Water Quality Monitoring in the Clearwater Basin: Continuing Citizen Science

Addendum to Completion Report for 2017
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Introduction

In 2013 and 2016 the Clearwater Resource Council in collaboration with the Southwest Crown Collaborative, local schools, volunteers, and neighboring organizations conducted extensive sampling to describe turbidity, Total Suspended Solids (TSS) and nutrient concentrations (Total Nitrogen and Phosphorous) in Clearwater Basin streams (Rieman and Wallenburn 2014, Rieman and Wallenburn 2015, Rieman and Wallenburn 2017). In 2016 sampling extended across the basin including most of the major tributaries to the larger valley bottom lakes. Turbidity, TSS, total N, and total P were sampled in 15 streams throughout the spring runoff. Turbidity was sampled in an additional 13 streams over the same period. Results indicated that water quality varied substantially within and among streams across the basin and that continued work would be useful to resolve important nutrient sources potentially influencing the lakes, refine monitoring techniques and build a foundation to understand long-term change.

Monitoring continued in 2017 and detailed sampling (turbidity, Total P and Total N) was replicated in the 15 streams sampled in 2016. Regular nutrient sampling was added in 5 more streams where turbidities in 2016 indicated that water quality could be of concern or where nutrient samples had not been collected in the past because of limited funding, logistical constraints or oversight. The 2017 samples represent the most complete look at water quality across the major tributary streams of the Clearwater Basin above Salmon Lake to date. Samples were collected weekly from mid March through June 2017, a period typically encompassing more than 80% of total discharge in the basin. Five additional sites were sampled intermittently or for turbidity only, to resolve local sources within larger tributaries. A single nutrient sample was also collected upstream of the housing development and a major road in the Seeley Creek drainage in an effort to refine understanding of potential sources in that watershed. Sampling was by trained volunteers and all protocols and analysis were the same as in 2016 (Rieman et al. 2017). Sample sites are shown in Figure 1 and described in Appendix A. All raw data are available in Appendix B. This report provides the 2017 results across streams, a comparison of median turbidity and nutrient concentrations within streams across years, and comparison of relative nutrient loading estimated for different sources in the sub-basins encompassing Salmon and Seeley Lakes. Additional summary information and graphs are available from CRC.

Detailed monitoring of stream flow, water quality and estimates of annual nutrient loading in Morrell Creek also continued in 2017, but will be summarized in a separate report.

Results

2017 Water Quality for Across Streams
As in the past turbidity, Total P, and Total N varied substantially within and among streams in 2017. Turbidity tended to increase with flow, often substantially early in the runoff, and then decline later in the season even with subsequent peaks in runoff (data not shown but available from CRC). Peaks in turbidity commonly exceeded 6 NTU and were as high as 36 NTU (Figure 2), but medians exceeded 6 NTU in only one stream (EFC). Several sites including OWL, LCL and LLC remained relatively clear throughout the period and SWP was remarkably clear remaining below 1.2 NTU in all samples.

Total P tended to increase with flow and varied substantially across the season. Ten streams exceeded 25 µg/l in a single sample, but only three streams CLT, SEL and UHL had medians that exceeded 15 µg/l (Figure 3). Medians for MDM, TRL and SWP were all less than 7 µg/L and BLI was less than 4. Total P varied directly with turbidity across all streams (Figure 4). It also varied directly with turbidity within each stream except SWP, but the associations differed sometimes substantially, among streams (Figure 5).

Peaks in total N ranged from 130 µg/L (MDM) to more than 700 to 1000 µg/L (SWP, SEL and MTN respectively) across streams in 2017 (Figure 6). Median concentrations exceeded 300 µg/L in two streams (BER and SEL) and BER remained above 275 µg/L through the entire season. MDM remained below 130 µg/L the entire season.

To identify potential concerns in water quality across the basin we highlighted concentrations for three metrics that exceeded several threshold values and also ranked streams relative to each other (Table 1). SEL consistently was among the worst conditions across all metrics. RCM and RIC ranked among the poorest water quality overall as well. Multiple streams ranked highly in one or two metrics, but not all three. BER had the highest concentrations of total N, exceeding water quality standards (275 µg/L) through the entire period, was among those with higher total P, but remained low in turbidity throughout the season. BOL, PLC, OWL, CLT, UHL, and LCL all had high levels of total P, but moderate (OWL, CLT) or lower levels in the other metrics. Conversely, BLI, TRL, and SWP were consistently among the streams with the best conditions across metrics and MDM was not substantially worse.

Water Quality Across Years
Differences among streams were relatively consistent across years. For streams sampled in both 2016 and 2017, median turbidity was higher in 16 of the 19 streams sampled in 2017 (Figure 7). EFC, RCM, RIC, SEL, CLT, and INZ were the

most turbid streams while BLI, TRL, PLC and OWL were the clearest. SWP was remarkably clear with median turbidity below 0.5 NTU in both years. Median total P varied among years within streams, but with the exception of BLI and TRL differences within streams were not substantial (Figure 8) and differences among streams were generally consistent. SEL, RIC, BOL, PLC were among the streams with the highest total P and MDM, BLI and TRL the lowest across years. Even so, median concentrations of total P in BLI and TRL varied approximately 2 fold across years. In streams where total N was sampled across two or more years, median concentrations varied relatively little within most streams (Figure 9). Differences among years were largest in streams that were among those with the highest concentrations (RIC, DER, SEL).

For streams also sampled in 1975 (RIC, DER, SEL) all appeared to decline in concentrations of total N over the longer period (Figure 10). Differences in medians were most pronounced in DER. Total P also appeared to decline substantially in DER, but increased modestly in RIC and more substantially in SEL (Figure 11).

Because of the apparent increase in SEL relative to 1975 we collected a single sample for TN and TP in March of 2017 when concentrations in both tend to be higher. We hypothesized that increases in P in SEL might be associated with more recent development (housing, increased road traffic) just above the sampling point on that stream. The added site was at the bridge on the Seeley Creek ski trails well upstream of the other potential effects. Total N was 392 at the upstream site and 504 µg/L at the regular site. Total P was 25.9 µg/L and 24.9 µg/L respectively.

Relative Nutrient Loading

Watershed model estimates of mean annual flow varied more than 100 fold among streams, from 1.5 CFS in Rice Creek (RIC) to more than 171 CFS in the Lower Clearwater River (LCL) (Table 2). The index of nutrient load varied as a function of both mean flow and nutrient concentration. The largest streams and sites with the higher concentrations of nutrients (e.g. UCL, LCL, and OWL) were far more important potential nutrient sources than many smaller streams.

To explore the potential importance of different streams we looked at the relative contribution of every sampled tributary stream above Salmon and Seeley lakes. In both cases we estimated the contribution from unknown sources as the differences in downstream sites (i.e., OWL, LCL, UCL) from the total of all tributaries directly contributing to those sites (Appendix C).

When we considered all relative loading of Total P to Salmon Lake (Table 3), PLC was most important estimated as contributing (22%) almost twice any other stream. BOL, WFC and unknown sources associated with Seeley Lake, all were estimated to contribute 10% or more of the total. For Total N PLC, WFC and unknown sources in Morrell and Seeley Lake watersheds were most important (Table 3). In all we estimated that 23% of the total P and 52% of the Total N loading for Salmon lake came from unknown sources.

When we considered all relative loading of P and N to Seeley Lake (Table 4), WFC, EFC and DER and unknown sources associated with Seeley Lake and the Upper Clearwater were most important. We estimated that 39% of both the Total P and Total N came from unknown sources.

Discussion

Water Quality Across Streams
The volunteer data collection in 2017 provided replication for many streams across the Clearwater Basin and also filled important gaps. Nutrient concentrations and turbidity are now available for at least one season for every sizeable sub watershed above Salmon, Seeley, and Placid lakes and multiple tributary streams within those watersheds.

Our sampling was not focused on formal (regulatory) water quality impairment. Water quality standards apply only to nutrient concentrations from July through September when stream ecological functioning may be impaired. We focused on the spring period when most of the water and nutrients are flushed from the tributaries and contribute most strongly to the total load in the lakes. Despite that, three streams BER, SEL, and RIC were near, or exceeded the 275 µg/L standard for Total N in most samples. BER may be of particular concern because concentrations were among the highest in late June just before formal standards take effect.

We found multiple streams that did not exceed regulatory standards, but should be of concern because of elevated concentrations of Total P (EFC, RCM, UCL, BOL, PLC, OWL, CLT, UHL, INZ) Total N (DER) or both (SEL, RIC, RCM, LCL, OWL, BER). Further work to understand and mitigate any nutrient sources within any of these watersheds could be important.

In some cases that work may already be underway. Elevated N and P in several streams in the Basin have been associated with the effects of past industrial scale forestry (logging and roading). The common association of turbidity and total P in our streams and others indicates that accelerated erosion may be an important source of P. MT FWP, the USFS and Nature Conservancy, all major landowners in the basin, have done and continue to plan considerable work to mitigate erosion and sediment delivery on road segments across several of these watersheds. Though we do not understand the specific causes for elevated nutrients in any of these streams, the information summarized from this work provides a foundation for monitoring and resolution of potential sources. Over the long term, broad scale monitoring like that initiated here, could help resolve the benefits of current restoration. More refined monitoring within problematic watersheds might also help resolve particularly important problem areas or sources that could help focus restoration more effectively.

Water Quality Across Years
Continued monitoring should help clarify how ongoing management, active restoration, passive recovery, and natural disturbance influence water quality across the basin. Consistent patterns among streams between years indicated real differences that must result from watershed conditions. Still variability within streams among years is important. That suggests it will be important to have multiple years of data to characterize the condition of any stream or recognize long-term change in the future.

Total N and total P are key information and especially relevant to the condition of the lakes. Turbidity also provided information that guided us to more detailed (and expensive) nutrient sampling. Turbidity does tend to vary with total P, but turbidity can also be highly episodic (Rieman and Wallenburn 2017) and the relationships within streams were not consistent among them. Turbidity might be used as a simple and inexpensive index, but more detailed nutrient sampling will likely be needed to identify and monitor important changes through time.

Apparent long-term decline in both N and P in Deer Creek and P in Rice and Seeley creeks indicates that watersheds may recover over a period of decades with the cessation of intensive watershed disturbance. Recent work by the CFLR indicates that road traffic can have a substantial influence on erosion, so reducing or eliminating heavy logging traffic may have had positive effects. Alternatively, increased activity could aggravate conditions in the future. Recent forest and watershed restoration and fire suppression activities could also have an important influence on water quality, but the effects may play out over an extended time. CLT and UHL for example had the highest levels of total P observed across streams in 2017. They have a history of industrial forestry, but also recent intensive forest and watershed restoration work. Whether current water quality is the result of a long history of disruption or recent activity that could lead to more rapid recovery can't be resolved. The foundation for further monitoring that might clarify questions like that, however, is now in place.

Relative Nutrient Loading
A number of streams across the Clearwater Basin should be of concern as sources of nitrogen and phosphorous loading to the lakes. Three may violate or threaten water quality standards, while others appear to be substantially elevated above levels characteristic of minimal human or natural disturbance. Any work that can be done to resolve and mitigate sources within any of these watersheds should be useful.

It is also important to consider priorities more strategically if possible. Although multiple streams show elevated nutrient concentrations, some are more important as sources simply because of the total amount they contribute. For example, three streams PLC, BOL, and the WFC contribute an estimated 44% of the Total P and 28% of Total N that enters the system above Salmon Lake. Nutrient concentrations were higher in the first two. Because Placid and Boles have only recently entered conservation ownership, they may present more obvious opportunities for shortterm restoration (i.e., the "low hanging fruit"). WFC has a longer history of conservation ownership and active restoration by MTFWP has been underway for several years so remaining mitigation opportunities may be less obvious. Some consideration of the opportunities across the basins within the watersheds that appear to be the largest sources might be a first step toward a more strategic approach to basin wide restoration.

