UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

JUN 2 4 2016

Mr. Scott Mandirola, Director
Division of Water & Waste Management
West Virginia Department of Environmental Protection
601 57th Street, S.E.
Charleston, WV 25304

Dear Mr. Mandirola: Scott

On June 2, 2016, the West Virginia Legislature approved revisions to the State's water quality standards rule (47CSR2 Requirements Governing Water Quality Standards). Those revisions were then signed by the Governor on June 7, 2016. The West Virginia Department of Environmental Protection's (WVDEP) General Counsel certified on June 8, 2016 that the regulations were duly adopted in accordance with State law. In accordance with Section 303(c)(2)(A) of the Clean Water Act (CWA), 33 U.S.C. §1313(c)(2)(A), and 40 CFR §131.20(c), WVDEP forwarded the amended regulation to the Environmental Protection Agency, Region III, on June 8, 2016, and we received it on June 9, 2016. Included in this submittal is a revision to West Virginia's selenium criteria for the protection of aquatic life. The purpose of this letter is to approve those revisions to the selenium criteria pursuant to CWA §303(c) and the implementing regulation at 40 CFR §131. Enclosure 1 to this letter provides details as to EPA's specific approval.

The revisions to the selenium criteria are being approved subject to the outcome of consultation with the U.S. Fish and Wildlife Service (USFWS) under §7(a)(2) of the Endangered Species Act (ESA). EPA initiated informal consultation with the USFWS on this revision by letter dated June 24, 2016 (Enclosure 2). Section 7(a)(2) requires that federal agencies, in consultation with the Services, ensure that their actions are not likely to jeopardize the existence of federally listed species or result in the adverse modification of designated critical habitat of such species.

In approving the standard subject to the outcome of consultation, EPA is explicitly stating that it retains its discretion to take appropriate action if the consultation identifies deficiencies in the standards requiring remedial action by EPA. EPA retains the full range of options available under §303(c) for ensuring water quality standards are environmentally protective and are consistent with the Clean Water Act. Upon completion of this consultation, EPA will notify the WVDEP of the results.

If you have any questions regarding this action, please do not hesitate to contact me or have your staff contact Denise Hakowski, at 215-814-5726.

Sincerely,

Jon M. Capacasa, Director
Water Protection Division

Enclosures (2)

cc: Laura Cooper (WVDEP)
John E. Schmidt (USFWS)

Enclosure 1

Decision Document of the United States Environmental Protection Agency Review of West Virginia's 2016 Revision to Selenium Criteria for the Protection of Aquatic Life in the 47CSR2 Requirements Governing Water Quality Standards Under Section 303(c) of the Clean Water Act

Introduction

In a letter dated June 8, 2016, the West Virginia Department of Environmental Protection (WVDEP) submitted new and revised water quality standards (WQS) for review under Section 303(c) of the Clean Water Act (CWA or Act). The EPA received the original signed package for review from WVDEP on June 9, 2016.

The June 8, 2016 submittal included several provisions: revisions to West Virginia's selenium criteria for the protection of aquatic life; revisions to West Virginia's aluminum criteria for the protection of aquatic life; and the adoption of two variances from water quality standards for the Muddy Creek watershed of Cheat River and for Sandy Creek watershed of Tygart River. This action will only address the revisions to the State's selenium criteria. EPA will take its 303(c) action on the other new or revised provisions of this submittal at a later date.

Clean Water Act Requirements

Section 303 of the CWA, 33 U.S.C. § 1313, requires states to establish WQS and to submit any new or revised standards to the EPA for review and approval or disapproval. The CWA implementing regulation require states to adopt water quality criteria that protect the designated use. See 40 CFR §131.1 l(a). Such criteria must be based on sound scientific rationale.

West Virginia's Selenium Criterion

WVDEP initiated the rule revision that included the revision to its current selenium criteria by opening a public comment period on June 17, 2015, which included a public hearing on July 21, 2015. During the public comment period, EPA published its draft selenium nationally recommended criterion: Draft Aquatic Life Ambient Water Quality Criterion for Selenium – Freshwater (EPA 822-P-15-001, July 2015). EPA provided comments to WVDEP on the State's proposed revisions to the selenium criteria on July 30, 2015.

WVDEP made several revisions to its selenium criteria, and EPA is approving those specific revisions as being protective of the use in light of the best science currently available as presented in EPA's Draft Aquatic Life Ambient Water Quality Criterion for Selenium – Freshwater (EPA-822-P-15-001, July 2015). The West Virginia revision includes the following:

- **Deletion of the acute selenium criterion.** EPA's draft selenium criterion does not recommend an acute criterion as selenium is bioaccumulative and toxicity to aquatic life is primarily driven by dietary (chronic) exposure and acute toxicity associated with selenium occurs only at very high levels, making an acute criterion in the presence of a protective chronic criterion unnecessary. EPA is approving WV's deletion of the acute selenium criteria.

- **Adoption of fish tissue-based elements.** Selenium is bioaccumulative and current science indicates that organisms in aquatic environments exposed to selenium accumulate it primarily through their diet, and not directly through water (Chapman et al. 2010). It is also recognized that selenium toxicity occurs primarily through transfer to the eggs and subsequent reproductive effects. Therefore, EPA is developing a chronic criterion reflective of the reproductive effects of selenium concentrations on fish species. EPA's draft recommended criterion applies the species sensitivity distribution concepts from the *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and their Uses* (Stephen et al. 1985) to derive the selenium criterion. Based on the available data, expressed as EC_{10} values, or the concentration that will have an effect on 10% of the population of test organisms, the draft egg-ovary criterion element is 15.8 mg Se/kg dw. All other selenium criterion elements in the draft document are derived from this egg-ovary criterion element. The magnitudes of the fish whole-body element and fish muscle elements are derived from the egg-ovary element coupled with data on concentration ratios among tissues. WV has adopted the draft recommended egg-ovary criterion element (15.8 ug.g), as well as the draft recommended whole-body of fish criterion element of 8.0 ug/g and muscle tissue of fish criterion element of 11.3 mg ug/g. All of these criterion elements are not to be exceeded, instantaneous measurements. EPA is approving WV's adoption of the fish tissue-based elements of EPA's draft selenium criterion.
- **The fish tissue-based elements are given precedence over WV's unrevised water column element, and the egg-ovary criterion element is given precedence over whole-body criterion elements or fish muscle criterion element.** As indicated above, the EPA's draft recommended chronic selenium criterion was developed to address the reproductive effects of selenium concentrations on fish species, and all of the other selenium criterion elements in the draft document are derived from the egg-ovary criterion element. Therefore, EPA's draft recommendation also indicates that the criterion should be adopted in a manner that explicitly affirms the primacy of the whole-body or muscle elements over water column element, and the egg-ovary element over any other element. EPA is approving WV's adoption of the primacy of the egg-ovary element over the other criterion elements, and the primacy of fish tissue over the water column element (WV's regulation revision allows an exception in cases when new inputs of selenium occur in waters previously unimpacted by selenium. In these cases, until equilibrium is reached between water column and fish tissue, the water column values take precedence over fish tissue values).

West Virginia's Aquatic Life Selenium Criterion
47CSR2, Requirements Governing Water Quality Standards
Appendix E, Table 1
As amended, effective date June 2, 2016

PARAMETER	USE DESIGNATION			
	AQUATIC LIFE			
	B1, B4 (warmwater fisheries & wetlands)		B2 (trout waters)	
	ACUTE[1]	CHRON[2]	ACUTE[1]	CHRON[2]
8.27 Selenium (ug/l) Water Column Concentration[f]	~~20~~	5	~~20~~	5
8.27.1 Selenium (ug/g)[g] (based on instantaneous measurement 8.0 ug/g Fish Whole-Body Concentration or 11.3 ug/g Fish Muscle (skinless, boneless filet) Fish Whole-Body Concentration[g]		X		X
8.27.2 Selenium (ug/g) Fish Egg/Ovary Concentration[h] (based on instantaneous measurement)		15.8		15.8

[1] One hour average concentration not to be exceeded more than once every three years on average, unless otherwise noted.

[2] Four-day average concentration not to be exceeded more than once every three years on average, unless otherwise noted.

[f] Water column values take precedence over fish tissue values when new inputs of selenium occur in waters previously unimpacted by selenium, until equilibrium is reached between the water column and fish tissue.

[g] Overrides any water column concentration when water concentrations and either fish whole body or fish muscle (skinless, boneless filet) are measured, except in situations described in footnote [f]

[h] Overrides any fish whole-body, fish muscle (skinless, boneless filet), or water column concentration when fish egg/ovary concentrations are measured, except in situations described in footnote [f]

References

Chapman P.M., W.J. Adams, M.L. Brooks, C.G. Delos, S.N. Luoma, W.A. Maher, H.M. Ohlendorf, T.S. Presser and D.P. Shaw (eds). 2010, Ecological Assessment of Selenium in the Aquatic Environment. SETAC Press, Pensacola, FL, USA.

U.S. Environmental Protection Agency. 2015. Draft Aquatic Life Ambient Water Quality Criterion for Selenium – Freshwater. EPA 822-P-15-001. Office of Water.

USEPA. 1985. Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses. NTIS #PB-85-227049. Office of Water Regulations and Standards.

Enclosure 2

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

JUN 24 2016

Mr. John E. Schmidt, Field Supervisor
U.S. Fish and Wildlife Services
West Virginia Field Office
694 Beverly Pike
Elkins, WV 26241

Dear Mr. Schmidt:

The U. S. Environmental Protection Agency (EPA) has completed its review of West Virginia's revised selenium criteria for the protection of aquatic life, as amended on June 2, 2016. The amended selenium criterion and supporting material were forwarded to EPA for review on June 8, 2016. EPA Region III has determined that West Virginia's revised selenium criterion is approvable under Section 303(c) of the Clean Water Act (CWA). In order to fulfill our obligation under Section 7 of the Endangered Species Act (ESA), EPA prepared the enclosed Biological Evaluation and found that our approval will have no effect, or may affect, but is not likely to adversely affect federally-listed threatened and endangered species, and their critical habitat, in West Virginia. The purpose of this letter is to formally submit and seek concurrence from the U.S. Fish & Wildlife Service on the Biological Evaluation. We hope we can obtain the Service's concurrence through informal consultation.

EPA plans to approve the revised selenium criterion shortly, likely before the conclusion of ESA consultation. Therefore, EPA's approval of this aquatic life criterion is subject to the outcome of this consultation. EPA is taking its approval action because we do not believe that approving West Virginia's revised selenium aquatic life criteria subject to the results of the consultation will result in impacts to listed species that would violate Section 7(d) of the ESA. EPA recognizes that in approving West Virginia's criterion submissions subject to the results of this consultation, EPA may need to revise its decision if this consultation identifies a situation where the approved criterion may not be adequate. If this were to occur, EPA would determine a reasonable solution. For instance, EPA could work with West Virginia to obtain revisions to the standards in the next triennial review; or EPA could work with the State to facilitate a more narrow set of revisions to the standards in the short term. In choosing from these and other options, EPA's actions would be tailored to the facts of the situation, taking into consideration the environmental risks at stake, West Virginia's regulatory revision process, and the availability of a scientifically defensible federal alternative. Thus, as a general matter, EPA approval of this water quality criterion is not irreversible or irretrievable because the Agency retains substantial discretion to revise its decision based on the results of any consultations.

We ask that you respond to this letter as soon as possible, but in no case later than August 30, 2016. We look forward to an early reply to this letter and a favorable response to your review of the information. Should you have any questions concerning this correspondence or the enclosure, please contact me at (215) 814-5717, or Denise Hakowski of my staff at (215) 814-5726 or hakowski.denise@epa.gov.

Sincerely,

Evelyn S. MacKnight

Evelyn S. MacKnight, Associate Director
Office of Standards, Assessment & TMDLs

Enclosure

cc: Kathleen Patnode (USFWS)

Biological Evaluation of
West Virginia's Selenium Criterion
for the Protection of Aquatic Life

Prepared by U.S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19107

June 24, 2016

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I. Executive Summary

The focus of this Biological Evaluation (BE) is on the effects which may occur to federally listed threatened and endangered species as a result of the U.S. Environmental Protection Agency (EPA) approval of water quality standards (WQS) under the Clean Water Act (CWA) for selenium adopted by the State of West Virginia. The specific focus of this evaluation is (1) EPA approval of fish-tissue based criterion elements (egg-ovary and fish whole-body or muscle), (2) EPA approval of a criterion structure where fish tissue criterion elements have primacy over water column criterion elements, and (3) EPA approval of the deletion of West Virginia acute selenium criterion for the protection of aquatic life.

It is apparent from EPA's research that the most significant threats to all the threatened and endangered species in West Virginia are habitat loss and degradation associated with various kinds of human activities, such as development, impoundments, stream channelization, siltation caused by poor land use practices, logging, and oil, gas and mineral development. Selenium at levels allowed under West Virginia's fish-tissue based criterion elements is not a major threat to listed species. This biological evaluation provides the EPA's analysis of the potential effects of the EPA's approval action on threatened and endangered species and designated critical habitat by the approval of specific aspects of West Virginia's WQS. EPA has found that the approved chronic aquatic life fish-tissue based criterion elements for selenium will generally be beneficial to listed species and these provisions are not likely to lead to adverse effects. EPA has also found that it is more accurate to rely on measures of selenium in fish tissue that measures of selenium in the water column to determine potential effects and protective levels for aquatic life in general, and also for threatened and endangered species. Finally, EPA found that selenium is bioaccumulative and toxicity primarily occurs via dietary (chronic) exposure. Acute toxicity associated with selenium occurs only at very high levels, making an acute criterion unnecessary.

Of note is the recently completed Endangered Species Act (ESA) consultation for the whole-body fish tissue criterion for selenium in the neighboring state of Kentucky. Many aspects of Kentucky and West Virginia are relatively similar, such as ESA listed species, critical habitat, species sensitivity, life-history traits, and current threats. Given the similarities between Kentucky and West Virginia, EPA considered many aspects of the Kentucky selenium BE (2015) to assess potential selenium effects on federally listed species in West Virginia. Additionally, in a letter dated February 5, 2016, the Kentucky Field Office of the US Fish and Wildlife Service (USFWS) concurred with the science presented in the KY BE and considers the whole-body fish tissue criterion for selenium criterion to be protective of ESA listed species in KY.

II. Description of Federal Action

Under CWA Section 303(c) and its implementing regulations at 40 CFR § 131, States and authorized tribes have primary responsibility to develop and adopt WQS to protect their waters. As required by CWA Section 303(c) and 40 CFR § 131, EPA reviews new and revised WQS that have been adopted by States and authorized tribes. New and revised State WQS are not considered effective for CWA purposes until approved by EPA under CWA Section 303(c).

