

# Filamentous Algae Monitoring Program: Potomac River Basin

Report to the West Virginia Department of Environmental Protection,  
Division of Water and Waste Management

by

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Interstate Commission on the Potomac River Basin

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### **ICPRB Report 18-1**

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### **Disclaimer**

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## Executive Summary

West Virginia Department of Environmental Protection (WVDEP) has been observing and evaluating the breadth and causes of filamentous green algae blooms in rivers across the state since 2007. Blooms of filamentous algae occur in rivers of the Potomac Basin and the Interstate Commission on the Potomac River Basin (ICPRB) has assisted the WVDEP in documenting algae blooms in the South Branch Potomac, Cacapon rivers since 2012.

Standard WVDEP algal observation of the Cacapon and South Branch Rivers frequency was reduced for 2017. Algal observation of the historical 14 sites was conducted once monthly in the months of June, July, August, and September. No water chemistry was conducted during observation rounds. The purpose of the June-September observations was to identify and describe recreationally impaired locations that are not flagged as regularly bloom-producing annually.

Unlike the large scale, two-river effort of the last five years, ICPRB and WVDEP directed focus on an often algae impaired reach of the Cacapon River between Yellow Springs, West Virginia and Capon Bridge, West Virginia. Since the start of WVDEP's filamentous algae monitoring in the Cacapon River, a five (5) mile reach around CA\_RMRCK (PC-60.3) has been represented by a single sampling location, despite dense algal blooms several miles above and below the site. The frequency and duration of algal bloom within this 5-mile reach prompted WVDEP and ICPRB biologist to increase effort to bimonthly sampling at an increased number of sites proximal to the historical CA\_RMRCK location. Five (5) new sampling locations and the historical CA\_RMRCK site (six total sites) were chosen to focus water chemistry, sediment sampling, continuous DO, continuous pH, and algal assessments.

As expected, recreational impairment levels of dense algal blooms became established around the historic Rim Rock site (CA\_RMRCK) in 2017. There were no outstanding trends that explained elevated primary production in this reach. Nitrogen and phosphorus species were similar across all locations with the exception of a small tributary, Lowman Branch above the upper rim Rock site, which can be ruled out as a potential nutrient source due to consistently low nutrient inputs. Phosphorus concentrations were lower where blooms were densest, suggesting that it is being taken up by primary producers. Ionic chemistry (calcium and magnesium, alkalinity, and hardness) was equal across all stations ruling out any possibility that increased production relative to any other site was due to a more favorable environment.

Results from the 2017 intensive Cacapon River study are inconclusive as there were no trends that stood out at any one site when compared to another with one exception, Lowman Branch. Lowman branch was consistently assessed to have lower nutrient and ionic concentrations when compared to the mainstem Cacapon River. ICPRB suggests additional sampling points above Yellow Springs up to the Wardensville wastewater treatment plant to attempt to have a control to compare to the Rim Rock reach as well as potentially identify nutrient inputs upstream.

## Field methods

ICPRB biologists implemented the WVDEP Filamentous Algae Monitoring Protocol (WVDEP 2013) at 19 fixed locations between May and October 2017. The WV filamentous algae protocols consist of routine water chemistry sampling, a rapid assessment style field form, semi-quantitative algae coverage estimates, and longitudinal surveys to document the extent of bloom events. A single ICPRB biologist (Gordon Selckmann) made nine (9) routine observations. A second biologist was present when bloom sites were extensive or extra support was required.

In addition to regular observations, a total of three longitudinal surveys were performed in 2017. The field crews consisted of at least two biologists from ICPRB and/or WVDEP for all longitudinal surveys (ICPRB personnel: Gordon Selckmann and Zachary Smith).

Information on the WVDEP filamentous algae monitoring program, including the Standard Operating Procedures for algae observation and water chemistry sampling, and the program's field data sheet can be found on-line at:

<http://www.dep.wv.gov/WVE/Programs/wqs/Pages/FilamentousAlgaeinWestVirginia.aspx>

## Station locations

The nineteen sampling stations were targeted by the WVDEP in 2017 based upon past observations, targeted inquiries, and best professional judgment. Thirteen stations are in the Cacapon basin: twelve (12) on the Cacapon River main-stem between the towns of Largent and Wardensville, and one on North River, the Cacapon's largest tributary. Six stations were located on the South Branch Potomac, three above and three below the town of Moorefield, WV (**Table 1 and Figure 1**). Nine out of fourteen stations were located at or near bridge crossings, while the other five were accessed along nearby roadways. Seven stations had public access put-ins, and the remainder were accessed from bridge right-of-ways or through private landowner permission. Stations were generally sampled one river at a time, traveling sequentially upstream.

Table 1. Site codes and locations for the 19 observed locations on the South Branch Potomac and Cacapon Rivers. Bolded locations were sampled more frequently and were subject to water chemistry sampling.

<b>SITE_NAME</b>	<b>WATERBODY</b>	<b>SITE DESCRIPTION</b>	<b>LATITUDE</b>	<b>LONGITUDE</b>
CA_LRGNT	CACAPON	North River at Gaston Rd. / Forks of Cacapon	39.40194	-78.42448
CA_FRKS	CACAPON	Cacapon River at Rt. 9 in the town of Largent	39.48112	-78.38448
NO_FRKS	NORTH RIVER	Cacapon River at Rt. 127 / Forks of Cacapon	39.40387	-78.41842
CA_D_CPBRG	CACAPON	Cacapon River at farm off Cold Stream Road	39.32716	-78.42336
CA_CPBRG	CACAPON	Cacapon River at Rt. 50 in Capon Bridge	39.29754	-78.43517
<b>CA_LWR_RMRCK</b>	<b>CACAPON</b>	<b>River Public Access on Capon River Road</b>	<b>39.23373</b>	<b>-78.46534</b>
<b>CA_RMRCK</b>	<b>CACAPON</b>	<b>Historic Site. on Capon River Rd.</b>	<b>39.21969</b>	<b>-78.47605</b>
<b>CA_MID_RMRCK</b>	<b>CACAPON</b>	<b>Lower Ford for Camp Rim Rock</b>	<b>39.20818</b>	<b>-78.48742</b>
<b>CA_UP_RMRCK</b>	<b>CACAPON</b>	<b>Upper Ford for Camp Rim Rock</b>	<b>39.20573</b>	<b>-78.493212</b>
<b>CA_LOWMAN</b>	<b>CACAPON</b>	<b>Downstream riffle/pool on Lowman Branch</b>	<b>39.20419</b>	<b>-78.49622</b>
<b>CA_DAVIS</b>	<b>CACAPON</b>	<b>Davis Ford crossing</b>	<b>39.19674</b>	<b>-78.50042</b>
CA_YLWSPR	CACAPON	Cacapon River at Rt. 259 below Wardensville	39.18281	-78.50597
CA_WRDS	CACAPON	Cacapon River at farm ford in Wardensville	39.07861	-78.61134
SB_L_TRGH	SO. BRANCH	South Branch at Harmison's Landing	39.2281	-78.85251
SB_U_TRGH	SO. BRANCH	South Branch at South Branch WMA	39.1463	-78.92519
SB_L_MRFLD	SO. BRANCH	South Branch at Rt. 220/28 in Moorefield	39.10424	-78.95801
SB_U_MRFLD	SO. BRANCH	South Branch at Fisher Rd above Moorefield	39.05006	-78.99316
SB_L_PBRG	SO. BRANCH	South Branch at Weldon Park	38.98815	-79.12126
SB_U_PBRG	SO. BRANCH	South Branch at Rt. 200 bridge	38.99955	-79.08596

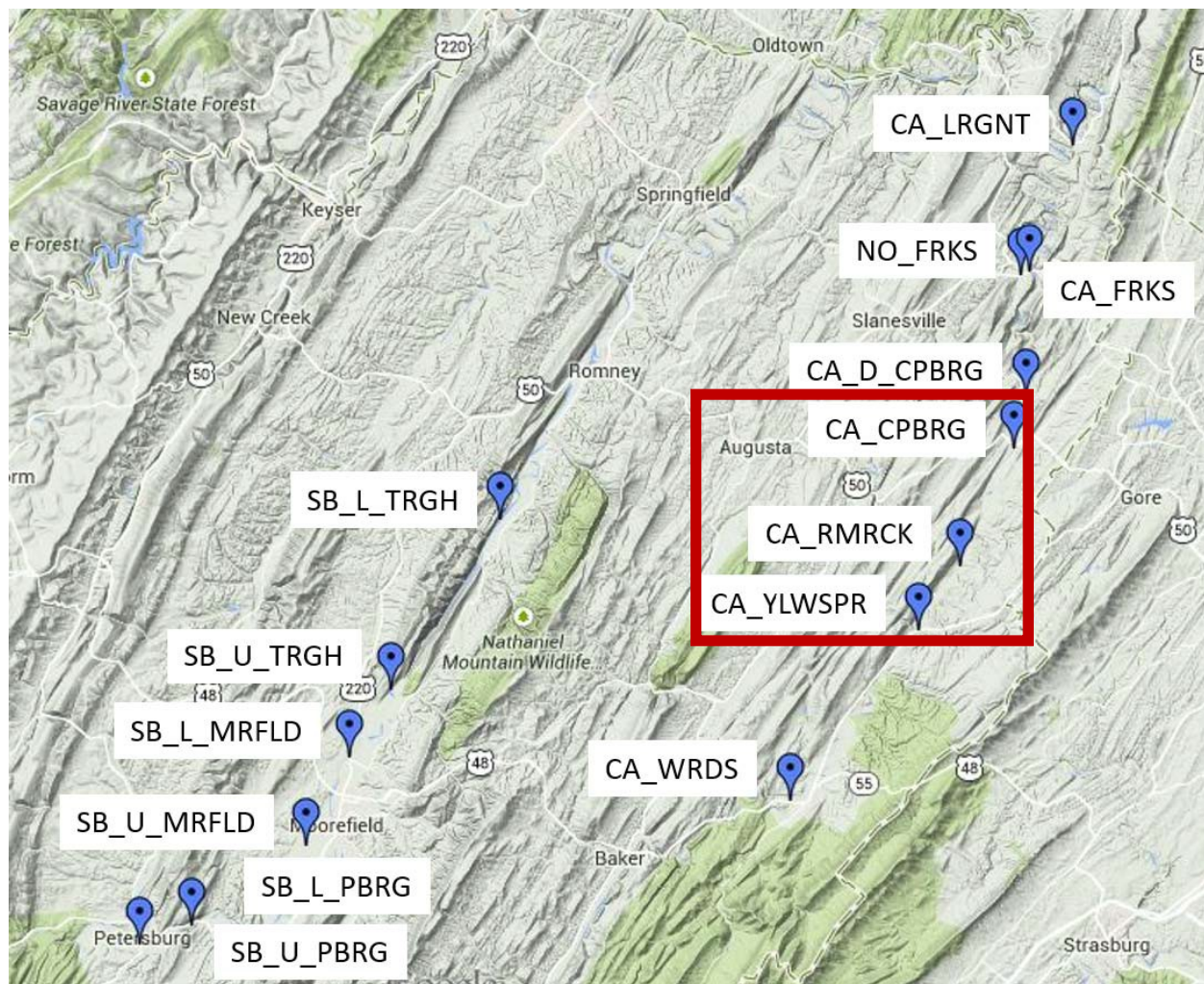


Figure 1. Map of algae monitoring stations on the Cacapon River, North River, and South Branch Potomac River. Red box indicates 5-mile reach of increased spring/early-summer sampling effort.



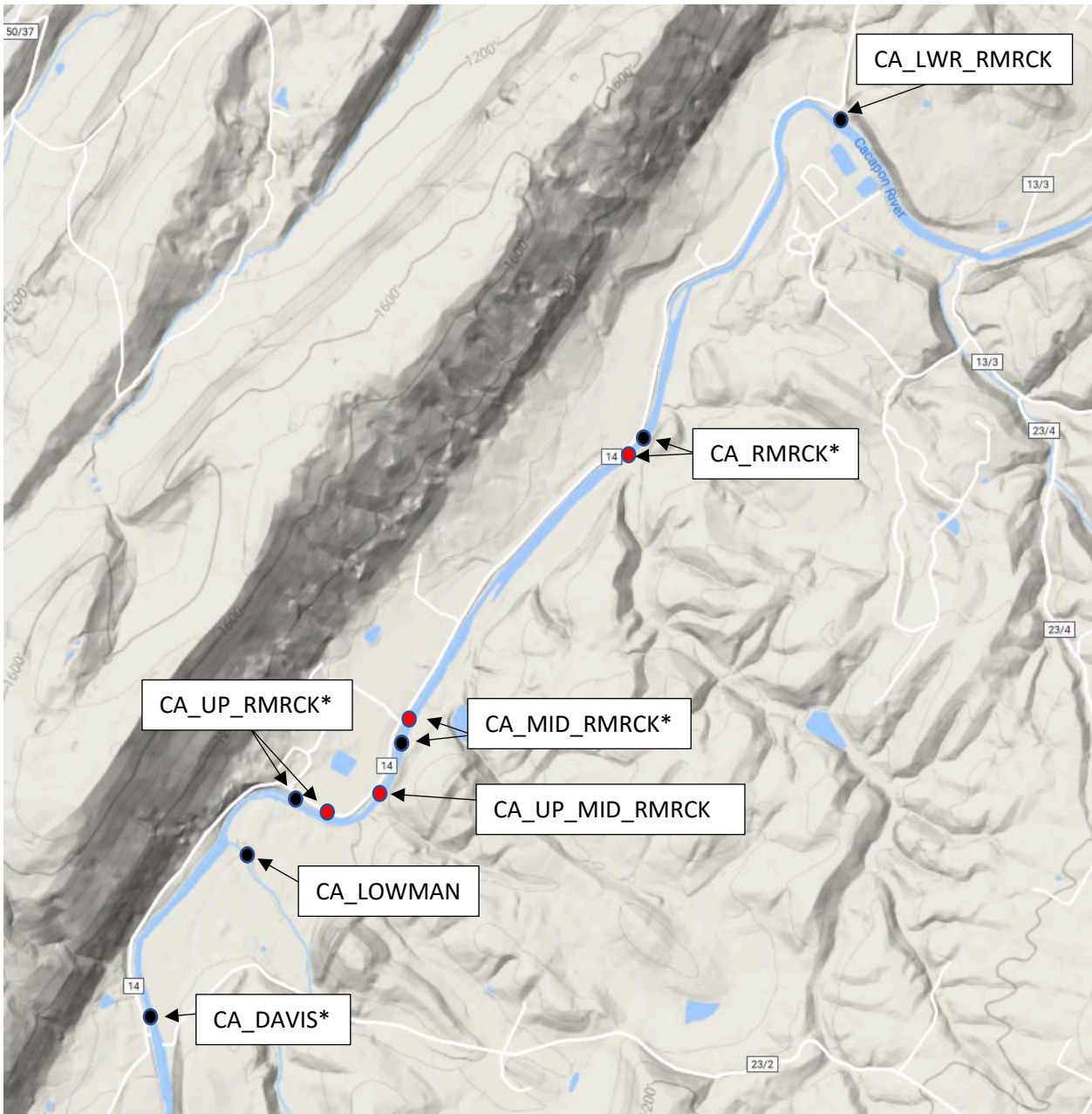


Figure 2. Map of the five-mile elevated primary production reach of the Cacapon River mainstem. Sites with \* denote locations where flow measurements were collected alongside water chemistry and transects. Red circles represent sediment sample locations. CA\_UP\_MID\_RMRCK was collected only as a sediment sample.