More work is needed to resolve the unknown sources of nutrients and that could mean refocusing work on and around the lakes and larger tributaries immediately upstream. We estimated that about 43% of total N entering above Salmon Lake came from unknown sources. Even though we sampled all major streams above the lake and many of the smaller tributaries, a large part of the N and important part of the P (23 %) must ultimately come from ground water, shoreline erosion, very small tributaries associated with the lakes and larger streams (OWL, LCL, or UCL) or even the lakes themselves. Placid, Seeley, and Inez all have significant housing development and past work in the basin has shown that failing septic systems are an important sources of N contamination to ground water in the basin (Watson 2012). Our own work shows that Salmon and Seeley lakes experience Dissolved Oxygen Deficits (Rieman et al 2015) that might lead to a tipping point as lakes move from acting as nutrient sinks to nutrient sources. We also noted a substantial influx of unexplained N in lower Morrell Creek downstream of housing and resort development and the same thing could be occurring with homes and septic systems in the Clearwater River downstream of Seeley Lake, around Placid Lake and Lake Inez.

The new sewer anticipated for downtown Seeley Lake could provide some mitigation for nitrogen loading in that immediate area. It may be important, however, to address similar issues more broadly to mitigate nutrient contamination important for the long-term future of the lakes.

Recommendations

1. Rather than continue routine monitoring on all streams, further work could be focused on resolving important unknowns in watersheds that appear most important to nutrient loading of downstream lakes (i.e. Owl Creek and Placid Lake, Morrell Creek between upstream tributaries and the Clearwater River, Seeley Lake and the Upper Clearwater above Seeley Lake).

2. Work with primary landowners in Boles Creek, Placid Creek, West Fork Clearwater, Deer Creek, East Fork Clearwater, Colt Creek, Uhler Creek, Inez Creek and Richmond Creek watersheds to understand existing watershed evaluations and any ongoing or planned restoration. Determine whether further work is needed to identify in-watershed sources or whether the focus should be on periodic monitoring to understand the benefits of planned or already completed work.

3. Work with Landowners and/or State Regulatory Agencies to address apparent water quality issues in Rice, Seeley, and Bertha Creeks.

4. Use turbidity collected by volunteers on a weekly basis only as a coarse filter for water quality. Rely on nutrient sampling to resolve the importance of any potential sources.

5. Work to archive all water quality data and reports so they are available in the future.

6. Find funding for a paleolimnological study to determine the long-term history of change in one or more of the downstream lakes.

References

Rieman, B.E., J. Wallenburn. 2014. Water quality monitoring to determine the influence of roads and road restoration on turbidity and downstream nutrients: a pilot study with citizen science. Completion report Southwest Crown CFLRP, Agreement # 12-PA-11011600-039 (available online: https://static1.squarespace.com/static/58ac86718419c25e73caff05/t/5a1c8ceae2c483f5ad347105/1511820598785/2014ContractCompletionWaterQualityMonitoring050114-1.pdf)

Rieman and Wallenburn. 2015. Water quality monitoring to determine the influence of roads and road restoration on turbidity and downstream nutrients: a pilot study with citizen science. Addendum to the Completion report Southwest Crown CFLRP, Agreement # 12-PA-11011600-039 (available on line: https://static1.squarespace.com/static/573f50e4e32140034604e862/t/580625501b631b4e18972f2d/1476797782003/Addendum+to+Water+Quality+Report+Final.pdf)

Rieman, B. and J Wallenburn. 2017. Water quality monitoring in the Clearwater Basin including data from the Swan and Blackfoot Basins: Continuing Citizen Science. Completion report for the Southwest Crown CFLRP, Supplemental Project Agreement 16-PA-11011600-040. With Technical support from Shane Hendrickson, Elaine Caton, Jennifer Schoonen, Joe Zimbric and Sara Halm (available on line: https://static1.squarespace.com/static/58ac86718419c25e73caff05/t/5984e637c534a5778bd15d0c/1501881957180/2016+Adopt-A-Stream+Annual+Report.pdf)

Rieman, B., J. Wallenburn, G. Niederoest, C. Harrits, and J. Harrits. 2015. Adopt A Lake monitoring 2014 progress report. Clearwater Resource Council, Seeley Lake, MT (available on line: https://static1.squarespace.com/static/573f50e4e32140034604e862/t/587546979de4bbc175ee6c68/1484080814851/AdoptALake2014report.pdf)

Water Quality Report 2017 water year

Figures

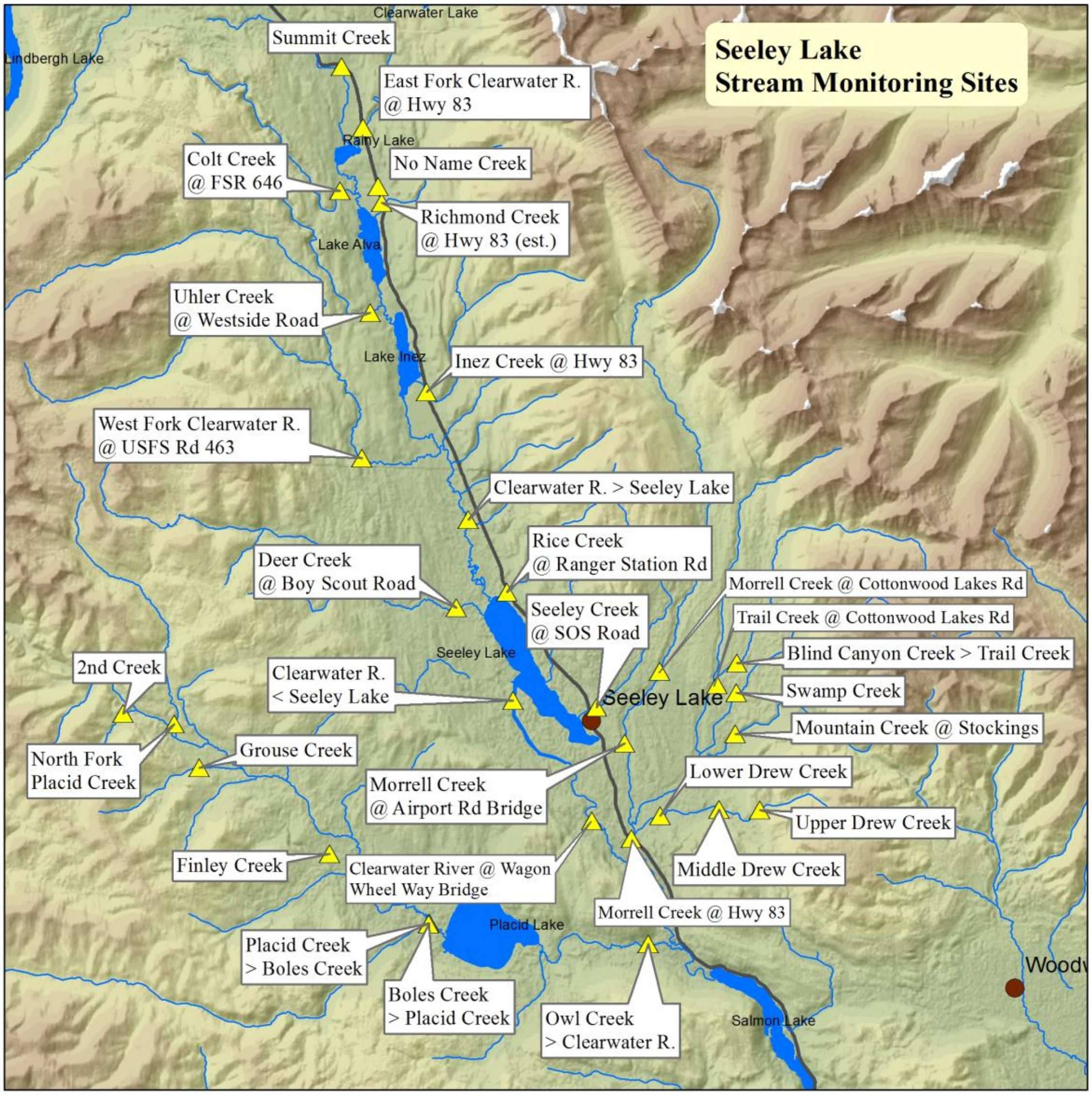


Figure 1. Sample Sites for 2017. Note that Summit Creek on the map should be Bertha and is identified as BER in the data set and Appendix A.

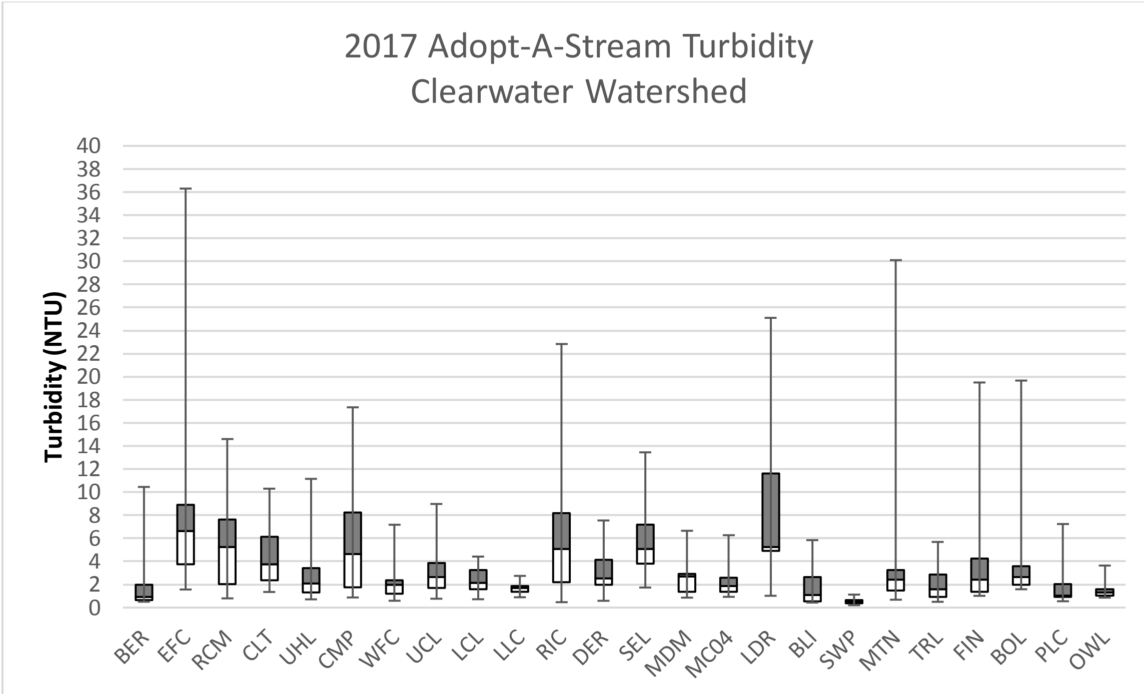


Figure 2. Turbidity in 24 sites in the Clearwater Basin, mid-March through June 2017. The vertical lines show the range of samples. The tops/bottoms of the bars show the 25th, 50th (median), and 75th quartiles. The codes for stream names are in Appendix A.