The Federal action being evaluated is EPA's approval of revised selenium criteria for the protection of aquatic life use as set forth in West Virginia's *Water Quality Standards Rule* (Title 47, Code of State Regulations, Series 2) The specific focus of this evaluation is (1) EPA approval of West Virginia's adoption of fish whole-body, fish muscle and egg/ovary fish tissue selenium criterion elements, and (2) EPA approval of a criterion structure where fish tissue criterion elements have primacy over water column criterion elements.

III. Background on West Virginia's Water Quality Standards Modification

These modifications of West Virginia's water quality standards regulation were initially adopted by the West Virginia legislature as an Emergency Rule during the 2015 legislative session. The revisions were submitted to EPA on October 26, 2015 and EPA received the package on November 1, 2015. EPA had a number of concerns about the submission, including the incorrect application of duration and frequency of the fish tissue elements, so revisions were considered during the 2016 legislative session. Those revisions were approved by the West Virginia Legislature on June 2, 2016, and submitted to EPA for our CWA Section 303(c) action on June 8, 2016, and EPA received the submittal on June 9, 2016. The CWA Section 303(c) states in part:

> If the Administrator, within sixty days after the date of submission of the revised or new standard, determines that such standards meets the requirements of the Act, such standard shall thereafter be the water quality standard for the applicable waters of the State.

A. Overview of Water Quality Standards

A water quality standard defines the water quality goals for a waterbody by designating the use or uses of the water, by setting criteria necessary to protect the uses, and by preventing or limiting degradation of water quality through antidegradation provisions. The CWA provides the statutory basis for the water quality standards program and defines broad water quality goals.

Section 101(a)(2) of the CWA sets out a national goal that wherever attainable, waters achieve a level of quality that provides for the protection and propagation of fish, shellfish, and wildlife, and for recreation in and on the water ("fishable/swimmable").

Section 303(c) of the CWA requires that all states adopt water quality standards and that the EPA review and approve these standards. In addition to adopting water quality standards, states are required to review those standards every three years and to then revise the standards, as necessary. This public process, commonly referred to as the triennial review, allows for new technical and scientific data to be considered in order to update the standards. The regulatory requirements governing water quality standards are established at 40 CFR 131.

The stated goal of the CWA, 33 U.S.C.S. §1251(a), is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. Consistent with the CWA, as part of their water quality standards, states must designate the uses for which their waters are to be protected, such as fish and swimming, and identify water quality criteria to protect the uses for pollutants that could reasonably be expected to interfere with the designated uses. In addition, states' water quality standards must include an antidegradation policy and implementation procedures that are consistent with the EPA's policy to protect existing uses, high quality waters, and water quality in waters identified by the state as outstanding national resource waters. Id. § 1313(c)(2)(A) (Supp. 1993); 40 CFR § 131. Under Section 303 of the CWA, states must submit new and revised water quality standards to the EPA for review and approval. When a state submits its water quality standards to EPA for review, the standards must include: (1) the designated uses for each body of water; (2) what methods were used and analyses conducted to support the revisions to state water quality standards; (3) water quality criteria, which protect the designated uses for each water body and which may be expressed as either a narrative standard or a numeric concentration level; and (4) an antidegradation policy to protect existing uses of bodies of water and high-quality waters. 40 CFR §§ 131.3(i), 131.3, 131.6, 131.12.

B. Description of Specific West Virginia Provisions Approved by EPA

The West Virginia Legislature adopted, and the WVDEP submitted, revised water quality standards to EPA Region 3 on June 8, 2016. The EPA intends to approve the following:

PARAMETER	USE DESIGNATION			
	AQUATIC LIFE			
	B1, B4		B2	
	ACUTE[1]	CHRON[2]	ACUTE[1]	CHRON[2]
8.27 Selenium (ug/l) Water Column Concentration[f]	~~20~~	5	~~20~~	5
8.27.1 Selenium (ug/g)[g] (based on instantaneous measurement 8.0 ug/g Fish Whole-Body Concentration or 11.3 ug/g Fish Muscle (skinless, boneless filet)		X		X
8.27.2 Selenium (ug/g) Fish Egg/Ovary Concentration[h] (based on instantaneous measurement)		15.8		15.8

[1] One hour average concentration not to be exceeded more than once every three years on average, unless otherwise noted.

[2] Four-day average concentration not to be exceeded more than once every three years on average, unless otherwise noted.
[f] Water column values take precedence over fish tissue values when new inputs of selenium occur in waters previously unimpacted by selenium, until equilibrium is reached between the water column and fish tissue.
[g] Overrides any water column concentration when water concentrations and either fish whole body or fish muscle (skinless, boneless filet) are measured, except in situations described in footnote [f]
[h] Overrides any fish whole-body, fish muscle (skinless, boneless filet), or water column concentration when fish egg/ovary concentrations are measured, except in situations described in footnote [f]

The Legislature updated the West Virginia selenium criteria by deleting the acute criterion and adding fish tissue-based elements. It also added footnotes that indicate that the fish tissue elements be given precedence over the water column elements. These revisions to the chronic selenium criterion are consistent with EPA's draft freshwater selenium criterion, which was published for comment on July 27, 2015 in the Federal Register (80 FR 44350).

IV. Action Area

EPA's approval of the West Virginia WQS applies to all surface waters of the United States within the State under federal jurisdiction. Jurisdiction over non-navigable and isolated waters would likely have to be determined on a case-by-case basis. The area evaluated for action is the surface waters of the State. In West Virginia, "waters" are defined in Section 22-11-3(23) of the State Water Pollution Control Act as "any and all water on or beneath the surface of the ground, whether percolating, standing, diffused or flowing, wholly or partially within this State, or bordering this State and within its jurisdiction, and includes, without limiting the generality of the foregoing, natural or artificial lakes, rivers, streams, creeks, branches, brooks, ponds (except farm ponds, industrial settling basins and ponds and water treatment facilities), impounding reservoirs, springs, wells, watercourses and wetlands."

A. List of Federally Listed Species Which May be Found Within the Action Area

Attachment 1 is a complete listing of all federally listed threatened and endangered species in West Virginia as complied by the U.S. Fish and Wildlife Service (USFWS) and available at:

http://www.fws.gov/westvirginiafieldoffice/PDF/KnownandPotentialDistributionofFederally-June2015.pdf.

This list is current as of April 2015. The species listed include mammals, amphibians, fishes, crustaceans, mollusks and plants. The level of information for each species varies. Not all threatened or endangered species are aquatic-dependent organisms, and for this evaluation we are only considering the aquatic-dependent species that occur in West Virginia.

This Biological Evaluation will consider the following aquatic-dependent proposed, threatened or endangered species:

Mammals

Indiana bat	*Myotis sodalis*
Virginia big-eared bat	*Corynorhinus (=Plecotus) townsendii virginianus*
Northern long-eared bat	*Myotis septentriolnalis*

Fishes

Diamond darter	*Crystallaria cincotta*

Crustaceans

Madison Cave isopod	*Antrolana lira*
Big Sandy Crayfish	*Cambarus callainus*
Guyandotte River Crayfish	*Cambarus veteranus*

Mollusks

Mussel, clubshell	*Pleurobema clava*
Mussel, fanshell	*Cyprogenia stegaria (=irrorata)*
Mussel, James spiny	*Pleurobema (=Canthyria) collina*
Mussel, pink mucket	*Lampsilis abrupta (=orbiculata)*
Mussel, northern riffleshell	*Epioblasma torulosa rangiana*
Mussel, rayed bean	*Villosa fabalis*
Mussel,sheepnose	*Plethobasus cyphyus*
Mussel,spectaclecase	*Cumberlandia monodonta*
Mussel,snuffbox	*Epioblasma triquetra*
Mussel, tubercled-blossom pearly	*Epioblasma (=Dysnomia) torulosa torulosa*

Plants

Northeastern bulrush	*Scirpus ancistrochaetus*
Harperella	*Ptilimnium nodosum*
Virginia spiraea	*Spiraea virginiana*

V. **Effects of the Action**

A. Overview

The ESA Section 7 implementing regulations (50 CFR 402.02) define "effects of the action" as:

> "The direct and indirect effects of an action on the species or critical habitat together with the effects of other activities interrelated or interdependent with that action, that will be added to the environmental baseline. The environmental baseline includes the past and

present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early Section 7 consultation, and impact of State or private actions which are contemporaneous with the consultation in process. Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur."

B. Direct Effects

EPA's action is limited to EPA's approval of new and revised water quality standards for the state of West Virginia. Approval of West Virginia's water quality fish tissue criterion for whole body, muscle and fish egg/ovary would not cause direct or immediate effects on species or critical habitat. Therefore, any effects that may occur to federally listed species or designated critical habitat would be indirect effects.

C. Indirect Effects

Approving water quality standards may have indirect effects to listed species when CWA programs are applied. These effects are indirect because they are likely to occur later in time when the programs are implemented. Examples of CWA programs that may lead to indirect effects include TMDL management plan implementation, issuance of WV NPDES permits, CWA 401 certifications of federally licensed projects, and implementation of non-point source management plans designed to meet the water quality standards over time. These programs are intended to control inputs of point-source and nonpoint-source pollution to waterbodies such that the water quality standards are met in the receiving waters and aquatic life is protected.

Note: The discussion below describes the various CWA programs related to implementation actions to attain water quality standards. Effects to listed species may occur when on-the-ground implementation occurs. However, EPA is not assessing the adequacy of these programs to attain standards because EPA's action does not address approval of these various programs. The action addressed in this biological evaluation is limited to EPA's approval of the standards. Therefore the effect analysis beginning on page 34 examines the effects to listed species and critical habitat of the standards themselves, assuming the standards are attained. The discussion below is intended to provide context of how EPA's approval of standards relates to real on-the-ground actions that may affect listed species.

West Virginia's surface water quality standards consist of three primary components: (1) designated uses (e.g., propagation and maintenance of fish and other aquatic life) that are assigned to the waters; (2) numeric and narrative criteria that are designed to protect the specified designated uses; and (3) a water quality antidegradation program that provides protection for existing uses and high quality waters.

The water quality standards establish the foundation for the State's water pollution control programs. Under state and federal laws and regulations, human sources of pollution must not cause or contribute to an exceedance of the water quality standards. As such, regulated activities must be designed and implemented to achieve the water quality standards. While the water quality standards of the State of West Virginia apply broadly to all categories and sources of pollution, there are jurisdictional and practical limitations that affect how well certain sources of pollution are brought into compliance. The following discussion is intended to provide a general overview of how water quality standards may be applied to protect water quality in West Virginia.

VI. Overview of WQS Implementation in the Point Source Discharge Program

Point sources are "any discernable, confined and discrete conveyance...from which pollutants are or may be discharged" (such as from a pipe, ditch, or channel). See 33 U.S.C. 1362(14). Formal permit programs are established under state and federal laws and regulations for point source discharges. These regulations include the requirement that permits be established to achieve the applicable water quality standards. See 40 CFR § 122.44(d)(1).

Water quality criteria that are part of approved water quality standards are the basis for establishing effluent limits in WV NPDES permits where there is reasonable potential that a point source discharge will cause or contribute to its violation. Current discharges would generally not be expected to increase their selenium loading based on a revised WQS (a discharger that is meeting a current limit for selenium would be expected to continue to at least meet that current limit), but may be subject to more stringent limits. However, new or expanding dischargers may increase loading to the environment, but at levels not to exceed the ambient level specified in the revised WQS, generally applying conservative assumptions such that a margin of safety is provided.

A. WV NPDES Permits for Municipal and Industrial Dischargers

Municipal wastewater treatment facilities and industrial facilities that discharge wastewater are regulated under WV NPDES permits. West Virginia identifies point sources of wastewater and requires that those facilities obtain and comply with a wastewater discharge permit. These permits set limits for the amount of pollutants that may be discharged to ambient waters. Limitations are established for wastewater wherever: (a) EPA or the State has established minimum technology-based controls for a wastewater pollutant for the type of activity being regulated, or (b) a reasonable potential exists for the wastewater discharge to exceed a water quality standard. Permit conditions generally include effluent limits, periodic monitoring to ensure that the effluent limits are being met, compliance conditions requiring improvements in operations or special studies, special operating conditions, and other administrative requirements such as prompt reporting of any spills. WV NPDES permits are on a five year renewal cycle that allows new water quality standards to be considered and incorporated into existing permits. Permits can be administratively extended under Chapter 22, Article 11, Section 11(c) of the West Virginia Code, but this is not the EPA's preferred mode of action.

B. WV NPDES General Permits

General permits issued by West Virginia cover categories of discharges within a geographic area. See 40 CFR §122.2. General permits usually cover numerous discharge sources that share common characteristics. General permits cover a wide range of potential dischargers (e.g., municipal stormwater, industrial stormwater, construction stormwater, and coal mining). General permits normally include best management practices, or in some cases discharge benchmarks, designed to meet standards.

VII. Environmental Baseline for Selenium

Natural selenium introduction occurs via water percolation through seleniferous soils (Dobbs et. al. 1996). Of all the priority and non-priority pollutants, selenium has the narrowest range of what is beneficial for biota and what is detrimental. Aquatic and terrestrial organisms require 0.5 µg/g dry weight (dw) of selenium in their diet to sustain metabolic processes, whereas concentrations of selenium that are only an order of magnitude greater than the required level have been shown to be toxic to fish. Acute effects are observed after short exposure durations of typically 96 hours or less. Acute effects from the inorganic forms of selenium, selenite and selenite, require concentrations exceeding 300 µg/l, concentrations rarely reached in the environment. In contrast, toxic effects from long-term chronic exposure via diet and water can result in reduction of species in aquatic systems with aqueous concentrations less than 20 µg/l (Lemly 1985). As a result of the greater sensitivity to selenium from chronic exposures, water quality management practices over the last 10-15 years have focused on the control of chronic effects. Studies have shown that diet is the primary route of exposure that controls chronic toxicity to fish, the group considered to be the most sensitive to chronic selenium exposure (Coyle et. al. 1993; Hamilton et. al. 1990; Hermanutz et. al. 1996).

VIII. Description of the Listed Species' Critical Habitat

A. Critical Habitats where EPA's Action will have no effect: Indiana Bat and Virginia Big-Eared Bat

Critical habitat (CH) for the Indiana bat is found in Hellhole Cave in Pendleton County. This area was designated on September 22, 1977 (42 FR 47840).

CH for the Virginia big-eared bat is found in Cave Mountain Cave, Hellhole Cave, Hoffman School Cave and Sinnet Cave, all in Pendleton County, and Cave Hollow Cave in Tucker County. These areas were designated on November 30, 1979 (44 FR 69206).

The most significant range wide threats to the Indiana bat have been habitat loss/degradation, forest fragmentation, winter disturbance, and environmental contaminants. In addition to these threats, climate change and White-Nose Syndrome are increasingly being identified as significant threats to the future recovery of the Indiana bat and its congeners. Anthropogenic factors that may affect the continued existence of Indiana bats include numerous environmental contaminants (e.g., organophosphate and carbamate insecticides, oil spills, and PCBs), collisions with manmade objects (e.g., poorly constructed cave gates, vehicles, aircraft, communication towers, and wind turbines) and climate change (Indiana Bat 5-Year Review: Summary and Evaluation 2009).