## Site characterization

The WVDEP Filamentous Algae Monitoring Form was generally completed in the field by the crew leader. As the sites are fixed positions, Global Positioning System (GPS) coordinates were taken using a Garmin Etrex20 on the first field visit to verify historical GPS recordings (2014-present). No change in GPS location were observed so locations were recorded as HIST on data sheets. If for any reason the sampling location was moved, the recorded GPS coordinates reflect that change. Five new sites were added in 2017. They were located via satellite imagery, confirmed with WVDEP, and confirmed with handheld GPS. Relevant USGS gage hydrographs for the study period are included in **Appendix I**. Qualitative observations of periphyton, aquatic moss, aquatic vascular plants, filamentous green algae (FGA) and cyanobacteria/blue-green algae (BGA) abundance were made on each site visit.

## Photo documentation

Pictures were taken on each site visit, arranged in folders according to site and sampling date, and stored on a SharePoint website that was shared with WVDEP staff. Generally, photos were taken at the x- site, one picture each looking upstream, downstream, and across the channel. Photos were also taken of any algae observed or measured, including underwater photos, or anything else of note, including sample collection or processing, in-situ probe placement, etc. Photos were documented on page 4 of the field sheet. A Nikon AW100 and/or Iphone7 were the primary cameras used and can attach GPS coordinates of the pictures as they were taken. This information is in the details of the file properties. GPS coordinates did not always accompany pictures and are generally missing from underwater shots and videos. All pictures and videos were arranged by sample location and date within the SharePoint file tree.

## Filamentous algae abundance measurements

Percent algae coverage measurements were performed according to Standard Operating Procedures (SOP) provided by WVDEP. Measurements were recorded in feet and tenths of a foot. Protocols refinements in 2014 included guidance on when algae measurements are measured by transect, versus a single visual estimate of the transect. Single visual estimates of the entire transect are sufficient if algae is estimated to be below 10% or above 80%. Moderate amounts of algae require transect-segment based estimate-measures. If algae is measured between 20% and 40%, three separate transect measures are required spanning a length of 3X the average channel width. Lengths and depths of the lateral transects were reported in tenths of a foot using a field tape and surveying rod. Large rivers were measured using a laser range finder. All values were entered on the field form and translated to the percent algae calculation spreadsheet file. The file was modified from that provided by WVDEP to receive the measurements as recorded, to calculate the percent coverage of the entire transect. The modified percent algae coverage calculation spreadsheets and associated data are provided separately as a Microsoft Excel© file with each measurement occupying one tab. Algal measurements were also performed during longitudinal surveys when filamentous algae were encountered.



## In-situ water quality

In-situ water quality was collected at every site with the same YSI-556 multi-parameter sonde throughout the season. Water temperature (WTEMP), dissolved oxygen (DO), pH, specific conductance (SPCOND) and total dissolved solids (TDS) were measured in-situ and recorded on the field data sheet. The YSI-556 was calibrated at the beginning of each sampling round using concentration standards. Specific conductance was calibrated using a 447.1  $\mu\text{S}/\text{cm}$  standard solution and pH was calibrated using a 2-point (7.01 and 10.00) calibration. Dissolved Oxygen was calibrated using a saturated air calibration method, according to the user manual of the YSI-556.

## Remote continuous loggers

On May 22, 2017 ICPRB biologist, Gordon

Selckmann and WVDEP biologist Nicholas Snider deployed two HydroLab® continuous monitoring probes at two sites in the upper Cacapon River. Probes were anchored onto the river bottom via rebar and plastic-coated stainless cable. One probe was deployed above the town of Wardensville (CA\_WRDS) and acted as an upstream of bloom control site. A second probe was deployed at the historically high production site, CA\_RMRCK. Probes were collected by Nick Snider on October 30<sup>th</sup>, 2017. Continuous monitoring data was downloaded and processed by WVDEP using Aquarius® software and is not summarized in this report.

## Water chemistry

Four sample containers were filled at each sampling location on the Cacapon River for the following parameters: total phosphorous (TP), dissolved phosphorous (DP), ortho-phosphorus, total kjeldahl nitrogen (TKN), nitrate-nitrite-N ( $\text{NO}_3\text{-NO}_2\text{-N}$ ), total alkalinity (TALK), calcium (CA), magnesium (MG), and total suspended solids (TSS). Water chemistry sample containers were provided pre-fixed with acid preservatives by the contracted analysis laboratory PACE. At each sampling location, a collection container was rinsed 3 times and samples were collected facing upstream. The sampling location within the river was indicated on the monitoring form. Filtering for the dissolved phosphorous sample was performed using PACE provided sterile syringe with attached 45 $\mu\text{m}$  filter. The vacuum flask and filter apparatus were also rinsed 3 times mid-stream prior to filtering. Samples were collected according to WVDEP Standard Operating Procedures for water chemistry sampling. Sample duplicates were collected during each round and were analyzed alongside the 8 station samples. No water chemistry samples were collected in the South Branch Potomac River in 2017. Water chemistry samples were labeled with a permanent marker and immediately stored on ice. All samples were collected within a single day and delivered directly to PACE (formerly BioChem) drivers, typically in Wardensville at the end of the Cacapon River sampling round.

## In-situ soil chemistry

In-situ soil chemistry was collected at four (4) benthic, in-stream locations on June 14, 2017. Samples were collected by WVDEP staff James Peterson, Chris Smith and ICPRB biologist Gordon Selckmann according to WVDEP protocols. Sediment samples were collected in areas of mud and fine

particulate. A point was made to avoid sand bars as well as leaf packs to get the best measure of sediment bound nutrients. Samples were delivered on ice by WVDEP staff to PACE analytical laboratories within the same day. Sediment samples were analyzed for nitrogen (nitrate + nitrite as N), total phosphorus (TP), and total kjeldahl nitrogen (TKN).

## Longitudinal surveys

Longitudinal surveys were employed to document the magnitude and extent of filamentous algae blooms at and between regularly visited sites. To survey suspected bloom areas that are not visible from roadways, biologists used canoes/kayaks to travel along a river reach and record observations and measurements in suspected algae occurrence areas. The longitudinal surveys are an informal assessment method, but consist primarily of documenting observations with written accounts, photographs and videos, and associated GPS coordinates at observation points.

ICPRB conducted three longitudinal surveys in 2017; two within the Cacapon River and one within the South Branch. ICPRB staff (Gordon Selckmann and Zach Smith) conducted the first longitudinal from the town of Capon Bridge to Cacapon Forks on July 14, 2017. The second longitudinal was conducted on the South Branch Potomac river between Old fields, WV and the Lower Trough site. The South Branch longitudinal was conducted by Gordon Selckmann (ICPRB) and James Summers (WVDEP) in response to a reported cyanobacterial bloom in Old fields one week prior. The third longitudinal was conducted by ICPRB staff (Gordon Selckmann and Zach Smith) from the Rt 259 Bridge to the town of Capon Bridge.

## Completeness

All 19 stations were identified by WVDEP prior to the first sampling round in May. WVDEP defined two different efforts for sampling the Cacapon and South Branch Rivers. (1) Early season efforts (May-July) required two site visits per month at the higher intensity sampling locations, a five mile stretch of the Cacapon River 1.5 miles downstream of the Rt. 259 bridge at Yellow Springs, WV. These early season efforts require algal surveys, water chemistry sampling, and flow measurements. The second round of surveys (5/12/2017) were omitted from the sampling schedule due to heavy rainfall that rendered the river unsafe to work in as well as outside of WVDEP sampling protocols. Except for the second round, the early season efforts were completed in their entirety.

Four (4) monthly observation rounds were completed at all 19 sites. ICPRB biologists attempted to complete all observations within a single 24-hour period. In cases where additional effort was required, sample rounds were conducted on consecutive days until completion of the round. Complete sets of Cacapon River water chemistry samples were collected on each of the 5 rounds. Algae transects were performed whenever algae were observed and estimated to be above 10% coverage. At the start of Round 5, Laura Cooper (WVDEP) visited the Rim Rock locations and confirmed bloom severity and reviewed methodology with Gordon Selckmann.

Table 2. Event log of sampling rounds and project tasks.

Round	Date	Rim Rock Sites	Flow	Historic Site Observation	Sediment Sample	Continuous Logger	Longitudinal
1	5/1/2017	X	X				
2	5/12/2017	X					
3	5/22/2017					Deployed	
	5/23/2017	X	X				
4	6/14/2017				X		
	6/15/2017	X					
	6/16/2017		X	X			
5	6/28/2017	X					
6	7/12/2017			X			
	7/13/2017	X					
	7/14/2017						#1
	7/26/2017						#2
7	8/3/2017	X	X				
8	8/21/2017	X		X			
9	9/20/2017	X		X			
	9/25/2017		X				#3
	10/30/2017					Recovered	

## Data Processing and Laboratory Methods

### Data processing

Digital scans and hard-copy datasheets were sent to WVDEP c/o James Peterson and Chris Smith. Data were entered into MS Excel for exploratory analyses. A copy of this electronic dataset is included in the MS Excel spreadsheet appendix accompanying this report. All analyses were performed using R and analysis scripts are provided, preceding the associated analysis or chart in the data file. Four parameters were calculated from the water chemistry data for analysis purposes. Total nitrogen (TN) was calculated by summing the NO<sub>3</sub>-NO<sub>2</sub>-N and TKN values for each independent sample. Total hardness (HARDNESS) is represented as molar equivalents of CaCO<sub>3</sub> in mg/L, calculated using the equation:

$$[\text{CaCO}_3] = 2.5[\text{Ca}^{2+}] + 4.1[\text{Mg}^{2+}]$$

Two Calcium-Magnesium ratio indices were calculated, following the analysis performed in the 2008 WVDEP Report on filamentous algae assessment report (Summers 2008). A traditional Ca:Mg ratio index with both ratio and additive terms of Ca<sup>2+</sup> and Mg<sup>2+</sup> (CA\_MG\_INDEX):

$$\log[\text{Ca}^{2+}/\text{Mg}^{2+}] - 0.5 \log[\text{Ca}^{2+} + \text{Mg}^{2+}],$$

A modified index considering only an additive variable (MOD\_CA\_MG):

$$-\log[\text{Ca}^{2+} + \text{Mg}^{2+}].$$

### Algal identification

Algae samples were collected opportunistically from the Cacapon River and South Branch Potomac and preserved on ice. The samples were transported back to the ICPRB lab where identifications were made. No cyanobacterial samples were identified in 2017. Predominant filamentous green algae species in the Cacapon were *Hydrodictyon*, *Cladophora*, and *Rhizoclonium*.

## Results: 2017 Season

### Summary of algal observations by station

Summary algae measurements are included in **Table 3** below. This table includes actual measurements, and qualitative visual estimates of low abundance algae occurrences. The below subsections are brief narratives that describe general trends in algal abundance at each site during 2017.

#### Cacapon River at Rt. 9 in the town of Largent (CA\_LRGNT)

The Largent location did not produce any significant filamentous green algae blooms in the four observation rounds (June, July, August, and September). This site frequently has more turbid water as well as a large SAV bed upstream of the site location (access from Kilgore Lane). The SAV bed is often described locally as a problematic algae bloom by the local population.

#### North River at Gaston Rd. / Forks of Cacapon (NO\_FRKS)

The North River location did not produce any significant filamentous green algae blooms in the four observation rounds (June, July, August, and September). The site at the North River continues to be dominated by a form of benthic riverweed (*Podostemum* sp.). No significant algae were observed in 2017. Trace amounts of filamentous green algae were observed in near the bridge in August and September.

#### Cacapon River at Rt. 127 / Forks of Cacapon (CA\_FRKS)

Very little filamentous green algae were observed at this site throughout 2017. Small isolated tufts of SAV were common but not overly abundant. Typical small isolated tufts of filamentous green algae were observed stuck to SAV. The high traffic boat ramp and deep pool at the bridge base are not the most ideal habitats to promote algal growth. Observations were made roughly 15-25 meters downstream where the pool become a shallow glide.

#### Cacapon River at farm off Cold Stream Road (CA\_D\_CPBRG)

Filamentous green algae were not present at densities greater than 5% coverage throughout 2017. In years past this site has manifested FGA blooms as well as had unattached BGA clusters floating through the site due to the production roughly a mile upstream of the site. Neither FGA or BGA that has been observed in previous years was observed in 2017.

#### Cacapon River at Rt. 50 in Capon Bridge (CA\_CPBRG)

This site continues to produce dense periphyton beds through the warm season. With the dense periphyton there are unusually high densities of gastropods throughout the year, potentially explaining the low amounts of algae production due to grazing pressure.

#### Capon River below historic Rim Rock Site (CA\_LWR\_RMRCK)

Th Cacapon River narrows at this location due to its substrate and banks being made of primarily

bedrock. The increased flow and non-ideal substrate makes this site a poor candidate for algal blooms. This site never produced any significant algae greater than 10% coverage over the course of 2017. A 200m walk upstream from this site appears to be where the 3-mile bloom terminates.

#### Cacapon River along Capon River Rd. and downstream of Camp Rim Rock (CA\_RMRCK)

This site continues to be the epicenter of the dense filamentous green algae bloom. Located roughly 3.5 miles downstream from where filamentous green algae production begins, this site frequently has impairment levels of filamentous green algae covering greater than 70% of the river area for most of the year. May and early June sampling dates were affected by strong scouring flows greater than 1,000 cfs. These flows were strong enough to damage established SAV beds as well. Despite SAV dominating the site through round 3, by round 4 ICPRB biologists observed impairment levels of FGA production (57% coverage). By Round 5 existing SAV stands were nearly completely covered by FGA. By round 6 to the end of the season, FGA dominated the site with greater than 80% coverage as well as resulted in SAV that looked sickly and in decline. The last round (Rd 9.) in September still held impairment levels of FGA at the end of the observation period. Autumn turnover and the senescence of the FGA was not observed in 2017.

#### Cacapon River at downstream horse ford (CA\_MID\_RMRCK)

2017 was the first year the middle Rim Rock site was regularly sampled. This site was selected based on it being the beginning of the most recreationally impaired reach of the Cacapon. This site experiences significant traffic by horses, campers and vehicles throughout the summer months. Although the ford at CA\_MID\_RMRCK is often devoid of primary production, 75 meters downstream below the island is the start of the most significant bloom site. Driving transects between CA\_RMRCK and CA\_MID\_RMRCK reveal nearly 2.5 miles of filamentous green algae with greater than 80% coverage area.

#### Cacapon River at upstream horse ford (CA\_UP\_RMRCK)

2017 was the first year the upper Rim Rock site was regularly sampled. This site is a short switchback section in between the termination of a large pool and the beginning of a long glide (CA\_MID\_RMRCK). The primary substrate is bedrock and boulder with a quicker flow than what is seen above or below this site. Due to the substrate morphology and flow, this site did not produce a significant algae bloom in 2017. If not for the deep pool and the cascade morphology of the 1.5-mile reach between CA\_DAVIS and CA\_MID\_RMRCK, ICPRB biologists believe this section would likely connect blooms observed at CA\_DAVIS and CA\_RMRCK.

#### Lowman Branch at the confluence with the Cacapon River (CA\_LOWMAN)

2017 was the first year Lowman Branch was regularly sampled. Lowman Branch was suspected of being a potential nutrient source to the mainstem Cacapon and therefore was visually assessed for algal production as well as underwent water chemistry testing. This site throughout the year did not produce any FGA blooms and on rare occasion held low amounts of BGA. This site does not appear to deliver any significant nutrients to the mainstem Cacapon at any timepoint during the year. By September the flow of this small stream was too little to get accurate flow measurements.



#### Cacapon River at Davis Ford river crossing (CA\_DAVIS)

2017 was the first year Davis Ford was sampled. The sampling area was defined as the ford and above. This area never produced any significant algae (>10% coverage) over the course of 2017. The lack of primary production is likely due to the shallow fast flows of the ford and the frequent crossing.

Interestingly, an estimated 75-100 meters downstream of the Davis Ford site appears to be start of the 3-mile bloom. For roughly 300m the medium depth, slow velocity section reach held impairment levels of algae throughout August and September. The bloom ends at a deep pool that spans nearly 500m (past Lowman Branch and the Upper Rim Rock site) and begins again near the middle Rim Rock site (CA\_MID\_RMRCK). Davis Ford should be considered the upstream extent of the Rim Rock bloom.

