LOXAHATCHEE RIVER WATER QUALITY EVENT SAMPLING

TASK 2: FINAL REPORT
ASSESSMENT OF 2007-2008 LOXAHATCHEE RIVER WATER QUALITY

In Partial Fulfillment of Agreement No. 4600001281

For the Period

October 2007 through September 2008

Respectfully Submitted by

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&
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Loxahatchee River District

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Introduction

Since 1971 the Loxahatchee River District (LRD) has been fulfilling its mission to preserve and protect the Loxahatchee River through an innovative wastewater treatment and reuse program and an active research and monitoring program within the Loxahatchee River. For more than 15 years, the Loxahatchee River District has carefully documented water quality in the Loxahatchee River through a monthly water quality sampling program termed Project RiverKeeper. More recently, efforts by the South Florida Water Management District (SFWMD) to develop a water quality model for the Loxahatchee River have resulted in the need to better understand short-term nutrient dynamics in the system. In particular, some research suggests that nutrient dynamics and nutrient loading in the Loxahatchee River may be strongly affected by runoff derived from short-term rainfall events. The monthly sampling of Project RiverKeeper may miss such short-term effects. Therefore, in addition to the RiverKeeper water quality monitoring the Loxahatchee River District partnered with the SFWMD to conduct high-frequency water quality sampling in response to rainfall events in the Loxahatchee River watershed. We designed this event-based project to determine the effect of rainfall events and associated increased discharge on various water quality parameters by conducting high-frequency (every 4 hours) short duration (3–5 days) water quality monitoring. This year LRD staff sampled a canal draining Jupiter Farms and in the Northwest Fork of the Loxahatchee River at river mile 15 (Indiantown Road bridge).

In this report we summarized results from the water quality event sampling as well as rainfall and discharge data for the period October 2007 – September 2008. These water quality event sampling data explore the rapid and short-term changes in water quality (i.e., nutrient concentrations, conductivity, alkalinity, pH, etc) during and immediately following rainfall events (Appendix A). We interpreted these results in the context of average wet and dry season water quality conditions derived from the monthly RiverKeeper data (Figure 3). We also assessed potential relationships between water quality conditions and surface water discharge rates (Figure 4; Appendix A).

Study Area

The Loxahatchee River estuary encompasses approximately 400 ha and drains a watershed of approximately 700 km^2 located in northeastern Palm Beach County and southeastern Martin County, Florida, USA. Freshwater discharges into the estuary from the North Fork, the Northwest Fork, and the Southwest Fork of the Loxahatchee River. Since the 1950's, flood control efforts have substantially altered the hydrology of the basin. Historically (pre-1950), most surface water runoff reaching the estuary originated in the Loxahatchee and Hungryland Sloughs and flowed gradually to the Northwest Fork. In the 1930s the Lainhart Dam, a small fixed-weir dam, was constructed in the Northwest Fork at river mile 14.5 to reduce "over" drainage of upstream reaches of the Northwest Fork during the dry season. In 1958 a major canal (C-18) and flood control structure (S-46) were constructed to divert flows from the Northwest Fork to the Southwest Fork, which increased the intensity and decreased the duration of storm-related discharge to the estuary.

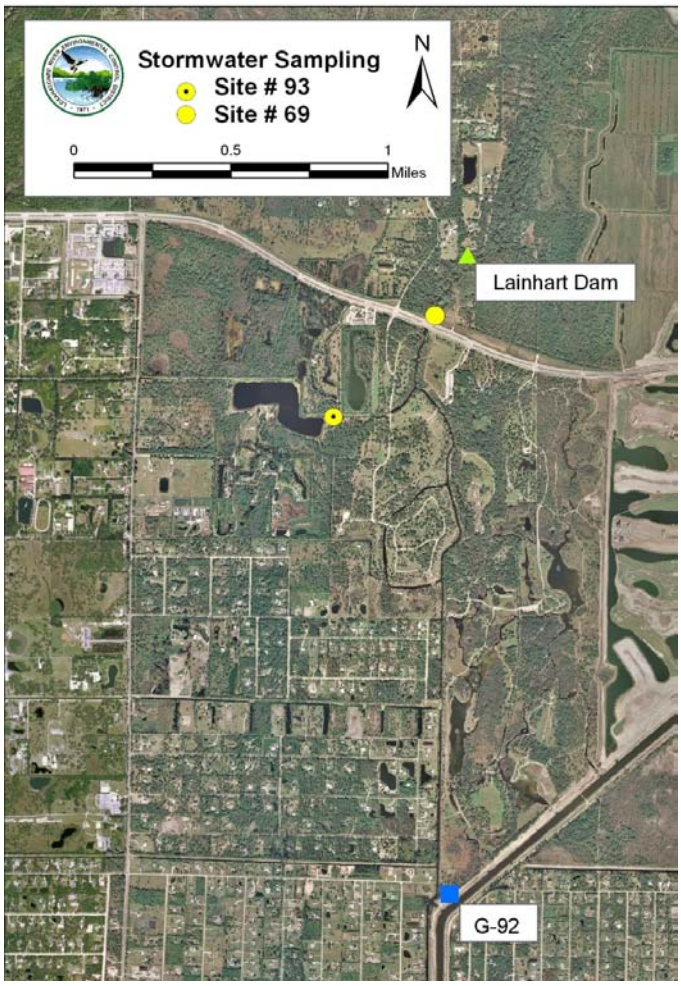


Figure 1. Water quality was assessed during and after rainfall events at Station 69 and Station 93, both of which are located in the far upstream reach of the Northwest Fork of the Loxahatchee River.

The Northwest Fork of the Loxahatchee River was the first federally designated wild and scenic river in the state of Florida, and is the southern most wild and scenic river in the nation. The headwaters of the Loxahatchee River are formed by water flowing from the C-18 canal through the G-92 structure into the C-14 canal and then on to the Northwest Fork of the Loxahatchee River. In addition to water from the C-18 canal, the Northwest Fork also receives flow from the major east-west canals that drain the Jupiter Farms area. Sampling station 93 was located near the eastern terminus of the northern east-west Jupiter Farms drainage canal

(26°55'58"N, 80°10'52"W; Figure 1). We sampled water from this canal after it had passed through a large stormwater retention lake and an operable weir structure but before it entered the western branch of the Northwest Fork of the Loxahatchee River. Sampling station 69 was located in the Northwest Fork of the Loxahatchee River at river mile 15 – where Indiantown Road crosses the river (26°56.233'N, 80°10.567'W; Figure 1).

Materials and Methods

We monitored water quality following three rainfall events during the period October 2007 – September 2008. Two water sampling events occurred at Station 69, and the third event occurred at Station 93 (Table 1). An automatic water sampler (Teledyne ISCO, Avalanche Portable Refrigerated Sampler 6700 Series) collected duplicate water samples (one raw, one acidified) every 4 hours during and after a heavy rain event. LRD's WildPine Laboratory analyzed the samples for turbidity (ntu), total suspended solids (mg/l), color (pcu), orthophosphorus (mg-P/L); total phosphorus (mg-P/L); alkalinity (mg/L); total kjeldahl nitrogen (mg-N/L); ammonia (mg-N/L); nitrate + nitrite (mg-N/L); and total nitrogen (mg-N/L). An accompanying HydroLab Data Sonde 3 or 4 recorded temperature, PH, conductivity, dissolved oxygen and water depth each hour.

Table 1. Characterization of the three rainfall events that triggered water quality event sampling during the period October 2007 through September 2008.

Event Number	1	2	3
Sampling Station #	69	69	93
Sampling Location	Indiantown Rd	Indiantown Rd	Jupiter Farms
Sampling Date/Time	2/13/2008 01:00 to 2/16/2008 09:00	5/22/2008 16:00 to 5/26/2008 17:00	8/18/2008 12:00 to 8/22/2008 08:00
Season	Dry	Dry	Wet
Total rainfall (in) during event at Jupiter Farms	2.35	3.53	6.98
Total rainfall (in) during event at LRD Plant	1.66	2.83	8.34
Peak daily discharge @ Lainhart Dam (cfs)	107	40	356
Peak daily discharge @ S-46 (cfs)	30	0	641

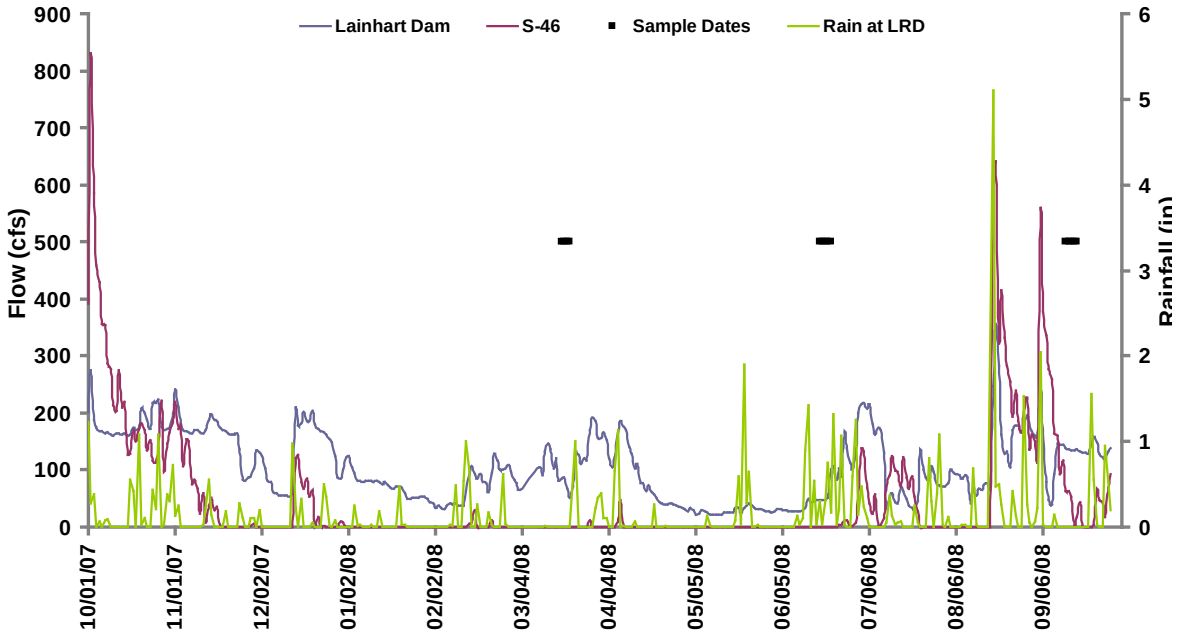


Figure 2. Water quality event samples were collected during and immediately following rainfall events (i.e., storms). Mean daily discharge data were from Lainhart Dam, which corresponds to flows at the sampling stations, and S-46, which illustrates the magnitude of flood control releases through this period. LRD staff measured rainfall at our wastewater treatment facility.

Results & Discussion

Fifty-seven inches of rain fell in Jupiter, FL (i.e., the Loxahatchee River watershed) during the period October 1, 2007 through September 30, 2008. The most rainfall observed during any one day occurred on August 19, 2008 when Tropical Storm Fay delivered 5.1" of rain (Figure 2). Between October 2007 and September 2008 57.42 inches of rain fell over 142 days. More than 2" of rain fell on 2 days, more than 1" of rain fell on 15 days, and more than 0.5" of rain fell on 37 days, thus the majority of rainfall events (74%) delivered <0.5" of rainfall. During this period, the SFWMD recorded freshwater flow over Lainhart Dam and S-46 (Figure2).

Rainfall exceeding 0.5 inches in two hours triggered the sample collection for Events 1 and 2. We manually initiated Event 3 in advance of Tropical Storm Fay. Sample collection lasted 4 to 5 days, depending on rain duration. During each sampling event, LRD staff collected samples and replaced empty bottles every 24 hours. The first and second sampling events at Station 69 occurred in February and May, during the dry season (December – May), while the third event, monitored at Station 93, occurred during the wet season (June – November). More rain fell during the third storm event, which resulted from a wet-season tropical storm during the, than during the two monitored events that occurred during the dry season (Table 2).

Figure 3 shows the relative impact of stormwater runoff from short-term rainfall events on water quality in the upstream reaches of the Loxahatchee River (at Station #69). Event-based sampling documented relatively ephemeral spikes in water quality driven by stormwater runoff. For example, both turbidity and TSS showed significant increases during the event sampling relative to values obtained during routine Riverkeeper monitoring. Rainfall events and associated stormwater runoff drive short-term changes in most water quality parameters. Nutrient dynamics in and nutrient loading to the Loxahatchee River were clearly affected by runoff following rainfall events.

Table 2. Summary of daily rainfall totals during each storm water sampling event, measured at Jupiter Farms and the Loxahatchee River District facility, Jupiter, Florida.