Major threats to the Virginia Big-Eared Bat include loss of habitat, human disturbance including "increased human visitation to maternity roosts and hibernacula," and vandalism (Harvey 1975, Humphrey and Kunz 1976, USFWS 1984f, USFWS 2011f). Human disturbance is the primary threat causing the decline of the Virginia Big-Eared Bat (USFWS 1984f). Human disturbance has increased as a result of increased levels of recreational spelunking and research in caves (USFWS 1984f, Barbour and Davis 1969, Graham 1966). This bat has a high sensitivity to human disturbance. Adult bats may abandon caves and/or young after only slight disturbances which "force bats to use valuable energy reserves needed to survive hibernation," (USFWS 1984f, Brady et al. 1982, Humphrey and Kunz 1976, Pearson et al. 1952). Further, Humphrey and Kunz (1976) found that after a disturbance many populations decline and do not recover the following year. Compounding this problem is the tendency of the Virginia Big-Eared bat to form maternity colonies in the spring and summer, and hibernating colonies in the winter, by congregating in large numbers comprising the majority of the small population in a small number of caves such that any human disturbance of these roosts may affect a large proportion of the population (USFWS 1984f). The installation of gates on cave entrances to prevent human disturbance may lead to cave abandonment, changes in behavior, or a possibility of increased predation as bats slow down and circle before passing through gated cave entrances (USFWS 1984f, Tuttle 1977).

EPA's action will have no effect on designated CH for the Indiana bat and the Virginia big-eared bat because the cave systems designated as CH for these species are not aquatic habitats and the proposed action is unlikely to result in any alteration of these CH areas that would result in the adverse modification of the CH.

B. Critical Habitat where EPA's Action may have an Indirect Effect: Diamond Darter

Critical habitat for the Diamond darter is found in the Lower Elk River in Kanawha and Clay Counties. The rule for designation of critical habitat for the diamond darter was published on August 22, 2013, and became effective September 23, 2013 (78 FR 52364). In total, approximately 197.1 river kilometers (122.5 river miles) in West Virginia and Kentucky have been designated as critical habitat for the diamond darter.

Habitat features essential to the diamond darter (*Crystallaria cincottaare*) are clean, stable substrates, good water quality, and healthy benthic invertebrate populations. The diamond darter has been found in moderate-to-large (fourth- to eighth-order) perennial warmwater streams with moderate to strong velocities (e.g., 32 cm/sec), and clean sand and gravel substrates. Riffle-pool complexes and glide habitats are also an important habitat for this species (78 FR 52364, Welsh et. al. 2013). Riffle-pool transition areas are used for cover and shelter as well as for ambush foraging. Some studies suggest that *Crystallaria* travel upstream to reproduce, and free-floating young-of-year disperse downstream during spring high water to find a suitable habitat to grow and mature, suggesting that *Crystallaria* make long-distance movements in large rivers. Thus, variability in the substrate and available habitat conditions are important because darters may shift to different habitat types during different life stages to adapt to changing conditions (78 FR 52364). Feeding habits of the diamond darter in the wild are not known; however, based on studies of the crystal darter, adult diamond darter are benthic invertivores. Adult crystal darters eat midge and caddisfly larvae, and water mites; and juvenile and young eat immature stages of aquatic insects such as mayflies, craneflies, blackflies, caddisflies, and midges as well as zooplankton prey (78 FR 52364)

Critical habitats include primary constituent elements (PCEs) that exist for the diamond darters:

Crystallaria cincotta, Diamond Darter (78 FR 52364, August 22, 2013)

(1) Primary Constituent Element 1 – A series of connected riffle-pool complexes with moderate velocities in moderate- to large-sized (fourth- to eighth-order), geomorphically stable streams within the Ohio River watershed.
(2) Primary Constituent Element 2 – Stable, undisturbed sand and gravel stream substrates that are relatively free of and not embedded with silts and clays.
(3) Primary Constituent Element 3 – An instream flow regime (magnitude, frequency, duration, and seasonality of discharge over time) that is relatively unimpeded by impoundment or diversions such that there is minimal departure from a natural hydrograph.
(4) Primary Constituent Element 4 – Adequate water quality characterized by seasonally moderated temperatures, high dissolved oxygen levels, and moderate pH, and low levels of pollutants and siltation. Adequate water quality is defined as the quality necessary for normal behavior, growth, and viability of all life stages of the diamond darter.
(5) Primary Constituent Element 5 – A prey base of other fish larvae and benthic invertebrates including midge, caddisfly, and mayfly larvae.

EPA's action will not physically alter the riffle-pool structure, stream bottom substrates, or flow regimes of rivers and streams within the state. Therefore, EPA's approval action will have no effect on the diamond darter's PCEs 1-3 for critical habitat. Because surrogate toxicity indicate diamond darters are not chronically sensitive to selenium at criteria concentrations (see section XI-C), EPA's approval action will not likely adversely affect or degrade water quality necessary for diamond darters (PCE 4). Furthermore, EPA's approval action is may improve water quality for diamond darters by considering novel and sensitive toxicity endpoints not previously considered in existing water quality criteria. Additionally, diamond darter food sources (PCE 5) are not likely to be adversely affected at proposed criteria concentrations (see section XI-D).

IX. **Species Accounts**

A. Mammals

1. Indiana Bat

The Indiana bat was listed as an endangered species on March 11, 1967 (32 FR 4001). The majority of the population hibernates at relatively few sites, including several caves and one mine in Missouri, southern Indiana, and Kentucky (Brady et al. 1983, USFWS 1999a).

A significant threat to the Indiana bat is human disturbance at winter caves, which causes aroused bats to deplete energy reserves (Twente 1955, Mohr 1972). Vandalism and indiscriminant killing have been a problem at some caves. Commercialization of caves result in excessive disturbance (Mohr 1972) or intentional elimination by cave owners (Hall 1962). Other threats include exclusion of bats by poorly designed gates (Long's Cave in Mammoth Cave National Park, Kentucky), changes in cave temperatures induced by opening additional entrances (Matthews and Moseley 1990) or poorly designed barriers to human access (Richter et al. 1993). Improperly constructed gates can alter the air flow, trap debris, and block the entrance by not allowing enough flight space (Brady et al. 1982). Altered exchange of air with the outside environment can cause significant changes in cave temperature and humidity and may cause the bats to abandon the cave (Tuttle 1977).

Despite protection at overwintering sites, populations continue to decrease in several portions of their range, suggesting that the species is being negatively affected by disturbance of loss of summer habitat. Loss and degradation of summer habitat and roost sites due to impoundment, stream channelization, housing development, clear cutting for agricultural use (Herkert 1992), or incompatible forest management practices that result in a shortage of the microhabitats used for maternity roosts may be the primary factors in recent population declines (Sparks et al. 2005).

Flying insects are the typical prey items; diet reflects prey present in available foraging habitat. The bat forages along river and lake shorelines, in the crowns of trees in floodplains (Humphrey et al. 1977), and in upland forest (Brack and LaVal 1985).

The most significant range wide threats to the Indiana bat have been habitat loss/degradation, forest fragmentation, winter disturbance, and environmental contaminants. In addition to these threats, climate change and white-nose syndrome are increasingly being identified as significant threats to the future recovery of the Indiana bat and its congeners (Indiana Bat 5-Year Review: Summary and Evaluation 2009).

2. Virginia big-eared bat

The Virginia big-eared bat was listed as endangered on November 30, 1979 (44 FR 69206). This bat is found in three separate populations, centered in eastern Kentucky, southwestern Virginia, and eastern West Virginia, but many caves within this region have been abandoned. More Virginia big-eared bats occur in West Virginia than any other state, and populations in the state are increasing. Populations in some caves have increased as much as 512% from 1983 to 2006 (West Virginia Wildlife Magazine, Fall 2006).

Some of these bats have been killed for sport. In addition, well-meaning biologists and spelunkers, observing the bats for scientific or educational purposes, have caused disturbances and subsequent population reductions because of the high sensitivity of these species. The growing popularity of spelunking is a tremendous threat to these bats because they are very intolerant of disturbance. Forest defoliation by gypsy moth could adversely affect native Lepidoptera and impact bat population (Sample and Whitmore 1993).

The Virginia big-eared bat feed principally on moths. They forage over fields and woods, with individuals routinely traveling 3-5 miles from roost cave to foraging area. The Virginia big-eared bats were also observed foraging in corn, hay and alfalfa fields. Forest insects comprise a substantial portion of the diet (Virginia big-eared bat 5 year review 2008; Sample and Whitmore 1993).

3. Northern long-eared bat

The Northern long-eared bat was listed as threatened on April 2, 2015 (80 FR 17974). This bat is widely but patchily distributed in the eastern and north central United States and adjacent southern Canada, from Newfoundland and eastern Quebec south through New England and the mountains of Virginia, North Carolina, South Carolina, and Georgia to the north central panhandle of Florida (formerly) and northwestward through Alabama, northern Arkansas, the eastern Great Plains, and the western Canadian provinces, to northeastern British Columbia and southern Northwest Territories (Barbour and Davis 1969, Harvey 1992, van Zyll de Jong 1985, Hall 1981).

The general summer and winter ranges appear to be identical (Barbour and Davis 1969). This species is more common in the northern part of the range than in the south (Harvey 1992), and it is rare in the northwestern portion of the range (Nagorsen and Brigham 1993, Caceres and Barclay 2000). It is reported uncommon in Indiana, Kentucky, Tennessee, and Wisconsin (Mumford and Cope 1964, Harvey et al. 1991; Jackson 1961), more common in northern Michigan than in southern Michigan (Kurta 1982), and quite common in New York (Hamilton and Whitaker 1979).

The most serious threat is white-nose syndrome (WNS), an often (but not always) lethal condition caused by a fungal pathogen (*Geomyces destructans*). WNS was first noticed in 2006 in New York. Since its initial discovery, WNS has spread rapidly and now occurs throughout most of northeastern United States and adjacent southeastern Canada. WNS affects *Myotis septentrionalis* and several other bat species (Gargas et al. 2009) and resulted in more than a million bat deaths in northeastern United States in just 5 years.

Loss, degradation, and fragmentation of mature forest habitat (associated with various kinds of human activities, such as logging; oil, gas and mineral development; and wind energy development) also may be a significant threat (Center for Biological Diversity 2010, USFWS 2011a). Mortality caused directly by wind turbines may pose a significant threat in some areas (USFWS 2011a).

This species is sensitive to disturbance during hibernation (Thomas 1995). Frequently aroused bats may deplete their energy reserves. Nursery colonies are very sensitive to disturbance by humans; bats may move to an alternate roost after a single examination, even if no attempt is made to capture the bats (Layne 1978).

Populations of this species in New York, Massachusetts, and Vermont declined 93 percent overall in the few years since white-nose syndrome was first discovered (Langwig et al. 2009). Small, highly fragmented, or young forests that provide limited areas of sub-canopy foraging habitat may not be suitable. Young forests may also lack appropriate nursery sites. A lack of suitable hibernacula may prevent occupancy of areas that otherwise have adequate habitat (Kurta 1982).

The Northern long-eared bat is an opportunistic insectivore (Kunz 1973). Prey composition varies widely among sites and seasons and their diet included Lepidoptera, Coleoptera, Neuroptera, Diptera, Hymenoptera, Homoptera, and Hemiptera (Whitaker 1972, LaVal and LaVal 1980, Griffith and Gates 1985). The presence of green plant material is some individuals, suggesting that some insects may have been gleaned from vegetation (Fenton 1982). Foraging typically occurs in forested habitats, above and below the canopy, over forest clearings and occasionally over water. Eleven individuals (10 males, 1 female) tagged with chemical lights observed during the summer in Missouri (LaVal et al. 1977), foraged almost exclusively among the trees of hillside and ridge forests, rather than utilizing floodplain and riparian forest. Foraging bats doubled back frequently and only slowly moved out of the observation area. In Iowa, Kunz (1973, 1971) found primarily females foraging in mature deciduous uplands with adjacent deep ravines and in a disturbed riparian area with an adjacent floodplain and agricultural lands (NatureServe 2014c).

B. Fish

1. Diamond Darter

The Diamond darter was listed as endangered on July 26, 2013 (78 FR 45074). In total about 122.5 river miles in Kanawha and Clay Counties, West Virginia, and Edmonson, Hart and Green Counties, Kentucky, have been designated as critical habitat.

The diamond darter is a small fish that is a member of the perch family (Percidae). Diamond darters bury into the sand of a stream bottom and ambush the insects that serve as their prey. Adult diamond darters are benthic invertivores, feeding primarily on stream bottom-dwelling invertebrates. This species was historically distributed throughout the Ohio River Basin including the Muskingum River in Ohio; the Ohio River in Ohio, Kentucky, and Indiana; the Green River in Kentucky; and the Cumberland River Drainage in Kentucky and Tennessee. This darter has been extirpated from all of these streams and is now known to occur only within the lower Elk River in West Virginia.

Habitat includes clean sand, gravel, and cobble runs of small or medium rivers (Page and Burr 2011). The impoundment of rivers in the Ohio River Basin, such as the Kanawha, Ohio, and Cumberland, has eliminated much of the species' habitat and isolated the existing population from other watersheds that the species historically occupied. This species no longer occurs in most of its historical range (Welsh et al. 2009); was last collected in Kentucky in 1929 (Burr and Warren 1986a) and in Tennessee in 1939 (Etnier and Starnes 1993). This fish needs clean water without too much silt (FR Vol. 78, No. 144, July 26, 2013 pages 45074-45095).

The **diamond darter** (*Crystallaria cincotta*) currently only occurs in a single reach of the Elk River. In addition to being listed as endangered in 2013, critical habitat for the species was also designated in West Virginia in Kanawha and Clay Counties. A recovery plan has not yet been developed, but it has been determined that this darter is endangered by water quality degradation; habitat loss; a small population size that makes the species vulnerable to the effects of the spread of invasive species; loss of genetic fitness; and catastrophic events, such as toxic spills.

C. Crustaceans

1. Madison Cave isopod

Listed as threatened in 1982 (45 FR 43699) and a recovery plan developed. The **Madison Cave isopod** (*Antrolana lira*) is known to occur in Jefferson County in West Virginia and may potentially also occur in Berkeley County. The Madison Cave isopod is an eyeless, unpigmented, freshwater crustacean. It is found in flooded limestone caves beneath the Great Valley of Virginia and West Virginia where it swims freely through calcite-saturated waters of deep karst aquifers. Agriculture and encroaching industrial and urban development threaten the quality of groundwater habitat and thus the survival of this species (USFWS 2010).

