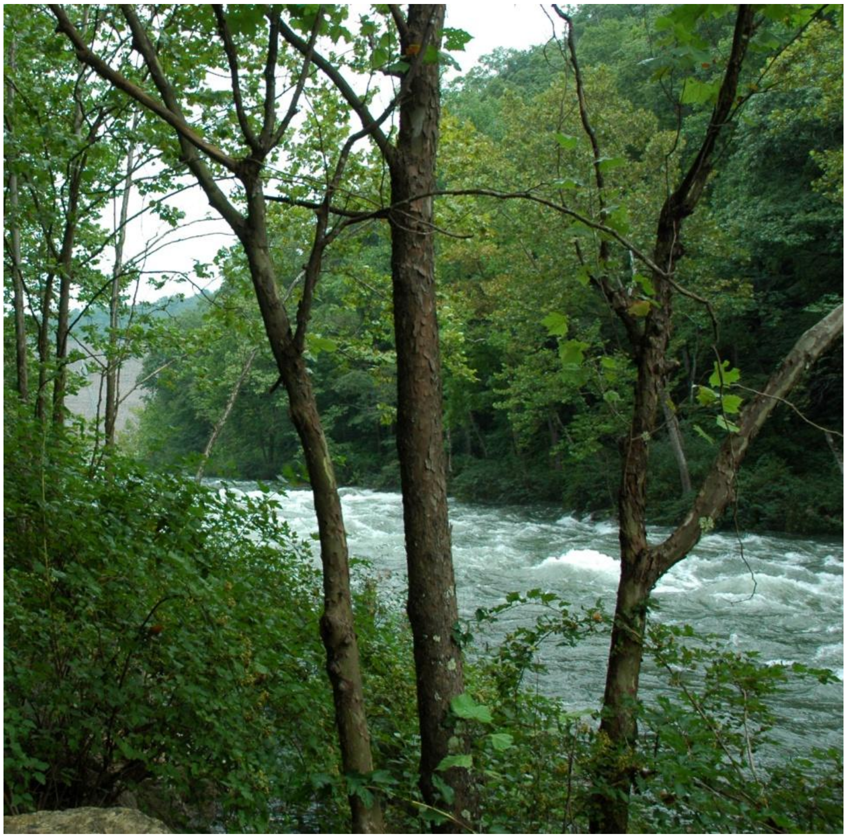
Characterization of Jackson River Base Flow and Pulse Flow Water Quality: 2011 and 2012



Water Quality Monitoring, Biological Monitoring and Water Quality Assessment Programs

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Executive Summary

The Virginia Department of Environmental Quality's (VDEQ) monitoring and assessment data (VDEQ 1996, VDEQ 2002, VDEQ 2004, VDEQ 2006, VDEQ 2008, VDEQ 2010) and Jackson River benthic Total Maximum Daily Load (TMDL) development (VDEQ 2010) has documented that low flow conditions in the fall represent the most stressed water quality conditions in the Jackson River. The Jackson River benthic TMDL study established nitrogen and phosphorous reduction targets in the Jackson River and called for restoring natural flow variability during the growing season (defined in the TMDL study as June 1st to October 31st). To assess flow variability impacts on water quality habitat and biology, VDEQ asked the U.S. Army Corps of Engineers (ACE) to perform a 216 study that could result in permanent flow modifications in the Jackson River. The 216 Study was later changed to the Gathright Dam Water Control Plan. As part of the study and later the plan, the ACE performed test pulses during the following dates: August 17, 2010, September 28, 2011, and October 3, 2012. In 2010 thru 2012, VDEQ collected an extensive suite of field data, water chemistry, habitat, and biological parameters in order to document baseline conditions and evaluate effects of the test pulses. This report expands on the data collection results presented in the *Characterization of 2010 Base Flow and Pulse Flow Water Quality in the Jackson River* report by documenting results from the 2011 and 2012 pulse events. VDEQ is committed to extensive water quality monitoring in the Jackson River throughout the development of the Water Control Plan project and during the implementation of the recommended hydrologic changes.

This year's report documents both baseline conditions and, where evident, the effects associated with modifying flows in the Jackson River. Temperature, dissolved oxygen, pH, and specific conductance in the Jackson River were not negatively impacted by the pulse events. In fact, dissolved oxygen improved significantly below Covington. As expected, total suspended solids and turbidity increased significantly during pulse events throughout the entire reach. It is expected that multiple pulse events over the entire growing season would result in more moderate solids levels because sediment would be flushed out on a regular basis. This occurrence would be noticeable at tributary outlets on the Jackson River where, without the pulse events, sediment tends to accumulate. Habitat in the Jackson River is considered optimal for benthic macroinvertebrate colonization and maintenance of populations with few sedimentation issues. Slight habitat improvements were documented for in-stream embeddedness, an important parameter for improving aquatic life in the Jackson River below Covington. It is evident that periphyton levels were reduced following the pulse events; however, re-growth rates were highly inconsistent based on a variety of factors. Fish and

benthic macroinvertebrate community structure was documented to ensure that the river above Covington tailwater maintains high biotic integrity and to establish a baseline to demonstrate improved biotic integrity below Covington. 2012 benthic macroinvertebrate data were not available at the time of this report but may begin to show the effects from the pulse events. Lake Moomaw thermocline remained intact during the summer pulse event. Metals data that were collected in 2011 showed all constituents meeting Virginia's Water Quality Standards.

Introduction

It is well documented from Virginia Department of Environmental Quality's monitoring data and assessment reports (VDEQ 1996, VDEQ 2002, VDEQ 2004, VDEQ 2006, VDEQ 2008, VDEQ 2010) and Jackson River benthic TMDL development (VDEQ 2010) that low flow conditions in the fall represent the most stressed water quality conditions in the Jackson River. The Jackson River benthic TMDL study established nitrogen and phosphorous reduction targets in the Jackson River and called for restoring natural flow variability to the Jackson River during the growing season defined in the TMDL study as June 1st to October 31st. The nutrient reductions and flow variability will result in improved benthic habitat and water chemistry in the Jackson River, which will result in improved aquatic life allowing VDEQ to eventually delist the Jackson River from the 303(d) impaired waters list. In order to assess flow variability impacts on water quality habitat and biology, VDEQ requested that the ACE perform a 216 study (which was later changed to a Water Control Plan) that could result in permanent flow modifications in the Jackson River. VDEQ supports the 216 study/Water Control Plan by monitoring habitat and water quality before, during and after test pulse events. The ACE performed test pulses on the following dates: August 17, 2010, September 28, 2011 and October 3, 2012. During the first test pulse, a storm event was mimicked for eight hours with flows reaching 3000 cubic feet per second (cfs) for two hours. Subsequent pulse events resulted in flows of 3500 cfs at Gathright Dam. The 2011 and 2012 pulse event data and preliminary conclusions are presented in this report. The water quality data from the 2010 event is summarized in a separate report, which can be found on VDEQ's website at: http://www.deq.state.va.us/Portals/0/DEQ/Water/jacksonpulse2010final.pdf.

VDEQ designed a special study to document current water quality, habitat, and biological conditions in the Jackson River from Gathright Dam to the head of the James River. This monitoring plan is detailed in a Quality Assurance Project Plan for the Jackson River Watershed Special Study (VDEQ 2009). Station locations and data collection activities that VDEQ performed throughout the year are found in Tables 1 and 2. A map of the station locations is found in Figure 1. Data collection activities related to before, during and after the pulse event are summarized in Tables 3, 4, 5 and 6.

Baseline conditions and preliminary conclusions are discussed in the sections that follow. Field data, flow information, solids data, nutrient data, dissolved metals data and lake profiles are presented in the first section, *Water Chemistry Data Results.* Habitat data is presented in the second section entitled *Habitat Data Results.* The *Biological Data* section encompasses benthic algae data, benthic macroinvertebrate community data and fish community data. Finally, the *Summary and Conclusions* section includes a summary of all of the data presented in this report and observations based on this data. VDEQ continues to collect water quality information on the Jackson River and will continue to publish updated reports as needed.

Table 1. Monitoring Station ID with location description.

Station Number*	Station ID	Location Description
1	2-JKS044.10	Jackson River below Gathright Dam at gage
2	2-JKS030.65	Jackson River at Rt. 687 Bridge – Clearwater Park
3	2-JKS026.01	Jackson River at Covington Water Filtration Plant
--	2-JKS023.61	Jackson River at City Park – Covington at gage
4	2-JKS018.68	Jackson River at Rt. 18 Bridge at Covington
5	2-JKS013.29	Jackson River off Rt. 696 above Low Moor
6	2-JKS006.67	Jackson River at low water bridge near Dabney Lancaster Community College
7	2-JKS000.38	Jackson River at Iron Gate
8	2-JMS345.73	James River at Rt. 220; first bridge below confluence with Cowpasture R.
9	2-JMS309.13	James River at Rt. 11 bridge, Buchanan
10	2-JMS282.28	James River at Rt. 501 bridge SE of Glasgow
11	2-JMS275.75	James River below Big Island

*Corresponds to Field Data Figures.

Table 2. Station ID with monitoring activities throughout the year.

Station ID	Fish Community Data (Annual)	Benthic Algae (Semi-Annual)	Macroinvertebrate Biomonitoring (Annual)	Dissolved Metals (Semi-Annual)	Solids (Bi-Monthly)	Nutrients (Bi-Monthly)
2-JKS044.10		X		X	X	X
2-JKS030.65	X	X	X	X	X	X
2-JKS023.61	X	X	X	X	X	X
2-JKS018.68	X	X	X	X	X	X
2-JKS013.29		X	X	X	X	X
2-JKS006.67	X	X	X	X	X	X

Figure 1. Map of Jackson River Monitoring station locations

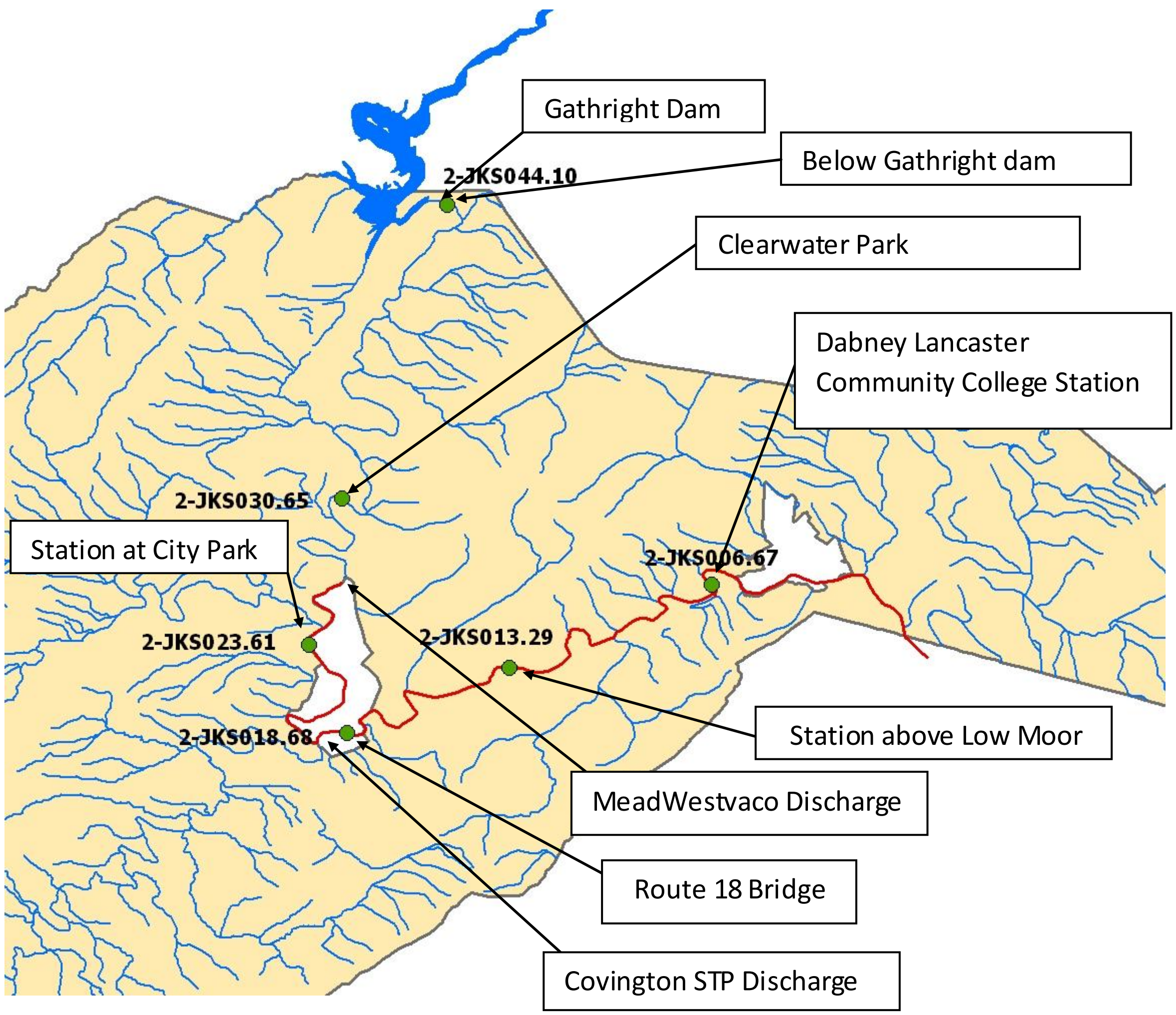


Table 3. Data collection activities on September 27, 2011 and October 2, 2012 (day before the pulse).

Station IDs	Data Collection Activity
2-JKS030.65, 2-JKS023.61	Deployed water quality sondes to collect field data (Dissolved Oxygen, pH, Temperature, and Specific Conductivity) for 3 days
2-JKS026.01, 2-JKS023.61, 2-JKS018.68, 2-JKS013.29, 2-JKS006.67	Collected Benthic Chlorophyll A and Ash Free Dry Mass to document pre-pulse conditions
2-JKS044.10, 2-JKS030.65, 2-JKS023.61, 2-JKS018.68, 2-JKS013.29, 2-JKS006.67	Collected Dissolved Metals to document pre-pulse metal levels (2011 only)
2-JKS044.10, 2-JKS030.65, 2-JKS023.61, 2-JKS018.68, 2-JKS013.29, 2-JKS006.67	Performed RBP Habitat Survey
ACE stations in Lake Moomaw	ACE monitoring team collected dissolved oxygen and temperature profile data

Table 4. Data collection activities on September 28, 2011 and October 3, 2012 (day of pulse).

Station IDs	Data Collection Activity
2-JKS044.10, 2-JKS030.65, 2-JKS023.61, 2-JKS018.68, 2-JKS013.29, 2-JKS006.67	Collected dissolved metals to document metal levels during pulse events (2011 only)
2-JKS044.10, 2-JKS030.65, 2-JKS023.61, 2-JKS018.68, 2-JKS013.29, 2-JKS006.67	Collected water chemistry parameters and field data which includes solids and nutrient parameters to document nutrient and solids conditions during pulse event
ACE stations in Lake Moomaw	ACE monitoring team collected dissolved oxygen and temperature profile data

Table 5. Data collection activities on September 29, 2011 and October 4, 2012 (day after pulse).

Station IDs	Data Collection Activity
2-JKS030.65, 2-JKS023.61	Pull deployed water quality sondes
2-JKS023.61, 2-JKS018.68, 2-JKS013.29, 2-JKS006.67	Collected Benthic Chlorophyll A and Ash Free Dry Mass to document post-pulse conditions
2-JKS044.10, 2-JKS030.65, 2-JKS023.61, 2-JKS018.68, 2-JKS013.29, 2-JKS006.67	Performed RBP Habitat Survey
ACE stations in Lake Moomaw	ACE monitoring team collected dissolved oxygen and temperature profile data

Table 6. Data collection activities on October 5, 2011, October 19, 2011, October 11, 2012 and October 25, 2012.

Station IDs	Data Collection Activity
2-JKS023.61, 2-JKS13.29	Collected Benthic Chlorophyll A and Ash Free Dry Mass to evaluate re-growth rates

Water Chemistry Data Results

Real-Time Field and Flow Data

Real-time field data were collected using YSI multiprobe sondes. The station numbers on the following Figures correspond to Table 1. Temperatures at City Park were several degrees higher than Clearwater Park while dissolved oxygen levels at City Park were significantly lower than Clearwater Park. The real-time dissolved oxygen level collections show a drop of 0.5 mg/L at Clearwater Park for 30 minutes and a drop of 1.5 mg/L at City Park for 30 minutes before the pulse increases the oxygen levels. Specific conductivity readings in the Jackson River at City Park during the low flow months are above the normal ranges seen in Virginia. Normal ranges in Virginia are typically below 400 µS/cm. pH appeared normal and followed expected seasonal patterns. These changes in field parameters below the paper mill are not unusual and well-documented in VDEQ water quality collections.

Figures 2 to 9 show temperature, pH, dissolved oxygen, and specific conductivity readings that were recorded every 15 minutes at Clearwater Park and City Park. These data were collected from August 16th to August 18th in 2010, September 27th to September 29th in 2011, and October 2nd to October 4th in 2012. The time period that indicated peak pulse flow influence is illustrated on the graphs. In general, the pulse decreased temperatures, increased oxygen levels, and reduced specific conductivity. The 2010 dissolved oxygen and pH data at City Park failed the Quality Assurance/Quality Control (QA/QC) post-check and is not reported.

Real-time flow is provided from six USGS stream gages (02011800 Jackson River below Gathright Dam, 02012500 Jackson River at Falling Springs, 02013100 Jackson River at Covington, 02016500 James River at Lick Run, 02019500 James River in Buchanan, and 02025500 James River at Holcomb Rock). 2012 flow data in this report is considered provisional by the USGS. The hydrograph of the pulse (which was intended to mimic a storm event) is seen in Figures 10 to 13. Figure 10 illustrates individual pulse stages, figure 11 displays references pulse stages, figure 12 presents individual pulse flows, and figure 13 shows referenced pulse flows.

Figure 2. Clearwater Park (2-JKS030.65) Temperature (^{o}C) data.

Figure 3. City Park (2-JKS023.61) Temperature (^{o}C) data.

