Technical Review of Evidence to Determine the Presence, Extent, and Consequences of Excessive Algal Growths in the Shenandoah River and its Tributaries

Submitted to the Virginia Department of Environmental Quality on Behalf of Potomac Riverkeeper and Shenandoah Riverkeeper

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I. Introduction

Shenandoah Riverkeeper ("SRK" or "Riverkeeper") has collected and analyzed a huge volume of information related to algal growths in the mainstem of the Shenandoah River and in the North and South Forks. This report presents findings and conclusions from this effort. The evidence presented, supported by hundreds of attachments and references, overwhelmingly supports the following conclusions:

A. Excessive algal growths in the Shenandoah River, North Fork Shenandoah River, South Fork Shenandoah River, North River, and South River interfere with and sometimes prevent human uses of these streams, including but not limited to boating, swimming, wading, fishing, and aesthetic enjoyment of the environment.
B. Excessive algal growths in the streams cited in A. damage the biological integrity and cause imbalances in aquatic communities in each stream.
C. Excessive algal growths in the streams cited in A. constitute undesirable and nuisance plant growths in each stream.
D. Excessive algal growths in the streams cited in A. result in the presence of floating mats of algae and decaying plant materials, color, odors, and turbidity in each of the streams.
E. The excessive algal growths and impacts described in A. through D. occur throughout the following sections: on the Shenandoah River, from its beginning near Front Royal to its confluence with the Potomac River; on the North Fork Shenandoah River, from its beginning near Bergton to its confluence with the South Fork; on the South Fork Shenandoah River, from its beginning near Grottoes to its confluence with the North Fork; on North River, from River Mile 4 to the mouth; and on South River, from River 4 to the mouth.
F. The excessive algal growths and impacts described in A. through D. have occurred on a persistent basis, throughout at least the period from 2007 to 2014, with variations from season to season and year to year. Impacts are most frequently observed in summer and early fall periods, when recreational users are most affected.

The succeeding sections of this document are as follows. Appendices A through H are attached
:

II. Citizen Reports
III. Expert Findings and Opinions
IV. Photographs
V. Transect Data
VI. Water Quality Goals
VII. Comparison of Data to Water Quality Goals
VIII. Conclusions
IX. References
X. Expert Testimony - Kelble
XI. Qualifications of David Sligh

II. Citizen Reports

Attached to this report are one hundred and twenty six (126) separate submittals from citizens describing conditions in the Shenandoah watershed and the citizens' responses to those conditions. These letters tell of algae-related problems in the River and the two Forks; many listing specific times and locations when they observed conditions caused by an overabundance of algae. Other citizen statements include observations gathered over wider time periods and larger areas and changes observed through the last several decades.

Most of the submittals are from people who use the rivers for recreational and aesthetic purposes, some of whom have done so for many years. Complaints from less frequent or newer users are also represented among the citizen statements. Those whose properties border one of the waterbodies are also well represented and have obvious economic interests that they believe to be affected by the degradation of the streams by excessive algal growths and die-off. Almost all of the commenters have long and intimate familiarity with one or more of the streams addressed and with the conditions that have been conducive to their enjoyment of activities in, on, and around the waters. Many explain in some detail the problems they have observed, the ways in which these problems interfere with their uses, and the areas and time periods affected.

A spreadsheet summarizing much of the information gleaned from the submittals is contained in Appendix A to this report and electronic versions of all of the submittals are submitted with this report. Some of the general patterns we can observe from the table in Appendix A are:

A. Numbers of comments addressing problems on the mainstem, North Fork, and South Fork are 61, 58, and 70, respectively.

B. Cumulatively, the complaints cite algae problems spanning the entire lengths of each of the three streams.

C. The numbers of comments citing specific uses that were impaired includes: Fishing - 102, Primary Contact Recreation - 44, Boating - 55, Wading - 40, General Aesthetic Enjoyment - 57.

D. The numbers of comments citing specific problems that impaired their uses includes: Periphyton, general - 31, Filamentous Algae - 55, Plankton and/or Floating Masses - 50, Color - 40, Odor - 60, Turbidity - 10, Health Concerns: Toxicity and/or pathogens - 19, Fish Lesions and Diseases - 26. Almost all commenters named more than one of the problems listed.

E. Thirty (30) of the comments specifically compared the conditions in the Shenandoah streams with those they have experienced in other waters and noted that the conditions here were worse than those in any of the other streams they have used.

In addition to the summary of comments described above, quotes from some of the comment letters are provided below, to provide a fuller sense of the facts and opinions included in the comments. The C# notations match those that are used in Appendix A and in the file names for the individual comments. The dates on the written comments are included, next to each person's name. The specific locations discussed in these comments are spread throughout the watershed and on all three of the major streams.

Quotes from Comment Letters

C1 - Alan Lehman (9/3/14)
"In the late afternoons and early evenings on late summer and fall days, floating globs of algae nearly fill the river at my house. This discourages me and my guests from swimming in the river, since it is extremely gross when it gets on our bodies and in our hair."

C2 - Alan Lehman (4/10/12)
"I've seen globs of floating algae on the back eddies and channels on the North Fork Shenandoah River in March and April of this and past years, near Woodstock, New Market, and Toms Brook. In May and June of each of the past few years, I've seen filamentous algae on the bottom of the North Fork near Toms Brook, and Strasburg, and also on the bottom of the South Fork near Island Ford, Elkton, Shenandoah, Luray, and on the Main Stem Shenandoah River near Morgans Ford Landing, Rt. 50 and Rt. 7 in Clarke County. I've seen the smelly floating algae on the North Fork in July, August, and September near New Market, Mt. Jackson, Edinburg, Woodstock, Strasburg, Toms Brook, and Riverton. This smelly floating algae is also persistent on the South Fork in late summer around Port Republic, Island Ford, Elkton, Shenandoah, Newport, Alma, Luray, and near the Andy Guest/Shenandoah River State Park in Warren County."

C3 - Allan Thomson (4/12)
"I have noticed that there is often in the spring and summer a slimy mat of algae covering the rocks and native grasses which makes the river not only unsightly but also hazardous to walk in. This is especially true in the North fork and the main stem north of Front Royal."

C4 - Amy Mrstik (9/16/14)
"As we approached the lower end of our trip, near Front Royal, we stopped so Rick could spend some time in an area he said looked fishy. But I noticed the area was full of dark green algae, and it smelled way worse than fishy. I didn't want to get into the water here because of the smell, so I took pictures of some wild flowers growing along the bank. Rick waded in but soon complained that his lure was getting full of algae and his favorite fishing shirt was getting stained green. I was never able to get that gunk completely out of his shirt."

C6 - Andrew Riccobono (4/13/12)
"I still regularly fish the for smallmouth bass and panfish at the Shenandoah River Andy Guest State park near Bentonville and my experiences from spring through summer have become alarmingly predictable. . . . By July my flies are covered in green muck after every cast – whether I am fishing on the surface or with a sinking lure. When the algae die off, the decomposing clumps smell pretty nasty."

C7 - Andrew Thayer (4/12)
"During that time on the river in April and early May, I witnessed something at the area known as Shenandoah Shores on the main stem below Front Royal. There were large clumps of green and brown stuff that were floating around. As I passed, the clumps had a sewage-like stench that could be smelled."

C14 - Bernard Griswold (4/12/12)
"I have had riverfront property directly on the North Fork outside of Woodstock since 1991. . . . During dry low water spells, planktonic algae also increases dramatically to the point that it covers and clogs grass beds from shore to shore. . . . Fifteen years ago, vegetation in this area consisted primarily of rooted grasses which provided cover and food for a variety of river creatures, especially from mid-June through early fall. Now, beginning in early June, rooted filamentous brown algae begins to coat rocks and rubble in pools and runs and increases by mid-August to provide floating clumps of brown gunk in such quantity as to collect in masses around any object at the surface. This has resulted, in recent years, in much reduced use of the river in late summer and early fall for all our activities and provides a real eyesore from our vantage point on shore. It also provides a severe odor problem during hot dry, low water periods in late summer."

C16 - Bill Millhouser (4/6/12)
"When these algaes are blooming, the fishing is frustrating because you cannot fish without fouling your line on the algae, the fish won't bite lures or bait with algae sticking to it. I just cannot use the River due to the odors and annoyance. I found this problem in the following areas last year from July through August: Strasburg, Bentonville, Front Royal, Luray Dam, 211, Shenandoah, Route 50, and Route 7."

C24 - Charles V. Loudermilk, II (4/18/12)
"I have seen in recent years when on the river that the water has an odd dark greenish color that seems almost like it could glow in the dark to it in the spring. I have witnessed this just last weekend on 4-15-12 when I had floated from Rt. 50 to a takeout 4 miles downstream."

C25 - Charles V. Loudermilk, II (8/14)
"I can recall a float from Alma to Whitehouse on the South Fork in July of 2012 that there were section of the river that the algae was so thick that that my canoe in about 2 foot of water would get stuck. I had to use my oar to push myself off the long strings of algae in these sections. I would wade Edinburg area or should I say tried to wade this area. It was very hard to even get in the water and move around because the algae were so thick."

C31 - Douglas Lees (8/31/14)
" I fished the South Fork and Main Stem of the river this summer in July and August as follows: . . . July 20, . . . on the South Fork near Luray, catching no bass and no sunfish and noticing numerous clumps of foul-smelling algae—this section of the river smelled like an outhouse."

C41 - Elwyn "Chip" Comstock (4/10/12)
"The places I like to wade and fish are mile 13, 16 and up stream from Andy Guest Park. The past two years I've fished these locations less due to the fact that I not only find algae as mentioned above but I find fish that have abnormal growths on them. I typically fish these areas from May through September; however, I've begun seeking out other locations due to the poor conditions of the water."

C63 - Jeff Browne (8/25/14)
"Last week I was paddling up-river from the Hazard Mill landing in Bentonville (Hazard Ford Road) and for the first quarter mile you can see the devastation caused by algae as the river grass has been killed over time. The largest smallmouth bass I've caught on the river have been in that stretch, but no more. Now I just paddle through it in order to get to faster waters that haven't been hit as hard."

C64 - Jeff Little (4/9/12)
"The last time I visited the Shenandoah River to fish was last September near Pugh's Run on the North Fork I took my two sons to wade and fish where I have fond memories of catching feisty smallmouth bass. We spent about t})rte hours wading downstream, catching a few small bass, a far cry from my memories of this previously impressive fishery. The slippery filamentous algae that permeated the river bottom made wading treacherous for my sons. The "snot grass" coated their water sandals and when the decided to jump in further:, the rest of their clothes. It also made for frustrating fishing as each cast yielded a crop of algae that prevented our catching many fish."

C68 John F. Ehrlich (4/6/12)
"Finally in 2008, I decided to visit the low water bridge at Bentonville to see if the river quality had improved since I last fished here. . . . It was during a particularly hot period in July. I was shocked to see the amount of algae both upstream and downstream from the bridge. The slime that clung to the rocks was clearly evident and the noxious odors that l first noticed in the 1990s had become worse . lt is a sad epitaph for a river that so many considered one of the premier rivers in the Mid Atlantic."

C69 - John Holmes (8/27/14)
"I have a cottage on the North Fork near Woodstock Virginia and my sole reason for choosing this location was to have access to the river and the ability to enjoy the river.

. . .

I want to share a specific problem that occurred this year. In early July we had some heavy rain that washed out some of the algae that had been accumulating. I was at the cottage on the weekend of July 12th and was able to wade and fish. With that good experience I invited my partner's family of five ... two adults and three boys ... to come out the following weekend of July 19th and 20th. We and they had planned to canoe, fish, and swim. When we got to the cottage, we found the algae was back with vengeance. The swimming and tube floating were cancelled. We fished a little from the low water bridge but could not wade fish. Clumps of algae in the slow water near the bridge made it a stinky environment. The older boys asked what was wrong with the river, when they smelled the algae and saw the slimy floating clumps during a brief canoe trip."

C80 - Leslie D. Mitchell (4/12/12)
"I am a volunteer water monitor for Friends of the North Fork of the Shenandoah River, so I observe the portions of the North Fork near Strasburg on a bimonthly basis. . . . In recent years, I have noticed or been alerted to numerous and different types of algae blooms and observed thick algae growth on the river's surface and below the surface. The blooms I have observed have been in the summer and early fall of the year. Please see photos below of an algae blooms: 1) June 22,

2010 about a mile downstream of Deer Rapids Bridge; 2) Same location and date; 3) and 4) Bloom that occurred in the North Fork between Deer Rapids south of Strasburg and the Rt. 55 Bridge across the North Fork, northeast of Strasburg in July of 2011. The algae smells bad, is difficult to paddle through and creates an unpleasant recreational experience in general, especially as it causes one to wonder what it is that is causing these imbalances in the water, allowing this unusual algae growth to occur."

C81- Mark J. Frondorf (4/13/12)
"This past summer, I donated my time as a fishing guide to the Shenandoah River Rodeo that took place in Front Royal, VA. I was embarrassed to take major contributors out on the supposed crown jewel of Virginia rivers as rock snot coated every rock and eddy pocket on the river."