Rainfall Event	Date	Rainfall (inches) Jupiter Farms	LRD Plant Site
1	2/13/08	1.93	1.00
	2/14/08	0.42	0.66
	2/15/08	0.00	0.00
	2/16/08	0.00	0.00
	Total	2.35	1.66
2	5/22/08	0.00	1.90
	5/23/08	2.47	0.28
	5/24/08	0.48	0.65
	5/25/08	0.58	0.00
	5/26/08	0.00	0.00
	Total	3.53	2.83
3	8/18/08	0.00	2.00
	8/19/08	2.40	5.10
	8/20/08	3.64	0.48
	8/21/08	0.67	0.50
	8/22/08	0.27	0.26
	Total	6.98	8.34

Our data, illustrated in Figure 3 and two appendices, clearly depict substantial variation among events and between locations. This variation was likely influenced by differences in antecedent rainfall, ambient water levels, magnitude of rainfall, as well as a host of other potential factors (e.g., river stage, flood control operations).

Graphs presented in Appendix B show the response at Station 93 was substantially different than the responses observed at Station 69. In particular, conductivity, alkalinity, ortho-phosphorus, and total phosphorus showed a clearer response following the rainfall event and a much larger magnitude of effect at Station 93 than Station 69. We believe differences in hydraulics between the two sites may drive these findings. For example, water sampled at Station 93 was derived from Jupiter Farms drainage, whereas water at Station 69 was comprised of water from (1) the C-18 canal, (2) water draining from Jupiter Farms, and (3) water draining from Riverbend Park. Of course, high quality water flowing from the C-18 canal and Riverbend Park wetlands may have buffered nutrient loads flowing in from Jupiter Farms.

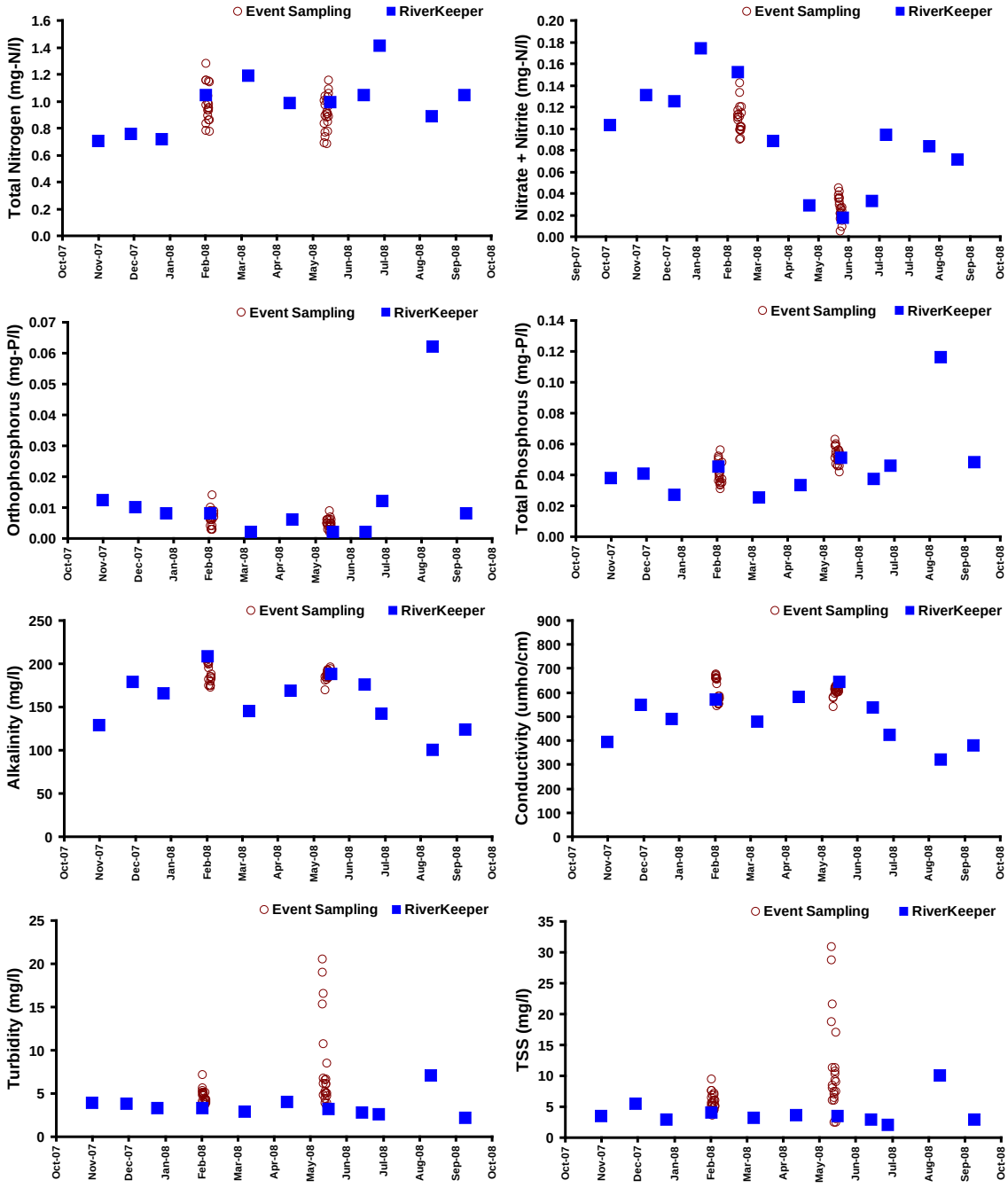


Figure 3. Comparison of water quality at Station 69 (Loxahatchee River @ Indiantown Road bridge) during storm events (using samples taken every 4 hours) and during routine, monthly sampling (RiverKeeper Data). All samples were collected at the exact same location. Monthly samples provide a reliable picture of average water quality conditions at the site over the year. Nonetheless, our event sampling showed significant, short-term departures from 'average' conditions during and immediately following rainfall events, i.e., see turbidity and TSS plots.

In addition, sampling Station 69 during dry season rainfall events, may have contributed to the low concentrations of nutrients running off the landscape and transported in the water column. In fact, the South Indian River Water Control District (SIRWCD) installed operable structures at the eastern end of the major canals draining Jupiter Farms, and these structures may have been sufficient to retain dry season runoff, which would clearly benefit water quality in the Northwest Fork of the Loxahatchee River.

A large and ongoing challenge is the creation of a water quality model that adequately characterizes nutrient inputs and water quality in the Loxahatchee River. In an effort to facilitate the calibration and validation of such a model, we explored potential relationships between each of the monitored water quality parameters and surface water discharge (flow) rates (Appendix A). First, note that there were meaningful differences in average surface water discharge and water quality conditions between wet and dry seasons. On average, rainfall events during the dry season result in small increases in surface water discharge (as measured at Lainhart Dam; see Figure 2), while similar amounts of rain in the wet season result in large increases in discharge. The third event monitored was associated with a substantial amount of rainfall derived from Tropical Storm Fay. This large amount of rainfall resulted in a significant amount of stormwater runoff, which likely carried larger loads of nutrients. Clearly, the magnitude of the rainfall event appears to affect the magnitude of nutrient loaded to the river. Nonetheless, it may be somewhat inappropriate to generate gross relationships for water quality parameters as an overall function of rainfall or discharge amount.

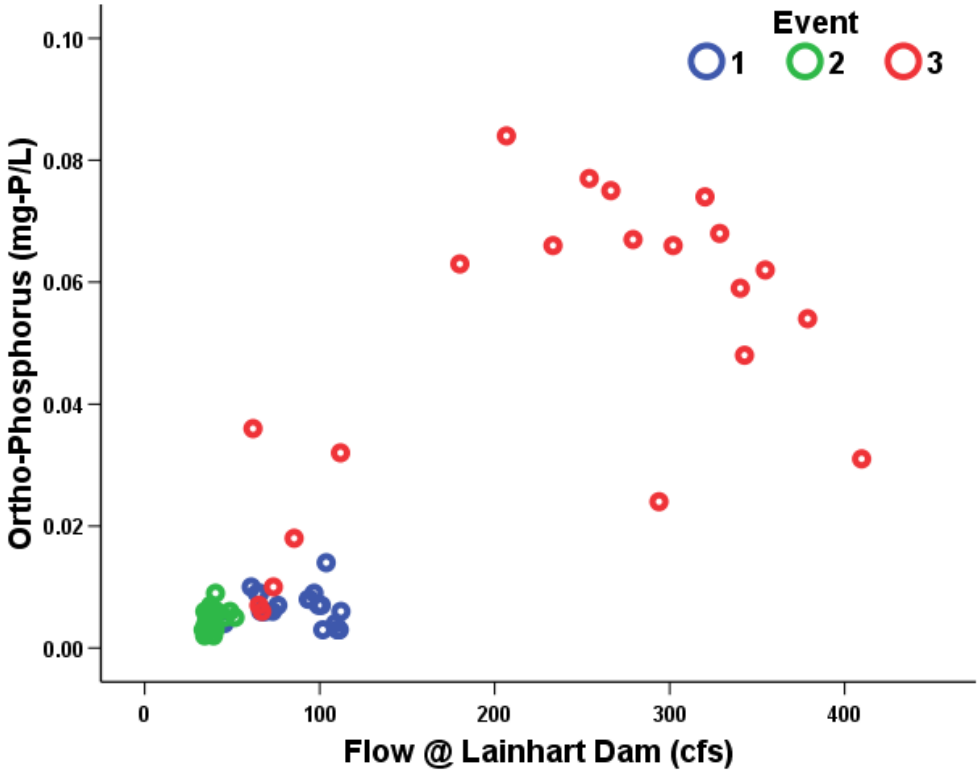
Finally, we organized the water quality event sampling data to show the temporal succession in water quality conditions following each event. These data illustrate a number of interesting findings. The figures in Appendix B clearly illustrate the rapid, short-term increase in orthophosphorus and total phosphorus concentrations at Station 93 during the third event monitored. Based on the present sampling protocol, we were unable to determine the relative effect of antecedent rainfall events on water quality aspects of surface water runoff; however, it seems that the duration between rainfall events may serve to influence the magnitude of the response by different water quality parameters such as orthophosphorus, total phosphorus, and nitrate+nitrite. Such questions deserve further attention during the development of a water quality model for the Loxahatchee River.

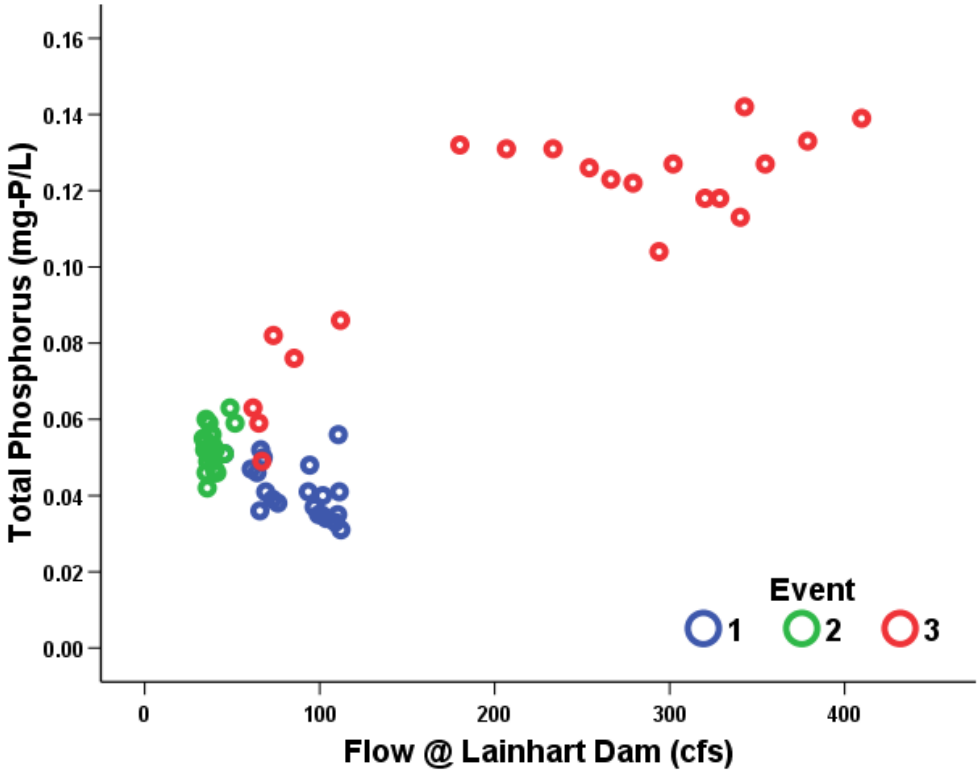
In conclusion, we acknowledge that stormwater runoff derived from rainfall events clearly drive short-term fluctuations in measured water quality parameters. Nonetheless, data from the Loxahatchee River District's monthly Riverkeeper water quality monitoring program provided a surprising level of accuracy when compared to results from the stormwater event sampling. Thus, while some short-term effects may be missed during routine water quality sampling, Project RiverKeeper sampling provides a sound understanding of typical water quality conditions in the Loxahatchee River. Therefore, we suggest the Project RiverKeeper continue as an excellent approach to characterizing the general water quality conditions within the surface waters of the Loxahatchee River and estuary. We look forward to our ongoing work with SFWMD personnel to refine our water quality monitoring to further our understanding of nutrient dynamics in and loading to the Loxahatchee River watershed.