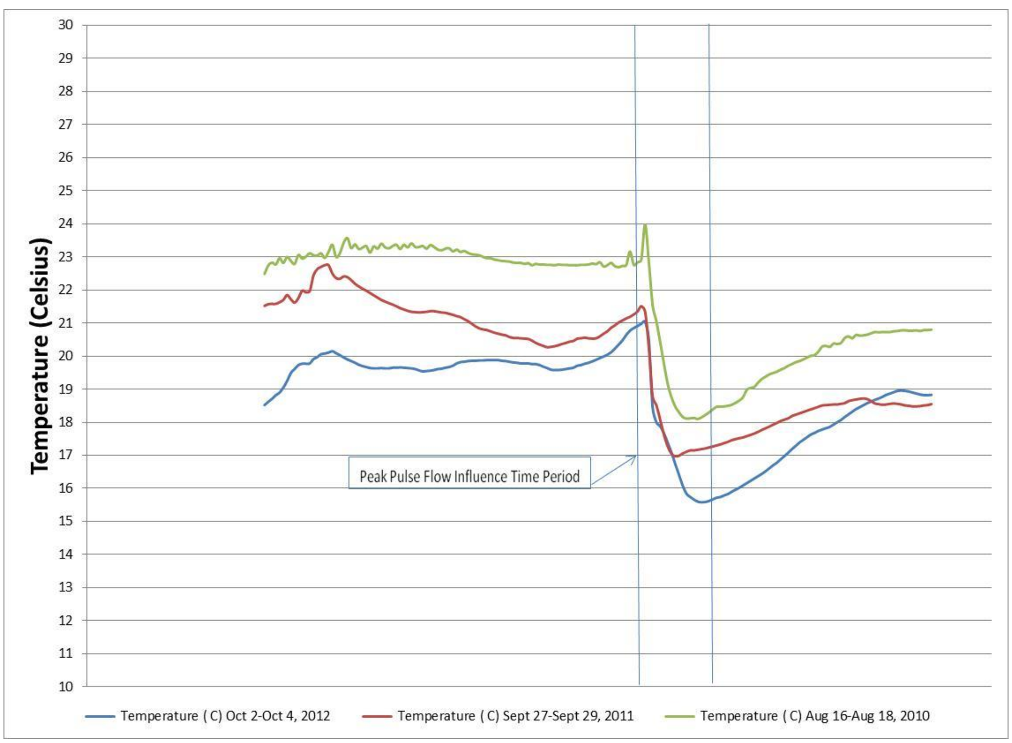


Figure 4. Clearwater Park (2-JKS030.65) pH data.

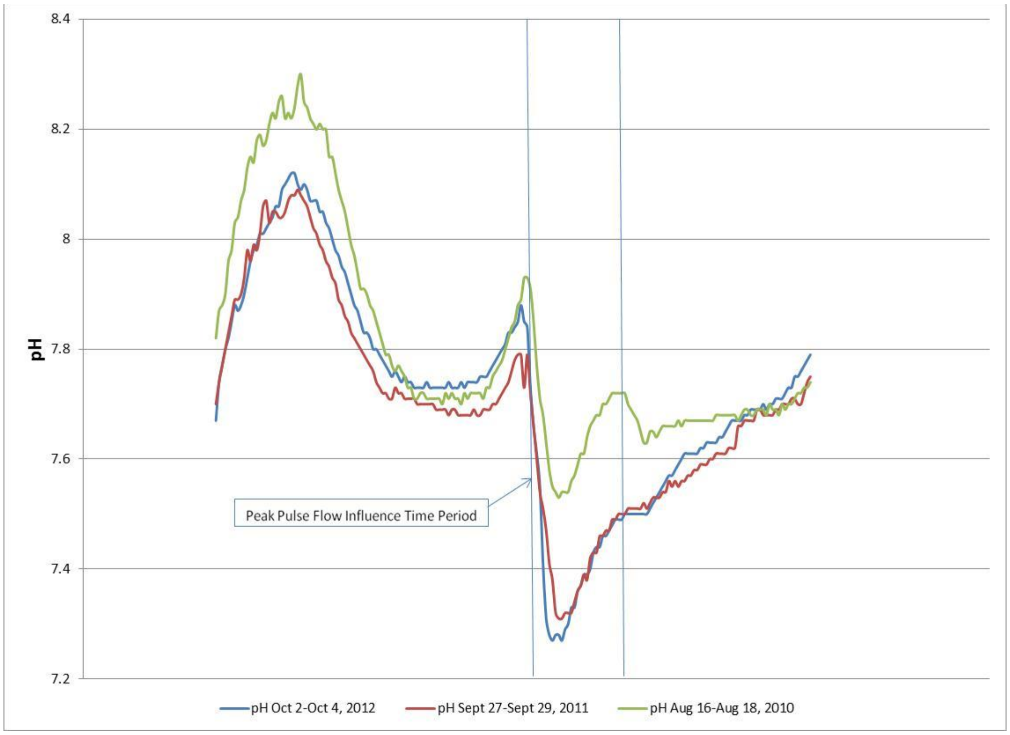


Figure 5. City Park (2-JKS023.61) pH data.

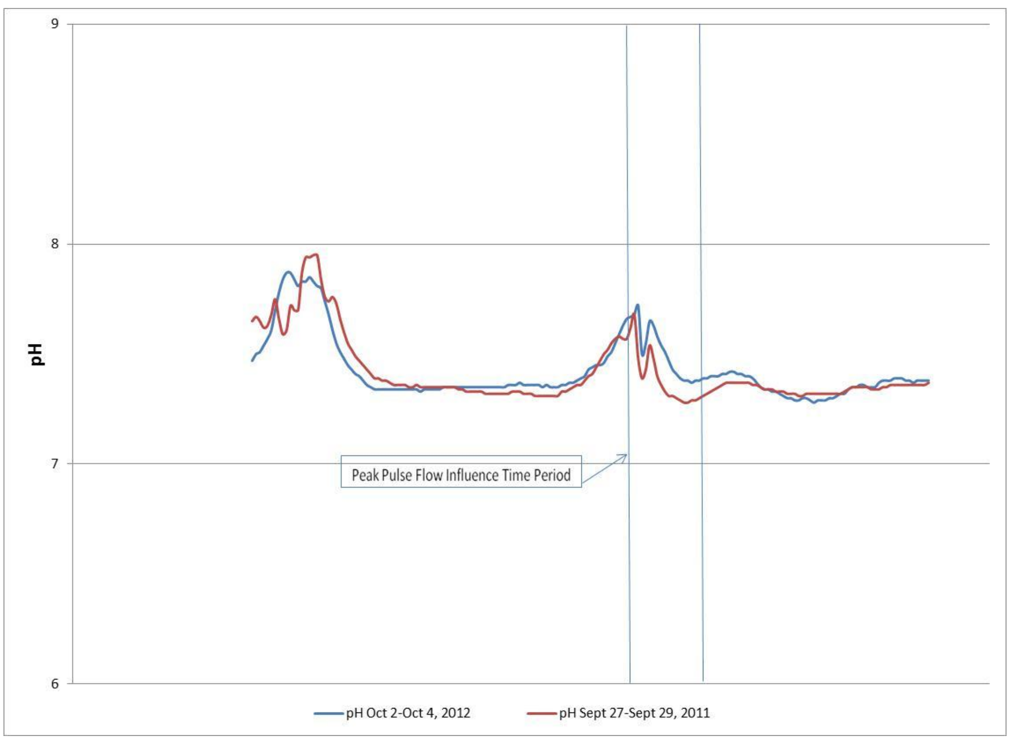


Figure 6. Clearwater Park (2-JKS030.65) Dissolved Oxygen (mg/L) data.

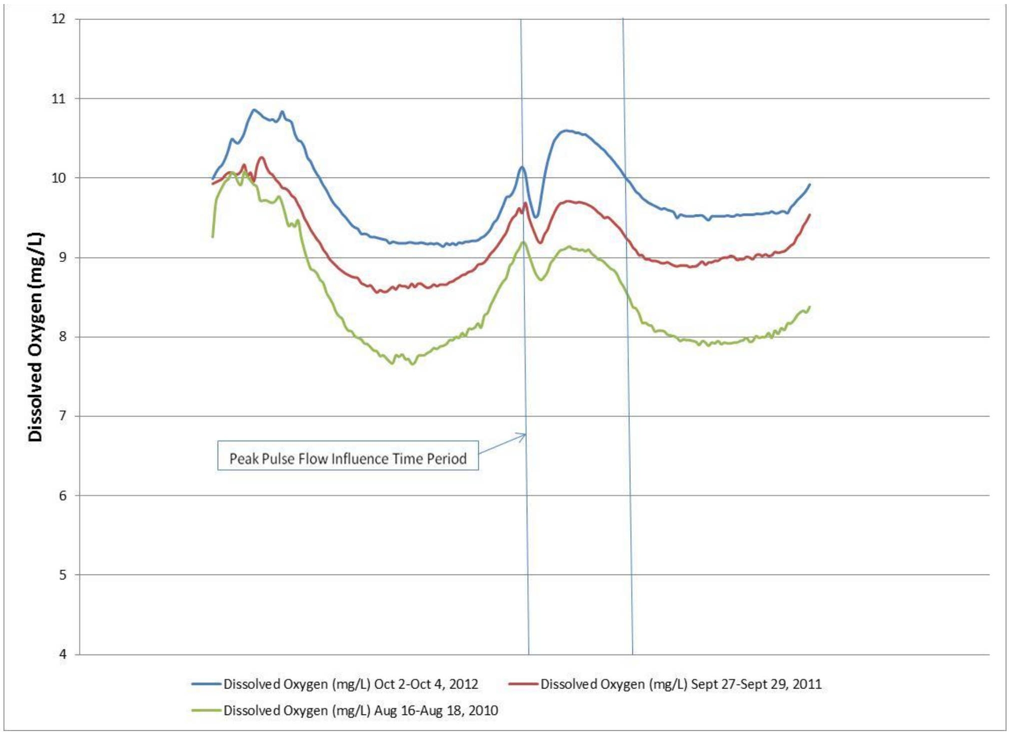


Figure 7. City Park (2-JKS023.61) Dissolved Oxygen (mg/L) data.

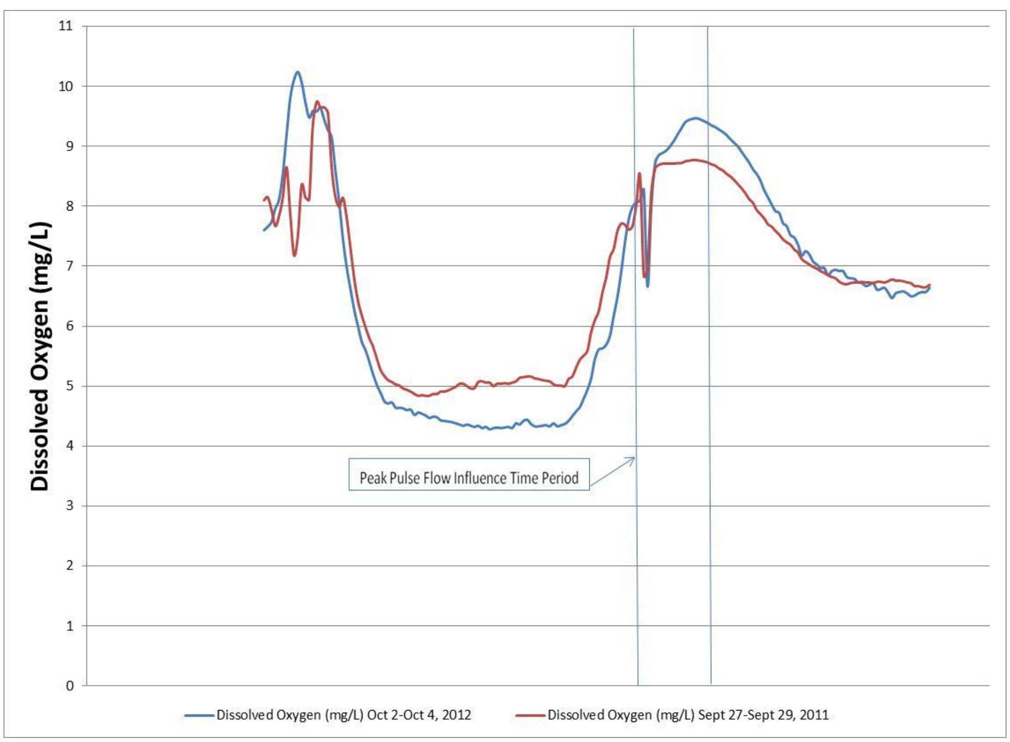


Figure 8. Clearwater Park (2-JKS030.65) Specific Conductivity (µS/cm) data.

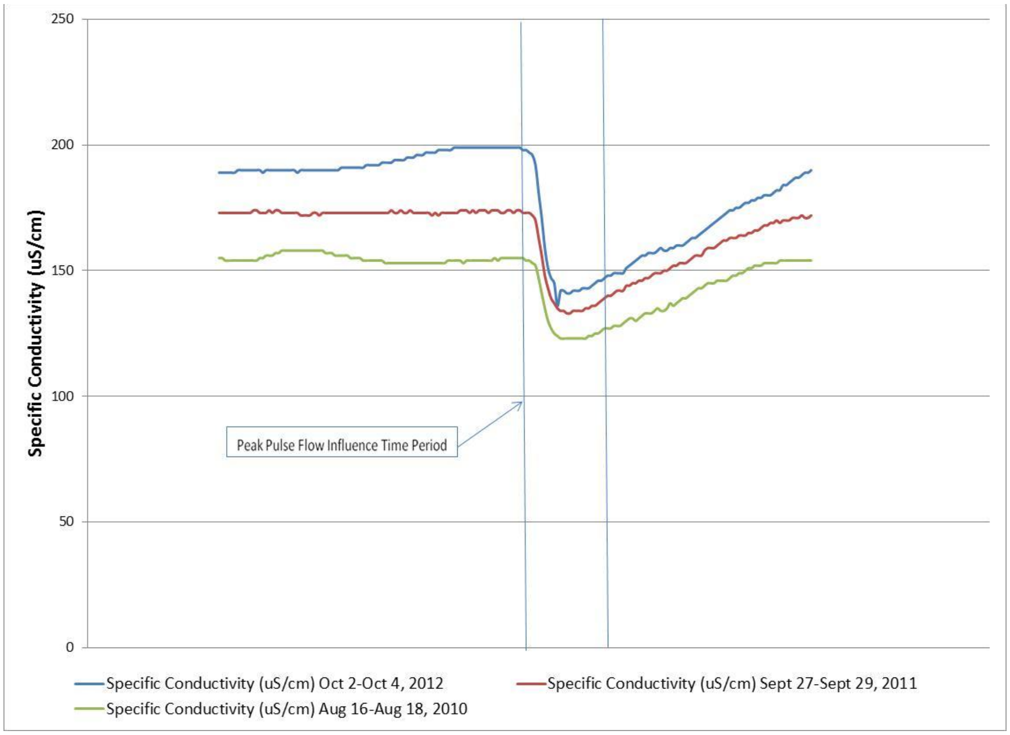


Figure 9. City Park (2-JKS023.61) Specific Conductivity (µS/cm) data.

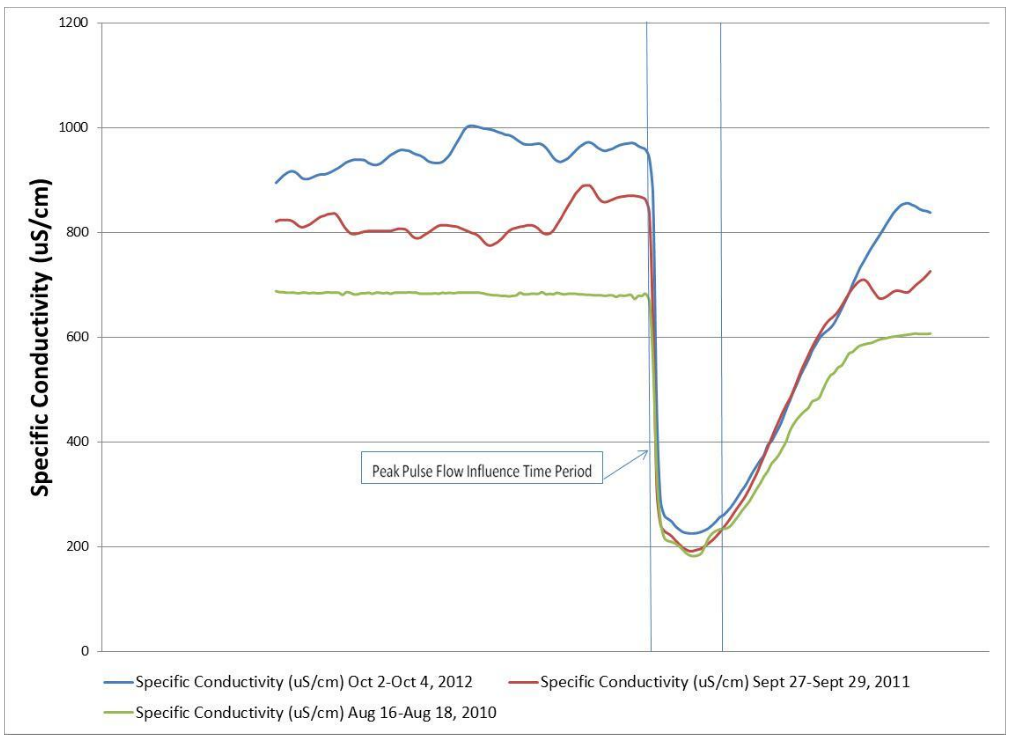
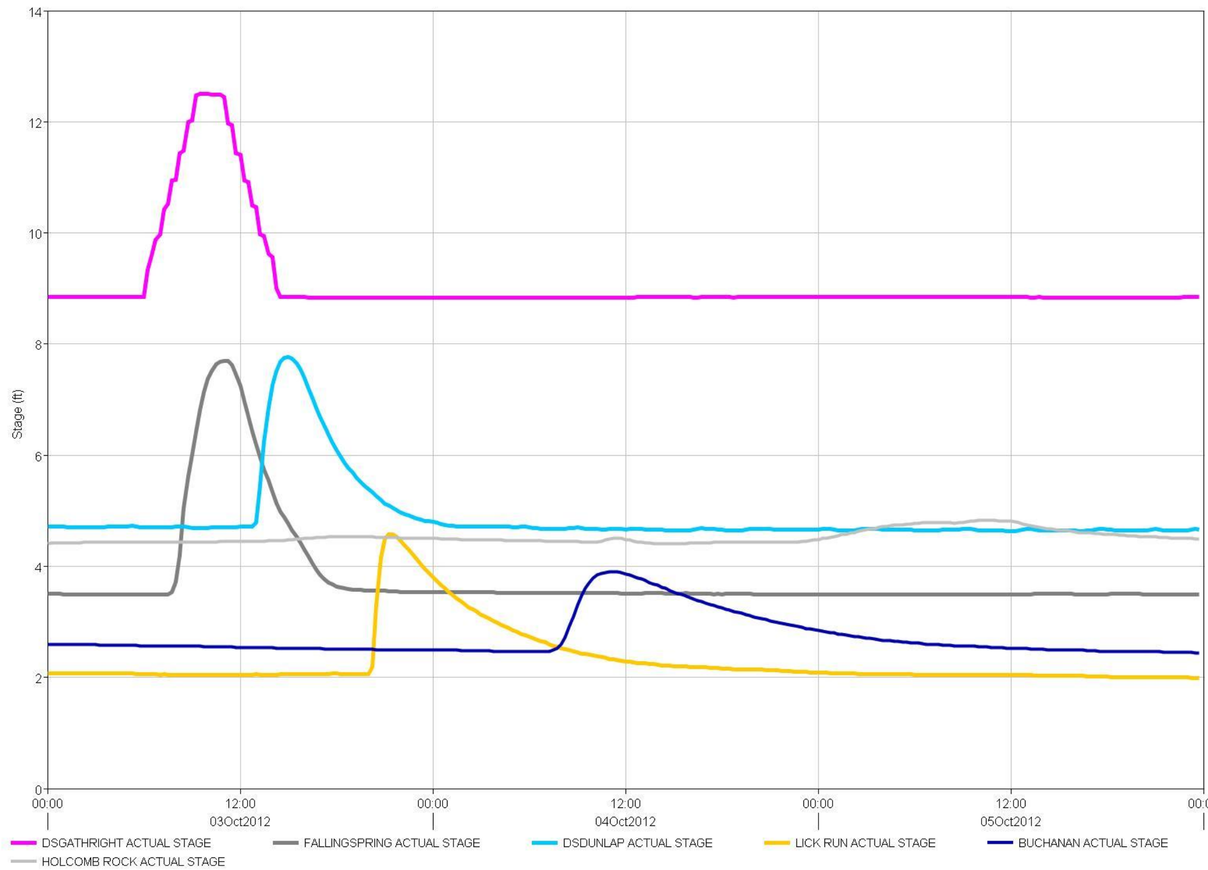
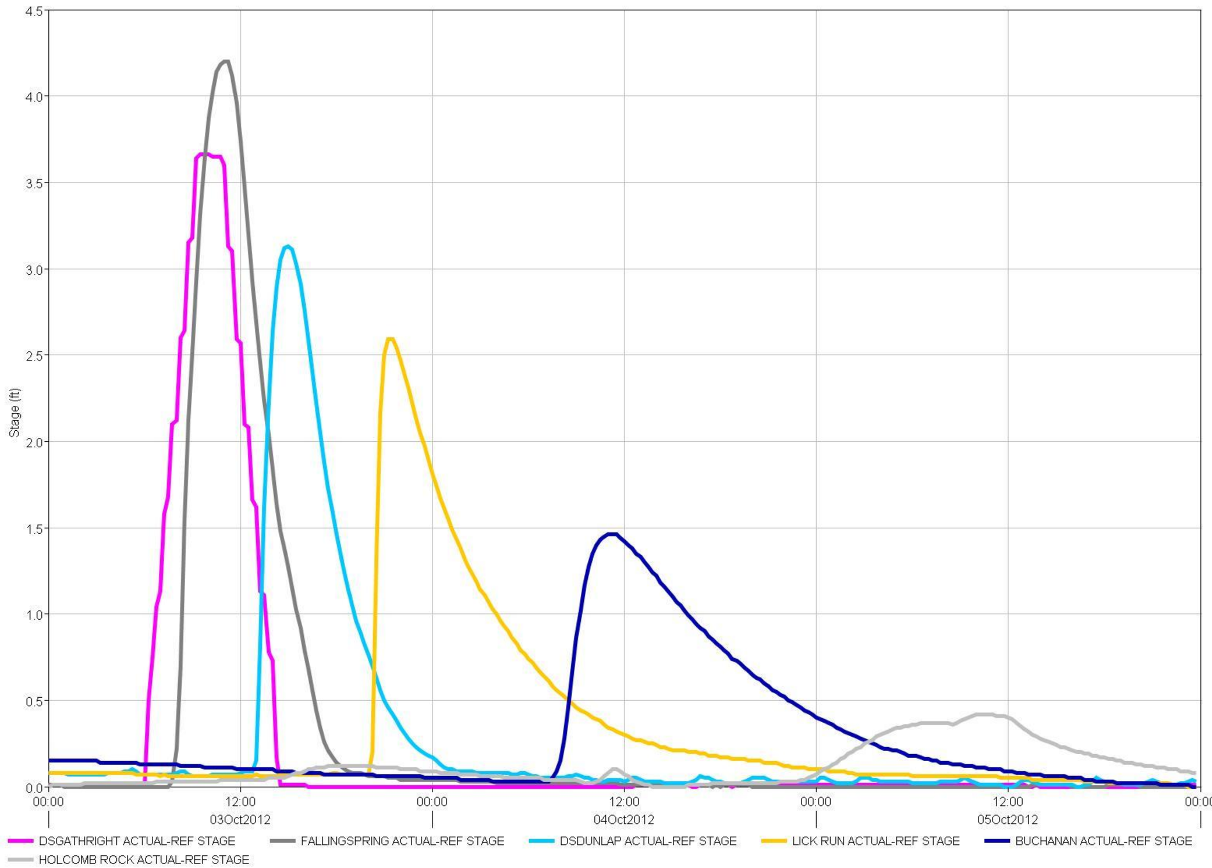


