2019 Water Quality Monitoring Report

2019 Stream Team Volunteers say “cheers” to clean water during the volunteer training day in June.

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Monitoring Team

The Rethink Runoff Stream Team (formerly known as the Chittenden County Stream Team) is a program that engages citizens across a nine-municipality region to implement projects that reduce nonpoint source pollution and stormwater volume at the local level. The participating municipalities are Burlington, Colchester, Essex, Essex Junction, Milton, Shelburne, South Burlington, Williston, and Winooski. The Water Quality Monitoring program is managed by the Chittenden County's Municipal Stormwater Separate System Committee, coordinated by the Winooski Natural Resources Conservation District, and made possible through the support of the Vermont Department of Environmental Conservation LaRosa program. This report describes the results from the 2019 collection season; the eighth, consecutive year data was collected by this volunteer-led stream water quality monitoring effort in Chittenden County.

When, Where, and What the Stream Team Monitors

The Rethink Runoff Stream Team (RRST) has collected biweekly water quality samples at several pollutant "impaired" or "stressed" stream sites in Chittenden County since 2012. These urban or suburban streams suffer from excessive nutrient loads, sodium chloride, sedimentation, high temperatures, bacteria, and/or other pollutants. Samples were collected on six different dates in 2019: on five, scheduled bi-weekly dates and on one "high-flow" date (i.e. during or shortly after a rain event). High-flow sampling provides a snapshot of the potentially elevated or diluted pollutant-loads moving through these systems when it rains. Samples were analyzed for total phosphorus and chloride at all 21 sites. The specific sampling sites and their locations are listed in Table 1 and a map of the sites is shown in Figure 1.

Biweekly sampling occurred on: June 25th, July 9th, July 23th, August 6th, and August 20th. Rain event sampling or "high-flow" (freshet) sampling occurred on August 8th at sites on Indian, Muddy, Potash, Centennial and Morehouse brooks. Between August 7th and 8th, 1.19 inches of rain fell overnight, therefore the sampling on August 8th is classified as a highflow event. All other biweekly sampling dates fell during dry conditions or base flow events.

Date	Type of Day	Total Rainfall (inches)
06/25/19	Bi-weekly	0.00
07/09/19	Bi-weekly	0.00
07/23/19	Bi-weekly	0.08
08/06/19	Bi-weekly	0.00
08/08/19	Rainy Day	1.22 (freshet flow)
08/20/19	Bi-weekly	0.07

Table 1. Average regional rainfall, in inches, for the preceding day and day of sampling. Sum of rainfall data for each day was gathered from the Burlington International Airport Weather Station.

Stream	*Location*	*Site ID*	*Sampling Reason*	*Types of Samples*	*Lat / Long*
Centennial Brook	Grove Street in Burlington	Centennial 10	Long Term monitoring since 2012	TP, Chloride	44.48453, -73.18423
	Patchen Road in Burlington	Centennial 20	Monitoring since 2017	TP, Chloride	44.47402, -73.17334
Indian Brook	Essex High School	Indian 10	Long Term monitoring since 2012	TP, Chloride	44.49668, -73.11093
	Lang Farm in Essex	Indian 20	Long Term monitoring since 2012	TP, Chloride	44.50442, -73.09190
Malletts Creek	McMullen Road	Malletts 10	Long Term monitoring since 2012	TP, Chloride	44.60855, -73.10693
Munroe Brook	Spear & Webster Intersection	Munroe 20	Monitor impact of new housing development upstream. Monitored since 2012	TP, Chloride, Turbidity	44.38984, -73.20103
Morehouse Brook	Landry Park Winooski - Pine Grove Terrace Branch	Morehouse PGT	Town of Winooski will install a detention pond this year. Monitor effectiveness.	TP, Chloride, Turbidity	44.50081, -73.194
	Landry Park - Industrial Park Branch	Morehouse IPB	Compare two branches of Morehouse brook	TP, Chloride, Turbidity	44.50015, -73.1937
Muddy Brook	River Cove Road in Williston	Muddy 10	Long Term monitoring since 2012	TP, Chloride	44.47293, -73.13505
	Whale Tails walking path in S. Burlington	Muddy 20a	Monitor effectiveness of new town easements in watershed	TP, Chloride	44.44356, -73.13648
	Van Sicklen Road in Williston	Muddy 30	Long Term monitoring since 2012	TP, Chloride	44.42823, -73.14622
Potash Brook	Kindness Court in South Burlington	Potash 10	Long Term monitoring since 2012	TP, Chloride	44.44572, -73.21348
	Farrell Street in South Burlington	Potash 20	Long Term monitoring since 2012	TP, Chloride	44.44660, -73.20415
	Spear Street in S. Burlington	Potash 30	Long Term monitoring since 2012	TP, Chloride	44.45150, -73.17849
Engelsby Brook	Pine St in Burlington	Engelsby 10	Long Term monitoring since 2012	TP, Chloride	44.45627, -73.21394

	Redstone Campus in Burlington	Engelsby 20	Monitoring since 2017	TP, Chloride	44.46654, -73.19741
Sunderland Brook	Pearl St Park in Essex Junction	Sunderland 10	Part of Town of Essex /Essex Junction chloride Study	TP, Chloride	44.50179, -73.12983
	Just above Rte 2/7 culvert in Colchester	Sunderland 20	Part of Town of Essex /Essex Junction chloride Study	TP, Chloride	44.51685, -73.20421
Sunnyside Brook	Near Hercules Rd. Colchester	Sunnyside 10	Brook impaired for chloride, awaiting TMDL	TP, Chloride	44.50654, -73.17823
Allen Brook*	Milton	Allen 10	Currently NOT stormwater impaired. Will monitor for changes	TP, Chloride, Turbidity	44.59229, -73.16283
Alder Brook	Off of Rte 289 in Essex	Alder 10	Part of Town of Essex/Essex Junction chloride Study	TP, Chloride	44.51742, -73.06559

* Although we planned to sample on Allen Brook, our volunteer experienced issues accessing the site so we were not able to submit any samples to the lab. We will try to find a better site in 2020.

Table 2. Rethink Runoff Stream Team 2019 Water Quality Sampling Sites. Note that sites located further up a streamshed are labeled with high numbers except at Sunderland where this labeling was switched and Sunderland 20 is actually downstream of Sunderland 10. Stream Team will look into fixing this labeling anomaly with our records and those of the lab starting next field season.

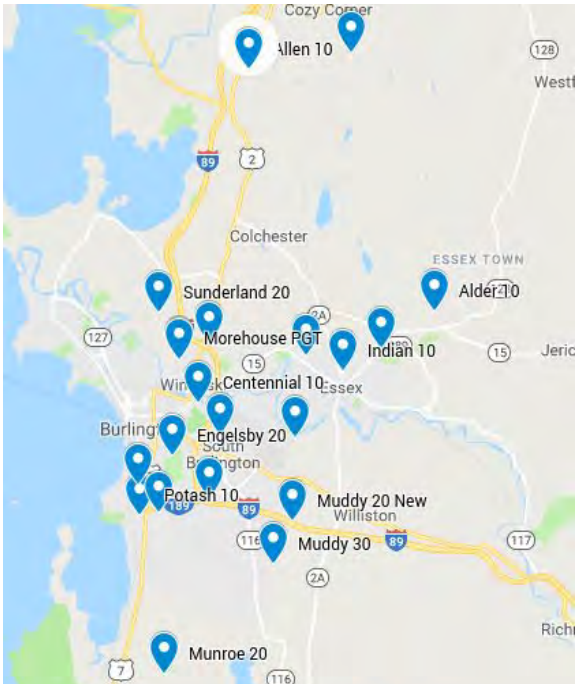

Figure 1: 2019 Rethink Runoff Stream Team Sample Sites. An interactive version of this map is available here: https://drive.google.com/open?id=1bVQHKJYIEUkII75Yw8HVXVvNLZF_rLXe&usp=sharing

Stream Profiles

Alder Brook (1 site) This brook originates in agricultural headwaters and then winds through the Town of Essex . Our sampling is currently in the headwaters. The phosphorus values at this site have exceeded the standard for two years in a row. The chloride values are very low, likely because there is less impervious surface in this sub-watershed than other sites.

Allen Brook (1 site) "The headwaters of Allen Brook are in Milton west of Cobble Hill. The brook flows westerly and then southerly through the subdivisions of Milton along Route 7. After the brook crosses into the town of Colchester, it flows southeasterly for about a mile before curving sharply and going under Route 7 and into Malletts Creek Marsh."[1] This brook is not currently listed as impaired for stormwater, but there is growing concern that it may be heading in that direction. We were unable to collect samples this year due to challenges with site access, but are eager to help monitor the health of this stream in the coming years as the Town implements water quality improvement projects.

Centennial Brook (2 sites) This brook has its origins near the Burlington Airport and winds through the Centennial Woods natural area. The phosphorus values at this site have exceeded the standard for many years. The chloride values are high, especially at Centennial 10 where there was a median chloride value of 716mg/L this year. Data demonstrates a significant increasing trend in chloride at this site over the past 8 years.

Engelsby Brook (2 sites) "Englesby Brook flows east to west across south central Burlington before eventually emptying into Lake Champlain in Burlington Bay. The brook's headwaters originate within the Burlington Country Club near the South Burlington town line. Throughout its course the brook flows through dense residential development."[2] Sections of this brook are impaired for stormwater and e.coli and a Total Maximum Daily Load (TMDL) is in place.[3] Both phosphorus and chloride levels are very high in this brook. Engelsby displayed the highest median values for chloride of all the streams sampled by our team this year.

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[1] https://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/mp_MallettsBayStreams.pdf
[2] https://dec.vermont.gov/sites/dec/files/documents/WSMD_mapp_8englesbybrook.pdf
[3] https://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/mapp_2015b05tbp.pdf

Indian Brook (2 sites) "Indian Brook rises in the hills around Colchester Pond and Indian Brook Reservoir. The brook was dammed to create the reservoir for a public water supply in the late 1800s. From the reservoir, the brook flows south to Essex Junction and then makes a wide sweep in the village and heads northwesterly to Colchester. It continues northwesterly in Colchester to Mill Pond dammed for a sawmill that once operated there and then on to Malletts Creek Marsh adjacent to Malletts Bay. A portion of Indian Brook is stormwater impaired and a TMDL has been written and approved for this stream."[4] This brook displayed phosphorus levels above the standard and an increasing trend in chloride over the past 5 years.

Mallets Creek (1 site) "Malletts Creek originates in the northeastern portion of Milton at Milton Pond. It flows southwesterly towards the town core of Milton. A small stream joins Malletts Creek from the north as the creek turns and flows in a southerly direction parallelling East Road in Milton. It continues winding generally south to the Milton-Colchester town line. In the southeastern portion of Milton, the creek flows through a large wetland complex, which has been recognized as an important wetland. In Colchester, the creek meanders in an overall southwesterly direction and near the mouth, it is part of another large wetland complex."[5] This brook displayed phosphorus levels above the standard and one of the lowest values for chloride of all our sites.