2. Big Sandy and Guyandotte River Crayfish

On April 7, 2016, the **Big Sandy crayfish** (Cambarus callainus) was listed as threatened and the **Guyandotte River crayfish** (Cambarus veteranus) was listed as endangered (81 FR 20450). Both are freshwater, tertiary burrowing crustaceans of the Cambaridae family. Tertiary burrowing crayfish do not exhibit complex burrowing behavior; instead, they shelter in shallow excavations under loose cobbles and boulders on the stream bottom. The two species are closely related and share many basic physical characteristics and behaviors.

Thoma (2009 & 2010) reported demographic and life-history observations for the Big Sandy crayfish in Virginia and Kentucky. He concluded that the general life cycle pattern of the species is 2 to 3 years of growth, maturation in the third year, and first mating in midsummer of the third or fourth year. Following midsummer mating, the annual cycle involves egg laying in late summer or fall, spring release of young, and late spring/early summer molting. Thoma hypothesized the likely lifespan or the Big Sandy crayfish to be 5 to 7 years, with the possibility of some individuals reaching 10 years of age.

There is less information available specific to the life history of the Guyandotte River crayfish, but based on other shared characteristics with the Big Sandy crayfish, the USFWS concluded the life span and age to maturity are similar. The best available data indicate both species are opportunistic omnivores, feeding on plant and animal matter (Thoma 2009b; Loughman 2014).

In West Virginia, the best available data indicate that the historical range of the Guyandotte River crayfish is limited to the Upper Guyandotte River basin in the State and that the historical range of the Big Sandy crayfish is limited to the upper Big Sandy River basin in southern West Virginia. Both river basins are in the Appalachian Plateaus physiographic province, which is characterized by rugged, mountainous terrain with steep hills and ridges dissected by a network of deeply incised valleys (Ehlke et al. 1982; Kiesler et al. 1983). The dominant land cover in the two basins is forest, with the natural vegetation community being characterized as mixed mesophytic (moderately moist) forest and Appalachian oak forest (McNab and Avers 1996).

Suitable habitat for both species is generally described as clean, third order or larger (width of 4 to 20 meters, fast-flowing, permanent streams and rivers with an abundance of large, unembedded slab boulders on a sand, cobble, or bedrock stream bottom (Jezerinac et al. 1995; Channell 2004; Taylor and Shuster 2004; Thoma 2009b; Thoma 2010; Loughman 2013; Loughman 2014; Loughman 2015a; Loughman 2015b). Under natural (i.e., undegraded) conditions, this habitat was common in streams throughout the entire upper Big Sandy and Upper Guyandotte River basins, and historically, both species likely occurred throughout their respective ranges where this habitat existed. However, by the late 1800s, commercial logging and coal mining, coupled with rapid human population growth and increased development in the narrow valley riparian zones, began to severely degrade the aquatic habitat throughout both river basins. USFWS concluded, based on the best available data, this widespread habitat degradation, most visible as stream bottom embeddedness, likely led to each species' decline and their eventual extirpation from many stream within much of their respective historical ranges.

Both species appear to be intolerant of excessive sedimentation and embeddedness of the stream bottom substrate. This statement is based on observed habitat characteristics from sties that either formally supported the Big Sandy or Guyandotte River crayfish or from sites that either of the species' historical ranges that were predicted to be suitable for the species, but where neither of the species (and in some cases no crayfish from any species) were observed (Jezerinac et al. 1995; Channell 2004; Thoma 2009b; Thoma 2010,, Loughman 2013; Loughman 2015a; Loughman 2015b).

D. Mollusks

1. Mussel, clubshell

This subspecies was listed as federally endangered January 22, 1993 (58 FR 5638) in the U.S. and a recovery plan developed (USFWS 1994a). According to the recovery plan, along with the northern riffleshell, few mussel species have declined in numbers as drastically as this species. This species has been extirpated from most of its range in this century (probably less than 20 percent of historical range remains). Continued loss of habitat and water quality deterioration threaten remaining population.

In West Virginia, the **clubshell mussel** (*Pleurobema clava*) is found in the Elk River and the lower ½ miles of the Birch River, Blue Creek and Laurel Creek in Braxton, Clay and Kanawha Counties as well as Harrison, Lewis, Doddridge, Pleasants, Tyler, Ritchie and Wirt Counties.

The clubshell is found in clean, coarse sand and gravel in runs, often just downstream of a riffle. It cannot tolerate mud or slackwater conditions, and is very susceptible to siltation. It is threatened by runoff and channelization, domestic and commercial pollution, in-stream sand and gravel mining, impoundments, and zebra/quagga mussel infestation. The recovery plan focuses on ecosystem conservation efforts, population management on a site-specific basis, collection of species data, restoration of habitat, reintroduction, and public support and outreach.

2. Mussel, fanshell

The Fanshell mussel was listed as endangered on June 21, 1990 (USFWS 1990b). A recovery plan addressing the Fanshell was approved on July 9, 1991 (USFWS 1991a). This freshwater mussel is characterized as a medium to large river species (Bates and Dennis 1985). In West Virginia, the **fanshell mussel** (*Cyprogenia stegaria*) is found in Fayette, Kanawha, Mason, Putnam, Cabell, Jackson, Mason, Pleasants, Tyler, Wayne, Wetzel and Wood Counties. This species inhabits gravel substrate in medium to large rivers. Threats contributing to its vulnerability included construction and operation of reservoirs and impacts on water and substrate quality. Recovery plans focus on the utilization of existing legislation, monitoring of existing populations, education programs, reintroduction and protection of eight viable populations, development and implementation of cryopreservation protection of species.

This mussel feeds by filtering food particles including disintegrated organic debris, algae, diatoms and bacteria from the water. The diet of fanshell glochidia, like other freshwater mussels, comprises water (until encysted on a fish host) and fish body fluids (once encysted).

The reproductive cycle of the fanshell is similar to that of other native freshwater mussels. Males release sperm into the water column; the sperm are then taken in by the females through their siphons during feeding and respiration. The females retain the fertilized eggs in their gills until the larvae (glochidia) fully develop. The mussel glochidia are released into the water, and within a few days they must attach to the appropriate species of fish, which they parasitize for a short time while they develop into juvenile mussels. The species is a long-term brooder and holds glochidia overwinter for spring release (Ortmann 1919). Fanshell glochidia are released in the form of a unique spiral worm-like conglutinate suggesting that this species relies on fish hosts that visually search for food (USFWS 1991a). Recent induced infestations of glochidia on nine of sixteen fish species tested indicate that the following species are suitable hosts: mottled sculpin (*Cottus bairdi*), banded sculpin (*Cottus carolinae*), greenside darter (*Etheostoma blennioides*), snubnose darter (*Etheostoma simoterum*), banded darter (*Etheostoma zonale*), tangerine darter (*Percina auranitiaca*), blotchside logperch (*Percina burtoni*), logperch (*Percina caprodes*), and Roanoke darter (*Percina roanoka*) (Jones and Neves 2000).

The fanshell has undergone a substantial range reduction. It was historically distributed in the Ohio, Wabash, Cumberland and Tennessee Rivers and their larger tributaries in Pennsylvania, Ohio, West Virginia, Illinois, Indiana, Kentucky, Tennessee, Alabama, and Virginia (Johnson 1980, Ahlstedt 1986, Bates and Dennis 1985, Cummings et al. 1987 and 1988, USFWS 1991a). It is believed that reproducing populations are now present in only three rivers, the Clinch River

(Hancock County, TN and Scott County, VA), the Green River (Hart and Edmonson Counties, KY), and the Licking River (Kenton, Campbell, and Pendleton Counties, KY). In addition, based on collections of a few older individuals in the 1980s, small remnant (apparently non-reproducing) populations may still persist in the Muskingum River (Morgan and Washington Counties, OH), the Walhonding River (Coshocton County, OH), the Wabash River (White County, IL and Posey and Wabash Counties, IN), the Kanawha River (Fayette County, WV), Tygarts Creek (Greenup and Carter Counties, KY), the Barren River (Allen and Barren Counties, KY), the Cumberland River (Smith County, TN), and the Tennessee River (Rhea, Meigs, and Hardin County, TN)(USFWS 1990b, 1991a).

The loss of many historic populations was likely due to the impacts of impoundments, navigation projects, water quality degradation, and other forms of habitat alternation, including gravel and sand dredging that directly affected the species and reduced or eliminated its fish host (USFWS 1991a).

3. Mussel, James spiny

The **James spinymussel** (*Pleurobema collina*) was listed as endangered on July 22, 1988 (53 FR 27689). According to the Federal Register notice, it is known to survive in only four creeks, including Potts Creek in Monroe County, West Virginia.

This species inhabits stream sites of slow to moderate flow and clean sand and cobble bottom sediments, and is limited to areas of unpolluted water. Like other freshwater mussels, it feeds by filtering food particles from the water, a characteristic that makes it particularly susceptible to detrimental effects of water-borne pollutants.

Threats contributing to its vulnerability include water quality perturbations, disease, and displacement by the exotic clam species. Recovery plans focus on the identification of essential habitat, investigation of principal threats, assessment of projects posing negative effects on the species and its habitat, and monitoring of threats.

4. Mussel, pink mucket

This species was listed as federally endangered in the U.S. in 1976 and a recovery plan (USFWS, 1985) was drafted. The overall range of this once very widespread species has diminished, but this species was always considered rare whenever it was found and it seems to be surviving and reproducing in sections of river that have been altered by impoundments. More dramatic has been the decline in area of occupancy (probably greater than 30%) as it continues to be found in historical sites but often only in very low numbers. Although currently known from a few dozen localities, most are represented by very few individuals and have poor viability. If populations west of the Mississippi River prove to be a different species the conservation status will need to be reevaluated.

The **pink mucket pearly mussel** (*Lampsilis abrupta*) is found in Braxton, Clay, Kanawha, Fayette, Mason, Putnam, Cabell, Jackson, Pleasants, Tyler, Wayne, Wetzel and Wood Counties.

This freshwater mussel inhabits a range of substrates, from silt to boulder and gravel and is associated with medium to large rivers. Threats contributing to its vulnerability include destruction of habitat, mainly by impoundments, siltation, and pollution. Recovery plans focus on conducting population and habitat surveys, preserving populations and presently used habitat, and developing education programs.

Although this species is characterized as a large river species (Dennis, 1984) associated with fast-flowing waters, in recent years it has been able to survive and reproduce in impoundments with river-lake conditions but never in standing pools of water (USFWS, 1985). Found in waters with strong currents, rocky or boulder substrates, with depths up to about 1 m, it is also found in deeper waters with slower currents and sand and gravel substrates (Gordon and Layzer, 1989; USFWS, 1985). Despite extensive declines historically, the species appears to have adapted somewhat to existence in impounded sections of big rivers. Rarer occurrence of this species in smaller streams such as the Clinch River and Paint Rock River may result from sub-optimal habitat for this otherwise large river species (USFWS, 1985).

Known threats include modification of habitat (e.g., dams and dredging), degradation of water quality, and over harvest by commercial mussel industry. Also, siltation, pollution, and channelization in Ohio. Continued threats to the survival of this species include alteration or destruction of stream habitat due to impoundment for flood control, navigation, hydroelectric power, and recreation; siltation due to strip mining, coal washing, dredging, farming, logging, and road construction; and pollution from municipal, industrial, and agricultural waste discharges (USFWS, 1985).

5. Mussel, northern riffleshell

On January 22, 1993, the Northern riffleshell was designated by the USFWS as endangered (USFWS, 1993c: 58 FR 5638). The species is also considered as endangered by the freshwater mussel subcommittee of the endangered species committee of the American Fisheries Society (Willams et al., 1993). A recovery plan addressing the Northern riffleshell was approved by the USFWS on September 21, 1994 (USFWS, 1994a).

The **northern riffleshell mussel** (*Epioblasma torulosa*) is found in the Elk River and the lower ½ miles of the Birch River, Blue Creek and Laurel Creek in Braxton, Clay and Kanawha Counties. According to the recovery plan, along with the clubshell, few mussel species have declined in numbers as drastically as these two species. The northern riffleshell occurs in packed sand and gravel in riffles and runs. It is threatened by runoff and channelization, domestic and commercial pollution, in-stream sand and gravel mining, impoundments, and zebra/quagga mussel infestation. The recovery plan focuses on ecosystem conservation efforts, population management on a site-specific basis, collection of species data, restoration of habitat, reintroduction, and public support and outreach.

The Northern riffleshell is approximately 3 inches in length; the shell's exterior surface is brownish to yellowish-green with fine green rays. The inside of the shell is usually white, but can be pink (Stansbery et al. 1982). Ortmann (1919: 334) reported that this species was "always found…on riffles, on a bottom of firmly packed and rather fine gravel, in swiftly flowing, shallow water or coarse gravel" and Clark (1983: 362) characterized its habitat as "highly oxygenated riffle." Its preferred habitat appears to require swiftly moving water. The high oxygen concentrations in swift streams may be necessary for survival. It is a species of riffle area of smaller streams, and as such has fared better than larger river species, which have been heavily impacted by dredging and impoundment. Of the eleven or so species of naiads thought to be extinct in 1971 by Stansbery, most were from this latter type of habitat and all were species of *Epioblasma.*

Historically, the riffleshell occurred throughout much of the Ohio River watershed; however, the range has been dramatically reduced to ten populations scattered over four states and one province with only three that are considered viable. Currently the Northern riffleshell is extant in only seven streams; the Green River in Kentucky, French and LeBoeuf Creeks and the Allegheny River in Pennsylvania, the Detroit River in Michigan (possibly extirpated), and Big Darby Creek in Ohio (USFWS, 1993c), and recently discovered in at least one additional river in Ontario (Metcalfe-Smith et al., 1998). This species now exists in eight to ten isolated populations, most of which are small and peripheral and with little signs of reproduction. It is known from the Kentucky, Licking, and Green River drainages in Kentucky (Johnson 1978), but is likely only still extant in the Upper Green. It historically occurred in the Ohio River in several places including the Smithland dam pool in Illinois, Meldahl dam pool in Ohio/Kentucky, and as far as the upper Ohio just into Pennsylvania (Watters and Flaute, 2010). Taylor and Hughart (1981) presumed that it was no longer present in the Elk River of West Virginia. *Epioblasma torulosa rangiana* has experienced greater than a 95% range reduction (USFWS, 1993c; 1994a; Staton et al., 2000).