Figure 10. October 2012 Pulse stages (from USGS provisional data).



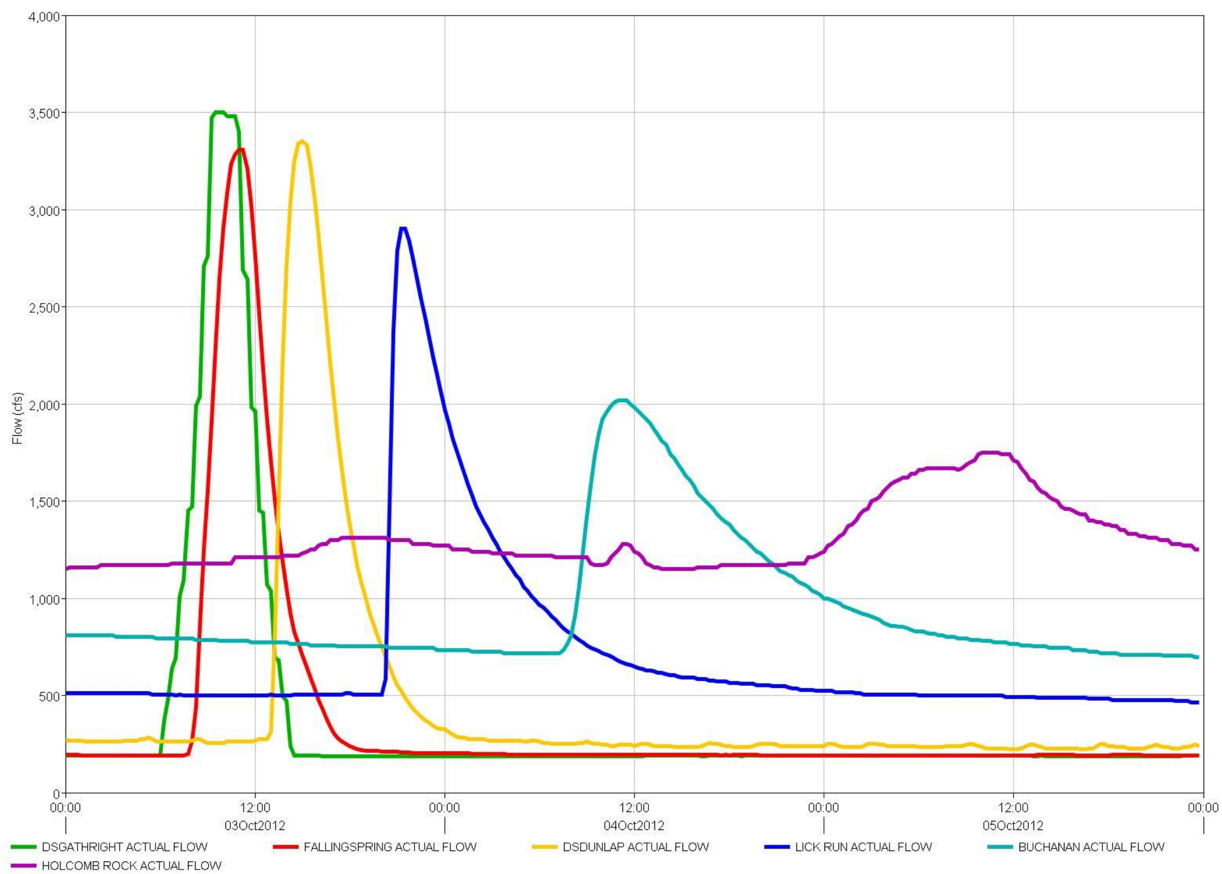
The pink line on the graph illustrates the stage height on the Jackson River at Gathright dam. The dark grey line shows the stage height on the Jackson River at Falling Springs. The light blue line shows the stage height on the Jackson River at City Park. The yellow line depicts the stage height at the James River at Lick Run. The dark blue line displays the stage height on the James River in Buchanan. The light grey line graphs the stage height on the James River at Holcomb Rock (note the diminished impact of the pulse on stage height).

Figure 11. October 2012 Pulse stages referenced in feet (from USGS provisional data).



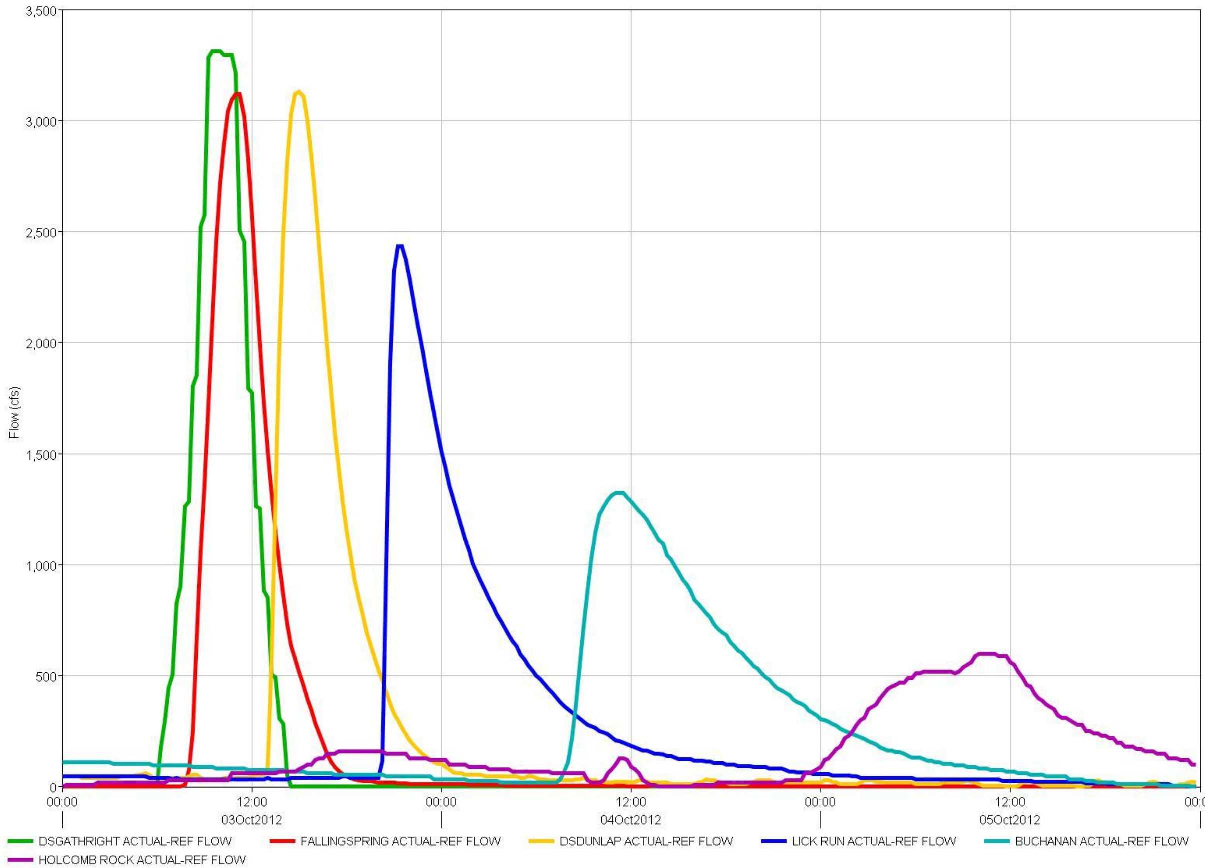
The pink line on the graph illustrates the stage height on the Jackson River at Gathright dam. The dark grey line shows the stage height on the Jackson River at Falling Springs. The light blue line shows the stage height on the Jackson River at City Park. The yellow line depicts the stage height at the James River at Lick Run. The dark blue line displays the stage height on the James River in Buchanan. The light grey line graphs the stage height on the James River at Holcomb Rock. This graph depicts each gage on the same scale in order to highlight the relative differences in pulse event stream height on the Jackson and James Rivers. For example, the Jackson River increased over 3.5 feet in height below the Gathright Dam, while the James River only increased 1.5 feet in Buchanan.

Figure 12. October 2012 Pulse flows in cfs (from USGS provisional data).



The green line on the graph illustrates the flow in cubic feet per second (cfs) on the Jackson River at Gathright dam. The red line shows the flow on the Jackson River at Falling Springs. The yellow line shows the flow on the Jackson River at City Park. The dark blue line depicts the flow at the James River at Lick Run. The light blue line displays the flow on the James River in Buchanan. The purple line graphs the flow on the James River at Holcomb Rock.

Figure 13. October 2012 Pulse flows referenced in cfs (from USGS provisional data).



The green line on the graph illustrates the flow in cubic feet per second (cfs) on the Jackson River at Gathright dam. The red line shows the flow on the Jackson River at Falling Springs. The yellow line shows the flow on the Jackson River at City Park. The dark blue line depicts the flow at the James River at Lick Run. The light blue line displays the flow on the James River in Buchanan. The purple line graphs the flow on the James River at Holcomb Rock. This graph has been scaled to show relative differences in flow that the pulse event had on the Jackson and James River. For example, the Jackson River increased to nearly 3500 cfs below the Gathright Dam, while the James River only increased over 1000 cfs in Buchanan.

Field Data

Field data were collected using an YSI multiprobe sonde. For the most part temperature, pH, and dissolved oxygen appeared normal and followed expected seasonal patterns on the Jackson River. One exception is the specific conductivity readings in Figure 17 for the month of February, VDEQ collected several high values, and the specific conductivity is usually lower during the winter months. Only 2011 river profiles are included in this report.

Figure 14. 2011 Temperature (^{o}C) data.

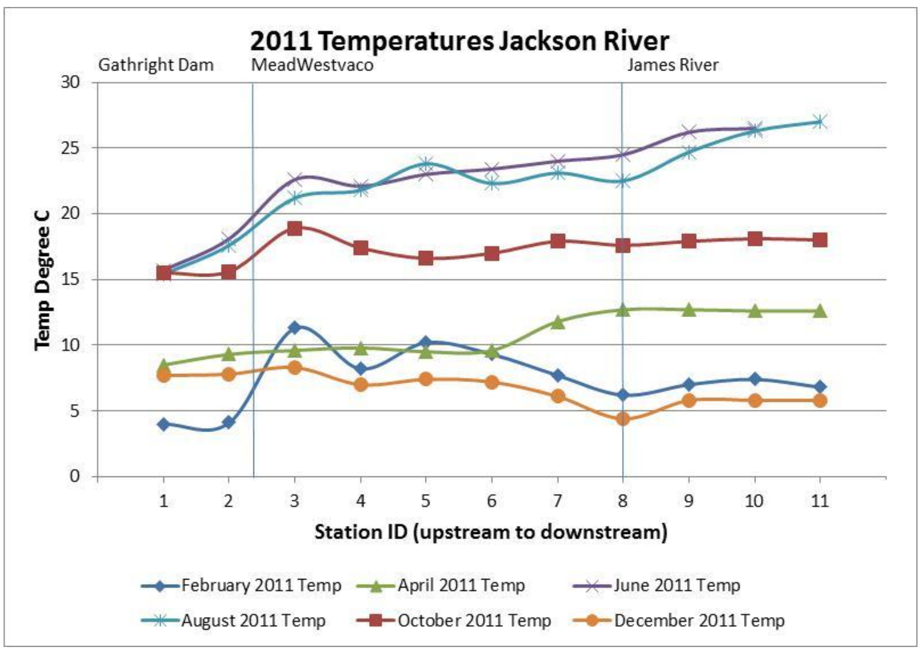


Figure 15. 2011 Dissolved oxygen (mg/L) data.

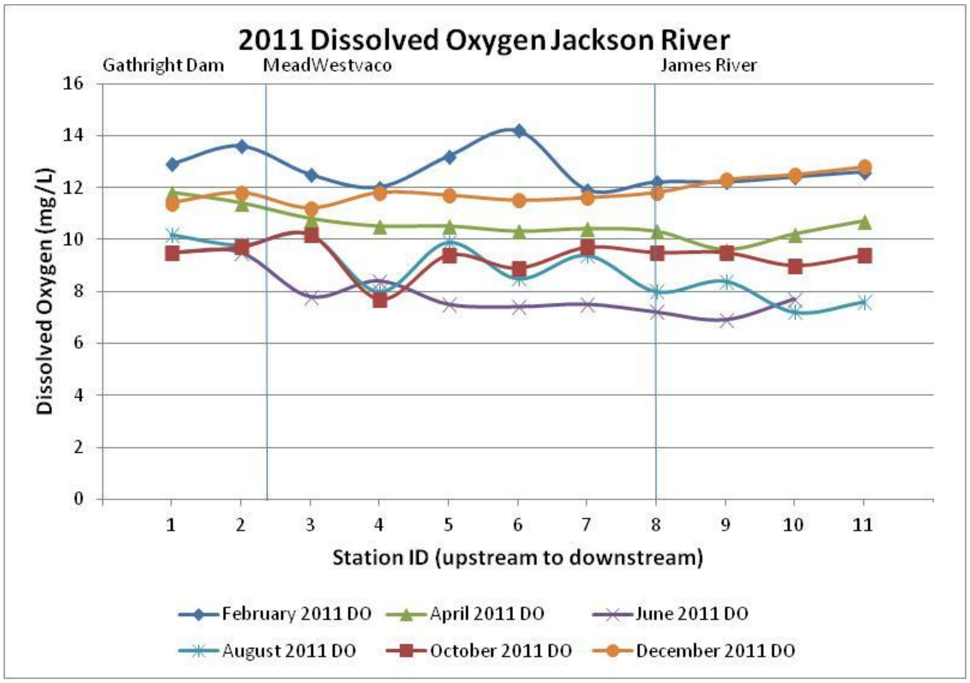


Figure 16. 2011 pH data.