Muddy Brook (3 sites) "Muddy Brook runs along Williston's western border forming the boundary to South Burlington … The Muddy Brook watershed includes the retail centers in Taft Corners and Maple Tree Place."[6] Muddy Brook is a tributary to the Winooski River. This brook has been listed as impaired for chloride with a plan to develop a TMDL.[7] This brook displayed phosphorus levels above the standard and one of the highest values for chloride of all our sites. There is an increasing trend in chloride at this site over the past 8 years.

Munroe Brook (1 site) Munroe Brook flows through the City of South Burlington and Town of Shelburne and outlets directly into Lake Champlain. Sections of this brook are impaired for stormwater and a TMDL is in place.[8] This brook displayed phosphorus levels above the standard and lower values for chloride compared to all our sites.

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[4] https://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/mp_MallettsBayStreams.pdf
[5] https://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/mp_MallettsBayStreams.pdf
[6] https://www.town.williston.vt.us/?SEC=90A15155-DB82-4B3C-A06B-7A5E00BEF218
[7] https://dec.vermont.gov/sites/dec/files/documents/2018%20Winooski%20River%20TBP.pdf
[8] https://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/mapp_2015b05tbp.pdf

Morehouse Brook (2 sites) "Morehouse Brook drains a small, highly urbanized 262 acre watershed that straddles the town boundary between the City of Winooski and the Town of Colchester. The land use breakdown within the Morehouse Brook watershed is 88% developed land, 1% open land and 11% forested areas."[9] This brook outlets directly into Lake Champlain. It is listed as impaired for stormwater and has a TMDL. The brook displayed phosphorus levels above the standard and high chloride values.

Potash Brook (3 sites) Sections of this brook are impaired for stormwater and e.coli and a TMDL is in place.[10] "The brook is principally located in the municipality of South Burlington, and encompasses an area of approximately 7.13 square miles. The land uses within the watershed are 53% developed land (residential,commercial, industrial, etc.), 30% agricultural or open land, and 17% forest, wetland or open water. Recent surveys indicate a watershed that is approximately 22% impervious."[11] This brook outlets directly into Lake Champlain. It displayed phosphorus levels above the standard and one of the highest values for chloride of all our sites.

Sunnyside Brook (2 sites) "Located in Colchester in the northwest portion of the state, the stream drains highly developed urban lands. The watershed area is 350.6 acres, 106.2 of which are impervious." [12] This brook has been listed as impaired for chloride with a plan to develop a TMDL.[13] This brook displayed phosphorus levels below the standard but had alarmingly high levels of chloride.

Sunderland Brook (1 site) "The headwaters in Essex Junction originate in the highly developed areas adjacent to Route 15. The main stem and minor tributaries flow to the north of Camp Johnson through more forested and less developed areas until the downstream end of the impaired segment is reached at the river at Route 7."[14] This brook displayed phosphorus levels well above the standard but comparatively low levels of chloride.

Sampling Summary Altogether, samplers collected 200 field samples (100 phosphorus samples and 100 chloride samples). Additionally they collected ~20 duplicate samples and ~20 blank samples for data quality checking purposes. These duplicate and blank numbers represent 10% of the total sampling effort, aligning with the requirements in the Quality Assurance Project Plan (QAPP) and the guidance of the lab. The combined total resulted in **140** samples submitted to the lab.

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[9] https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/Permitinformation/ResidualDesignationAuthority/sw_mor_tmdl_approved.pdf
[10] https://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/mapp_2015b05tbp.pdf
[11] https://www.epa.gov/sites/production/files/2015-09/documents/sw_pot_tmdl_final_epa_submittal.pdf
[12] https://www.stormh2o.com/home/article/13025322/monitoring-and-tracking-chloride-trends
[13] https://dec.vermont.gov/sites/dec/files/documents/2018%20Winooski%20River%20TBP.pdf
[14] https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/SWImpaired/sw_sun_tmdl_approved.pdf

Phosphorus Results

Phosphorus is an essential nutrient for plants and animals that is naturally limited in most freshwater systems. Even a modest increase can set off a chain of undesirable events, such as algal blooms, accelerated plant growth, low dissolved oxygen, and the subsequent die off of aquatic life. Although phosphorus occurs naturally in soils and rocks, additional phosphorus enters waterways through runoff from sources such as fertilized lawns and cropland, pet waste, failing septic systems, animal manure from storage areas or livestock access, wastewater treatment plants, and streambank erosion.

Stream Conditions - Phosphorus - One year

Phosphorus sample results continue to be high across most every sampling site. The VT 2016 water quality standard for phosphorus in Class B warm water medium-gradient streams is 27 µg/L but the median 2019 phosphorus level for every site except Sunnyside 10 exceeded this standard (see Table 3). Medians are calculated instead of means to account for possible outlier values. A few sampling occurrences were exceptionally high but still included in median calculations because they remained less than twice the site's standard deviation above the mean (i.e. were not technically outliers). While this is expected given the small sample size for any given year, it is worth recognizing that TP on 6/25 for both Centennial 10 and Centennial 20 were unusually high (845 µg/L and 364 µg/L respectively). Similarly, TP for Sunnyside 10 on 8/6/19 was 282 µg/L. Since 6/25 generated two high TP results for the same stream, it is worth giving this sampling a closer analysis to see if a common date or volunteer sampler contributed to this.

Location	Median Phosphorus during Baseflow - Dry Conditions	Phosphorus during Rain Event
Alder 10	62	--
Centennial 10	58	70
Centennial 20	58	--
Englesby 10	53	--
Englesby 20	74	--
Indian 10	35	115
Indian 20	54	--
Mallets Creek 10	36	--
Morehouse IPB	37	32
Morehouse PGT	33	70
Muddy 10	55	--

Muddy 20a	103.5	--
Muddy 30	67	105
Munroe 20	55	--
Potash 10*	32	--
Potash 20	38	139
Potash 30*	92	--
Sunderland 10*	61	--
Sunderland 20	62	--
Sunnyside 10	12	--

Table 3. 2019 RRST Phosphorus Results Summary: Median phosphorus levels in µg/L during both baseflow (dry) and high-flow (rain) sampling events in 2019. Dupe values are not included in calculations.Values exceeding the Vermont chronic chloride standard of 27 µg/L are shown in red. Sites denoted with an * had at least one sampling date in which blank or dupe results were flagged but still included in median calculations. Raw data is presented in Appendix C.

Stream Conditions - Phosphorus- Multi-year aggregate data

Phosphorus levels in Chittenden County Streams 2012-2019

Since the onset of this monitoring program in 2012, mean and/or median concentrations of phosphorus during baseflow have remained notably above the 27 µg/L standard at all stream sites. In fact only 5 out of the 20 sites sampled in 2019 have ever exhibited phosphorus concentrations below this standard (Indian 20, Malletts 10, Potash 10 and 20, and Sunnyside 10). Out of these 5, only one site (Sunnyside 10) reports a median below the standard but the 2-yr sampling mean still falls above the standard. Sites of notable historic levels include Engelsby 20, Muddy 10 and 30, Munroe 20, Potash 30, and Sunderland 10 although newer sites like Alder 10, Muddy 20a, Sunderland 10 and Sunnyside 10 have some alarming medians and/or outliers.

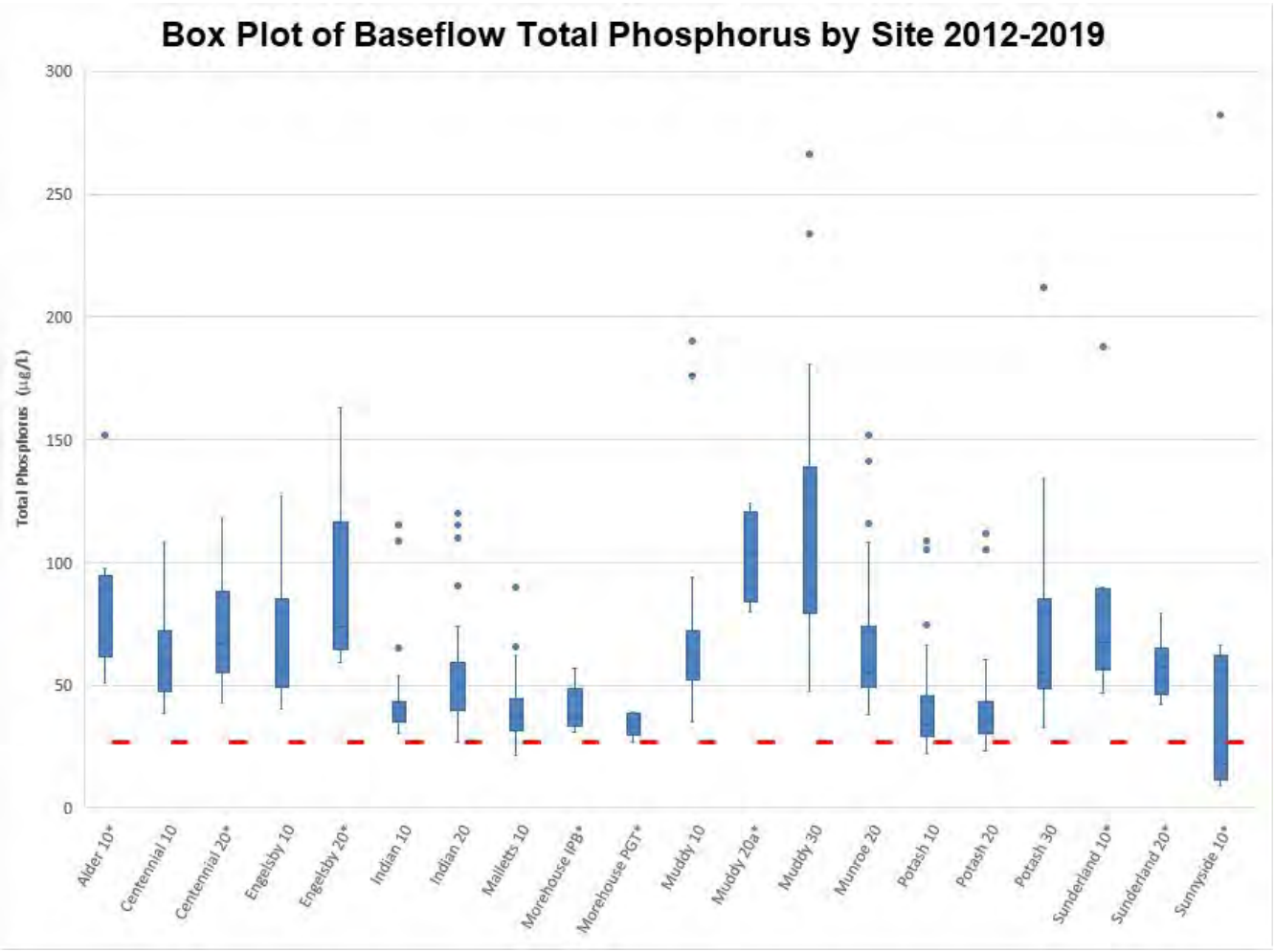


Figure 2. Comparison of total phosphorus levels across sites 2012-2019. Box plots indicate first and third quartiles and median values of total phosphorus concentrations for all sites. These values were calculated including sampling dates that may or may not have associated flagged dupe or blank samples. Asterixed sites indicate 1-3 years of sampling data, all other sites represent 7-8 years of sampling data. Dots indicate outliers which were identified as equal to or greater than 1.5 times the site's interquartile range. Red line indicates Vermont's 2016 Water Quality Standard of 27 µg/L. Three outliers were excluded from this graph for easier viewing: Centennial 10, 6/25/19, 845 µg/L, Centennial 20, 6/25/19 364 µg/L, Muddy 10, 6/25/13, 339 µg/L. Note that box plots do not reveal trends over time but, rather, aggregate many years of data to provide a more comprehensive view of each stream's condition.