C82 - Mark R. Myers (4/5/12)
"When my wife and I were dating in the 1980s we found several locations along the North Fork of the Shenandoah in the Strasburg area where we would picnic, wade and fish. For a number of years we occasionally returned to these spots, such as the VA Rt. 55 crossing. When we visited that area in the summer of 2011, the river bottom and water conditions were drastically changed from a decade earlier. There was abundant 'snot weed' and a lack of grasses that were previously in the river. The river bottom was not visible and what was previously an attractive river for wading was not at all inviting. What should have been a pleasant outing remembering good times from earlier years turned out to be very disappointing and left us concerned that future generations will not realize what a lovely resource the Shenandoah one was."

C91 - Preston Lazer (8/27/14)
"I was both embarrassed and disgusted back in mid July when I took a guest for a first trip on the section of the South Fork from Karo Rapids to Front Royal landing. I thought this would be a great chance to show what a gem Virginia has! Instead, what I had talked up as "one of the top things to do in Virginia" turned into bewilderment at what had happened to our river. For much of the trip, it was just an exercise in frustration to fish because every time we retrieved a fly, it was covered in algae snot. Also, the stench was overpowering at times. . . . I am sorry to say that when one of my friends called to ask for advice on unique things to do in Virginia with his visitors from Denmark, I told them to go visit the New River in West Virginia rather than to float the Shenandoah so they don't embarrass themselves like I did."

C97 - Robert Forbes (9/17/14)
"After one South Fork fishing trip in July, 2014, when I got in my car, I noticed an overpowering odor of rotting material and thought the odor must have come from something decaying in my car. Then I realized the odor came from my shorts that had been immersed in the Shenandoah River while I was fishing!"
C99 - Rodney Miner (8/27/14)
"My most recent outing was July 12th when I floated and fished from Island Ford to Elkton. My friend and I saw lots of algae and the fishing was absolutely terrible. We saw dead fish lying on the bottom of the river and caught very few fish which is very unusual on this stretch of river. I caught two smallmouth bass with lesions on their sides. . . . I had planned to float the river

numerous times this summer but, when one sees these conditions you have to wonder how healthy it is to be in water when you see high levels of algae and dead fish."

C103 & 104 - Stan Ikonen (8/23/14 & 4/12)
"My group of two canoeists and one kayaker encountered a fairly significant bloom just last Sunday, 8/17, on the same stretch [the main stem of the Shenandoah between Shepherds Ford and the bridge at Rt 7. It was nasty enough that our teenaged female guest asked that we get out of the river as she was not comfortable with the floating algae. We stopped about halfway through our float. I hitched a ride to the takeout point to retrieve my truck and a nice day was ruined as the result of the algae in the water."

"Last June I canoed the South Fork of the Shenandoah from Bentonville to Front Royal with a group of friends. It was one of the most unpleasant experiences of the year. Worse than the record-breaking heat was the appearance, smell, and an almost slimy feeling of the water. It was disgusting. We stayed overnight on a sand bar. I usually take a swim before I bed down to remove the day's dirt and sweat. Not that night. I choose not to expose myself to the water anymore than needed."

C107 - Steven R. Adams (9/7/14)
"Just this past July 2014, on a float trip on the South Fork of the Shenandoah River, from Alma to White House near Luray, I encountered numerous stretches of the south fork with large amounts of algae. The algae smelled like something was rotting, it was slimy, and stuck to everything on my kayak and fishing gear. The algae also made the bottom very slippery and dangerous in places. Just trying to get in and out of my kayak was problematic."

III. Expert Observations and Opinions

In addition to experience as river users, 9 of the commenters listed in Appendix A have expertise in areas pertinent to the issues addressed in this report. The first group has extensive professional experience and expertise in fishing and river recreation and in the preferences of stream users. The second has expertise in water quality science, pollution investigations, water monitoring, and comparison of data to water goals.

Fishing and River Recreation Experts - The following listed commenters have many years of experience in outfitting and guiding fishermen and boaters on the Shenandoah watershed streams and on other waters.

C21 - Brian Trow
C26 - Colby Trow
C58 - Jacob Russo
C78 - L.E. Rhodes
C100 - Ron Evans
C102 - Scott Osborne
C114 - Trace Noel
Section X of this Report - Jeff Kelble

Because their livelihoods have depended on knowledge of the natural conditions in these streams, as those conditions relate to fishing success and the enjoyment of their clients, the expert opinions of these persons must receive extra weight regarding the streams' abilities to meet certain water quality goals.

They are qualified to give expert testimony about objective questions regarding the presence or absence of color, turbidity, floating materials, the extent of algal growths, odors, and the integrity and balance of the ecosystems in which they have worked. Subjective questions regarding the levels of algal cover and extent of other effects which rise to the level of nuisance or undesirable conditions and which have and/or will impair clients' enjoyment of their experiences are also within their areas of special expertise. As stated by Kelble (Section X):

> *What is MOST IMPORTANT about my life's fishing history and my professional career as a fishing guide was the fact that I made a living selecting the very best body of water in the Mid-Atlantic to take people fishing. This required that I have access to multiple sections of river, on multiple rivers in multiple states. My reputation and my success hinged on my ability to evaluate the physical conditions of the river including flow, water clarity and seasonal movements of fish to determine where I would take my clients through the ten month full-time season. (underlining added)*

Included below are some quotes from these experts' comments that are especially pertinent to the degrees to which the Shenanandoah and the North and South Forks provide pleasurable conditions for recreationists and the effects of algae on those experiences:

C21 - Brian Trow
"Half of the beauty of floating the rivers of our state is underwater. Looking into a river and seeing nothing but green water, brown and green rocks, and smelling the awful smells of rotting algae is very discouraging. We already have to deal with poor water quality that takes trophy bass from us every year, and now we can't even enjoy the beauty of looking into the river. . . . I guide and fish on many other rivers in the state including the James in central Virginia, The Rappahannok, the Cowpasture, and the New. All of these drainages have algae, but not nearly to the degree that the Shenandoah does."

C26 - Colby Trow
"We are on the river 12 months a year and almost daily in the spring and summer. We have 7 boats and run more float fishing trips on this river than any other fishing guide service. We do target the James River and New River for smallmouth bass and musky, however we consider the Shenandoah River our home water. Unfortunately claiming the Shenandoah our home water is becoming more and more embarrassing each year as we see constant algae blooms, fish kills, disease, foul smelling water, experience waterborne infections, and more. Some of our guests will not return to fish the Shenandoah or our area again as a result of what they see on the water."

C58 - Jacob Russo
"I fish and guide on the North Fork, South Fork and Main Stem of the Shenandoah. However, for much of the year, large sections of each river seems to experience a series of noxious algae blooms that seriously diminish my use and enjoyment of the rivers. . . . Over the course of the year I use the entire river system and have seen this on all three rivers from Port Republic down to Front Royal, from Broadway to Front Royal and from Front Royal to the Confluence with the Potomac River. This bloom turns the river a dark murky green color, like green paint, from late winter until about July. When the algae blooms I often choose not to swim or fish. When I do fish I find the fishing is poor and I don't enjoy the experience as much. Whenever the river is this murky color, it's disturbing to fish and the fish are usually lethargic and often they don't feed at all. Activity in the river drops to near zero."

C78 - L.E. Rhodes
"Over the years I have enjoyed spending time with family and friends as well as customers on the river. The algae problem has gotten bad enough that I am hesitant to take trips during the time of the algae blooms. It has a musky smell that takes the pleasure out of what would have been a great day on the water. Plus when fishing it is forever fouling in your hooks. I refuse to allow anyone to get in the water to wade or swim."

C102 - Scott Osborne
"I use the river extensively throughout the spring, summer and fall months for recreational fishing as well as professionally guided fly fishing services. Typically, I use the river 2-4 times a week during these months as flows allow for successful navigation of the river. . . . There have been numerous days that my clients were relatively disgusted by the incredible amounts of algae in the river and all of us knew it was the culprit for the slow day of fishing as well as the terrible smell. They did not even want to get in the river to cool off on the hottest of days. . . . I have fished all over the world, and the Shenandoah is one of my favorite, but only when it is not choked by algae."

C114 - Trace Noel
"As a retired outfitter on the South Fork of the Shenandoah with more than 20 years of daily and first hand experience I can speak directly to the impact that both phases of the algal bloom has on the river. . . . During the Spring and Summer large clots of algae break loose and head downstream. Resembling tumbling and floating human waste, these algal turds gross out urban guests, exasperate anglers, collect in slow moving water and leave a vomitus stench that diminish the experience by both private landowner and thousands recreational users. . . . The impact to the watersport recreation industry in the Shenandoah Valley – read economic loss to struggling rural communities - is substantial From float tubers to anglers with tangled lines our operation suffered diminished participation from urban guests who chose other ways to spent discretionary income."

The most detailed comments from an expert in the field of river recreation and fisheries come from Jeff Kelble (labeled C120 in Appendix A). Kelble's testimony is at Section X. of this report.

Water Quality Expert

The author of this report submits this document, attachments, and appendices as expert testimony on the matters addressed herein and has included information, including a resume, to support his status as an expert in the fields of water quality assessments, stream ecology, and pollution impacts.

Agencies

Because resource agency personnel have special expertise in the issues examined in this report, we cite two examples of agency opinions that bear on our assertions.

Virginia Department of Game and Inland Fisheries ("VDGIF") - On its web site, the VDGIF provides descriptions of certain segments of Virginia streams and of the fishing opportunities in these locations. One item on the web site reads as follows:

> *The North Fork is a relatively small, shallow river and is very accessible to wade angling.* ***Excessive nutrients in the watershed promote the growth of algae and aquatic plants.*** *The vegetation* ***can become very dense during the summer/fall months and impede fishing and boating****. (VDGIF 2014)(emphasis added)*

Virginia Department of Environmental Quality - In response to a citizen who reported the possible dumping of cow manure in the North Fork Shenandoah River, Don Kain, Water Monitoring and Assessment Manager in DEQ's Valley Regional Office investigated and responded to the complainant, in part, as follows:

> *I just returned from the river. The material in your photo was indeed still there. . . .* ***based on the appearance and odor (both definitely nasty), I think what we are seeing is decaying blue-green algae mats****. I took a trip down the river 2 weeks ago from Deer Rapids to Strasburg with Jeff Kelble specifically to evaluate nuisance algae problems. The material at Black Bear crossing looks the same as the mats we observed on that section of the river. . . .* ***By the way, these blue-green algae mats are quite often mistaken for sewage, due to both appearance and odor****." (Kain 2012) (emphasis added)*

IV. Photographs

Attached to this report are more than 1,000 photographs and 15 videos. These pictures show a great variety of different kinds of excessive algal growth, including planktonic species, algae attached to substrates and to vascular plants, and floating algal mats and decaying materials. The photos and videos are listed in Appendix B. Each has a designated number (A1, A2, etc.) and in almost all cases is identified by date, stream, and river mile. Through the photographers, the photos can be verified to be true representations of the actual conditions at the sites and times named. The electronic records for each photo shows that the images have not been altered. All of the photos and videos are included as attachments to this report.

Below are examples of certain types of conditions depicted by the photographs. The significance of these views in relation to water quality goals is discussed in Section VII below.

Highly Colored Waters

As described in citizen comments, at times stream segments in the Shenandoah and major tributaries appear to have a bright or dark green color throughout the water column - "like green paint," according to numerous witnesses. Examples of such conditions are shown in Figures 1 - 8. These eight photographs range in time from 2007 through 2014 and represent widespread segments from each of the three streams cover in this report.

Floating Materials

Figures 9 - 15 show scenes of floating masses in the streams, including algae and other plant-related materials, some in different stages of decomposition. Again, the photos range from 2007 to 2014. Most of these Figures are taken from those on the North Fork Shenandoah to show the wide array of appearances that occur in this one stream. Additional examples of floating materials in a variety of forms are shown in photos of the South Fork Shenandoah, which can be found in the attachments to this report, at: photos A659 (river mile 92), A634 (river mile 70), A595 (river mile 38), and A573 (river mile 18). Likewise, photos in the attachments show portions of the mainstem Shenandoah River with various forms of plant-related floating matter at: A453 (river mile 39) and A454 (river mile 38).

Stream Bottom Coverage

Many of the photographs attached to this report show benthic algal growths in the Shenandoah River and its tributaries. These photos show a variety of types of algae that are attached to bottom substrates, from filamentous forms to various low-growing brown and green forms that coat the rocks. Attached form of blue-green algae are present in very substantial amounts and in a wide range of locations. Figures 16 - 21 show the variety of forms and the density and extent of these growths at a number of sites. Overall, the photographs submitted with this report show hundreds of views of excessive algal growth spread throughout the lengths of the North and South Forks of the Shenandoah and on the mainstem. While still photographs are only capable of showing limited fields of visions, the videos show that the algae covering certain portions of the stream bottoms stretch over long distances.

In combination with the pictures and videos taken on these streams, from above and below the surface of the water, SRK submits many more aerial photographs which also show heavy growths at virtually every one of the hundreds of miles of streams photographed.

Algae and Vascular Plants

In some areas in the Shenandoah streams there have historically been healthy growths of underwater grasses and other vascular plants. In Figures 22 through 24 are photos of heavy algal growths on the surface of these vascular plants and throughout these plant beds. In some cases, it is evident from the photographs that dead and dying vascular plants have been covered by algal growths.

More discussion of this issue is presented in Sections VII.F. and X.

V. Transect Data

During 2012, personnel working with Riverkeeper conducted a systematic study to characterize stream bottom conditions in the Shenandoah River, the North and South Forks of the Shenandoah, South River and North River. This study revealed extremely high substrate coverage by periphytic algae in many areas during the months of June and July of 2012. These data are representative of patterns throughout stream segments where the transects were sampled and, given similarities in environmental conditions and observations between these segments and larger segments of the streams represented, are arguably indicative of the wider stream conditions.