#### Cacapon River at Rt. 259 below Wardensville (CA\_YLWSPR)

Filamentous green algae and blue-green algae were not observed in 2016. This site is comprised of primarily bedrock and is moderately channelized, making it not ideal for algal establishment and longevity. Cool water springs were found upon investigation of this site which suggest this region and proximally further downstream could be affected by ground water chemistry and nutrient transport.

#### Cacapon River at farm ford in Wardensville (CA\_WRDS)

Filamentous green algae and blue-green algae were not observed in 2017. The most upstream site on the Cacapon has consistently been the location where the least number of algae is observed. This site, as has been reported in earlier years, is able to produce dense periphyton communities. This location was the upstream location for WVDEP's continuous logger.

#### South Branch at Harmison's Landing (SB\_L\_TRGH)

The Lower Trough location did not produce any significant filamentous green algae blooms in the four observation rounds (June, July, August, and September). As has been observed in previous years, small isolated clusters of filamentous green algae were witnessed growing atop infrequent SAV clusters. The epiphytic FGA never manifested into a large area bloom.

#### South Branch at South Branch WMA (SB\_U\_TRGH)

The Upper Trough location did not produce any significant filamentous green algae blooms in the four observation rounds (June, July, August, and September). This site experiences some of the highest sustained water velocity of any of the South Branch survey locations. The shallow cobble substrate and narrow channel width increases flow velocity and likely suppresses FGA and BGA production. Early in the summer season when water levels are decreasing there are some ephemeral pools that produce FGA, separate from mainstem flow. These pools are desiccated early in the season.

#### South Branch at Rt. 220/28 in Moorefield (SB\_L\_MRFLD)

The Lower Moorefield location did not produce any significant filamentous green algae blooms in the four observation rounds (June, July, August, and September). One report of a heavy cyanobacteria

bloom, most likely of the genus *Phormidium* was reported to have occurred the week of June 24, 2017 by WVDNR fisheries biologist Brandon Keplinger. Keplinger reported, "It can be found profusely throughout the region of the stream from Old Fields (where pictures and samples were collected) all the way down past the Hampshire County border..." This report prompted James Summers(WVDEP) and Gordon Selckmann (ICPRB) to conduct a longitudinal survey of the bloom area. No cyanobacterial blooms were observed in response to initial reports of dense cyanobacterial mats. The lower Moorefield site held abundant SAV throughout with in frequent BGA tufts the rest of the observation season.

#### South Branch at Fisher Rd above Moorefield (SB U MRFLD)

The Lower Moorefield location did not produce any significant filamentous green algae blooms in the four observation rounds (June, July, August, and September). This site did not produce any excessive primary production in any form during the 2017 observation rounds. The upstream portion of this site is primarily a channelized riffle with a cobble/boulder substrate which is non-ideal for establishment of FGA or BGA. The downstream section of this site by the boat ramp is a deep pool which also appears to be non-conductive to FGA and BGA establishment.

#### South Branch at Weldon Park off Rt.220/55 (SB L PBRG)

The lower Petersburg location did not produce any significant filamentous green algae blooms in the four observation rounds (June, July, August, and September). This site did not produce any excessive primary production in 2017. At the boat ramp there is infrequent SAV clusters. Filamentous green algae (FGA) is only observed in very low densities roughly 300 meters upstream. Early summer observations recorded light *Hydrodictyon* blooms established on the descending left bank shoreline (<5% total coverage).

#### South Branch at Rt.220 in Petersburg (SB U PBRG)

The upper Petersburg location did not produce any significant filamentous green algae blooms in the four observation rounds (June, July, August, and September). This site did not produce any excessive primary production in 2017. The descending left bank (boat ramp) is a fast running riffle with substrate void of periphyton, SAV, FGA, or BGA. The descending right bank is a shallow low flow region that has produced light blooms in the past, however this was not the case in 2017.

Table 3. Summary of percent filamentous algae cover measurements made during the 2017 season. Null values indicate when judgment was impaired by poor visibility, "ND" values indicate non-detects, values up to 10% were visually estimated and recorded as "<5" or "<10", all other values are actual algae measurements using the Wadeable Transect Method.

SITE_NAME	WATERBODY	Rd 1	Rd 2	Rd 3	Rd 4	Rd 5	Rd 6	Rd 7	Rd 8	Rd 9
CA_LRGNT	CACAPON				<5		<5		<5	<5
CA_FRKS	CACAPON				<5		<5		<5	<5
NO_FRKS	NORTH RIVER				<5		<5		<5	<5
CA_D_CPBRG	CACAPON				<5		<5		<5	<5
CA_CPBRG	CACAPON				<5		<5		<5	<5
CA_LWR_RMRCK	CACAPON	<5	ND	<5	<5	<5	<5	<5	<10%	<10%
<b>CA_RMRCK</b>	CACAPON	<5	ND	<5	<b>58.13%</b>	<b>78%</b>	<b>&gt;80</b>	<b>&gt;80</b>	<b>&gt;80</b>	<b>&gt;80</b>
CA_MID_RMRCK	CACAPON	<5	ND	<5	<5	<5	<5	<5	<10%	<10%
CA_UP_RMRCK	CACAPON	<5	ND	<5	<5	<5	<5	<5	<5	<5
CA_LOWMAN	CACAPON	<5	ND	<5	<5	<5	<5	<5	<5	<5
<b>CA_DAVIS</b>	CACAPON	<5	ND	<5	<5	<5	<5	<5	<b>&gt;80</b>	<b>&gt;80</b>
CA_YLWSPR	CACAPON				<5		<5		<5	<5
CA_WRDS	CACAPON				<5		<5		<5	<5
SB_L_TRGH	SO. BRANCH				<5		<5		<5	<5
SB_U_TRGH	SO. BRANCH				<5		<5		<5	<5
SB_L_MRFLD	SO. BRANCH				<5		<5		<5	<5
SB_U_MRFLD	SO. BRANCH				<5		<5		<5	<5
SB_L_PBRG	SO. BRANCH				<5		<5		<5	<5
SB_U_PBRG	SO. BRANCH				<5		<5		<5	<5

## Water Chemistry Results 2017

### YSI readout results

Water temperature did not vary greatly between waterbodies or sites, though the sites proximal to large SAV beds saw elevated temperatures and wider pH ranges. Daytime dissolved oxygen (DO) and pH were elevated around the highly productive reach in the Cacapon River. In the Cacapon River there was a noticeable drop in the specific conductance from the upstream sites (~160 uS) to the bloom site locations (~140 uS) around CA\_RMRCK. Specific conductance levels return to the upstream baseline specific conductance (~160 uS) downstream of CA\_LWR\_RMRCK. Trends from these results suggest, lower specific conductance, elevated daytime DO and elevated daytime pH may all be indicators of excessive primary production without the need of continuous monitoring.

SITECODE	Average					Median			
	WTEMP	PH	DO	SPCOND		WTEMP	PH	DO	SPCOND
CA_LRGNT	25.80	7.47	7.38	165.25		26.69	7.70	7.43	164.50
NO_FRKS	23.26	7.57	8.14	164.00		24.02	7.67	7.69	164.00
CA_FRKS	24.02	7.76	7.14	176.25		24.75	7.78	7.19	176.50
CA_D_CPBRG	24.02	7.83	7.77	164.50		24.70	7.86	7.77	162.00
CA_U_CPBRG	25.04	7.98	8.17	160.00		25.44	7.91	7.99	160.00
<b>CA_LWR_RMRCK</b>	<b>22.93</b>	<b>7.93</b>	<b>8.29</b>	<b>146.75</b>		<b>23.55</b>	<b>7.94</b>	<b>8.41</b>	<b>147.00</b>
<b>CA_RMRCK</b>	<b>23.46</b>	<b>8.53</b>	<b>11.16</b>	<b>141.38</b>		<b>24.12</b>	<b>8.65</b>	<b>10.42</b>	<b>142.50</b>
<b>CA_MID_RMRCK</b>	<b>23.19</b>	<b>8.34</b>	<b>9.20</b>	<b>147.13</b>		<b>24.07</b>	<b>8.36</b>	<b>9.14</b>	<b>149.50</b>
<b>CA_UP_RMRCK</b>	<b>23.16</b>	<b>8.16</b>	<b>8.92</b>	<b>149.25</b>		<b>23.76</b>	<b>8.11</b>	<b>8.94</b>	<b>150.50</b>
<b>CA_DAVIS</b>	<b>23.33</b>	<b>8.32</b>	<b>9.54</b>	<b>146.38</b>		<b>23.99</b>	<b>8.26</b>	<b>9.46</b>	<b>152.00</b>
<b>CA_LOWMAN</b>	<b>19.91</b>	<b>8.01</b>	<b>6.20</b>	<b>95.38</b>		<b>20.28</b>	<b>8.03</b>	<b>4.85</b>	<b>97.00</b>
CA_YLWSPR	24.84	8.42	8.97	166.25		24.62	8.30	9.55	167.50
CA_WRDS	22.51	8.35	9.57	168.00		23.04	8.24	9.66	166.50
SB_L_TRGH	25.96	8.16	8.76	229.75		25.76	8.55	8.69	227.00
SB_U_TRGH	26.22	8.39	6.81	233.25		26.06	8.48	8.68	230.00
SB_L_MRFLD	25.21	8.40	9.12	216.00		24.76	8.33	9.25	212.00
SB_U_MRFLD	25.24	8.43	8.74	213.25		25.03	8.35	8.96	212.50
SB_L_PTBRG	24.99	8.53	9.65	213.50		24.54	8.40	9.89	214.00
SB_U_PTBRG	25.15	8.61	9.31	189.25		24.77	8.48	9.38	196.50

## Rim Rock Sites Water Chemistry

Median and mean values of the measured water quality parameters (mg/L) for each site are provided in Table 4 and Table 5, respectively. Temporal trends can be observed graphically in Appendix III. ICPRB did not collect water chemistry for the South Branch or Cacapon sites not included in the intensive study in 2017.

		NOx	TKN	TN	TP	DP	TSS	ALK	CA	MG	CA_MG_RAT	HARDNESS	CA_MG_INDEX	MOD_CA_MG
SITECODE														
<i>Average</i>	<b>CA_LWR_RMRCK</b>	0.19	0.28	0.46	0.02	0.01	2.88	66.93	22.60	4.23	0.11	73.82	2.44	2.99
	<b>CA_RMRCK</b>	0.17	0.26	0.43	0.02	0.01	2.63	64.55	22.40	4.26	0.12	73.48	2.43	3.00
	<b>CA_MID_RMRCK</b>	0.20	0.27	0.47	0.05	0.01	2.63	67.63	23.00	4.25	0.11	74.93	2.44	2.99
	<b>CA_UP_RMRCK</b>	0.20	0.28	0.48	0.02	0.02	2.63	68.33	23.30	4.30	0.11	75.88	2.44	2.98
	<b>CA_DAVIS</b>	0.21	0.26	0.47	0.02	0.02	2.38	67.41	23.38	4.29	0.11	76.02	2.44	2.98
	<b>CA_LOWMAN</b>	0.10	0.15	0.25	0.01	0.01	2.00	41.85	12.71	3.39	0.16	45.67	2.41	3.24
<i>Median</i>	<b>CA_LWR_RMRCK</b>	0.16	0.27	0.39	0.02	0.01	2.00	68.05	23.55	4.50	0.11	77.94	2.43	2.97
	<b>CA_RMRCK</b>	0.16	0.24	0.40	0.02	0.01	2.00	67.45	23.65	4.45	0.11	77.17	2.42	2.97
	<b>CA_MID_RMRCK</b>	0.22	0.25	0.47	0.02	0.01	2.00	70.45	24.35	4.45	0.11	78.71	2.43	2.96
	<b>CA_UP_RMRCK</b>	0.24	0.26	0.48	0.03	0.02	2.00	71.60	24.75	4.55	0.11	80.94	2.43	2.95
	<b>CA_DAVIS</b>	0.26	0.25	0.49	0.02	0.02	2.00	71.30	25.00	4.50	0.11	81.57	2.43	2.94
	<b>CA_LOWMAN</b>	0.10	0.16	0.25	0.01	0.01	2.00	44.40	13.00	3.45	0.16	46.65	2.40	3.21

### Total Alkalinity and Hardness

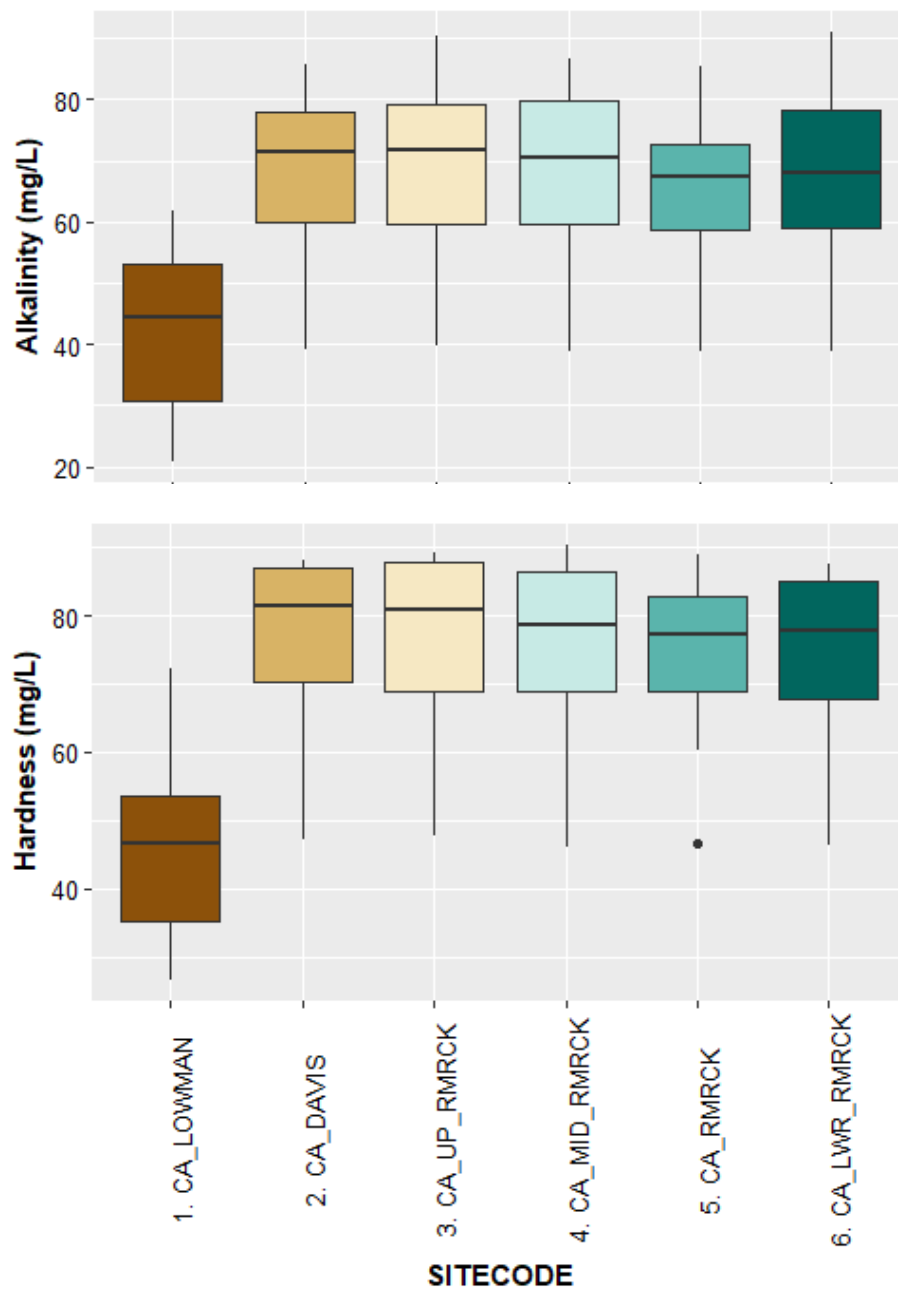


Figure 3. Boxplots of ionic species across 2017 sample locations. Station CA\_LOWMAN is located in a the tributary to the Cacapon mainstem and therefor is presented to the left of the plot, separate of the 5 continuous Cacapon sites.