Chloride Results

Chloride is a component of salt found naturally in minerals and in oceans. While a low level of instream chloride can originate from natural sources, higher levels are generally due to the use of deicing salts. Elevated chloride levels in surface waters can negatively impact the health and reproduction of aquatic species. The Stream Team took grab samples of chloride, which do not provide adequate data to label a stream impaired or acute, however, the data acts as a spot check. For reference, the Environmental Protection Agency's (EPA) and State of Vermont's (VT) current water quality standard for chloride is 230 mg/L (chronic criteria) and 860 mg/L (acute criteria). 860 mg/L is the highest concentration of chloride to which aquatic life can safely be exposed for one hour once every 3 years. 230mg/L is the highest concentration of chloride to which aquatic life can safely be exposed for four consecutive days once every 3 years.[15]

Stream Conditions - Chloride - One year

In 2019, six sampled brooks presented median values above 230 mg/L and chloride levels were higher during baseflow conditions in four of the six streams sampled under both conditions. Chloride grab sample levels exceeded the acute standard (860 mg/L) in Sunnyside 10 (6/25, 7/9, 7/23, 8/6, 8/20), Centennial 20 (8/6) and Engelsby 20 (6/25, 7/9, 7/23, 8/6) in 2019. Notably this presents 10 occurrences across our sampling area in which the acute standard was surpassed in 2019. This is up from four occurrences in 2018, the first time this value had been surpassed in any individual sample over the eight year sampling period. This data suggests that we are continuing to see an increase in chloride levels.

Location	Median Chloride in Dry Conditions Only	Chloride during Rain Events
Alder 10	11.7	--
Centennial 10	716	600
Centennial 20	226	--
Englesby 10	519	--
Englesby 20	1457.5	--
Indian 10	247.5	152
Indian 20	193	--
Mallets Creek 10	45.8	--
Morehouse IPB	131.5	358
Morehouse PGT	332	65.8

[15] https://dec.vermont.gov/sites/dec/files/documents/wsmd_water_quality_standards_2016.pdf
https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table#table

Muddy 10	139.2	--
Muddy 20a*	93.85	--
Muddy 30	28.2	38.3
Munroe 20	36.4	--
Potash 10	438	--
Potash 20	442	183.4
Potash 30	324	--
Sunderland 10	177	--
Sunderland 20	187	--
Sunnyside 10	1320	--

Table 5. 2019 RRST Chloride Results Summary: This table depicts median chloride levels in mg/L during baseflow (dry) and high-flow (rain) sampling events in 2019. Values exceeding the Vermont chronic chloride standard of 230 mg/L are shown in red. Sites denoted with an * had at least one sampling date in which blank or dupe results were flagged but still included in the median calculations. Raw data is presented in Appendix C.

Stream Conditions - Chloride - Multi-year aggregate data

Chloride levels in Chittenden County Streams 2012-2019

Since the onset of this monitoring program, mean chloride levels at Centennial 10 and Potash 10, 20 and 30 have remained notably above 230 mg/L. Recently added sampling sites have also presented alarmingly high data including Engelsby 20, Morehouse PGT, and Sunnyside 10.

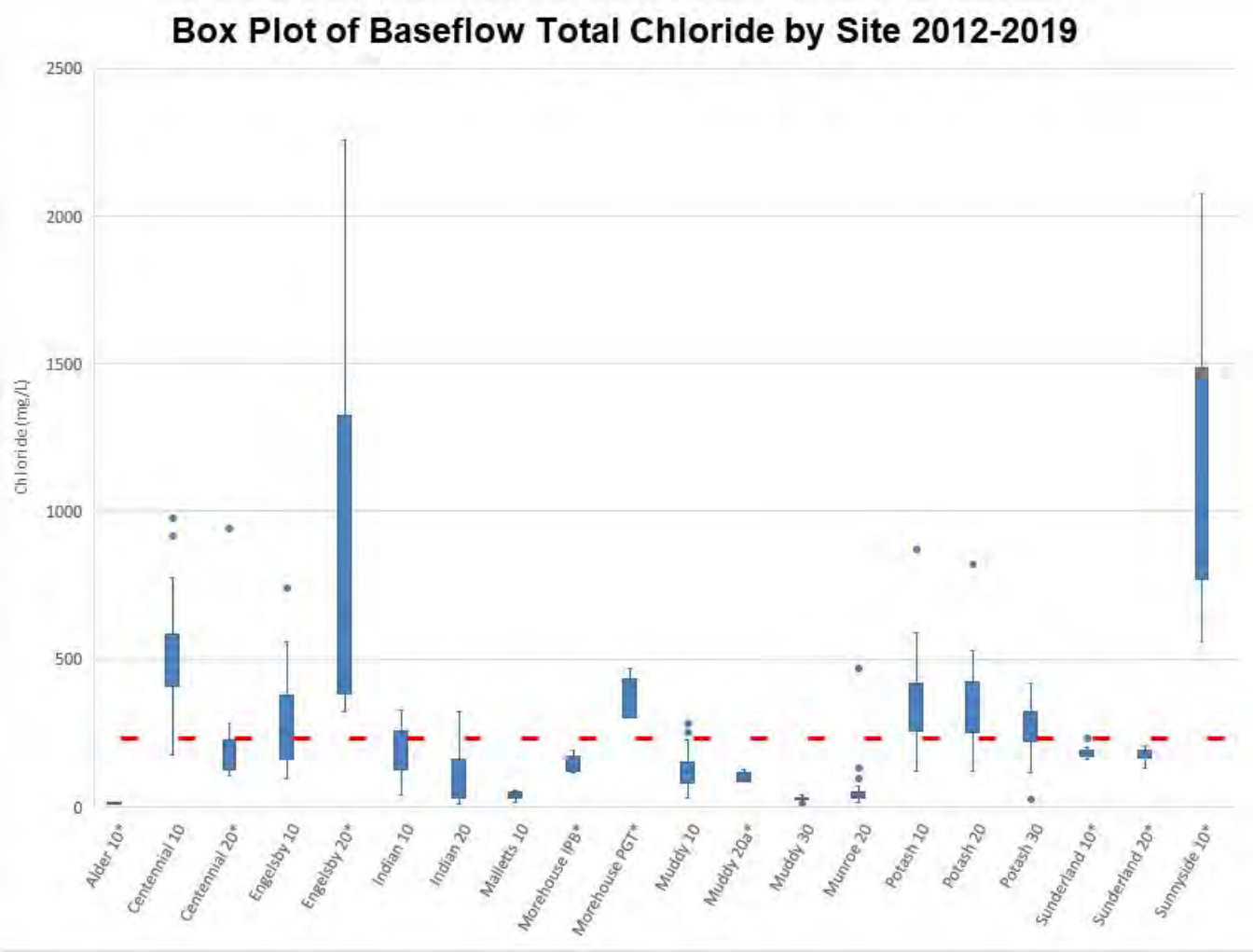


Figure 5 - Comparison of Chloride levels across sites 2012-2019. Box plots indicate first and third quartiles and median values of chloride levels (mg/L) for all sites. Asterixed sites indicate 1-3 years of sampling data, all other sites represent 7-8 years of sampling data. Dots indicate outliers which were identified as equal to or greater than 1.5 times the site's interquartile range. Red line indicates EPA's and Vermont's standard for 4-day average chloride levels (230 mg/L). Note that box plots do not reveal trends over time but, rather, aggregate many years of data to provide a more comprehensive view of each stream's condition.

Aggregated data also suggests a general increasing trend in chloride. Figure 6 below shows that the mean and standard deviation values have increased slightly over time (although medians are holding relatively constant). Also, notably, the R^2 value of the best fit line for the mean and standard deviation have both increased from 2018 values; from 0.32 to 0.42, and from 0.45 to 0.56 respectively. This suggests that as we add more years of data, this increasing trend is gaining significance. With medians remaining somewhat constant this is suggesting an increase in more extreme values.