The SRK researchers used a square frame of fixed area (see photograph A1027) at every sampling point and placed this frame at, generally, ten evenly distributed locations across a stream transect. They visually assessed the percent coverage of attached algae within the frame at each sampling point. The exceptions to the sampling of tens sites were made when, for example, the water depth prohibited sampling at a particular spot on a certain occasion. For each of the stream segments, which ranged in length from 3 - 6 river miles and wherever possible, given physical conditions, divided into transects 0.25 miles apart.

This method of transect sampling is similar to ones outlined in documents such as the Stream Periphyton Monitoring Manual (Biggs and Kilroy 2000) (See also: . The transect sampling program fits into the category described as a resource survey, which is designed to "establish general patterns of periphyton biomass and composition in time and/or space. Such data can then be used for desk-top assessments in discussions of possible changes to water resources/landuse management regimes, classification of waterways according to degree or type of human impact, etc."

Because the primary objective of this sampling was to see whether algae growths would qualify as nuisances or be termed "undesirable" by recreational river users, many of the aspects that might be important for other studies of benthic algae were not needed in this case. For example, while taxonomic descriptions of the types of algae present would certainly be necessary to meet the objectives of some studies, such information would be of little use here. The SRK study aimed to determine the overall nature and percent coverage of stream transects and the use of general descriptive terms such as "filamentous" or "thick mat" and notations of the color of algae, as contained in the monitoring reports (Appendix C), are fully sufficient.

Biggs and Kilroy (2000) list transect sampling under what they term as "rapid assessment protocols" and note that some such programs are "specifically designed for assessing compliance with the periphyton guidelines for cover to protect aesthetic, recreational and fishing values." (citing: Biggs 2000a). The following description of "rapid assessment protocol 1" by Biggs and Kilroy (2000) is a relatively accurate description of the methods used in the SRK study:

> *This method involves setting up transects across a site and recording the percentage cover of filamentous algae > 3 cm in length for a given number of quadrat points. Percentage cover values for the individual points are then averaged to obtain an estimate of the average cover of the site by*

filamentous green/brown algae. These individual records can also be used to later construct a map of the distribution of filamentous algae and, if repeated sampling is performed, then changes in the distribution of mats or patches of these algae can be traced over time. Such analyses, if combined with some physical measurements (e.g., shading, water velocities, depths and/or substrate composition), can provide useful insights into the primary factors controlling the local development of proliferations.

Aside from limiting the types of algae to filamentous forms of > 3 cm in length, the SRK program is entirely consistent with that described.

Figures 25, 26, and 27 show locations of the stream segments where the sampled transects are located within the Shenandoah River watershed. Researchers sampled three segments on the South Fork and two on the North Fork of the Shenandoah. The North Fork segments covered areas within river miles 11 - 17 and 83 - 86. The South Fork segments covered areas within river miles 18 - 21, 32 - 37, and 75 - 80. For the mainstem Shenandoah one segment stretching from river mile 22 to river mile 27 was monitored and for the North and South Rivers the segments covered river miles 0 - 4 and 1 - 4, respectively.

The results of the transect surveys are contained in Appendix C to this report and Appendix D shows spatial representations of the algal % cover results. Table 1 shows the mean values for percent cover by benthic algae for each stream segment and date monitored.

The results show particularly high mean values on the most upstream segment on the North Fork [NF RMs 83-87], with values of 31% and 35.1% algal coverage for all transects in late June and early July of 2012, respectively. Figure 28 shows a representation of these observations and reveals that, of nine transects where algal cover was measured in the July 12, 2012 sample run, almost all transects had very high percent cover across 60 - 100% of the stream's width. For transect 3, all measurements showed at least 70% coverage.

Table 1 also shows that in at least one sampling period for each segment, two areas on the South Fork [RMs 18-21 and 32-37] had especially high mean values. Likewise, the segment near the mouth of South River had an overall mean coverage of 30.8% on June 16, 2012.

While these mean values are of some value in characterizing conditions in these streams at certain times, more detailed views of the distributions of results are required, because mean calculations are not fully appropriate for situations like those we are trying to represent here. Mean values are most useful in understanding the nature of a sample population where the data are normally distributed, however the variability in stream substrates and other factors that affect plant growth in streams causes an inherent "patchiness" in distribution and a large degree of variability through time.

As explained by Hynes (1966):

A notable feature of plant communities is that they do not occur everywhere; there are nearly always bare areas due to scour, periodic drought or other factors, and the individual patches of plants expand and contract and move around. . . . This sort of impermanence is one of the

reasons for the rapid and often spectacular changes shown by the plant communities of running water. Undoubtedly the general stability of the river bed and the amount of fluctuation in current play and important part in the life of river weeds. . . . The algal community of rivers is essentially sessile, it grows on solid bodies and can develop only where these are present; in places where the substratum is soft mud it can grow only on weeds or hard parts of the bank.

As explained by Biggs and Kilroy 2000, "the degree to which our 'sample' represents the 'whole' of what we are interested in is a function of the number of samples we take in relation to the degree of variability (or patchiness) of communities or populations." To gain a true picture of the effects of algal growth on the Shenandoah streams, a more detailed examination of growth patterns than that which can be gained by looking at averages for entire segments is necessary.

For example, while the overall percent coverage in the most upstream segment in the South Fork on July 17, 2012 was only 18.1%, Figure 29 shows that certain transects within that segment had extraordinarily high degrees of bottom growth. Transect 6 has coverages of from 50 - 90% in 9 of the 10 samples taken that day, for an average of 63% coverage in this section of the stream. Also, in the North Fork on June 29, 2012, the overall percent coverage is 21.1% but in a number of the transects coverage was much higher (Figure 30).

Table 1

Stream Segment	**Date**	**Segment Mean % Cover**
Shenandoah R. [MS RMs 22-27]	June 20, 2012	2.9
" "	July 11, 2012	6.5
" "	July 25, 2012	2.5
North Fork Shen. [NF RMs 11-17]	June 15, 2012	23.2
" "	June 29, 2012	21.9
" "	July 16, 2012	25.2
North Fork Shen. [NF RMs 83-86]	June 26, 2012	31.0
" "	July 12, 2012	35.1
" "	July 26, 2012	0.4
South Fork Shen. [SF RMs 18-21]	June 21, 2012	39.0
" "	July 10, 2012	13.0
South Fork Shen. [SF RMs 32-37]	June 14, 2012	42.2
" "	June 27, 2012	10.5
" "	July 15, 2012	11.5
South Fork Shen.[SF RMs 75-80]	June 13, 2012	4.1
" "	June 28, 2012	10.2
" "	July 17, 2012	18.2
North River [NR RMs 0-4]	June 23, 2012	15.1
" "	July 9, 2012	11.5
" "	July 23, 2012	9.3
South River [SR RMs 1-4]	June 16, 2012	30.8
" "	July 2, 2012	16.7
" "	July 14, 2012	4.1

VI. Water Quality Goals

The water quality requirements set by the Clean Water Act ("CWA" or "the Act"), though necessarily interpreted in legal contexts, also reflect qualities by which scientists routinely judge the health of water bodies. Though terms used in the scientific literature may differ in some aspects from those used in the law, the concepts behind the terms used in the Act are consistent with those used by water quality scientists and ecologists.

Congress stated that the Act's objective is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." This focus on the "integrity" of water bodies emphasizes the fact that for environments to be truly functional and sustainable they must be maintained so they continue to work as integrated systems. Those systems that most closely approximate "un-impacted" conditions (where there has been very little or no anthropogenic disturbance) are likely to have the highest levels of integrity. Biological integrity, for example, has been defined as "the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region" (Karr and Dudley 1981).

The CWA also requires that uses, both human and ecological, must be fully supported and sustained to fulfill the law's purposes. As one authority has stated, "drawing a sharp line between the human and natural realms serves no purpose when our imprint is as ancient as it is pervasive" (Western 2001). Humans have evolved alongside natural features such as streams and can use streams to supply basic as well as recreational and aesthetic needs in ways that do not destroy the basic nature and structure of the systems. A healthy ecosystem will support reasonable, beneficial human uses and the impairment of such uses indicates that the integrity of that system is also likely to be impaired (Carlisle et al. 2013).

In sum, if a stream doesn't fulfill its purposes - as a sustainable home for plants and animals; a resilient whole, designed by time and ever-evolving to handle natural changes; and a resource suitable for beneficial human uses - then it lacks those characteristics that make it a "healthy" body of water. Virginia's water quality standards contain both narrative statements and, for some parameters, numeric measures of required quality. In this report we compare the narrative guidelines in the standards to conditions in Shenandoah River watershed streams and, thereby, decide whether these streams meet the kinds of technical measures that make them "healthy" streams.

The foundation of water quality standards is the designation of reasonable and beneficial uses, including the maintenance of healthy communities of plants and animals, that must be possible in each water body. Where necessary to support those uses, officials must develop specific measurable "criteria" to make it easier to know when there's a problem but, regardless of such technical analyses, the bottom line is the same - that the streams still be useable for reasonable purposes. The criteria must be measurable in some way (either quantitatively or qualitatively - or usually both) to be meaningful. Both types evidence are routinely and necessarily collected and used by scientists to assess water body health and each is fully valid, when applied in the correct context.

Virginia's water quality standards regulation contains a number of requirements that are pertinent to our study of excessive algal growth in the Shenandoah River system.

A. **Uses designated for all streams in Virginia include**: "**recreational uses**, e.g., swimming and boating; **the propagation and growth of a balanced, indigenous population of aquatic life**, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish." 9VAC25-260-10 (emphasis added).

B. "**State waters** . . . **shall be free from substances** attributable to sewage, industrial waste, or other waste **in concentrations, amounts, or combinations which** contravene established standards or **interfere directly or indirectly with designated uses of such water** or which are inimical or harmful to human, animal, plant, or aquatic life." 9VAC25-260-20.A. (emphasis added).

C. "**Specific substances to be controlled include**, but are not limited to: floating debris, oil, scum, and other **floating materials**; toxic substances (including those which bioaccumulate); **substances that produce color**, tastes, turbidity, **odors**, or settle to form sludge deposits; **and substances which nourish undesirable or nuisance aquatic plant life**." 9VAC25-260-20.A. (emphasis added).

D. "All surface waters of the Commonwealth shall be provided" a level of protection which maintains and protects "existing instream water uses and the level of water quality necessary to protect the existing uses." 9VAC25-260-30.A.1. (emphasis added).

To make a technical determination as to whether Shenandoah watershed streams meet these required levels of quality, the following questions are answered in this report.

✦Do these waters exhibit unnatural colors?
✦Do these waters exhibit unnatural odors?
✦Are there unusual floating materials present in these waters?
✦Are there forms of undesirable or nuisance plant growths in these waters?
✦Does the quality of these waters interfere with the recreational uses, including aesthetic enjoyment?
✦ Does the quality of these waters interfere with the maintenance of balanced, healthy aquatic communities?

VII. Comparison of Data to Water Quality Goals

The following sections A. through F. discuss the evidence of conditions occurring in Shenandoah valley streams, to answer each of the questions posed in Section VI. After the individual categories are addressed, the temporal and areal coverage of conditions is described.

In discussing its response to citizen complaints regarding excessive algae growth in the Shenadoah in 2012, the Virginia Department of Environmental Quality ("DEQ") has stated its views as to the nature of data that will be sufficient to determine whether a water quality impairment exists or not (VADEQ 2014b):

> *Waters that do not meet Water Quality Standards due to a pollutant(s) may be listed as impaired. "Pollutant" is defined in Federal law and either narrative or numeric water quality standards may be used to list waters as impaired. However, an "impaired" designation can only be made based on specific and objective monitoring data, in terms of location, extent, and duration, as well as an accepted, scientifically valid assessment method that compares monitoring data to water quality standards or criteria.*

While this statement acknowledges that violation of narrative standards may qualify a water body for an "impaired" designation, the Department's approach to the data citizens have submitted for excess algal growths seems to betray an unwillingness to do so. The assertion that "objective monitoring data" is required, when there are subjective aspects to the criteria in the WQS regulation, substitutes the staff's judgement for that of the State Water Control Board, the body empowered to establish these regulatory requirements. This failure to take the narrative requirements seriously is especially problematic, since the DEQ has so far refused to adopt the kind of objective (numeric) criteria they claim are necessary to control nutrients and algal problems.

Further, the Department's stance, that citizen observations of stream features that are readily and accurately assessed by human senses fail as "scientifically valid assessment method(s)," is simply technically and practically wrong. The agency derogates public comments as "largely anecdotal," despite the fact that many of those comments include specific descriptions of the problems encountered and the ways those problems interfered with human uses (and in some cases aquatic life uses-such as algal growths covering and replacing vascular plant beds).

In many cases, including a number of those quoted in this report, the citizens name exact locations where they've observed problems. (e.g.: C1 - "floating globs of algae nearly fill the river at my house," C68 - "slime that clung to the rocks was clearly evident and . . . noxious odors" at "the low water bridge at Bentonville"). In many other cases comments name a particular stretch that is commonly traversed by boaters and describe conditions with a significant degree of detail. Some commenters cite exact dates (see e.g.: C24 - "water [that] has an odd dark greenish color that seems almost like it could glow in the dark . . . on 4-15-12," C69 - the "weekend of July 19th and 20th [2014] . . . smelled the algae and saw the slimy floating clumps"), while others described longer periods of time within which they had observed algae nuisances on numerous occasions. Finally, some to the people who submitted testimony cited and quoted from the detailed fishing logs they maintain, in a demonstration of systematic data gathering (e.g.: C47).