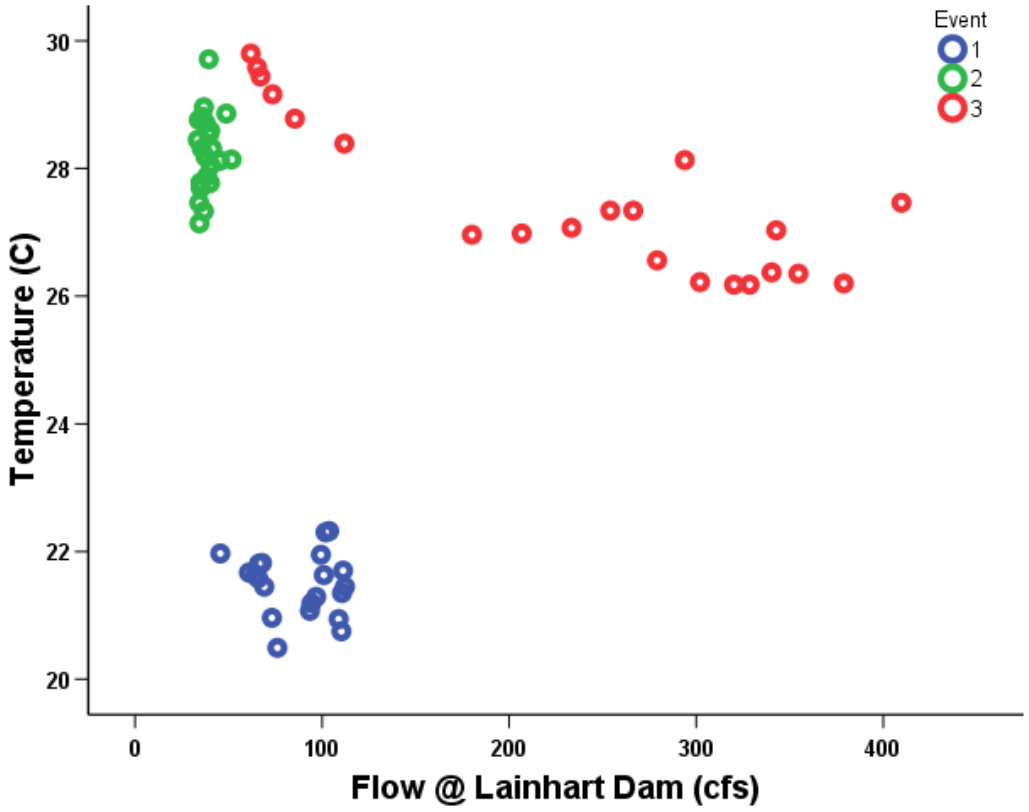
Literature Cited

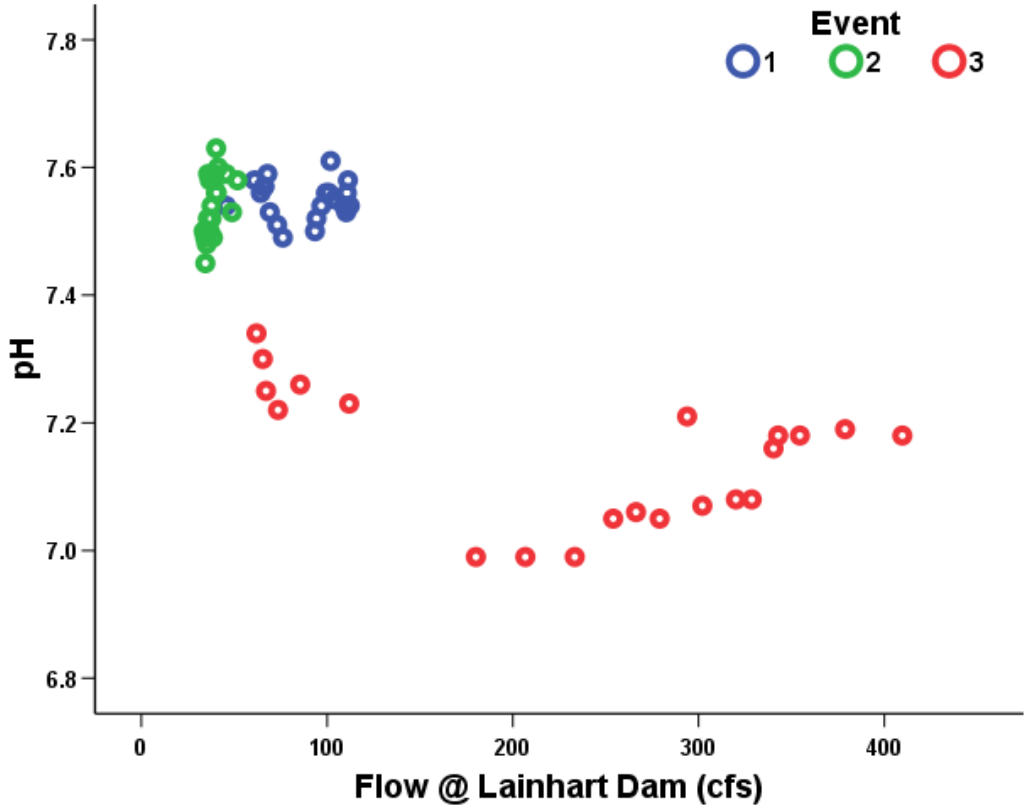
SFWMD. 2006. Restoration Plan for the Northwest Fork of the Loxahatchee River. South Florida Water Management District, West Palm Beach, Florida.

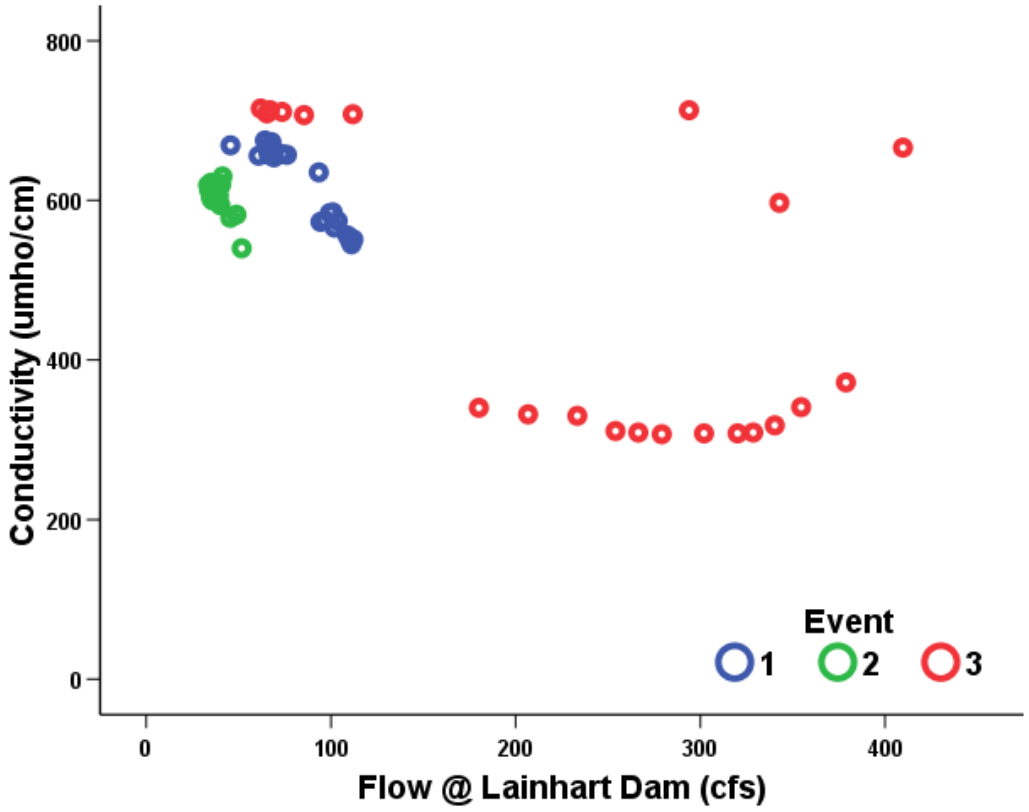
Appendix A. Scatter plots show the relationship (or lack thereof) between freshwater discharge over Lainhart Dam and water quality following three discrete rainfall events. Data collection occurred every four hours at station 69 for events 1 and 2 and at station 93 for event 3.