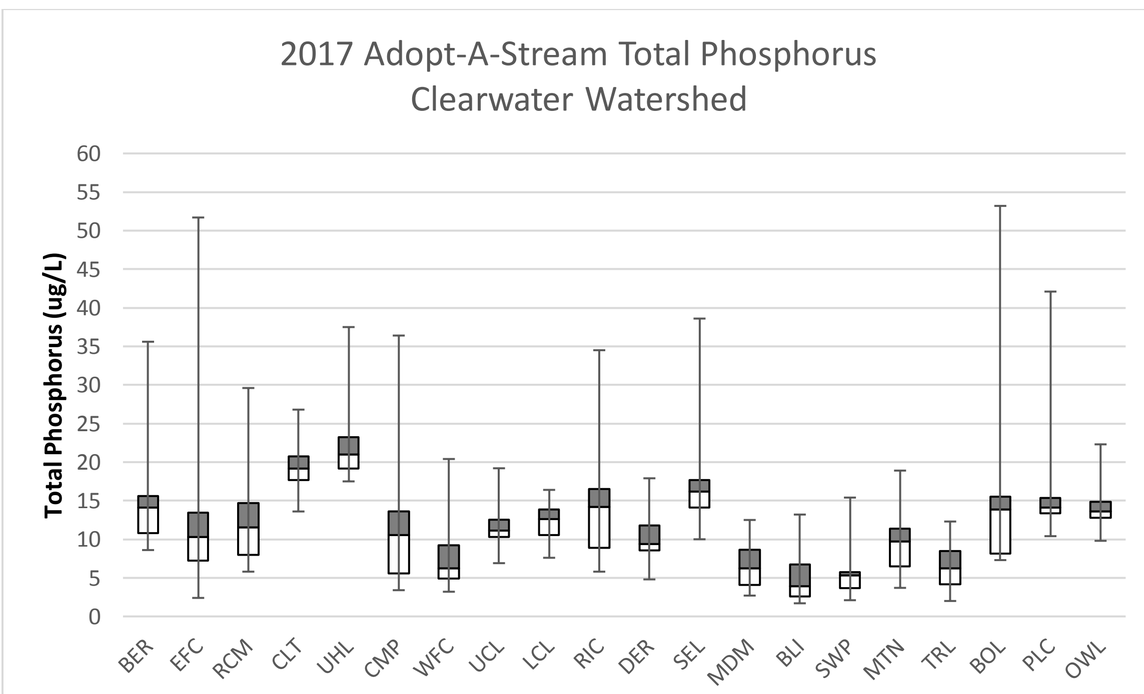


Figure 3. Total phosphorous in 20 sites in the Clearwater Basin, March through June 2017. The vertical lines show the range of samples. The tops/bottoms of the bars show the 25th, 50th (median), and 75th quartiles. The codes for stream names are

in Appendix A.

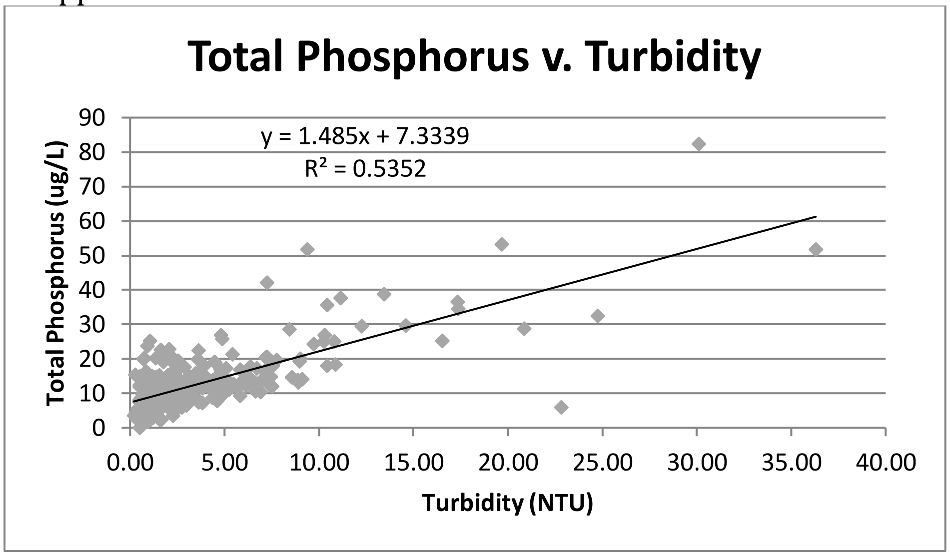
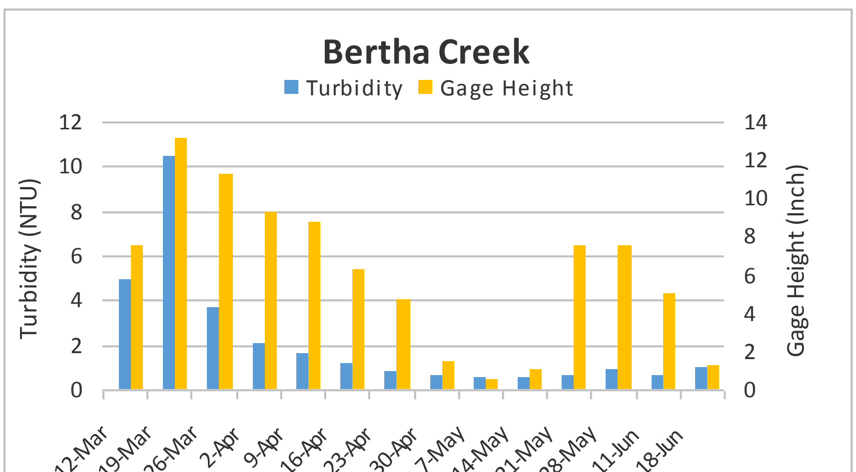


Figure 4. Associations of total phosphorous with turbidity across all sites sampled in the Clearwater Basin during runoff in 2017.

A.



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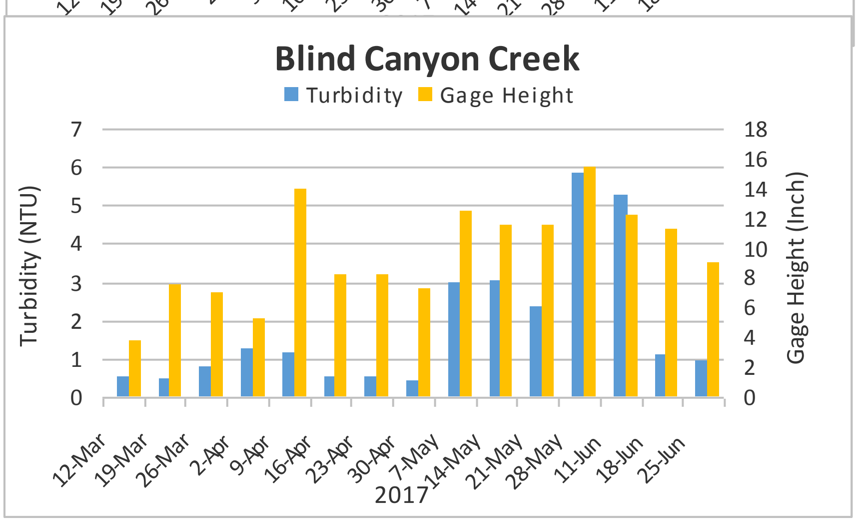

C.

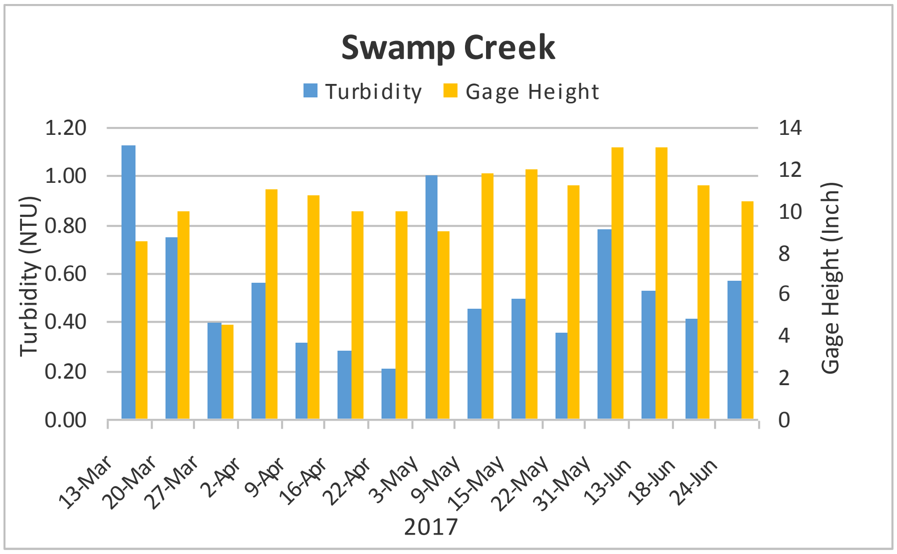

Figure 5. Associations of total phosphorous with turbidity in three sites (A=BER, B= BLI, C=SWP) sampled in the Clearwater Basin during runoff in 2017.

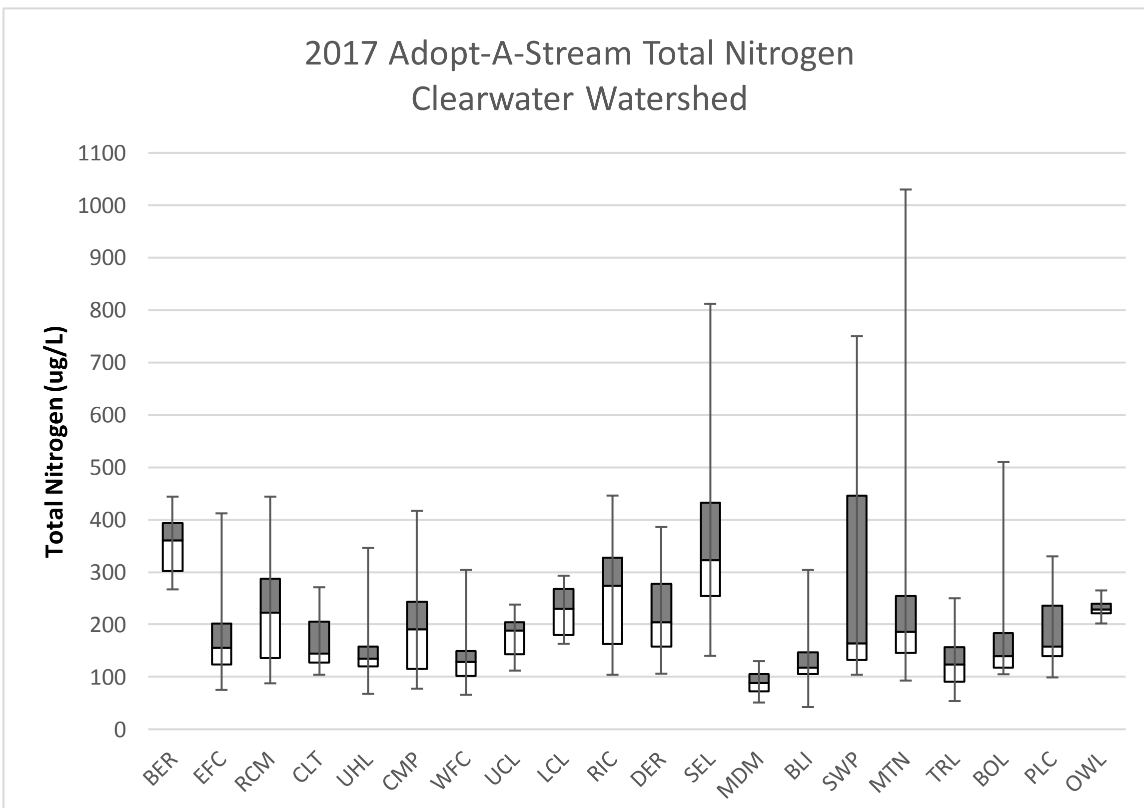

Figure 6. Total nitrogen in 20 sites in the Clearwater Basin, March through June 2017. The vertical lines show the range of samples. The tops/bottoms of the bars show the 25th, 50th (median), and 75th quartiles. The codes for stream names are in Appendix A.

