Bone 2015 Tributary Analysis

Introduction

There were six tributary sites evaluated from May until August, 2015 (five storm events). The sites were "Vilstrup 1", "Culvert 5", "Vilstrup 3", and "Culvert 4" all on the north end of the lake. On the east side of the lake was "Graham" and Belich" on the west side of the lake. The maps below show the site locations.

Vilstrup 1, Culvert 5 and Vilstrup 3 are all located on the same main tributary that recently had settling ponds installed. Part of this analysis is to see how those may be functioning.

Each tributary was sampled with a grab sample technique with the water samples tested for total phosphorus, orthophosphate, and total dissolved solids. The sampling took place during storm events, of which there were five. When the grab samples were taken the flow was also evaluated in ft^3/sec using a digital flow meter and calculating the cross section area of water in the channel or pipe.

Orthophosphate is the form of phosphorus that is available for plants and algae to absorb and use immediately for growth. Total phosphorus measures all forms of phosphorus , which includes orthophosphate. If a large fraction of the total phosphorus is orthophosphate, then the plants and algae will be able to respond to this additional phosphorus quickly. Others forms of phosphorus can eventually be converted to orthophosphate and then get used for growth.

Total suspended solids are particles in the water that are not dissolved and can be filtered out. High total suspended solids can add nutrients to the lake and can also lead to sediment build up where the water slows and accumulate on the lake bottom.

Results

Nutrient concentration

The grab samples were obtained during or shortly after storm events. The flow in each stream varied as the amount of rainfall and the intensity varied. In order to compare the tributaries in relation to the impact on Bone Lake, the values of all combined events were averaged. Figure 1 shows the mean Total phosphorus and figure 2 shows the mean orthophosphate at each tributary from the five events.

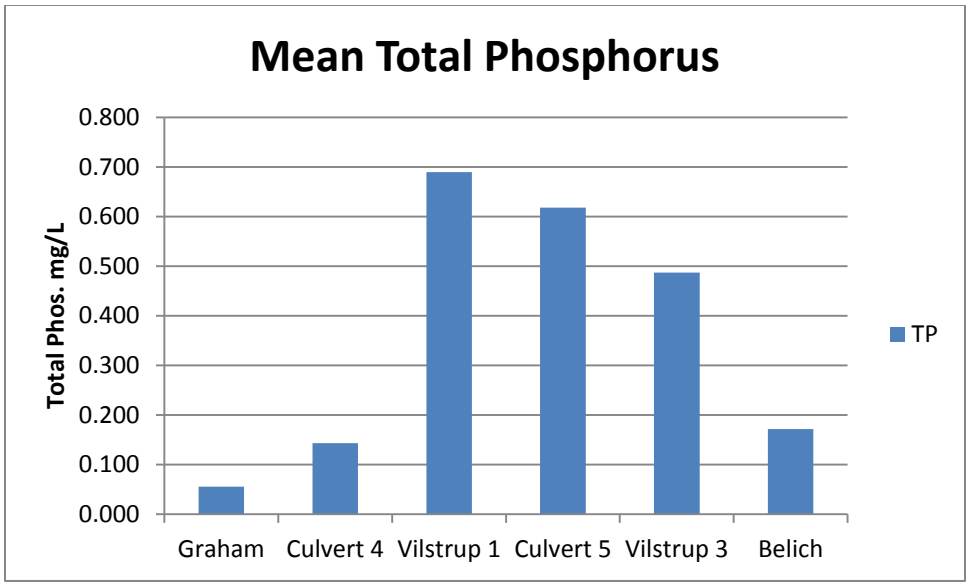

Figure 1: Mean total phosphorus concentration at each sample site. Total P is in mg/L.