*Nutrients: Phosphorous*

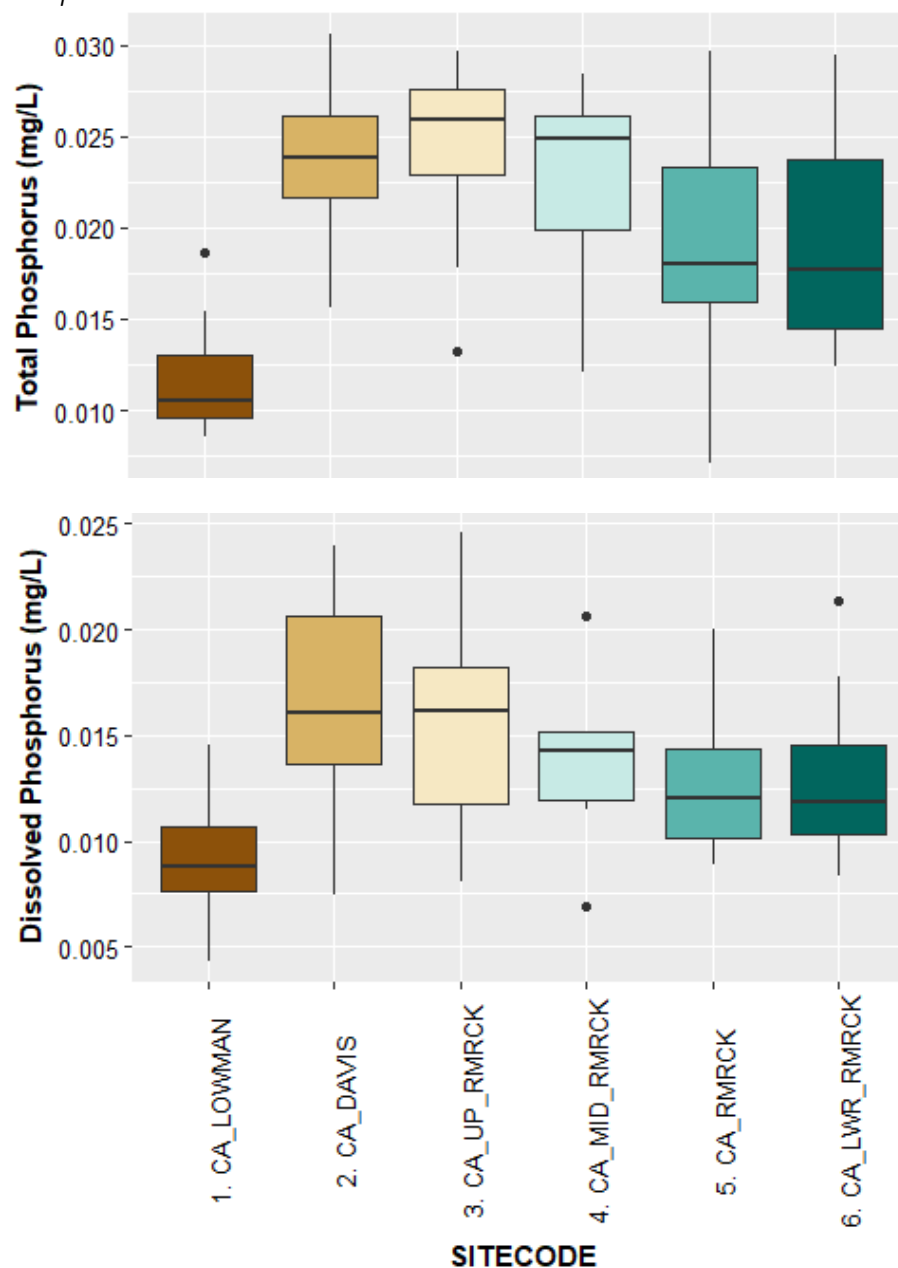


Figure 4. Boxplots of phosphorus species across 2017 sample locations. Ortho-phosphorus samples were omitted due to most concentration falling below detectable limits. Station CA\_LOWMAN is located in a the tributary to the Cacapon mainstem and therefor is presented to the left of the plot, separate of the 5 continuous Cacapon sites.

Nutrients: Nitrogen

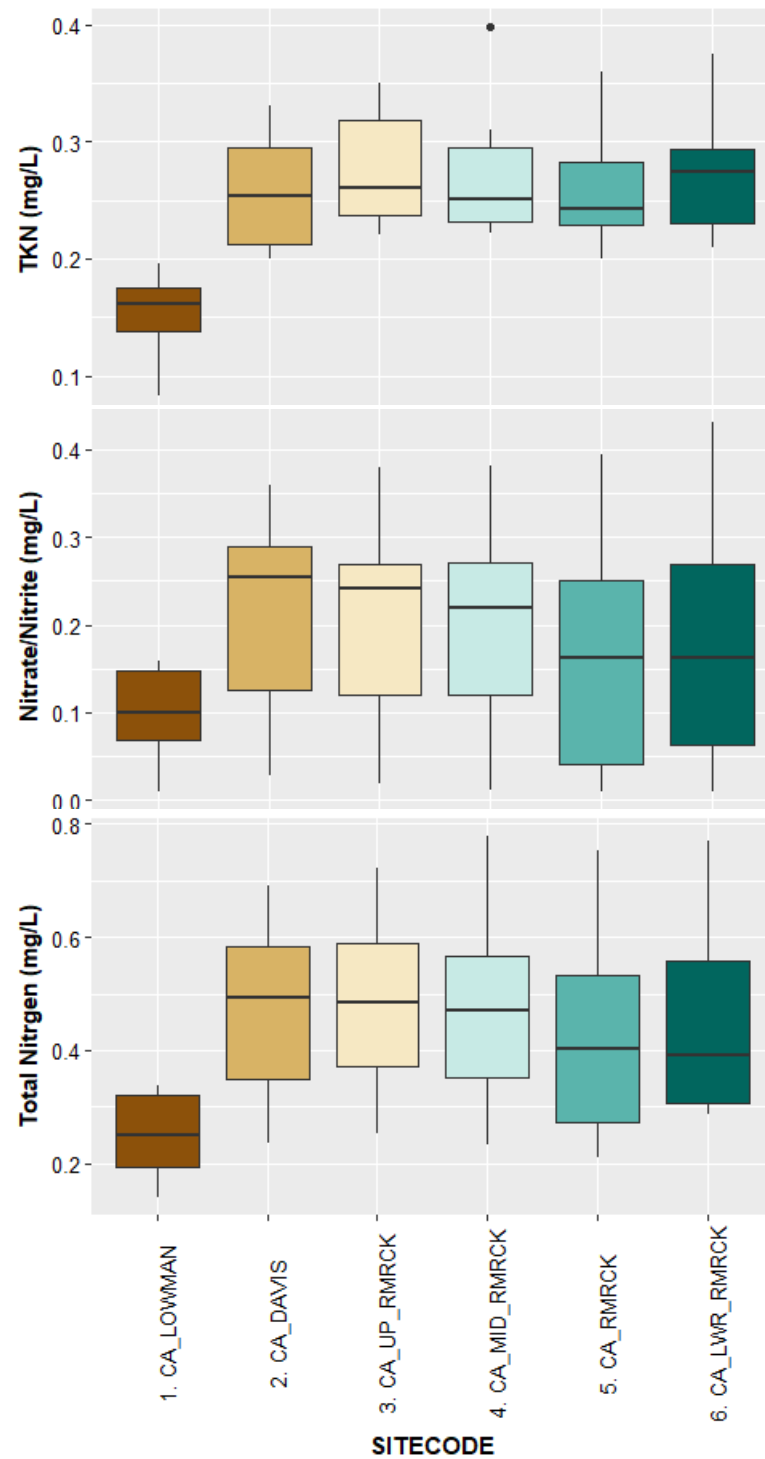


Figure 5. Boxplots of nitrogen species across 2017 sample locations. Station CA\_LOWMAN is located in a the tributary to the Cacapon mainstem and therefor is presented to the left of the plot, separate of the 5 continuous Cacapon sites.

#### Ionic compounds: Alkalinity and Hardness (Figure 3)

Historically the highest alkalinity and hardness concentrations in the Cacapon were observed at the most upstream sites. The highest alkalinity and hardness measurements were observed later in the season (July, August and September, Appendix III) when primary production was at its highest and flows were at their lowest. There were no observed differences in ionic species across the Cacapon mainstem sites. Lowman Branch had consistently lower hardness and alkalinity values throughout 2017.

#### Nutrients: Phosphorus (Figure 4)

Since 2012 WVDEP and ICPRB have assessed phosphorus levels in the forms of total phosphorus (TP) and dissolved phosphorus (DP). New to 2017 was the inclusion of ortho-phosphate to the water chemistry profile. Ortho-phosphate was not included in analysis of phosphorus species as almost all values were below detection limit. The highest phosphorus concentrations were observed at Davis ford (CA\_DAVIS) and the Upper Rim Rock site (CA\_UP\_RMRCK). These two sites were largely void of primary production for most of the season. In rounds 8 and 9 algal production rapidly increased to >80% cover at the Davis location. Starting at the middle Rim Rock Site (CA\_MID\_RMRCK) and continuing through the lower Rim Rock site (CA\_LWR\_RMRCK) dense SAV beds were abundant. Dense filamentous green algae began 200m downstream of the CA\_MID\_RMRCK location. The reduction of phosphorus at the Middle Rim Rock site downstream is likely due to biological demand of the filamentous green algae, cyanobacterial colonies, and dense SAV beds.

#### Nutrients: Nitrogen (Figure 5)

There are no significant differences in nitrogen species across sites except for Lowman Branch (CA\_LOWMAN) which had significantly lower nitrogen concentrations when compared to the mainstem Cacapon River. Starting at the middle Rim Rock Site (CA\_MID\_RMRCK) and continuing through the lower Rim Rock site (CA\_LWR\_RMRCK) dense SAV beds were abundant. Dense filamentous green algae began 200m downstream of the CA\_MID\_RMRCK location. The reduction of phosphorus at the Middle Rim Rock site downstream is likely due to biological demand of the filamentous green algae, cyanobacterial colonies, and dense SAV beds.

*Nutrients: Sediment bound nitrogen and phosphorus*

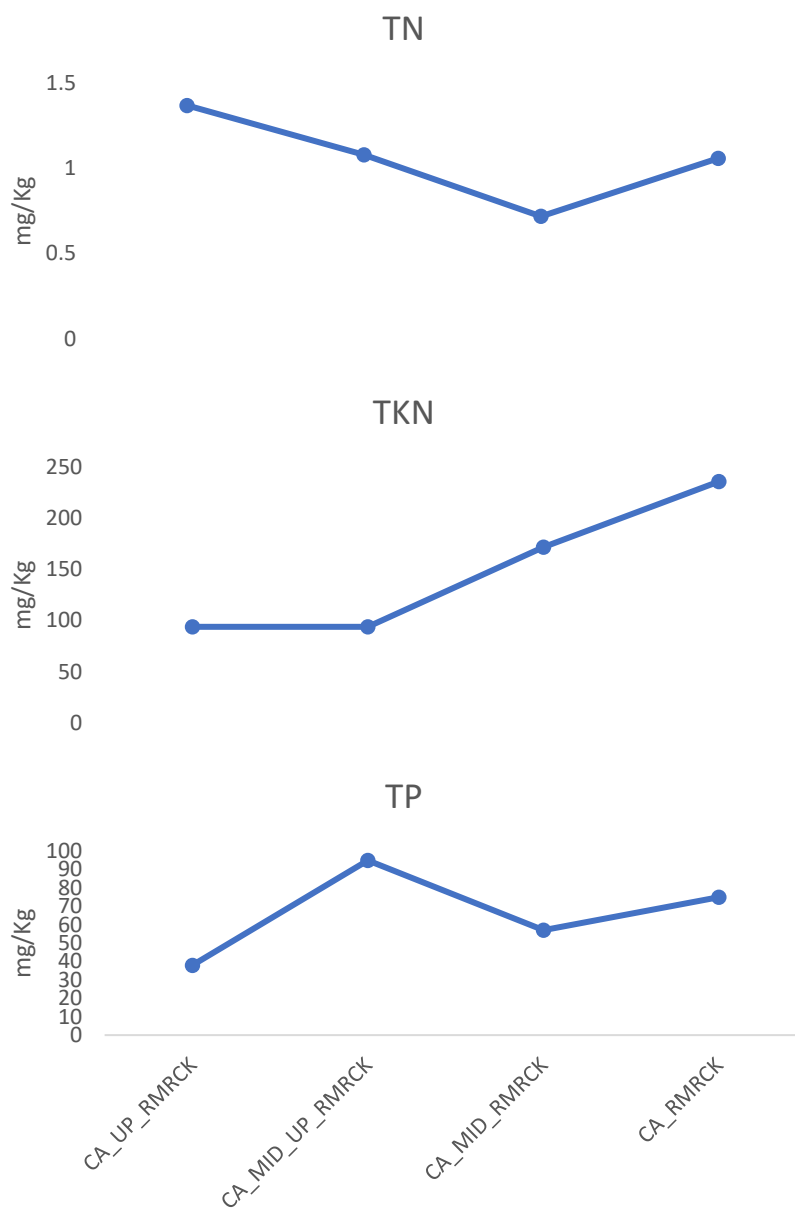


Figure 6. Line graphs of sediment bound nutrient concentrations across sites.

Four sediment samples were collected by James Peterson, Chris Smith, and Gordon Selckmann on June 14, 2017 using WVDEP protocols. Due to low replication trends taken from sediment samples should be considered preliminary. It is difficult to describe any trends in the sediment samples without historical reference points or additional sampling to observe variation within the samples. It appears sediment bound nitrogen increases the closer the sample is taken to a bloom site. No trends can be reported for phosphorus at these locations.

## Longitudinal Surveys

### *Longitudinal #1: July 14, 2017*

### *Capon Bridge to Cacapon at Forks*

On July 14, 2017 Gordon Selckmann and Zach Smith conducted a 16KM longitudinal survey via canoe from the town of Capon Bridge to the boat ramp at Cacapon Forks. As has been observed in other years, heavy periphyton and high snail densities were observed at the bridge in Capon Bridge, WV.

Shortly after starting the longitudinal we arrived at the WWTP outfall (permit # WV0103730). The condition of the river below outflow continues to suggest nutrient enrichment via an underperforming treatment plant. The smell and size of the grey water plum was less noticeable than has been observed in years past, however, the dense SAV beds observed in July are now 90% covered with *Cladophora* giving the appearance of nearly total coverage of FGA. Closer investigation revealed that the FGA was only 15cm- 30cm thick and had established on top of dense *Hydrilla* and *Potamogeton* blooms. SAV coverage approached 100% with nearly 90% column fill. Production in this area made paddling a boat nearly impossible as we were forced to push through the SAV/FGA beds for nearly 2Km.

Once below the deep pool at the riverbend above the CA\_D\_CPBRG, there was little FGA or BGA observed until the riffle with *Potostemum*. A floating transect through this section revealed around 40% FGA (*Cladophora*) coverage intermixed with SAV. At the beginning of the inaccessible area (Appendix II, Event 8) *Rhizoclonium* beds were witnessed growing atop dense SAV on the descending left bank. Floating transects estimated roughly 50% algal coverage for 500m downstream. For the next 7Km of longitudinal the river held dense SAV beds with light *Rhizoclonium* growing amongst them. The remainder of the longitudinal did not bear any significant SAV, FGA, or BGA.