While these types of citizen reports might be dismissed as merely anecdotal if there were only one or several of them and the commenters attempted to claim a specific sighting represented the conditions of entire streams, such is not the case here. Along with dozens of descriptions of specific problems at specific places and times, the statements include those by river users who describe long-term observations and are able to describe changes over time in some detail. Further, as noted above, the observations were primarily statements of fact, not assertions that commenters' scattered perceptions qualified them to make scientific conclusions for which they are unqualified.

It is very important to recognize that the type of monitoring that is most appropriate for any situation is determined by the nature of the subject under study and the degrees of precision necessary to make valid and usable findings. Virginia DEQ officials seem to assert that only persons with scientific training in the use of specialized equipment, in sampling of water, sediments, or fish, or in the conduct of benthic macroinvertebrate studies may contribute useful and necessary information for use in determining the quality and status of waterbodies. This position is not supportable.

Visual assessments of water bodies are used by all scientists, including those at the DEQ, and often provide data that are as or more important than the concentrations of pollutants or taxonomic identifications. As rightly noted by the DEQ, and as confirmed by the author's experience, when identifying the cause of a fish kill, "notations on conditions at a kill site and the affected species may often be as helpful to the diagnostician as samples sent to the lab." (VA DEQ 2002). The exact types of data that are pertinent to assess compliance with most the narrative criteria are ones that any water user can provide.

The existence of unusual color, odor, or floating materials in a stream do not require special expertise and the testimony of dozens of people, many who have frequented these streams for decades and with great frequency, is sound evidence of these conditions. Whether these same river users have avoided use of these waters or have had their uses impaired is a question that only they can answer. Whether algal growths are undesirable or reach "nuisance" levels are subjective questions but the evidence shows that there is close agreement amongst citizens of various regions who have been surveyed, authors in the scientific literature, regulators in other states and nations - and the dozens of frequent Shenandoah River users who have given their opinions to the DEQ.

The one question that does require scientific expertise to determine whether a portion of the water quality goals is violated, is whether "the quality of these waters interfere with the maintenance of balanced, healthy aquatic communities." Lay observations are of value here even here, especially when made systematically, but must be interpreted, along with other data, by experts before sound conclusions can be made. That recreational users' observations can be valid sources of information upon which to base scientific findings is clearly demonstrated by the common use of creel surveys by fisheries experts or census reports from birdwatchers by avian researchers.

As explained below, an examination of the evidence available to the State of Virginia in 2012, in light of the scientific literature on the nature of streams that exhibit the kinds of growth

described, supported a positive response to the question about the biological integrity of these streams as well as the other questions posed. There is no evidence, however, in the public record that the DEQ conducted such an analysis.

Over two-thirds of the comments accompanying this report were also submitted to the DEQ for consideration in the 2012 Integrated Report's preparation. As discussed in regard to each of the subject areas below in this Section, those reports were fully adequate to assess compliance with all but one of the water quality goals we identified in Section VI.

Because the evidence provided in 2012 supported designation of the Shenandoah River and its tributaries as "impaired" in 2012, the Department's failure to do so then and EPA's failure to override Virginia's decision are not supported by the technical record. Despite the fact that the citizen testimony should have met the threshold test for designation as "impaired" for recreational and aesthetic uses and should meet it even more strongly now, with additional statements in the record, SRK decided to provide the additional and extensive evidence contained in and submitted with this report. The expert opinions, photographs, videos, and results of transect analyses only amplify and make even more overwhelming the scientific and technical case, proving that excessive algal growths cause violation of at least six separate provisions of the Virginia WQS regulations.

The determinations for each of the conditions examined below depend on either objective or subjective evidence. Of course, scientists depend heavily on objective standards to assess the quality of streams and in almost all of the categories discussed here there are measurable, reproducible methods for making these determinations. Only in one of the categories, whether excessive plant growths produce "undesirable" or "nuisance" conditions, are subjective standards used. Even in this category, however, scientists routinely make such determinations, as demonstrated by the published literature.

This kind of common understanding and definition of terms displayed by water quality experts, even on matters where precise measurements may not be easily made, is not only possible - it is common. While any one individual's perceptions of what is undesirable or is a nuisance is subjective, the opinions of a group of people, such as water quality scientists, who are very familiar with a range of situations and who regularly exchange information and opinions within their field of expertise can be relied upon and used to make substantive decisions as to when problems exist and action is needed to address them.

Water pollution experts have recognized for more than fifty years that subjective terms were necessary to the definition of problems and protection of our water bodies. In the foundational 1963 work, "Water Quality Criteria," McKee and Wolf (1963) defined parameters used to determine when certain human uses were supported. Among their definitions:

> *To be acceptable to the public and the regulatory authorities, waters that are used for swimming and bathing . . . must be esthetically enjoyable, i.e., free from obnoxious floating and suspended substances, objectionable color, and foul odors. . . .*

Conditions of water quality that affect boating and esthetic enjoyment are . . . heavy growths of attached plants or animals; blooms or high concentrations of plankton; discoloration or excessive turbidity . . . .

McKee and Wolf (1963) also offer descriptions of the ways that so-called "inferential" or "circumstantial" information from citizens has historically been valued in making important decisions about water quality. When "non-technical" assessments are credible and pertinent, judges and citizen juries have often valued the opinions of "non-technical" people in such cases. One such case from 1937 is especially pertinent to the kinds of problems faced in the Shenandoah. As recounted by McKee and Wolf (1963):

In Albough v. Mt. Shasta Power Corporations (1937) 9 Cal. (2d) 751, 73 Pac (2d) 217, the circumstantial evidence of the growth of weeds, the foul odor that emanated from a pool, and the preferences of cattle and horses for other bodies of water were sufficient to cause the jury to conclude that the water was in fact polluted.

As to the effects of these changes in condition of the water body, the California Supreme Court, as quoted in McKee and Wolf (1963), noted that "[t]wo chemists were produced who testified that from a chemical analysis the water in the pool was fit to drink" but the Court also observed that "[v]arious witnesses for respondents testified as to the preference of cattle and horses for other fresh and nonstagnant water" and "[s]everal witnesses living on the pool testified that in the years since the diversion they have never seen cattle drink from the pool." The Court upheld the juries factual interpretation of the evidence.

Thus, as to matters of fact about whether real conditions in a water body in fact caused users (in this case cattle and horses) to avoid using the water for beneficial and desirable purposes, the subjective opinions of the users (the animals) as manifested in their behavior was determinative for the jury. That the Court upheld the factual findings of the jury in this case over the chemical evidence is not a rejection of sound, scientific methods. This decision simply shows that both the jury and the Court recognized that subjective qualities may be as or more important than those we can measure objectively, when suitability for certain uses is decided.

The authors of EPA's Water Quality Criteria, upon which Virginia's narrative standards are based, forcefully expressed the importance of those attributes the DEQ and the EPA have been asked to acknowledge and protect in this case. "Aesthetic qualities provide the general rules to protect water against environmental insults: they provide minimal freedom requirements from pollution; they are essential properties to protect the Nation's waterways." (U.S. EPA 1986, emphasis added).

After all, it is exactly these kinds of problems that motivated citizens to rise up and demand better protections and that led to adoption of the Clean Water Act. People complained not of parts per million of phosphorus or nitrogen but of water that smelled bad and was ugly; conditions where they were afraid or too repulsed by conditions to swim or boat.

In light of the high priority EPA apparently placed on these factors and the importance they hold for the general public, it is not credible to suppose that the Agency would have set a

criterion that was unusable - whose implementation would be "unscientific" and betray the dedication they'd shown to the scientific methods scientists had used in developing the many numeric criteria established in the same document.

Of course, water quality experts are not the only people who form common understandings about the subjective nature of resources and use common language as to the desirability of water bodies for recreational and aesthetic uses. The opinions of experienced fishermen, boaters, and guides and the ways they characterize conditions are part of a common understanding. The fact that dozens of river users quickly adopted the term "rock snot" to describe algal growths in the Shenandoah streams, shows that their perceptions could easily be summed-up in a term that could be understood by all.

As noted by Kain 2012, "blue-green algae mats" such as DEQ officials had seen floating in the North Fork Shenandoah River, "are quite often mistaken for sewage, due both to appearance and odor," both of which Kain described as "definitely nasty" People readily use descriptions of known entities and sensations to describe things they cannot quantify or precisely label. At a minimum, it seems that a water body where conditions are described as "nasty" by DEQ officials or one where citizens "often mistake" the products of heavy algal growth for sewage must meet anyone's definition of "undesirable" or as a "nuisance."

A. Unnatural Colors

Do these waters exhibit unnatural colors?

The perception of color is central to the basic human sense of sight and the vast majority of humans can readily perceive when the waters near where they live and on which they recreate are relatively "normal" or not. This is a question that can be answered objectively and, while certain types of electronic instruments can provide quantitative measures of color, the human eye is the most appropriate instrument for measurement when the uses to be protected are human recreational and aesthetic uses.

Whether the color present in the water column obscures the bottom and makes wading and swimming dangerous or scary is a question that the eye of the potential user must answer. Likewise, whether the water's color deters a potential user from fishing, because he or she cannot see a lure or the locations of habitat or fish underwater, is not a complex scientific question but one people who fish must answer. And people have answered these and other questions about how color affects their use of Shenandoah watershed streams. Forty of the commenters whose submittals are attached to this report specifically cited unusual colors in the streams as deterrents to their uses.

Kelble (Section X) notes that "when the planktonic/pelagic algae blooms in the river it turns a thick pea green color and fish become lethargic, they don't' find food effectively because they can't see and they reduce their feeding" and "when a planktonic bloom colored the water and decreased visibility there was no chance to see fish and narrow your search, observe their habitat or even to sight fish specifically to an individual fish."

Both scientists and members of the general public naturally compare the color of a stream they encounter to that in another part of the same stream or to a similar stream that is known to be in a relatively un-impacted state. The comparison of water body conditions with those in "reference" streams is a widespread and accepted method of assessing water quality. (See e.g.: U.S. EPA 2000; Dodds and Welch 2000) When conditions in a certain location are worse than those in one of these "reference" or "un-impacted" waters, then pollution problems may be assumed to be present - as long as the reference water body is truly close enough in type and underlying conditions to make the comparison valid.

It is true that, in some waters, organic materials or naturally-occurring minerals produce distinct colors. However, under natural conditions the water column of streams such as those in the Shenandoah valley streams have little or no color. The author of this report is aware of no stream in Virginia, or indeed in any part of the Southeastern or Mid-Atlantic regions of the U.S., where the kinds of colors shown in Figures 1 through 8 could possibly be considered to be "reference" conditions. In fact that these colors found in numerous locations in the Shenandoah watershed are not just marginally different from those in other streams in the region, they are startlingly different.

As stated in Section II, at least 40 of the comments received cited color in the water column as a problem that affected their use of the Shenandoah streams. That such colors exist, and over a wide range of areas, is easily determined by looking at Figures 1 - 8, which show conditions on the mainstem, at river miles 0, 22, and 39; on the North Fork at river miles 10 and 84; and on the South Fork at river miles 48 and 82.

Kelble's expert testimony describes color problems in "one of the worst sections of the North Fork . . . between Broadway and Timberville [NF RMs 83-86]" where he states: "Repeatedly our observations in this section of river has shown extremely off-color water, green from a nearly continuous planktonic/pelagic algae bloom."

That the descriptions of colored water given by commenters and those shown in the photographs submitted with this report match those from many other sources describing and warning of planktonic blue-green algae blooms, in the scientific literature, in news media, and in communications from government agencies (See Part F of this Section), can only lend added credibility and weight to complaints that were fully proven in 2012.

B. Unnatural Odors

Do these waters exhibit unnatural odors?

This is another question which can easily be answered with objective evidence and for which human senses are the best instrument of measurement. Note that, when detectable levels of odor are tested for in water and wastewater, a premier authority in such procedures cites "difficulties in testing for odor, including the fact that most odors are too complex and are

detectable at concentrations too low to permit their definition by isolating and determining the odor-producing chemicals." (APHA 2012)

This same authoritative reference, Standard Methods for the Examination of Water and Wastewater, proposes Method 2150B, "the threshold odor test," for determining odor thresholds in drinking water. Thus, in preferring human olfactory powers over laboratory methods, APHA (2012) verifies that people's noses can meet the definition of "an accepted, scientifically valid assessment method that compares monitoring data to water quality standards or criteria." (VA DEQ 2014b)

Sixty commenters specifically mentioned and described the odors they had encountered in using one or more of the Shenandoah streams. Many of the comments submitted with this report confirm the note in Kain (2012) that floating algal mats in the Shenandoah streams are often mistaken for sewage, due both to the odor and appearance of the mats. Some examples:

* "the clumps had a sewage-like stench" (C7);
* "numerous clumps of foul-smelling algae—this section of the river smelled like an outhouse" (C31);
* "this algae smells like sewage or rotting broccoli" (C16);
* "The algae had started to rot and the odor was horrible. It smelled like a combination of untreated human waste and a decaying body. The smell carried 1/3 of the way across the river; it took a long time for the smell to get out of my nostrils" (C60);
* "this algae piles up into giant greenish brown mats. The smell is horrendous as if a dead animal carcass was encased in it." (C26).