Impoundment of the Clinch River in Tennessee by the Norris Reservoir has resulted in the extirpation of the majority of species below the dam (Ahlstedt, 1984). The construction of the Wilson Dam on the Tennessee River has eliminated 20 of the orginal 22 Cumberlandian naiad species (Stansbery, 1971). Smith (1971) ranked the causes of extirpation or declines in fish species as follows: siltation, drainage of bottomland lakes, swamps, and prairie marches, desiccation during drought, species introductions, pollution, impoundments, and increased water temperatures. All of these factors render habitats unsuitable, cause extirpations, and lead to the isolation of populations thereby increasing their vulnerability to extirpation for many aquatic species (including mussels) throughout North America. Pollution through point (industrial and residential discharge) and nonpoint (siltation, herbicide and fertilizer run-off) sources is perhaps the greatest on-going threat to this species and most freshwater mussels. Destruction of habitat through stream channelization and maintenance and the construction of dams, although slowed in recent years, is still a threat in some areas. Impoundments reduce currents that are necessary for the most basic physiological activities such as feeding, waste removal and reproduction. In addition, reduced water flow typically results in a reduction in water oxygen levels and a settling out of suspended solids (silt, etc.), both of which are detrimental. Dredging of streams has an immediate effect on existing populations by physically removing and destroying individuals. Dredging also affects the long-term recolonization abilities by destroying much of the potential habitat, making the substrates and flow raters uniform throughout the system. Rotenone, a toxin used to kill fish in bodies of water for increased sport fishery quality, has been shown to be lethal to mussels as well (Heard, 1970). Natural predators include raccoons, otter, mink, muskrats, turtles and some birds, which feed heavily upon freshwater mussels (Simpson, 1899; Boepple and Coker, 1912; Evermann and Clark, 1918; Coker, et al. 1921; Parmalee, 1967; Snyder and Snyder, 1969). Domestic animals such as hogs can root mussel beds to pieces (Meek and Clark, 1912). Fishes, particularly catfish, Ictalurus spp., and Amierus spp., and freshwater drum, Aplodinotus grunniens also consume large numbers of unionids. USFWS (1994) lists the following reasons for decline: siltation (from agriculture, construction, and forestry runoff), impoundment (including dam construction and maintenance), instream sand and gravel mining (for channelization), pollutants (pesticides and fertilizers, heavy metals, ammonia from wastewater, acid-mine runoff, and invasive species (zebra mussel, quagga mussel).

This freshwater mussel occurs in a wide variety of large and small streams, preferring riffles and runs with bottoms composed of firmly packed sand and fine to coarse gravel (Watters, 1990). Preferred habitat appears to require flowing water in mid-size rivers. High dissolved oxygen concentrations in streams may be necessary for survival. No critical habitat has been designated for the riffleshell.

Riffleshells appear to have a relatively short life-span for a freshwater mussel. Sexual maturity can be reached in as little as three years, and most individuals probably live for only eight to 15 years (Rodgers et al, 2001). Most mussels probably experience very low annual juvenile survival. The combination of short life span and low fecundity indicates that populations depend on a large annual cohort resulting from a large population (Musick, 1999). Species following this reproductive strategy are susceptible to loss of individuals from predation and stochastic events, and are slow to recover from such losses (Rodgers et al, 2001), but may be well suited to exploit dynamic micro-habitat shifts characteristic of free-flowing rivers.

The primary factors that can be attributed to the reduction in riffleshell's range include impoundments, channelization, loss of riparian habitat, and the impacts of silt from poor land use (USFWS, 1995). Water pollution from municipalities, chemical discharges, coal mines, and reservoir releases have also impacted the species.

6. Mussel, rayed bean

In West Virginia, the **rayed bean mussel** (*Villosa fabalis*) is found in Braxton, Clay and Kanawha Counties. Its habitat is generally smaller, headwater creeks, but occurrence records exist from larger rivers (Cummings and Mayer 1992; Parmalee and Bogan 1998). They are usually found in or near shoal or riffle areas, and in the shallow, wave-washed areas of glacial lakes (West et al. 2000). Preferred substrates typically include gravel and sand. It is often found among vegetation in and adjacent to riffles and shoals (Watters 1988; West et al. 2000). Listed in 2012, there is no recovery plan yet in place, but according to the Federal Register notice (77 FR 8632), the decline of this species is primarily the result of habitat loss and degradation. Chief among the causes of decline are impoundments, channelization, chemical contaminants, mining and sedimentation.

7. Mussel, sheepnose

This species was listed as a U.S. federal endangered species on March 13, 2012a. The sheepnose has been extirpated throughout much of its former range or reduced to several dozen isolated populations. This species has been eliminated from two-thirds of the total number of streams from which it was historically known although it still has a very wide distribution with dozens of occurrences in the Mississippi and Ohio basins (over two dozen streams in 14 states). The majority of the remaining populations are small and geographically isolated (NatureServe 2014z).

The **sheepnose mussel** (*Plethobasus cyphyus*) is found in Fayette, Kanawha, Mason, Putnam, Cabell, Jackson, Pleasants, Tyler, Wayne, Wetzel and Wood Counties. Listed in 2012 (USFWS 2012a), there is no recovery plan yet in place, but according to Jthe Federal Register notice, the decline of this species is primarily the result of habitat loss and degradation. Chief among the causes of decline are impoundments, channelization, chemical contaminants, mining and sedimentation.

Smith (1971) ranked the causes of extirpation or declines in mussel species as follows: siltation, drainage of bottomland lakes, swamps, and prairie marshes, desiccation during drought, species introductions, pollution, impoundments, and increased water temperatures. All of these factors render habitats unsuitable, cause extirpations, and lead to the isolation of populations.

Pollution through point (industrial and residential discharge) and nonpoint (siltation, herbicide and fertilize run-off) sources is perhaps the greatest on-going threat to this species and most freshwater mussels. Lowered dissolved oxygen content and elevated ammonia levels (frequently associated with agricultural runoff and sewage discharge) have been shown to be lethal to some species of freshwater naiads (Horne and McIntosh 1979). Residential, mineral and industrial development also pose a significant threat. Rotenone, a toxin used to kill fish in bodies of water for increased sport fishery quality, has been shown to be lethal to mussels as well (Heard 1970). Destruction of habitat through stream channelization and maintenance and the construction of dams is still a threat in some areas.

Impoundments reduce currents that are necessary for basic physiological activities such as feeding, waste removal and reproduction. In addition, reduced water flow typically results in a reduction in water oxygen levels and a settling out of suspended solids (silt, etc.) both of which are detrimental. Dredging of streams has an immediate effect on existing populations by physically removing and destroying individuals. Dredging also affects the long-term recolonization abilities by destroying much of the potential habitat, making the substrates and flow rates uniform throughout the system.

Channelization impacts a stream's physical characteristics (e.g., accelerated erosion, reduced depth, decreased habitat diversity, geomorphic instability, riparian canopy loss) and biological composition (e.g., decreased fish and mussel diversity, changed species composition and abundance, decreased biomass, and reduced growth rates) (Hartfield 1993; Hubbard et al. 1993).

Heavy metal-rich drainage from coal mining and associated sedimentation have adversely impacted portions of the upper Tennessee River system in Virginia. Sedimentation is a pervasive problem in streams and has been implicated in the decline of stream mussel populations (Ellis 1936; Marking and Bills 1979; Vannote and Minshall 1982; Dennis 1984; Brim Box 1999; Fraley and Ahlstedt 2000).

No specific studies have considered this species. Densities have been determined in a few surveys (e.g., Jenkinson and Ahlstedt, 1988; Layzer and Gordon 1990).

8. Mussel, spectaclecase

The **spectaclecase mussel** was listed as endangered on March 13, 2012 (FR 77 14914). Adult mussels suspension feed, spending their entire lives partially or completely buried within the substrate (Murray and Leonard 1962). Adults feed on algae, bacteria, detritus, microscopic animals, and dissolved organic material (Christian et. al. 2004). For their first several months, juvenile mussels employ foot (pedal) feeding, consuming bacteria, algae and detritus (Yeager et al. 1994). The spectaclecase mussel (*Cumberlandia monodonta*) is found in Falyette, Kanawha, Mason and Putnam Counties. Listed in 2012, there is no recovery plan yet in place, but according to the Federal Register notice, the decline of this species is primarily the result of habitat loss and degradation. Chief among the causes of decline are impoundments, channelization, chemical contaminants, mining and sedimentation.

Mussel biologists know relatively little about the specific life-history requirements of the Spectaclecase. The Spectaclecase life cycle includes a parasitic phase; however, despite extensive investigation, the host species is not yet known.

The decline of mussels such as the Spetaclecase is primarily the result of habitat loss and degradation (Neves 1991). Chief among the causes of decline are impoundments, channelization, chemical contaminants, mining, oil and gas development, and sedimentation (Neves 1991; Neves 1993; Neves et al. 1997; Strayer et al. 2004; Watters 2000).

Below dams, including those operated to generate hydroelectric power, mussel declines are associated with changes and fluctuation in flow regime, scouring and erosion, reduced dissolved oxygen levels and water temperatures, and changes in resident fish assemblages (Layzer et al. 1993; Neves et al. 1997; Watters 2000).

Population losses due to impoundments have likely contributed more to the decline and imperilment of the Spectaclecase than any other factor. Large river habitat throughout nearly all of the range of the species has been impounded, leaving generally short, isolated patches of vestigial habitat in the area below dams. Navigational locks and dams, some high-wall dams and many lowhead dams have contributed significantly to the loss of Spectaclecase habitat.

Dam construction has a secondary effect of fragmenting the ranges of aquatic mollusk species, leaving relict habitats and populations isolated by the structures as well as by extensive areas of deep uninhabitable, impounded waters. These isolated populations are unable to naturally recolonize suitable habitat that is impacted by temporary, but devastating events, such as severe drought, chemical spills, or unauthorized discharges (77 FR 14936). Dams eliminate or reduce river flow within impounded areas, trap silts and cause sediment deposition, alter water temperature and dissolved oxygen levels, change downstream water flow and quality, decrease habitat heterogeneity, affect normal flood patterns, and block upstream and downstream movement of species (Layzer et al. 1993; Neves et al. 1997; Watters 2000).

Large river habitat throughout nearly all of the range of this species has been impounded, leaving generally short, isolated patches of remaining habitat in the area below the dams. The majority of the Tennessee and Cumberland River main stems and many of their largest tributaries are now impounded. There are 36 major dams located in the Tennessee River system, and about 90 percent of the Cumberland River downstream of Cumberland Falls (RM 550 (RKM 886)) is either directly impounded by the U.S. Army Corps of Engineers (Corps) structures or otherwise impacted by cold tail water released from several dams. Major Corps impoundments on Cumberland River tributaries have inundated an additional 100 miles (161 km) or more of Spectablecase habitat.

Coldwater releases from Wolf Creek, Dale Hollow and Center Hill Dams continue to degrade Spectaclecase habitat in the Cumberland River system. The scouring effect caused by 40 years of operation of the Center Hill Dam for hydroelectric power generation has dramatically altered the river morphology for 7 miles (12 km) downstream of the dam (Layzer et al. 1993). Layzer et al. (1993) reported that 37 of the 60 pre-impoundment mussel species of the Caney Fork River have been extirpated. Watters (2000) summarizes the tremendous loss of mussel species from various portions of the Tennessee and Cumberland River systems.

9. Mussel, snuffbox

The snuff box was listed as endangered on February 14, 2012. The **snuffbox mussel** (*Epioblasma triquetra*) is found in Braxton, Cabell, Calhoun, Clay, Doddridge, Gilmer, Harrison, Jackson, Kanawha, Lewis, Marion, Marshall, Mason, Monongalia, Pleasants, Ritchie, Roane, Tyler, Wetzel, Wirt and Wood Counties. There is not recovery plan yet in place, but according to the Federal Register notice (77 FR 8632), the decline of this species is primarily the result of habitat loss and degradation. Chief among the causes of decline are impoundments, channelization, chemical contaminants, mining and sedimentation.

It is a triangular-shaped freshwater mussel; relatively thick for its size, yellow or yellowish green with green rays, blotches, or chevron markings. The snuffbox is found in small- to medium-sized creeks, to larger rivers, and in lakes (Cummings and Mayer 1992; Parmalee and Bogan 1998). The species occurs in swift currents of riffles and shoals and wave washed shores of lakes over gravel and sand with occasional cobble and boulders. Individuals generally burrow deep into the substrate, except when spawning or attempting to attract a host (Parmalee and Bogan 1998). Strayer (1999a) demonstrated in field trials that mussels in streams occur chiefly in flow refuges, or relatively stable areas that display little movement of particles during flood events. Flow refuges conceivably allow relatively immobile mussels to remain in the same general location throughout their entire lives. Strayer thought that features commonly used in the past to explain the spatial patchiness of mussels (water depth, current speed, sediment grain size) were poor predictors of where mussels actually occur in streams.

The snuffbox has been eliminated from about 62 percent of the streams in which it historically occurred. Furthermore, extant populations, with few exceptions, are highly fragmented and restricted to short reaches. Available records indicate that 32 percent of streams considered to harbor extant populations of the snuffbox are represented by only one or two individuals. The primary cause of range curtailment for the snuffbox has been modification and destruction of river and stream habitats, primarily by the construction of impoundments.

The reproductive process of riverine mussels is generally disrupted by impoundments, making the snuffbox unable to successfully reproduce and recruit under reservoir conditions. Population losses due to impoundments have likely contributed more to the decline and imperilment of the snuffbox than has any other single factor. This species does not occur in reservoirs lacking riverine characteristics, although persists in some reaches of large rivers with dams (Ohio River and Allegheny River). It is restricted to sections retaining riverine characteristics (generally tailwaters).

Stream habitat throughout major portions of the range of this species has been impounded. The majority of the Tennessee and Cumberland River mainstems and many of their largest tributaries are now impounded. There are 36 major dams located in the Tennessee River system, and about 90 percent of the Cumberland River downstream of Cumberland Falls is either directly impounded by the U.S. Army Corps of Engineers (Corps) structures or otherwise impacted by cold tailwater released from dams. Watters (2000) summarizes the tremendous loss of mussel species from various portions of the Tennessee and Cumberland River systems. The snuffbox, once widespread throughout both systems, now persists in only five Tennessee River tributaries and one Cumberland River tributary.

Mussel biologists know relatively little about the specific life-history requirements of the snuffbox. This species is declining throughout its widespread range and has become increasingly rare, although several dozen occurrences remain; many of them with good viability. Distribution is greatly fragmented but remains relatively wide. Long-term viability of most populations is questionable especially those in large rivers where zebra mussel populations are now established.

It was historically widespread in the upper Mississippi and Ohio River drainages. It was widespread by never abundant in the Tennessee River system. It has been drastically reduced in range and is endangered in many states where it occurs. Extant populations can still be found in Wisconsin, Illinois, Indiana, Kentucky, Michigan, Ohio, Pennsylvania, Tennessee, and West Virginia. Most populations are small and geographically isolated from one another.