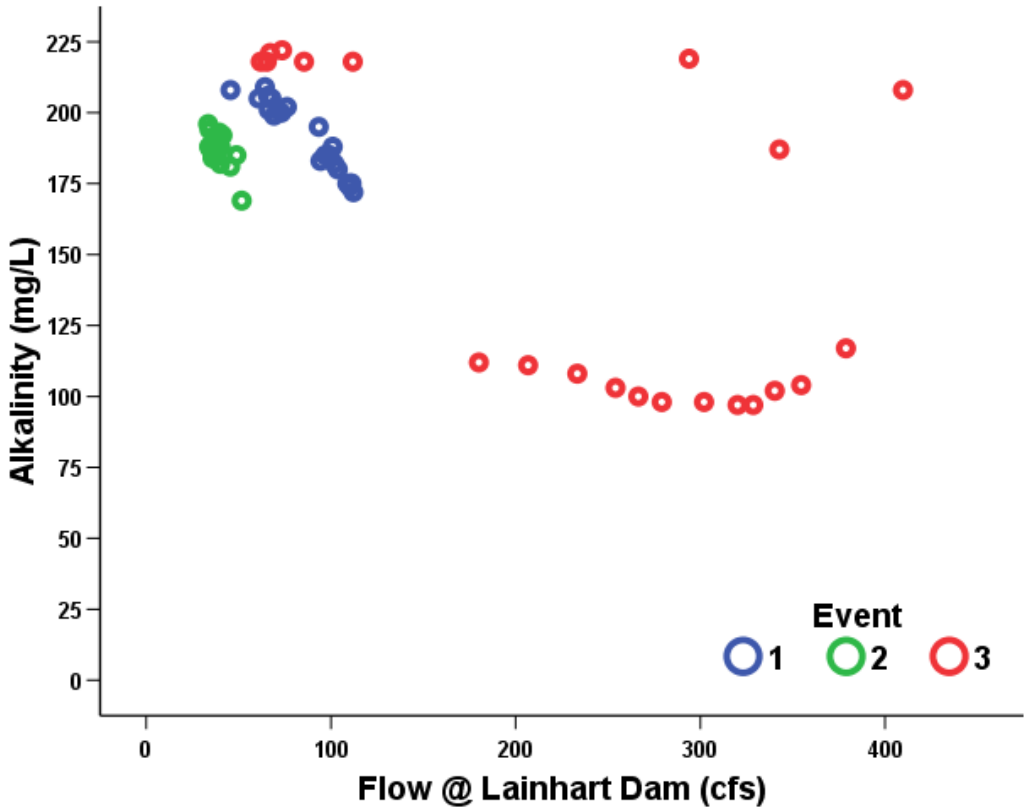


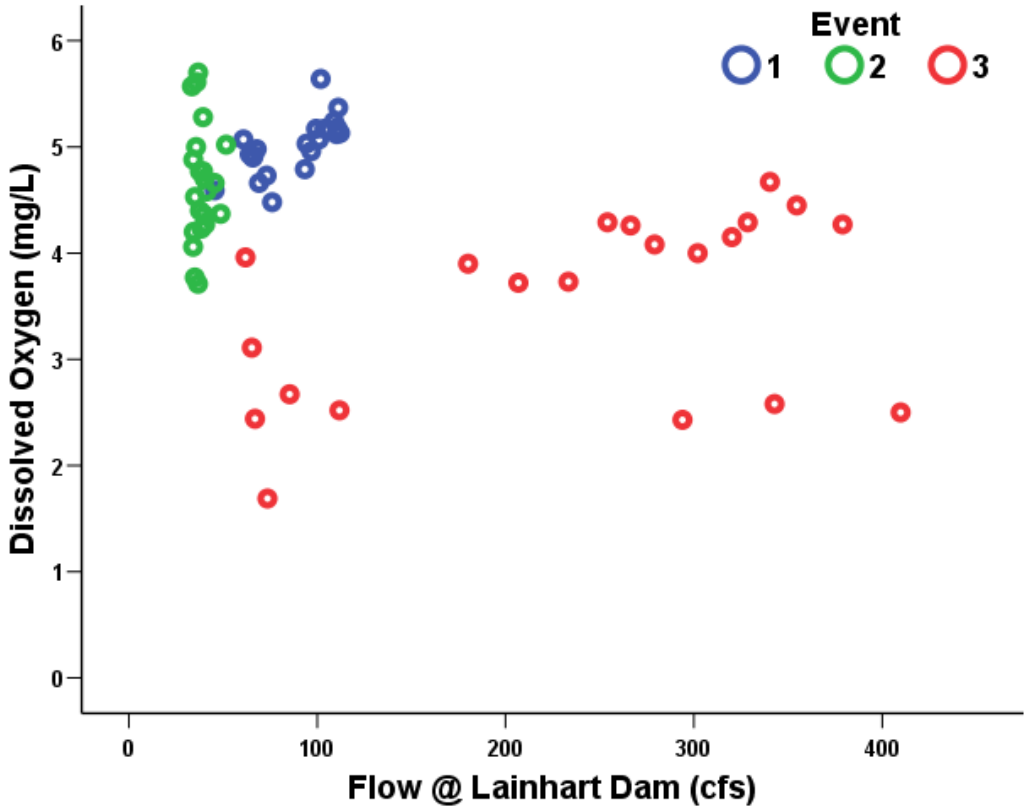


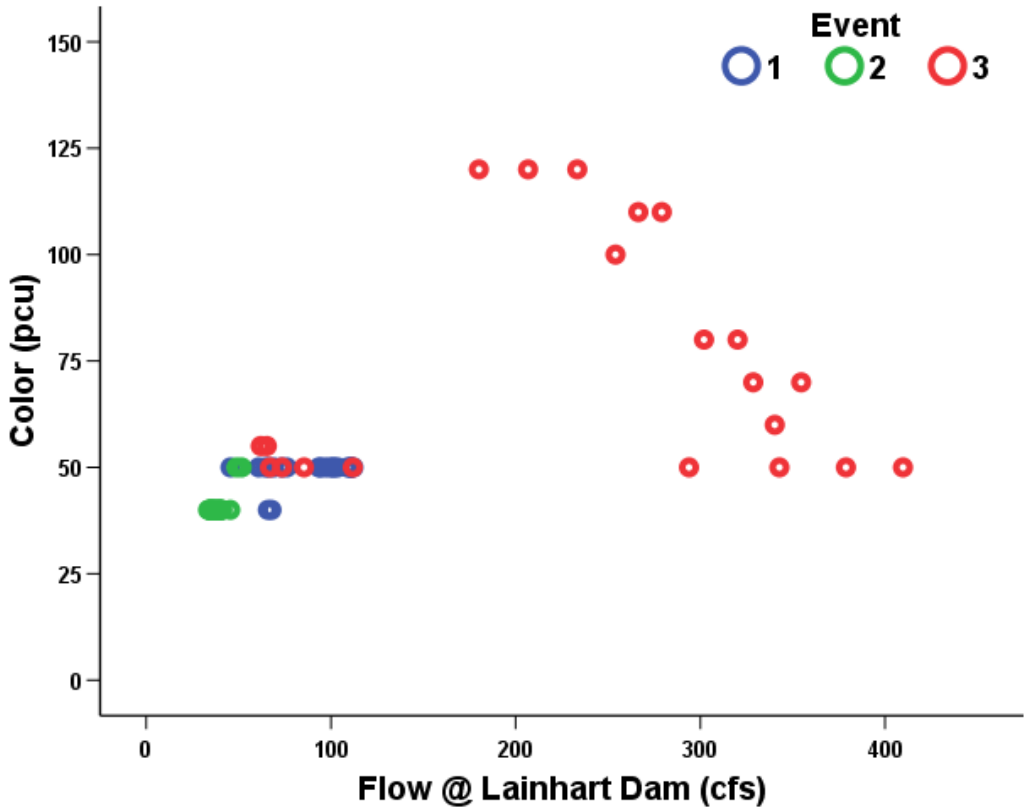

Event
1
2
3
Temperature (C)
30
28
26
24
22
20
0
100
200
300
400
Flow @ Lainhart Dam (cfs)

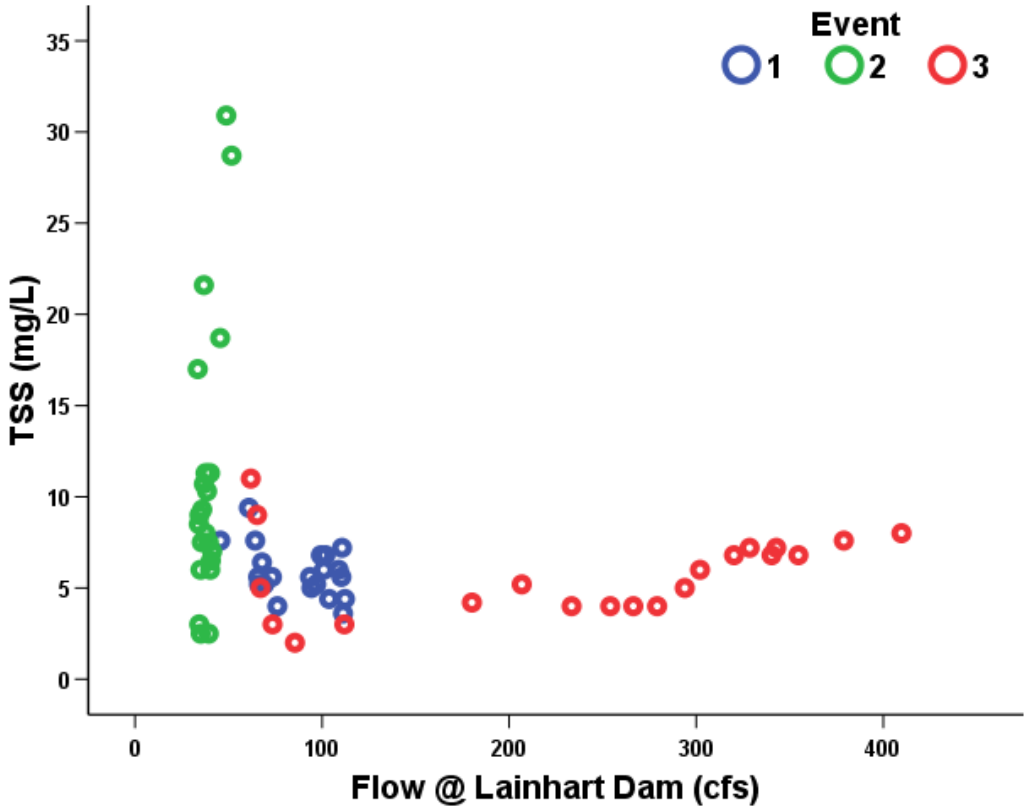

Event
1
2
3
pH
7.8
7.6
7.4
7.2
7.0
6.8
0
100
200
300
400
Flow @ Lainhart Dam (cfs)

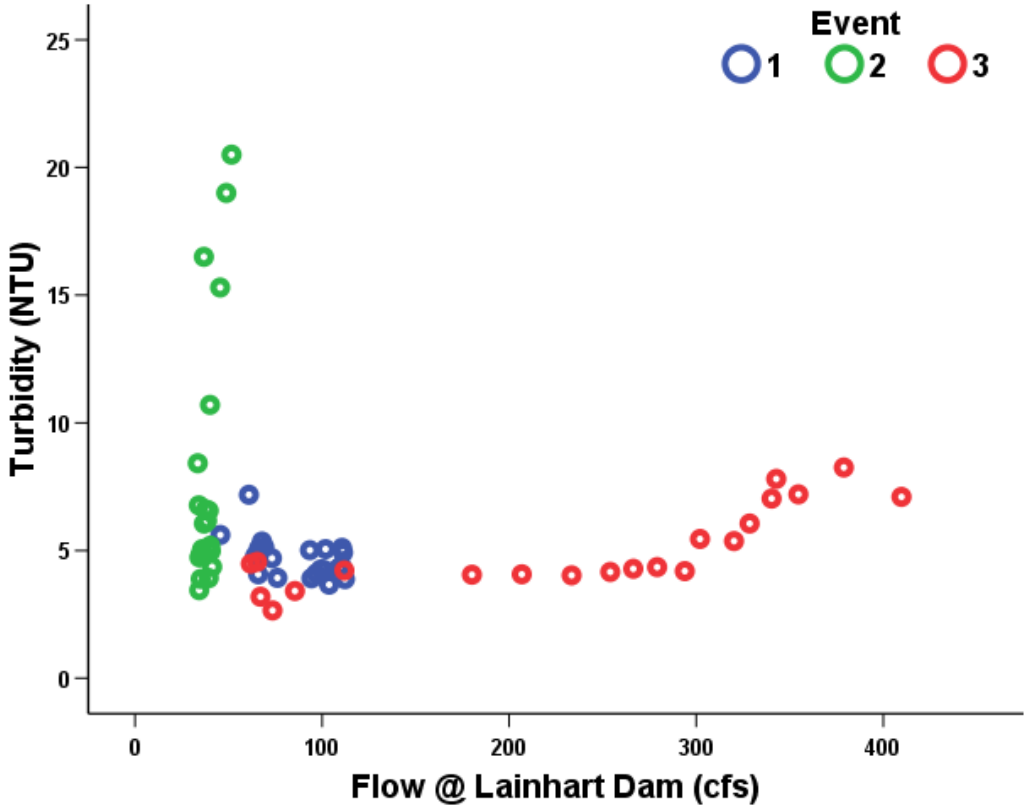

Conductivity (umho/cm)
800
600
400
200
0
0
100
200
300
400
Flow @ Lainhart Dam (cfs)
Event
1
2
3

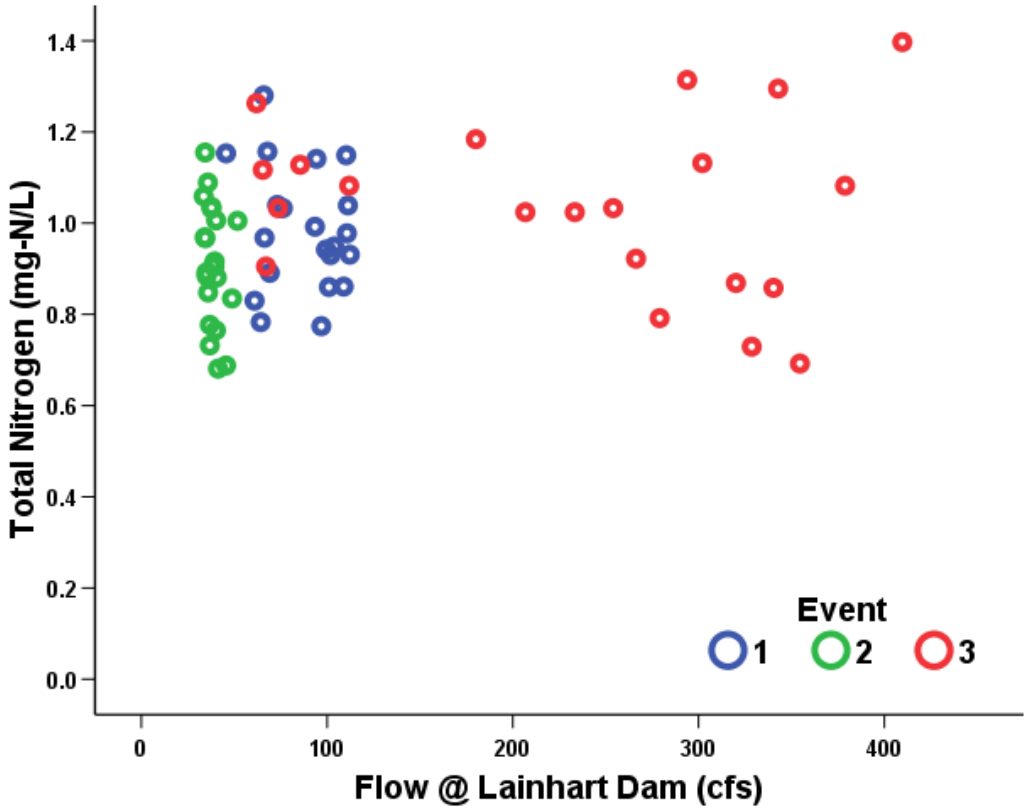

Alkalinity (mg/L)
225
200
175
150
125
100
75
50
25
0
0
100
200
300
400
Flow @ Lainhart Dam (cfs)
Event
1
2
3