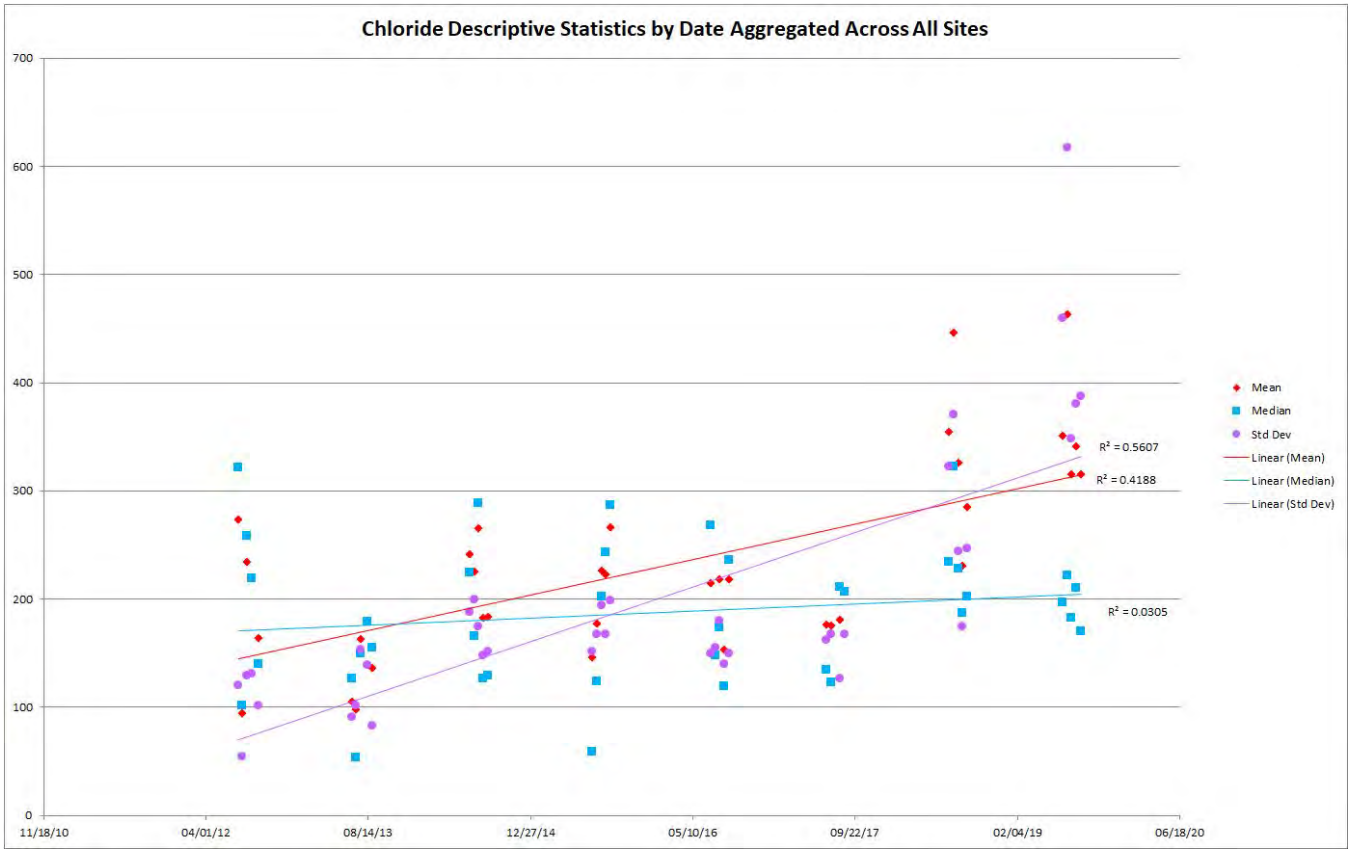


Figure 6. Descriptive Statistics for chloride data gathered across sites aggregated by date. Each sampling date had chloride values across sites averaged to determine mean, median, and standard deviation for the entire sampling area.

Conclusion

The Rethink Runoff Stream Team has monitored chloride and phosphorus in various streams in Chittenden County for the past eight consecutive years (2012-2019). The 2019 season results are similar to those obtained over the past seven years. This year's data indicates that all stream sites have sustained phosphorus levels well above the Vermont standard and that chloride continues to be a growing concern.

Phosphorus levels in almost all sampled streams have remained two to four times the Vermont water quality standard of 27 µg/L. Especially high levels of phosphorus were recorded along Engelsby Brook, Muddy Brook and Sunderland Brook this year.

Chloride levels continue to be elevated in several streams, most notably in Centennial Brook, Engelsby Brook, Indian Brook, Morehouse Brook, Potash Brook and Sunnyside Brook. For only the second year in Stream Team's sampling history, median chloride levels exceeded 860 mg chloride/L at two sites (Engelsby 20 and Sunnyside 10). Our data shows a general increasing trend in chloride across all sites over the 8-year sampling period.

In the years to come Stream Team will use this data to communicate with individuals, property management companies and municipalities about local water quality issues, with the hope of inspiring changes in behavior and management techniques. Future sampling will focus on identifying "problem areas" of streams rather than completing long-term monitoring at the same sites.

The Stream Team continues to request explicit guidance and documented practices in the QAPP for dealing with outliers and data points whose duplicates or blanks were flagged. For 2019 analysis, as with prior years, all data points were included because of a lack in standardized practice for dealing with this. The Stream Team did converse with Becky Tharpwho will be working with Kristen Underwood to develop some statewide guidance for groups working under the Watersheds United Vermont Train The Trainer Grant (WUV TTT).

This year the analysis team decided to not include information about spatial variation (upstream/downstream differences) in phosphorus and chloride. Through working with Becky Tharp and the WUV TTT program, we have learned more accurate techniques to account for spatial differences by delineating sub-basins and combining that data with regional flow rates. In the future we plan to use these methods to more accurately describe differences in parameters upstream and downstream, but this year our capacity to complete that analysis is limited.

Finally, when faced with the issues of non-point source pollution, we need everyone to pitch in to create a healthier, cleaner environment. Below are a few ideas about how you can help improve water quality.

1. Join the Rethink Runoff Stream Team community to learn about volunteer opportunities by signing up for our newsletter, connecting with us on social media or visiting our website www.rethinkrunoff.org.
2. Reduce the use of lawn fertilizer (a source of phosphorus) and de-icing salt (a source of chloride) on your property.
3. If you have a dog, always be sure to scoop the poop (a source of phosphorus) even in the woods, even in the winter
4. Install a rain barrel or a rain garden to help collect rain water and soak it into the soil before it reaches surfaces like pavement where it will pick up pollutants before reaching streams
5. Tell your friends! Share what you've learned and encourage other people to get educated and get involved in creating a cleaner Lake Champlain.

Appendix A. Quality Assurance Measures for phosphorus, chloride, and turbidity sampling in 2019. Values highlighted in red indicate a failed duplicate sample.

Location	Date	Test	Sample	Dup	RPD%	Precision for Field Duplicates (RPD)
Alder 10	6/25/19 8:20 AM	Chloride	8.85	8.12	8.603417796	≤ 5%
Engelsby 10	7/9/19 1:24 PM	Chloride	478	487	1.865284974	≤ 5%
Engelsby 20	7/9/19 9:15 AM	Chloride	1455	1470	1.025641026	≤ 5%
Mallets 10	7/23/19 9:30 AM	Chloride	44.2	41.7	5.820721769	≤ 5%
Munroe 20	7/23/19 10:10 AM	Chloride	36.9	36.3	1.639344262	≤ 5%
Muddy 10	8/6/19 6:45 AM	Chloride	139.2	137.4	1.301518438	≤ 5%
Muddy 20	8/6/19 8:00 AM	Chloride	93.5	382	121.3459516	≤ 5%
Potash 20	8/20/19 7:45 AM	Chloride	420	424	0.9478672986	≤ 5%
Potash 30	8/20/19 8:05 AM	Chloride	285	286	0.350262697	≤ 5%
Alder 10	6/25/19 8:20 AM	TP	75	73	2.702702703	≤30%
Engelsby 20	7/9/19 9:15 AM	TP	74	77	3.973509934	≤30%
Mallets 10	7/23/19 9:30 AM	TP	38	39	2.597402597	≤30%
Munroe 20	7/23/19 10:10 AM	TP	92	72	24.3902439	≤30%
Muddy 10	8/6/19 6:45 AM	TP	48	49	2.06185567	≤30%
Muddy 20	8/6/19 8:00 AM	TP	124	124	0	≤30%
Potash 20	8/20/19 7:45 AM	TP	41	34	18.66666667	≤30%
Potash 30	8/20/19 8:05 AM	TP	92	60	42.10526316	≤30%

RPD	Parameter	Mean	Median	Target
	Chloride	15.81	1.64	≤ 5%
	TP	12.06	3.34	≤30%

Appendix B. Project Completeness

Project proposal anticipated 5 dates for baseflow sampling across 21 sites (105 samples per parameter) as well as 2 rain dates sampling across 6 sites (12 samples per parameter). The number of anticipated samples also includes 10% blank and duplicate samples. Of note: It was only possible to sample during one high-flow event. Furthermore, the Allen Brook site was inaccessible by our volunteer and was not sampled at all this season, contributing to a lower percent completeness than in years past.

Parameter	Number of Samples Anticipated (including blanks and dups)	Number of Valid Samples* Collected and Analyzed	Percent Complete
Chloride	129	121	94%
Total Phosphorus	129	116	90%

*"Valid sample" includes all samples not flagged by issues that arose from blank or dupe results

Appendix C. Individual Sample Results. Boxes highlighted in yellow indicate issues flagged by inconsistent blank or duplicate results. All values in black text were included in graphing and statistical analyses of the 2019 report. Values in red text indicate blank samples and values in blue text indicate duplicate samples. See appendix A for more information about the use of blank and duplicate samples for quality assurance.

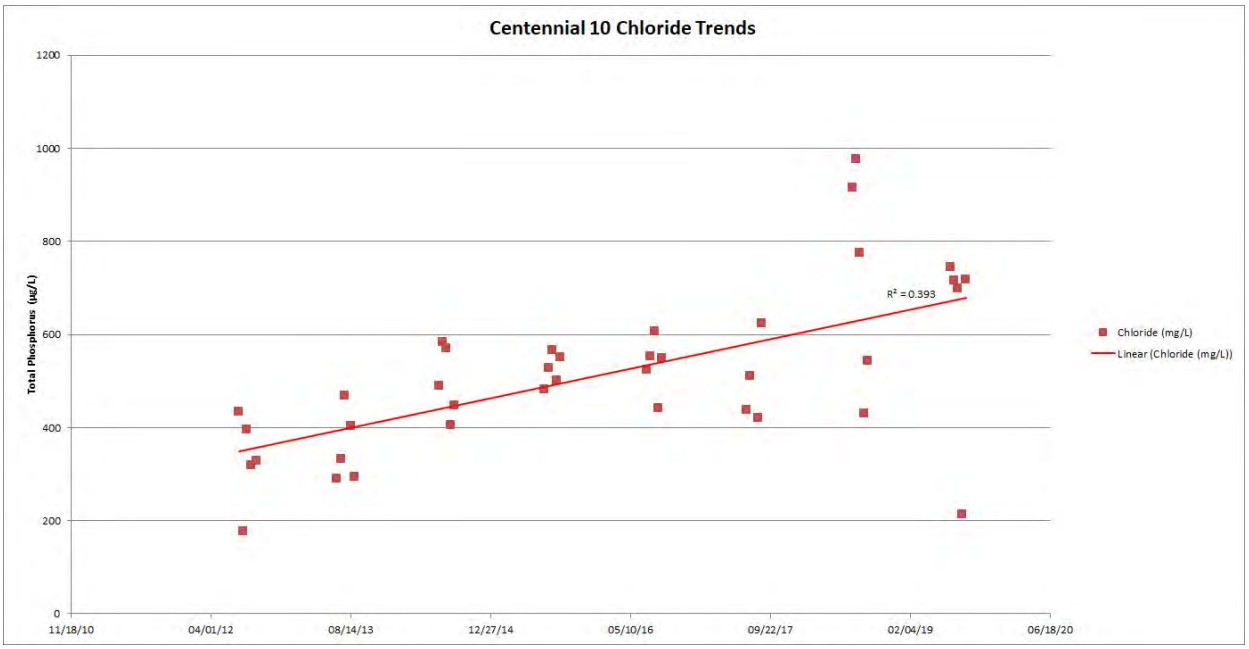
All Data 2019- ReThink Runoff Stream Team				
Lab Sample ID	**Location**	**Collected On**	**Total Phosphorus mg/L**	**Chloride ug P/L**
1900164-002	Alder 10	6/25/19 8:20 AM	75	8.85
1900321-002	Alder 10	7/9/19 8:45 AM	64	11.70
1900627-002	Alder 10	7/23/19 8:40 AM	62	11.60
1900629-002	Alder 10	8/6/19 9:00 AM	60	12.90
1900630-002	Alder 10	8/20/19 9:00 AM	51	11.70
1900164-023	Alder 10 DUP	6/25/19 8:20 AM	73	8.12
1900164-003	Centennial 10	6/25/19 1:00 PM	845	744.00
1900321-003	Centennial 10	7/9/19 10:05 AM	39	716.00
1900627-003	Centennial 10	7/23/19 8:51 AM	60	698.00
1900629-003	Centennial 10	8/6/19 8:48 AM	56	213.00
1900323-002	Centennial 10	8/8/19 9:35 AM	70	600.00
1900630-003	Centennial 10	8/20/19 9:32 AM	58	718.00
1900164-024	Centennial 10 BLANK	6/25/19 1:00 PM	<5	<2.00