As expected, the points of interest defined by Longitudinal #1 and #3 in 2016 were again areas of high production in 2017. It is relatively easy to pinpoint the waste water outflow as a nutrient point source below the town of Capon Bridge. It is more difficult, however, to identify why there is such significant primary production in a forested, low population area.

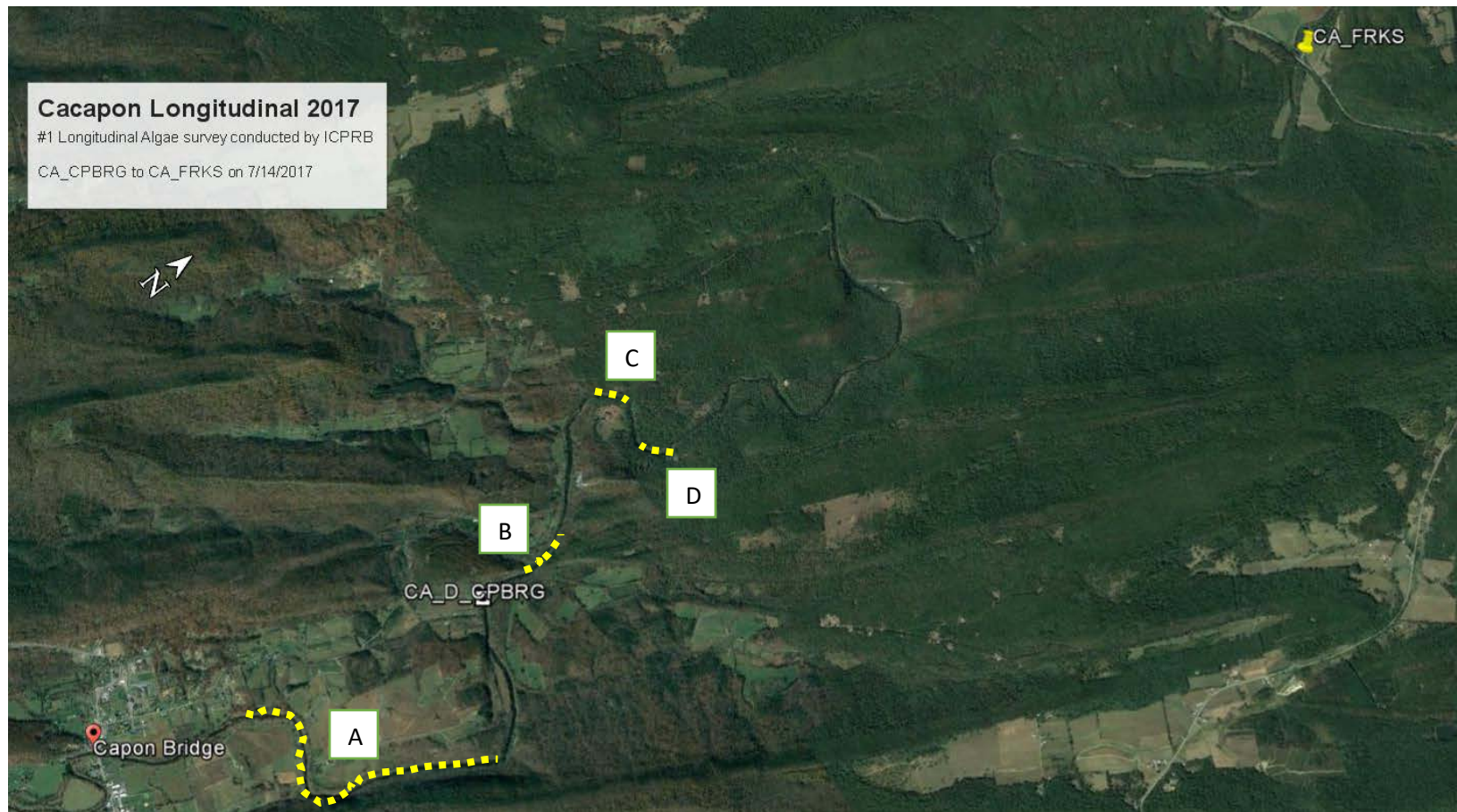


Figure 7. Map of longitudinal #1 conducted on 7/14/2017. Yellow highlighted regions represent areas of excess primary production.



*Longitudinal #2: July 26, 2017*

*South Branch: Old Fields to Lower Trough*

On July 26, 2017

A cyanobacteria bloom reported by Brandon Keplinger of WV Fish and Game prompted a longitudinal survey from Old Fields (SB\_L\_MRFLD) to the lower trough (SB\_L\_TRGH). Gordon Selckmann (ICPRB) and James Summers (WVDEP) met with Brandon Keplinger and the WV Department of Health to discuss the cyanobacterial bloom prior to the longitudinal.

Despite the initial report and photo-documentation of the cyanobloom at Old Fields (SB\_L\_MRFLD), the bloom appeared to have senesced by the time the longitudinal was organized. Evidence in the form of residual benthic cyanobacterial mats located along the shore lines and in strainer log jams were all that was left of the problematic bloom reported.

WVDEP and ICPRB have flagged several regions along this stretch as candidate locations for problematic over-production. A thorough visual inspection of these locations lacked any evidence of past or current blooms in 2017. Due to the lack of problematic over-production in South Branch Potomac River, no transects or additional sampling effort was required.



Figure 8. Map of longitudinal #2 conducted on 7/26/2017. Yellow highlighted regions represent areas of reported (B. Keplinger, WVDNR 7/22/2017) excess primary production.

The third longitudinal was conducted on September 25, 2017 due to a request by WVDEP to complete two objectives before the sampling season closed on October 1, 2017. The first objective was to (1) observe the full extent of the 5-mile intensive study reach, Yellow Springs (CA\_YLWSPR) to Lower Rim Rock (CA\_LWR\_RMRCK) and to (2.) observe the reach below CA\_LWR\_RMRCK to the town of Capon Bridge. The second objective was suggested due to its historical under sampling, in large part to the river's access being privately owned.

The Yellow Springs (CA\_YLWSPR) to Lower Rim Rock (CA\_LWR\_RMRCK) held the most filamentous green algae of any surveyed reach in 2017. Gordon Selckmann and Zach Smith launched a canoe-based longitudinal below the Rt. 259 bridge. No significant algal blooms were observed between CA\_YLWSPR and CA\_DAVIS. Two algal assessment transects were conducted at CA\_DAVIS. The first transect located 10 meters upstream of the CA\_DAVIS site yielded 24% coverage. Algal coverage increased significantly 50 meters downstream as the second transect yielded algal coverage of 65%. As the second transect was greater than 40% coverage, no additional transects were conducted within this section of river.

Below CA\_DAVIS, the Cacapon River makes a northward turn and becomes a deep pool that is not very conducive to algal blooms. Small tufts of filamentous green algae could be seen growing within straining debris and within shallow eddies. Lowman Branch (CA\_LOWMAN) enters the Cacapon mainstem during this deep pool stretch. Shortly after the confluence of Lowman Branch and the mainstem Cacapon river the river narrows into a long shallow run leading up to CA\_UP\_RMRCK site. This site is a maintained ford and with swift shallow flow, both of which make the site a poor host for filamentous algae and cyanobacterial mats.

Impairment levels of filamentous green algae started roughly 50 meters below the CA\_UP\_RMRCK site. A shallow layer of *Cladophora* established on the descending left bank and gradually extended towards the descending right bank (~60%). A deep pool marked the end of the bloom and continued until 20 meters above CA\_MID\_RMRCK. The CA\_MID\_RMRCK site was a shallow riffle/glide ford and was not conducive to algal establishment. Roughly 200 meters below CA\_MID\_RMRCK the largest filamentous algal bloom in the Cacapon River began.

The historic bloom reach held 90% or greater filamentous green algae coverage for nearly two miles. From the island below CA\_MID\_RMRCK to roughly 150 meters upstream of CA\_LWR\_RMRCK, impairment levels of filamentous green algae, and a dense abundance of SAV were present during the longitudinal. Due to bedrock substrate and the river narrowing, the CA\_LWR\_RMRCK site was not conducive to algal establishment. Arrival at CA\_LWR\_RMRCK concluded objective one (assess total production around CA\_RMRCK) for this longitudinal.

ICPRB biologists continued down the river towards Capon Bridge to describe the historically unobserved portions of the river below the high production reach. Interestingly, the reach between CA\_LWR\_RMRCK and CA\_CPBRG yielded very little filamentous green algae, blue green algae or SAV. This reach was predominantly bedrock substrate and was well forested with adequate riparian buffer near stream. The second objective of this longitudinal concluded at nightfall with no additional algal transects completed.

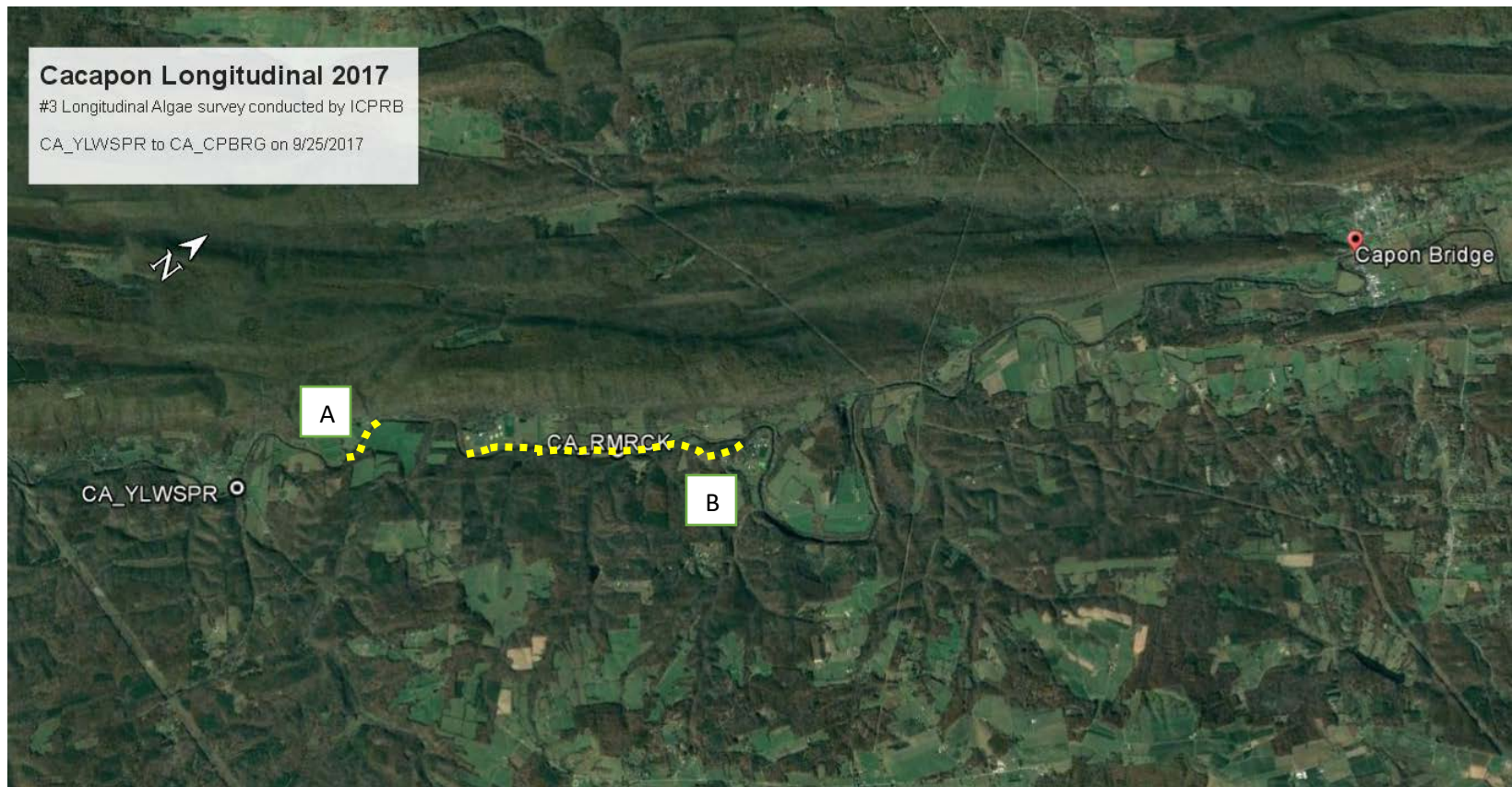


Figure 9. Longitudinal #3 conducted on 9/25/2017. Yellow highlighted regions represent areas of reported excess primary production.



## Conclusions and Suggestions for the Future

Algae observed in the Cacapon and South Branch Rivers during 2017 survey were very similar to observations made over the past five years. For the third year, early season elevated flows (Appendix I) appear to delay algal growth until later in the summer. The delay in spring algal blooms may potentially give slower growing rooted vegetation such as *Hydrilla sp.*, *Potostemum sp.* and *Potamogeton sp.* a competitive advantage which result in dense SAV beds where filamentous green algal beds would otherwise have grown. Despite the SAV dominance in years where elevated flows are prevalent in the spring, it has become clear from the 2017 season that these large SAV beds can act as complex three-dimensional structure capable of holding onto filamentous green algae when flows subside. It appears that filamentous green algae and cyanobacterial blooms are not adversely affected by the presence of SAV establishment, and in fact may benefit from their structure. Conversely, the dense filamentous green algae and cyanobacterial mats that appear do deleteriously affect the SAV. By late summer and early fall, the SAV beds are in poor condition at the same time the algae begin to senesce. The co-occurring die-off of FGA, BGA, and SAV may be leading to a late season eutrophication event that current sampling strategies are missing.

### Considerations for the Cacapon River

Future work on the Cacapon river should include another year of nutrient source tracking in the upper Cacapon. Regardless of spring time flows, the Camp Rim Rock site predictably produces the highest density of filamentous green algae year after year suggesting there is an abundance of nutrients impacting this region.

Increased effort in both temporal and spatial sampling of the upper Cacapon may elucidate an influx of nutrients and further explain why this reach is so much more productive than the rest of the lower Cacapon River. If nutrient source tracking were to take place, a year long sampling strategy that captures one full year would better describe nutrients available in the system, with and without primary production present. Another focus for future work should include groundwater connectivity and nutrient transport. The upper Cacapon has several spring inputs that effect the chemistry profile of this region and will likely complicate nutrient sourcing efforts. As there has not been a single point source identified that could explain the high biomass of the CA\_RMRCK region, more effort should be focused on better understanding nonpoint source pathways in this region.