Some of those who have complained of such odors described specific ways in which their uses of the waters had been impaired or prevented:

* "I have a Labrador retriever that absolutely loves the water. He'll go in the river all year long to swim and drink. Many times, he'll stink afterwards from getting algae in his fur. I always have to give him a bath after taking him to the river. Sometimes he'll also throw up from drinking the river water." (C40);
* "the algae presents a foul odor (somewhere between sewage and a dead animal) such that you do not want to be on the river in a canoe or along the banks. . . . The older boys asked what was wrong with the river, when they smelled the algae and saw the slimy floating clumps during a brief canoe trip" (C69);
* "During the summer one unfortunately has to check first for the presence of green algae clumps to determine if the river experience will be worth pursuing. These clumps smell terrible and are a strong indicator for my family and me to avoid recreating on or in the river. (C74)

Apparently DEQ and EPA did not consider such a compilation of reports from river users submitted in 2012 to constitute valid or sufficient data against which to compare that part of the narrative WQS, which states "Specific substances to be controlled include . . . substances that produce . . . odors." As stated above, the presence or absence of odors is an objective matter. Dozens of citizens and a number of river recreation experts have complained of the odors and their complaints are supported by a DEQ official (Kain 2012). There are no evident reasons to

question the honesty of these many commenters nor are there reasons to think their senses of smell are defective. Therefore, violation of the WQS against odor in Virginia's water bodies is clearly proven.

C. Presence of Floating Materials

Are there unusual amounts or types of floating materials present in these waters?

This is another simple, objective question that is answered routinely by scientists performing stream studies or investigating pollution complaints. Both qualitative and quantitative measures can be used in this analysis and non-scientists who are avid and frequent river users are just as able to make conclusions, in many cases, as are technical experts.

The citizen testimony on this issue shows that commenters have observed unusual floating masses in the Shenandoah watershed streams on many occasions and in many locations. The expert opinions, both recreational and scientific, agree with the information provided by other river users. The photographs strong support the citizen testimony.

Further discussion or exhaustive presentation and analysis of these sources is unnecessary. **The answer to the question "Are there unusual amounts or types of floating materials present in these waters?" is a strong and unequivocal "Yes."**

D. Undesirable or Nuisance Plant Growths

Are there forms of undesirable or nuisance plant growths in these waters?

As stated above, and as noted by the Virginia DEQ (DEQ 2014b), findings of undesirable or nuisance conditions do depend on subjective judgements by humans. However, the DEQ's refusal to make judgements as to the presence or absence of such conditions cannot be based on a lack of reliable and defensible guidance and information in the scientific or regulatory literature.

The Department states in the current draft Integrated Report (DEQ 2014b), that "an 'impaired' designation can only be made based on specific and objective monitoring data." This assertion is clearly wrong. Virginia law sets a criterion that is subjective. To assert that a measure of quality against which conditions are to judged, whether legally or scientifically derived, may be set in subjective terms but that decisions as to whether water bodies meet that measure cannot validly be based on subjective evidence is nonsensical. Researchers are continually striving to develop standards of ecosystem health and water quality that are more easily measurable and reproducible. However, these efforts will always require subjective judgements.

The DEQ further states that "the terms 'undesirable and nuisance' . . . require interpretation" and implies that without "numeric thresholds" such interpretations may not be made in a way that is scientifically valid and defensible. "The fact that there is no widely

accepted, objective threshold by which "nuisance" conditions caused by excessive algae may be judged has certainly not deterred respected authorities in the field from using the term and declaring that "nuisance" algal growths exist under certain circumstances. An abundance of journal articles and contributions to scientific treatises demonstrate as much.

The following references are just a small sampling of published sources using the term and confidently defining or describing conditions that meet that threshold: Neil 1957; Horner et al. 1983; Lembi et al. 1988; Welch et al. 1988; Berlind 1992; Dodds and Welch 2000; Paerl et al. 2007; and Matheson et al. 2012; Stevenson et al. 2012. One representative definition, from Berlind (1992): "Algae levels can be considered a nuisance if the algae interferes with some aspect of recreational, commercial, or natural use of the river. This interference can be purely aesthetic or have some more tangible physical effect."

Regulatory bodies in numerous jurisdictions also have not shown the kind of timidity that the Virginia DEQ has exhibited. The Saskatchewan Ministry of the Environment has stated that "certain aquatic plants and animals can be called 'aquatic nuisances' when they become present in sufficient numbers to pose problems for people or animals using a water body or its surrounding environment." (Saskatchewan Min. of Envir. 2002)

By commissioning a study to assess the levels of algal coverage in stream beds that the public found unacceptable (Responsive Mgt. 2012), the West Virginia Department of Environmental Protection clearly signaled that the Department felt and accepted the responsibility of making regulatory decisions as to the levels of algal growth that were undesirable or rose to "nuisance" status." Likewise, personnel from the Montana Department of Environmental Quality cited the body of scientific literature seeking to define "undesirable or nuisance level[s] of aquatic life in a water body" and decided that "some type of assessment of the public's opinion on the matter is clearly warranted." (Suplee et al. 2009)

New Zealand's Ministry for the Environment released "guidelines for the control of undesirable biological growths in water (MfE 1992). These guidelines included nuisance plants (phytoplankton, benthic algae (periphyton) and macrophytes) and were provided for different waterbody types including lakes, rivers/streams and estuaries" in 1992 and again in 2000.

Having dispensed with the idea that subjective decisions as to whether Virginia's narrative criterion prohibiting levels of pollutants in waterbodies "which nourish undesirable or nuisance aquatic plant life" cannot be validly made, the judgement as to whether such conditions exist in the Shenandoah River and other major streams in the watershed is relatively easy to make. Using the body of evidence presented in Sections II, III, IV, and V of this report the answer to the question "Are there forms of undesirable or nuisance plant growths in these waters?" is clearly and undeniably "Yes." The analyses in parts A., B., C., E., and F. of this section (VI) support this conclusion in an overwhelming fashion.

To reinforce this conclusion even further, we refer to transect analyses described in Section V. of this report. As noted, this type of survey of stream bottom coverage by algae has been conducted by numerous parties.

After determining the percent coverage of various stream stretches, parties working on behalf of the West Virginia Department of Environmental Protection surveyed about one thousand individuals, for a population determined to provide a valid representation of all West Virginians 18 years old or older. (Responsive Mgt. 2012) While the West Virginia study broke responses down into categories, based on the types of activities for which respondents used rivers and other factors, the survey report found that, over the entire population of respondents, views with 26 percent bottom coverage were "unacceptable" to nearly half of respondents (49%) and concluded: "This suggests that waters with any more than a quarter coverage will be unacceptable to a majority of residents. (Ibid.) As one would expect, at higher percent cover levels those finding conditions unacceptable was also higher. Seventy-one percent (71%) of those surveyed found 39% coverage unacceptable; 87% found 47% unacceptable; and 90% found 65% bottom coverage by algae to be unacceptable.

The results of the West Virginia study are particularly suitable for comparison with conditions in the Shenandoah Valley, addressing streams and stream users from the same region of the country and with many similarities in environment, culture, and preferences. Therefore, the overall threshold derived by the West Virginia surveyors is appropriately compared to the transect sampling results obtained by SRK.

Given that the most precise level of bottom coverage averages that can be applied across all segments is likely at the individual transect level or at an even smaller scale due to variability in stream conditions, as discussed in Section V, the mean values for each of these transects have been examined to see how many are equal to or greater than a threshold value of 26% and of the higher percentage coverage levels. The results of this comparison show that at many points the stream bottom coverage greatly exceeds the 26% level.

Table 2 shows results by stream segment and date sampled and reveals that only one of the eight stream segments sampled for percent algal coverage, on the mainstem Shenandoah, failed to exceed West Virginia's lowest threshold level. In fact, for every other segment, on the North and South Forks as well as North River and South River, the higher percentage threshold of 47% coverage (at which 87% found views unacceptable) was exceeded a least once. These results, combined with the data discussed above, indicates that undesirable or "nuisance" conditions are present throughout the Shenandoah watershed. The fact that heavy coverage was not found in the mainstem during June and July sampling does not indicate that high percent coverage does not occur here, though, because the photographic and witness evidence proves otherwise. This absence, as well as the absence of high cover in some other segments sampled, seems more likely to be related to the time of year and/or other factors. For example, that the South Fork segment between river miles 32 and 37 had drastically different results between samplings on June 14, 2012 and June 27, 2012.

Table 2 - Stream Bottom Algae Coverage

Stream Segment	Date	# of Transects Sampled	# ≥ 26%	# ≥ 39%	# ≥ 47%
North Fork Shen.					
(RMs 11 - 17)	6/15/12	22	10	2	1
	6/29/12	23	6	5	3
	7/16/12	21	10	7	6
(RMs 83 - 86)	6/26/12	10	6	4	2
	7/12/12	10	6	4	4
	7/26/12	5	0	0	0
South Fork Shen.					
(RMs 18 -21)	6/21/12	9	4	4	3
	7/10/12	10	3	2	1
(RMs 32 -37)	6/14/12	9	7	6	5
	6/27/12	12	1	1	0
	7/15/12	11	2	1	0
(RMs 75 - 80)	6/13/12	5	1	0	0
	6/28/12	11	0	0	0
	7/17/12	12	4	3	1
Main Stem Shen.					
(RMs 22 - 27)	6/20/12	17	0	0	0
	7/11/12	9	0	0	0
	7/25/12	2	0	0	0
North River					
(RMs 0 - 4)	6/23/12	18	4	4	1
	7/9/12	19	2	1	1
	7/23/12	7	0	0	0
South River					
(RMs 1 - 4)	6/16/12	14	5	4	3
	7/2/12	16	4	3	1
	7/14/12	13	1	0	0

E. Interference with Recreational Uses

Does the quality of these waters interfere with the recreational uses, including aesthetic enjoyment?

When river users say they have decided not to use a river or that conditions interfere with their traditional and habitual uses of the waters, then their testimony must be respected as a statement of fact, unless there is reason to believe their representations are untrue. More than 120 users, 8 of whom are river recreation experts, have testified that stream conditions related to excessive algal growth have interfered with their uses or eliminated them altogether.

All of the evidence discussed in section A. through D. above must also be considered in answering this question and must compel a positive response. "Noxious" and "nasty" odors, colors that make it impossible to see the river bottom to wade or fish, and benthic coverage by attached algae that greatly exceeds criteria, based on scientific surveys, to term waters unacceptable for use, floating masses of decaying algae - there is no rational basis to dispute that these are conditions that would deter most people from using and enjoying a river.

Further, these are exactly the kinds of algae-related problems that have been universally described in the scientific literature. While the author could quote from reference after reference from the list in Section IX of this report, such an exercise seems unnecessary.

However, one additional issue that has not been previously discussed is pertinent here and important to address. Heavy amounts of blue-green algae have been found throughout the Shenandoah River, both in phytoplankton and in attached algae. Just one source of evidence is found in Appendix H to this report. The images included there are satellite images in which spectral reflective signatures of several substances in the North Fork Shenandoah River are shown. These images indicate concentrations of chlorophyll and phycocyanin (the pigment in blue-green algae or cyanobacteria).

The results of the spectral imaging show that, not only were the blue-green algae/cyanobacteria present throughout the 70 miles of the North Fork we evaluated, it was present at high levels. In comparison to the chlorophyll analysis we did, the values for phycocyanin, which is the surrogate for blue-green algae/cyanobacteria were often higher than chlorophyll. Blue-Green algae/cyanobacteria negatively affect the ecosystem, present a potential danger to river users if they are developing toxins, and diminish peoples' use and enjoyment, because they almost always lead to the kinds of results described in parts A. through D. above.

Beyond these physical and ecological impacts, blue-green algae are a deterrent to use of water bodies where they are found to "bloom," because people rightly fear that toxins may be present. While not all forms of blue-green algae produce toxins and even where those that do produce them high levels are not necessarily found at any one time, the threat exists, and the uncertainties make it even harder for citizens and officials to react safely and appropriately to blue-green blooms.

SRK has obtained lab results for samples collected from the Shenandoah River and both Forks in April and May of 2014 (Appendix I), showing that at least two types of potentially toxicity-producing cyanobacteria are present in the Shenandoah watershed. The laboratory reports for these samples state, in part:

> *Microscopic observation of the . . . Farmers Mill sample collected on 4/18/2014 revealed the dominance of the filamentous cyanobacteria Phormidium cf. favosum. Phormidium autumnale and P. favosum share many morphological traits and are mainly separated based on habitat, slight differences in average trichome width and frequency of sheath formation. P. autumnale is described from mesotrophic to eutrophic streams and rivers, and P. favosum mostly from cold, flowing waters on limestone substrates. The trichomes observed in this sample fit the description for P. favosum. Phormidium autumnale and Phormidium favosum are both potential anatoxin producers. Recommendations: Toxin analysis for anatoxin is recommended at this time.*

Based upon the laboratory's recommendation, samples were analyzed for toxins but found no detectable concentrations. Subsequently, testing has been done by personnel from the U.S. Geological Survey ("USGS") and detectable amounts of microcystin toxins have been found.

F. Interference with Aquatic Life Uses

Does the quality of these waters interfere with the maintenance of balanced, healthy aquatic communities?