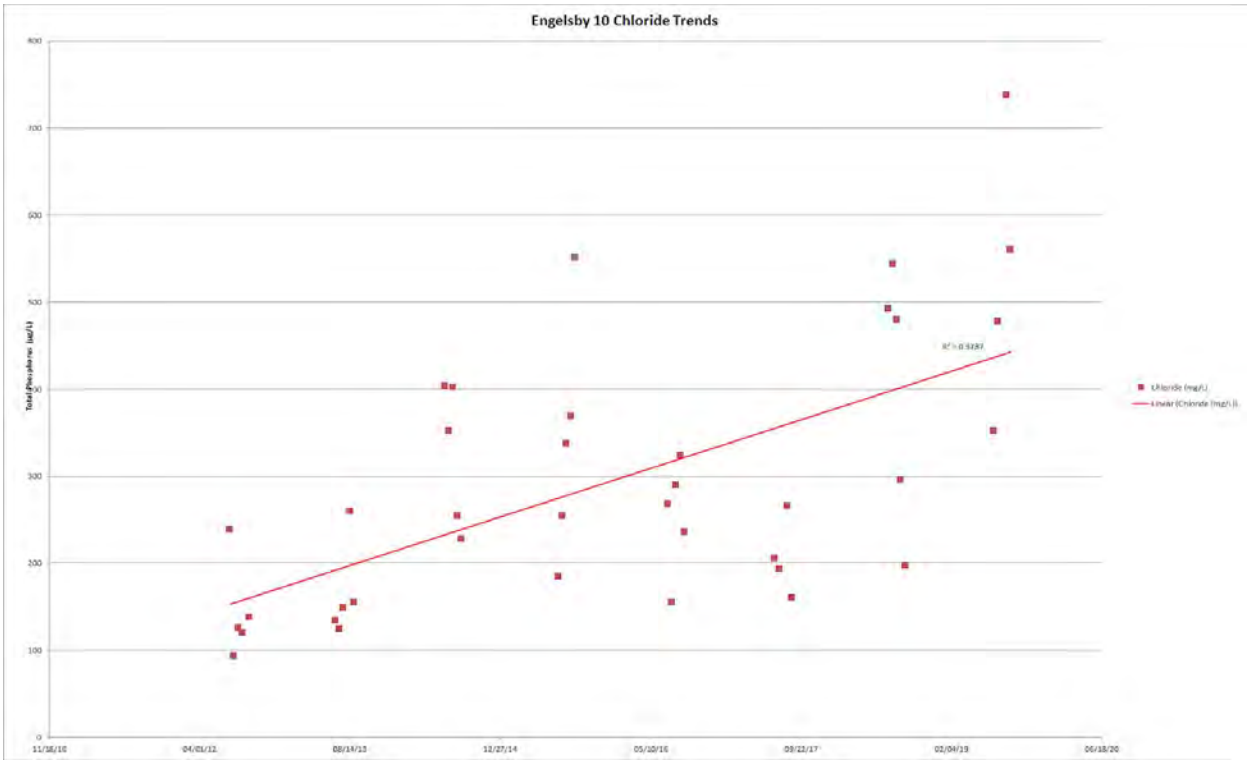
1900164-004	Centennial 20	6/25/19 1:20 PM	364	103.00
1900321-004	Centennial 20	7/9/19 9:45 AM	58	280.00
1900627-004	Centennial 20	7/23/19 8:42 AM	68	226.00
1900629-004	Centennial 20	8/6/19 8:37 AM	52	942.00
1900630-004	Centennial 20	8/20/19 9:28 AM	43	152.00
1900164-025	Centennial 20 BLANK	6/25/19 1:20 PM	<5	<2.00
1900164-005	Engelsby 10	6/25/19 8:00 AM	46	352.00
1900321-005	Engelsby 10	7/9/19 1:24 PM	44	478.00
1900627-005	Engelsby 10	7/23/19 7:15 AM	53	
1900629-005	Engelsby 10	8/6/19 7:30 AM	55	738.00
1900630-005	Engelsby 10	8/20/19 7:00 AM	75	560.00
1900321-022	Engelsby 10 DUP	7/9/19 1:24 PM		487.00
1900164-006	Engelsby 20	6/25/19 9:10 AM	75	1460.00
1900321-006	Engelsby 20	7/9/19 9:15 AM	74	1455.00
1900627-006	Engelsby 20	7/23/19 8:40 AM	64	990.00
1900629-006	Engelsby 20	8/6/19 8:00 AM		2255.00
1900321-023	Engelsby 20 DUP	7/9/19 9:15 AM	77	1470.00
1900164-007	Indian 10	6/25/19 9:10 AM	35	170.00
1900321-007	Indian 10	7/9/19 9:10 AM	38	219.00
1900627-007	Indian 10	7/23/19 9:07 AM	42	247.50
1900629-007	Indian 10	8/6/19 9:05 AM	34	312.00
1900323-006	Indian 10	8/8/19 8:45 AM	115	152.00
1900630-007	Indian 10	8/20/19 9:05 AM	33	296.00
1900321-024	Indian 10 BLANK	7/9/19 9:10 AM	<5	<2.00
1900164-008	Indian 20	6/25/19 9:30 AM	46	59.00
1900321-008	Indian 20	7/9/19 9:30 AM	56	201.00
1900627-008	Indian 20	7/23/19 9:20 AM	71	108.00
1900629-008	Indian 20	8/6/19 9:20 AM	50	230.00
1900630-008	Indian 20	8/20/19 9:30 AM	54	193.00
1900321-025	Indian 20 BLANK	7/9/19 9:30 AM	<5	<2.00
1900164-009	Mallet 10	6/25/19 6:30 AM	31	37.00
1900321-009	Mallets 10	7/9/19 6:20 AM	48	45.80
1900627-009	Mallets 10	7/23/19 9:30 AM	38	44.20
1900629-009	Mallets 10	8/6/19 6:15 AM	36	54.00
1900630-009	Mallets 10	8/20/19 7:45 AM	34	54.80
1900627-022	Mallets 10 DUP	7/23/19 9:30 AM	39	41.70
1900164-012	Morehouse IPB	6/25/19 8:00 AM	31	116.50

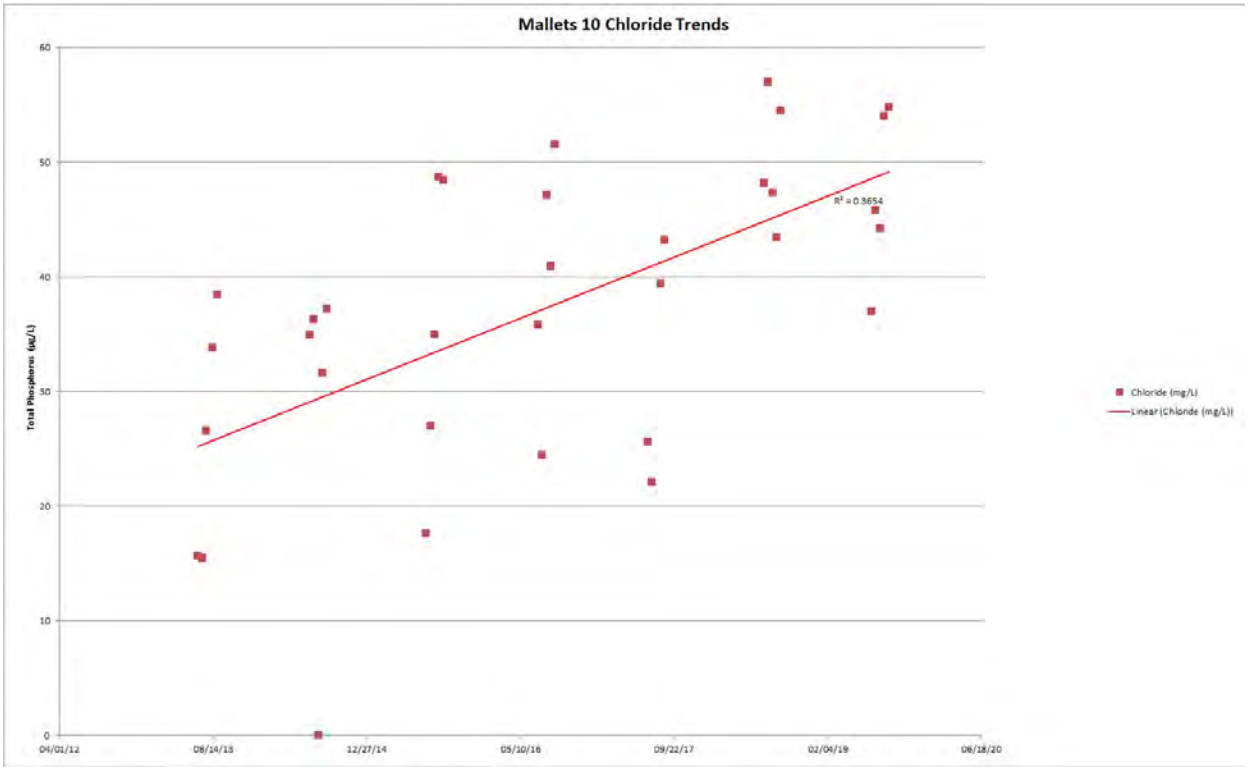
1900321-012	Morehouse IPB	7/9/19 7:00 AM	37	127.00
1900627-012	Morehouse IPB	7/23/19 7:15 AM	36	131.50
1900629-012	Morehouse IPB	8/6/19 7:00 AM	40	154.00
1900323-004	Morehouse IPB	8/8/19 9:25 AM	32	358.00
1900630-012	Morehouse IPB	8/20/19 7:15 AM	57	188.60
1900627-024	Morehouse IPB BLANK	7/23/19 7:15 AM	<5	<2.00
1900164-011	Morehouse PGT	6/25/19 8:00 AM	27	307.00
1900321-011	Morehouse PGT	7/9/19 7:00 AM	38	332.00
1900627-011	Morehouse PGT	7/23/19 7:15 AM	32	301.00
1900629-011	Morehouse PGT	8/6/19 7:00 AM	33	398.00
1900323-003	Morehouse PGT	8/8/19 9:20 AM	70	65.80
1900630-011	Morehouse PGT	8/20/19 7:15 AM	39	466.00
1900627-025	Morehouse PGT BLANK	7/23/19 7:15 AM	<5	<2.00
1900164-013	Muddy 10	6/25/19 7:00 AM	63	90.00
1900321-013	Muddy 10	7/9/19 6:45 AM	55	116.50
1900627-013	Muddy 10	7/23/19 6:45 AM	68	151.00
1900629-013	Muddy 10	8/6/19 6:45 AM	48	139.20
1900630-013	Muddy 10	8/20/19 9:00 AM	35	193.80
1900629-022	Muddy 10 DUP	8/6/19 6:45 AM	49	137.40
1900321-014	Muddy 20	7/9/19 9:00 AM	80	85.00
1900627-014	Muddy 20	7/23/19 7:45 AM	97	94.20
1900629-014	Muddy 20	8/6/19 8:00 AM	124	93.50
1900630-014	Muddy 20	8/20/19 7:45 AM	110	125.00
1900629-023	Muddy 20 DUP	8/6/19 8:00 AM	124	382.00
1900164-015	Muddy 30	6/25/19 7:40 AM	75	25.70
1900321-015	Muddy 30	7/9/19 7:15 AM	67	28.20
1900627-015	Muddy 30	7/23/19 8:00 AM	65	28.90
1900629-015	Muddy 30	8/6/19 8:04 AM	59	27.00
1900323-001	Muddy 30	8/8/19 10:00 AM	105	38.30
1900630-015	Muddy 30	8/20/19 8:00 AM	73	32.10
1900629-024	Muddy 30 BLANK	8/6/19 8:04 AM	<5	<2.00
1900164-010	Munroe 20	6/25/19 11:00 AM	59	39.20
1900321-010	Munroe 20	7/9/19 9:40 AM	55	33.40
1900627-010	Munroe 20	7/23/19 10:10 AM	92	36.90
1900629-010	Munroe 20	8/6/19 10:07 AM	55	36.40
1900630-010	Munroe 20	8/20/19 9:30 AM	44	35.00
1900627-023	Munroe 20 DUP	7/23/19 10:10 AM	72	36.30