### Considerations for the South Branch River

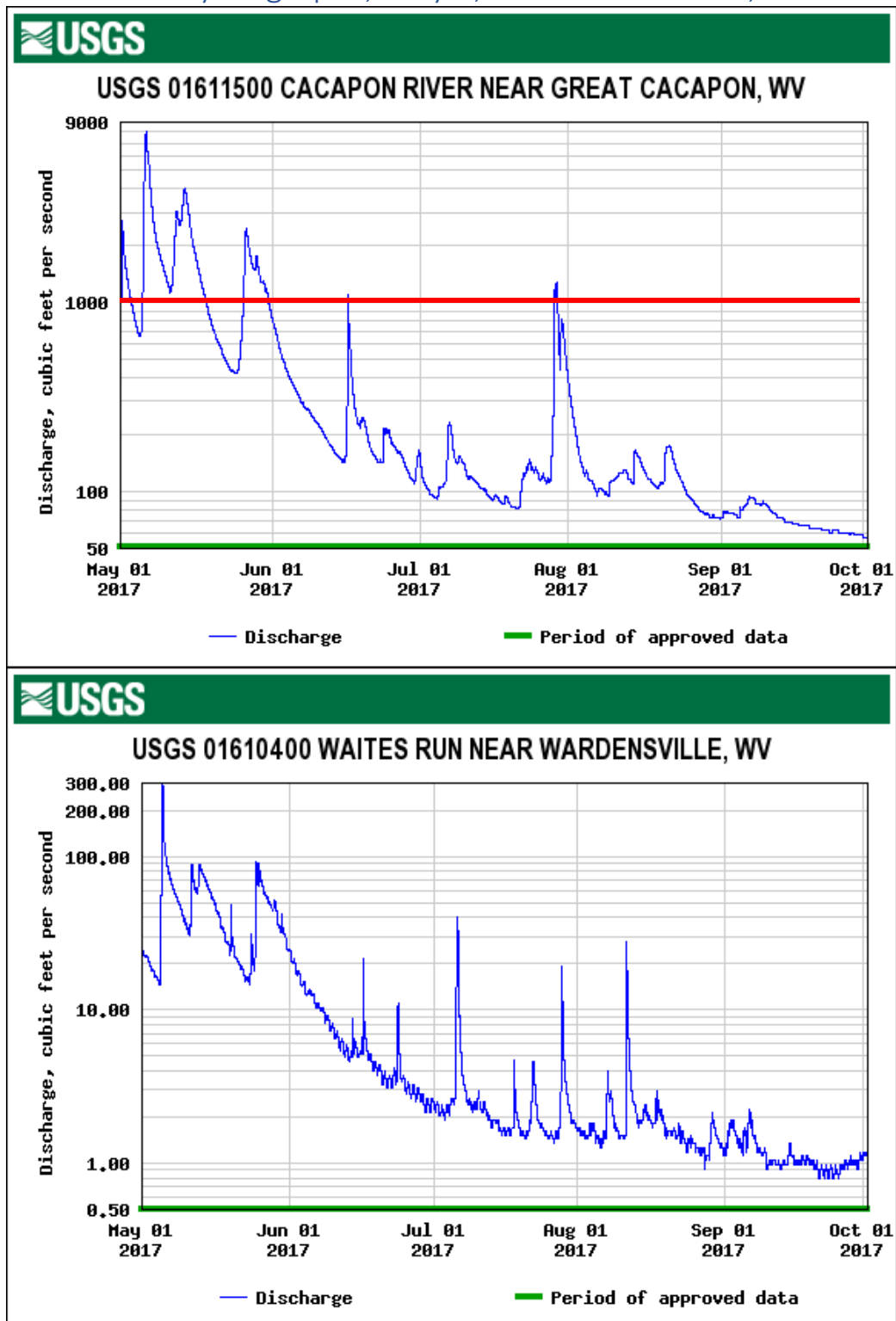
Due to scale of the South Branch Potomac River and its broad reaching recreational uses, algal observation of the river should extend upstream of Petersburg and/or below the town of Romney. As was the case in 2016, ICPRB biologist in 2017 often had to observe the lower South Branch Potomac below the town of Romney, WV while conducting other work in the basin. During this time dense algal mats were observed just below the scope of this study at the Rt 9 Romney Bridge, the Indian Rocks Boating Access, and at Little Orleans off of High Germany Rd. Inclusion of other problematic locations may further elucidate algal bloom trends in the South Branch Potomac.

In addition to the scale of observation effort, WVDEP should consider options on how to more

frequently observe the lower Moorefield (SB\_L\_MRFLD) location. Reports by WV Fish and Game recorded a cyanobacterial bloom that would have otherwise been missed by ICPRB regular monthly sampling. The cyanobacterial blooms at this location appear to manifest abruptly and senesce after only a few days. The rapid senescence may also be exacerbated by increased flows due to rain. Partnerships with local volunteer observers, other agencies, or increased visitation by ICPRB may be required to adequately record the annual cyanobacterial bloom at Old Fields.

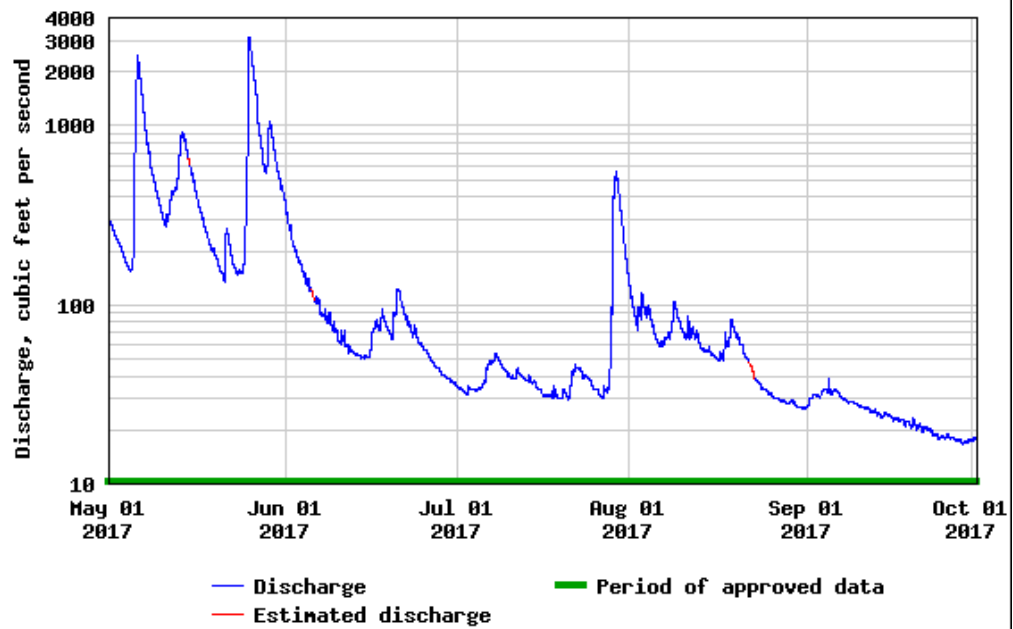


Appendix I. USGS Hydrographs; May 1, 2016 – October 1, 2017.