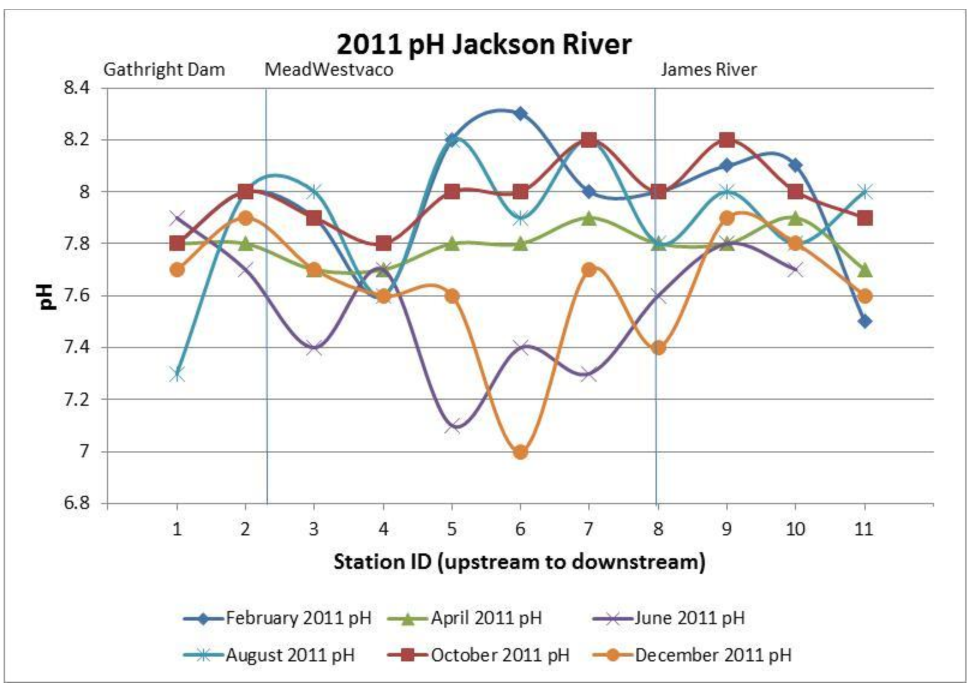
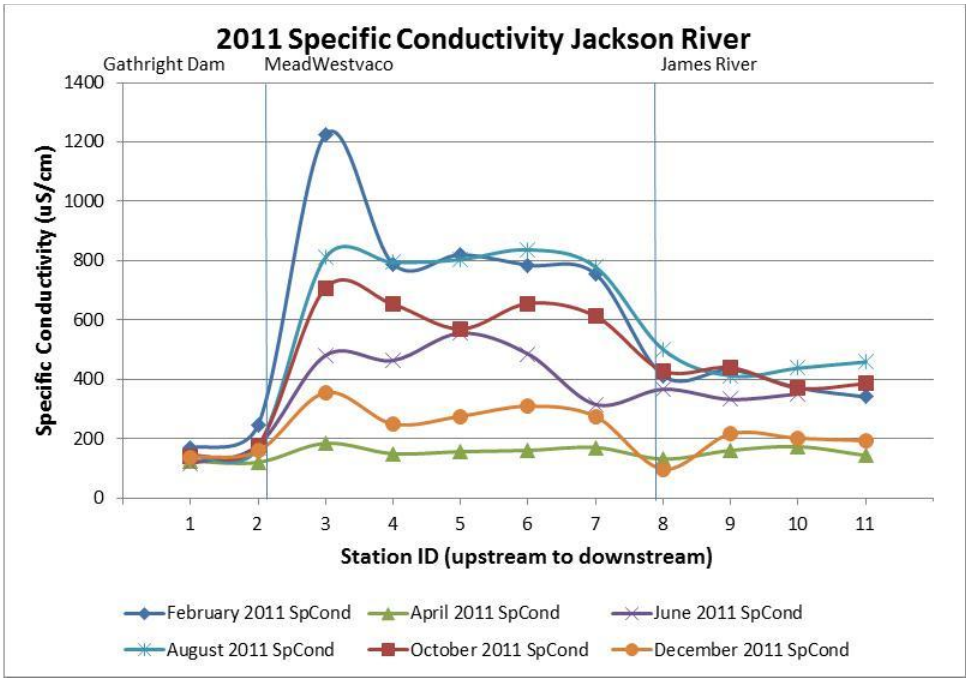


Figure 17. 2011 Specific conductivity (μS/cm) data.



Solids Data

Total solids increased in concentration significantly below the MeadWestvaco discharge. Total suspended solids (TSS) and turbidity measure the amount of particles suspended in the water column. In a controlled river system like the Jackson River, the effect of storm pulse flows are muted by the dam, thus increases in TSS and turbidity are not typically observed. The pulse event mimicked a storm event and a significant increase in TSS and turbidity was observed throughout the entire reach except directly below the dam. TSS and turbidity were very low below the dam (see cover photo). Below the dam, very little sediment builds up as no tributaries deposit sediment into the reach. If pulse events were a regular occurrence in the Jackson River, sediment transport from tributaries would occur more frequently. Presumably the TSS and turbidity increases would not be as dramatic as those observed during the September 2011 pulse event when several months of sediment deposition were moved through the river. The same solids pattern was observed in the 2010 pulse event. Only 2011 river profiles are presented in this report.

Figure 18. 2011 Total Solids (mg/L) data.

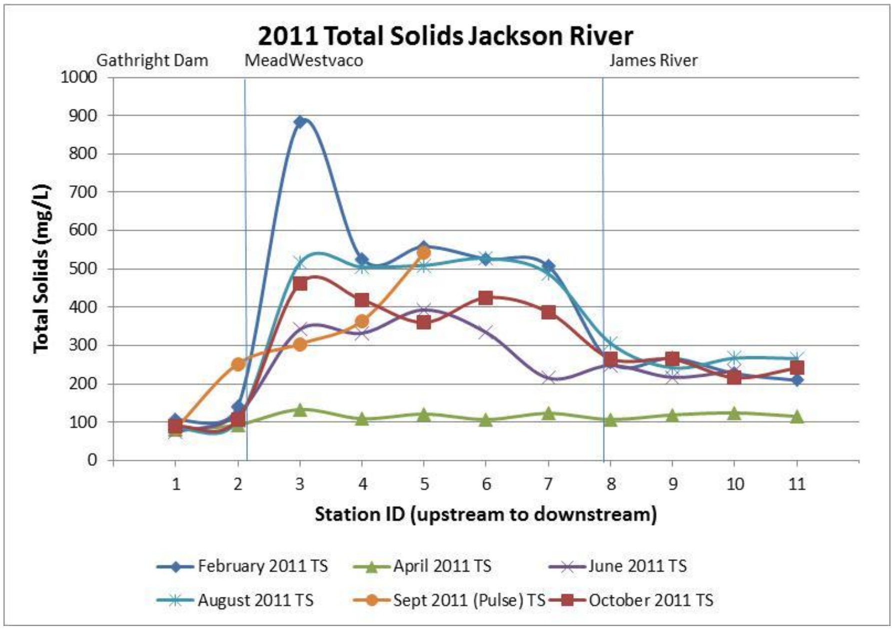


Figure 19. 2011 Total Suspended Solids (mg/L) data.

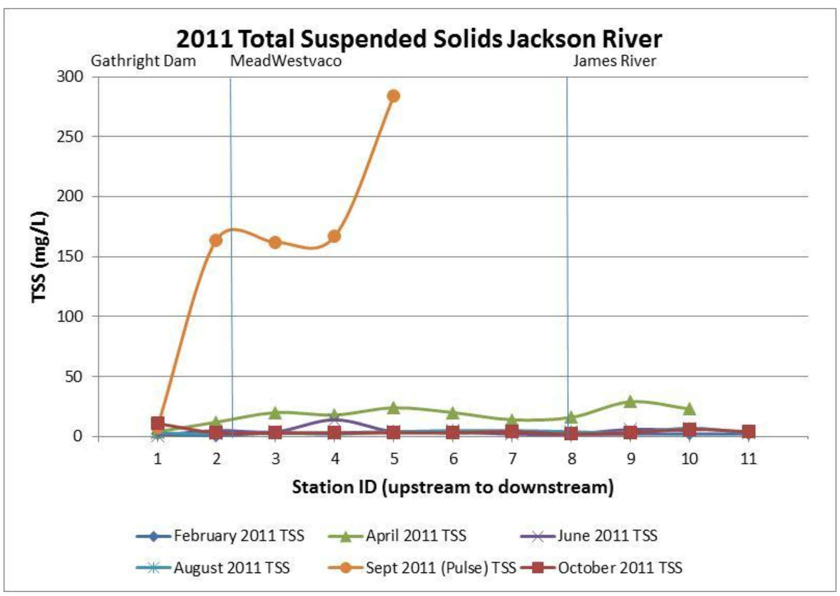


Figure 20. 2011 Total Dissolved Solids (mg/L) data.

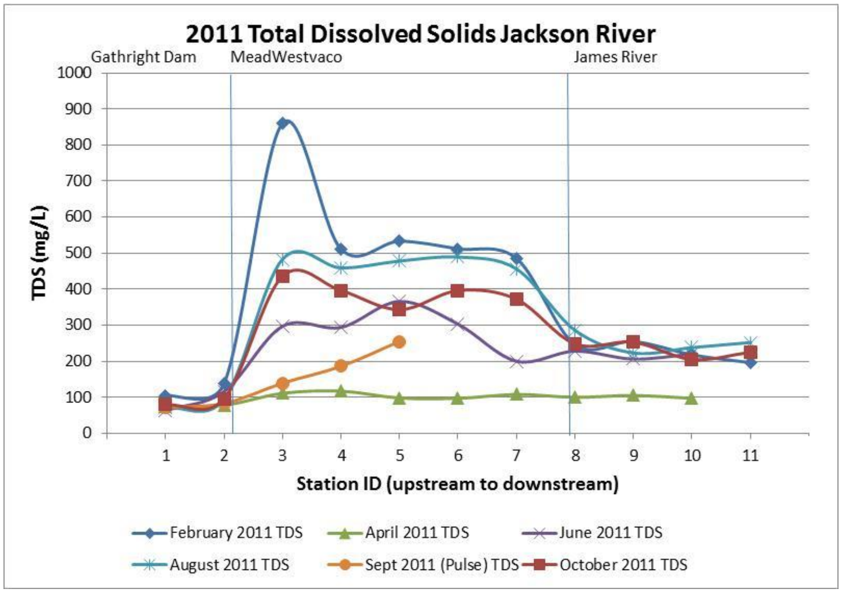
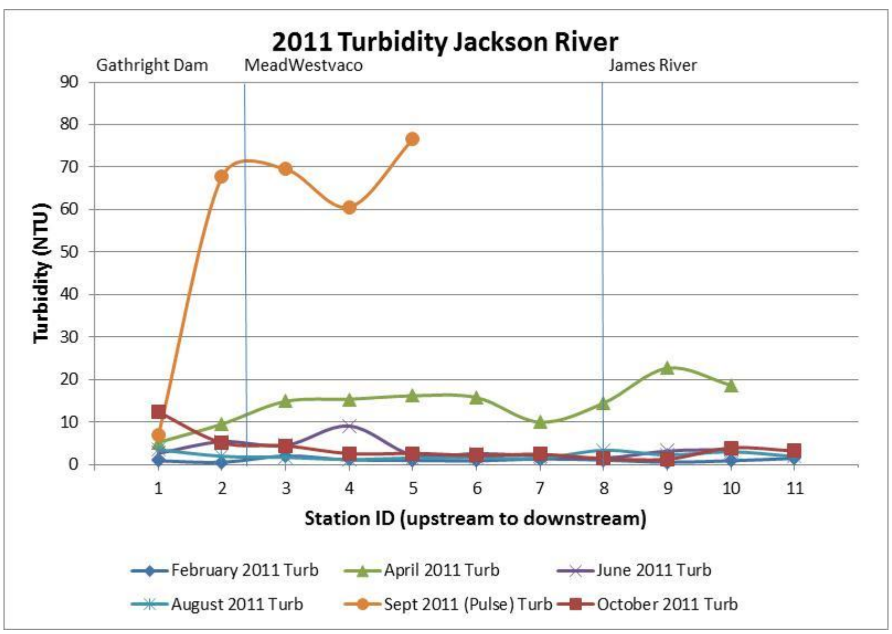


Figure 21. 2011 Turbidity (NTU) data.



Nutrient Data

The Jackson River Benthic TMDL found excessive nutrient loads are causing increased benthic algal growth. Excessive biomass from nutrients is the most probable stressor to the aquatic community. In general, nutrient concentration increases were observed below the MeadWestvaco Mill discharge and remain elevated downstream to the Route 18 Bridge where the Covington Sewage Treatment Plant enters just above of the bridge (Figure 1). Gradually nutrient levels decrease and benthic algae growth returns to a more normal level and around Dabney Lancaster Community College, aquatic communities improve significantly (see Benthic Macroinvertebrate section, Figure 52).

More recent total phosphorus levels were comparable to the 2010 results; however the composition of the phosphorus was different. In 2010, ortho-phosphorus (biologically available phosphorus) made up 80% of total phosphorus. The 2011 data shows that ortho-phosphorus was much lower making up only 10% of total phosphorus. Lower ortho-phosphorus levels in the Jackson, combined with hydrologic change should lead to lower biomass during the warmer months of the year. A high level of phosphorus was observed in the James River near Buchanan, Virginia but it appears to be an isolated event.

Nitrogen levels were similar in 2011 to the previous year of monitoring. The bioavailable nitrate-nitrogen is found within normal ranges, ammonia-nitrogen is low (higher levels were observed in October 2011, but were below the water quality standard and were atypical compared to normal Jackson River conditions). Organic nitrogen, Total Kjeldahl Nitrogen (TKN), makes up most of the nitrogen in the Jackson River and typically is found at normal levels. Total nitrogen and phosphorus are found at higher levels during the pulse than at base flow. Only 2011 river profiles are presented in this report.

Figure 22. 2011 Total Nitrogen (mg/L) data.

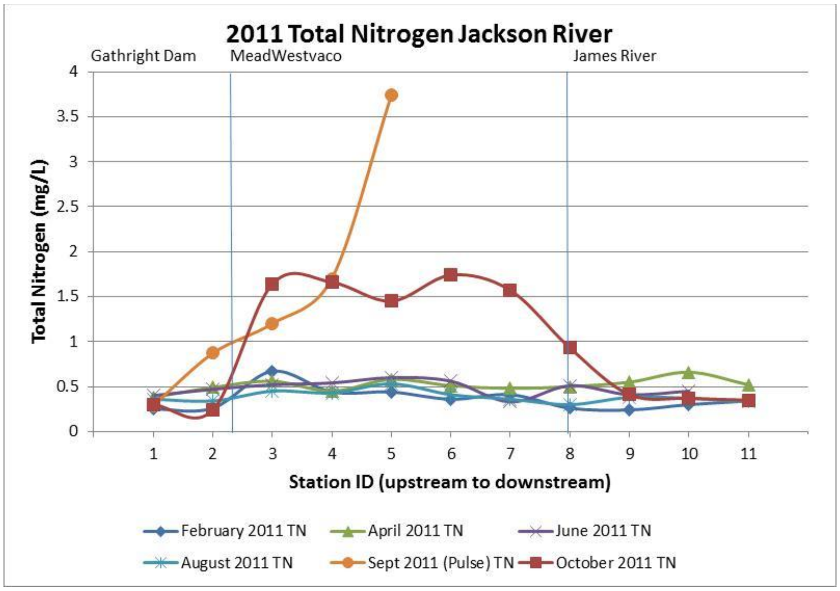


Figure 23. 2011 Total Kjeldahl Nitrogen (mg/L) data.

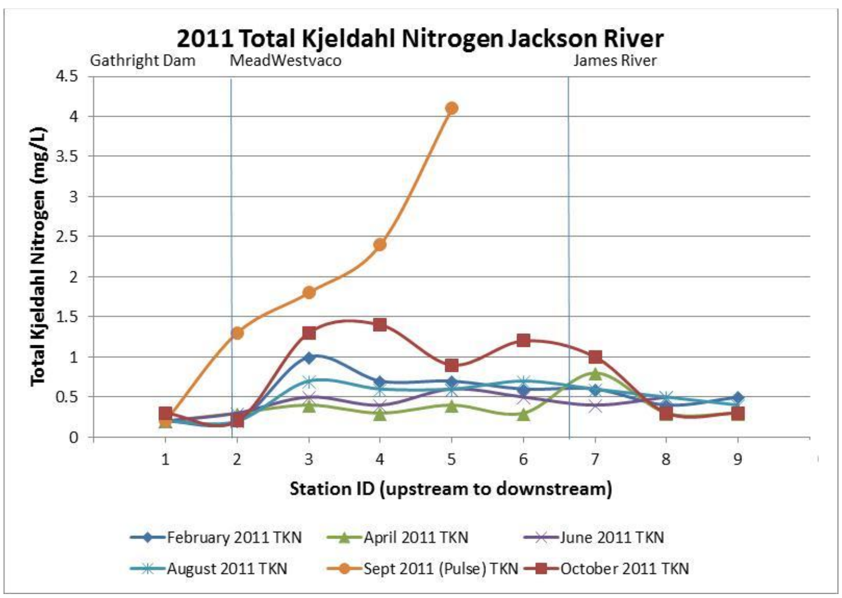


Figure 24. 2011 Nitrate-Nitrogen (mg/L) data.

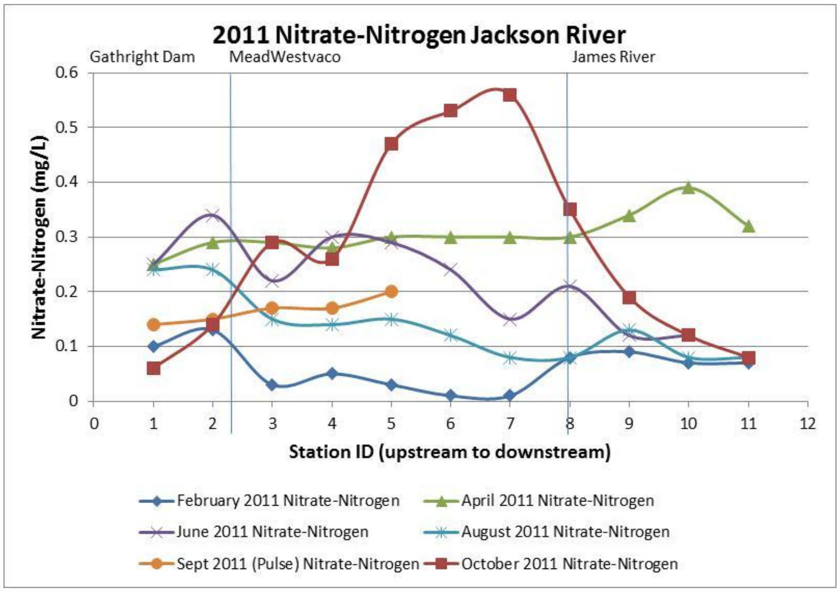


Figure 25. 2011 Ammonia (mg/L) data.

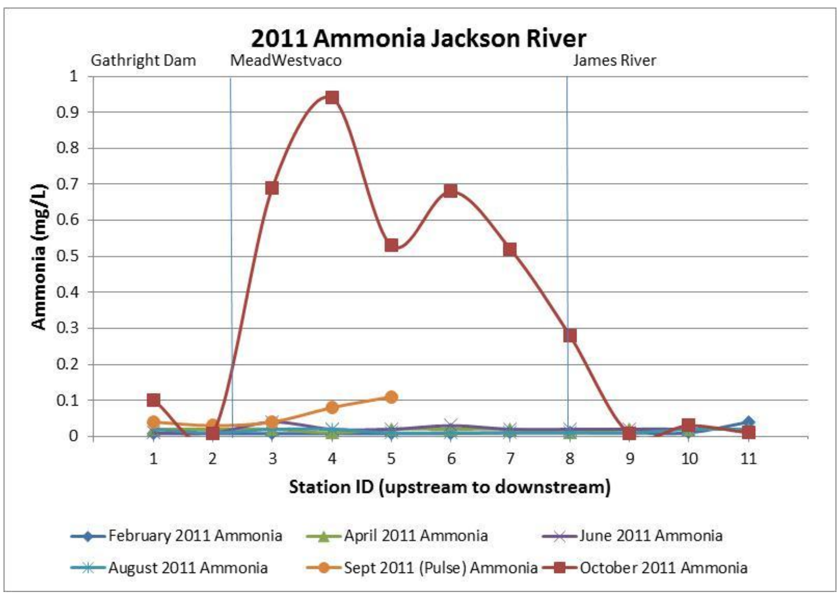


Figure 26. 2011 Total Phosphorus (mg/L) data.

