 24% more than the estimated flow for the Pine at County Line Rd. Although the flow measured at the outlet of Van Etten Lake was approximately the same as that estimated for the tributaries, stream measurements taken for the Pine at the county line did not show the existing curve to be a source of the imbalance. Likewise the estimates for the tributaries (P at 32 percent greater) and the (TSS at 31 percent greater) indicate that estimates for the Pine at the county line although closer were still not in agreement. There is a possibility that solids were being deposited between the sampling points which would account for the wider discrepancy in the P and TSS results. However, the source of the imbalance is not readily apparent. Additional flow measurements will be taken in 2019 to confirm and improve the accuracy of the flow/stage curves.

At different times, the discharge at each location was measured using standard velocity and area measurement techniques. The stage/flow curves, the sampling location details and a summary of stream flow measurement and sampling methods used are available on request as an appendix to this report. Through the good graces of Huron Pines, a flow meter is being made available so that stage/flow measurements can continue and the curves can be refined.

Four samples were taken over the summer from each of the major tributaries to the Pine and seven samples were collected from the Pine River and the Van Etten River (Lower Van Etten Creek) below the dam. The 2018 sampling results are presented in Appendix A. A summary of the estimated quantities of phosphorus (P) and total suspended solids (TSS) contributed to the lake by the Pine River and the other tributaries are shown in Figures 2 and 3. The estimated quantity calculations are based on the geometric mean estimates as the quantities estimated during relatively infrequent high flow periods tend to skew the arithmetic mean to the high side. Both the P and TSS estimates for 2018 are based on a regression analysis using the readings from the Crowd Hydrology gauges.

The data for 2018 show that 6% less P entered the lake from the rivers and streams than left via the Van Etten River based on the regression analyses. However, the raw data showed very high levels of P leaving the lake during the last four months of sampling. The laboratory reanalyzed these samples using an alternate procedure and the resulting concentrations were approximately ½ half the first values. The difference is thought to be because of interferences of unknown origin with the first colorimetric procedure. The source of this significant increase in P concentrations is unknown at this time and will be watched closely in 2019. Based on the regression analysis, 265% more TSS entered the lake than left it as expected due to the settlement of solids during the flow through the lake. The estimated amount of P entering the lake was **14.9 lbs/day**, 43% percent of the nine year mean, and the estimated amount of TSS was **5.41 tons/day**, 77% of nine year mean. The Pine River continues to be the major contributor of both P and TSS to the lake.

The estimated flows and the phosphorus concentrations leaving Van Etten Lake were higher than expected or historically observed. Besides possible interferences, another possible reason

for the increase in P and TSS may be because of the need to change the sample location after the installation of the new security fence at the dam. A new sample location will be used in 2019. Measurements will also be made in 2019 of the flow downstream of them dam to verify or revise the stage/flow curve.

Continued measurement of flows is planned for 2019 to improve the accuracy of the stage/flow curves for the Lower Van Etten Creek at F-41, the East/West Branch at F-30, the West Branch of the Pine and to strengthen the curves for the South Branch and Van Etten Creek.

Figure 2

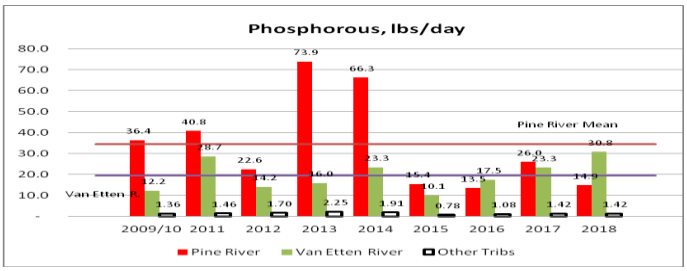
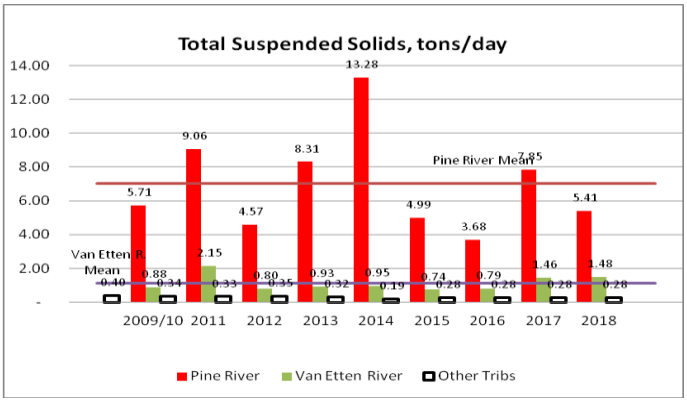


Figure 3



NUTRIENT AND SEDIMENT LOADINGS TO VAN ETTEN LAKE

Nutrients and sediments can enter Van Etten Lake through stream input, overland flow, ground water seepage and within lake processes. The McNaught study and this sampling are designed to assess stream input. The Pine River, Huron (Sims) Creek, Phalen Creek, Coppler Creek, Hill Creek (west of the Pine on County Line Road) and Dry Creek (near Colbath Road) add nutrients and sediments directly to Van Etten Lake. The total contribution from each stream depends on the concentration of nutrient or sediment in the stream and the rate of stream flow (discharge). The contribution from each stream, called "load", is calculated as pounds or kilograms per day. Streams with high concentrations and high discharge will contribute the most nutrients and sediments to the lake. The Pine River is the primary source of nutrients and sediments. By also measuring the water that flows out of the lake for nutrients and sediments, the total contribution (or deduction) from non-stream related sources (runoff, seepage and within-lake processes) can be estimated. Most of the sediments entering the lake are carried by the inlet streams following storm events. After stream water enters the lake, sediment quickly settles to

the bottom as the velocity decreases. Many of the settling particles have phosphorous and nitrogen bound to their surface. These attached nutrients become part of the stored nutrient pool at the bottom of the lake.