The determination as to whether stream conditions in the Shenandoah River and its tributaries meet the requirement of supporting "the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them" is exactly the kind of scientific inquiry that stream ecologists make on a routine basis.

The Virginia DEQ has recognized that excessive algal growths may lead to certain impairments such as low dissolved oxygen and fish kills. However, the Department has failed to acknowledge a widely-recognized fact - that the presence of excessive and unusual growths of aquatic plants, including algae, represent an imbalance in the local ecosystem even if the known follow-on impacts are not present or measurable. The nature of algal populations in these streams can be compared to those in streams that are minimally affected or unaffected by high nutrient inputs and the extreme densities of certain types, such as those presented with this report, are not typical of "normal," or "un-impacted" streams in the region where the Shenandoah watershed lies.

"Blooms" of planktonic algae or very large populations of attached or floating algae are often the first step in producing the severe chemical and biological results. Whether the subsequent steps in degradation of water quality will result cannot necessarily be predicted based on the present of the blooms or excessive growths alone, because many other factors affect these outcomes. In fact, Voshell et al. 2000 stated, after they performed benthic macroinvertebrate

sampling throughout the watershed, that while conditions in the larger rivers were not yet affected in the same ways as numerous smaller streams by heavy nutrient loads that those larger streams would be so impacted if nutrient pollution continued.

That the scientific literature is replete with descriptions of the progressions that can occur, from heavy nutrient pollution, to excessive algal growth, to a plethora of outcomes is indisputable. Once of the prominent changes that are intimately connected with the changing populations of algae, in both density and diversity, is the change in vascular plant health and populations, which can have cascading effects on benthic animals, on nutrient cycling, and on sediment washout patterns in-stream.

Example sources discussing this type of effect are:

Balls et al. (1989), explaining that in response to "very large" crops of phytoplankton "submerged plant growth may dwindle, with subsequent loss of the plant beds" and noting that "this represents a major change of structure in the ecosystem;"
Irvine et al. (1989) noting that great increases in nutrient inputs to freshwater systems frequently lead to "a switch from dominances by submerged plant communities to dominance by phytoplankton and that "the mechanism of this switch is generally seen in terms of a set of relationships between nutrient availability and competition between the plants and the algae" (internal citations omitted); and
Brönmark and Vermaat (1998) "Eutrophication of shallow freshwater . . . ecosystems has often resulted in a drastic decline in the areal extension and biomass of submerged macrophytes and a concomitant increase in the biomass of phytoplankton. Light availability is usually the most important factor determining the distribution pattern, biomass, and production of submerged macrophytes and it has been suggested that increasing phytoplankton biomass due to higher nutrient input results in a reduction of available light to a level at which net photosynthesis by submerged macrophytes is impossible)." Other researchers suggest "that macrophytes may disappear even when the bottom is within the euphotic zone" but "increasing nutrient levels stimulate epiphyton growth, which has a negative effect on the macrophyte host through shading and competition for nutrients." (internal citations omitted)

Temporal Extent of WQS Violations

The problems with excessive algal growths and the consequences have persisted in the large streams within the Shenandoah River watershed on a yearly basis since 2007 or before. This window matches the stated coverage period for Virginia's 2014 Integrated Report.

Criteria which are designed to protect against negative impacts should have three dimensions:

* level of severity of a condition to avoid problems (e.g. concentration of a pollutant),
* length of occurrence allowed (how long can the condition exist for any one period?), and
* frequency of occurrence (how many times can this recur over a period of time without uses being impaired?)

The narrative criteria/general standards set in Virginia's WQS do not specify time components (either length of one occurrence or recurrence of key conditions). Therefore, these features of the WQS must be interpreted such that the conditions named are prohibited - "nuisance" or "undesirable" conditions due to algae may not be created, unnatural odors and colors may not be caused, etc.

The lengths of time that any problem algae growths exist and the locations where they are found are extremely hard to predict, because changes in stream flow, temperature, sunlight, and any number of other factors can cause accumulations to form and be dispersed. The key is that, if these excessive growths occur even once, the baseline conditions (amounts of nitrogen, phosphorus, etc.) that were needed to produce that "bloom" are very unlikely to disappear without intervention. Therefore, if algal problems severe enough to produce the kinds of narrative violations described herein have occurred at any time and are proven, then a designation of impairment is appropriate. Further, the creation of a situation where people are unable to use their wasters, even once, must be investigated and measures must be taken to prevent additional episodes.

In light of this analysis, the frequent and long-recurring excessive growths of various types of algae in many places in the Shenandoah watershed definitely meet the temporal requirements for an "impaired" designation.

Areal Extent of WQS Violation

The complex matrix of various algae-related problems identified on various sections of the Shenandoah River, as well as the North and South Forks, and other tributaries presents a picture of extremely heavy infestations of the mainstem, the North and South Forks, and North and South Rivers. While not all segments are plagued to the same degrees or at the same times by any one of the problems described and proven herein, more than one of the seven areas of violation of Virginia WQS is shown to reach nearly every river mile of the three larger streams. Because significant data is presented here for only the 4 miles nearest each of the mouths of

North River and South River, a judgment as to the degrees to which the remainders of these two Rivers are in violation of WQS would be premature.

To substantiate the extremely wide coverage of these streams by the variety of problems cited above (1-colors, 2-odors, 3-floating materials, 4-undesirable or nuisance growths, 5-interference with recreational uses, and 6-interference with aquatic life uses), series of maps have been prepared to represent the areal extent of just a limited sampling of the findings from the various assessment methods.

Although the evidence submitted in this report and attachments does show an extraordinarily widespread occurrence of algal problems on the stream segments where impairments have been found, it should be noted that standard proving the areal extent of problems required to designate larger stream segments applied to this survey effort is much more demanding than that applied in the DEQ's and the EPA's normal process for making "impaired" designations. Given that the excessive algal growths are biological indicators of stream health, in a way that can be compared to the representative nature of benthic macroinvertebrate surveys, similar rationales for setting the boundaries of "impaired" segments should be sufficient here. Benthic sampling is generally conducted on just one or a few sites within a relatively large stream reach and are held to represent conditions well beyond those sites. For example,

The Department's method for designating "Nutrient Enriched Waters," which the DEQ has followed in some circumstances, is just as strongly supported in these waters. Section 9VAC25-260-350. of the VA WQS regulations designated four waterbodies as "nutrient enriched" and in three of these four named waters, the dowstream bounday of the segments is set while the upstream extent of the waters affected is listed as reaching "all tributaries to their headwaters." Such an approach is technically and practically jjstified in the regulation and is just as well supported for the waters draining to the Shenandoah River. At least some of the contributors of the condtions causing excess plant growths can be expected to reach to any upstream waters where the nature of the streams and the influences exerted on those streams are similar.

Findings as to the factors producing the excessive growths in Shenandoah watershed streams are beyond the capabilities of the studies so far completed. Therefore, measures to solve theses problems cannot possibly be designed at this time. Such determinations cannot be made with any degree of scientific validity and are not properly addressed at this stage of the regulatory process in any case. Despite this fact, Virginia officials have asserted that pollutant allocationns and controls mandated under the Chesapeake Bay TMDL may be adequate to address problems in these local waters. Such as assertion is unsound for a number of reasons.

First, and most obvious, is the fact that those Bay-related allocations were derived for the major tributaries to the Bay are made to address conditions in the estuarine waters of the Bay and those tributaries. The allocations that are applied to the various upstream waters in each of these major stream basins were then applied to upstream waters in a way that takes no account of the characteristics of upland and headwaters streams. In some instances, these basin allocations were then translated into required load reductions on a county-by-county basis in Virginia, based on the relative estimation of inputs from the various local areas and on the perceived

opportunities for reducing those pollutant amounts, based on known and estimated pollution sources. It is simply scientifically unsound to propose that such methods, which are based on large-scale modeling, could necessarily result in any significant improvement in specific headwaters streams, such as those we address in this report.

Second, it is universally acknowledged that the suite of factors needed tol protect or restore waters subject to excessive growth will require examination of the particular characteristics of those streams. This is exactly the rationale used to avoid the setting of criteria for nutrients and sediments in the free-flowing waters of Virginia. The necessity of setting criteria with due consideration of regional conditions, including typical "background" conditions, hydrologic conditions, soils, stream flows, and other parameters has led EPA to recommend the development of criteria on ecoregion, or even sub-ecoregion bases, with the understanding that only such suitably tailored criteria are scientifically valid for local waters. (EPA ecoregion doc.)

Likewise, the Academic Panel tasked with recommending criteria for nutrients in Virginia's upland waters has recommended measures for finding waters to be impaired or un-impaired, suggested different levels for each of four hydrogeologic provinces of the state upstream of the coastal plain. (Academic Panel report). Streams in the Shenandoah watershed arise in and flow through three of these provinces: with streams arising from the Blue Ridge on the east, the Appalachian Plateau on the west, and the central part of the watershed, which lies in the Valley and Ridge province. Given that such variability exists across the Shenandoah watershed, reliance upon allocations from the Bay TMDL, which fail to account for these differences in any detailed manner would be irresponsible and scientifically unsupportable. If Virginia officials though otherwise, it would seem that the State would be confident in seting numeric criteria based upon the Bay allocations but, of course, this has not been the case.

Third, the Bay TMDL and Virginia's implementation plans allow for permitting of discharges for facilities that exceed Bay-protective allocations to meet their goals through pollutant trading. In this way, facitities or activities may exceed allocations in one part of the Bay watershed where credits from load reductions in other parts of the watershed are to be achieved. (VA imple plans) This aspect of the Bay cleanup plan invariably leave some loal streams without the protections supposed to result from the Bay TMDL. In fact, SRK has identified local streams where high pollutant loadings will continue unabated, because dischargers have bought credits from supposed load-reducers far away from the local environments we seek to protect.

VIII. Conclusions

A. The level of information provided by citizens and SRK is, and was in 2012, more than sufficient and technically valid for making conclusions about the nature of impairments related to excessive algae growth in the Shenandoah watershed.

B. The failure of the DEQ to develop methods to measure whether a water quality goal, such as the prohibition of discharges that result in nuisance conditions is inexplicable and does not conform to professional standards. These water quality standards, with the subject language, have been in force for approximately forty years - the author must ask what, if any, specific measures the DEQ has contemplated during that long period and why the State has failed to act before now.

C. The DEQ's reluctance to value and make decisions based on evidence, such as citizen observations of issues well within the ability of the general public and the Department's failure to take any account of odor and color evidence, of which even the Department's personnel are well aware, is not a defense of valid scientific methods, as officials seem to suggest. Rather, it is a rejection of valid and appropriate assessment methods that are perfectly, and sometimes uniquely, suited to find the answers that are being sought.

D. The evidence shows that the conditions that are prohibited in Virginia WQS which are analyzed for the Shenandoah watershed streams (listed in Section VI.A.- D.) , every one is exceeded, frequently and over large areas in the major streams. By any one of these measures, the Shenandoah River, the North Fork Shenandoah River, the South Fork Shenandoah River, and 4-mile segments of each the North and South Rivers are impaired and should be designated as such by Virginia and the U.S. EPA.

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X. Expert Testimony from Jeff Kelble

Statement of Jeff Kelbe
January 28, 2015

I am submitting this document for inclusion in the comments presented to the Virginia Department of Environmental Quality (DEQ) regarding the 2014 Draft Integrated Report, on behalf of Potomac Riverkeeper and Shenandoah Riverkeeper. I will include my observations about some particular problems I've observed in the watershed, because I believe some of them may not have been as well explained as some other problems by algae. I also believe that there I am better equiped to address these issues than anyone else I know of. After those descriptions and opinions, I describe my background and the way I came to be an expert on fishing, fish behaviours, and the environment of the streams in the Shenandoah, as well as many other streams. Because I made my living by knowing about these things, I depended on all of the training and information I'd received, both from others and through my determination to teach myself.

During my career as a heavy user of the Shenandoah and other mid-atlantic rivers, with a pattern of use heavier than any other known individual, and as a professional fishing guide for nine years, I became extremely familiar with the seasonal rhythms of our rivers. The quality of the fishing trips I was able to provide hinged on the river that I chose. One of the primary factors for choosing both the river I fished and the stretch of that river was the physical condition of the river. Smallmouth bass are residents of our Mid-Atlantic rivers. They are always there. They are also generalist predators so for much of the year they occupy most or the river from bank to bank, along nearly every mile. They also feed almost every day between March and November. So the biggest driving force to catching fish was the ability of the fish to see your lure/bait, and the ability for you to make an unimpeded presentation.

First though I want to make and overall statement. The environment for fish and for people in most parts of the Shenandoah Mainstem and the North and South Forks has deteriorated greatly since I started fishing here and the effects of an explosion of algae are very serious and destructive. As DEQ and EPA officials, I have been petitioning to have these rivers listed as impaired for some years now and I am frustrated that the agencies have not used the information I and others have given them. I renew my request that the listing be made now.

Comparisons with Other Streams

As a professional fishing guide I used four stretches of the Potomac River, three stretches of the North Fork, three stretches of the South Fork, three stretches of the main stem, three stretches of the Rappahannock, one stretch of the Rapidan, two stretches of the James River, three stretches of the Susquehanna River and five stretches of the New River. It is widely accepted that my guiding business was unique in that I made a living as a smallmouth bass guide through all four seasons. There was no other person who spent as much time on these various bodies of water.