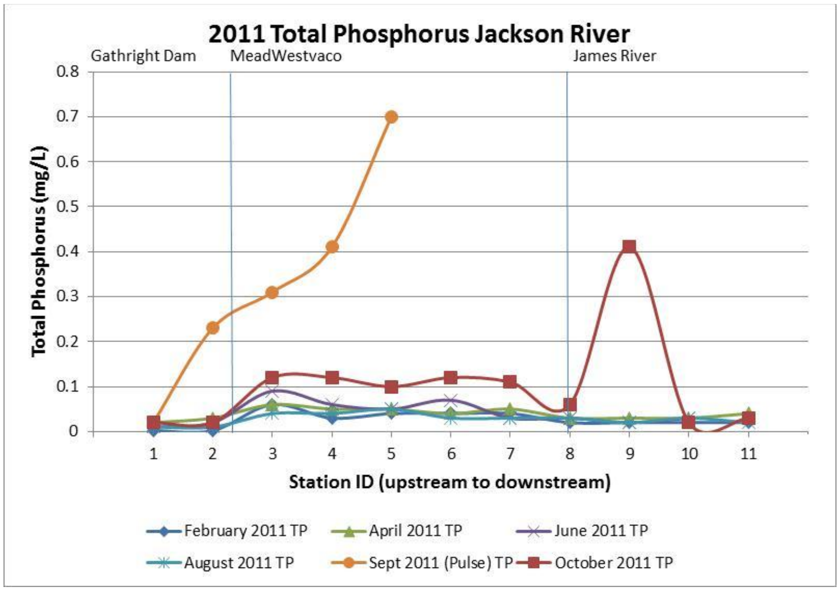
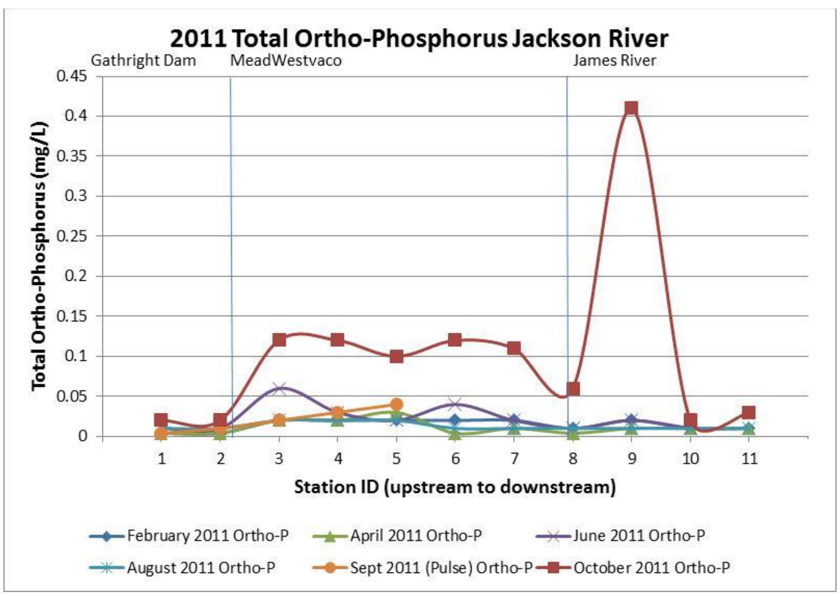


Figure 27. 2011 Total Orthophosphate (mg/L) data.



Dissolved Metals Data

VDEQ collected an extensive suite of common metals before and during the 2010 and 2011 pulse events to ensure that the pulses, which pulled a significant amount of water from the hypolimnion, did not cause any exceedences of water quality standards. The metals data are reported as dissolved metals because most water quality standards are based on the biologically available form of metal, which is the dissolved constituent. The dissolved metals results show that all standards were attained during the pulse event. Most dissolved metals are actually lower during the pulse event than at base flow. The only metal's parameter that was found above the 95th percentile statewide was mercury in the water column below Covington, which previous monitoring (as late as 2007) had never observed. While not a standards violation or a result of the pulse event, the elevated mercury levels may warrant a separate investigation. The graphs from both the 2010 and 2011 mercury sampling events are included in this report for comparison (Figures 46 and 47). Over 80% of mercury samples in the water column are below 2 parts per trillion (ng/L) in Virginia streams and rivers (VDEQ 2010b). All baseflow samples below Covington have been above 4.5 parts per trillion.

Figure 28. 2010 Dissolved Calcium (µg/L) data.

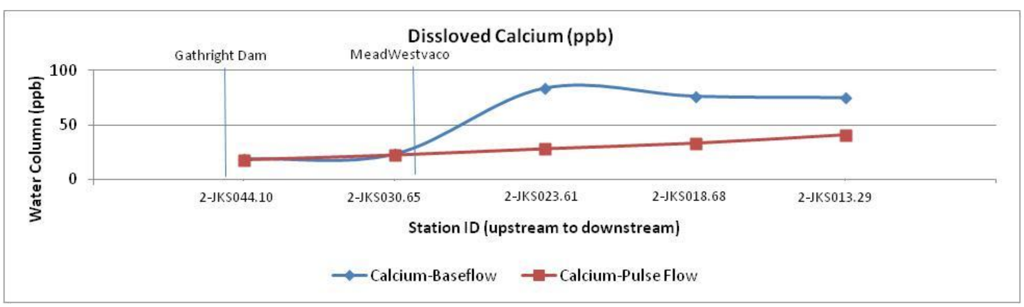


Figure 29. 2010 Dissolved Magnesium (µg /L) data.

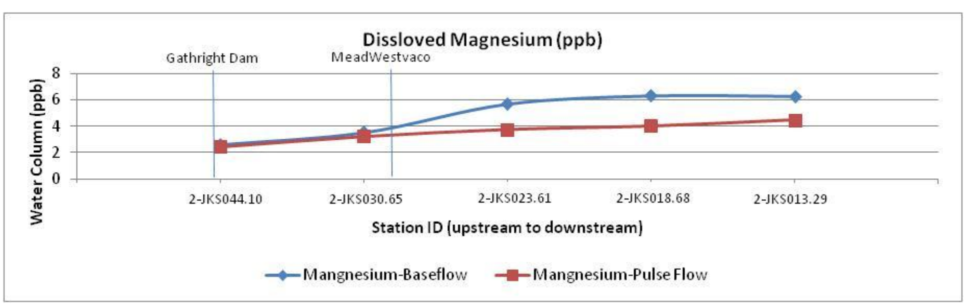


Figure 30. 2010 Dissolved Arsenic (µg /L) data.

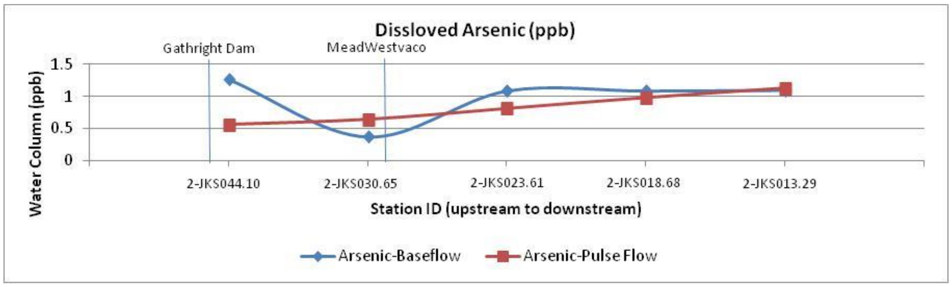


Figure 31. 2010 Dissolved Barium (µg /L) data.

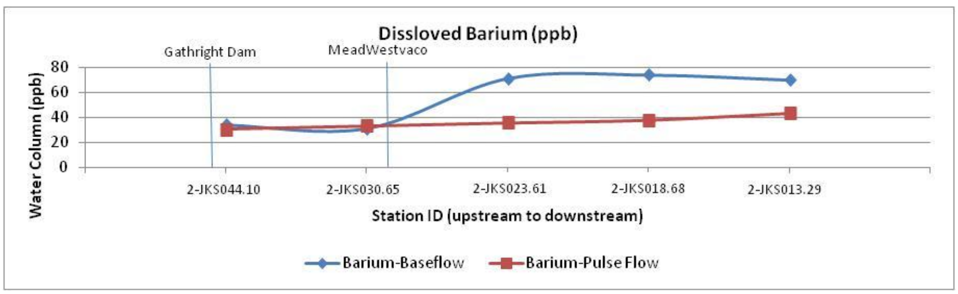


Figure 32. 2010 Dissolved Beryllium (µg /L) data.

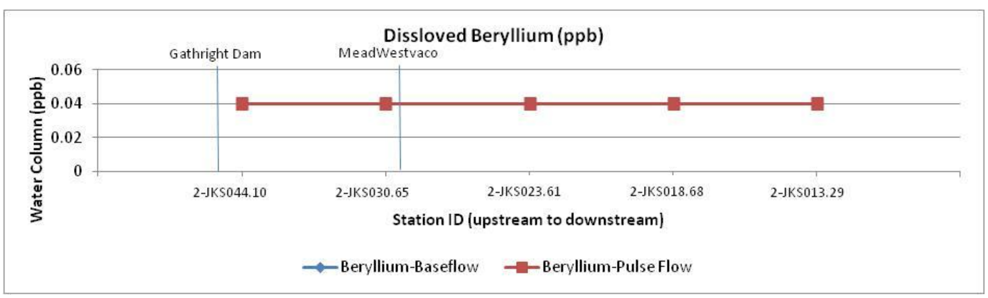


Figure 33. 2010 Dissolved Cadmium (µg /L) data.

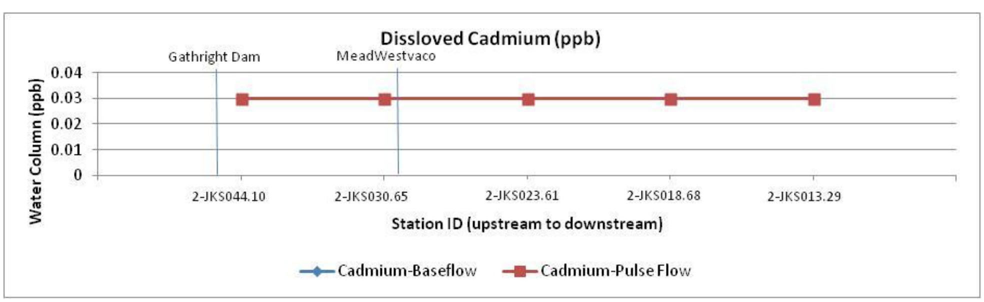


Figure 34. 2010 Dissolved Chromium (µg /L) data.

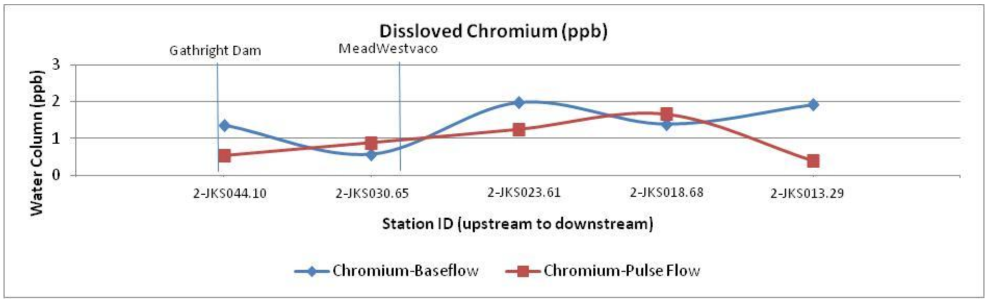


Figure 35. 2010 Dissolved Copper (µg /L) data.

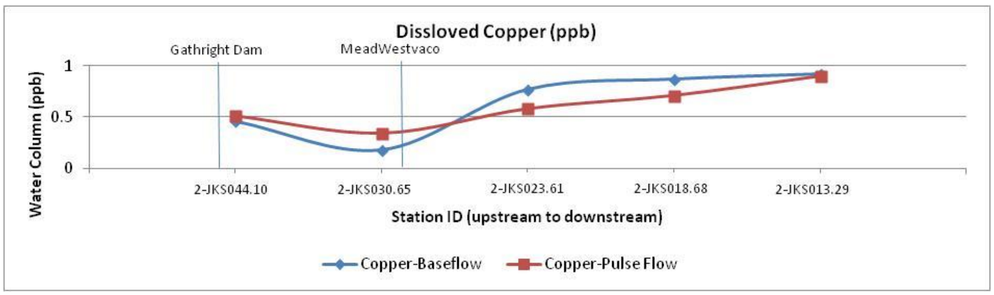


Figure 36. 2010 Dissolved Iron (µg /L) data.

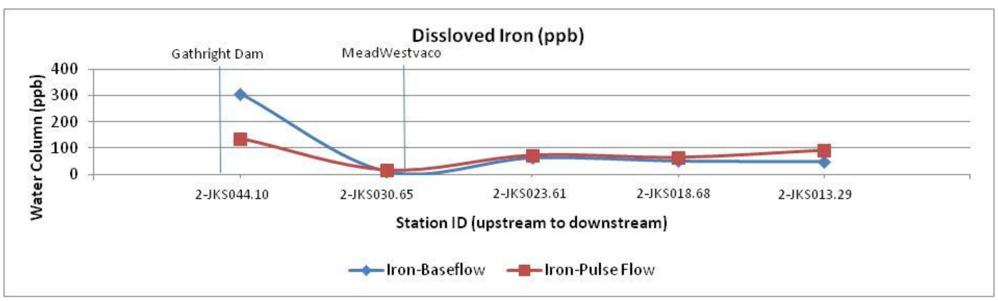


Figure 37. 2010 Dissolved Lead (µg /L) data.

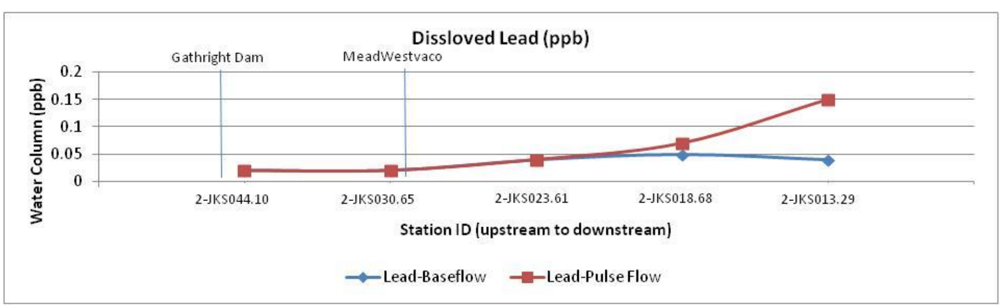


Figure 38. 2010 Dissolved Manganese (µg /L) data.

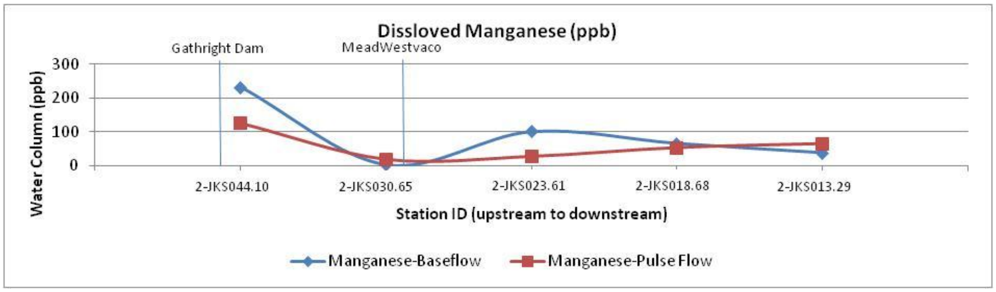


Figure 39. 2010 Dissolved Thallium (µg /L) data.

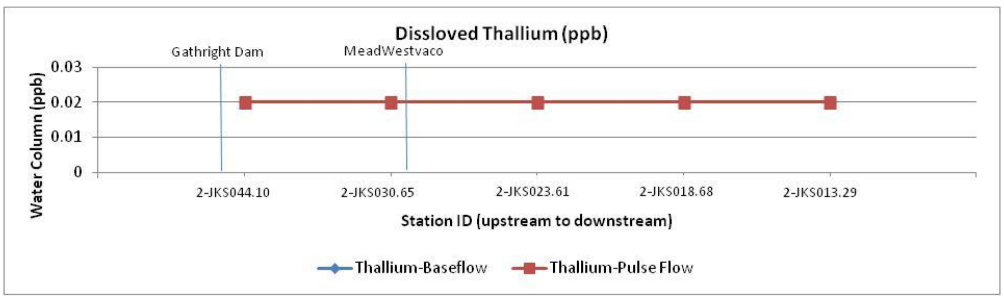


Figure 40. 2010 Dissolved Nickel (µg /L) data.

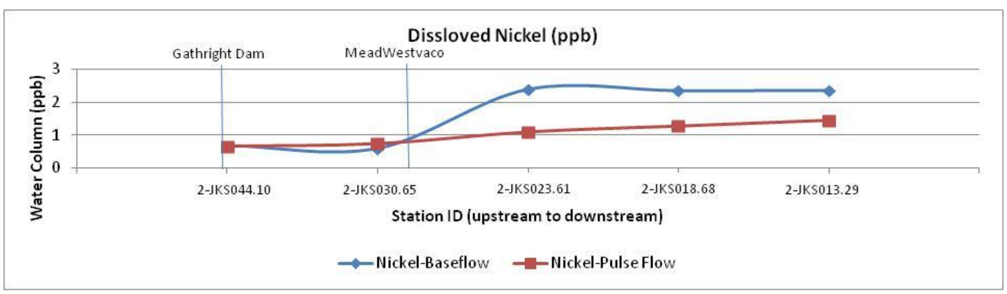


Figure 41. 2010 Dissolved Silver (µg /L) data.

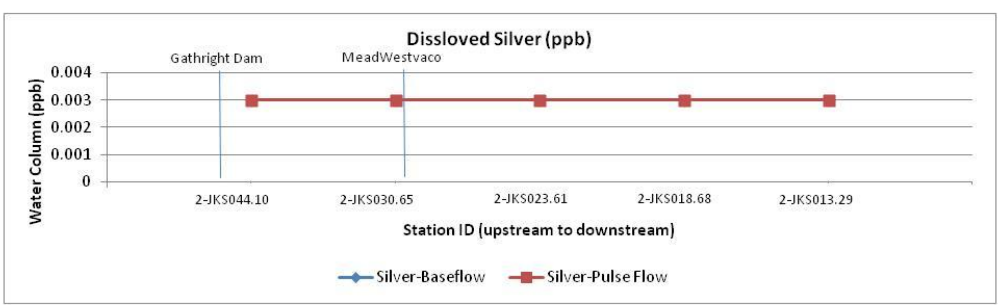


Figure 42. 2010 Dissolved Zinc (μg/L) data.