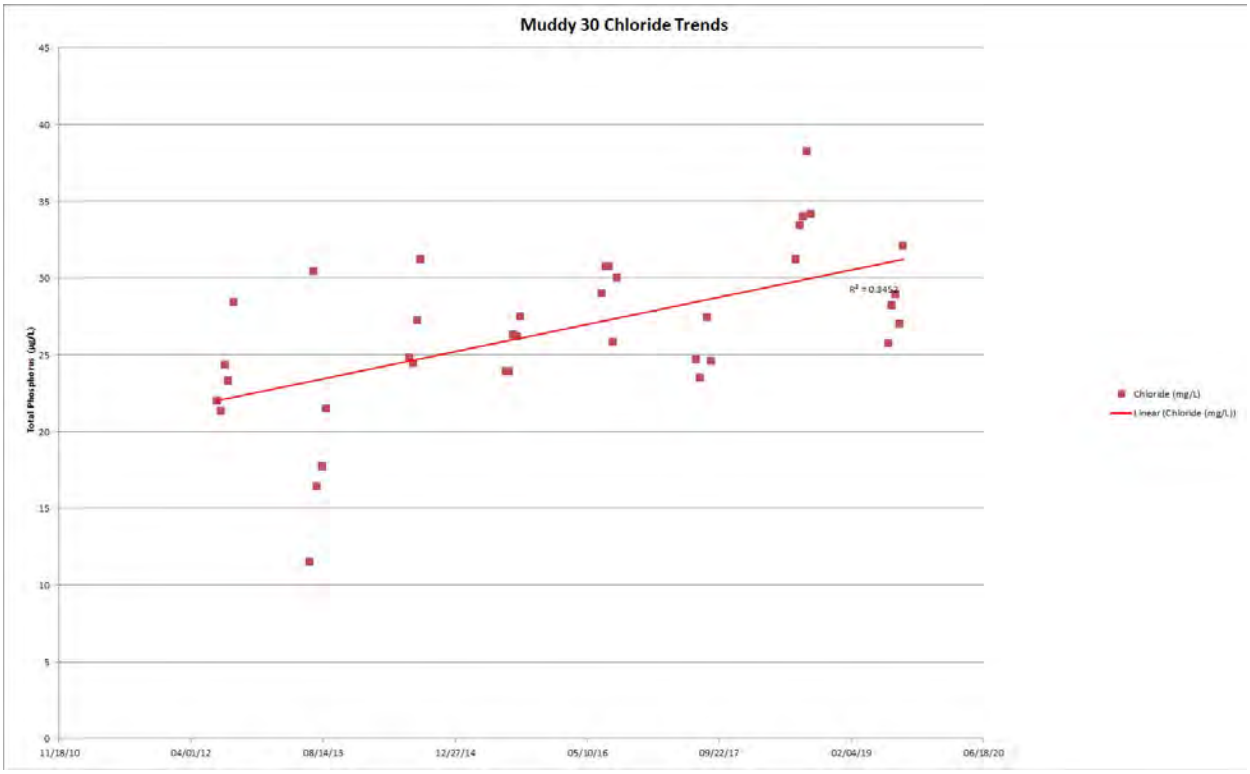
1900164-016	Potash 10	6/25/19 7:20 AM	34	374.00
1900321-016	Potash 10	7/9/19 7:20 AM		400.00
1900627-016	Potash 10	7/23/19 7:15 AM		446.00
1900629-016	Potash 10	8/6/19 7:25 AM	29	480.00
1900630-016	Potash 10	8/20/19 7:25 AM	32	438.00
1900629-025	Potash 10 BLANK	8/6/19 7:25 AM	6	<2.00
1900164-017	Potash 20	6/25/19 7:35 AM	38	371.00
1900321-017	Potash 20	7/9/19 7:45 AM	33	442.00
1900627-017	Potash 20	7/23/19 7:25 AM	40	462.00
1900629-017	Potash 20	8/6/19 7:40 AM	30	528.00
1900323-005	Potash 20	8/8/19 8:20 AM	139	183.40
1900630-017	Potash 20	8/20/19 7:45 AM	41	420.00
1900630-022	Potash 20 DUP	8/20/19 7:45 AM	34	424.00
1900164-018	Potash 30	6/25/19 7:45 AM	48	289.00
1900321-018	Potash 30	7/9/19 8:03 AM	49	328.00
1900627-018	Potash 30	7/23/19 8:10 AM	103	336.00
1900629-018	Potash 30	8/6/19 7:55 AM	212	324.00
1900630-018	Potash 30	8/20/19 8:05 AM	92	285.00
1900630-023	Potash 30 DUP	8/20/19 8:05 AM	60	286
1900164-019	Sunderland 10	6/25/19 11:15 AM	90	161.50
1900321-019	Sunderland 10	7/9/19 7:26 AM	58	165.00
1900627-019	Sunderland 10	7/23/19 11:02 AM	61	177.00
1900629-019	Sunderland 10	8/6/19 10:02 AM	72	177.40
1900630-019	Sunderland 10	8/20/19 10:30 AM	51	230.00
1900630-024	Sunderland 10 BLANK	8/20/19 10:30 AM	5	<2.00
1900164-020	Sunderland 20	6/25/19 8:18 AM	62	189.50
1900321-020	Sunderland 20	7/9/19 9:20 AM	42	187.00
1900627-020	Sunderland 20	7/23/19 6:54 AM	79	182.50
1900629-020	Sunderland 20	8/6/19 7:05 AM	64	171.60
1900630-020	Sunderland 20	8/20/19 7:00 AM	52	196.60
1900630-025	Sunderland 20 BLANK	8/20/19 7:00 AM	<5	<2.00
1900164-021	Sunnyside 10	6/25/19 10:10 AM	10	1090.00
1900321-021	Sunnyside 10	7/9/19 10:30 AM	9	1170.00
1900627-021	Sunnyside 10	7/23/19 9:15 AM	12	1320.00
1900629-021	Sunnyside 10	8/6/19 10:48 AM	282	1980.00
1900630-021	Sunnyside 10	8/20/19 9:20 AM	61	2075.00

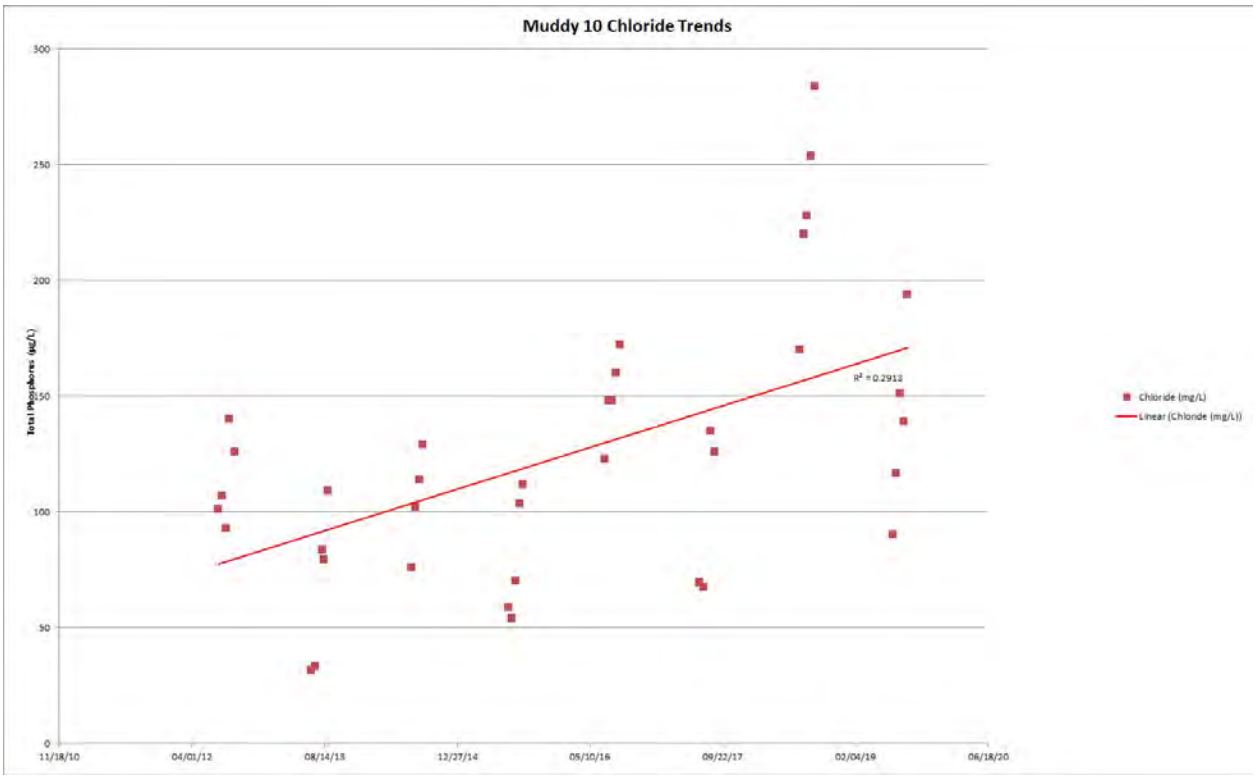
Appendix D. Notable Trends in Chloride Increases Over Time By Site. Sorted in descending order by R2 values.