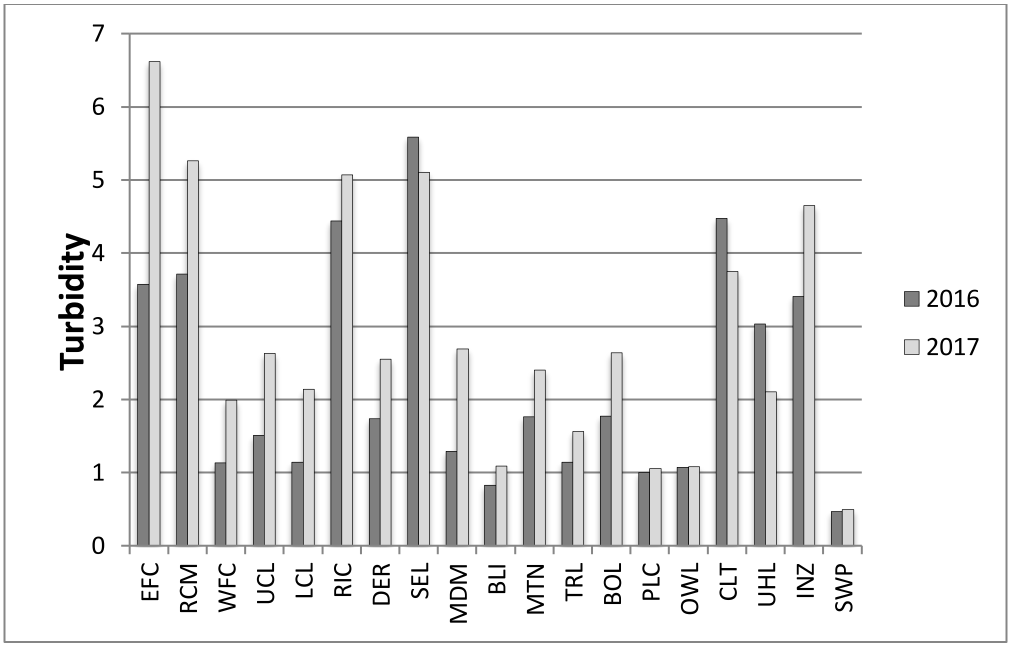

Figure 7. Median turbidity in 19 sites in the Clearwater Basin sampled from mid March through June in 2016 and 2017.

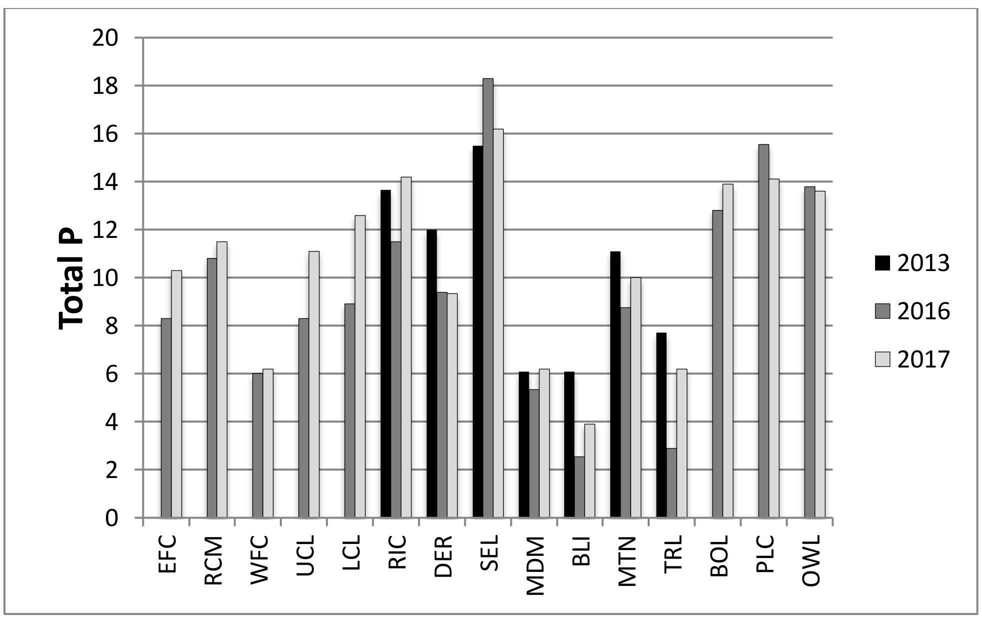

Figure 8. Median total P in eight sites in the Clearwater Basin sampled from mid March through June in 2016 and 2017 and 7 sites sampled in 2013, 2016 and 2017.

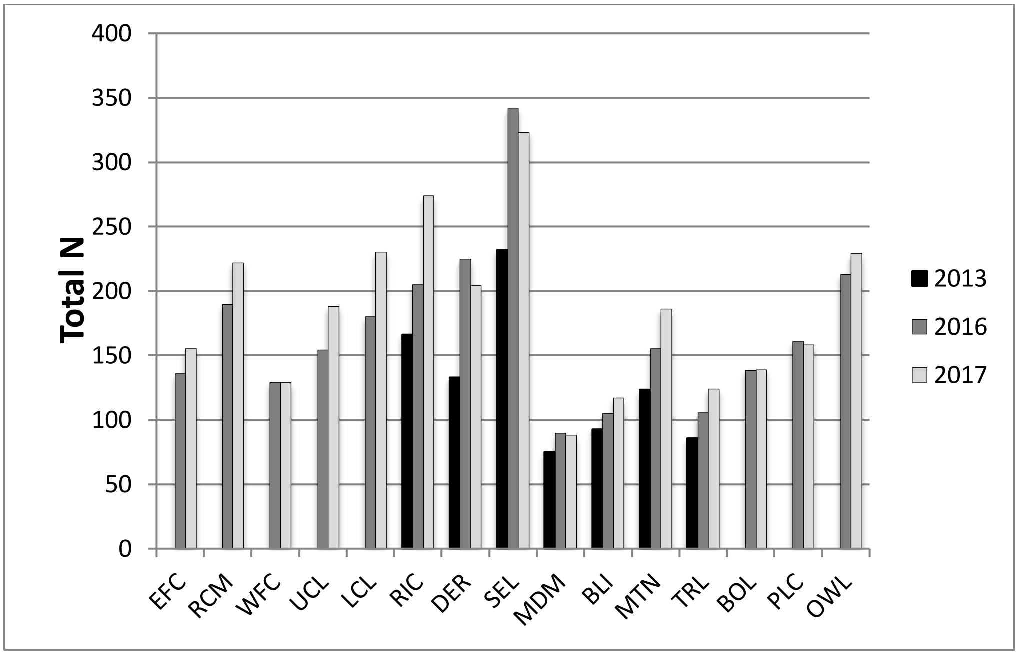

Figure 9. Median total N in eight sites in the Clearwater Basin sampled from mid March through June in 2016 and 2017 and 7 sites sampled in 2013, 2016 and 2017.

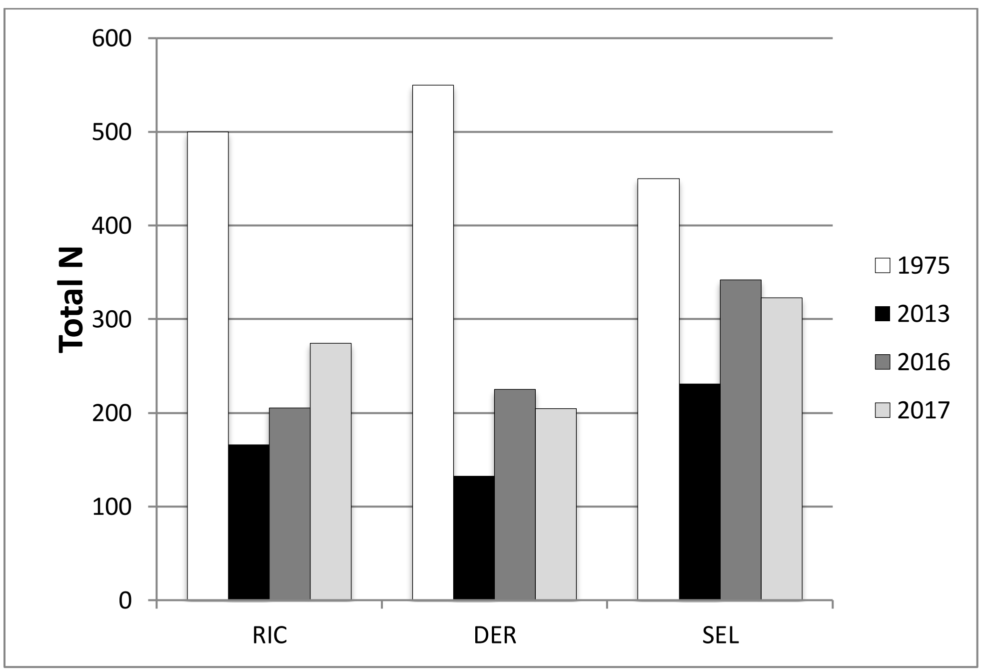

Figure 10. Median total N in three (RIC, DER, SEL) streams sampled in 1975, 2013, 2016 and 2017.

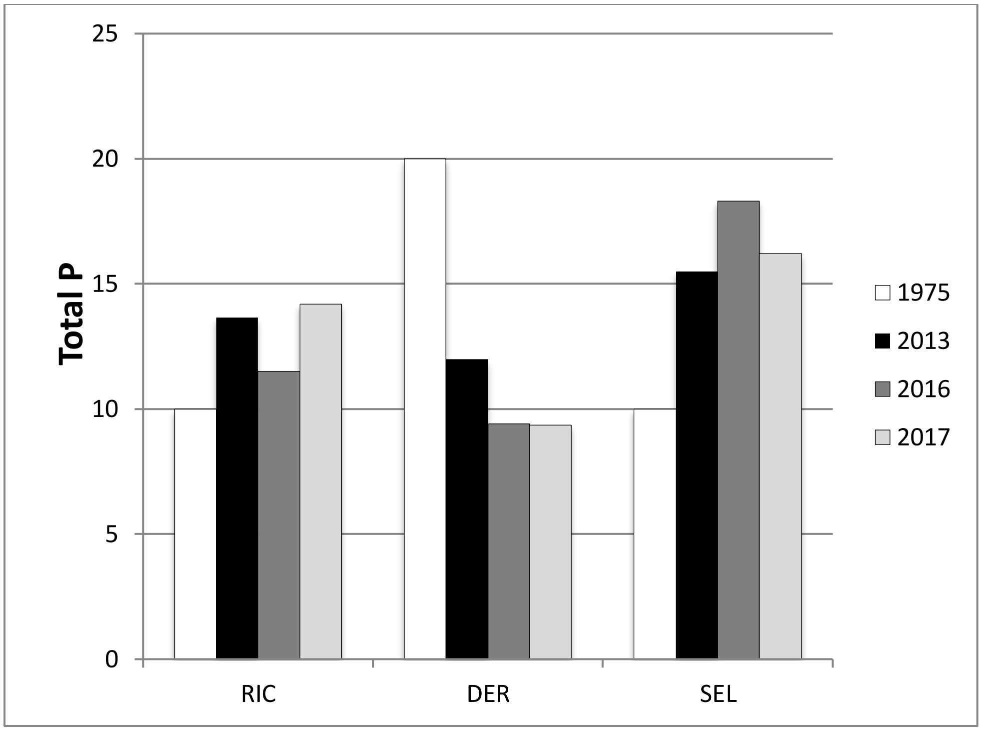

Figure 11. Median total P in three (RIC, DER, SEL) streams sampled in 1975, 2013, 2016 and 2017.