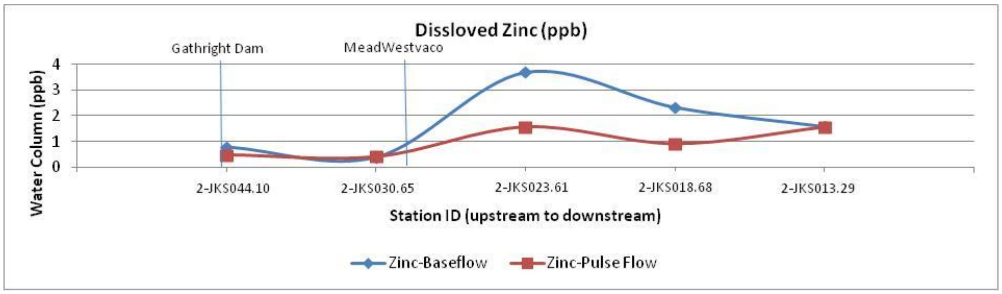


Figure 43. 2010 Dissolved Antimony (μg/L) data.

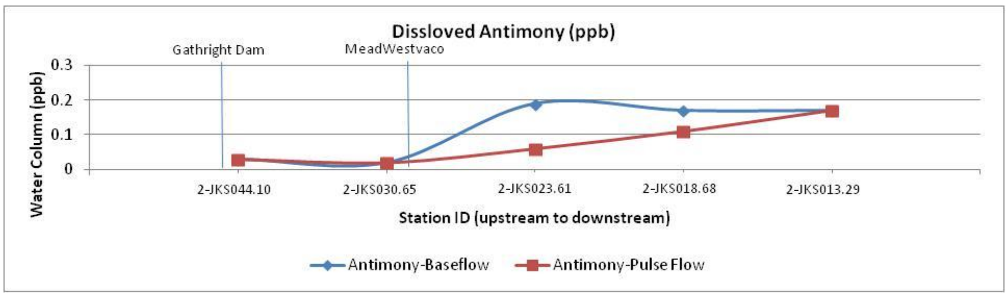


Figure 44. 2010 Dissolved Aluminum (μg/L) data.

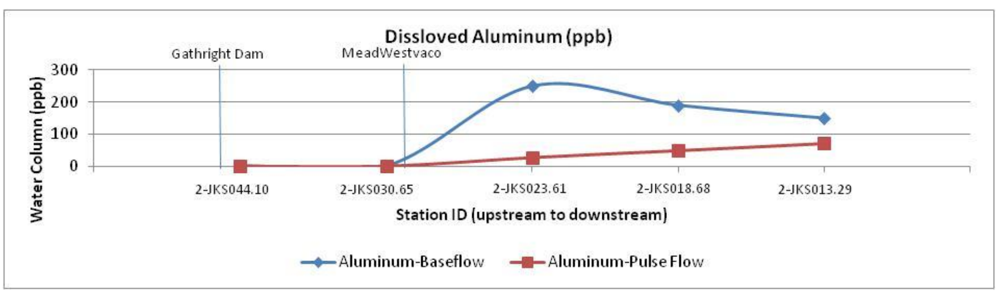


Figure 45. 2010 Dissolved Selenium (μg /L) data.

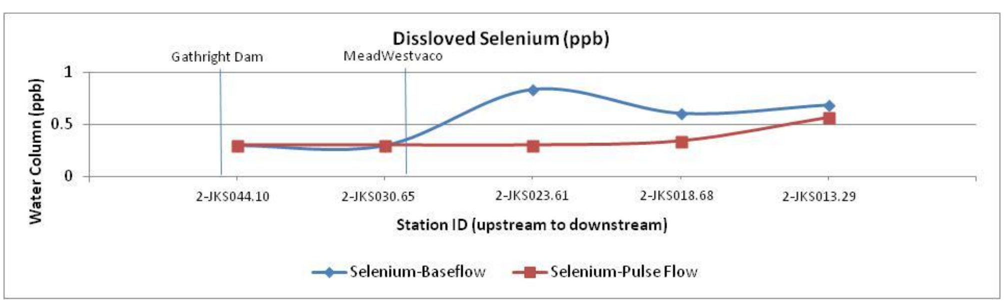


Figure 46. 2010 Dissolved Mercury (ng/L) data.

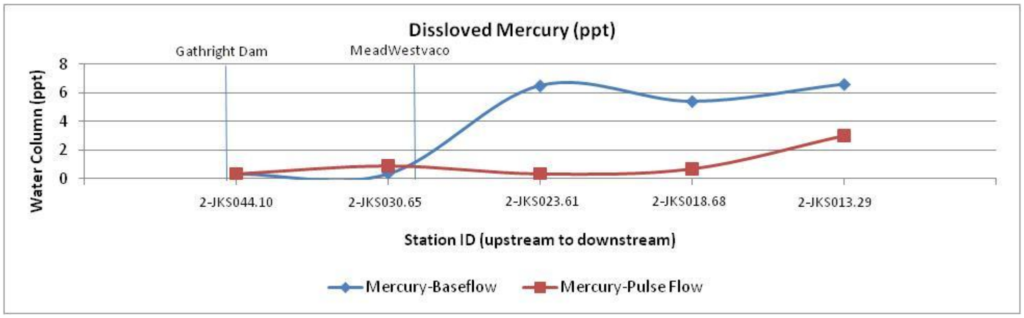


Figure 47. 2011 Dissolved Mercury (ng/L) data.

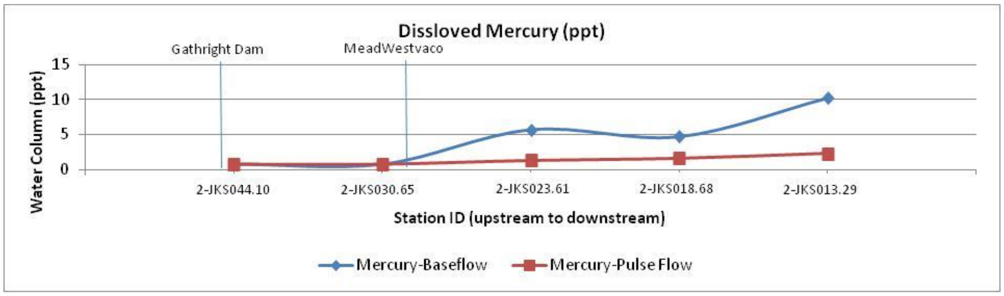
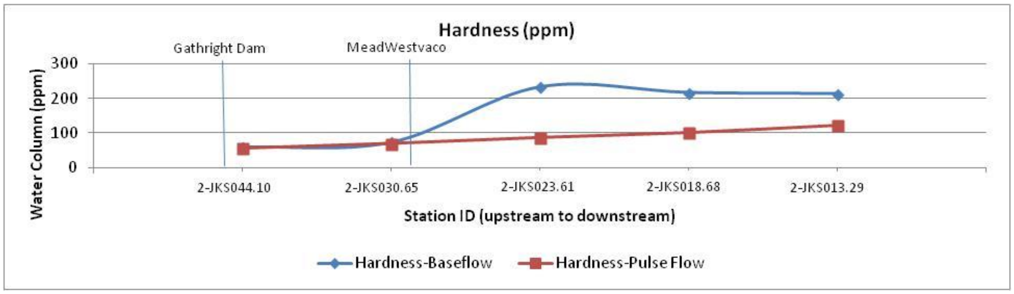


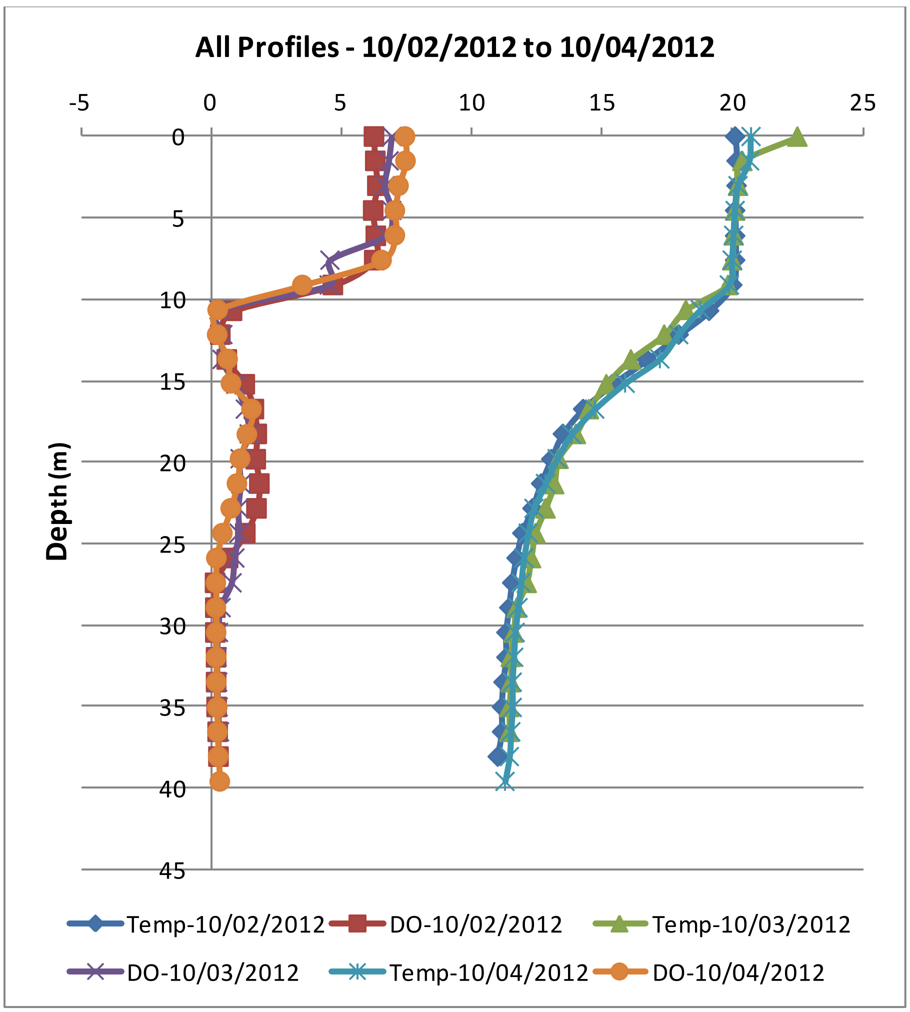
Figure 48. 2010 Hardness (mg/L) data.



Lake Profiles

Lake profile data collection during the 2011 pulse was incomplete and is not presented in this report. Figures 49 shows Lake Moomaw's temperature and dissolved oxygen profile data from October 2nd to October 4th, 2012. The profile shape is not significantly different the day of the pulse (October 3rd, 2012) than either the day before or the day after. The dissolved oxygen drops one meter before the thermocline on the day of the pulse. However, dissolved oxygen levels appear to return to normal the day after the pulse. Temperature is shown in degrees Celsius and dissolved oxygen is displayed in mg/L in figure 49.

Figure 49. Lake Moomaw Temperature (°C) and Dissolved Oxygen (mg/L) Profiles during the 2012 Pulse (October 2 to October 4, 2012).



Habitat Data Results

Rapid Bioassessment Protocol Habitat Data

Habitat is defined as the area or environment where an organism or ecological community resides. It encompasses the organism's or community's surroundings, both living and non-living. Fish, aquatic insects and plants require certain types of habitat to thrive, so instream and riparian (stream bank) habitat is evaluated to complement a biomonitoring sample. Since different organisms require diverse habitat components, a variety of available habitat types in a stream or river will support a diverse aquatic community. Habitat is scored by evaluating ten habitat parameters and adding them together (total scores range from 0 to 200) (Appendix A). Habitat scores lower than 120 tend to represent degraded habitats in Virginia while scores above 150 indicate habitat conditions that are favorable for supporting a healthy aquatic community (EPA 1999).

As seen in Tables 7 and 8, total habitat scores reflect favorable habitat conditions in the Jackson River and most scores improved slightly after the pulse event. A notable exception is the City Park score in 2011. Total habitat improved from 147 to 165, largely due to improvements to the embeddedness parameter. In fact, the substrate and embeddedness parameters were the sole reason for the slight increase in the total habitat scores. Embeddedness is an important parameter that refers to the extent to which rocks and snags are covered in silt, sand, or biomass. As embeddedness scores decrease, many forms of aquatic life no longer have suitable habitat in which to live. The Substrate metric represents availability of diversely sized particles and newfall. The Jackson River consistently scores in the optimal range for Substrate.

Table 7. 2011 Rapid Bioassessment Protocol Habitat Scores.

Parameter	Clearwater Park		City Park		Rt. 18 Bridge		Low Moor Cave	
	Pre-Pulse	Post-Pulse	Pre-Pulse	Post-Pulse	Pre-Pulse	Post-Pulse	Pre-Pulse	Post-Pulse
Substrate	18	18	17	18	18	17	18	19
Embeddedness	19	19	2	17	11	13	9	11
Velocity	19	19	17	17	17	17	18	8
Sediment Deposition	20	19	17	19	13	13	13	18
Flow	20	20	18	18	18	18	20	20
Channel Alteration	15	15	15	15	15	15	16	16
Riffle Frequency	19	19	18	18	15	15	19	19
Bank Stability	18	18	17	17	17	17	17	17
Bank Veg	19	19	17	17	15	15	18	18
Riparian Veg	18	18	9	9	11	11	8	8
TOTAL Habitat	**185**	**184**	**147**	**165**	**150**	**151**	**156**	**154**

Table 8. 2012 Rapid Bioassessment Protocol Habitat Scores.

Parameter	City Park			Rt. 18 Bridge			Low Moor Cave			Dabney Lancaster		
	Pre-Pulse	Post-Pulse	1 Week Post	Pre-Pulse	Post-Pulse	1 Week Post	Pre-Pulse	Post-Pulse	1 Week Post	Pre-Pulse	Post-Pulse	1 Week Post
Substrate	17	17	11	17	19	18	19	20	19	16	18	18
Embeddedness	8	12	12	14	13	16	15	15	14	15	16	17
Velocity	18	20	19	17	20	16	19	19	20	18	19	19
Sediment Deposition	18	15	17	14	13	13	18	16	17	14	15	17
Flow	18	18	18	19	19	19	18	18	18	18	18	18
Channel Alteration	15	15	15	15	15	15	15	15	15	17	17	17
Riffle Frequency	17	17	17	15	15	15	19	19	19	18	18	18
Bank Stability	16	16	16	15	15	15	18	18	18	19	19	19
Bank Veg	16	16	16	15	15	15	18	18	18	18	18	18
Riparian Veg	9	9	9	11	11	11	11	11	11	13	13	13
TOTAL Habitat	**152**	**155**	**150**	**152**	**155**	**153**	**170**	**169**	**169**	**166**	**171**	**174**

Biological Data

Benthic Algae Data

This section includes benthic algae data from 2012. The 2010 data were presented and discussed in the *Characterization of 2010 Base Flow and Pulse Flow Water Quality in the Jackson River* report found at http://www.deq.state.va.us/Portals/0/DEQ/Water/jacksonpulse2010final.pdf (VDEQ 2011). The 2011 benthic algae data are not presented here due to a change in analysis methodology resulting in a lack of confidence in the data. Consequently, the 2012 data were collected as splits with one split being sent to the Academy of Natural Sciences and the other to VDEQ's contract lab, Division of Consolidated Laboratory Services (DCLS). DCLS's data is presented in this section.

Benthic Chlorophyll A (Chl A) and Ash Free Dry Mass (AFDM) were both observed to be low above the Mead Westvaco discharge the day before the pulse (2012 data presented in Figures 50 and 51). In the Jackson River below the Mead Westvaco discharge, Chl A and AFDM were significantly higher the day before the pulse, especially at City Park (2-JKS023.62) and Route 18 Bridge (2-JKS018.68). 2012 City Park Chl A (1159 mg/m^2) and AFDM (261 g/m^2) were measured at much higher levels than in 2010 (335 mg/m^2 Chl A and 74 g/m^2 AFDM) on the day before the pulse. The increase in biomass in 2010 is probably due to the pulse event occurring two months later in the growing season. The day after the 2012 pulse, Chl A was 82% lower and AFDM was 65% lower at City Park when compared to the day before the pulse. Chl A did not show significant regrowth after one week (82% lower than the day before the pulse) but a slight increase in Chl A was observed three weeks after the pulse (76% lower than the day before the pulse). Figures 50 and 51 illustrate the changes in Chl A and AFDM, respectively.

Pre-pulse levels of Chl A and AFDM downstream of City Park were much lower than levels observed at City Park. Route 18 data showed a 30% decrease in Chl A and a 5% increase in AFDM the day after the 2012 pulse. Further downstream, a Chl A increase of 45% was observed the day after the pulse at Low Moor Cave (2-JKS013.29); whereas AFDM doubled the day after the pulse. AFDM levels at Low Moor Cave spiked after one week to over 500% compared to the day before the pulse. Three weeks after the pulse, Low Moor Cave AFDM levels were back down to levels comparable to the day after the pulse. Low Moor Cave Chl A followed a similar trend to AFDM. Dabney Lancaster (2-JKS006.67) stations showed noticeable decreases in both Chl A and AFDM the day after the pulse (46% and 61%, respectively). See Figures 50 and 51 for graphical depictions of changes in algae biomass.

Figure 50. Benthic Chlorophyll A (mg/m^2) before and after the October 2012 Pulse event.