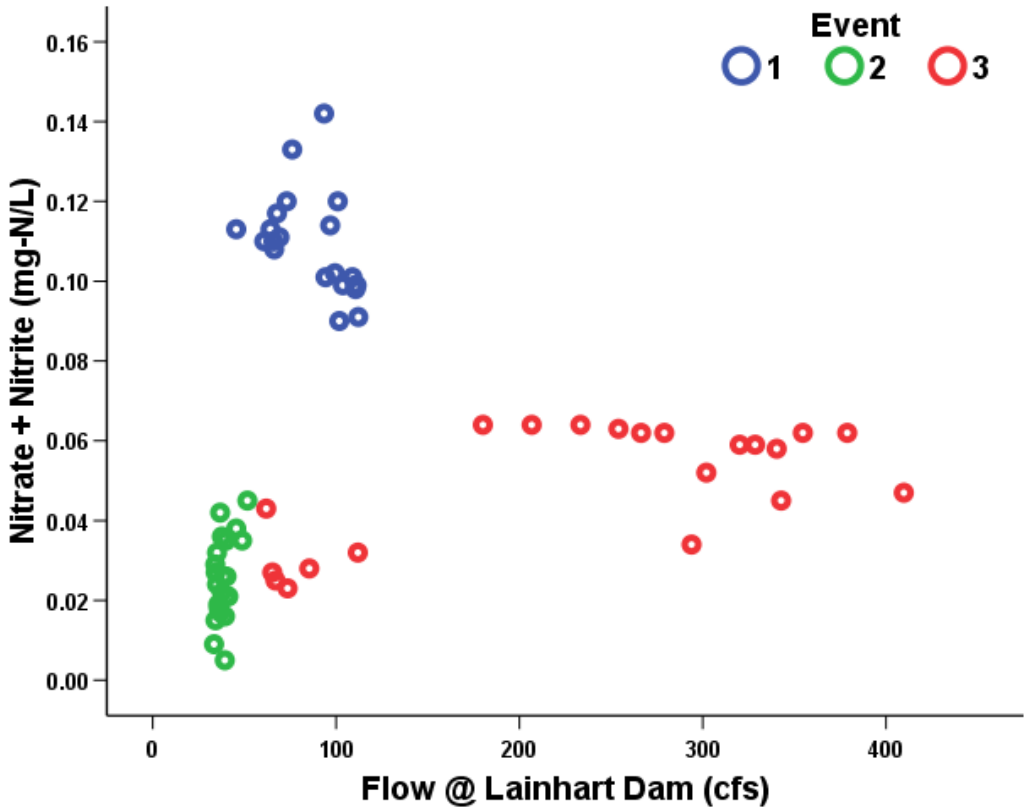

Event
1
2
3
Dissolved Oxygen (mg/L)
0
1
2
3
4
5
6
0
100
200
300
400
Flow @ Lainhart Dam (cfs)

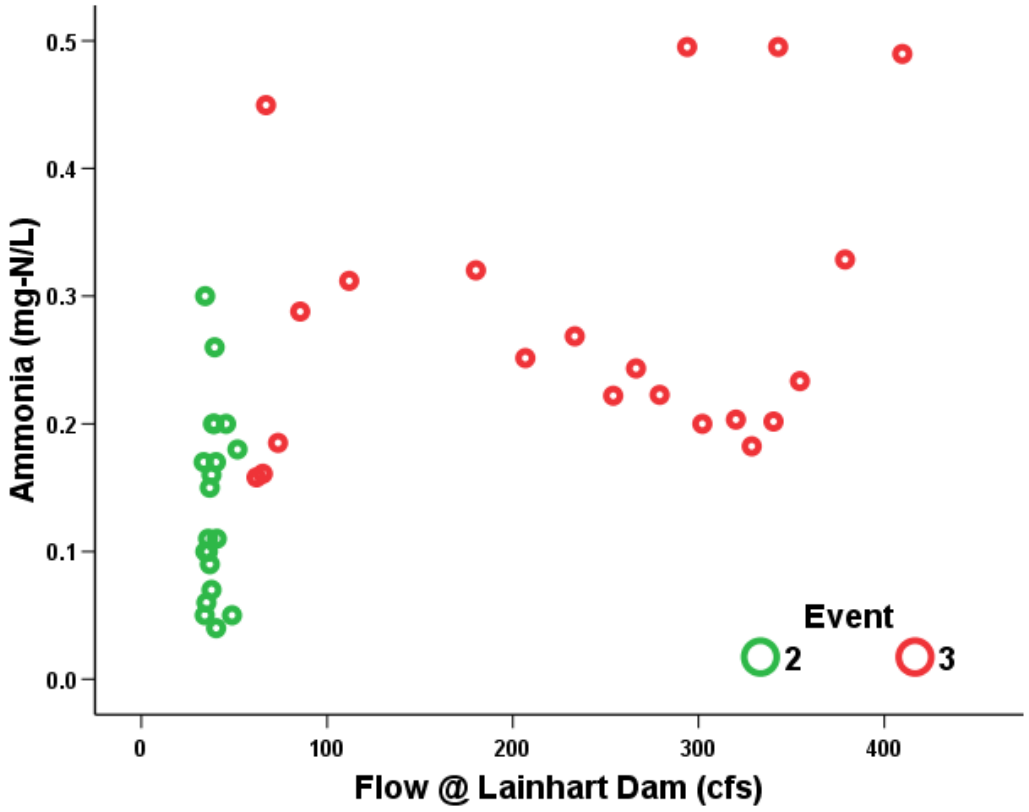

Event
1
2
3
Color (pcu)
0
25
50
75
100
125
150
0
100
200
300
400
Flow @ Lainhart Dam (cfs)

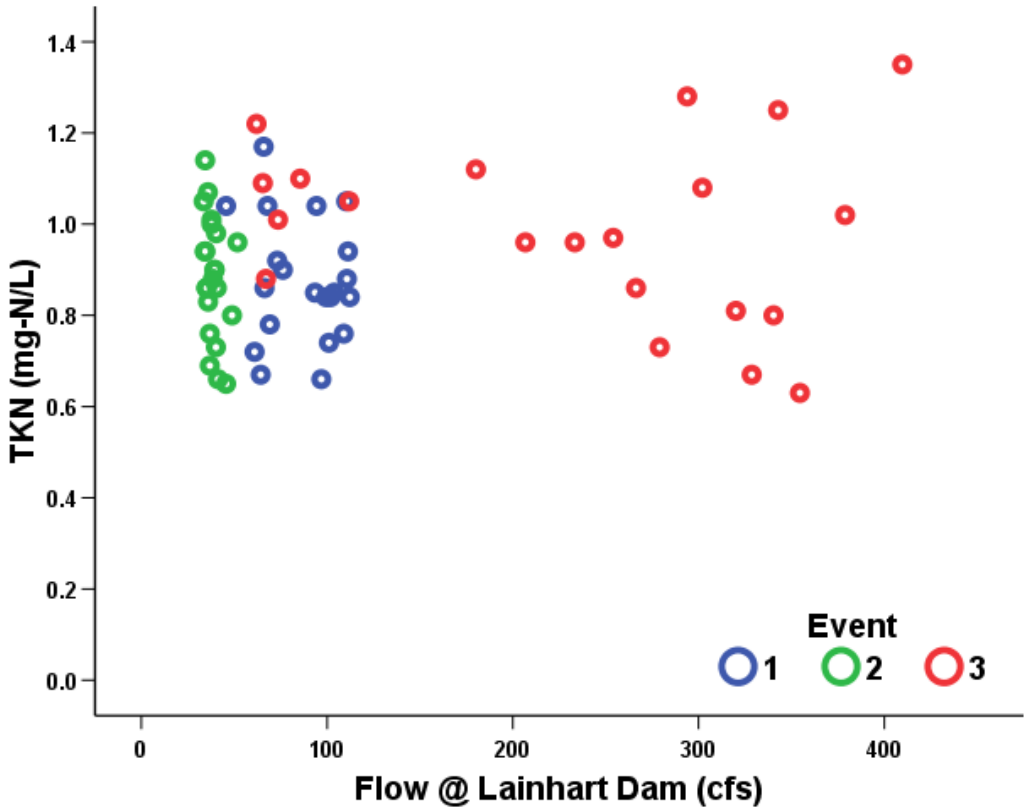

Event
1
2
3
TSS (mg/L)
0
5
10
15
20
25
30
35
0
100
200
300
400
Flow @ Lainhart Dam (cfs)


Event
1
2
3
Turbidity (NTU)
0
5
10
15
20
25
0
100
200
300
400
Flow @ Lainhart Dam (cfs)

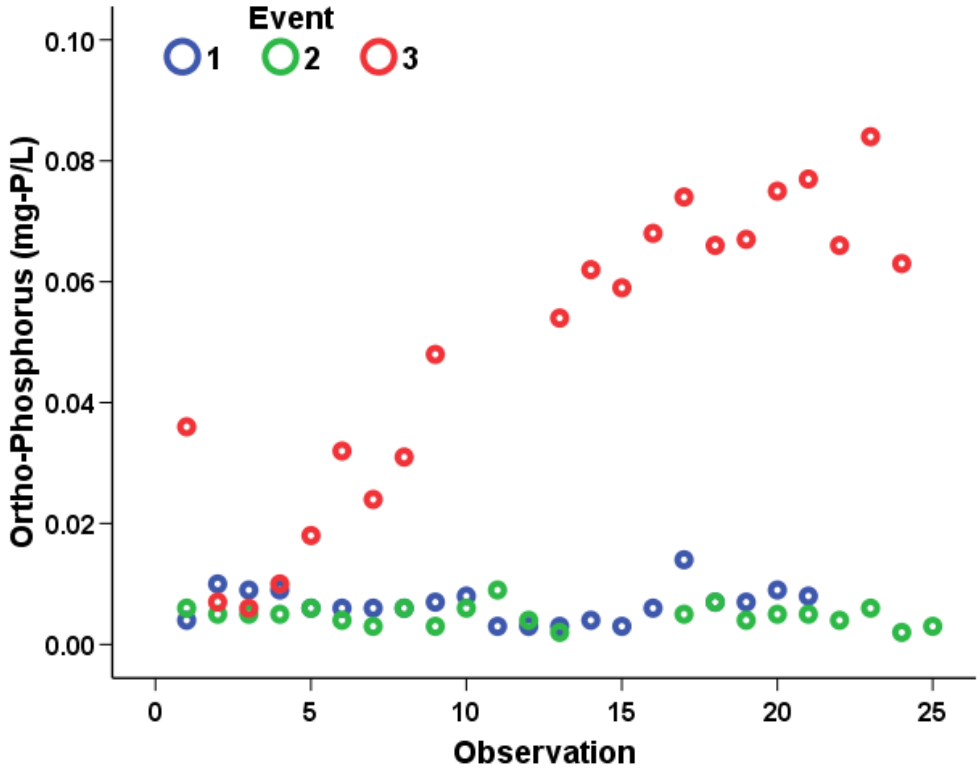

Total Nitrogen (mg-N/L)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
Flow @ Lainhart Dam (cfs)
Event
1
2
3

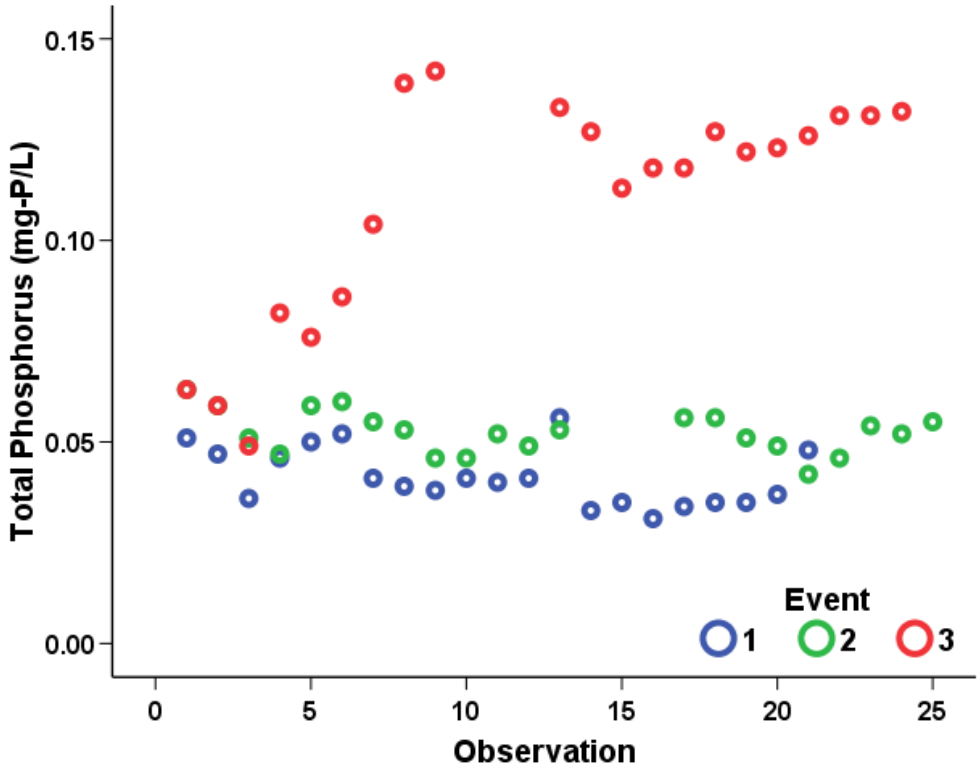

Nitrate + Nitrite (mg-N/L)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0
100
200
300
400
Flow @ Lainhart Dam (cfs)
Event
1
2
3