Tables

Table 1. Median concentrations and rank among all streams for total phosphorous, total nitrogen (both µg/L), and turbidity (NTU) in 2017. Streams with median concentrations above 200 µg/L total N and 10 µg/L total P are highlighted as are those that rank among the top three in the watershed for any metric or the combination of all three metrics. The codes for stream names are in Appendix A.

Median	**EFC**	**RCM**	**WFC**	**UCL**	**LCL**	**RIC**	**DER**	**SEL**	**MDM**	**BLI**
Phosphorous	10.30	11.50	6.20	11.01	12.60	14.20	9.35	16.20	6.20	3.90
Nitrogen	155.00	222.00	129.00	188.00	230.00	274.00	204.50	323.00	88.00	117.00
Turbidity	6.62	5.26	1.99	2.63	2.14	5.07	2.55	5.10	2.69	1.09
Rank										
Phosphorous	13	10	16	11	9	4	15	3	17	20
Nitrogen	13	6	17	9	4	3	7	2	20	19
Turbidity	1	2	14	9	12	4	10	3	7	17
Rank All	8	3	17	9	5	2	13	1	16	20

Median	**MTN**	**TRL**	**BOL**	**PLC**	**OWL**	**CLT**	**UHL**	**INZ**	**SWP**	**BER**
Phosphorous	10.00	6.20	13.90	14.10	13.60	19.20	21.00	10.55	5.30	14.10
Nitrogen	186.00	124.00	139.00	158.00	229.00	144.00	135.00	191.00	164.00	360.50
Turbidity	2.40	1.56	2.64	1.05	1.29	3.75	2.10	4.65	0.49	0.94
Rank										
Phosphorous	14	18	7	5	8	2	1	12	19	6
Nitrogen	10	18	15	12	5	14	16	8	11	1
Turbidity	11	15	8	18	16	6	13	5	20	19
Rank All	14	19	11	15	10	4	12	6	18	7

Table 2. Mean annual flow and a weighted index of the load of total phosphorous (P) and total nitrogen (N) among intensively sampled streams in the Clearwater Basin 2017. Mean flow was the annual mean estimated from watershed models (VIC) of stream flow at the sampling site. Normalized flow is the annual flow for each site divided by flow at the long-term site on Morrell Creek. The indices of total P load and N load were calculated as the products of the median concentrations x mean annual flow. Normalized P load and N load are relative calculated by dividing the index for a stream in question by the index at Morrell Creek. The codes for stream names are in Appendix A.

Stream	EFC	RCM	WFC	UCL	LCL	RIC	DER	SEL	MDM	BLI
Mean Flow (CFS)	28.1	1.91	65.41	131.57	171.64	1.5	25.14	2.98	40.47	12.23
Normalized Flow	0.69	0.05	1.62	3.25	4.24	0.04	0.62	0.07	1.00	0.30
P Load	289	22	406	1449	2163	21	235	48	251	48
N Load	4356	424	8438	24735	39477	411	5141	963	3561	1431
Normalized P Load	1.15	0.09	1.62	5.77	8.62	0.08	0.94	0.19	1.00	0.19
Normalized N Load	1.22	0.12	2.37	6.95	11.08	0.12	1.44	0.27	1.00	0.40

Stream	MTN	TRL	BOL	PLC	OWL	CLT	UHL	INZ	SWP	BER
Mean Flow (CFS)	5.4	19.94	34.6	64.79	110.9	4.08	2.99	9.83	5.87	4.23
Normalized Flow	0.13	0.49	0.85	1.60	2.74	0.10	0.07	0.24	0.15	0.10
P Load	54	124	481	914	1508	78	63	104	31	60
N Load	1004	2473	4809	10237	25396	588	404	1878	963	1525
Normalized P Load	0.22	0.49	1.92	3.64	6.01	0.31	0.25	0.41	0.12	0.24
Normalized N Load	0.28	0.69	1.35	2.87	7.13	0.16	0.11	0.53	0.27	0.43

Table 3. The estimated relative load of total phosphorous (P) and total nitrogen (N) for sampled tributaries upstream of Salmon Lake. Unknown (UNK) reflects the difference in load at downstream sites (OWL, UCL, LCL) and the accumulation of sampled sites upstream. Unknown sources could include smaller tributaries and groundwater that enter the major streams below the upstream sample sites, enter the lakes directly, or the lakes (Rainy, Alva, Inez, Seeley, and Placid) themselves. Shaded values are those that appear to contribute 10% or more of the total. The codes for stream names are in Appendix A.

	OWL Watershed			Seeley Lake			
Stream	**BOL**	**PLC**	**UNK**	**DER**	**RIC**	**SEL**	**UNK**
Total P	481	914	114	235	21	48	409
Total N	4809	10237	10350	5141	411	963	8228
Relative P	0.12	0.22	0.03	0.06	0.01	0.01	0.10
Relative N	0.06	0.12	0.13	0.06	0.00	0.01	0.10

	Morrell Watershed					
Stream	**MDM**	**BLI**	**MTN**	**TRL**	**SWP**	**UNK**
Total P	251	48	54	124	31	0
Total N	3561	1431	1004	2473	963	8298
Relative P	0.06	0.01	0.01	0.03	0.01	0.00
Relative N	0.04	0.02	0.01	0.03	0.01	0.10

	Upper Clearwater Watershed							
Stream	**EFC**	**RCM**	**WFC**	**CLT**	**UHL**	**INZ**	**BER**	**UNK**
Total P	289	22	406	78	63	104	60	428
Total N	4356	424	8438	588	404	1878	1525	7124
Relative P	0.07	0.01	0.10	0.02	0.02	0.02	0.01	0.10
Relative N	0.05	0.01	0.10	0.01	0.00	0.02	0.02	0.09

Table 4. The estimated relative load of total phosphorous (P) and total nitrogen (N) for sampled tributaries upstream of Seeley Lake. Unknown (UNK) reflects the difference in load at a downstream site (UCL, LCL) and the accumulation of sampled sites upstream. Unknown sources could include smaller tributaries and groundwater that enter the major streams below the upstream sample sites, enter the lakes directly, or the lakes (Rainy, Alva, Inez, and Seeley,) themselves. Shaded values are those that appear to contribute 10% or more of the total. The codes for stream names are in Appendix A.

Stream	DER	RIC	SEL	UNK SL	EFC	RCM	WFC	CLT	UHL	INZ	BER	UNK UCL
Total P	235	21	48	409	289	22	406	78	63	104	60	427
Total N	5141	411	963	8228	4356	424	8438	588	404	1878	1525	7124
Relative P	0.11	0.01	0.02	0.19	0.13	0.01	0.19	0.04	0.03	0.05	0.03	0.20
Relative N	0.13	0.01	0.02	0.21	0.11	0.01	0.21	0.01	0.01	0.05	0.04	0.18

Appendices

Appendix A. Sampling sites for Clearwater Basin water quality in 2017. Tier 1 streams were also sampled in 2013. Tier 1, tier 2 and tier 3 streams were sampled weekly throughout the runoff and included stage, turbidity, total nitrogen and total phosphorus. Tier 4 streams were sampled only for turbidity; and some were sampled only occasionally.

Site Name	Site Code	Latitude °N	Longitude °W	Elevation (ft)	Drainage Area (km2)	Mean Annual Flow (cfs)	Mean Summer Flow (cfs)	Mean August Flow (cfs)
Tier 1: Prior AAS sites								
Morrell Creek @ Cottonwood Lakes Rd	MDM	47.19403	-113.45562	4194	68.39	40.47	57.22	19.19
Trail Creek @ Cottonwood Lakes Road	TRL	47.19064	-113.43141	4265	40.01	19.94	23.56	7.45
Blind Canyon Creek > Trail Creek	BLI	47.19705	-113.42330	4281	23.88	12.23	14.29	4.50
Deer Creek @ Boy Scout Road	DER	47.21035	-113.54176	4042	51.70	25.14	19.34	7.99
Seeley Creek @ SOS Road	SEL	47.18307	-113.48162	4124	13.51	2.98	2.35	1.85
Mountain Creek @ Stockings	MTN	47.17679	-113.42311	4386	16.88	5.40	5.07	2.46
Rice Creek @ Ranger Station Rd	RIC	47.21526	-113.52072	4065	7.38	1.50	1.24	0.92
Swamp Creek	SWP	47.18862	-113.42317	4333	12.12	5.87	6.72	2.20
Tier 2: Major Tributaries								
East Fork Clearwater R. @ Hwy 83	EFC	47.34684	-113.58779	4180	45.15	28.11	26.10	9.37
West Fork Clearwater R. @ USFS Rd 463	WFC	47.25227	-113.58351	4153	87.65	65.41	60.77	16.76
Richmond Creek @ Hwy 83 (est.)	RCM	47.32545	-113.57875	4239	5.02	1.91	1.61	0.77
Placid Creek > Boles Creek	PLC	47.11986	-113.54896	4137	128.16	64.79	52.60	20.89
Boles Creek > Placid Creek	BOL	47.11953	-113.54912	4136	51.52	34.60	26.67	9.08
Owl Creek > Clearwater R. (est.)	OWL	47.11589	-113.45695	3953	235.89	110.90	87.32	36.11
Clearwater R. < Seeley Lake	LCL	47.18433	-113.51684	3960	385.29	171.64	145.36	59.13
Clearwater R. > Seeley Lake	UCL	47.23570	-113.53805	4045	258.31	131.57	113.95	42.14

Appendix A (continued)

Site Name	Site Code	Latitude °N	Longitude °W	Elevation (ft)	Drainage Area (km2)	Mean Annual Flow (cfs)	Mean Summer Flow (cfs)	Mean August Flow (cfs)
Tier 3: Tribs w/ lot of USFS and/or activity								
Camp Creek @ Hwy 83	INZ	47.27176	-113.55724	4150	28.64	9.83	8.40	4.27
Uhler Creek @ Westside Road	UHL	47.29386	-113.58204	4203	8.49	2.99	1.59	1.02
Colt Creek @ FSR 646	CLT	47.32857	-113.59657	4474	10.20	4.08	2.06	1.29
Bertha Creek @ Summit Park Rd	BER	47.36367	-113.59835	4110	13.68	4.23	2.39	1.60
Tier 4: Other interesting tribs or sites, turbidities only								
Finley Creek	FIN	47.13879	-113.59158	4280	5.41	1.63	1.04	0.68
North Fork Placid Creek	NFP	47.17440	-113.65852	4652	25.79	24.02	28.16	6.78
Grouse Creek	GRS	47.16216	-113.64738	4605	6.85	3.18	1.82	1.06
2nd Creek	2ND	47.17694	-113.68010	4890	7.99	5.34	2.82	1.32
Lower Drew Creek	LDR	47.15262	-113.45359	4062	13.68	3.03	2.27	1.74
Clearwater R. @ Wagon Wheel Way Bridge	LLC	47.15060	-113.48213	3960	394.57	173.19	146.68	60.21
Morrell Creek @ Hwy 83	MC04	47.14579	-113.46528	3976	159.17	40.47	57.22	19.19

Appendix B. Clearwater Valley Water Quality Data collected in 2017. Gage represents water depth either on a temporary staff (Gage units = in) installed at the sampling site or on a permanent gage (gage units = ft). Negative values represent water levels that fell below the bottom of the gage and were measured from that point with a hand held ruler.