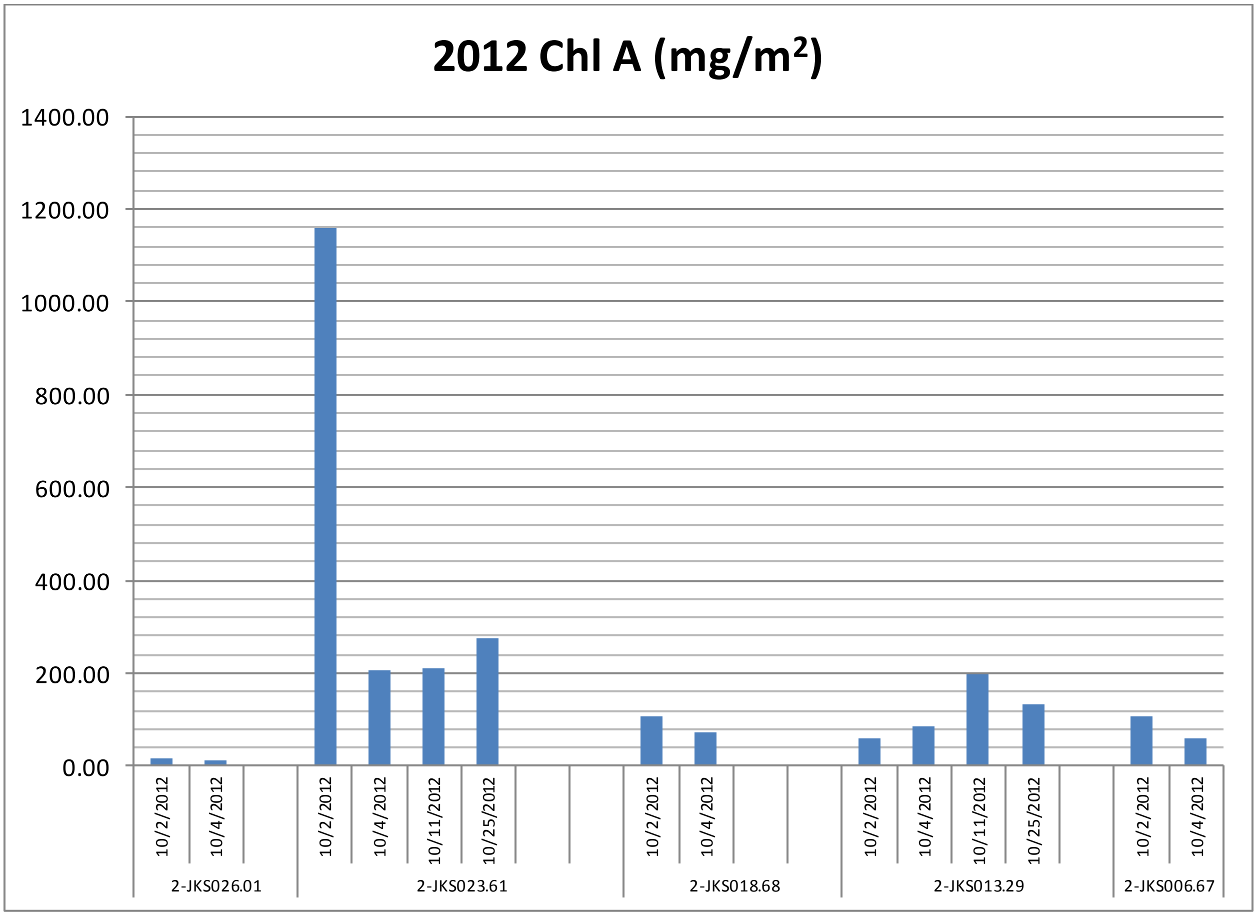
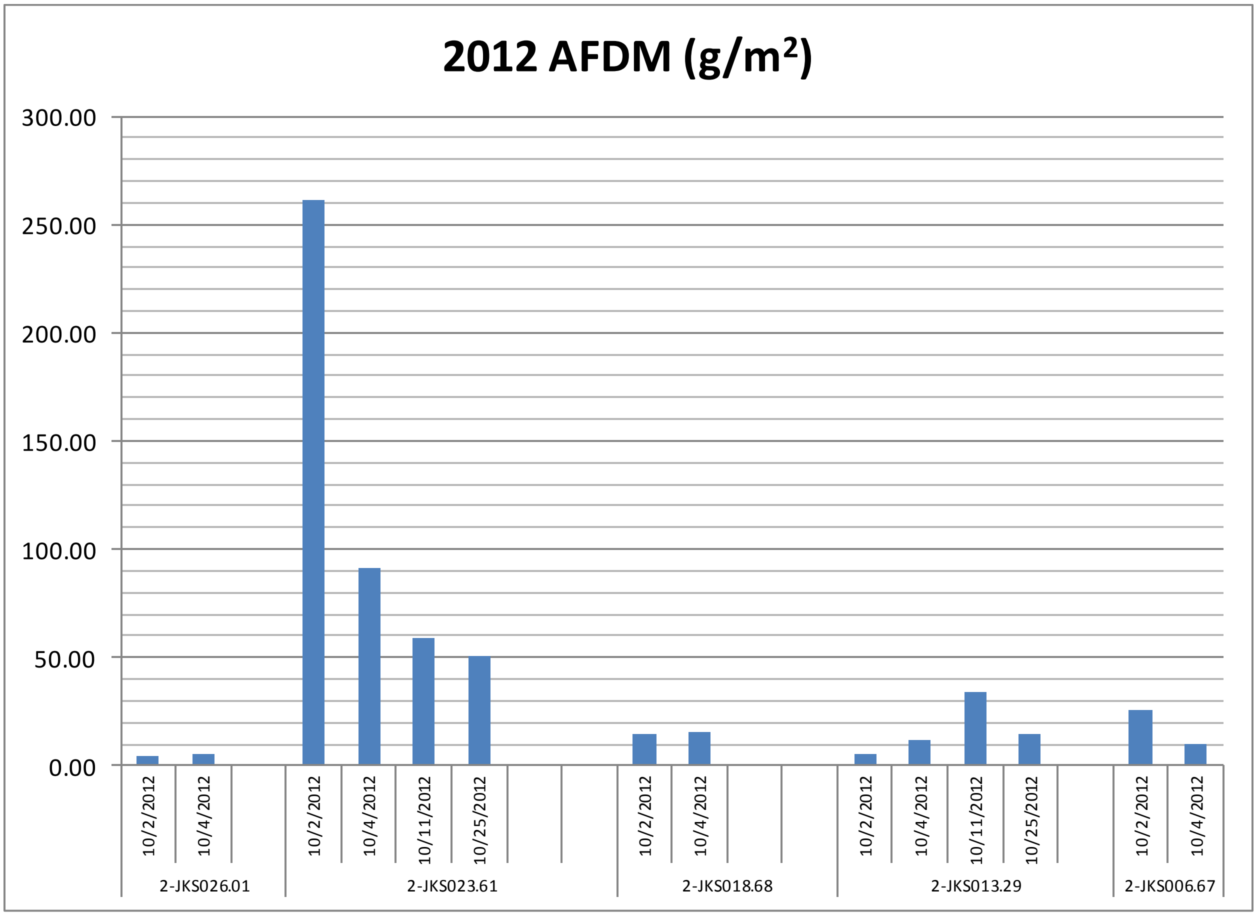


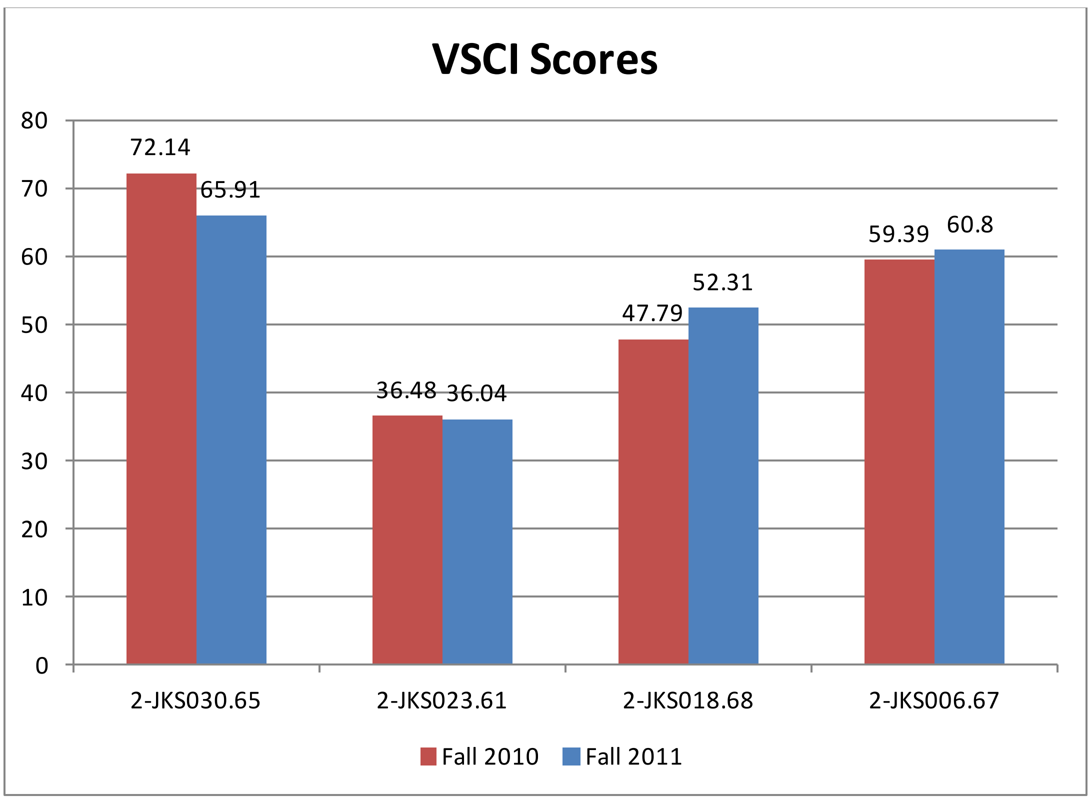
Figure 51. Ash Free Dry Mass (g/mg^2) before and after the October 2012 Pulse Event.



Benthic Macroinvertebrate Data

Benthic macroinvertebrates were collected on August 23rd, 24th, and 25th, 2010 and August 22nd, 23rd, and 24th, 2011 at four stations on the Jackson River (Figure 52). Benthic macroinvertebrate communities were assessed using Virginia's Stream Condition Index (VSCI), a single-value index comprised of eight core metrics. VSCI scores above 60 are considered unimpaired. VSCI scores follow the same general trend in 2010 and 2011 and are well above 60 at Clearwater Park (2-JKS030.65) and then decline at City Park (2-JKS023.61). The benthic macroinvertebrate community gradually recovers downstream of City Park. VSCI scores from 2012 were not available for this report.

Figure 52. 2010 and 2011 Virginia Stream Condition Index scores.



Fish Community Data

The Jackson River fishery is very important and beloved by many of the Commonwealth's citizens. VDEQ, Virginia Department of Game Inland Fisheries (VDGIF), and the 216 Study/Water Control Plan stakeholders collected fish in 2010 and 2011 in order to characterize the fish community before any hydrologic modification occurs. VDEQ does not have an official index of biotic integrity to assess aquatic life using fish communities. However, a number of common metrics were utilized in this report to summarize the current health of the fish community. It is believed that the fish community will improve along with the benthic macroinvertebrate community as the TMDL is implemented.

The eight fish community metrics included in this report are as follows: number fish species (Figure 53), proportion of sculpin (Figure 54), proportion of omnivore species (Figure 55), proportion of species with anomalies (Figure 56), proportion of invertivores (Figure 57), proportion of simple lithophils (Figure 58), proportion of intolerant fish (Figure 59), and proportion of general habitat fish (Figure 60). The number of fish species appears normal for the James River basin. The proportion of sculpin species, which tend to be more sensitive to environmental stressors, decreases below Covington. The proportion of omnivore species increases at City Park and Route 18, which corresponds to the excessive benthic algae found at those sites. The proportion of fish with anomalies, such as lesions and eroded fins, increases in Covington and downstream. It should be noted that fish in the upper James River have been experiencing an unknown affliction for the last several years and the anomalies observed may not be directly correlated with environmental stressors. The proportion of invertivores decreases as you go downstream on the Jackson River; these fish species exclusively feed on aquatic insects. Proportion of simple lithophils (rock-gravel) refers to the percent of fish species that need clean substrate to reproduce. Simple lithophils were reduced at City Park and Route 18 probably due to the lack of interstitial spaces in the large cobble from increased biomass around the rocks. Proportion of intolerant fish refers to a subset of fish species that are considered vulnerable to environmental stressors, these fish populations are reduced at City Park, Route 18, and Dabney Lancaster Community College. The proportion of general habitat fish metric refers to species that are able to spawn on various substrates; these fish species increase at City Park and Route 18.

Figure 53. Number of Fish Species collected in 2010 and 2011 by sample site.

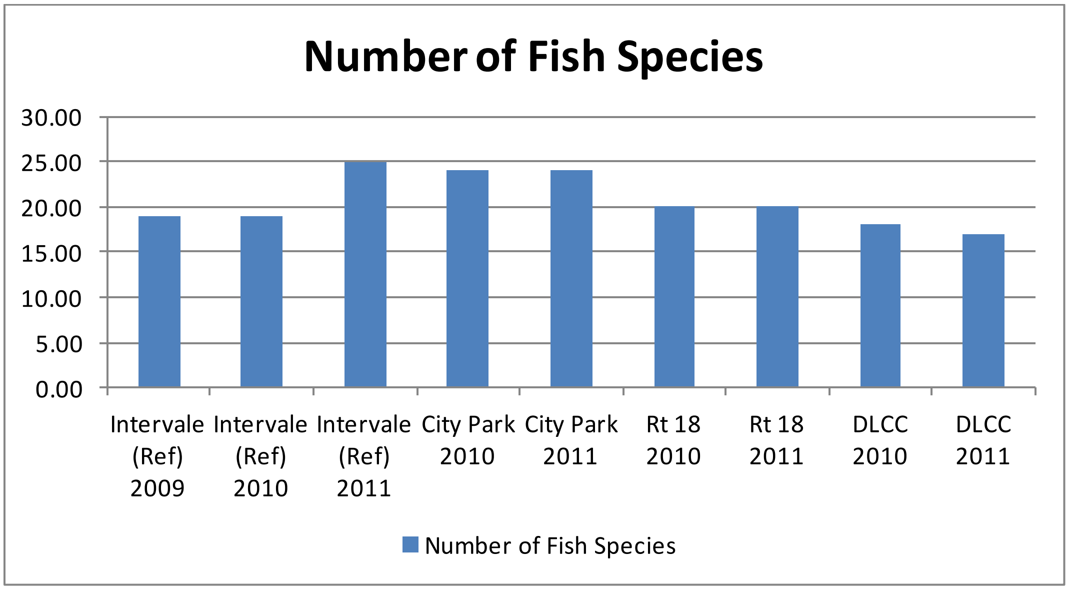


Figure 54. Proportion of sculpin collected in 2010 and 2011 by sample site.

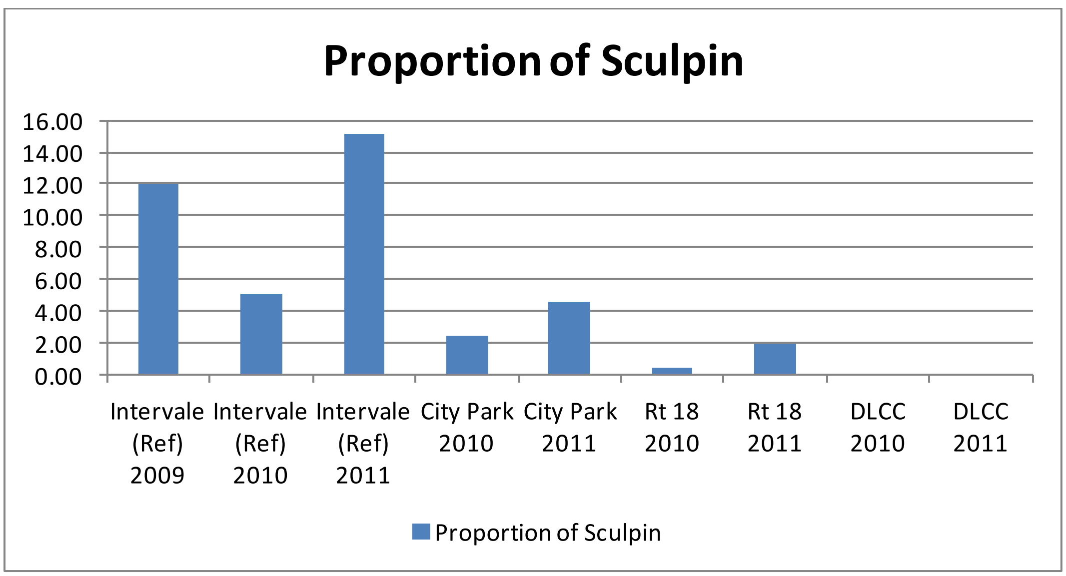


Figure 55. Proportion of omnivores collected in 2010 and 2011 by sample site.

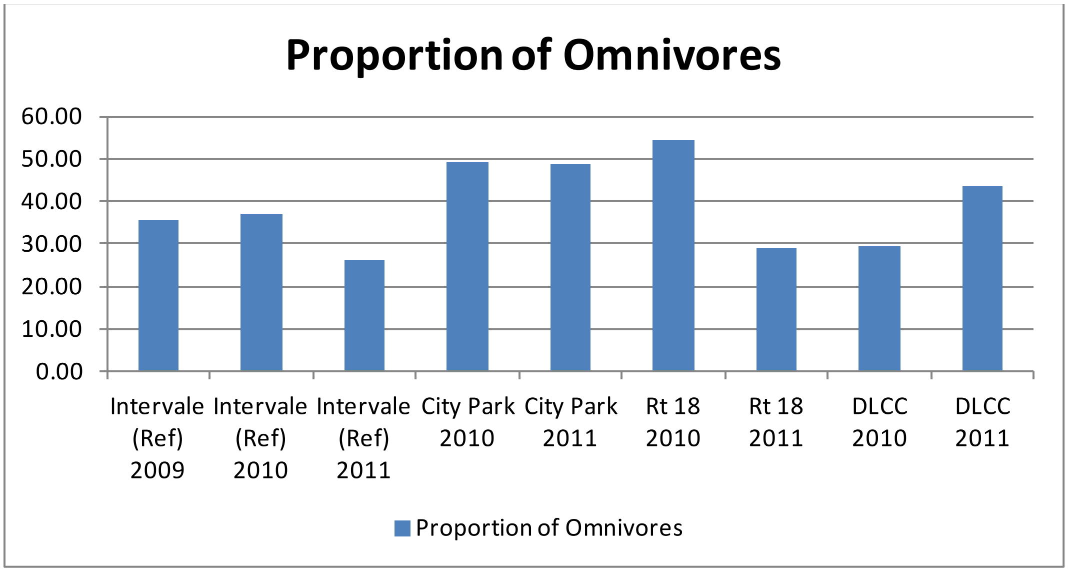


Figure 56. Proportion of fish with anomalies collected in 2010 and 2011 by sample site.

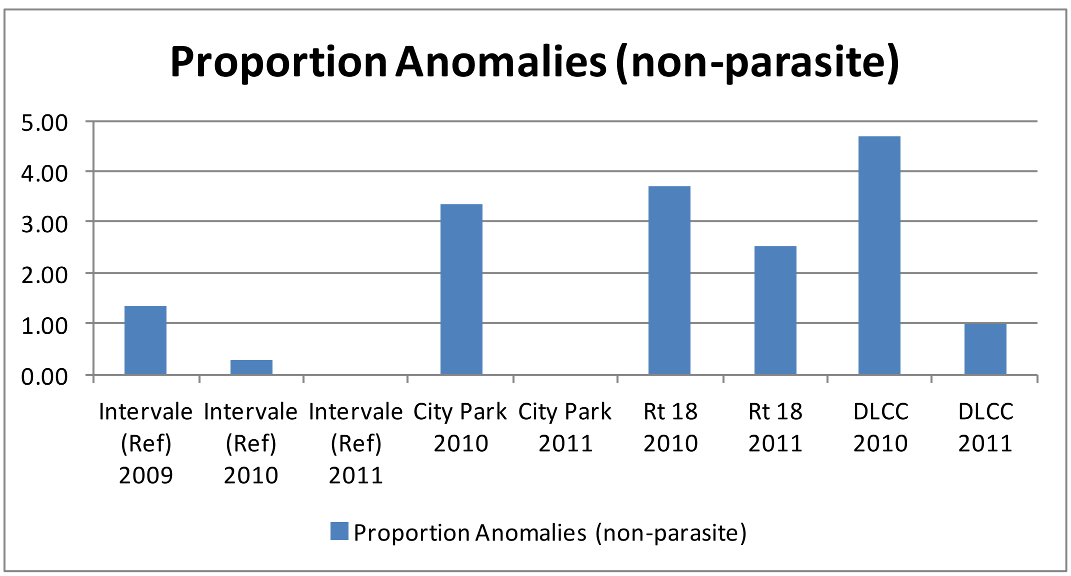


Figure 57. Proportion of invertivores collected in 2010 and 2011 by sample site.