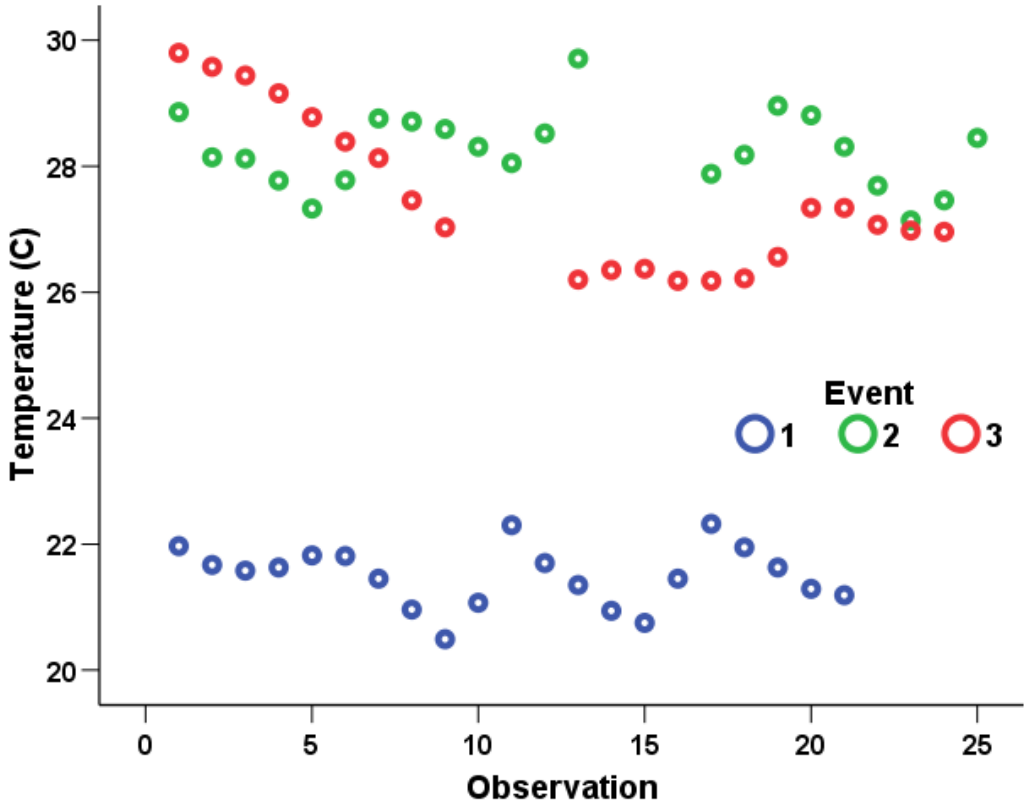

Ammonia (mg-N/L)
0.5
0.4
0.3
0.2
0.1
0.0
0
100
200
300
400
Flow @ Lainhart Dam (cfs)
Event
2
3

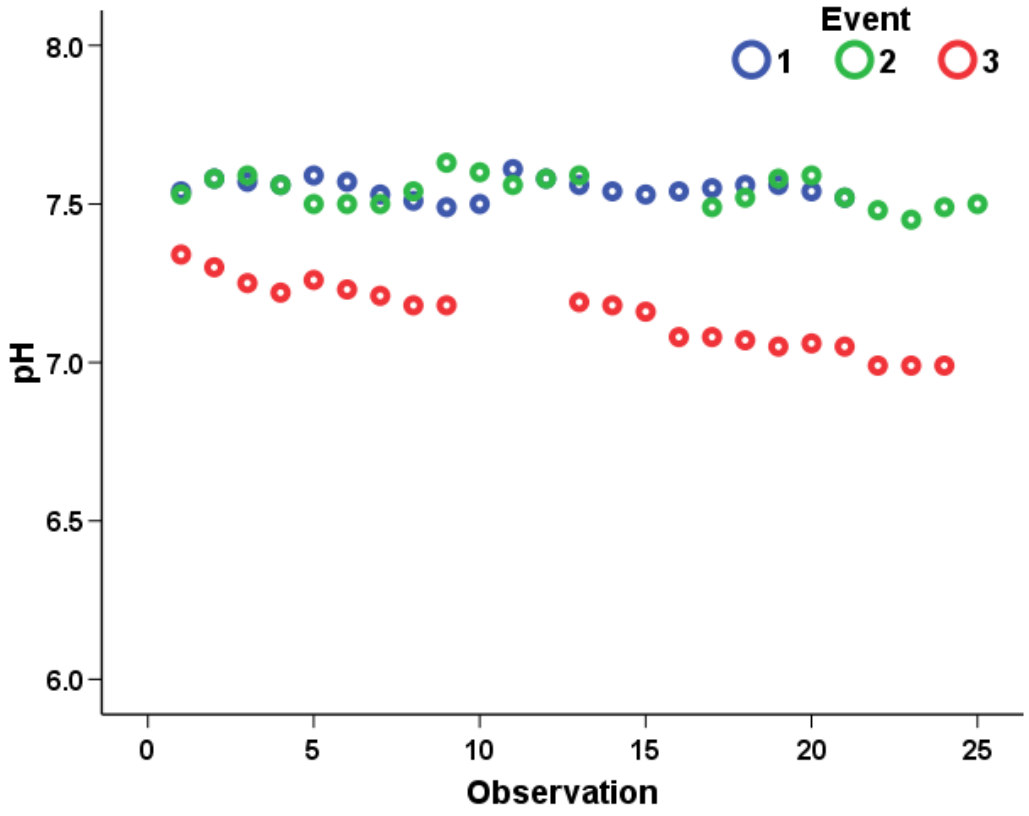

TKN (mg-N/L)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
Flow @ Lainhart Dam (cfs)
Event
1
2
3

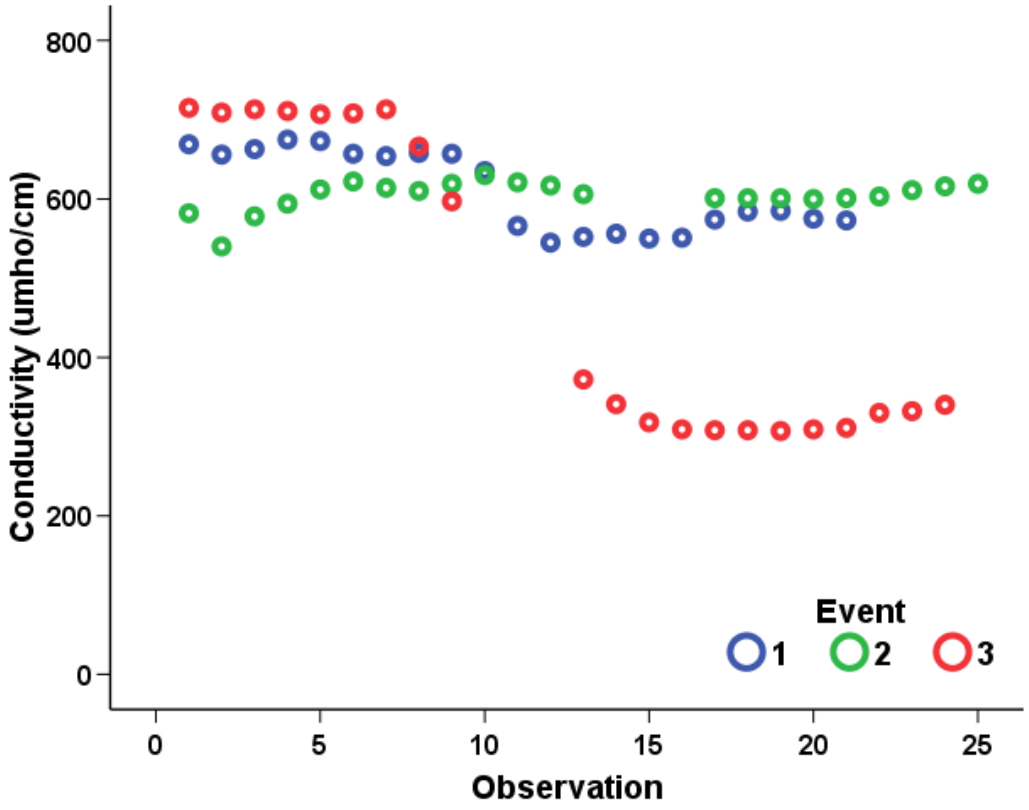
Appendix B. Scatter plots show the short-term water quality response following three discrete rainfall events. Data collection occurred every four hours at station 69 for events 1 and 2 and at station 93 for event 3.