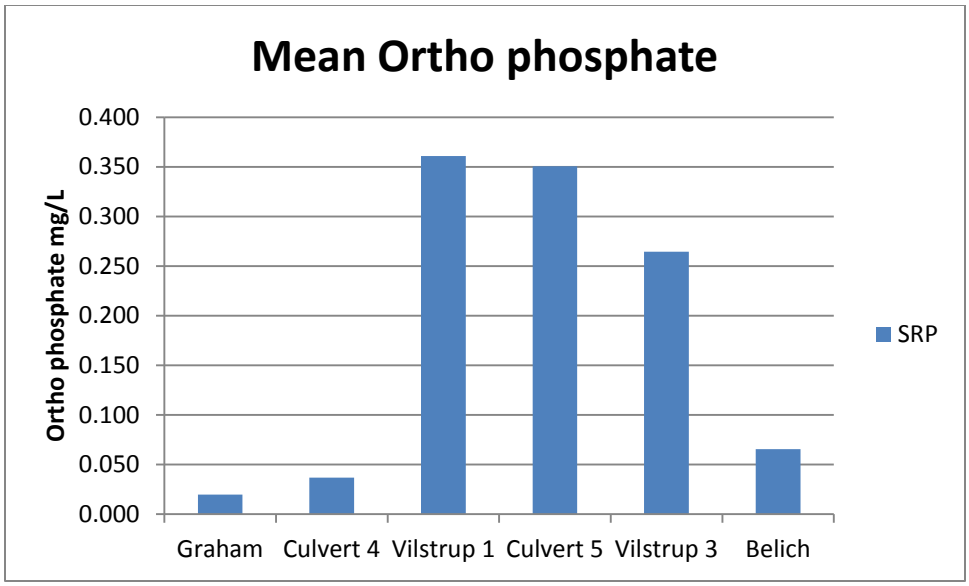

Figure 2: Mean orthophosphate concentration at each sample site. Orthophosphate is in mg/L.

As both graphs show, Vilstrup 1 has the highest concentration of total phosphorus and orthophosphate on average. This is followed by Culvert 5 and then Vilstrup 3. All three of these sample locations are from the same basic tributary. Belich, Culvert 4 and Graham were substantial less in concentration in both total phosphorus and orthophosphate.

Figure 3 shows the mean TSS. Belich had the highest TSS followed by Culvert 4, Vilstrup 1 and then Culvert 5. Graham had the lowest mean TSS. This is not completely consistent with the phosphorus concentrations, but TSS is not dissolved and can contribute to phosphorus loading from the sediment accumulation eventually and affect lake substrate habitat, especially in sandy and gravel areas.

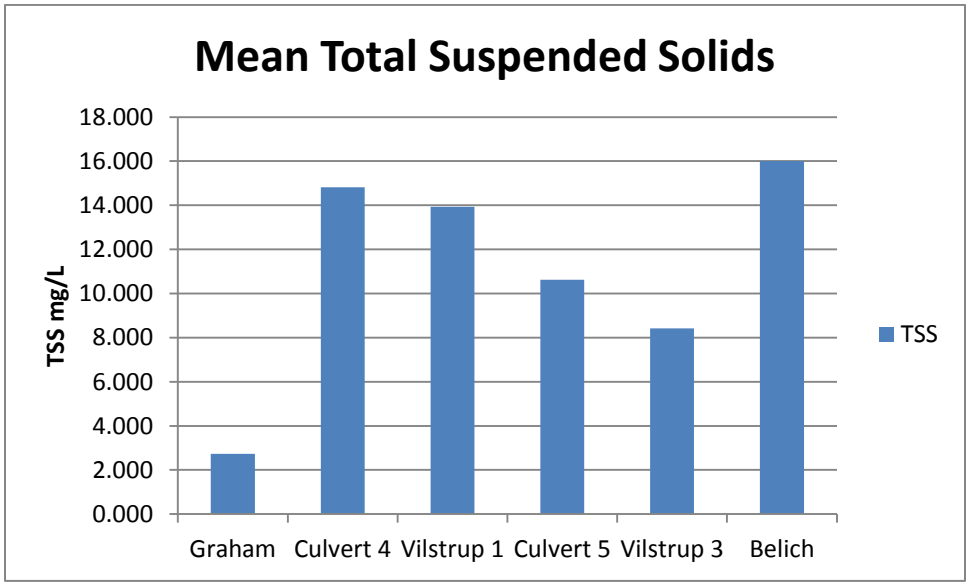

Figure 3: Mean total suspended solids (TSS) concentration at each sample site. TSS is in mg/L.

Flow

Again, the flow varied immensely from one storm event to the next, but all events were averaged to allow comparison of the tributaries. Figure 4 shows the mean flow (ft^3/second) for each tributary.