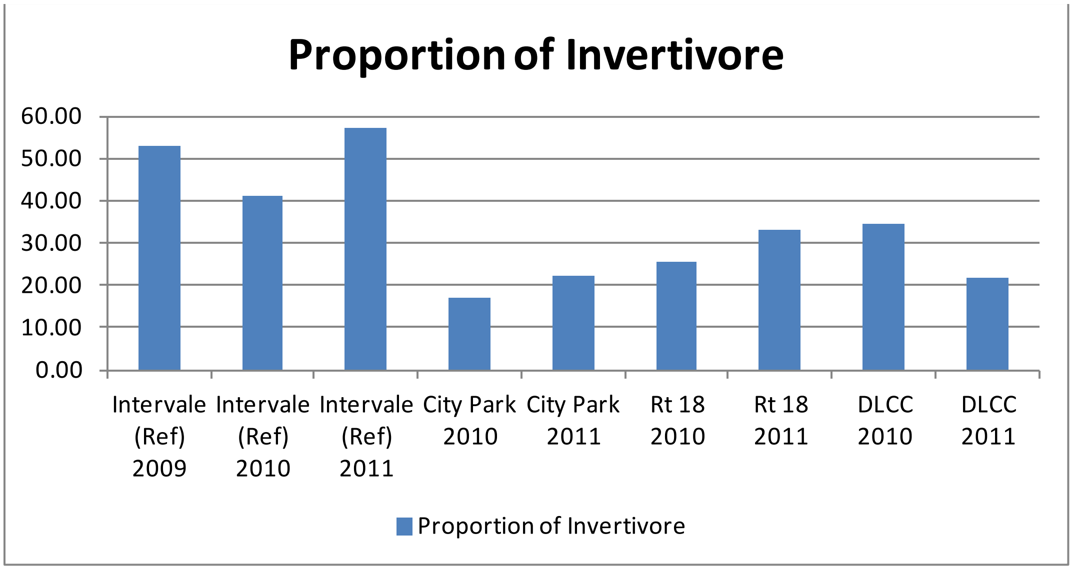


Figure 58. Proportion of simple lithophils collected in 2010 and 2011 by sample site.

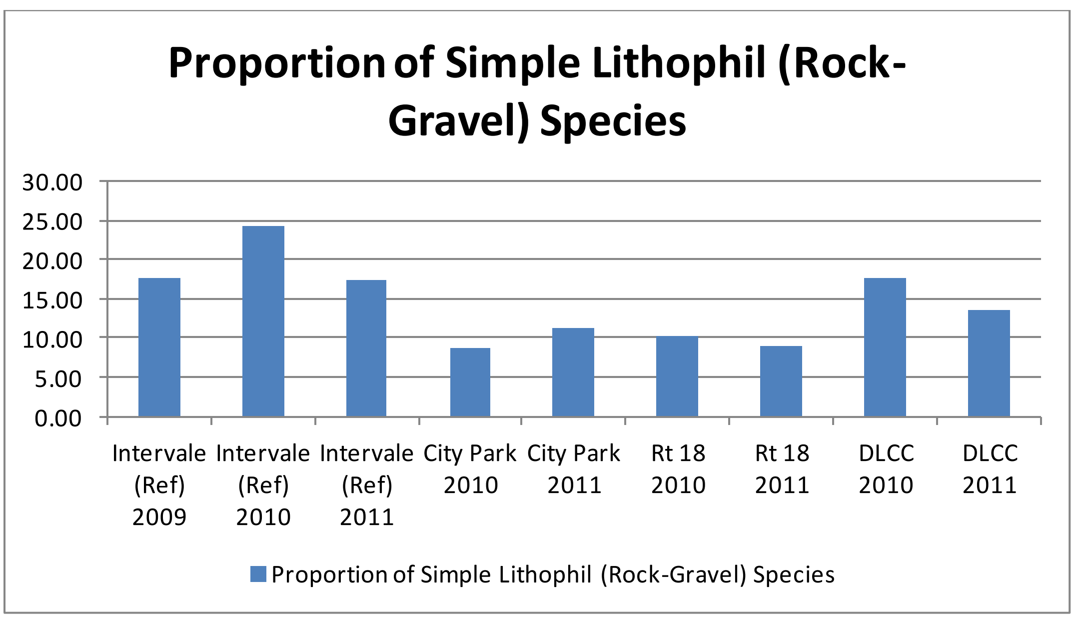


Figure 59. Proportion of intolerant species collected in 2010 and 2011 by sample site.

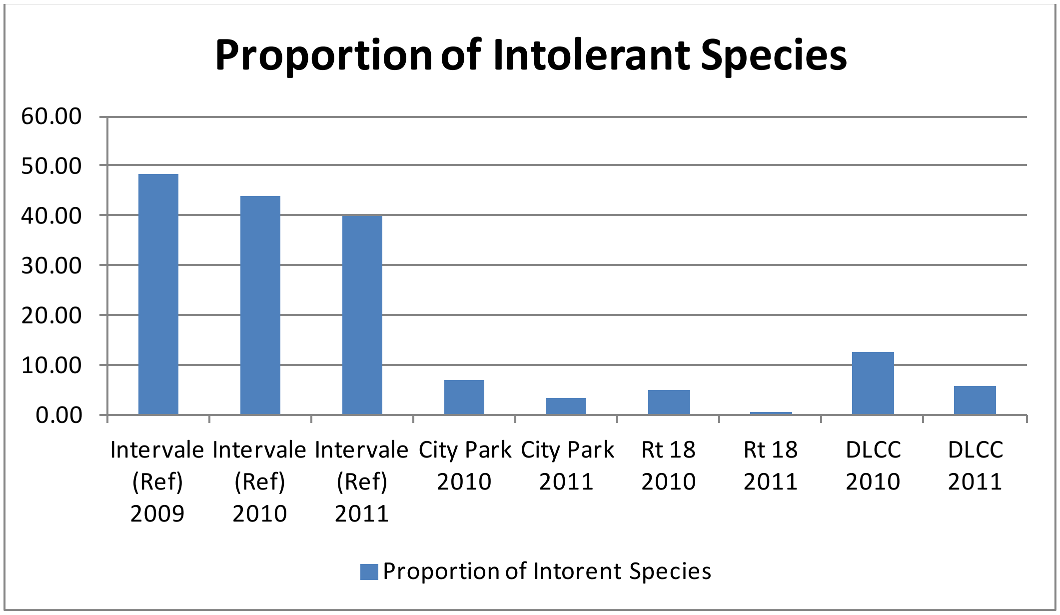
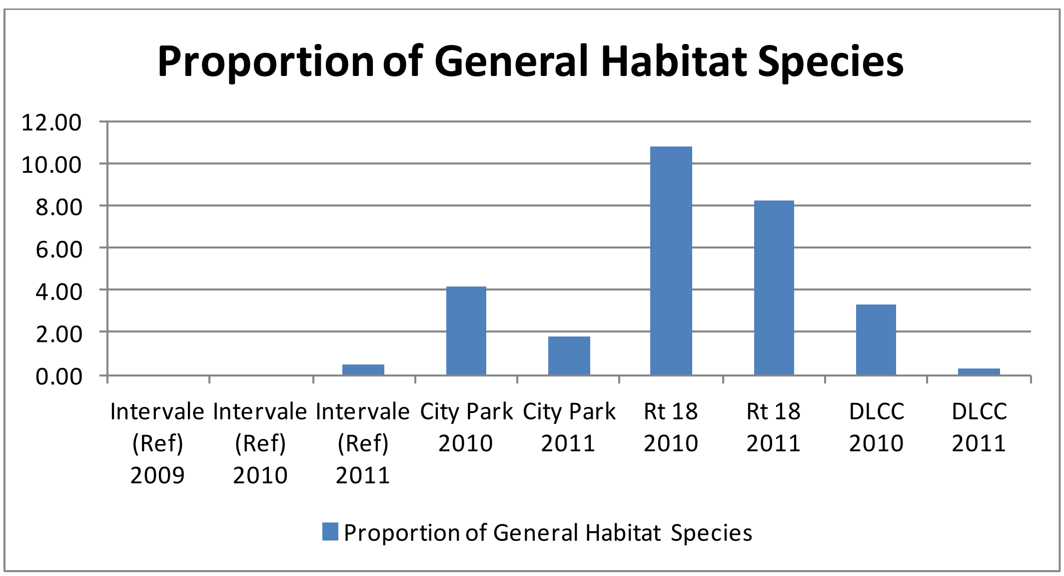


Figure 60. Proportion of general habitat species collected in 2010 and 2011 by sample site.



Summary and Conclusions

The culmination of data collection efforts on the Jackson River during 2010-2012 establishes a solid foundation for understanding and interpreting the effects of flow modifications. While documentation of existing water quality conditions is a critical first step, this dataset has already yielded useful results beyond baseline condition establishment. Notably, temperature, dissolved oxygen, pH and specific conductance are not negatively impacted from the pulse events. Further, dissolved oxygen levels are much improved below Covington. Total suspended solids and turbidity increased during pulse events. However, it is expected that multiple pulse events over the entire growing season would reduce sediment accumulation at the tributary outlets. Dissolved metals concentrations were low and did not exceed Virginia's Water Quality Standards. In Lake Moomaw, the thermocline remained intact during the summer pulse event. Habitat is optimal with few sedimentation problems. In-stream embeddedness showed slight improvement from the pulse events. Embeddedness is significant because decreased embeddedness frees up interstitial spaces and is an important factor in improving benthic macroinvertebrate communities. The benthic algae (Chl A and AFDM) levels downstream of the Mead Westvaco discharge were reduced significantly by the pulse. Since the Covington Sewage Treatment Plant upgrades were completed in 2011, actual effects of the pulse are becoming more evident in the Covington area. Extensive historic and recent benthic macroinvertebrate community data will allow for tracking changes and improvements. Sufficient fish community data has been collected to establish baseline conditions and ensure that the fishery above Covington remains intact and that downstream recovery can be documented.

References

Kaufmann, P. R., P. Levine, E. G. Robinson, C. Seeliger, and D. Peck. 1999. Quantifying physical habitat in wadeable streams. EPA/620/R-99/003, USEPA, Washington, D.C.

USEPA. 2000. Mid-Atlantic Highlands Streams Assessment. EPA/903/R-00/015. United States Environmental Protection Agency, Region 3, Philadelphia, PA 19103.

USEPA. 1999. Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers. Office of Water. EPA/841/B-99/002.

Virginia Department of Environmental Quality. 2010. Benthic TMDL Development for the Jackson River, Virginia. Richmond, Virginia. VDEQ TMDL Study. <Available at <http://www.deq.virginia.gov/portals/0/DEQ/Water/TMDL/apptmdls/jamesrvr/jackben.pdf>

Virginia Department of Environmental Quality. 2010b. 2010. 2010 Integrated Report Probabilistic Monitoring Chapter. Available at: <http://www.deq.virginia.gov/Portals/0/DEQ/Water/WaterQualityMonitoring/ProbabilisticMonitoring/ProbMon2010.pdf>

Virginia Department of Environmental Quality. 2009. *Quality Assurance Project Plan for Special study of Jackson River Watershed in Support of Benthic Total Maximum Daily Load Implementation Plan Alleghany County and Covington City, VA (Waterbodies I04R and I09R).* Richmond, Virginia.

Virginia Department of Environmental Quality. 2010. *Virginia 2010 Water Quality Assessment 305(b)/303(d) Integrated Report.* Available at: http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityAssessments/2010305b303dIntegratedReport.aspx

Virginia Department of Environmental Quality. 2008. *Virginia 2008 Water Quality Assessment 305(b)/303(d) Integrated Report.*

Virginia Department of Environmental Quality. 2006. *Virginia 2006 Water Quality Assessment 305(b)/303(d) Integrated Report.*

Virginia Department of Environmental Quality. 2004. *Virginia 2004 Water Quality Assessment 305(b)/303(d) Integrated Report.*

Virginia Department of Environmental Quality. 2002. *Virginia List of Impaired Waters.* Virginia DEQ, 2002.

Virginia Department of Environmental Quality. 1996. *Virginia Total Maximum Daily Load Priority and Report.* Virginia DEQ, 1996.

Virginia Department of Environmental Quality (DEQ). 2011. VDEQ Technical Bulletin WQA/2011-001: *Characterization of 2010 Base Flow and Pulse Flow Water Quality in the Jackson River.* Available at <http://www.deq.state.va.us/Portals/0/DEQ/Water/jacksonpulse2010final.pdf>

Appendix A. Benthic Macroinvertebrate Field Data Sheet.

Benthic Macroinvertebrate Field Data Sheet (front)

Station ID: ________________ Ecoregion: ________________ Land Use ______________

Field Team: ________________ Survey Reason: ________________________ Start Time: __:__

Stream Name: ___________________ Location: ________________________ Finish Time: __:__

Date: __/__/__ Latitude: ______________ Longitude: ______________

Stream Physicochemical

Instrument ID number: _________________ pH: ____________

Temperature: __________Co Conductivity: _________uS/cm

Dissolved Oxygen: _______mg/l Did instrument pass all post-calibration checks? Y / N

If NO - which parameter(s) failed and action___________________________________

Benthic Macroinvertebrate Collection

Method used (circle one) Single Habitat (Riffle) Multi Habitat (Logs, plants, etc)

Riffle Quality (circle one) Good Marginal Poor None

Habitats sampled (circle one) Riffle Snags Banks Vegetation Area Sampled (sq. m.):

jabs ______ ______ ______ ______ ___________

Weather Observations

Current Weather (circle one) Cloudy Clear Rain/Snow Foggy

Recent precipitation (circle one) Clear Showers Rain Storms Other ____________

Stream flow (circle one) Low Normal Above Normal Flood

Biological Observations

0 1 2 3	Periphyton	0 1 2 3	Salamanders	0 1 2 3	Other....
0 1 2 3	Filamentous algae	0 1 2 3	Warmwater Fish	0 1 2 3	______________
0 1 2 3	Submerged Macrophytes	0 1 2 3	Coldwater Fish		0 = Not Observed
0 1 2 3	Emergent Macrophytes	0 1 2 3	Beavers		1 = Sparse
0 1 2 3	Crayfish	0 1 2 3	Muskrats		2 = Common to Abundant
0 1 2 3	Corbicula	0 1 2 3	Ducks/Geese		3 = Dominant -
0 1 2 3	Unionidae	0 1 2 3	Snakes		abnormally high density where other taxa are insignificant
0 1 2 3	Operculate Snails	0 1 2 3	Turtles		in relation to the dominant taxa. There can be situations
0 1 2 3	Non-operculate Snails	0 1 2 3	Frogs/Tadpoles		where mulitiple taxa are dominant such as algae and snails.

NOTES:

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HighGradient Habitat Data Sheet

	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/Available Cover	Greater then 70% of substrate favorable for epifauna colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e. logs/snags that are not new fall and not tranisent).r	40-70% mis of stable habitat; well suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of new fall, but not yet prepared for colinzation (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; sbustrate frequently disturbed or removed.	Less than 20% stable habitat, lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
2. Embeddedness	Optimal Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Suboptimal Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Marginal Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Poor Gravel, cobble, and boulder partilces are more thatn 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
3. Velocity/Depth Regime	Optimal CoverAll four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). Slow is <0.3 m/s, deep is >0.5	Suboptimal Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Marginal Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Poor Dominated by 1 veolcity/depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
4. Sediment Deposition	Optimal Little or no enlargement of islands or point bars	Suboptimal Some new increase in bar formation, mostly	Marginal Moderate deposition of new gravel, sand or fine	Poor Heavy deposits of fine material, increased bar

	and less than 5% (<20% for l;ow-gradient streams) of the bottom affected by sediment deposition.	from gravel, sand or fine sediment. 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	sediment on old and new bars; 30-50% (50-80% for low-gradient) of	development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent.
SCORE	20 19 18 17 16 m/s.	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
5. Channel Flow Status	Optimal Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Suboptimal Water fills >75% of the available channel; or 25% of channel substrate is exposed.	Marginal Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Poor Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
6. Channel Alteration	Optimal Channelization or dredging absent or minimal; stream with normal patter.	Suboptimal Some channelization present, usually in areas of bridge abutements; evidence of past channelization, i.e., dredging, (greater than past 20 yr.) may be present, but recent channelization is not present.	Marginal Channelization may be extensive; embankments or shoring structures present on both banks; and 40 - 80% of stream reach channelized and disrupted.	Poor Banks shored with gabion or cement over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7. Frequency of Riffles (or bends)	Optimal Occurrence of riffles relatively frequent ratio of distance btw. riffled divided by width of the stream <7:1 *generally 5 to 7): variety of habitats if key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Suboptimal Occurrence of riffles infrequent; distance btw. riffles divided by the width of the stream is btw. 7 to 15.	Marginal Occasional riffle or bend; bottom contours provide saome habitat; distance btw. riffles divided by the width of the stream is btw. 15 to 25.	Poor Generally all flat water or shallow riffles; poor habitat; distance btw. riffles dividied by the width of the stream is a ration of >25%.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
8. Bank Stability (score each bank)	Optimal Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. < 5% of bank affected.	Suboptimal Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Marginal Moderately unstable, 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Poor Unstable; many eroded areas "raw" areas
SCORE RB	10 9	8 7 6	5 4 3	2 1 0
SCORE LB	10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank)	Optimal More than 90% of the stream bank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or non-woody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	Suboptimal 70-90% of stream bank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	Marginal 50-70% of the stream bank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less then one-half of the potential plant stuibble height remaining.	Poor Less than 50% of the stream bank surfaces covered by vegetation; disruption of stream bank vegetation is very high; vegetation has been removed to 5 cm or less in average stubble height.
SCORE RB	10 9	8 7 6	5 4 3	2 1 0
SCORE LB	10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank)	Optimal Width of riparian zone >18 m; human activities (i.e. parking lots, roadbaeds, clear-cuts, lawns, or crops) have not impacted zone.	Suboptimal Width of riparian zone 12-18 m; human activites have impacted zone only minimally.	Marginal Width of riparian zone 6-12 m: human activiteid have impacted zone a great deal.	Poor Width if riparian zone <6 m; little or no riparian vegetation due to human activities.
SCORE RB	10 9	8 7 6	5 4 3	2 1 0
SCORE LB	10 9	8 7 6	5 4 3	2 1 0

SCORE ______