Date	Time	Site	Gage	Gage units	Turbidity NTU	Total Nitrogen ug/L-N MDL: 25.0	Total Phosphorus ug/L-P MDL: 1.5
3/6/2017	14:00	MTN	5.00	IN	0.55	100	4.1
3/7/2017	11:30	SEL	7.25	IN	2.86	157	10
3/7/2017	11:45	RIC			0.43	104	5.8
3/7/2017	12:00	MTN	5.00	IN	0.65		
3/8/2017	11:20	MTN	5.00	IN	0.68		
3/8/2017	10:50	MC04	0.60	FT	0.30		
3/8/2017	11:00	LLC	0.74	FT	0.74		
3/8/2017	12:25	FIN			4.22		
3/13/2017	13:00	TRL	6.50	IN	0.50	88.1	12.3
3/13/2017	13:30	BLI	3.75	IN	0.51	117	< DL
3/13/2017	14:00	SWP	8.50	IN	1.12	173	5.5
3/13/2017	14:30	MDM			0.86	51.1	2.7
3/14/2017	11:40	CLT	7.25	IN	5.44	204	21.2
3/15/2017	13:20	WFC	1.25	IN	7.18	304	20.4
3/15/2017	14:10	UCL	1.60	FT	8.98	238	19.2
3/15/2017	9:40	FIN			19.50		
3/15/2017	10:50	LLC	0.96	FT	0.89		
3/15/2017	11:00	MC04	0.85	FT	3.26		
3/15/2017	11:30	PLC	24.50	IN	7.24	305	42.1
3/15/2017	11:40	BOL	11.75	IN	19.67	510	53.2
3/15/2017	12:55	OWL	12.50	IN	1.47	202	12.8
3/17/2017	10:20	BER	7.50	IN	4.89	401	25.7
3/17/2017	11:00	EFC	9.25	IN	20.86	306	28.7

Appendix B continued

Date	Time	Site	Gage	Gage units	Turbidity NTU	Total Nitrogen ug/L-N MDL: 25.0	Total Phosphorus ug/L-P MDL: 1.5
3/17/2017	11:40	RCM	7.25	IN	14.60	444	29.6
3/17/2017	12:15	UHL	11.00	IN	11.15	346	37.5
3/17/2017	13:15	RIC	13.00	IN	22.83		
3/17/2017	12:45	CMP	8.25	IN	16.53	332	25.2
3/19/2017	12:50	LDR	6.25	IN	22.52		
3/20/2017	12:35	LDR	6.25	IN	14.53		
3/20/2017	10:49	MTN	8.00	IN	2.46	309	10.0
3/20/2017	11:30	SWP	10.00	IN	0.75	674	5.3
3/20/2017	12:25	BLI	7.50	IN	0.47	210	2.2
3/20/2017	11:55	TRL	9.50	IN	1.56	201	6.2
3/20/2017	14:13	MDM	0.46	FT	6.65	130	10.5
3/21/2017	15:55	SEL	14.25	IN	13.45	812	38.6
3/21/2017	16:10	RIC	14.00	IN	17.37	425	34.5
3/21/2017	16:25	DER	0.60	FT	7.55	323	17.9
3/21/2017	16:35	LCL			3.96	270	15.0
3/22/2017	12:00	PLC	34.50	IN	4.82	330	26.8
3/22/2017	12:00	BOL	20.75	IN	9.40	359	51.7
3/22/2017	13:20	OWL	34.00	IN	3.64	265	22.3
3/22/2017	10:00	FIN			6.46		
3/22/2017	13:50	LLC	2.26	FT	2.74		
3/22/2017	14:00	MC04	1.25	FT	3.22		
3/24/2017	11:30	BER	13.13	IN	10.45	426	35.6
3/24/2017	11:55	EFC	8.75	IN	8.89	203	13.9
3/24/2017	12:25	RCM	7.25	IN	10.45	314	17.9
3/24/2017	12:50	UHL	13.25	IN	8.44	220	28.5

Appendix B continued

Date	Time	Site	Gage	Gage units	Turbidity NTU	Total Nitrogen ug/L-N MDL: 25.0	Total Phosphorus ug/L-P MDL: 1.5
3/24/2017	13:15	CMP	10.13	IN	10.87	276	18.3
3/26/2017	14:06	UCL	2.66	FT	3.84	204	11.4
3/26/2017	14:43	WFC	5.50	IN	1.99	160	7.1
3/21/2017	14:25	LDR	6.25	IN	11.45		
3/22/2017	17:30	LDR	6.75	IN	40.00		
3/24/2017	14:30	LDR	6.25	IN	10.70		
3/25/2017	16:10	LDR	6.25	IN	16.00		
3/26/2017	17:45	LDR	6.25	IN	11.75		
3/27/2017	8:45	CLT	11.00	IN	9.72	267	24.2
3/21/2017	11:00	MTN			3.04		
3/22/2017	10:30	MTN			3.15		
3/27/2017	10:35	MTN	9.50	IN	3.06	253	9.5
3/27/2017	11:31	TRL	9.50	IN	1.50	250	5.1
3/27/2017	12:02	BLI	7.00	IN	0.81	304	3.4
3/27/2017	12:50	SWP	4.50	IN	0.40	624	5.5
3/27/2017	13:55	MDM	0.61	FT	2.99	112	8.5
3/28/2017	12:15	MTN			3.19		
3/29/2017	15:30	MTN			3.59		
3/30/2017	10:30	MTN			3.76		
3/31/2017	12:30	MTN			4.60		
3/28/2017	10:05	FIN			4.77		
3/28/2017	11:30	LLC	2.30	FT	2.40		
3/28/2017	11:40	MC04	1.29	FT	2.36		
3/28/2017	13:05	SEL	17.00	IN	10.80	504	24.9
3/28/2017	13:16	RIC	15.50	IN	12.25	446	29.5

Appendix B continued

Date	Time	Site	Gage	Gage units	Turbidity NTU	Total Nitrogen ug/L-N MDL: 25.0	Total Phosphorus ug/L-P MDL: 1.5
3/28/2017	13:30	DER	0.60	FT	4.96	386	12.3
3/28/2017	13:45	LCL			4.21	282	13.3
3/30/2017	13:00	OWL	35.00	IN	2.44	257	16.2
3/30/2017	13:30	PLC	29.00	IN	2.63	284	17.3
3/30/2017	13:30	BOL	16.50	IN	3.46	214	15.7
3/31/2017	11:00	CMP	10.25	IN	9.10	250	14.1
3/31/2017	11:25	UHL	13.00	IN	4.47	172	19
3/31/2017	11:50	BER	11.25	IN	3.64	316	16.1
3/31/2017	12:10	EFC	9.75	IN	7.52	201	11.9
3/31/2017	12:30	RCM	6.50	IN	8.59	300	14.6
3/28/2017	14:35	LDR	6.00	IN	9.49		
3/29/2017	14:00	LDR	6.00	IN	9.49		
3/30/2017	17:25	LDR	6.50	IN	13.50		
3/31/2017	15:15	LDR	6.75	IN	11.25		
4/1/2017	15:00	LDR	6.75	IN	11.55		
4/2/2017	16:00	LDR	7.00	IN	14.35		
4/3/2017	9:05	CLT	12.25	IN	10.25	271	24.9
4/2/2017	13:10	MTN	11.50	IN	4.50	339	18.9
4/2/2017	14:00	TRL	12.00	IN	2.94	250	7.2
4/2/2017	14:30	BLI	5.25	IN	1.26	278	6.6
4/2/2017	14:55	SWP	11.00	IN	0.56	750	6.0
4/3/2017	15:37	MDM	0.68	FT	2.69	111	7.5
4/3/2017	16:30	MTN			2.65		
4/4/2017	14:00	MTN			2.66		
4/5/2017	10:30	MTN			2.02		

Appendix B continued

Date	Time	Site	Gage	Gage units	Turbidity NTU	Total Nitrogen ug/L-N MDL: 25.0	Total Phosphorus ug/L-P MDL: 1.5
4/6/2017	9:30	MTN			2.78		
4/7/2017	14:00	MTN			2.64		
4/2/2017	14:54	UCL	2.88	FT	4.01	204	12.7
4/4/2017	11:45	OWL	35.50	IN	2.00	236	13.7
4/4/2017	12:10	PLC	28.75	IN	2.04	245	14.1
4/4/2017	12:15	BOL	16.25	IN	2.64	183	13.9
4/6/2017	9:55	SEL	16.00	IN	7.47	465	18.2
4/6/2017	10:25	RIC	15.25	IN	9.02	410	20.0
4/6/2017	10:35	DER	0.40	FT	3.42	297	9.0
4/6/2017	10:45	LCL			4.42	293	13.9
4/7/2017	11:30	BER	9.25	IN	2.10	297	13.9
4/7/2017	11:50	EFC	9.50	IN	6.62	164	13.0
4/7/2017	12:10	RCM	6.25	IN	7.46	275	14.7
4/7/2017	12:25	UHL	12.50	IN	3.93	152	17.9
4/7/2017	12:45	CMP	10.25	IN	7.39	225	12.3
4/3/2017	15:30	LDR	6.50	IN	8.58		
4/4/2017	11:45	LDR	6.25	IN	5.74		
4/6/2017	18:50	LDR	6.50	IN	10.55		
4/7/2017	16:00	LLC	2.25	FT	1.87		
4/7/2017	15:25	LDR	6.00	IN	10.75		
4/9/2017	15:40	LDR	6.75	IN	7.79		
4/9/2017	15:50	MC04	1.42	FT	2.42		
4/9/2017	11:00	PLC	30.50	IN	2.00	226	15.1
4/9/2017	11:05	BOL	18.75	IN	3.87	183	18.0
4/9/2017	12:05	OWL	31.50	IN	1.64	220	12.6

Appendix B continued

Date	Time	Site	Gage	Gage units	Turbidity NTU	Total Nitrogen ug/L-N MDL: 25.0	Total Phosphorus ug/L-P MDL: 1.5
4/9/2017	12:20	UCL	2.83	FT	4.35	149	6.2
4/9/2017	13:54	WFC	8.00	IN	2.08	218	12.5
4/9/2017	13:27	MTN	11.75	IN	3.42	256	13.0
4/9/2017	14:45	MDM	0.76	FT	2.77	94.2	6.2
4/9/2017	17:10	SWP	10.75	IN	0.31	541	4.4
4/10/2017	8:50	CLT	12.5	IN	6.39	208	17.8
4/11/2017	18:30	LDR	6.25	IN	6.25		
4/13/2017	14:15	LDR	6.50	IN	7.04		
4/14/2017	18:40	LDR	6.50	IN	6.08		
4/15/2017	11:15	LDR	6.50	IN	4.87		
4/17/2017	10:00	LDR	6.25	IN	5.08		
4/11/2017	16:40	FIN			4.32		
4/11/2017	17:55	LLC	2.26	FT	1.83		
4/11/2017	18:05	MC04	1.34	FT	1.39		
4/11/2017	16:00	SEL	16.00	IN	6.70	336	17.1
4/11/2017	16:09	RIC	14.00	IN	7.39	305	17.5
4/11/2017	16:19	DER	0.50	FT	2.82	216	10.3
4/11/2017	16:29	LCL			3.30	260	12.3
4/11/2017	13:30	MTN			1.75		
4/13/2017	10:25	MTN			2.27		
4/14/2017	15:45	MTN			2.75		
4/14/2017	11:40	BER	8.75	IN	1.65	267	9.8
4/14/2017	11:55	EFC	10.75	IN	6.91	162	10.3
4/14/2017	12:10	RCM	6.50	IN	6.95	268	13.6
4/14/2017	12:25	UHL	12.75	IN	2.89	164	17.6