I can say, without question that there is no other river, stream, or lake I have observed which even approaches the Shenandoah River in the temporal and spatial coverage of algae, nor has any

river ever achieved the severity of bloom that the Shenandoah Rivers experience. I have even fished in rivers with heavy populations of people like the Rappahannock River and Potomac River downstream of towns and cities like Fredericksburg, Culpeper, Warrenton. The Rappahannock and Rapidan, while heavily affected by sediment pollution has never exhibited heavy algae growth of any kind.

The Potomac River, with the exception of the waters downstream of where the Shenandoah pours into it, has occasional algae blooms. Except in the areas downstream of the Shenandoah influence these algae blooms are light and sporadic. The grasses in these areas still predominate and are healthy and lush. I have never observed the algae interfering with fishing. However in the areas downstream of the Shenandoah the algae can be extremely prolific and does affect fishing. I have observed and other guides have corroborated that when the Shenandoah has algea blooming in it the fish in the Shenandoah-influenced water are lethargic or absent. The affects of this can be observed down to Swains Lock Virginia downstream of Violetts Lock. In these areas the same colonized algaes form in the summer after one or two months of planktonic/pelagic bloom.

The New River downstream of Radford and the Arsenal have occasional light blooms of colonized algae but I would estimate that the river sees 1-2% of what the Shenandoah River sections see.

The Susquehanna Downstream of Harrisburg and the farming areas of Lancaster has the most algae I've seen on any other Mid-Atlantic River, but doesn't approach the degree or depth of algae that the Shenandoah produces.

<u>Concerns with the Upstream Reaches of the North Fork</u>
Access is very limited on the Upper North Fork but we spent a significant amount of time observing sections we had access to. One day, day for example, I followed the algae bloom upstream into Broch's Gap, up the North Fork, up Fulks Run and up to Hopkins Gap. Algae was heavy all the way upstream until I found a place where the stream flowed out form between the cobblestones just downstream from a poultry operation. There was heavy algae that high up the river and filled the water column.

One of the worst sections of the North Fork is that between Broadway and Timberville. Repeatedly our observations in this section of river has shown extremely off-color water, green from a nearly continuous planktonic/pelagic algae bloom. During low flows in the summer this stretch is literally choked with algae. It's so heavy that the turtle carapaces are often completely covered with algae. River users under the Route 42 Bridge have complained to us during our investigations and have thought the blue green clumps on the survace were actually raw sewage from the Cargill/Pilgrims/ Broadway discharge.

<u>Algae's Impacts on Underwater Grasses in the Shenandoah Watershed</u>
I have taken specific interest in these kinds of impacts, because the process has been quite visible and disturbing. I know that a number of commenters mentioned such concerns and that quite a few of the photos in our collection show dead and dying grasses covered by thick algae coatings.

For example, for the section of river between Route 50 and Lockes Landing on the Main Stem Shenandoah, grasses predominated during the period between 1994 when I started using this float and 2002 which is the last season any substantial grasses were observed. During 2002, the river was so lush with grass which grew in nearly the entire 16 mile length from bank to bank. That year the majority of flow of the river existed under the shade of the tree canopy along the bank.

During those years small fish and bugs found tremendous refuge in the grasses. The spaces in between the grasses were full of the predatory fish. Very little algae was ever present during the lush periods of grass growth. I did notice during the very last year of 2002, that during the lowest flows many of the grasses began to be covered by algae growth during the end of the summer and very low flow. But the preponderance of growth was grass. However, that year marked the last time grass was observed in any quantity and now what we have from year to year are small vestige patches at times miles apart. These grasses emerge in late May only to be overwhelmed by algae which grow on top of the grasses causing the leaves to fall off. What remains are grass stems.

I have made the exact same observations regarding the North Fork between Deer Rapids and Strasburg except the algae took over earlier. During the peak of the drought in 1999 I recall the VDGIF predicting that there would be a full wipeout of the fish population in the North Fork if the algae in the river died before a substantial flushing event. I fished the North fork a number of times during that period and could not believe the extent of algae growth. There were places where the algae was three feet thick and it filled up the water column in the slowest areas. Blue Green Algae's predominated but there were also filamentous greens that both covered the bottom AND filled the water column in the slowest flowing backwaters. Fish went nearly dormant intheir feeding. On approximately September 7th a tropical storm flushed the river with a 7 foot rise. I fished three days later and the river was clear of algae but there were huge piles of it on the bridge pilings and on everything stationary along the banks including rocks, trees and tree limbs. The fish were literally ravenous and had begun feeding again. I was with professional guide Lou Giusto who specialized in the North Fork Smallmouth and we noted that every cast for several hours we hooked a fish and there would be up to a dozen starving fish following the hooked fish to the boat hoping to pick up regurgitated scraps.

Since then this section of the North Fork has been one that I spent a lot of time on fishing, guiding and observing. Each year the grasses and the algae engage in a battle for space and dominance. Most years now the algae wins and the grasses are stunted, die or never emerge.

The same exact pattern has emerged on the South Fork, the area I have frequent most as a professional has been the section of river from Andy Guest State Park downriver to Karo Landing.

<u>Personal History</u>

My history with fishing began at the age of 5 during a trip to the finger lakes. Like many kids I experienced an immediate attraction to fishing but it seemed like my interest went way beyond normal and when I look back at the patterns, I tended to orchestrate most of the rest of my life

around fishing in some way. When I was in second grade I moved to a house in rural Massachusetts surrounded by a network of streams connected to natural and man-made ponds.

By fourth grade I was fishing three to four days a week May through October. I learned how to catch minnows, worms, frogs, salamanders, crayfish, and just about every other possible live bait by the time I was nine, and used all of them. I sold golden shiners to my friends when I was ten after I taught myself how to catch more than I needed for my own fishing. I used my skateboard to transport myself and my bait from pond to pond, stream to stream, identifying and fishing the water body that was in the best condition and was fishing best. I learned this from a young age.

In fourth grade I proposed a school project which constituted taking time during the school week to travel all over the state to find access to, paddle and fish most of the rivers, ponds and lakes in half of the State of Massachusetts. My project included authoring a book called "Fishing In Massachusetts." My best friend and I pooled our lawn-mowing money and bought a canoe which we learned to transport, with our parents permission and help, on top of their cars. My mother and my teacher took their time to work with my friend and I for over a year researching for the book which was published by fifth grade and carried by most of the region's fishing and tackle stores.

Additionally, our family acquired a saltwater boat when I was approximately 8 years old and our weekends through the summer were spent traveling down the Charles River, through the Locks into the Boston Harbor. We spent hundreds of days through high school exploring the islands, feeder streams to the bays and harbors of the New England coast, sleeping on our boat, fishing, and swimming where we went.

By the time I graduated high school I estimate I had fished over 1000 days on more than 200 bodies of water around inland Massachusetts as well as the coasts from Salem to Block Island. I had fished rivers from the Penobscot in Maine to tributaries of the Connecticut River in Western Massachusetts, all the way down to rivers and streams in Connecticut and Rhode Island. There wasn't a stream that was safe or private property we weren't willing to cross to get to our fishing destinations. I cringe at the thought, but am thankful for understanding landowners. We left no trace. I also fished and explored rivers and streams in Montana, Colorodo and Wyoming, all the way up to and through Calgary Canada.

In college I set up carp fishing tournaments on the incredibly impaired Mystic River. I was determined to fish. In our tournaments our goal was not to catch the biggest or the most fish, it was to see how many different things we could use to catch carp. Our fishing was limited to the region around college but we explored the mostly polluted rivers and water storage reservoirs north of Boston.

After graduating college my roommate and I moved to Virginia from Massachusetts and our stated reason for the move to our parents was that the fishing season was longer. We ogled at the idea that we might be able to fish through the winter some years. Living in Arlington I built relationships with the local fishing and flyfishing communities, fishing stores and rod/reel repair shops and began exploring and fishing the waters of the Mid-Atlantic with . Over twenty years

this exploration continues and I have walked, fished and seen hundreds of bodies of water as a result. Here are some details:

In 1995 I joined the 200+ member Potomac River Smallmouth Club. By 2001 I had won every fishing contest in the club for several years running, had served as Newsletter Editor, Vice President and President.

Along the way I was invited to guide for Mark Kovach Fishing Services in Harper's Ferry, learned how to row an oar rig, and guided my first year in 1999 approximately 60 days. By the end of 2000 I had built a full time business and guided March through November, 5 days a week through 2005, a total of seven years. I spent three years guiding part time even after starting the Shenandoah Riverkeeper program during 2006 as I continued guiding six weeks a year for several more years.

Another example of the breadth of my experience on Virginia waters was my participating in the development of the "Flyfishers Guide to Virginia". author David Hart got a contract to write the "Flyfishers Guide to Virginia" and he asked me to be his primary companion in exploring most of the fishable streams, rivers, and reservoir in the state ranging from Goose Creek in Loudon County to the South Holston Reservoir on Virginia's Southern border and the mountain and valley streams in between. We fished for trout, bass and everything with fins and a mouth, at times camping along the way and at other times sustenance fishing.

In 2000 I helped LL Bean open their first retail store outside of Maine by setting up a flyfishing shop in Tysons Corner, and I also worked with their staff to start up their first flyfishing school outside of Maine. I taught their 1, 2 and 3 day classes for the next five years until my guide schedule became so heavy I had no time left to teach. During my time as an instructor I took hundreds of students to the water and into their first fishing experiences in multiple locations in the Shenandoah Valley centered near Front Royal.

By 2003 I had moved to the Shenandoah Valley to tend to my full guiding schedule which meant over 150 guided days per year. In addition to those 150 days I spent another 50 days with other professional guides exploring new water, learning existing water and working on new fishing techniques. My wife and I completed renovation of our old home in 2005 and opened a bed and breakfast to cater to our fishermen. We integrated the bed and breakfast with my guide business.

When we lost 80% of the smallmouth and sunfish population in the Shenandoah during 2005 and 2006 I was invited to join Virginia's Fish Kill Task Force as a fishing guide. This task force convened for five years and engaged in an extremely robust series of studies to determine why fish were sick in the Shenandoah and why we lost huge numbers of fish during 2005 and 2006. Looking back, while no single cause has been identified, most of the theories that had evidence to support them related to water quality. We considered the role of ammonia from high nutrient loads and decomposition of nutrients, we considered toxic algae, we considered the role of pesticides and herbicides, we looked at a range of other factors.

During this time I provided countless hours of witness and testimony to the poor health of the Shenandoah River fish even during the years before the fish kills. Every published scientific study

from the Fish Kill Task Force shows a correlation with many factors that have a link to algae growth. 1) Herbicides have been found in high concentrations which studies show would hold back the growth of native grasses and favor algae growth 2) High nutrient loads lead to heavy algae growth which causes daily spikes in water PH, which leads to increased toxicity from existing ammonia 3) High parasite load mainly due to the extreme proliferation of the Leptoxis Snail which hosts parasites that prey on the same species of sick which are stick. The snails themselves feed on algae and proliferate due to the extreme algae levels. One study showed that the Leptoxis snail constituted the majority of the entire biomass alive in the river. This is tremendously informative when looking at the algae issue.

I testified that starting in May of every year, smallmouth bass lose a tremendous amount of weight, and muscle fitness. Smallmouth in the Shenandoah come July when the algae blooms are the heaviest have become thin and lethargic. Their fins droop and they don't fight when you pick them up. In the late 90's before I expanded my fishing out to other rivers in the state I thought that all smallmouth got sickly looking in the summer. We were also used to finding relatively high numbers of sick and dead fish in the Shenandoah even outside of the "normal" fish kill season in April – June. The fish were sick in the presence of a tremendously rich food base made up of legions of crayfish, schools of minnows and heavy terrestrial life. Smallmouth on all the other rivers I eplored were robust, thick and healthy during the summer months. This was left unexplained by the scientists who didn't have the time to study it. I noted a very clear correlation between the level of algae growth in the river and the lethargy level of the fish, and their overall health..

What is MOST IMPORTANT about my life's fishing history and my professional career as a fishing guide was the fact that I made a living selecting the very best body of water in the Mid-Atlantic to take people fishing. This required that I have access to multiple sections of river, on multiple rivers in multiple states. My reputation and my success hinged on my ability to evaluate the physical conditions of the river including flow, water clarity and seasonal movements of fish to determine where I would take my clients through the ten month full time season.

This becomes very important in the context of our efforts to get the Shenandoah River listed as impaired due to loss of recreational use. Algae has a deep impact on both of those factors so fishing often hinged on whether or not algae was blooming in the Shenandoah. When the planktonic/pelagic algae blooms in the river it turns a thick pea green color and fish become lethargic, they don't' find food effectively because they cant' see and they reduce their feeding. Often fish have sores when you catch them. There is strong inverse correlation between the murkiness of the water and the number of fish that can be caught in a day. Murky water from an algae bloom meant poor fishing, every time.

The planktonic/pelagic algae has a deep affect on the enjoyment of fishermen beyond the drop in the quality of fishing. Fishermen were acutely aware when the algae was blooming due to the unpleasant look of the river, poor visibility, fish behavior/health and often odor as well. As a guide I would not purposefully guide a river that had a heavy planktonic/pelagic bloom and would spend my time working to avoid these conditions because it damaged the quality of the fishing day.

Additionally, when a planktonic bloom colored the water and decreased visibility there was no chance to see fish and narrow your search, observe their habitat or even to sight fish specifically to an individual fish.