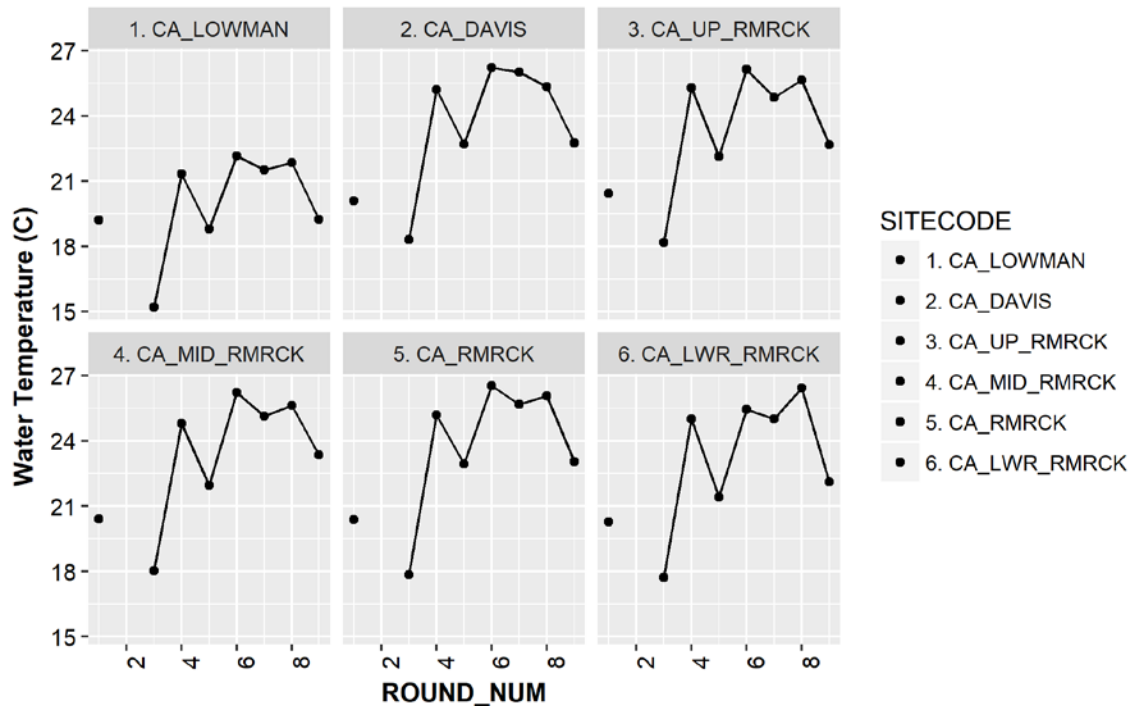


USGS 01608000 S F SOUTH BRANCH POTOMAC RIVER NR MOOREFIELD, WV

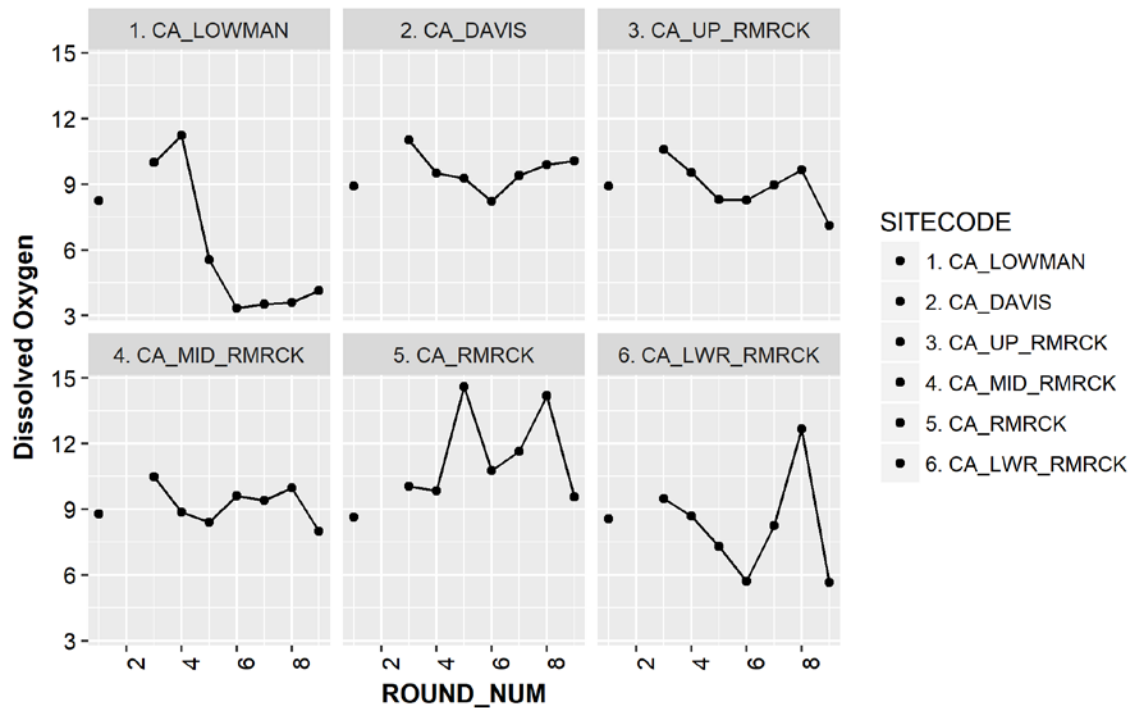


## Appendix II. Temporal Water Chemistry Trends: Rim Rock Sites

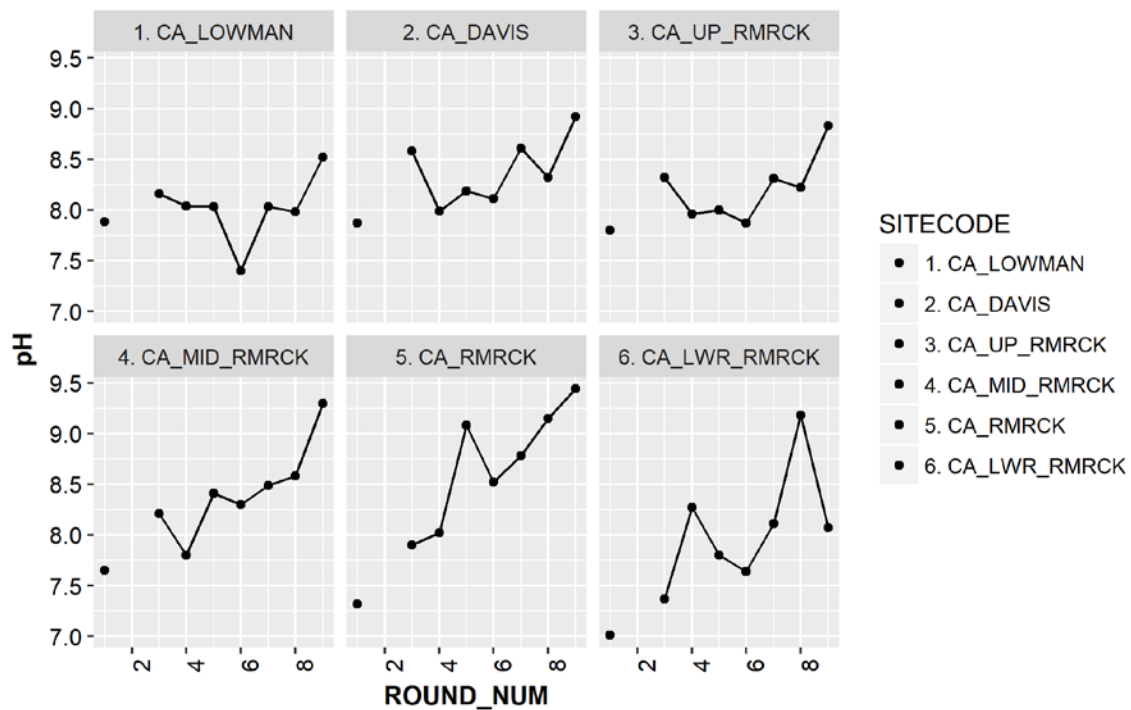
Water Chemistry across Stations 2017



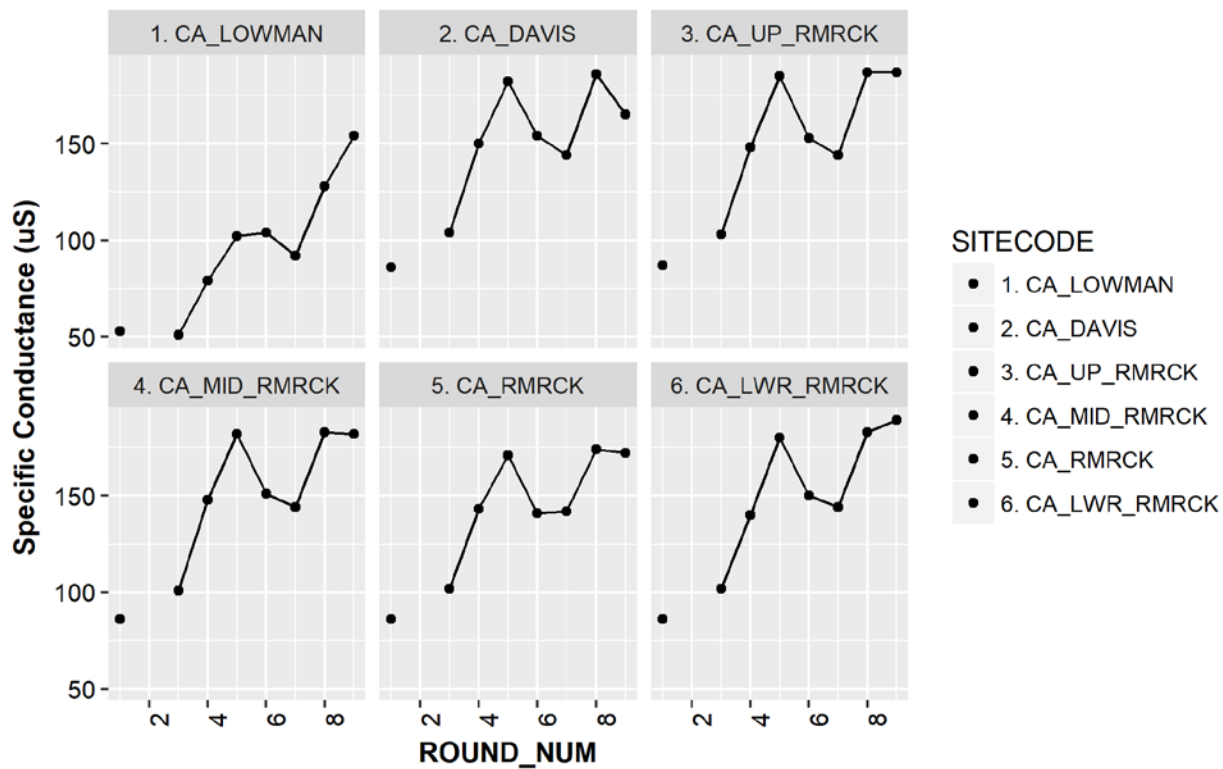
Water Chemistry across Stations 2017



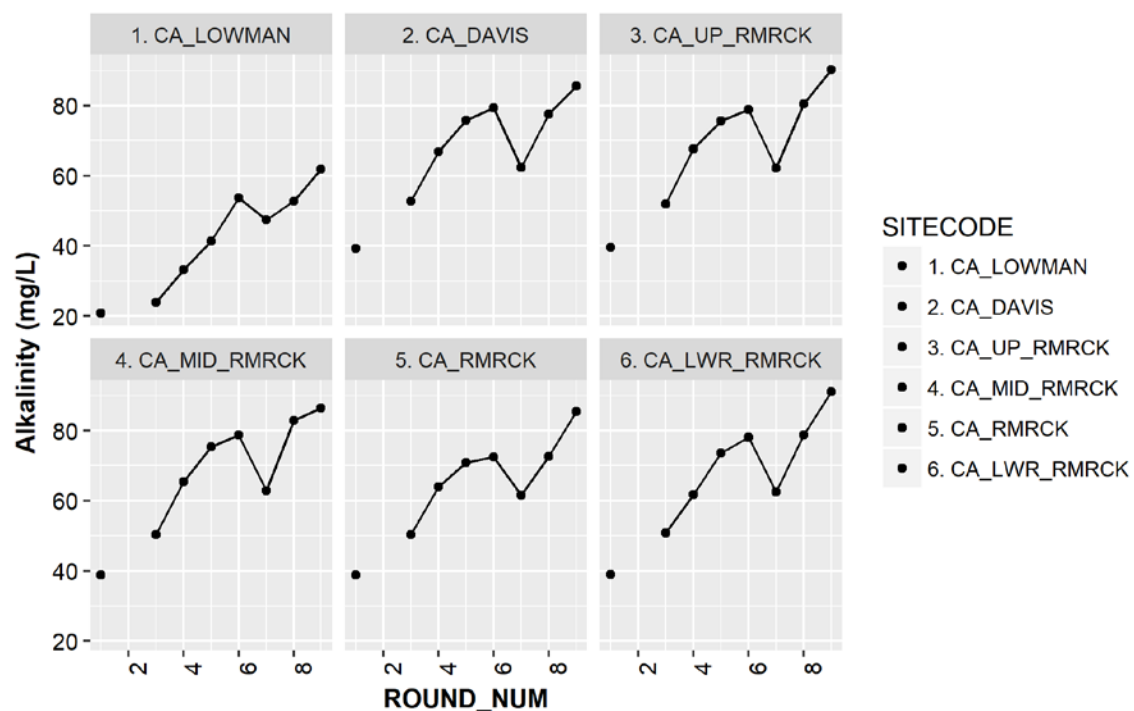
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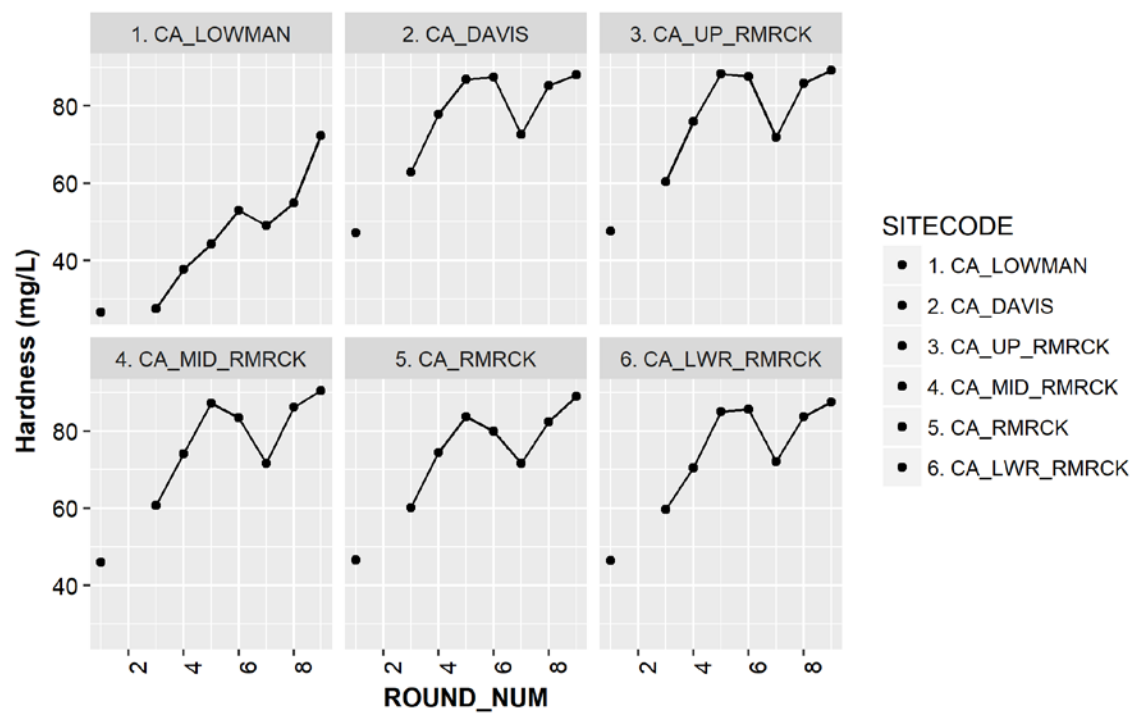
Water Chemistry across Stations 2017