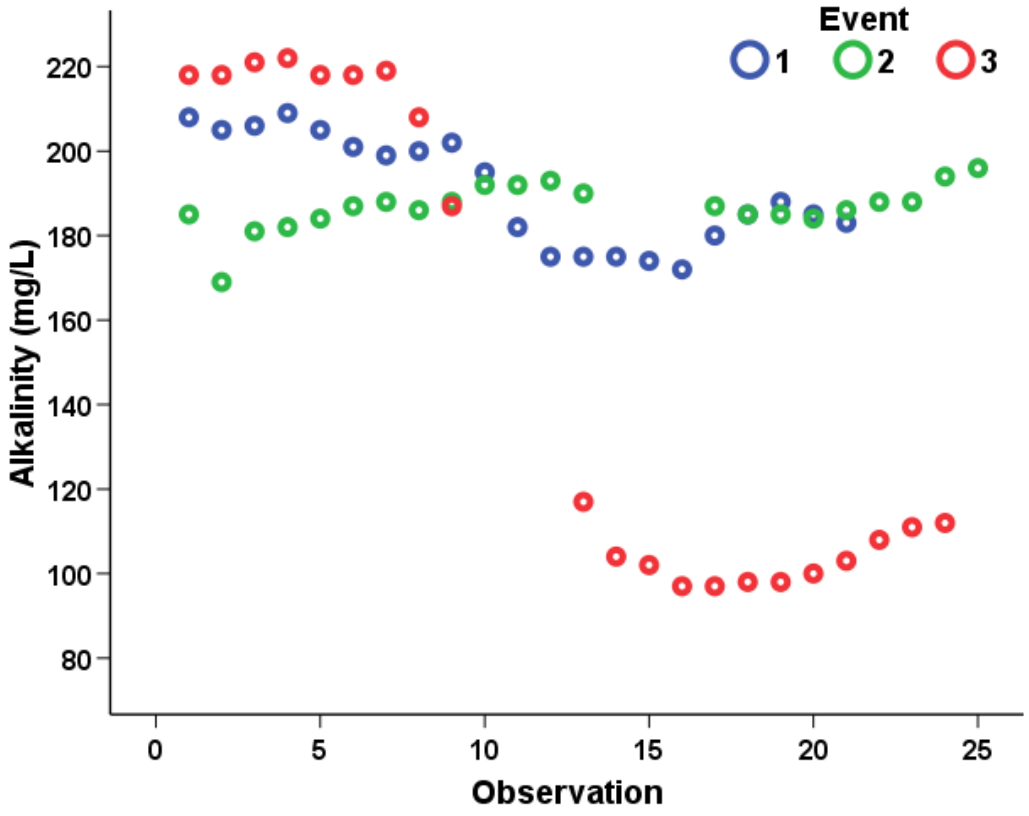


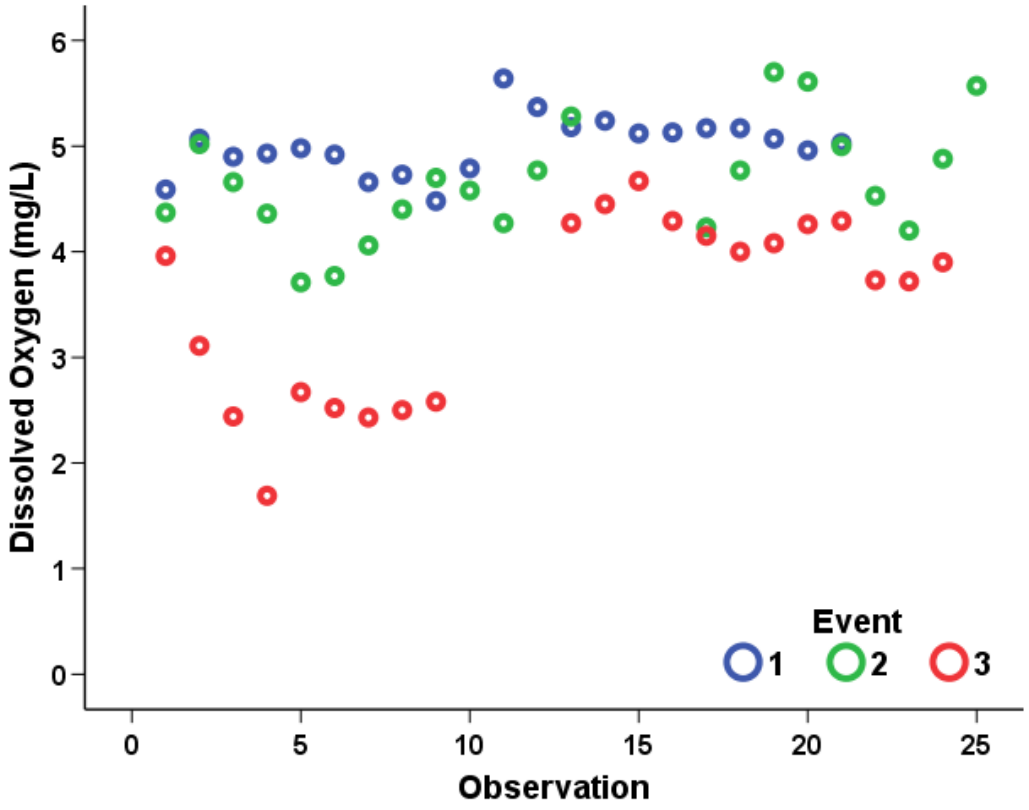


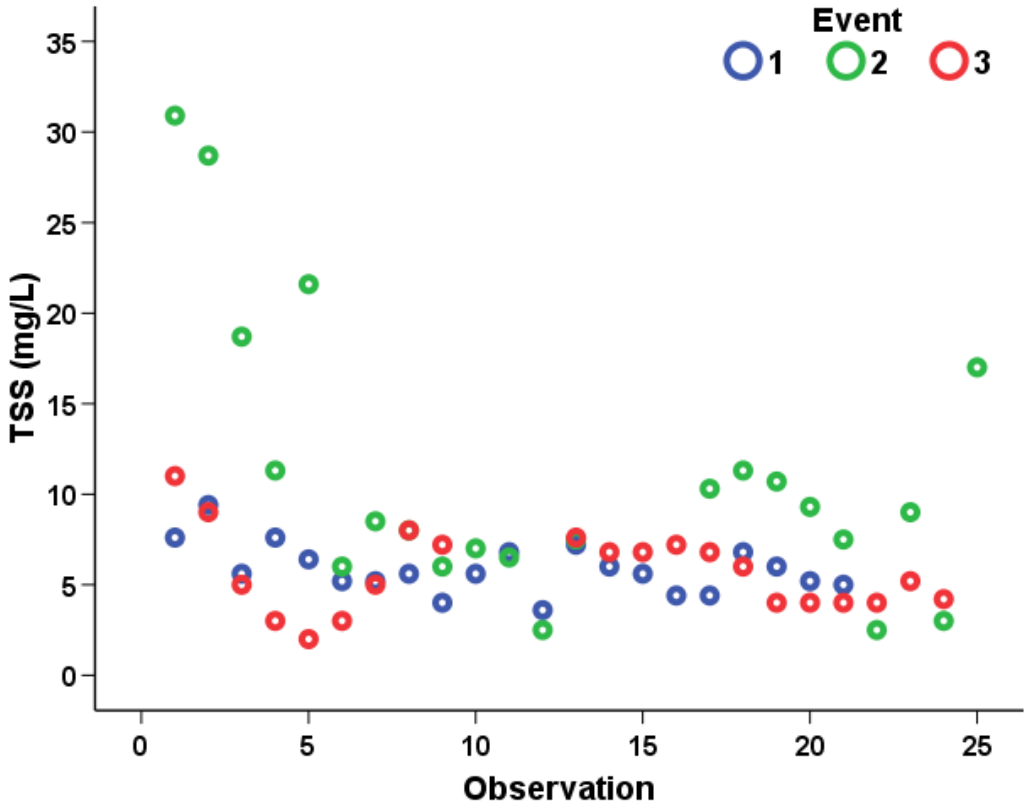

Temperature (C)
30
28
26
24
22
20
0
5
10
15
20
25
Observation
Event
1
2
3

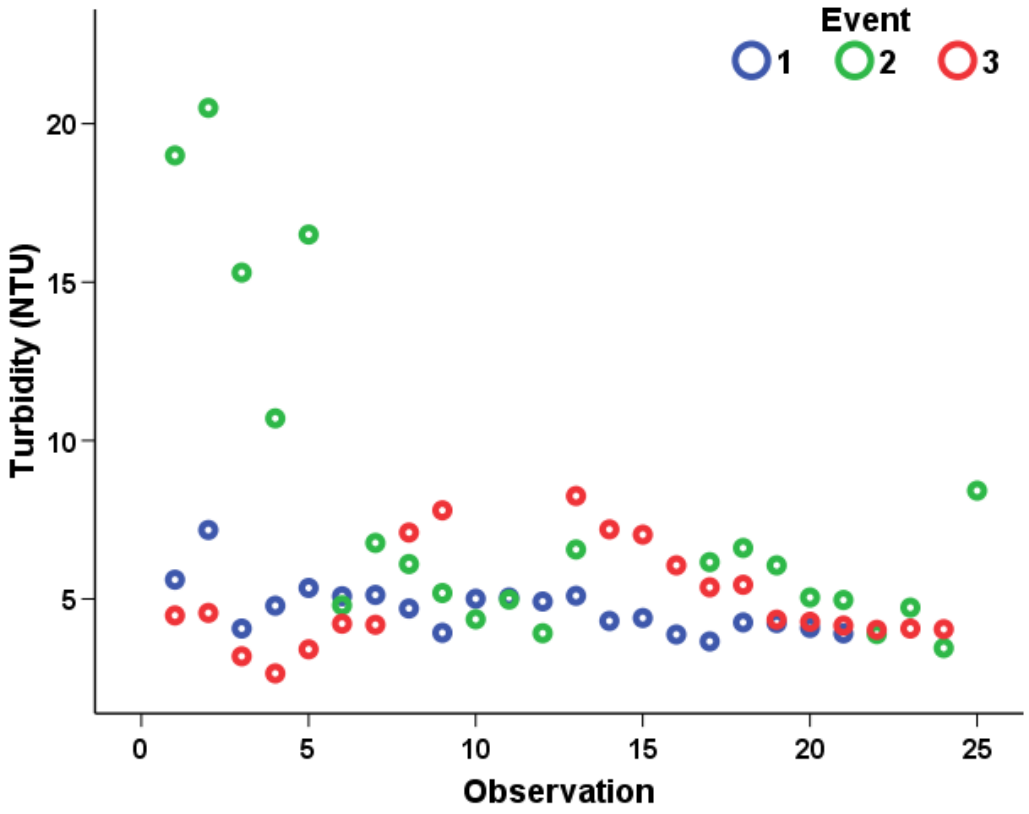

pH
8.0
7.5
7.0
6.5
6.0
0
5
10
15
20
25
Observation
Event
1
2
3

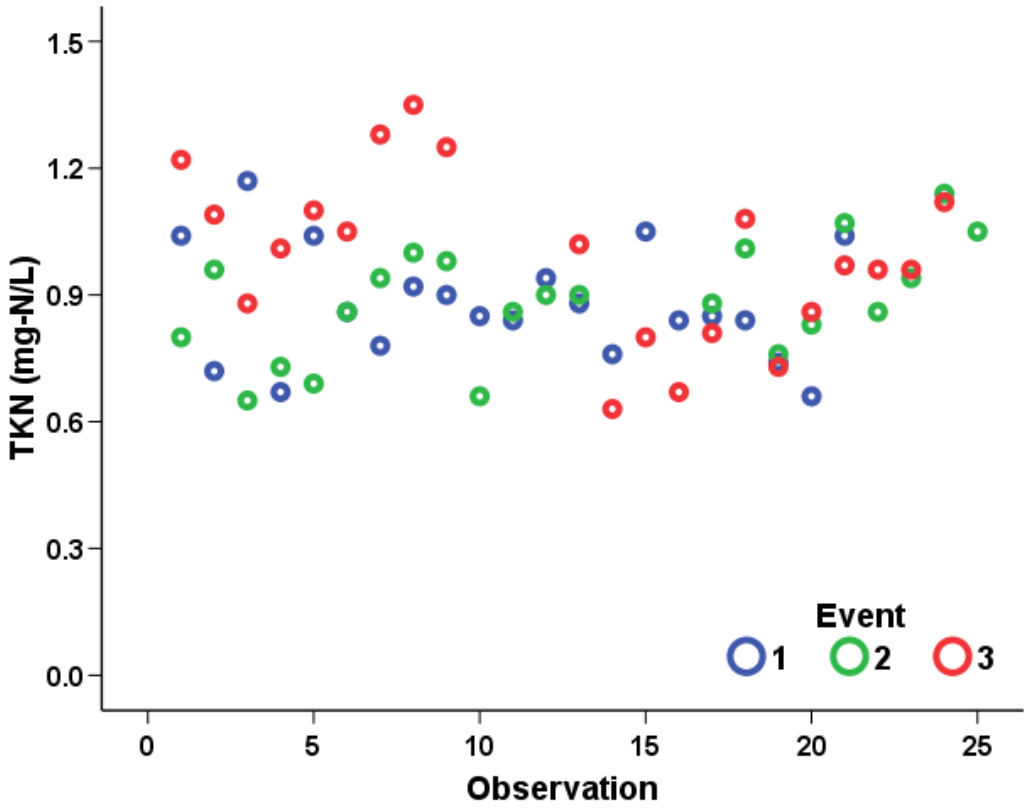

Conductivity (umho/cm)
800
600
400
200
0
0
5
10
15
20
25
Observation
Event
1
2
3

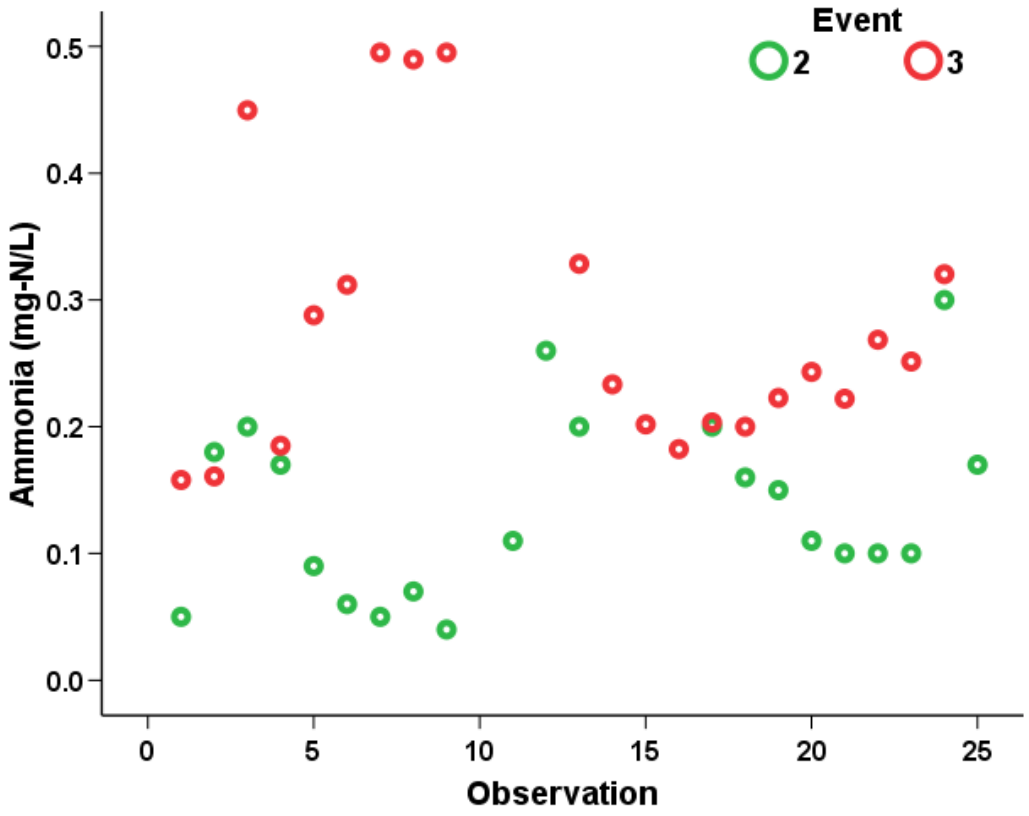

Alkalinity (mg/L)
220
200
180
160
140
120
100
80
0
5
10
15
20
25
Observation
Event
1
2
3