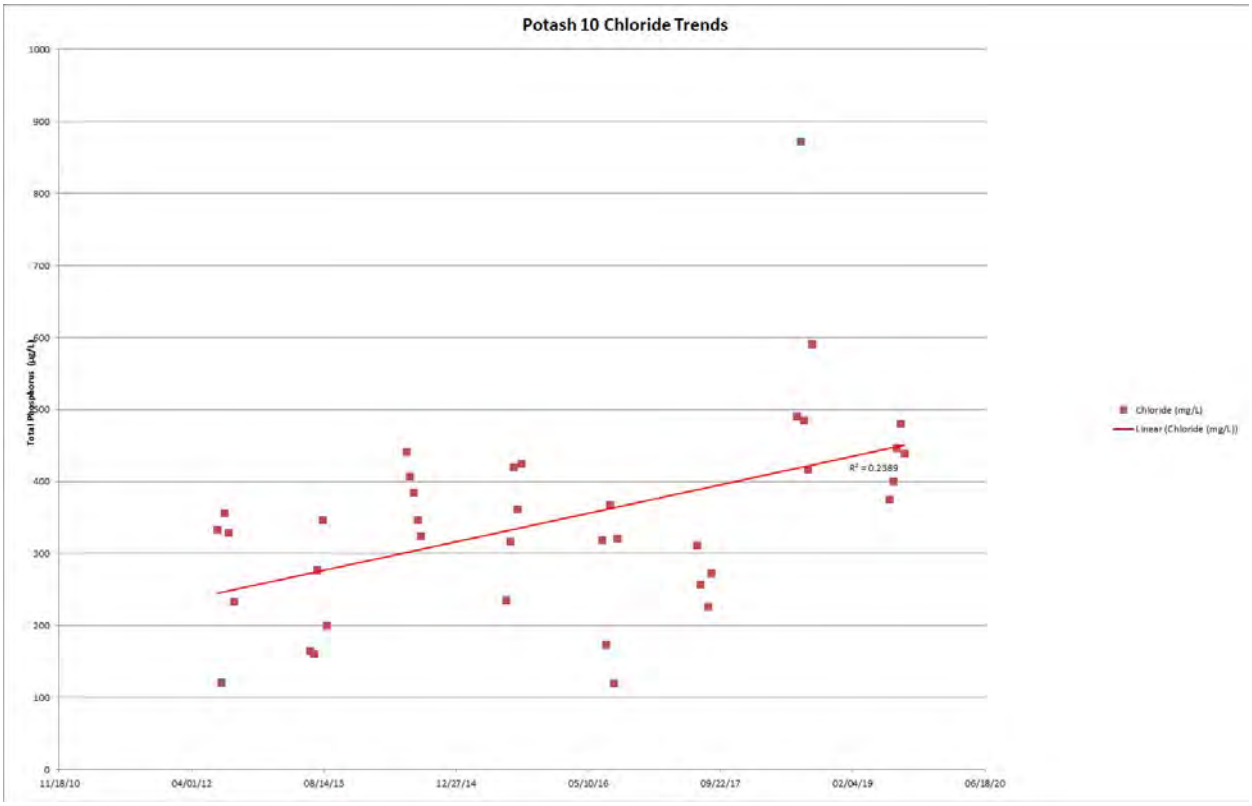


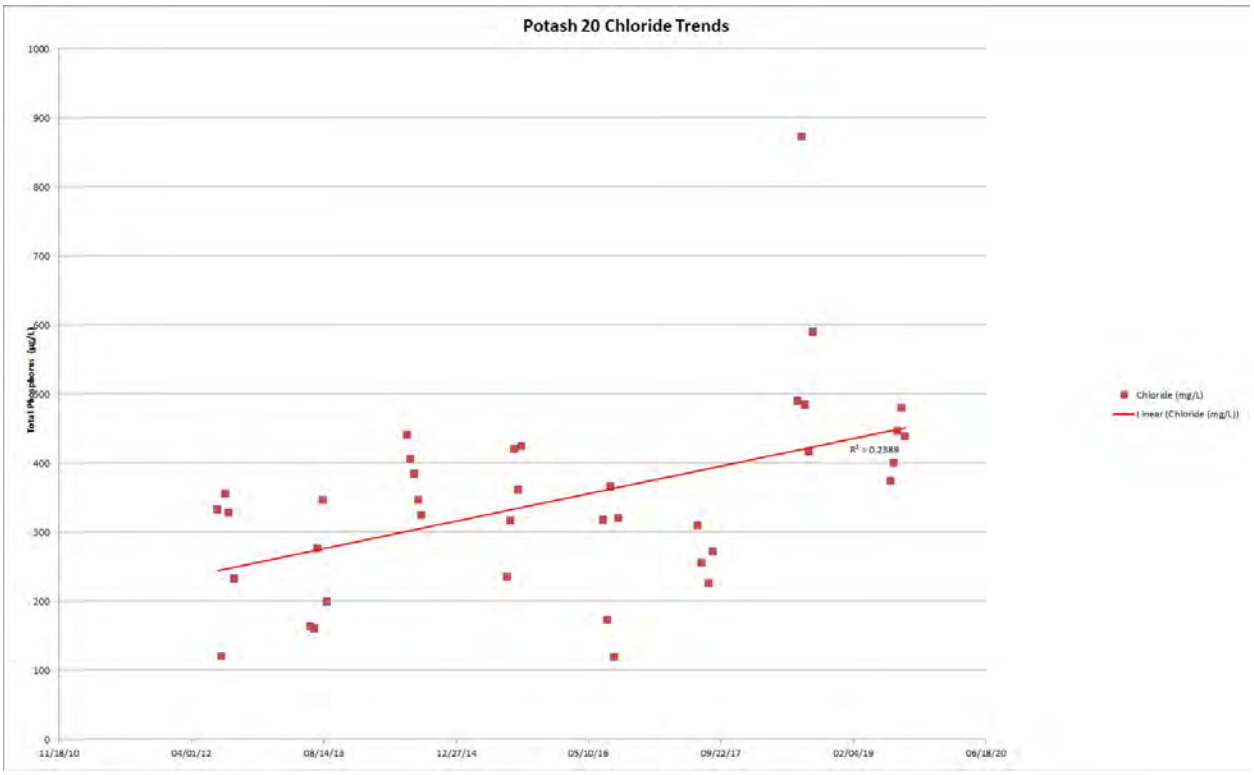


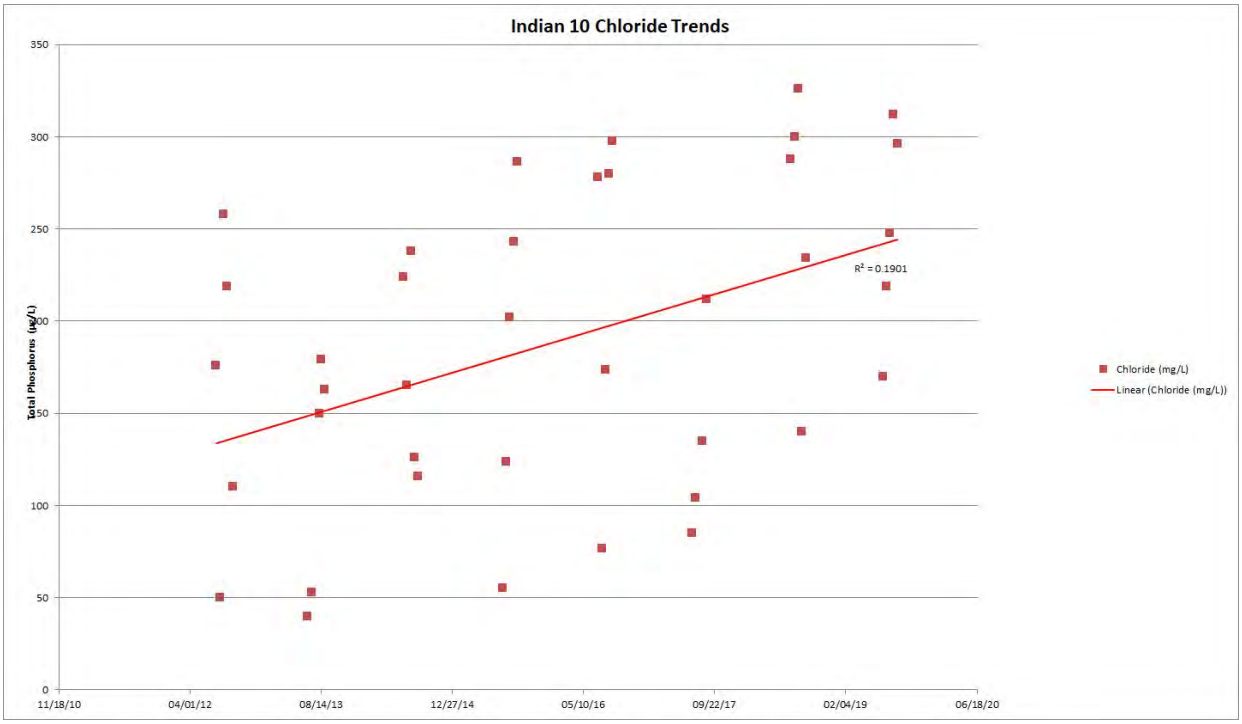

Mallets 10 Chloride Trends
Total Phosphorus (µg/L)
R² = 0.3654
Chloride (mg/L)
Linear (Chloride (mg/L))
04/01/12
08/14/13
12/27/14
05/10/16
09/22/17
02/04/19
08/18/20