Residential, mineral and industrial development also pose a significant threat. Rotenone, a toxin used to kill fish in bodies of water for increased sport fishery quality, has been shown to be lethal to mussels as well (Heard, 1970). Destruction of habitat through stream channelization and maintenance and the construction of dams is still a threat in some areas. Impoundments reduce currents that are necessary for basic physiological activities such as feeding, waste removal and reproduction. In addition, reduced water flow typically results in a reduction in water oxygen levels and a settling out of suspended solids (silt, etc.), both of which are detrimental. Dredging of streams has an immediate effect on existing populations by physically removing and destroying individuals. Dredging also affects the long-term recolonization abilities by destroying much of the potential habitat, making the substrates and flow rates uniform throughout the system. Natural predators include raccoons, otter, mink, muskrats, turtles and some birds (Simpson 1899, Boepple and Coker, 1912; Evermann and Clark, 1918; Coker, et al. 1921; Parmalee, 1967; Snyder and Snyder, 1969). Domestic animals such as hogs can root mussel beds to pieces (Meek and Clark, 1912). Fishes, particularly catfish, Ictalurus spp., and Amierus spp., and freshwater drum, Aplodinotus grunniens also consume large numbers of unionids.

10. Mussel, tubercled-blossom pearly

The **tubercled blossom pearly mussel's** (*Epioblasma torulosa torulosa*) was listed as endangered on June 14, 1976 (41 FR 21062). In West Virginia, its distribution is the Kanawha River in Fayette, Kanawha, Mason and Putnam Counties, but it may be extinct. This species inhabits parts of those streams which are shallow and have sandy-gravel substrate and rapid currents. Threats contributing to its vulnerability include impoundments, barge canals, and other flow alternation structures that have eliminated riffle and shoal areas. Recovery plans focus on conducting intensive surveys of essential habitat and specific areas in need of protection, determining present and foreseeable threats to the species and striving to minimize and/or eliminate them, and assessing the species' overall status (USFWS 1985).

E. Plants

1. Harperella

Harperella (*Ptilimnium nodosum*) is listed as endangered and is currently found in Back Creek in Berkeley County, and the Cacapon River, Potomac River and Sleepy Creek in Morgan County. This plant species is native to seasonally flooded rocky streams and coastal plain ponds, in only a narrow range of water depths. Threats contributing to its vulnerability include its intolerance of deep water or conditions that are too dry. Recovery plans focus on increasing populations through habitat protection and watershed conservation measures, increased understanding and implementation of management and propagation techniques, and increased public awareness (USFWS 1990a).

2. Northeastern bulrush

Northeastern bulrush (*Scirpus ancistrochaetus*) is listed as endangered and is currently found in Berkeley and Hardy counties and may potentially occur in Hampshire, Mineral, Morgan and Pendleton counties. This plant species inhabits ponds, wet depressions, or shallow sinkholes within small wetland complexes of seasonally variable water levels. According to the recovery plan, the most immediate threats to the species are human-related activities that lead to the destruction or modification of its habitat. The recovery plan focuses on restoring the species' rangewide distribution through protection of known extant populations and their habitat, as well as conducting searches for additional populations. To ensure its long-term viability, investigations into ecological requirements of the species should be conducted, possibility leading to management of the species (USFWS 1993a).

3. Virginia spiraea

Virginia spiraea (*Spiraea virginiana*) is listed as threatened and is distributed in the Gauley River, Meadow River and New River in Fayette County; the Greenbrier River and Meadow River in Greenbrier County; the Bluestone River in Mercer County; the Gauley River and Meadow River in Nicholas County; the Greenbrier River in Pocahontas County; the Marsh Fork River, Dingess Branch and Millers Camp Branch in Raleigh County; and the Bluestone River in Summers County. It may also occur in Upshur County. This plant species inhabits disturbed sites along rivers and streams; it requires disturbance sufficient to inhibit arboreal competition, yet without scour that will remove most organic material or clones. Threats contributing to its vulnerability include a small population size, a paucity of sexual reproduction and dispersal, and manipulation of riverine habitat. Recovery plans focus on protecting the known populations and their habitat, and restoring rangewide distribution, as well as understanding the environmental tolerances and genetic diversity of the species to ensure long-term reproductive viability (USFWS 1992a).

X. Analysis of the Potential for Selenium to Affect Endangered and Threatened Species

A. Bats

1. General Analysis

Three bat species are considered in this evaluation. Major risks to these species include disease, spelunking or cave recreation that disturbs sensitive taxa, and terrestrial habitat impacts, including loss of habitat and roost sites due to impoundment, stream channelization, housing development, and clear-cutting or other forest management practices (Adam et.al. 1994; NatureServe 2014a,b,c). Bats are not aquatic organisms; however, the taxa under consideration for this evaluation do depend on aquatic systems for drinking water, foraging habitat, and prey (which include aquatic insects).

A decline in water quality would affect bats through direct consumption, since they rely on surface water for drinking (USFWS 2006b). This view is supported by habitat data that indicate the taxa focus on waters with fair-to-good water quality, which may reflect diet preference but may also be related to water consumption (Clare et al. 2011).

Many of the taxa have small foraging ranges located close to their roosts, to which they retain a strong fidelity (Adam et al. 1994; Johnson et al. 2014; Silvis et al. 2014). Reduction in foraging habitat or its prey production would impact their survival since taxa (e.g. Myotis sodalis) may eat up to half their body weight in insects (USFWS 2006b, 2007a; NatureServe 2014bc). Foraging habitat for some of the bats is often associated with hydric areas like bottomland, riparian, and wetland habitat adjacent to water (Carter 2006).

Bat diets include a large variety of insects (Tuttle et. al. 2006), some of which include representative aquatic taxa (e.g., Ephemeroptera, Trichoptera, Diptera), but which are mostly dominated by species with primarily terrestrial representatives (e.g., Hemiptera, Hymenoptera, Lepidoptera, Neuroptera, Coleoptera) (Best et al. 1997; Lee and McCracken 2004; NatureServe 2014a, 2014b). Prey influence toxicity as well as energetics, since contaminants can accumulate in prey.

Bats are being negatively affected by disturbance or loss of summer habitat. Loss and degradation of summer habitat and roost sites due to impoundment, stream channelization, housing development, clear cutting for agricultural use (Herkert 1992), or incompatible forest management practices that result in a shortage of the microhabitats used for maternity roosts may be the primary factors in recent population declines (Sparks et al. 2005).

2. Selenium Analysis

Mammals are not as sensitive to selenium as fish and birds (Ohlendorf et al. 1989; Janz et al 2010). In studies conducted between 1984 and 1986 at Kesterson National Wildlife Refuge in central California, concentrations of Se were measured in various tissues (blood, liver, hair) and feces of 10 species of small mammals (Ohlendorf et al.1989). Results demonstrated a strong relationship to environmental Se concentrations, with the highest tissue Se concentrations associated with the most contaminated sites (Ohlendorf et al.1989). In spite of higher Se bioaccumulation in the exposed mammals, there were no apparent changes in the health of the organisms between exposed and reference areas. The exception was that no pregnant voles or mice were found in Kesterson,_whereas pregnant individuals were found in the reference area. Although this finding might suggest reproductive failure, selenium could not be definitively linked to the observation (Ohlendorf et al. 1989). In comparison, at the same locations there were overt and often severe signs of acute and chronic Se toxicity observed in both fish and birds (Ohlendorf et al.1989).

3. Specific Taxa Literature Evidence Relevant to Analysis

Corynorhinus (=plecotus) townsendii virginianus, Virginia big-eared bat

The Virginia big-eared bat is reported to consume lepidopteran (moths and butterflies), coleopteran (beetle), dipteran (true flies), and hymenopteran (sawflies, wasps, bees, and ants) prey (Burford and Lacki 1998; NatureServe 2014a).

Myotis septentrionalis, Northern long-eared bat

Northern long-eared bats are reported to consume lepidopteran, coleopteran, dipteran, ephemeropteran, neuropteran (lacewings), hymenopteran, hemipteran (true bugs), trichopteran (caddisfly), and arachnid (spider) prey (Carter et al 2003; Dodd et al. 2012;; Lacki et al. 2009; Lee and McCracken 2004; NatureServe 2014c).

Myotis sodalist, Indiana bat

Indiana bats are reported to consume nine orders and 26 families (Tuttle et al. 2006), including lepidopteran, coleopteran, dipteran, and trichopteran prey (Kurta and Whitaker Jr. 1998).

B. Fish

1. General Analysis

The diamond darter is considered is this evaluation.

Significant threats to the diamond darter relate to "the present or threatened destruction, modification, or curtailment of its habitat and other natural or manmade factors affecting its continued existence." Threats include water quality degradation, habitat loss and modification, a small population size, confinement of the population to the lower Elk River, West Virginia, and cumulative effects of threats. While the species "could be vulnerable to overutilization for scientific or recreational purposes," "...the significance of this threat is minimized through the State's administration of scientific collecting permits" (78 FR 45074).

Water quality degradation results from sedimentation and siltation, pollutant discharges from activities including coal mining and oil and gas development, contaminants from untreated or poorly treated wastewater, and increased conductivity. Sedimentation and siltation occurs from sources including coal mining, oil and natural gas development, timber harvests, "construction and maintenance projects" including access roads, stream bottom disturbance from installation or repair of sewer, gas, and water lines, and removal of riparian vegetation (78 FR 45074; WVDEP 2011b; USEPA 2001b; WVDEP 2008b; WVDEP 1997; Penkal and Phillips 2011; Levesque and Dube 2007). Discharges of pollutants such as selenium, chloride, metals, and other solids from sources such as coal mining and oil and gas development impact water quality (78 FR 45074; WVDEP 2011b; WVDEP 1997; Pond 2004; Curtis 1973; Hartman et al. 2005; Mattingly et al. 2005; Palmer et al. 2010). Contaminants including "ammonia, pathogenic bacteria, nutrients (e.g., phosphorous and nitrogen), and organic matter" (78 FR 45074; Chu-Fa Tsai 1973; Cooper 1993) originating from untreated or inadequately treated wastewater also impact water quality. Increased conductivity due to discharges of pollutants such as dissolved metals and other solids from coal mining (78 FR 45074; Curtis 1973; Pond 2004; Hartman *et al.* 2005; Mattingly *et al.* 2005; Palmer *et al.* 2010) also have the potential to threaten diamond darters by negatively impacting the benthic macroinvertebrates they prey on and interfering with fish physiology (78 FR 45074 final rule; USEPA 2011; Pond et al. 2008). Further, the region where the last remaining population of the diamond darter is found is expected to see a "surge in oil and natural gas exploration and drilling above the levels experienced in the previous 5 years" (78 FR 45074; West Virginia Oil and Natural Gas Association 2013; also National Energy Technology Laboratories 2010).

Habitat loss and modification occurs through siltation and sedimentation (discussed above), isolation caused by impoundments (discussed below), and direct habitat disturbance (78 FR 45074). Siltation and sedimentation cover the stream bottom filling in the interstitial spaces in the sand and gravel substrates diamond darters require to carry out their life-history functions (78 FR 45074; Barbour at al. 1999; Sylte and Fischenich 2007; Waters 1995, and USFWS 2008b). Siltation and sedimentation may also contribute to destabilization of stream channels which could alter or remove the habitat the diamond darter relies on, suffocate the benthic macroinvertebrates the diamond darter forages on, and suffocate fish eggs and larvae (78 FR 45074; Waters 1995; USEPA 2013; Powell 1999; Ruble 2011b). Both the covering of the stream bottom with sediments and the destabilization of stream channels reduce the extent and quality of suitable habitat for this species. *Crystallaria* species are noted to be particularly sensitive to siltation (Grandmaison et al. 2003and sources therein). Impoundments of rivers in the historical range of diamond darters have eliminated suitable habitat for the species (78 FR 45074; Grandmaison et al. 2003; Trautman 1981). Direct habitat disturbance can occur through activities such as the installation and repair of sewer, gas and water lines (78 FR 45074 and references therein; Levesque and Dube 2007) and sedimentation and siltation from various sources (discussed above).

The small population size of the diamond darter makes the species vulnerable to the spread of invasive, nonnative species (78 FR 45074; Urgenson 2006, p. 35), loss of genetic variation (78 FR 45074; Allendorf and Luikart 2007; Noss and Cooperrider 1994; Gilpin and Soule 1986), catastrophic events (78 FR 45074; USEPA 2001a), and climate change impacts (78 FR 45074; Byers and Norris 2011). The confinement of the population to one 45km (28 mi) section of the lower Elk River, West Virginia (78 FR 52363) combined with the historical destruction of other suitable habitat or blockage of this species from other suitable habitat in its historical range due to impoundments on rivers in the Ohio River Basin such as the Kanawha, Ohio, and Cumberland Rivers (78 FR 45074; Grandmaison et al. 2003) makes it more difficult for the species to recover from disturbance such as invasive species, catastrophic events, or climate change impacts (78 FR 45074; Harris 1984; Noss and Copperrider 1994; 78 FR 52363).

According to the Federal Register Notice listing the species as endangered (78 FR 45074) some of the threats discussed above may cumulatively impact the diamond darter to a greater degree than a threat acting alone. For example, the diamond darter is threatened by many sources of habitat and water quality degradation which reduce the amount and quality of suitable habitat for this species and act as chronic threats (discussed above). In addition, as suitable habitat is threatened so is the amount and quality of prey for this species which leads to declines in physiological fitness and reproductive success. Taken together these threats likely decrease the resiliency of the species to acute threats and catastrophic events such as toxic spills, climate change impacts or the spread of invasive species. Further, the small population is restricted to one reach of one river and isolated from its historical range and other suitable habitat by impoundments. Cumulatively, these threats make the diamond darter particularly sensitive to extinction from new disturbances or threats (Yount and Niemi 1990, pp. 547-555).

2. Selenium Analysis

Selenium is a naturally occurring chemical element that is also an essential micronutrient. Trace amounts of selenium are required for normal cellular function in almost all animals. However, excessive amounts of selenium can also have toxic effects, with selenium being one of the most toxic of the biologically essential elements (Chapman et al. 2010). Egg-laying vertebrates have a lower tolerance than do mammals, and the transition from levels of selenium that are biologically essential to those that are toxic occurs across a relatively narrow range of exposure concentrations (Luckey and Venugopal 1977; USEPA 1987, 1998; Haygarth 1994; Chapman et al. 2009, 2010).

Selenium is a member of the sulfur group of nonmetallic elements and consequently the two chemicals share similar characteristics. Selenium can replace sulfur in two amino acids, the seleno-forms being selenomethoionine and selenocysteine. It has been a long-standing hypothesis that the cause of malformations in egg-laying vertebrates is due to substitution of selenium for sulfur in these amino acids and their subsequent incorporation into proteins causing disruption of the structure and function of the protein. When present in excessive amounts, selenium is erroneously substituted for sulfur, resulting in the formation of a triselenium linkage (Se-Se-Se) or a selenotrisulfide linkage (S-Se-S), either of which was thought to prevent the formation of the normal disulfide chemical bonds (S-S). The end result was thought to be distorted, dysfunctional enzymes and protein molecules that impaired normal cellular biochemistry (Diplock and Hoekstra 1976; Reddy and Massaro 1983; Sunde 1984).