Appendix B continued

Date	Time	Site	Gage	Gage units	Turbidity NTU	Total Nitrogen ug/L-N MDL: 25.0	Total Phosphorus ug/L-P MDL: 1.5
4/22/2017	14:30	LDR	6.25	IN	7.26		
4/15/2017	11:30	MTN			1.59		
4/16/2017	12:35	MTN	11.00	IN	1.63	188	7.1
4/16/2017	13:30	TRL	12.00	IN	0.75	127	3.3
4/16/2017	14:00	BLI	8.25	IN	0.52	118	2.1
4/16/2017	14:30	SWP	10.00	IN	0.28	350	15.4
4/16/2017	15:40	MDM	0.70	FT	1.48	79.1	8.8
4/18/2017	12:00	MTN			1.83		
4/16/2017	16:02	WFC	4.50	IN	1.21	129	4.9
4/16/2017	16:52	UCL	2.50	FT	3.06	208	11.5
4/21/2017	11:25	BER	6.25	IN	1.19	297	10.5
4/21/2017	11:40	EFC	10.25	IN	4.62	155	7.7
4/21/2017	11:55	RCM	5.25	IN	5.90	257	13.3
4/21/2017	12:10	UHL	12.50	IN	2.57	131	17.5
4/21/2017	12:25	CMP	11.25	IN	4.75		
4/21/2017	9:45	OWL	22.50	IN	1.44	241	14.7
4/21/2017	10:15	BOL	14.25	IN	2.27	138	13.9
4/21/2017	10:20	PLC	26.25	IN	1.01	175	11.6
4/21/2017	10:55	FIN			3.58		
4/21/2017	11:40	LLC	2.19	FT	1.86		
4/21/2017	11:50	MC04	1.37	FT	1.32		
4/23/2017	16:25	DER	0.50	FT	3.03	295	10.2
4/23/2017	17:00	SEL	16.50	IN	7.15	380	16.2
4/23/2017	16:50	RIC	16.00	IN	6.31	293	14.5

Appendix B continued

Date	Time	Site	Gage	Gage units	Turbidity NTU	Total Nitrogen ug/L-N MDL: 25.0	Total Phosphorus ug/L-P MDL: 1.5
4/22/2017	12:50	MDM	0.76	FT	1.49	72.1	4.8
4/22/2017	13:10	TRL	12.00	IN	0.79	105	2.8
4/22/2017	13:30	BLI	8.25	IN	0.50	107	3.3
4/22/2017	13:50	SWP	10.00	IN	0.21	265	3.5
4/23/2017	20:00	MTN			2.12		
4/24/2017	16:00	MTN			2.31		
4/25/2017	13:00	MTN			1.41		
4/24/2017	17:53	WFC	8.50	IN	1.50	142	5.8
4/24/2017	18:15	UCL	2.68	FT	2.61	188	10.6
4/26/2017	8:50	FIN			3.40		
4/26/2017	9:25	PLC	27.00	IN	1.13	164	13.6
4/26/2017	9:30	BOL	15.75	IN	3.45	149	14.2
4/26/2017	10:05	OWL	23.00	IN	1.58	229	15.1
4/26/2017	10:20	LLC	2.22	FT	1.80		
4/26/2017	10:25	MC04	1.41	FT	1.44		
4/27/2017	16:35	DER	0.50	FT	4.39	210	8.6
4/27/2017	16:18	SEL	17.00	IN	6.13	323	15.2
4/27/2017	16:26	RIC	16.00	IN	5.07	268	14.2
4/27/2017	16:45	LCL			3.11	236	15.0
4/28/2017	11:45	BER	4.75	IN	0.80	298	8.6
4/28/2017	12:05	EFC	9.75	IN	3.83	114	7.1
4/28/2017	12:15	RCM	4.75	IN	5.26	222	11.0
4/28/2017	12:30	UHL	12.75	IN	2.53	126	19.3
4/28/2017	12:50	CMP	10.75	IN	4.65	186	9.3
4/29/2017	9:30	WFC	5.75	IN	1.43	116	5.9

Appendix B continued

Date	Time	Site	Gage	Gage units	Turbidity NTU	Total Nitrogen ug/L-N MDL: 25.0	Total Phosphorus ug/L-P MDL: 1.5
5/4/2017	10:00	MTN			1.05		
5/2/2017	14:45	LDR	6.00	IN	3.61		
5/3/2017	20:12	LDR	5.75	IN	4.01		
5/5/2017	13:50	LDR	6.00	IN	4.71		
5/6/2017	15:30	LDR	6.00	IN	4.89		
5/7/2017	18:40	LDR	6.50	IN	11.20		
5/3/2017	7:15	OWL	21.25	IN	1.06	231	13.5
5/3/2017	7:45	PLC	22.75	IN	1.00	158	10.4
5/3/2017	7:50	BOL	13.25	IN	1.81	111	8.6
5/3/2017	8:20	FIN			2.39		
5/3/2017	8:53	LLC	1.99	FT	1.70		
5/3/2017	9:00	MC04	1.30	FT	0.93		
5/3/2017	13:30	MDM	0.76	FT	1.00	72.3	3.2
5/3/2017	13:51	TRL	10.75	IN	0.68	89.8	2.0
5/3/2017	14:12	BLI	7.25	IN	0.43	112	4.0
5/3/2017	14:30	SWP	9.00	IN	1.00	164	3.2
5/3/2017	15:00	MTN	9.50	IN	1.28	139	6.3
5/4/2017	8:35	SEL	16.25	IN	4.78	485	16.9
5/4/2017	8:50	RIC	14.75	IN	3.92	350	11.9
5/4/2017	9:00	DER	0.40	FT	2.21	199	8.5
5/4/2017	9:15	LCL			1.70	202	10.5
5/6/2017	10:55	BER	1.50	IN	0.64	362	14.1
5/6/2017	11:10	EFC	17.25	IN	36.30	412	51.7
5/6/2017	11:25	RCM	5.75	IN	7.76	322	19.5
5/6/2017	11:45	CLT	14.50	IN	10.30	214	26.8

Appendix B continued

Date	Time	Site	Gage	Gage units	Turbidity NTU	Total Nitrogen ug/L-N MDL: 25.0	Total Phosphorus ug/L-P MDL: 1.5
5/8/2017	15:50	WFC	15.50	IN	3.04	214	9.6
5/9/2017	16:11	SEL	17.00	IN	7.26	400	20.5
5/9/2017	16:20	RIC	16.50	IN	6.15	278	15.5
5/9/2017	16:34	DER	0.50	FT	6.05	174	13.9
5/9/2017	16:45	LCL			1.98	247	13.8
5/9/2017	10:00	MTN	11.00	IN	2.40	172	11.0
5/9/2017	11:25	SWP	11.75	IN	0.46	131	5.3
5/9/2017	11:12	BLI	12.50	IN	2.98	117	6.4
5/9/2017	11:03	TRL	21.50	IN	2.82	124	8.7
5/9/2017	10:55	MDM	1.36	FT	2.84	118	7.9
5/10/2017	10:30	OWL	22.00	IN	1.06	215	12.7
5/10/2017	11:10	PLC	26.25	IN	1.23	153	13.3
5/10/2017	11:15	BOL	19.75	IN	3.66	160	15.4
5/10/2017	13:55	LLC	2.50	FT	1.57		
5/10/2017	14:05	MC04	1.76	FT	2.73		
5/10/2017	14:30	FIN			2.42		
5/12/2017	11:00	BER	0.50	IN	0.51	368	11.7
5/12/2017	11:15	EFC	18.25	IN	24.75	240	32.4
5/12/2017	11:30	RCM	4.00	IN	3.26	195	11.5
5/12/2017	11:50	CLT	13.25	IN	3.60	144	19.7
5/12/2017	12:05	UHL	11.75	IN	2.09	135	22.8
5/12/2017	12:20	CMP	13.50	IN	4.13	196	11.8
5/7/2017	13:30	MTN			2.23		
5/10/2017	10:45	MTN			2.86		
5/11/2017	10:00	MTN			2.27		

Appendix B continued

Date	Time	Site	Gage	Gage units	Turbidity NTU	Total Nitrogen ug/L-N MDL: 25.0	Total Phosphorus ug/L-P MDL: 1.5
5/15/2017	16:10	TRL	19.50	IN	3.27	115	8.2
5/15/2017	16:20	BLI	11.50	IN	3.03	98.6	7.1
5/15/2017	16:30	SWP	12.00	IN	0.49	127	3.9
5/16/2017	11:00	MTN			2.93		
5/16/2017	10:00	FIN			1.43		
5/16/2017	10:30	LLC	2.40	FT	1.43		
5/16/2017	10:38	MC04	1.64	FT	1.85		
5/17/2017	12:44	PLC	24.25	IN	0.86	152	15.0
5/17/2017	12:50	BOL	18.25	IN	3.05	139	12.8
5/17/2017	14:05	OWL	19.50	IN	0.96	207	9.8
5/18/2017	16:08	LCL			2.31	290	16.4
5/18/2017	16:17	DER	0.20	FT	2.04	162	12.7
5/18/2017	16:28	RIC	13.50	IN	3.15	202	9.5
5/18/2017	16:37	SEL	14.00	IN	4.81	266	14.0
5/19/2017	9:15	BER	1.00	IN	0.57	313	8.6
5/19/2017	9:25	EFC	10.75	IN	3.61	141	7.3
5/19/2017	9:40	RCM	2.00	IN	2.54	160	9.4
5/19/2017	10:00	CLT	12.00	IN	2.57	130	17.5
5/19/2017	10:15	UHL	10.50	IN	1.88	120	21.4
5/19/2017	10:30	CMP	8.75	IN	2.53	132	5.5
5/22/2017	11:20	PLC	22.00	IN	0.95	143	13.4
5/22/2017	11:25	BOL	14.50	IN	1.89	107	7.7
5/22/2017	13:30	OWL	16.75	IN	0.86	225	13.6
5/18/2017	18:00	MTN			2.04		
5/20/2017	7:00	MTN			2.36		

Appendix B continued

Date	Time	Site	Gage	Gage units	Turbidity NTU	Total Nitrogen ug/L-N MDL: 25.0	Total Phosphorus ug/L-P MDL: 1.5
5/22/2017	14:15	SWP	11.25	IN	0.36	146	4.5
5/23/2017	9:00	MTN			2.09		
5/15/2017	17:45	LDR	6.00	IN	5.28		
5/18/2017	13:45	LDR	6.00	IN	4.58		
5/19/2017	13:30	LDR	5.75	IN	5.01		
5/21/2017	19:00	LDR	5.25	IN	5.03		
5/22/2017	9:40	LDR	5.50	IN	6.36		
5/26/2017	9:08	LCL			1.46	168	7.6
5/26/2017	9:21	DER	2.20	FT	1.93	130	7.4
5/26/2017	9:36	RIC	24.00	IN	2.32	162	9.2
5/26/2017	9:55	SEL	25.00	IN	3.75	244	15.1
5/26/2017	10:45	BER	7.50	IN	0.60	359	14.2
5/26/2017	11:00	EFC	23.50	IN	4.89	133	9.4
5/26/2017	11:15	RCM	1.50	IN	2.01	124	7.7
5/26/2017	11:50	CLT	11.75	IN	2.59	124	18.1
5/26/2017	12:10	UHL	9.75	IN	1.63	112	22.5
5/26/2017	12:25	CMP	8.00	IN	2.09	110	5.3
5/26/2017	14:10	FIN			1.29		
5/26/2017	14:40	LLC	2.20	FT	1.50		
5/26/2017	14:50	MC04	1.78	FT	2.17		
5/23/2017	18:30	LDR	5.25	IN	5.40		
5/24/2017	16:30	LDR	4.25	IN	10.10		
5/25/2017	20:00	LDR	5.00	IN	4.83		
5/26/2017	19:00	LDR	5.00	IN	4.49		
5/27/2017	8:30	LDR	5.00	IN	4.58		