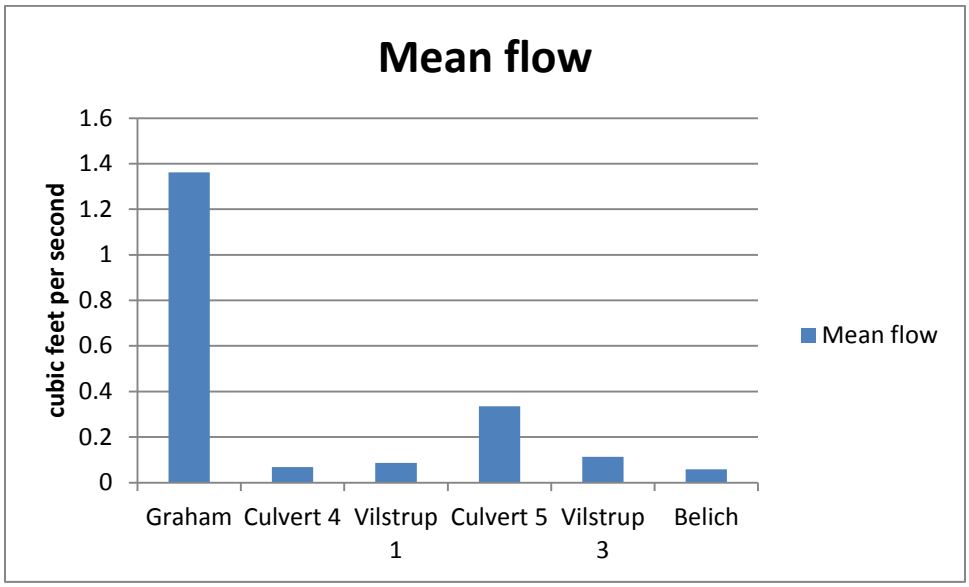

Figure 4: Mean flow at each sample site. Flow is in ft^3/second.

Graham had significantly higher flow than all other tributaries. Culvert 5 had the second highest mean flow, but was substantially less than Graham. Interestingly, Graham had much lower phosphorus concentration and TSS. Although Graham has a large amount of water flow by comparison, the phosphorus load and TSS load is lower than might be expected (higher flow) due to the lower concentration.

Phosphorus and sediment load comparison

The loading for phosphorus, orthophosphate and total suspended solids was calculated for a 24 hour period for comparison purposes. The mean concentration of each nutrient and the mean flow was used to extrapolate the amount of each that would be discharged in a 24 hour period. This is assuming that at the time the grab sample was obtained, and the flow, would remain the same for this calculation. This is unlikely and the flow and the concentrations likely changed immensely during a 24 hour period. However, this was calculated simply for comparison and should not be used to determine actual loading from these tributaries. Figures 5-7 show the estimated 24 hour load based upon mean values.

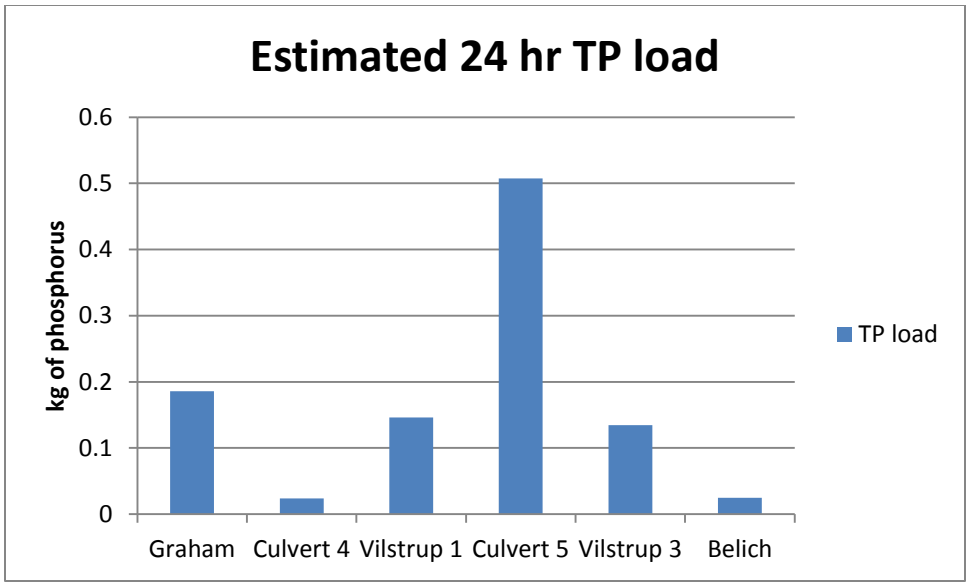

Figure 5: Estimated 24 hour total phosphorus load based upon mean flow and mean concentration of total phos.