Recent research, however, suggests that selenium's role in oxidative stress plays a role in embryo toxicity, whereas selenium substitution for sulfur does not. The substitution of selenomehionine for methionine does not appear to affect either the structure or function of proteins (Yuan et al. 1998; Mechaly et al. 2000; Egerer-Sieber et al. 2006). The reason is apparently due to selenium not being distally located in selenomethionine and therefore its effect on the tertiary structure of the protein is insulted. Although the incorporation of selenomethionine into proteins is concentration-dependent (Schrauzer 2000), selenocysteine's incorporation into proteins is not (Stadtman 1996). This suggests that neither selenomenthionine nor selenocysteine affect protein structure proteins as selenocysteine.

The role of selenium-induced oxidative stress in embryo toxicity and teratogenesis appears to be related to glutathione homeostasis. A review of bird studies by Hoffman (2002) showed exposure to selenium altered concentrations and ratios of reduced to oxidized glutathione thereby increasing measurements of oxidative cell damage. Palace et al. (2004) suggested oxidative stress due to elevated selenium levels results in pericardial and yolk sac edema in rainbow trout embyros. Evidence for the role of oxidative stress in selenium toxicity is growing but mechanistic studies are needed to better understand its effects on egg-laying including the evidence against sulfur substitution as a cause and the role of oxidative stress see Janz et al. (2010).

The most well-documented, overt and severe toxic symptoms in fish are reproductive teratogenesis and larval mortality. Egg-laying vertebrates appear to be the most sensitive taxa, with toxicity resulting from maternal transfer to eggs. Selenium consumed in the diet of adult female fish is deposited in the eggs, when selenium replaces sulfur in vitellogenin, which is transported to the ovary and incorporated into the developing ovarian follicle (Janz et al. 2010), the primary yolk precursor. In studies involving young organisms exposed through transfer of selenium from adult female fish into their eggs, the most sensitive diagnostic indicators of selenium toxicity in vertebrates occur when developing embryos metabolize organic selenium that is present in egg albumen or yolk. It is then further metabolized by larval fish after hatching.

A variety of lethal and sublethal deformities can occur in the developing fish exposed to selenium, affecting both hard and soft tissues (Lemly 1993b). Developmental malformations are among the most conspicuous and diagnostic symptoms of chronic selenium poisoning in fish. Terata are permanent biomarkers of toxicity, and have been used to identify impacts of selenium on fish populations (Maier and Knight 1994; Lemly 1997b). Deformities in fish that affect feeding or respiration can be lethal shortly after hatching. Terata that are not directly lethal, but distort the spine and fins, can reduce swimming ability and overall fitness. Because the rate of survival of deformed young would be less than that for normal young, the percentage of deformed adults observed during biosurveys will likely understate the underlying percentage of deformed young, although quantitation of the difference is ordinarily not possible.

In summary, the most sensitive indicators of selenium toxicity in fish larvae are effects modulated through the reproductive process and exhibited in fish larvae as teratogenic deformities such as skeletal, craniofacial, and fin deformities, and various forms of edema that result in mortality (Lemly 2002). The toxic effect generally evaluated is the reduction in the number of normal healthy offspring compared against the starting number of eggs. In studies of young organisms exposed to selenium solely through their own diet (rather than via maternal transfer), reductions in survival and/or growth are the effects that are generally evaluated.

3. Specific Taxa Literature Evidence Relevant to Analysis

Crystallaria cincotta, Diamond darter
Feeding habits of the diamond darter in the wild are not known, however, based on studies of crystal darters, adult diamond darters are benthic invertivores. Related crystal darters eat midge and caddisfly larvae, and water mites; and juvenile and young eat immature stages of aquatic insects such as mayflies, craneflies, blackflies, caddisflies, and midges as well as zooplankton prey (78 FR 52364).

C. Crustaceans

1. General analysis

Three species are considered in this evaluation, the Madison Cove Isopod, and two crawfish, the Big Sandy and Guyandotte. The Madison Cove Isopod (Antrolana lira) habitat is mainly deep karst aquifers. Threats to the species are agriculture and encroaching industrial and urban development that threaten the quality of the groundwater habitat. (USFWS 1996)

For the Big Sandy and Guyandotte Crawfish, the best available data indicate that the presence and abundance of both are correlated with habitat quality, specifically streams with slab boulders and low levels of sedimentation and substrate embeddedness (Jezerinac et al. 1995; Channell 2004; Thoma 2009b; Thoma 2010; Loughman 2014; Loughman 2015a; Loughman 2015b). In the historical range of these species, the aquatic habitat has been severely degraded by past and ongoing human activities (Hunt et al. 1937; Eller 1982; Jezerinac et al. 1995; Channell 2004; Thoma 2009b; Thoma 2010; Loughman 2013; Loughman and Welsh 2013; Loughman 2014). According to the Federal Register Notice, degradation of water quality and the species' habitat degradation is likely due to coal mining, forestry, gas and oil development, on- and off-road transportation, and residential/commercial development and associated stream modifications.

While the best available data indicate that erosion and sedimentation leading to stream substrate embeddedness is the primary threat to both crayfish species, other pollutants also degrade the streams and rivers within the ranges of these species and likely contributed to their decline and continued reduced distribution and abundance. There are widespread water quality problems throughout the Big Sandy and Upper Guyandotte River basins (USEPA 2004; WVDEP 2012. The pollutants commonly cited are metals, like selenium and pH impairments associated with coal mining, and bacteria. The Federal Register Notice concluded that it is difficult to attribute the decline or general low abundance of these species to a specific contaminant, or combination of contaminants, it is likely that poor water quality is an ongoing stressor to both throughout much of their existing range.

2. Selenium analysis

According to EPA's draft Aquatic Life Ambient Water Quality Criterion for Selenium – Freshwater (EPA 822-P-15-001, 2015), there is currently no data available on the chronic toxicity to crustaceans via dietary exposure to selenium. Since there are data available for insects, EPA used the taxonomic association at the level of phylum to allow insects to act as a surrogate for crustaceans. EPA also determined associative evidence that macroinvertebrates in general are less sensitive than fish. At sites where there have been documented effects to fish and aquatic-dependent birds from selenium exposure (e.g., Kesterson Reservoir, Belews Lake, Hyco Reservoir), field observations and data indicate that there has been no evidence of effects to macroinvertebrates including crustaceans (Janz et al. 2010).

D. Mollusks

1. General analysis

There are 10 federally listed species of freshwater mussels being evaluated. The large number of listed species reflects the general imperilment of this taxonomic group, the most imperiled freshwater organisms in the United States (Cope et al. 2008).

Freshwater mussels are filter feeding benthic bivalve mollusks that feed on detritus, diatoms, phytoplankton, and zooplankton (Parmalee and Bogan 1998). The juveniles and adults live burrowed in the substrate of permanent water bodies and use a set of siphons to inhale water through their gills, with which they filter food and breathe (McMahon and Bogan 2001). Freshwater mussels are general gonochoristic (two distinct sexes), although some taxa are hermaphroditic. Almost all taxa are ovoviviparous and brood their developing embryos in special modified gill marsupia. They release their fully formed larvae (glochidia) into the water. In unionid mussels, represented by the taxa above, the glochidia are obligately parasitic on specific host fish species. They encyst on the host and complete development while being dispersed by the host before final metamorphosis into juveniles, which settle on the bottom of the stream, burrow into the substrate, and develop into adults. Many species release glochidia in special conglutinates (many glochidia contained within a mucosal sac). Some representative species have elaborately developed conglutinates or superconglutinates that mimic insect or fish prey and lure host fish into consuming them, after which the glochidia attach to the fish gills or skin (McMahon and Bogan 2001). Even so, larval mortality is extremely high and most populations grow very slowly.

Freshwater mussel habitat requirements vary. They inhabit small-to-medium-sized streams to very large rivers. They generally require reaches with sand/gravel to cobble-size substrates, predominantly in riffle run geomorphic units with substantial flow. Some species, however, prefer mud/sandy substrate and even slower moving reaches. They generally require well-oxygenated waters.

These mussels, in general, live embedded in the bottom sand, gravel, and/or cobble substrates of rivers and streams. They also have a unique life cycle that involves a parasitic stage on host fish. Juvenile mussels require stable substrates with low to moderate amounts of sediment and low amounts of filamentous algae, and correct flow and water quality to continue to develop. The presence of suitable host fish is considered an essential element in these mussels' life cycles. In addition, because of their life cycle, small population sizes, and limited habitat availability, they are highly susceptible to competitive or predaceous nonnative species (69 FR 53147).

In the late 1800s and early 1900s mussels were heavily harvested on larger rivers to supply the button industry and also in the quest for pearls, until populations became severely depleted and states were forced to adopt harvest regulations (USFWS 2003c, d). More recently, freshwater navigation facilities, dredging for channel maintenance, sand and gravel mining, the proliferation of exotic zebra mussel (Dreissena polymorpha) in areas inhabited by native mussels, sedimentation, and water pollution, including both point and nonpoint sources of pollution (USFW 2003c, d) have caused a decline in native mussels. Relatively little information is known about the specific habitat associations, food sources and reproductive biology of endangered unionid mussels.

2. Selenium Analysis

EPA has determined that invertebrates are less sensitive to selenium than fish (EPA 2015) and that selenium effects on invertebrates typically occur at concentrations higher than those that elicit effects on the vertebrates (e.g., fish and birds) that prey upon them. In addition, a multi-seasonal in situ bioassay of mussels requested by EPA and USFWS on the Saline River, which is identified as critical habitat for the Arkansas fatmucket (Lampsilis powelii), found that a site-specific water column chronic criterion of 17 µg/l would not likely affect that species (USEPA Region 6 2014).

Some listed mussel species are known to have a life cycle which depends on fish species as an intermediate host. Typically, the intermediate hosts are from the genera that include stonerollers, darters and shiners i.e., Notropis and Etheostoma. As previously outlined, the toxicological profiles of these genera do not indicate that these genera will be adversely affected by selenium.

E. Plants

1. Selenium Analysis

According to the draft Aquatic Life Ambient Water Quality Criterion for Selenium – Freshwater (EPA 822-P-15-001, 2015) there is a relatively large number of tests from acceptable studies of aquatic plants available for possible derivation of a Final Plant Value. However, plant criteria were not developed because the relative sensitivity of freshwater plants to selenium is less than that of fish.

EPA's draft proposal indicates that data are available on the toxicity of selenite to 13 species of freshwater algae and plants. Results range from an LC_{50} of 70,000 µg/l for the green alga, *Chlorella ellipsoidea* (Shabada and El-Attar 1995) to 522 µg/l for incipient inhibition of the green alga, *Scenedesmus quadricauda* (Bringmann and Kuhn 1977a, 1978a,b, 1979, 1980b). Foe and Knight (Manuscript) found that 75 µg/l decreased the dry weight of *Selenastrum capricornutum*. Wehr and Brown (1985) reported that 320 µg/l increased the growth of the alga *Chrysochromulina breviturrita*.

Growth of several species of green algae was affected by selenate concentrations ranging from 100 to 40,000 µg/l. Blue-green algae appear to be more tolerant to selenate with 1,866 µg/l being the lowest concentration reported to affect growth (Kiffney and Knight 1990). Kumar (1964) found that a blue-green alga developed and lost resistance to selenate. The difference in the sensitivities of green and blue-green algae to selenate might be of ecological significance, particularly in bodies of water susceptible to nuisance algal blooms. For example, Patrick et al. (1975) reported that a concentration of 1,000 µg/l caused a natural assemblage of algae to shift to a community dominated by blue-green algae.

Although selenite appears to be more acutely toxic than selenate to most aquatic animals, this does not seem to be true for aquatic plants. Selenite and selenite are about equally toxic to the freshwater algae *Anabaena cylindrica, Anabaena flos-aquae, Anabaena variabilis, Anacystis nidulans*, and *Scenedesmus dimorphus* (Kiffney and Knight 1990; Kumar and Prakash 1971; Moede et al. 1980). The two oxidation states equally stimulated growth of *Chrysochromulina breviturrita* (Wehr and Brown 1985). On the other hand, selenate is more toxic than selenite to the freshwater *Selenastrum capriocornutum* (Richter 1982; Ibrahim and Spacie 1990).

XI. **Effect Determinations**

A. Selenium in general

West Virginia's selenium criterion fish tissue element values are consistent with EPA's draft freshwater selenium criterion as published for comment on July 27, 2015 in the Federal Register (80 FR 44350). EPA's draft document used fish data sufficient and relevant to support the criterion, and the derivation of the criterion was consistent with EPA's 1985 guidance. Therefore, West Virginia's fish tissue criteria elements fall within ranges that protect aquatic life against the harmful effects of selenium and are scientifically defensible and expected to be protective of the designated use.

In addition, fish tissue based values are more indicative of determining effects in aquatic life than a water column value because of the variability that exists with rates of uptake of dissolved selenium by plant life and trophic transfer factors among waterbodies. The same water column concentration could produce a fish tissue concentration within a two order of magnitude range of values, depending on the characteristics of the individual water. This is because, at the base of the food web, algae and other microorganisms accumulate selenium from water by factors ranging from several hundred to tens of thousands (Luoma and Presser 2009; Orr et al. 2012; Stewart et. al. 2010). As such, traditional methods for predicting toxicity on the basis of exposure to dissolved [water column] concentrations do not work for selenium because the behavior and toxicity of selenium in aquatic systems are highly dependent upon site-specific factors, including food web structure and hydrology. Thus, it is more accurate to rely on measures of selenium in fish tissue than measure of selenium in the water column to determine potential effects and protective levels for aquatic life in general, and also for proposed, threatened and endangered species.

B. Bats

1. Selenium Determination

As noted earlier, mammals are generally highly tolerant to selenium, especially compared to oviparous vertebrates. EPA is not aware of any selenium toxicity studies with bats or similar mammals. Sublethal liver changes have been found in laboratory rats (*Rattus norvegicus*) following lifetime exposure to natural selenium in the diet at a concentration of 1.4 ug/g (dry weight) and reduced longevity was found at 3 ug/g in the lifetime diet (Eisler 1985). Olson (1986) also reported reproductive selenosis in rats that consumed wheat with a concentration of 3 ug/g. Halverson et al. (1966) found a dietary selenium threshold of about 4.8 ug/g for growth retardation in rats. Given the bioaccumulative nature of selenium and the fish tissue elements of the selenium criterion being considered here (8.0 ug/g Fish Whole-Body Concentration, 11.3 ug/g Fish Muscle (skinless, boneless filet) and 15.9 Fish Egg/Ovary Concentration), concentrations in insect tissue should be substantially below those reported here to cause effects in rats due to lifetime dietary exposure. Based on these considerations, the EPA-approved changes to the selenium criterion may affect but are not likely to adversely affect the bat populations considered in this evaluation.