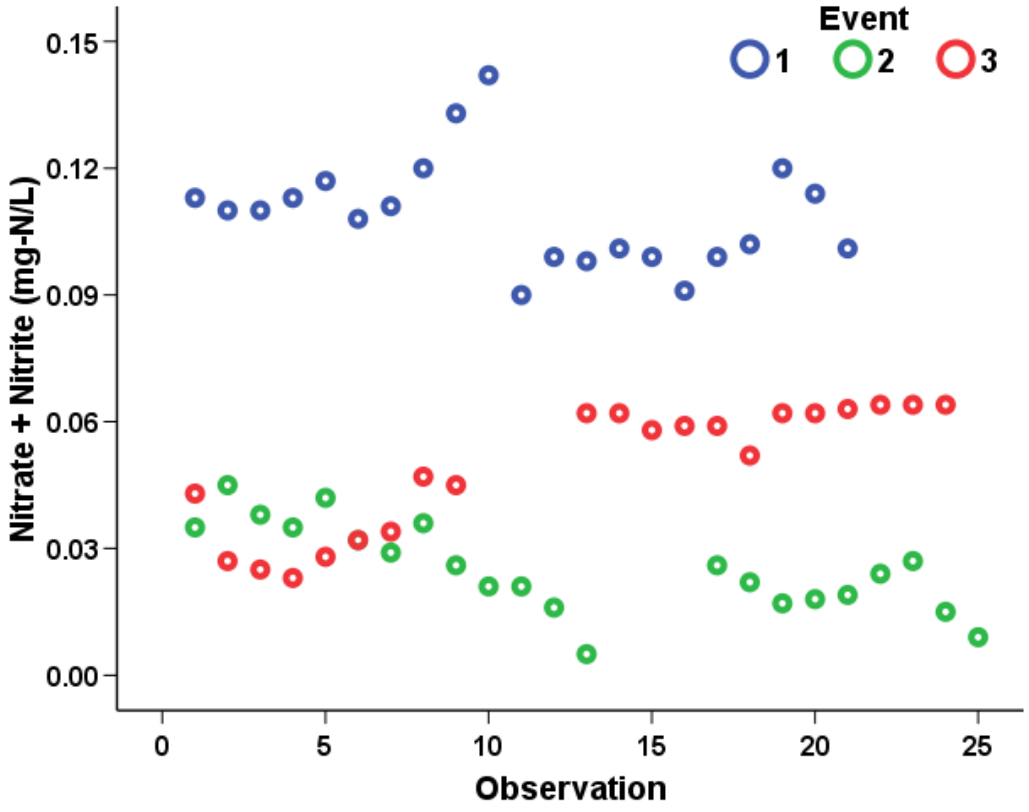

Dissolved Oxygen (mg/L)
0
1
2
3
4
5
6
0
5
10
15
20
25
Observation
Event
1
2
3

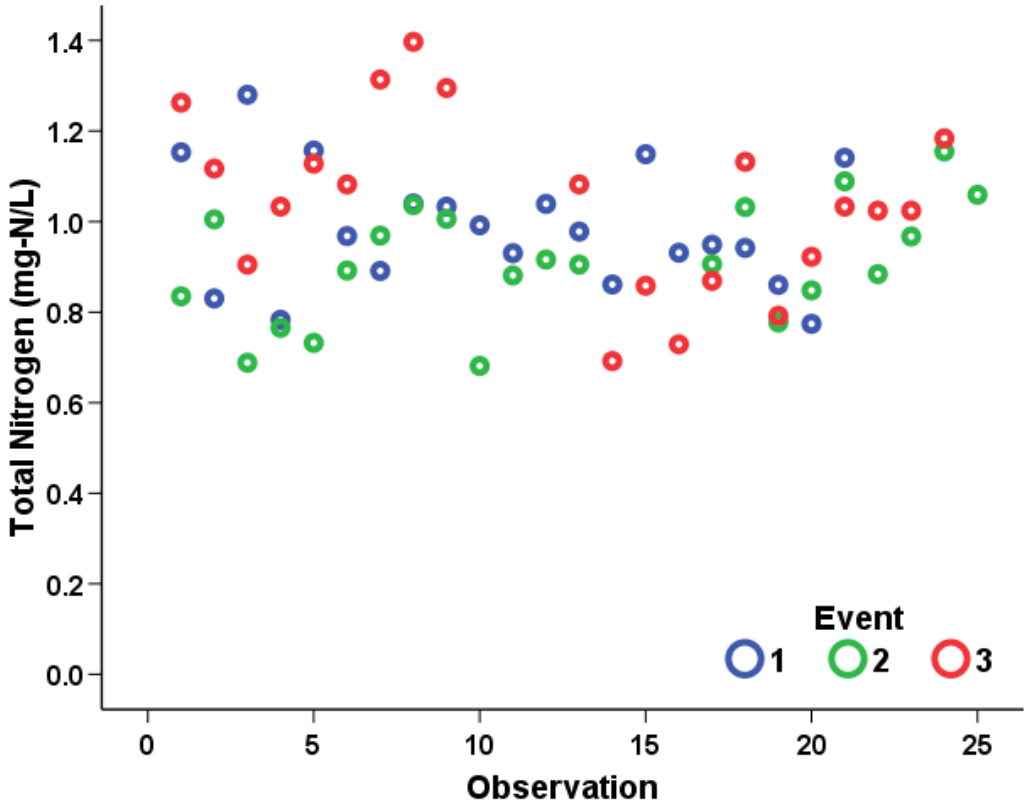

TSS (mg/L)
0
5
10
15
20
25
30
35
0
5
10
15
20
25
Observation
Event
1
2
3

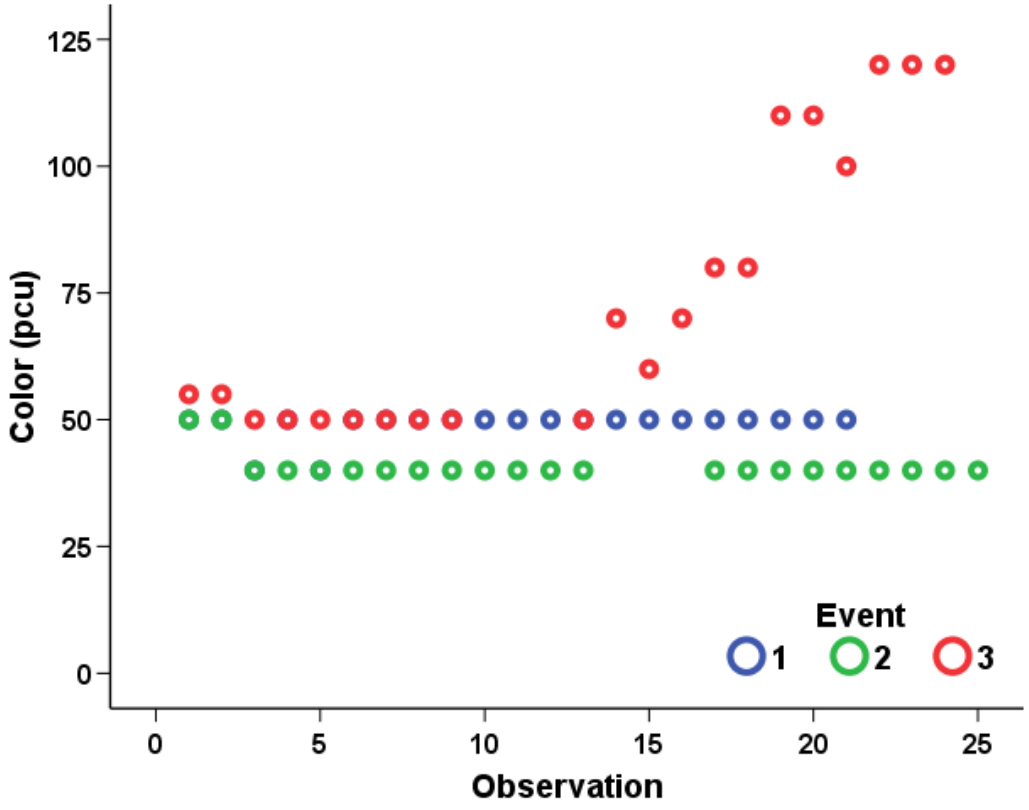

Event
1
2
3
Turbidity (NTU)
20
15
10
5
0
5
10
15
20
25
Observation

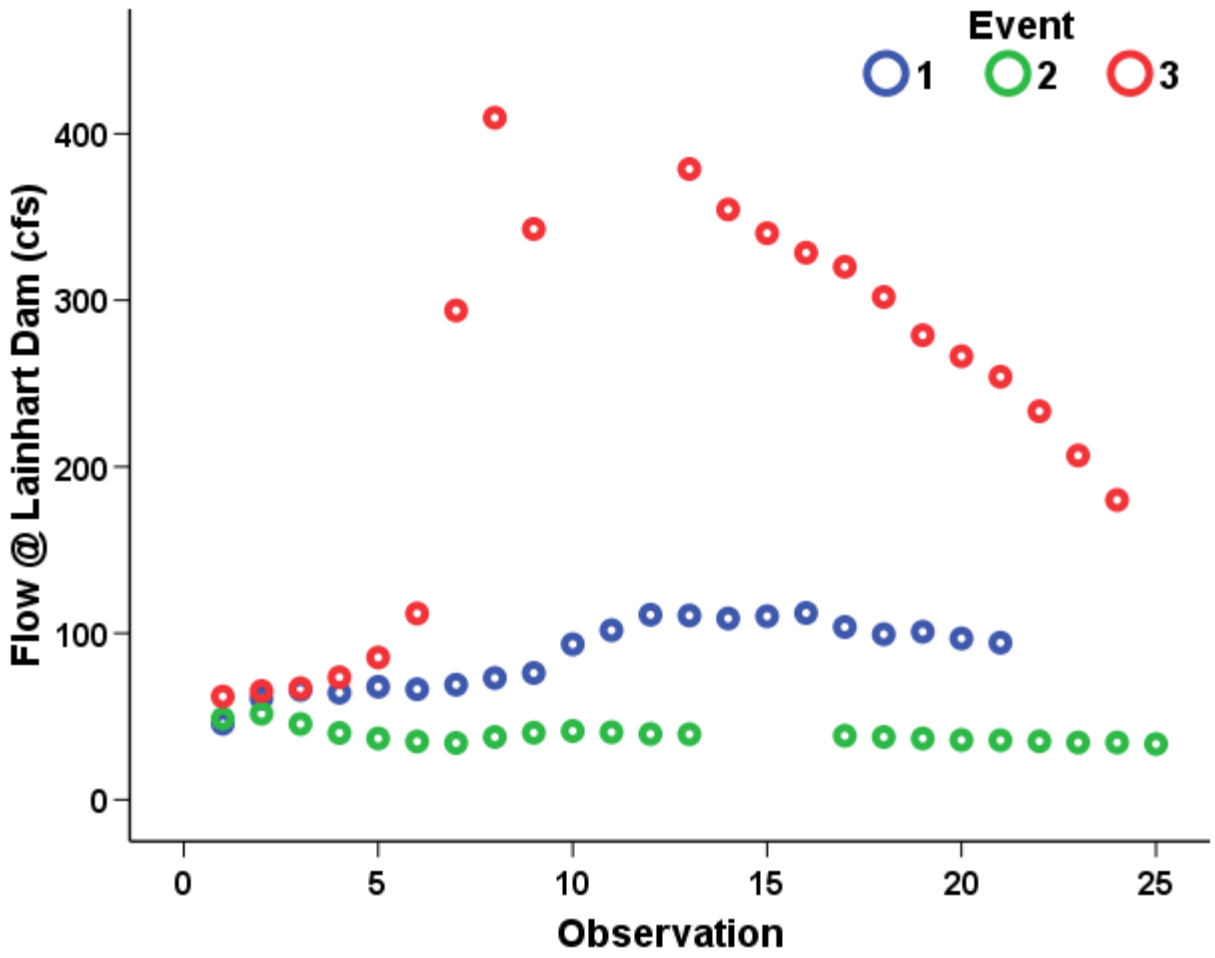

TKN (mg-N/L)
1.5
1.2
0.9
0.6
0.3
0.0
0
5
10
15
20
25
Observation
Event
1
2
3


Event
2
3
Ammonia (mg-N/L)
0.5
0.4
0.3
0.2
0.1
0.0
0
5
10
15
20
25
Observation


Event
1
2
3
Nitrate + Nitrite (mg-N/L)
0.15
0.12
0.09
0.06
0.03
0.00
0
5
10
15
20
25
Observation


Total Nitrogen (mg-N/L)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
5
10
15
20
25
Observation
Event
1
2
3


Color (pcu)
125
100
75
50
25
0
0
5
10
15
20
25
Observation
Event
1
2
3


Event
1
2
3
Flow @ Lainhart Dam (cfs)
400
300
200
100
0
0
5
10
15
20
25
Observation

Appendix C. Compact disk containing the full dataset for the October 2007 through September 2008 sampling period. Additional copies of the data is available by contacting Bud Howard (telephone: 561-747-5700 x108; email: bud@loxahatcheeriver.org) or Lorene Bachman (telephone: 561-747-5700 x143; email: wildpine@loxahatcheeriver.org).