The current estimates of phosphorus and total suspended solids contributions to the lake from all sources are summarized in Table 1. These are estimates from a mass balance model for the lake which will continue to be refined as additional sampling is completed.

Table 1

Source	Phosphorous	Total Suspended Solids
In	Lbs/yr	Tons/yr
Pine River	12,593	2,562
Other Tributaries	657	102
Septic Systems	1,264	---
Lawn and Woods Runoff	380	Not Estimated
Waterfowl	351	---
Release of settled P	375	---
Precipitation	84	---
Out		
Sedimentation by difference	(8,550)	(2,252)
Van Etten River	7,154	412

OBSERVATIONS

1. The flow, P and TSS in the Pine River at the county line continues to be under reported based on this sampling. Additional flow stage measurements will be taken in 2019 to better refine the flow/stage curves and hopefully improve the estimates.
2. Based on the first two years of estimates, it appears that the percentage contribution of TSS from each tributary is close to the percent estimated flow. However, the contributions of phosphorus from Van Etten Creek and the East Branch, both of which pass through agricultural areas are higher than would be indicated by their flows. It would be premature to make any long term conclusions based on the results of the first two years of sampling.
3. The Pine River is by far the major contributor of P and TSS to the lake. The indications are that the bulk of P and TSS are carried to the lake during spring melt runoff and during fall rain events.
4. Over the long term, the amounts of P and TSS leaving via the Van Etten River are significantly less than the amounts entering from all sources. The difference is due to a combination of settlement of solids after they enter the lake and uptake of P by aquatic growth which becomes a part of an internal recycle. However, the sampling during the last half of 2018 showed an apparent increase in the amounts of P and TSS leaving the lake from an unknown source. The higher P concentrations may also reflect an interference with the test procedure. If this continues in 2019, efforts will be made to locate the origin of these increases.
5. I plan to continue using the U of M laboratory in 2019.

6. The Crowd Hydrology readings were used in the development of these flow, P and TSS estimates.
7. The rating curves are in need of refinement, particularly at higher flow periods, through the collection of additional stage/flow measurements using an accurate flow meter and standard procedures.

Appendix A

2018

Location		Date	Stage	Flow, CFS	P, mg/L	P, lbs/day	TSS, mg/L	TSS, lbs/day
Pine River @ County Line								
		21-Apr-18	14.98	639	0.011	36	33.9	116,433
		21-May-18	11.82	129	0.012	8	7.3	5,087
		15-Jun-18	11.05	75	0.008	3	10.2	4,135
		17-Jul-18	11.88	135	0.015	11	58.5	42,477
		18-Aug-18	11.62	112	0.051	31	19.3	11,649
		19-Sep-18	10.94	69	0.019	7	63.4	23,685
		9-Oct-18	15.40	701	0.049	184	35.2	132,986
Geometric mean =				173	0.016	17	25.2	23,379
Van Etten River (Lower Van Etten Creek)								
	*	21-Apr-18	13.8	201	0.012	12	3.0	3,213
		21-May-18	13.6	230	0.018	23	0.6	754
		15-Jun-18	14.1	158	0.015	13	2.1	1,822
	**	17-Jul-18	13.6	230	0.057	71	2.0	2,447
	**	18-Aug-18	12.9	321	0.036	61	18.9	32,581
	**	19-Sep-18	14.1	150	0.065	53	14.0	11,322
	**	9-Oct-18	12.3	409	0.028	63	29.2	64,292
Geometric mean =				235	0.053	45	8.0	10,112
	*	High levels due to backwater from the AuSable						
	**	Higher P and TSS concentrations of unknown origin						
E/W Branch Pine								
		21-Apr-18	3.20	239	0.014	18.0	34.6	44,577
		15-Jun-18	0.94	49	0.009	2.4	8.3	2,166
		18-Aug-18	0.93	48	0.020	5.1	58.2	15,035
		9-Oct-18	2.90	215	0.101	117.5	51.1	59,173
Geometric mean =				105	0.023	12.7	30.4	17,119
West Branch Pine								
		21-Apr-18	2.65	108	0.026	15.4	19.1	11,141
		15-Jun-18	1.18	23	0.004	0.5	6.2	776
		18-Aug-18	1.14	15	0.019	1.5	71.8	5,916
		9-Oct-18	2.80	117	0.017	10.4	30.5	19,200
Geometric mean =				46	0.013	3.3	22.6	5,598

Appendix A cont.

2018

Location	Date	Stage	Flow, CFS	P, mg/L	P, lbs/day	TSS, mg/L	TSS, lbs/day
South Branch Pine							
	21-Apr-18	4.22	172	0.009	8.4	29.4	27,215
	15-Jun-18	1.28	52	0.007	2.1	7.5	2,087
	18-Aug-18	1.86	76	0.024	9.9	29.6	12,031
	9-Oct-18	3.80	148	0.029	23.1	34.7	27,532
Geometric mean =			100	0.015	8.0	21.8	11,712
Van Etten Creek							
	21-Apr-18	4.00	38.2	0.024	4.93	32.4	6,658
	15-Jun-18	0.60	4.8	0.021	0.55	15.4	397
	18-Aug-18	0.64	5.2	0.102	2.84	76.2	2,115
	9-Oct-18	3.20	25.0	0.094	12.68	45.7	6,159
Geometric mean =			9.8	0.037	1.98	33.6	1,775