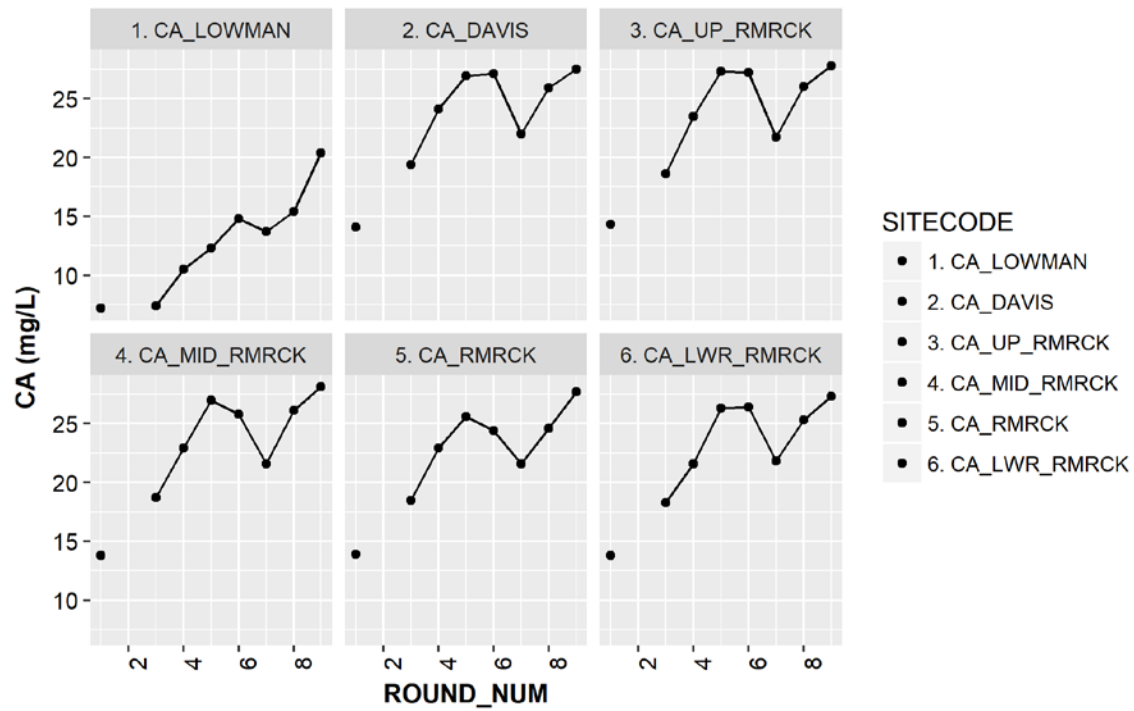
## Water Chemistry across Stations 2017



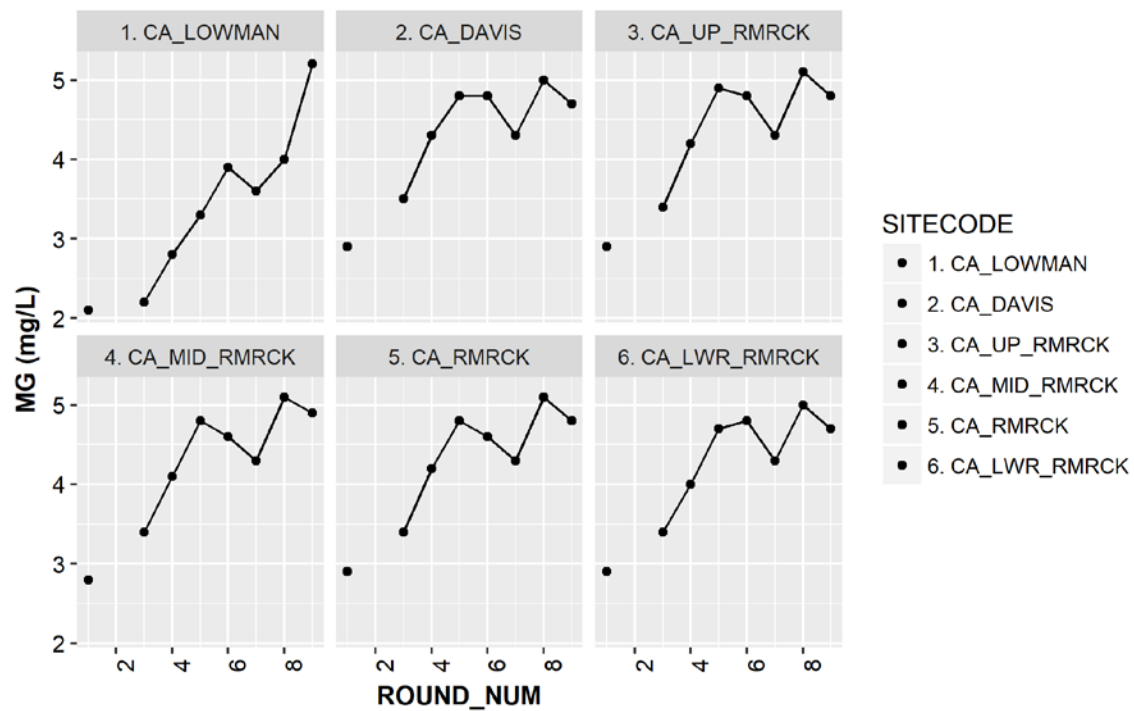
## Water Chemistry across Stations 2017



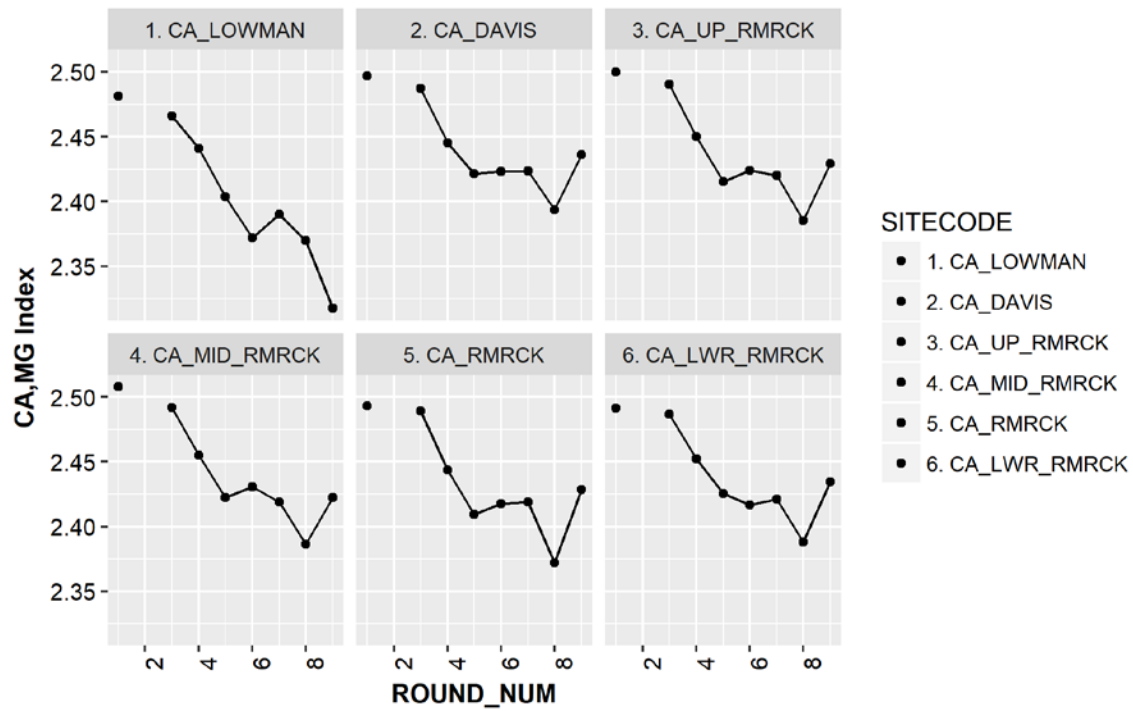
## Water Chemistry across Stations 2017



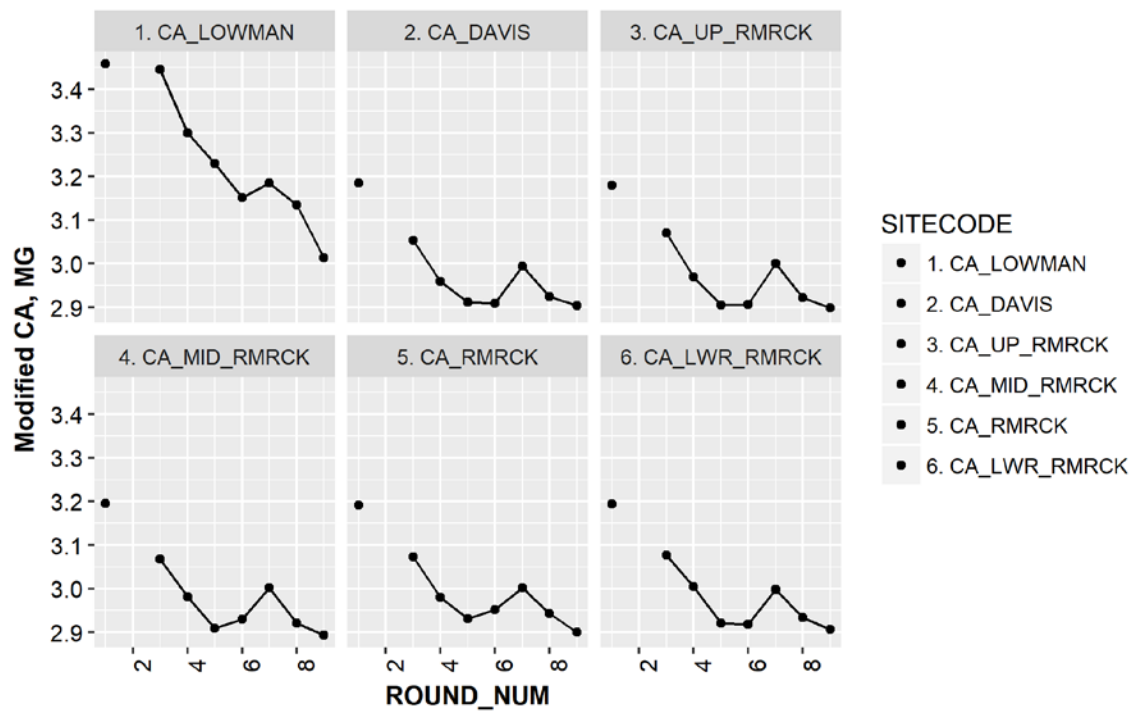
## Water Chemistry across Stations 2017



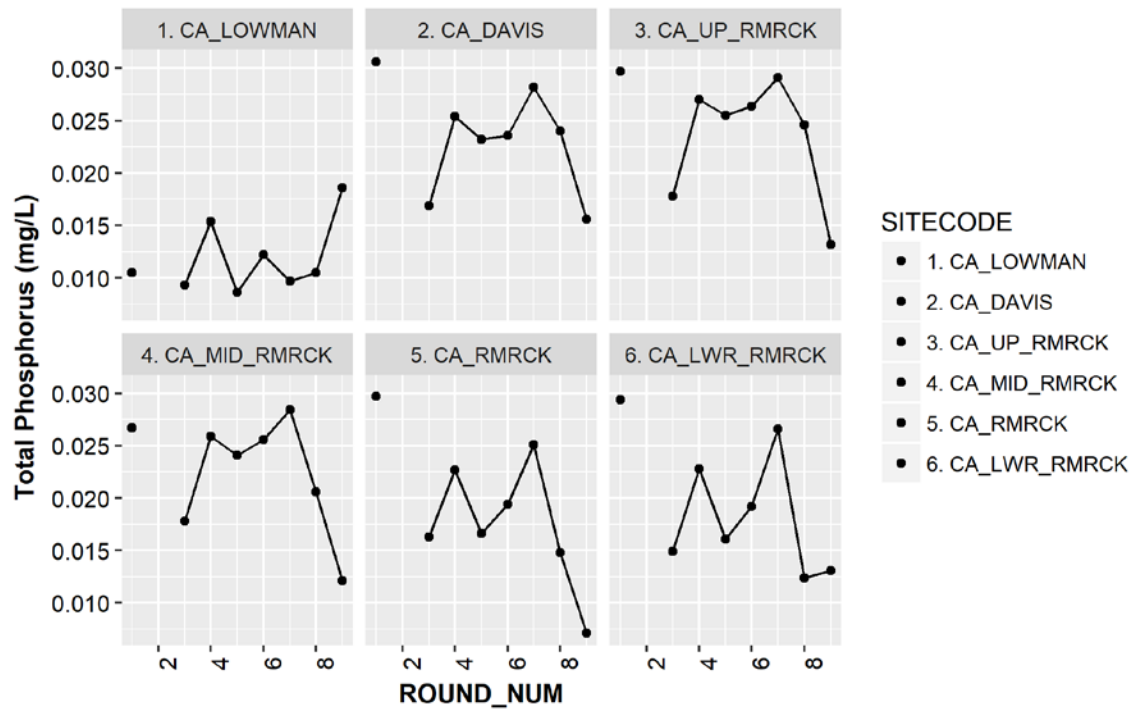
### Water Chemistry across Stations 2017



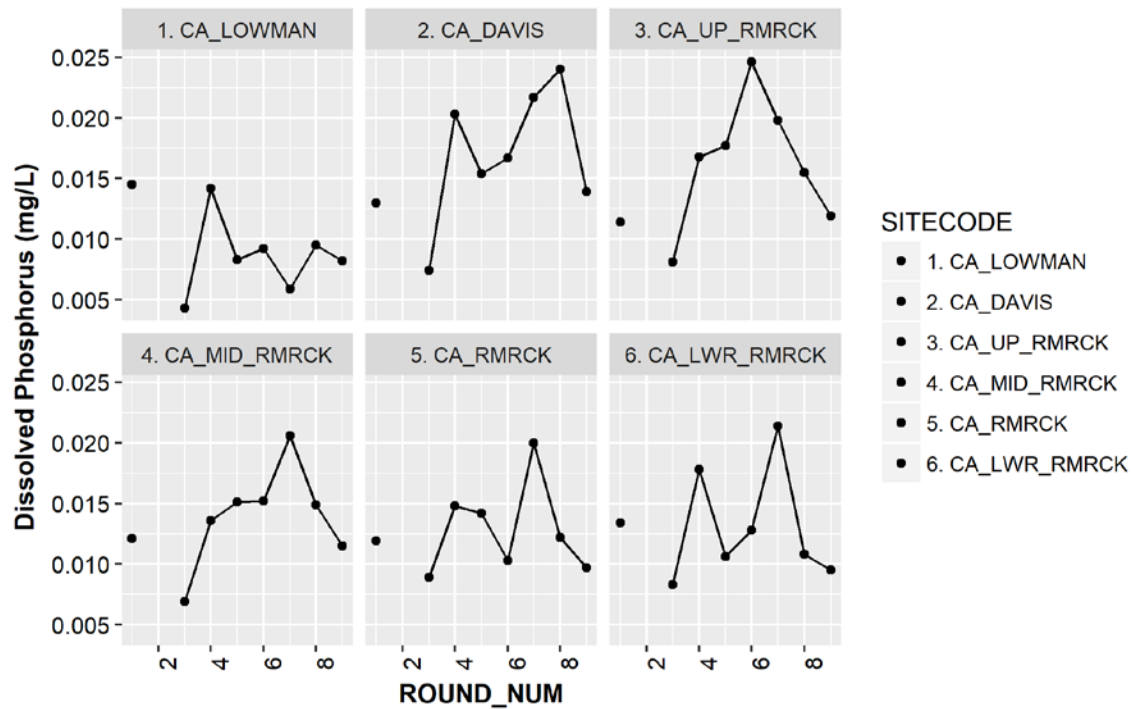
### Water Chemistry across Stations 2017



### Water Chemistry across Stations 2017

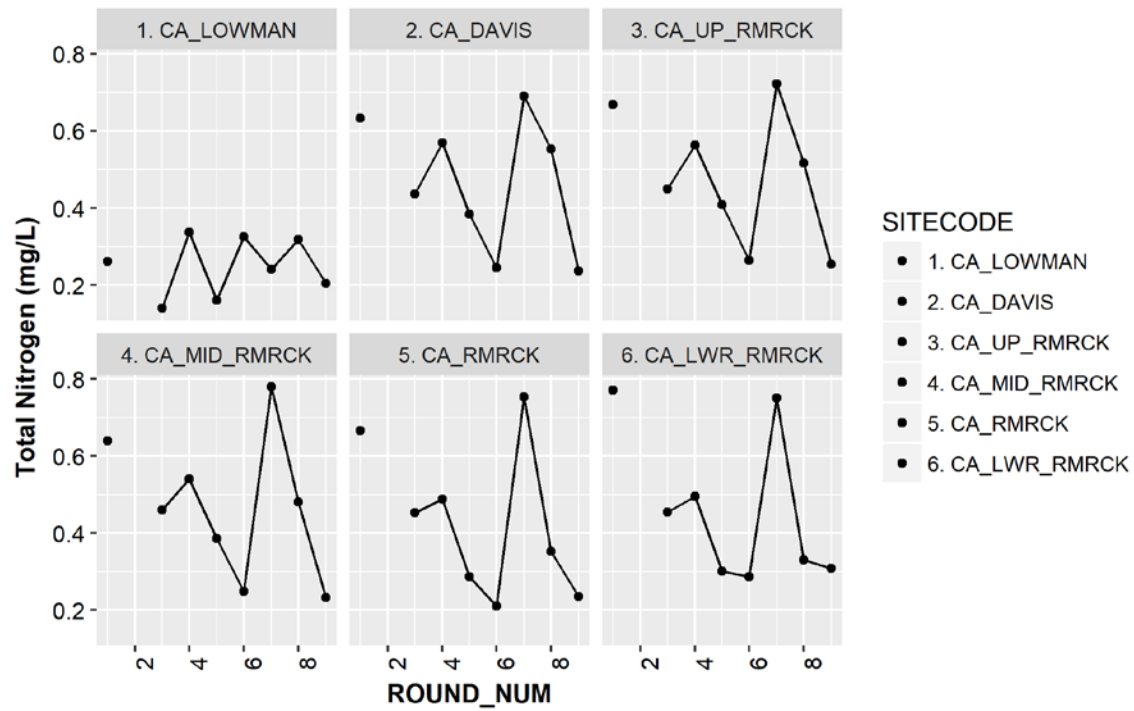


### Water Chemistry across Stations 2017

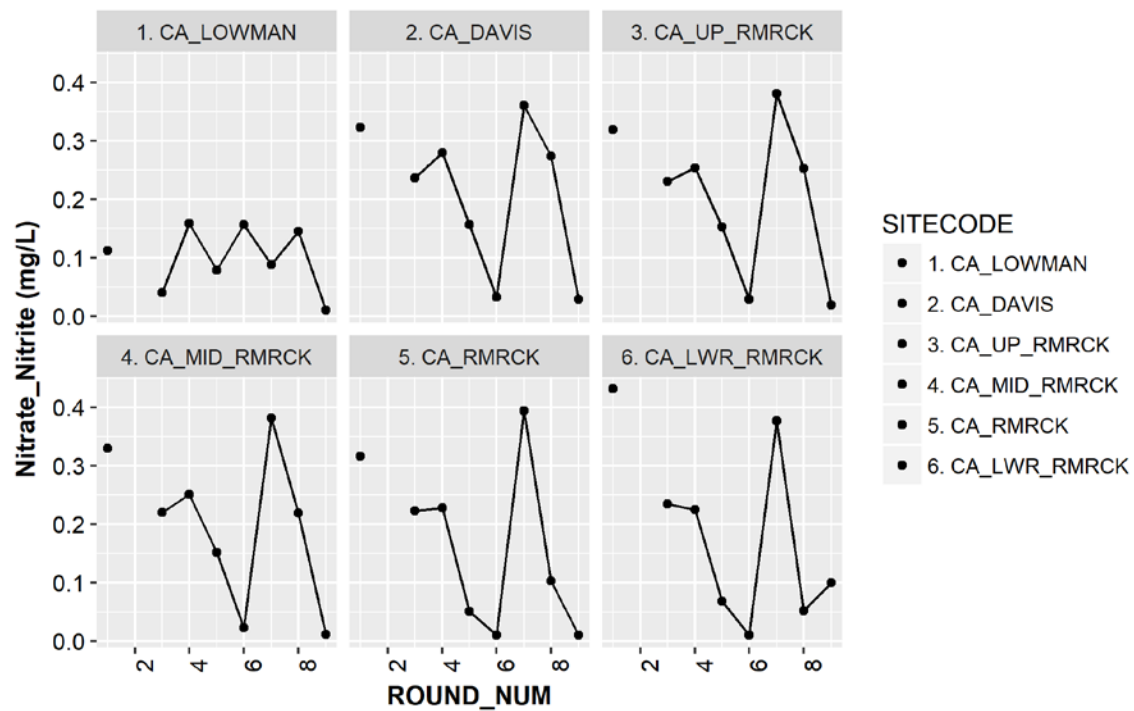




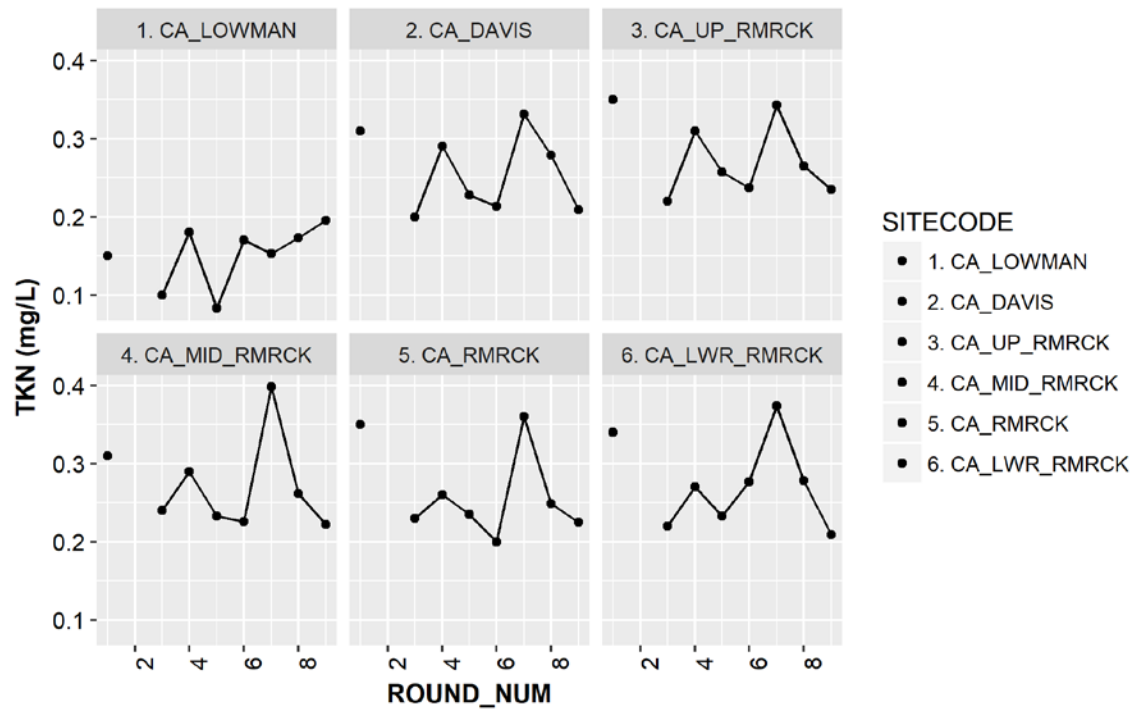
### Water Chemistry across Stations 2017



### Water Chemistry across Stations 2017



## Water Chemistry across Stations 2017



Appendix III. Flow data sheet form provided by WVDEP to ICPRB for flow assessment.

FLOW MEASUREMENTS>>>						Reviewers Initials		
AN-Code				Date		WQ Sample ID		
Stream Discharge Measurement (Calculated In Cubic Feet Per Second – cfs)								
Measurer				Recorder				Time
								Flow Meter ID
<b>IMPORTANT:</b> The flow rod is calibrated for readings to be taken at 0.4 (60%) depth. To set the flow rod to read at 0.2 depth, divide the depth by 2 and then set the rod to that value. To set the flow rod to read at 0.8 depth, multiply the depth by 2 and then set the rod to that value.								
Measurement	Location Description (e.g., LDB, RDB, EEF, Left Channel LDB, Left Channel EEF, Left Channel RDB)	Distance (ft)	Depth (ft)	Velocity (ft/s) at X distance from bottom (or % from top)			Measurement Notes	
				0.2 (80%)	0.4 (60%)	0.8 (20%)		
1			0	0	0	0		
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
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14								
15								
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17								
18								
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22								
23								
24								
25								
26								
27								
28								
29								
30								
<b>Final Discharge Reading (cfs) =</b>								
Do you think that this flow measurement is comparable?				<input type="checkbox"/> Yes <input type="checkbox"/> No    If Not, Why?				
U.S.G.S. Gage Name:		U.S.G.S. Gage Number:		Gage Height or Control:				