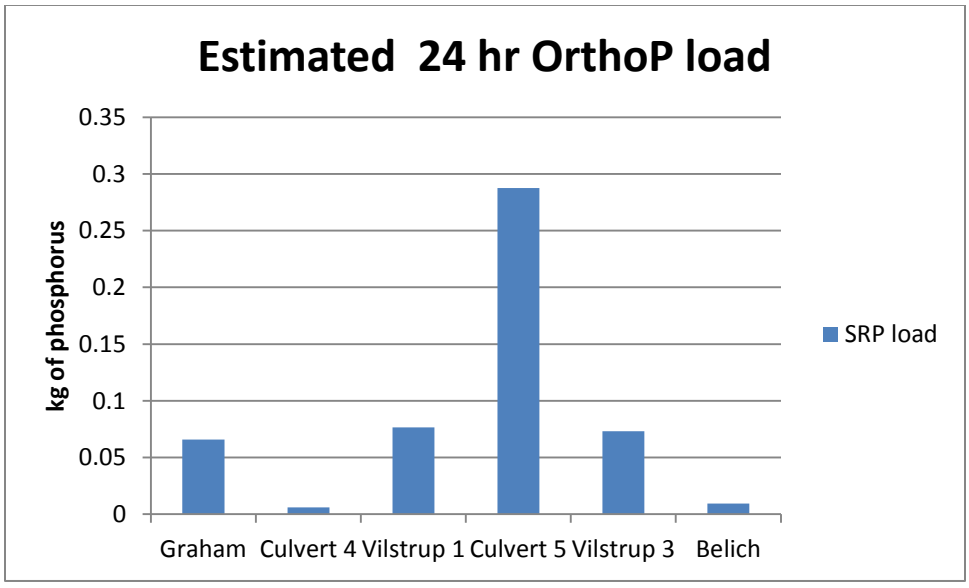

Figure 6: Estimated 24 hours orthophosphate load based upon mean flow and mean orthophosphate concentration.

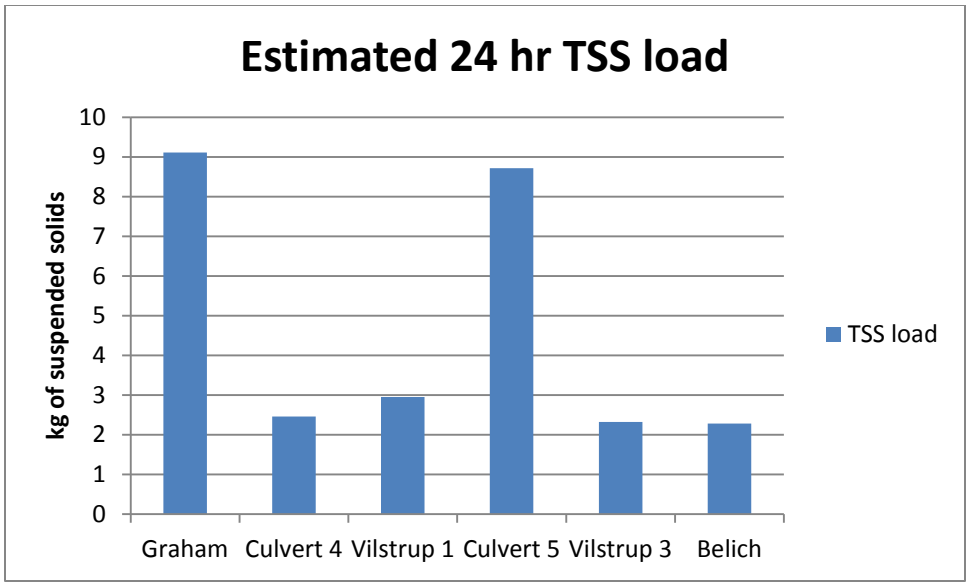

Figure 7: Estimated 24 hour total suspended solids load based upon mean flow and mean TSS concentration.