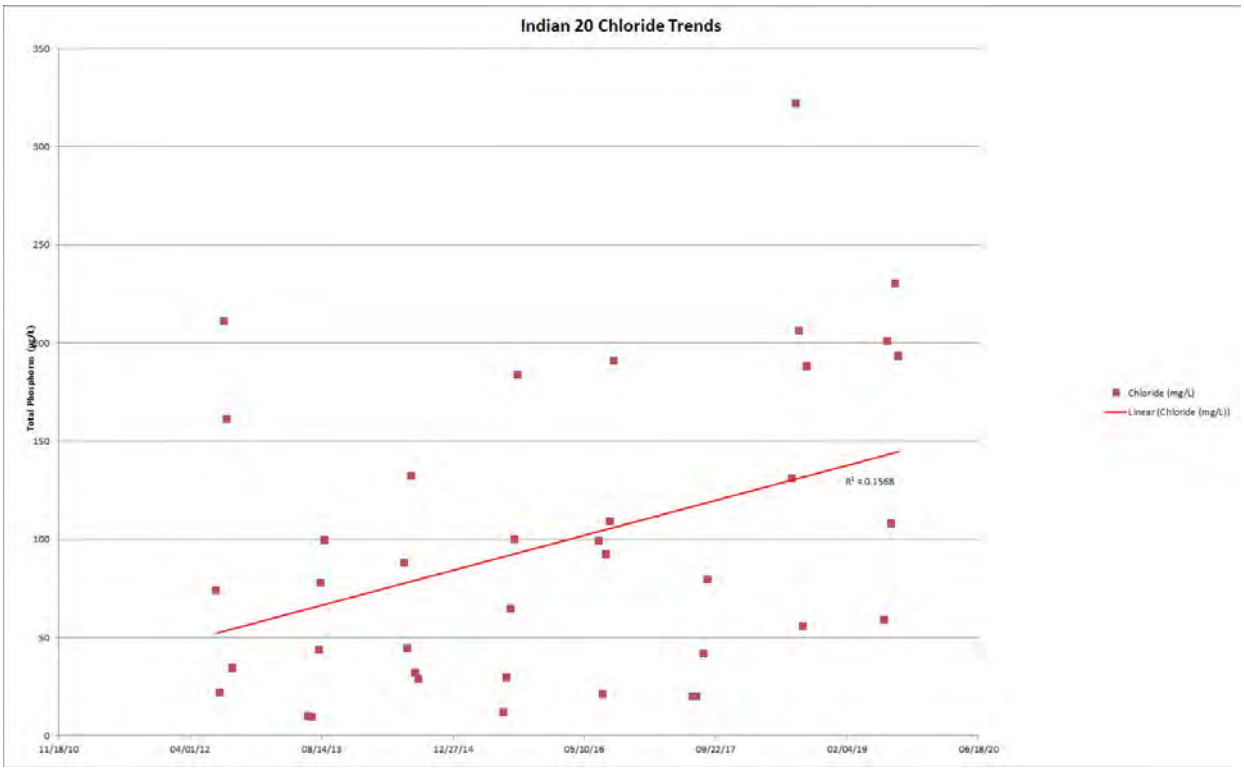

Muddy 30 Chloride Trends
Total Phosphorus (µg/L)
Chloride (mg/L)
Linear (Chloride (mg/L))
11/18/10
04/01/12
08/14/13
12/27/14
05/10/16
09/22/17
02/04/19
08/18/20

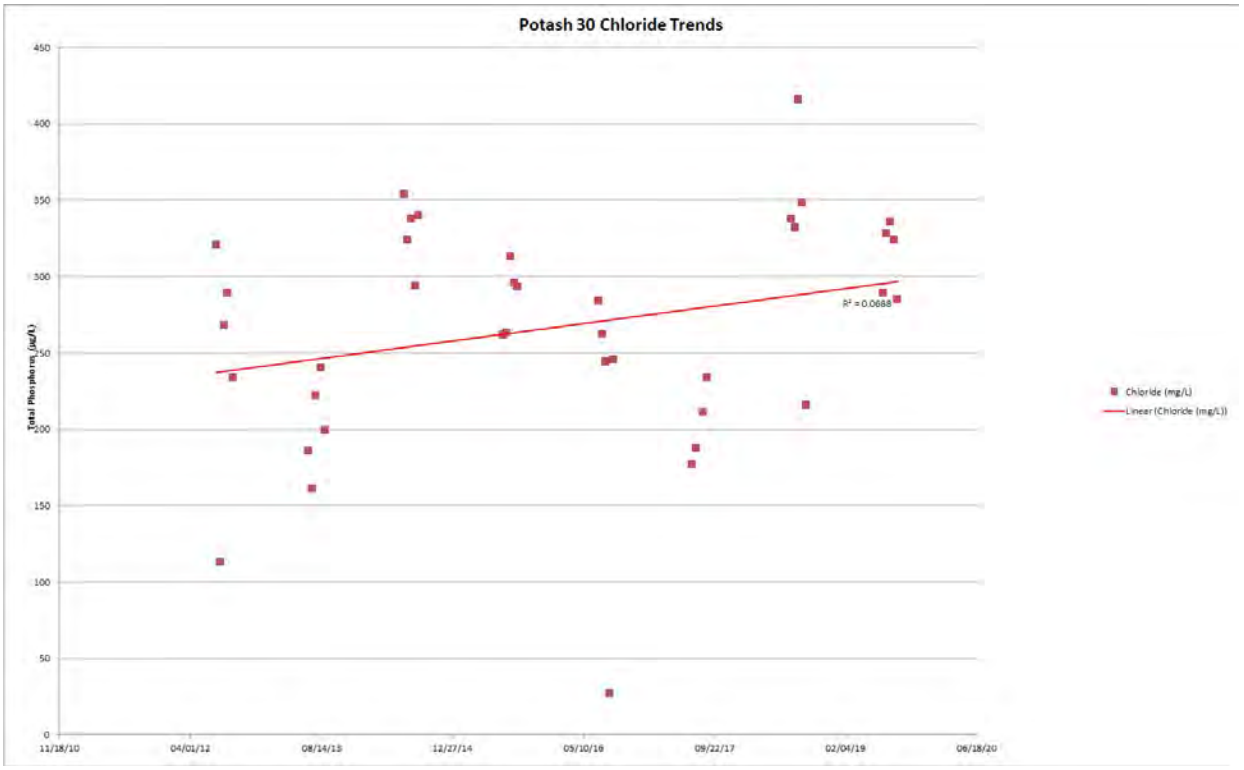

Muddy 10 Chloride Trends
Total Phosphorus (µg/L)
300
250
200
150
100
50
0
11/18/10
04/01/12
08/14/13
12/27/14
05/10/16
09/22/17
02/04/19
06/18/20
R² = 0.2912
Chloride (mg/L)
Linear (Chloride (mg/L))

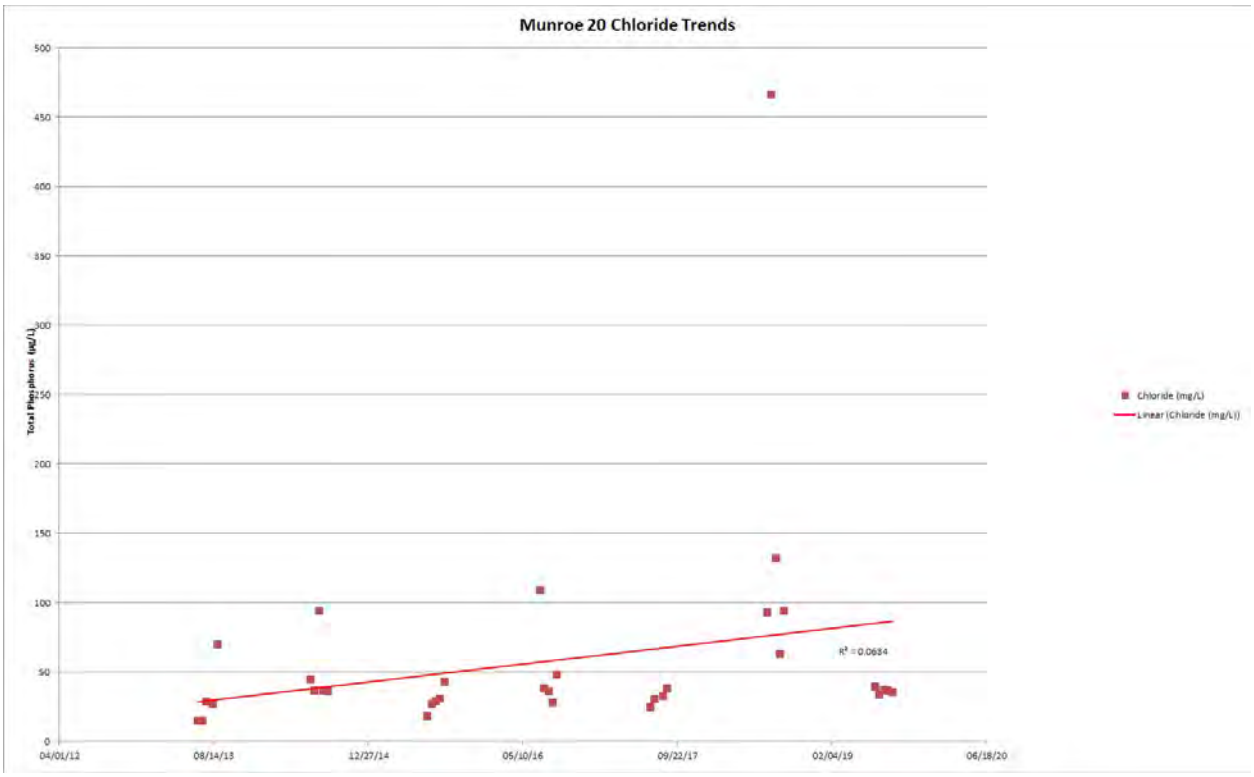

Potash 10 Chloride Trends
Total Phosphorus (µg/L)
1000
900
800
700
600
500
400
300
200
100
0
11/18/10
04/01/12
08/14/13
12/27/14
05/10/16
09/22/17
02/04/19
06/18/20
R² = 0.2389
Chloride (mg/L)
Linear (Chloride (mg/L))


Potash 20 Chloride Trends
1000
900
800
700
600
500
400
300
200
100
0
11/18/10
04/01/12
08/14/13
12/27/14
05/10/16
09/22/17
02/04/19
06/18/20
R² = 0.2389
Chloride (mg/L)
Linear (Chloride (mg/L))


Indian 10 Chloride Trends
350
300
250
200
150
100
50
0
11/18/10
04/01/12
08/14/13
12/27/14
05/10/16
09/22/17
02/04/19
06/18/20
R² = 0.1901
Chloride (mg/L)
Linear (Chloride (mg/L))


Indian 20 Chloride Trends
Total Phosphorus (µg/L)
350
300
250
200
150
100
50
0
11/18/10
04/01/12
08/14/13
12/27/14
05/10/16
09/22/17
02/04/19
06/18/20
R² = 0.1568
Chloride (mg/L)
Linear (Chloride (mg/L))


Potash 30 Chloride Trends
Total Phosphorus (µg/L)
450
400
350
300
250
200
150
100
50
0
11/18/10
04/01/12
08/14/13
12/27/14
05/10/16
09/22/17
02/04/19
06/18/20
R² = 0.0688
Chloride (mg/L)
Linear (Chloride (mg/L))


Munroe 20 Chloride Trends
Total Phosphorus (ug/L)
500
450
400
350
300
250
200
150
100
50
0
04/01/12
08/14/13
12/27/14
05/10/16
09/22/17
02/04/19
06/18/20
R² = 0.0684
Chloride (mg/L)
Linear (Chloride (mg/L))