Appendix B continued

Date	Time	Site	Gage	Gage units	Turbidity NTU	Total Nitrogen ug/L-N MDL: 25.0	Total Phosphorus ug/L-P MDL: 1.5
5/31/2017	6:00	MTN	12.75	IN	2.97	176	11.6
5/31/2017	7:37	MDM	1.58	FT	5.50	100	12.5
5/31/2017	7:46	TRL	24.50	IN	5.69	142	11.6
5/31/2017	8:00	BLI	15.50	IN	5.84	104	9.2
5/31/2017	8:10	SWP	13.00	IN	0.78	133	7.0
6/1/2017	11:40	FIN			1.02		
6/1/2017	12:15	LLC	2.30	FT	1.33		
6/1/2017	12:25	MC04	2.25	FT	6.27		
6/2/2017	10:15	BER	7.50	IN	0.87	444	16.3
6/2/2017	10:25	EFC	17.75	IN	8.92	134	13.0
6/2/2017	10:40	RCM	1.75	IN	2.09	132	8.1
6/2/2017	11:00	UHL	9.25	IN	1.04	136	25.2
6/2/2017	11:20	CLT	11.00	IN	2.20	139	19.2
6/2/2017	11:40	CMP	7.00	IN	1.38	114	5.7
6/2/2017	12:40	PLC	17.50	IN	1.05	130	12.4
6/2/2017	12:45	BOL	12.25	IN	1.98	131	10.0
6/2/2017	14:45	OWL	16.75	IN	1.16	246	15.0
6/2/2017	14:04	WFC	16.50	IN	2.84	125	10.7
6/2/2017	14:20	UCL	3.05	FT	2.47	142	9.0
6/3/2017	8:45	SEL	9.50	IN	3.90	264	14.3
6/3/2017	8:53	RIC	9.00	IN	2.07	163	8.6
6/3/2017	9:10	DER	0.50	FT	2.29	107	7.7
6/3/2017	9:15	LCL			1.58	163	7.6
5/31/2017	12:00	LDR	4.75	IN	3.87		
6/3/2017	14:35	LDR	4.25	IN	4.83		

Appendix B continued

Date	Time	Site	Gage	Gage units	Turbidity NTU	Total Nitrogen ug/L-N MDL: 25.0	Total Phosphorus ug/L-P MDL: 1.5
6/13/2017	12:47	MDM	1.26	FT	4.58	88.0	11.3
6/13/2017	13:02	TRL	19.00	IN	5.43	128	11.7
6/13/2017	13:09	BLI	12.25	IN	5.27	137	13.2
6/13/2017	13:13	SWP	13.00	IN	0.53	146	8.0
6/14/2017	17:11	LCL			1.57	221	12.9
6/14/2017	17:25	DER			0.90	226	8.6
6/14/2017	17:40	RIC	10.00	IN	2.02	274	15.2
6/14/2017	18:05	SEL			5.10	298	17.2
6/15/2017	9:55	PLC	13.25	IN	0.89	136	13.6
6/15/2017	10:00	BOL	9.00	IN	2.01	119	7.5
6/15/2017	10:45	OWL	13.25	IN	0.90	229	10.4
6/15/2017	11:20	LDR	4.25	IN	5.23		
6/15/2017	11:45	FIN			1.10		
6/15/2017	12:15	LLC	1.76	FT	1.10		
6/15/2017	12:35	MC04	1.70	FT	1.37		
6/16/2017	12:10	BER	5.00	IN	0.63	420	14.1
6/16/2017	12:20	EFC	10.50	IN	2.29	90.0	3.4
6/16/2017	12:35	RCM	0.75	IN	1.86	140	7.0
6/16/2017	12:55	CLT	9.75	IN	1.83	124	19.8
6/16/2017	13:10	UHL	8.75	IN	0.92	119	23.6
6/16/2017	13:35	CMP	6.75	IN	1.05	119	7.6
6/16/2017	12:19	WFC	6.00	IN	0.81	85.1	4.8
6/16/2017	12:35	UCL	1.90	FT	1.20	112	6.9
6/15/2017	10:30	MTN	13.00	IN	1.63		
6/16/2017	9:45	MTN	12.75	IN	0.89		

Appendix B continued

Date	Time	Site	Gage	Gage units	Turbidity NTU	Total Nitrogen ug/L-N MDL: 25.0	Total Phosphorus ug/L-P MDL: 1.5
6/21/2017	13:25	FIN			1.21		
6/21/2017	14:10	LLC	1.42	FT	1.05		
6/21/2017	14:17	MC04	1.56	FT	1.10		
6/22/2017	17:15	LCL			0.72	173	10.8
6/22/2017	17:25	DER	1.60	IN	0.66	157	9.7
6/22/2017	17:45	RIC	9.00	IN	0.85	114	6.5
6/22/2017	17:55	SEL	4.00	IN	2.15	194	11.3
6/23/2017	11:40	BER	1.25	IN	1.02	369	14.2
6/23/2017	11:55	EFC	9.25	IN	1.67	80.3	2.4
6/23/2017	12:10	RCM	1.75	IN	1.40	87.7	5.8
6/23/2017	12:35	CLT	9.25	IN	1.76	104	19.1
6/23/2017	12:50	UHL	8.25	IN	0.71	68.5	19.8
6/23/2017	13:10	CMP	6.50	IN	1.17	88.6	3.4
6/20/2017	10:00	MTN			1.31		
6/21/2017	12:00	MTN			0.84		
6/22/2017	16:00	MTN	12.00	IN	0.92		
6/24/2017	10:00	MTN	11.50	IN	0.84	93.0	3.7
6/24/2017	11:07	MDM	0.76	FT	1.08	58.8	3.3
6/24/2017	11:15	TRL	12.00	IN	1.54	69.9	5.1
6/24/2017	11:35	BLI	9.00	IN	0.94	42.4	1.7
6/24/2017	11:50	SWP	10.50	IN	0.57	104	2.6
6/24/2017	12:35	BOL	19.75	IN	1.59	117	7.4
6/24/2017	12:40	PLC	11.75	IN	0.77	110	15.6
6/24/2017	15:00	OWL	9.50	IN	1.07	223	13.1
6/26/2017	13:00	FIN			1.42		

Appendix B continued

Date	Time	Site	Gage	Gage units	Turbidity NTU	Total Nitrogen ug/L-N MDL: 25.0	Total Phosphorus ug/L-P MDL: 1.5
6/27/2017	11:10	BOL	8.50	IN	2.07	105	7.3
6/27/2017	15:05	OWL	9.50	IN	1.29	239	14.6
6/30/2017	11:24	UCL	1.20	FT	0.77	120	6.9
6/30/2017	11:41	WFC		IN	0.59	77.2	3.2
6/30/2017	11:25	BER					
6/30/2017	11:40	EFC	7.50	IN	1.57	75.1	2.4
6/30/2017	11:55	RCM	2.00	IN	0.80	103	7.8
6/30/2017	12:15	CLT	8.75	IN	1.35	117	20.2
6/30/2017	12:30	UHL	8.00	IN	0.74	67.5	20.1
6/30/2017	12:45	CMP	6.00	IN	0.88	77.4	4.0
7/2/2017	12:30	LDR	3.00	IN	1.02		
7/3/2017	13:51	LCL			1.24	172	7.7
7/3/2017	14:03	DER	1.50	FT	0.59	106	4.8
7/3/2017	14:18	RIC	8.50	IN	0.47	161	7.5
7/3/2017	14:26	SEL	6.00	IN	1.74	140	11.1

Appendix C.

Table C1. The estimated relative load of total phosphorous (P) and total nitrogen (N) for streams immediately upstream of Salmon Lake. The Morrell Watershed encompasses several tributaries (MDM, MTN, TRL, SWP) and the section of Morrell below the confluence of those streams and the mouth. The contribution estimated below the upper tributaries was based on upstream downstream sampling in 2013 showing a substantial influx of in that section. The codes for stream names are in Appendix A.

			Morrell Watershed							
Stream	**LCL**	**OWL**	**MDM**	**BLI**	**MTN**	**TRL**	**SWP**	**Unknown**	**Total**	**Total**
Total P	**2163**	**1508**	251	48	54	124	31	0	**507**	**4178**
Total N	**39477**	**25396**	3561	1431	1004	2473	963	8298	**17730**	**82603**
Relative P	0.52	0.36	0.06	0.01	0.01	0.03	0.01	0.00	0.12	
Relative N	0.48	0.31	0.04	0.02	0.01	0.03	0.01	0.10	0.21	

Table C2. The estimated relative load of total phosphorous (P) and total nitrogen (N) for streams immediately upstream of the lower Clearwater River site (LCL, shown as Total). Unknown (Unk) reflects the difference in load and proportion of the load at the downstream site the upstream tributaries that were monitored. Unknown sources could include groundwater and Seeley Lake itself. The codes for stream names are in Appendix A.

Stream	**UCL**	**DER**	**RIC**	**SEL**	**UNK**	**Total (LCL)**
Total P	1449	235	21	48	409	2163
Total N	24735	5141	411	963	8228	39477
Relative P	0.67	0.11	0.01	0.02	0.19	
Relative N	0.63	0.13	0.01	0.02	0.21	

Table C3. The estimated relative load of total phosphorous (P) and total nitrogen (N) for the two major streams immediately upstream of the Owl Creek site (OWL, shown as Total). Unknown (Unk) reflects the difference in load and proportion of the load at the downstream site and the upstream tributaries that were monitored. Unknown sources could include smaller upstream tributaries that were not sampled, groundwater and Placid Lake itself. The codes for stream names are in Appendix A.

Stream	BOL	PLC	UNK	Total (OWL)
Total P	481	914	114	1508
Total N	4809	10237	10350	25396
Relative P	0.32	0.61	0.08	
Relative N	0.19	0.40	0.41	

Table C4. The estimated relative load of total phosphorous (P) and total nitrogen (N) for tributaries upstream of the Upper Clearwater site (UCL, shown as Total). Unknown (Unk) reflects the difference in load and proportion of the load at the downstream site and upstream tributaries that were monitored. Unknown sources could include smaller upstream tributaries that were not sampled, groundwater and lakes Inez, Alva, and Rainy. The codes for stream names are in Appendix A.

Stream	EFC	RCM	WFC	CLT	UHL	INZ	BER	UNK	Total (UCL)
Total P	289	22	406	78	63	104	60	427	1449
Total N	4356	424	8438	588	404	1878	1525	7124	24735
Relative P	0.20	0.02	0.28	0.05	0.04	0.07	0.04	0.29	
Relative N	0.18	0.02	0.34	0.02	0.02	0.08	0.06	0.29	