As the graphs indicate, Culvert 5 represents the largest load estimate for phosphorus and is second for TSS, slightly behind Graham. Keep in mind, Vilstrup 1, Culvert 5 and Vilstrup 3 are the same tributary. Vilstrup 3 is the best reflection of the amount of phosphorus and suspended solids to be discharged into Bone Lake from this tributary as it is the closest sample site to the lake. A rationalization for the difference between Vilstrup 1 and 3 and Culvert 5 is discussed in the next section.

Graham has higher load largely due to high flow volumes even though the concentrations are quite low.

Function of settling ponds at Vilstrup 1, 3 and Culvert 5

The Vilstrup 1 site is just below the second of two settling ponds. The Culvert 5 site is downstream on the end of the culvert running under the road. The water was sampled from the end of this culvert. This water flows into a third settling pond, then down to Bone Lake. Vilstrup 3 is a small culvert that runs under a foot path between two private lots and is after the last settling pond and just upstream of Bone Lake.

As the nutrient concentrations show, Vilstrup 1 is the highest followed by Culvert 5, then Vilstrup 3. This may be showing that the nutrients are being reduced by the settling ponds, with the least concentration of the three being the last sample site, representing the water that is loading Bone Lake with phosphorus and sediment.

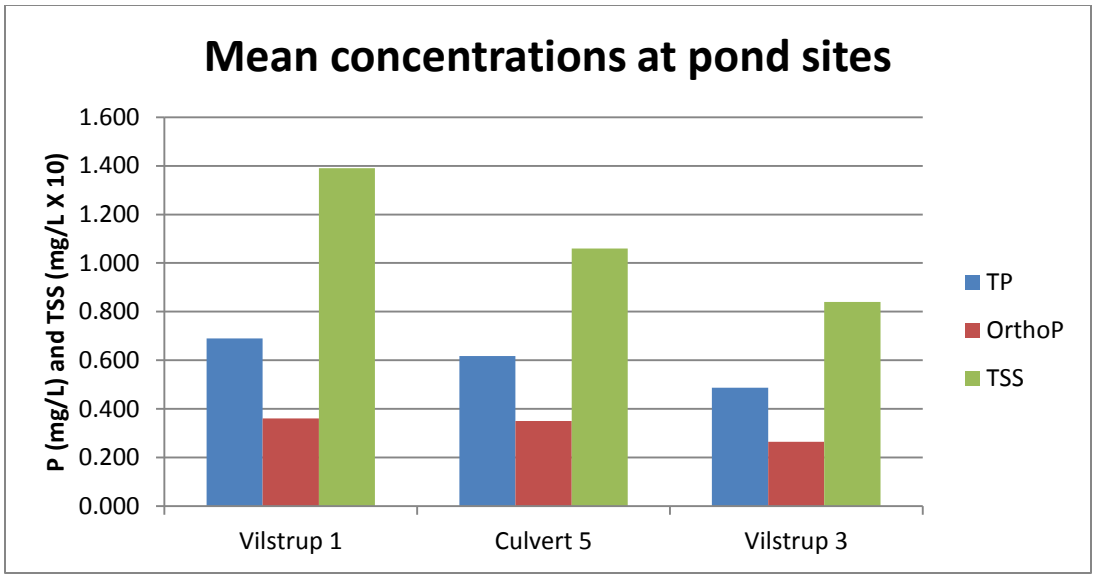

Figure 8: Mean total phosphorus, orthophosphate, and total suspended solids at the three sample sites incorporating the settling ponds. The sites are listed for upstream to downstream.

Culvert 5 did have the highest mean flow and as a result the highest estimated 24 hr load. This could be due to the water being reduced at Vilstrup 1 from the filling of the first settling pond, reducing flow at Vilstrup 1. Between Vilstrup 1, it appears that the tributary is picking up more flow, possibly from the road ditches and land surrounding that area, thus increasing flow at Culvert 5. It appears that Vilstrup 3 has lower flow, maybe due to the filling of the settling pond, thus reducing discharge to Vilstrup 3. It is not known precisely how these ponds are reacting to flow during rain events, but they do appear to be reducing phosphorus and suspended sediments from the water flowing into Bone Lake.