An even greater threat to fisherman enjoyment on the Shenandoah are the colonial algae, which colonizes on the bottom substrate of the river and makes the river completely un-fishable. Our research shows the majority of these are toxin producing blue-green algaes. This algae begins to colonize in April every year on the tops of rocks and rock ledges and as flows fall to normal summer levels they literally cover over between 50% and 100% of the bottom of the North Fork, South Fork and Main Stem Shenandoah. The algae grows a thick slimy layer which is dangerous and unpleasant to walk or wade on.

When algae has colonized the bottom of the river fishermen would complain that every single cast into the river end up fouled with the algae, the hook would gather frustrating clumps on your hook/lure/bait that literally had to be picked clean with your fingernails between casts. Fish literally will not eat your offering if there was so much as a tiny speck of algae on the hook/lure/bait. It has always been our belief that the algae makes the fish sick so they literally avoid getting it in their mouths. When the algae gets heavy fish will literally abandon vast areas of the river in favor of areas without algae growing. This greatly diminishes the amount of fishable miles of the river and confuses anglers when they literally can't find fish in their favorite holes any more. Many conclude the fish are dead. Sometimes they are dead. Fishermen often become depressed at the idea that there are only a few places they can catch fish in the river and don't understand

In addition, even for anglers using flies/lures/bait that floats or doesn't touch the bottom the colonized blue green algaes still impede fishing. Every day when the algaes photosynthesize they produce prolific gases which form bubbles on the surface of the algae and underneath the mats. Eventually the bubbles will lift a nearly infinite number of these chunks from the bottom and flaot them to the surface. On a bright sunny day it would not be unusual for this floating action to sour water clarity, but the worst part is that these floating mats cover the surface of the river. They look like human or animal feces. People mistake them for the this.

<u>Riverkeeper Experiences</u>
As Riverkeeper, we have spent significant time educating the public about the algae in the river. What we found when we surveyed users with an official survey form (attached) was that users had no idea what algae was. However they were very bothered by what they called snot grass, grass or in many cases manure balls. The users were deeply troubled by the coating of blue green algae on the bottom of the river and with few exceptions, mistook the masses of floating algae which had broken off the bottom and were floating to be manure, sewage our poultry litter. They noted the foul odor, the unsightliness and the interference with swimming and particularly fishing.

Many other users (approximately 25 complaints) complained to us about sewage odors and raw sewage spills or seeps. At first we would investigate the claims by visiting the river in the affected areas. The complaints almost always sounded like this "we were floating from point A to B, and when we passed X tributary or Y housing complex or Z poultry farm we began to see clumps of

feces on the surface of the river. The users always related the clumps of feces to a physical stationary feature on the bank. Noone knew in the beginning of our education campaign that the feces was actually blue-green algae.

What we learned upon investigation and eventually concluded is that the presence of those floating globs of feces were not related to a specific source. What was happening is that the algae would only begin to dislodge from the bottom to float to the surface during the noon/ afternoon period of the day when the algae was photosynthesizing oxygen. The river was saturated with oxygen during that narrow part of the day causing oxygen bubbles to form which floated these decaying mats of algae to the surface. Every user told us they were disgusted by the odor and alarmed by the idea that this substance threatened their health.

Since then I would estimate that we have received over 200 personal complaints about the algae.

XI. **Qualifications of David Sligh**

A. Statement

My name is David Sligh and I am qualified to present analyses and opinions on matters related to water quality monitoring and assessments, quality controls for monitoring data, water pollution, stream ecology, and investigative methods. My resume is included below at part B. of this Section but I offer some more specific information here about my background and abilities as they relate to the review performed in this Technical Report.

During my time in college, I worked for the Virginia State Water Control Board ("SWCB" or "the Board"), a predecessor agency to the Department of Environmental Quality, for two summers. This began a long series of jobs and advancements within the Water Board and the DEQ, where I was trained in many of the skills and began acquiring the knowledge I bring to this technical review.

After receiving my undergraduate degree in Environmental Science from the University of Virginia, I worked for the the SWCB in Roanoke on an EPA-funded monitoring study to assess runoff pollution problems and relative impacts from urban, suburban, agricultural, and forested watersheds. I helped plan and coordinate the sampling program, managed the data, performed a range of analyses, and co-wrote the final report for this study.

Next, I took a postion in the Roanoke office where I compiled and analyzed all of the ambient water quality data for the region covered by our office. I wrote portions of the narrative for the agency's 305(b) report and helped assemple the "priority water bodies list" - what is now generally known as the "impaired water list - under section 303(d) of the Clean Water Act.

I then received a promotion to a job where I conducted the first comprehensive review of all surface water monitoring activities by the Roanoke office. I documented the purposes of each sampling type and the individual locations and designed new protocols for monitoring parameters, schedules, and reporting. For this work, Ron Gregory, the Director of the Office of Water Quality Assessments for the Board, wrote that I had "pioneered the modernization of ambient water quality monitoring networks in Virginia" and noted that the methods I had developed were a model for changes made by regional offices around the state. Mr. Gregory also praised me for my "high level of competency" in the areas of aquatic ecology and limnology and for my knowledge of surface water monitoring programs and techniques, including quality assurance.

Finally, I served as a Senior Engineer for the SWCB and the DEQ, overseeing all aspects of permitting in the Roanoke region for NPDES facilities and land application operations. In this role I worte requirements for stream studies for permitted parties and reviewed their proposals and results.

Since leaving the DEQ, I have worked in several non-profit organizations, where my knowledge of stream ecology and water quality studies has been very important. I was the representative in the Southeast U.S. for American Rivers. In this role I worked in six states on

both state and federal regulatory matters, served on technical advisory teams for river studies undertaken in relation to hydropower dam relicensing cases in North Carolina, Tennessee, Alabama, South Carolina, and Georgia. Later, I was Executive Director of the a local watershed group in Northeast Georgia. I supervised and helped conduct a watershed-wide water quality study with EPA funds. I also served as Upper James Riverkeeper and most recently have worked as a consultant for many non-profit groups. Among the projects I have completed are: reviews of NPDES permitted facilities in Maryland, reviewed and commented on the District of Columbia's bacterial TMDL, and designed a monitoring program to assess impacts on a watershed on the Eastern Shore of Maryland, where major poultry operations and other farming activities were present.

Throughout my state agency work and time with non-profit groups I have investigated many pollution complaints and sampled hundreds of streams, many in the Ridge and Valley, Blue Ridge, and Appalachian regions. I have testified in court and administrative hearings for the SWCB and DEQ as an expert on the types of issues addressed in this Technical Report. As well, I testified in a number of court proceedings for the Georgia River Network and Altamaha Riverkeeper in Georgia.

Two of the areas in which I believe my trainng and expertise are most applicable to the Shenandoah algae question are my familiarity with:

* proper data gathering, quality control, and analyses and
* my long experience applying Water Quality Standards, including those in Virginia and the southeaster states mentioned above, as well as in Vermont, Pennsylvania, D.C., and Maryland

I well understand the need for high quality data for the State of Virginia Integrated Report and listing of impaired waters and it is with that understanding that I comment upon the nature and quality of data that are presented by SRK in this case.

B. Resume

David Sligh
1433 Wickham Pond Drive
Charlottesville, Virginia 22901
434-964-7455
davidwsligh@yahoo.com

Education

Vermont Law School, South Royalton, VT - J.D. degree - 1999

Pertinent Courses: watershed protection (CWA), water resources law, law of toxic and hazardous substances (RCRA & CERCLA), air pollution law (CAA), general environmental law, land use planning, administrative law, legislation

Independent Study: analysis of states' applications of water quality standards provisions - submitted as comments in response to EPA NOIRA

McNeese State University, Lake Charles, LA - Graduate course work in Biology - 1984

Pertinent Courses: ecology (focus on fish ecology in estuarine habitats), biochemistry

University of Virginia, Charlottesville, VA - B.A. degree in Environmental Science - 1982

Pertinent Courses: coastal and fluvial environments, hydrology, geology (field work in shoreline processes), fundamentals of ecology, applied ecology, forest ecology, aquatic chemistry, biology of fishes, tropical ecology

Independent Study: effects of low-flow conditions on the chemical, physical, and biological integrity, Roanoke River below Leesville Dam

Independent Study: trophic adaptations of marine benthic animals

Professional Qualification

Member of District of Columbia Bar

Employment

Environmental Consultant, Self-employed, Charlottesville, VA

Have completed projects including NPDES permit reviews, technical reviews of TMDLs, s. Clients include: Earthjustice, Gunpowder Riverkeeper, the Environmental Integrity Project, Miles-Wye Riverkeeper, and Shenandoah Riverkeeper.

Special Research Faculty, Virginia Tech,

Was assigned to the Virginia DEQ, to help develop and manage Annual Standards and Specifications program for compliance with Erosion & Sediment Control law and Stormwater Protection law, mandated by 2012 statutory changes. Conducted analysis of statute and regulations to ensure that requirements and fees are set appropriately for covered parties. Developed guidance for document preparation and conformance with legal requirements. Reviewed submitted documents for compliance.

Upper James Riverkeeper, James River Assoc., Charlottesville, VA

Protected the James River, its tributaries, and watershed through patrolling and monitoring, enforcement, involvement in regulatory matters, and education/motivation of citizens to act to improve and preserve their waters. Advocated and helped achieve improved regulation of poultry waste, industrial stormwater runoff, and construction stormwater pollution.

Executive Director, Soque River Watershed Assoc., Clarkesville, GA

Managed all programs, including a comprehensive, 3-year watershed study funded by the U.S. EPA and the State of Georgia. Supervised and conducted stream water sampling, benthic macroinvertebrate sampling, flow measurements, physical habitat assessments, and analyses of data.

Southeast Regional Representative, American Rivers, Chattanooga, Tennessee

Established regional office and led campaigns in TN, NC, SC, AL, GA, and VA. Advocated for river protection and restoration, through state and federal regulatory programs, news media, and education. Coordinated with and awarded/managed pass-through grants to state and local partners. Regularly served on technical and legal advisory committes, wrote and filed comments on studies and regulatory proposals. Consulted on technical and legal matters with partner environmental groups. Served as an expert witness on behalf of the Georgia River Network and the Altamaha Riverkeeper.

Adjunct Faculty Member, Univ. of Tennessee at Chattanooga

Taught environmental science.

Water Quality Assessment Assistant, Dept. of Environmental Conservation, Waterbury, Vermont (temporary job during law school)

Researched agency cases and files for data on pollution problems and conformance of programs with statutory and administrative mandates. Presented findings in state water quality assessment, impaired waterbodies listing, and legal and technical analyses of various programs.

Researcher, ARCS, Inc., Roanoke, Virginia

Researched energy trends and aerial pesticide spraying of power lines in West Virginia and Virginia and drafted formal submissions to Virginia State Corporation Commission. Prepared comments for U.S. Forest Service NEPA process regarding water quality and other issues. Lobbied state legislators to support citizen interests in state proceedings.

Senior Environmental Engineer, Virginia Dept. of Environmental Quality, Roanoke, Virginia,

Supervised division of engineers in: preparation of NPDES and Virginia Pollution Abatement permits (for land application of sludge and animal waste); analysis of environmental data and compliance records and preparation of enforcement documents; representation of agency at public hearings, negotiations, and in legal proceedings. Oversaw inspections of treatment facilities and land application operations, reviewed plans for special stream studies submitted by permit holders or applicants, completed stream models. Instructed environmental engineers under my supervision in technical, procedural, and legal matters associated with permitting processes.

Environmental Specialist, Virginia State Water Control Board

Coordinated all water quality research and monitoring activities in West Central region of state and designed new ambient monitoring system; prepared annual water quality reports on lakes program; conducted field surveys for benthic macro-invertebrates and water sampling; investigated pollution complaints and fish kills; prepared enforcement cases. Was the lead investigator in a landfill case, for which I testified in federal, state, and formal administrative court proceedings. Succeeded in closing the landfill, obtaining a judgement of $1.4 million for damages and penalties, and provided evidence for criminal prosecution of owners.

Environmental Technician, Virginia State Water Control Board

Compiled and analyzed regional water quality monitoring data and co-authored Virginia Water Quality Assessment (CWA section 305(b) report); analyzed data and wrote portions of water quality and water supply plans.

Environmental Technician, Virginia State Water Control Board

Planned and coordinated year-long EPA-funded research program to assess water quality impacts from non-point source pollution/storm water runoff. Conducted interest group meetings and public meetings. Co-wrote final report.

Intern, Summers of 1980 and 1981, Virginia State Water Control Board

Conducted water quality studies and pollution investigations; compiled and analyzed facility compliance data.

Other Activities and Positions

Technical Advisory Committee to Tennessee Clean Water Network, 2000-2002
Legal Advisory Committee to Dogwood Alliance Board of Directors, 2002 - 2004
Steering Committee Member, Southeastern Imperiled Fish Network

Speaker at numerous conferences on water quality issues, including:
Chesapeake Watershed Forum, Shepherdstown, WV, 2011, 2012.
Waterkeeper Alliance Conferences, 2009, 2013.
When the Water Runs Dry, New Orleans, LA, 2003 (speaker and session leader).
The Future of Flows, Morgantown, WV, 2002.
National River Rally - River Network, 2001, 2002, 2013, 2014.
Georgia River Network Conferences, Milledgeville, GA, 2002 & 2003.
Alabama Rivers Alliance, Annual Conferences 2000, 2001.