Data:

	5/18/2016						
SITE	**Flow (cfs)**	**TP conc (mg/L)**	**OrthoP conc(mg/L)**	**TSS conc(mg/L)**	**TP load(kg/day)**	**Ortho load(kg/day)**	**TSS load(kg/day)**
Graham	0.060	0.041	0.013	8.600	0.01	0.002	1.27
Culvert 4	0.009	0.103	0.030	3.200	0.00	0.001	0.07
Vilstrup 1	0.028	0.657	0.304	16.700	0.05	0.021	1.15
Culvert 5	0.079	0.367	0.214	3.000	0.07	0.041	0.58
Vilstrup 3	0.057	0.248	0.150	0.000	0.03	0.021	0.00
Belich	0	n/a	n/a	n/a	n/a	n/a	n/a
	5/26/2016						
SITE	**Flow (cfs)**	**TP conc (mg/L)**	**OrthoP conc(mg/L)**	**TSS conc(mg/L)**	**TP load(kg/day)**	**Ortho load(kg/day)**	**TSS load(kg/day)**
Graham	0.894	0.021	0.007	0.000	0.05	0.016	0.00
Culvert 4	0.005	0.085	0.018	2.600	0.00	0.000	0.03
Vilstrup 1	0.063	0.601	0.291	6.750	0.09	0.045	1.04
Culvert 5	0.058	0.495	0.332	2.800	0.07	0.047	0.40
Vilstrup 3	0.021	0.336	0.208	2.600	0.02	0.011	0.13
Belich	0	n/a	n/a	n/a	n/a	n/a	n/a
	7/6/2016						
SITE	**Flow (cfs)**	**TP conc (mg/L)**	**OrthoP conc(mg/L)**	**TSS conc(mg/L)**	**TP load(kg/day)**	**Ortho load(kg/day)**	**TSS load(kg/day)**
Graham	1.260	0.069	0.020	4.200	0.21	0.060	12.95
Culvert 4	0.042	0.155	0.048	10.800	0.02	0.005	1.11
Vilstrup 1	0.283	0.641	0.287	28.000	0.44	0.199	19.41
Culvert 5	0.546	0.797	0.442	12.300	1.06	0.590	16.43
Vilstrup 3	0.268	0.641	0.351	14.500	0.42	0.230	9.50
Belich	0.148	0.174	0.063	16.700	0.06	0.023	6.03

	7/13/2016						
SITE	**Flow (cfs)**	**TP conc (mg/L)**	**OrthoP conc(mg/L)**	**TSS conc(mg/L)**	**TP load(kg/day)**	**Ortho load(kg/day)**	**TSS load(kg/day)**
Graham	4.275	0.052	0.023	0.000	0.54	0.240	0.00
Culvert 4	0.014	0.134	0.043	5.000	0.00	0.001	0.17
Vilstrup 1	0.021	0.674	0.361	12.700	0.03	0.018	0.64
Culvert 5	0.118	0.392	0.199	4.200	0.11	0.057	1.21
Vilstrup 3	0.094	0.346	0.153	8.000	0.08	0.035	1.83
Belich	0.028	0.122	0.035	10.800	0.01	0.002	0.75
	8/18/2016						
SITE	**Flow (cfs)**	**TP conc (mg/L)**	**OrthoP conc(mg/L)**	**TSS conc(mg/L)**	**TP load(kg/day)**	**Ortho load(kg/day)**	**TSS load(kg/day)**
Graham	0.322	0.090	0.034	3.600	0.07	0.027	2.84
Culvert 4	0.270	0.238	0.046	52.500	0.16	0.030	34.68
Vilstrup 1	0.038	0.876	0.562	5.500	0.08	0.053	0.51
Culvert 5	0.876	1.040	0.565	30.800	2.23	1.211	66.03
Vilstrup 3	0.125	0.864	0.460	17.000	0.26	0.141	5.20
Belich	0.116	0.220	0.098	20.500	0.06	0.028	5.82
	Means						
SITE	**Flow (cfs)**	**TP conc (mg/L)**	**OrthoP conc(mg/L)**	**TSS conc(mg/L)**	**TP load(kg/day)**	**Ortho load(kg/day)**	**TSS load(kg/day)**
Graham	1.36	0.06	0.02	2.73	0.19	0.07	9.11
Culvert 4	0.07	0.14	0.04	14.82	0.02	0.01	2.46
Vilstrup 1	0.09	0.69	0.36	13.93	0.15	0.08	2.95
Culvert 5	0.34	0.62	0.35	10.62	0.51	0.29	8.71
Vilstrup 3	0.11	0.49	0.26	8.42	0.13	0.07	2.33
Belich	0.06	0.17	0.07	16.00	0.02	0.01	2.29