C. Fish

The USFWS has designated critical habitat for the diamond darter and identified physical or biological features essential to the conservation of the species. USFWS has listed PCEs, which are specific elements of the physical or biological features that provide for the species' life-history processes and are essential to the conservation of the species. Key PCE elements for the diamond darter are geomorphically stable streams, stable stream bottom substrates, sufficient instream flow regime, adequate water quality, and habitats allowing for an adequate prey base. Adequate water quality is characterized by moderate stream temperatures, acceptable dissolved oxygen concentrations, moderate pH, and low levels of pollutants, and provides the quality necessary for normal behavior, growth, and viability of all life stages of the diamond darter. Habitats must accommodate foraging, breeding, growth, and migration during various life stages of all eight species. In addition, habitats should support the physical, chemical, and biological conditions necessary for the survival of their prey. Habitat features essential to these taxa include good water quality, clean and stable substrates (i.e., silt-free), and health benthic invertebrate populations (78 FR 52364).

The impoundments of rivers in the Ohio River Basin, such as the Kanawha, have eliminated much of the species' habitat and isolated the existing population from other watersheds that the species historically occupied (Welsh et al. 2009).

Significant threats to the diamond darter relate to "the present or threatened destruction, modification, or curtailment of its habitat and other natural or manmade factors affecting its continued existence" (78 FR 45074). Threats include water quality degradation, habitat loss and modification, a small population size, confinement of the population to the lower Elk River, West Virginia, and cumulative effects of threats (78 FR 45074).

1. Selenium Determination

Given data limitations, selenium toxicity data using order-level surrogate species (i.e., *Micropterus* and *Lepomis*) provides the best available science for understanding diamond darter sensitivity to chronic selenium exposures. *Micropterus* and *Lepomis* (Order: *Perciformes*) are both phylogenetically related to diamond darters, with habitat and life-history similarities. In EPA's 2015 draft (EPA 822-P-15-001), the database of acceptable reproductive studies with fish include the reported toxicological value for *Micropterus* of 20.35 mg Se/kg dry weight (dw) and for *Lepomis macrochirus* a reported genus mean chronic value (GMCV) of 17.95 mg/kg dw. These values are greater than the chronic fish egg/ovary value adopted by West Virginia of 15.8 ug/g. In light of the this information, EPA believes that West Virginia's adopted fish egg/ovary fish tissue element of the selenium criterion is protective of the Diamond darter, and our approval of this criterion element for selenium may affect but is not likely to adversely affect this listed species. As the magnitudes of the fish whole-body and fish muscle elements are derived from the egg-ovary element, coupled with data on concentration ratios among tissues, EPA is also determining that West Virginia's whole-body and fish muscle elements are protective of the Diamond darter, and our approval of those elements may affect but is not likely to adversely affect this listed species.

D. Crustaceans

1. Selenium Determination

A review of available toxicology information revealed very limited data on the effects of selenium on crustaceans; however, limited in situ testing indicates that crustaceans are not affected, either short term or long term, by exposures up to 25 ug/l (Crane et al. 1992).

There is no current available data on the chronic toxicity to crustaceans via dietary exposure to selenium. At sites where there have been documented effects to fish and aquatic-dependent birds from selenium exposure (e.g., Kesterson Reservoir, Belews Lake, Hyco Reservoir), field observations and data indicate that there has been no evidence of effects to macroinvertebrates including crustaceans (Janz et al. 2010). In addition, Janz et. al. (2010) notes that the key vector for selenium toxicity via maternal transfer is selenium loading in the egg via vitellogenin in the egg compared with the oviparous vertebrates like fish, therefore, less selenium is likely transferred to the egg via deposition of vitellogenin. These mechanistic considerations are thus consistent with the absence of observed field effects on aquatic macroinvertebrates, including crustaceans and other arthopods, and with the Chapman et al. (2009, 2010) expert consensus that it is the egg-laying vertebrates that are most at risk. Therefore, EPA has determined that West Virginia's aquatic life chronic criterion for selenium may affect but is not likely to adversely affect these listed species.

E. Mussels

Mussel populations throughout the Central and Eastern United States have been declining since modern civilization began to significantly alter aquatic habitats. The Ohio River drainage was a center for freshwater mussel evolution and historically contained about 127 distinct mussel species and subspecies. Of this once rich mussel fauna, 11 mussels are extinct, and 33 mussels are classified as Federal endangered species. In less than 100 years, 35 percent of the Ohio River system's mussel fauna has either become extinct or federally endangered. No other wide ranging faunal group in the continental United States has experienced this degree of loss within the last 100 years.

Declines in these and other unionid freshwater mussels are attributed to a variety of factors, including:

- Impoundments and subsequent flow modifications, sediment alteration, temperature change, and impacts on host fish dispersal (Biggins 1991; Butler and Biggins 2004; Cummings and Cordeiro 2012; Jones and Neves 2002; Jones et al. 2004; USFWS 1997a, 1997b)
- Channel modification and habitat destruction/alteration from channelization, dredging, and sedimentation (Szymankski 1998; USFWS 2012a, USFWS 2014c; 77 FR 60804, October 4, 2012)
- Mining runoff including acid mine drainage and associated acidity, other toxins, and sediment (Butler and Biggins 2004; Watters 1994; 77 FR 60804, October 4, 2012)

- Land clearing and disturbance that creates erosion and sedimentation (Butler and Biggins 2004; Zanatta and Murphy 2007; 77 FR 60804, October 4, 2012)
- Invasive species (USFWS 1997c, 2009a)
- Point source discharge and nonpoint source runoff including toxins, sediment, organic enrichment, and nutrients (Davis and Layzer 2012; USFWS 2002; Strayer and Fettermen 1999; Szymanski 1998; USFWS 2012b)
- Loss of fish hosts (Bouvier et al. 2013; Miller et al. 1986; USFWS 1997b; USFWS 2014c)

The mussel fauna in most streams in West Virginia have been directly impacted by impoundments, siltation, channelization, and water pollution. Reservoir construction is an obvious cause of the loss of mussel diversity in larger rivers. In addition to the loss of riverine habitat within impoundments, most impoundments also seriously alter downstream aquatic habitat, and mussel populations upstream of reservoirs may be negatively impacted by changes in the fish fauna essential to a mussel's reproductive cycle.

Dam construction has a secondary effect of fragmenting the ranges of aquatic mollusk species, leaving relict habitats and populations isolated by the structures as well as by extensive areas of deep uninhabitable, impounded waters. These isolated populations are unable to naturally recolonize suitable habitat that is impacted by temporary, but devastating events, such as severe drought, chemical spills, or unauthorized discharges (Layzer et al. 1993; Neves et al. 1997; Watters 2000; Watters and Flaute 2010).

Dredging and channelization activities have profoundly altered riverine habitats nationwide. Hartfield (1993), Neves et al. (1997), and Watters (2000) reviewed the specific effects of channelization on freshwater mussels. Channelization impacts stream physically (for example accelerated erosion, reduced depth, decreased habitat diversity, geomorphic instability, and loss of riparian vegetation) and biologically (for example decreased fish and mussel diversity, altered species composition and abundance, decreased biomass, and reduced growth rates) (Hartfield 1993). Channel construction for navigation increases flood heights, partly as a result of a decrease in stream length and an increase in gradient (Hubbard et al. 1993 (in Hartfield 1993). Flood events may thus be exacerbated, conveying into streams large quantities of sediment, potentially with absorbed contaminants. Channel maintenance may result in profound impacts downstream, such as increases in turbidity and sedimentation, which may smother bottom-dwelling organisms.

Sedimentation, including siltation runoff, has been implicated as the number one factor in water quality impairment in the United States. Specific biological impacts on mussels from excessive sediment include reduced feeding and respiratory efficiency from clogged gills, disrupted metabolic processes, reduced growth rates, increased substrate instability, limited burrowing activity, and physical smothering. Host fish/mussel interactions may be indirectly impacted by changes in stream sediment regimes through three mechanisms: Fish abundance, diversity, and reproduction reduced; impedes host fish attractant mechanisms; interfere with the ability of some species adhesive conglutinates to adhere to rock particles. Waterborne sediment is produced by the erosion of stream banks, channels, plowed fields, unpaved roads, roadside ditches, upland gullies, and other soil disturbance sites. Agricultural activities produce the most significant amount of sediment that enters streams. Silvicultural sedimentation impacts are more the result of logging roads than the actual harvesting of timber. (NatureServe 2014)

Developmental activities associated with urbanization (e.g., highways, building construction, infrastructure creation, recreational facilities) may contribute significant amounts of sediment and other pollutants in quantities that may be detrimental to stream habitats. With development, watersheds become more impervious, resulting in increased storm-water runoff into streams and a doubling in annual flow rates in completely urbanized streams. Impervious surfaces may reduce sediment input into stream, but result in channel instability by accelerating storm-water runoff, which increases bank erosion and bed scouring (NatureServe 2014).

Coal mining related siltation and associated toxic runoff have adversely impacted many stream reaches. Numerous streams have experienced mussel and fish kills from toxic chemical spills, and poor land-use practices have fouled many waters with silt. Runoff from large urban areas has degraded water and substrate quality. Because of the extent of habitat destruction, the overall aquatic faunal diversity in many of the basins' rivers has declined significantly. As a result of this destruction of riverine habitat, 10 mussels have already required Endangered Species Act protection.

In addition, mussels may be indirectly affected if high turbidity levels significantly reduce the amount of light available for photosynthesis and thus the production of certain food items. Studies indicate that the primary impacts of excess sediment on mussels are sublethal, with detrimental effects not immediately apparent (Brim Box and Mosa 1999). The physical effects of sediment on mussels are multifold, and include changes in suspended and bed material load; changes in bed sediment composition associated with increased sediment production and run-off in the watershed; changes in the form, position, and stability of channels; changes in depth or the width-to-depth ratio, which affects light penetration and flow regime; actively aggrading (filling) or degrading (scouring) channels; and changes in channel position that may leave mussels stranded (Brim Box and Mosa 1999; Vannote and Minshall 1982). Increased sedimentation and siltation may explain in part why spectaclecase mussels appear to be experiencing recruitment failure in some streams.

Invasive species pose an additional threat to mussels. The alien Asian clam (Corbicula fluminea) has been implicated as a competitor with native mussels for resources such as food, nutrients, and space, particularly as juveniles. Paradoxically, large, seemingly healthy populations of unionids may coexist with Asian clams. The invasion of the nonnative zebra mussel (Dreissena polymorpha) poses a threat to the mussel fauna.

Selenium Determination

There are 10 mussel species of concern representing 7 genera and 2 families. Certain molluscan taxa, such as mussels and clams, can accumulate selenium to a much greater extent than planktonic crustaceans and insects (although the levels do not seem to be toxic to the mussels) due to higher ingestion rates of both particulate-bound (algae) and dissolved selenium from the water column through filter feeding, as well as the lower rate at which they eliminate selenium (Luoma and Rainbow 2005; Stewart et al. 2013). Because egg-laying (oviparous) vertebrates such as fish and birds are most sensitive to selenium effects, (Janz et al. 2010), these vertebrate consumers are also the most vulnerable groups to selenium poisoning and the focal point of most selenium environmental assessments (Ogle and Knight 1996; Stewart et al. 2010).

Additional review of the best available toxicology information revealed very limited data on the effects of selenium on mussels; however, limited testing indicates that mussels are not affected, either short term of long term, by exposures up to 400 ug/l with the exception of one reported LOEC at 100 ug/l for zebra mussel closure. Given that this value is above any water column value associated with EPA's fish tissue elements of the freshwater selenium criterion, the EPA concludes that the chronic fish tissue elements of the selenium criterion adopted by West Virginia may affect, but is not likely to adversely affect listed mussels in the State.

F. Plants

1. Selenium Determination

There are a relatively large number of tests from acceptable studies of aquatic plants that indicate that the sensitivity of freshwater plants to selenium is less than fish, so EPA did not development criteria for the protection of plant as aquatic life criteria would be protective of plants. Given that the aquatic life criterion will be protective of all aquatic organisms less sensitive to selenium toxicity than fish, including plants, the EPA concludes that the chronic fish tissue elements of the selenium criterion adopted by West Virginia may affect but is not likely to adversely affect listed plants in the State.

XII. **Conclusion**

EPA's research has shown that the most significant threats to all the species in West Virginia that are proposed, threatened and endangered are habitat loss and degradation associated with various kinds of human activities, such as development, impoundments, stream channelization, siltation caused by poor land use practices, logging and oil, gas and mineral development. This biological evaluation analyzes the potential effects of EPA's action on threatened and endangered species and designated critical habitat by approval of West Virginia's fish tissue elements of a freshwater aquatic life selenium criterion within their water quality standards. EPA has found that its approval of West Virginia's fish tissue elements (i.e., Fish Whole-Body Concentration, Fish Muscle (skinless, boneless) and Fish Egg/Ovary) of EPA's draft selenium criterion recommendation for the protection of aquatic life is not likely to lead to adverse effects.

The action to approve West Virginia's fish tissue elements of the selenium criterion will have No Effect on the designated critical habitat of 2 bat species because the areas designated as critical habitat are not aquatic habitats and the action is unlikely to result in any alteration of these critical habitat areas that would result in the adverse modification of the critical habitat.

EPA's action will not physically alter the riffle-pool structure, stream bottom substrates, or flow regimes of rivers and streams within the state. Therefore, EPA's approval action will have no effect on the diamond darter's PCEs 1-3 for critical habitat. Because surrogate toxicity indicate diamond darters are not chronically sensitive to selenium at criteria concentrations, EPA's approval action will not likely adversely affect or degrade water quality necessary for diamond darters (PCE 4). Furthermore, EPA's approval action may improve water quality for diamond darters by considering novel and sensitive toxicity endpoints not previously considered in existing water quality criteria. Additionally, diamond darter food sources (PCE 5) are not likely to be adversely affected at proposed criteria concentrations.

The EPA analysis indicates that its approval of the West Virginia adopted fish tissue elements of EPA's draft selenium criterion for the protection of aquatic life may affect but is not likely to adversely affect the proposed, threatened and endangered species in the State of West Virginia as listed below:

<u>Mammals</u>

Indiana bat	*Myotis sodalis*
Virginia big-eared bat	*Corynorhinus (=Plecotus) townsendii virginianus*
Northern long-eared bat	*Myotis septentriolnalis*

<u>Fishes</u>

Diamond darter	*Crystallaria cincotta*

<u>Crustaceans</u>

Madison Cave isopod	*Antrolana lira*
Big Sandy Crayfish	*Cambarus callainus*
Guyandotte River Crayfish	*Cambarus veteranus*

<u>Mollusks</u>

Mussel, clubshell	*Pleurobema clava*
Mussel, fanshell	*Cyprogenia stegaria (=irrorata)*
Mussel, James spiny	*Pleurobema (=Canthyria) collina*
Mussel, pink mucket	*Lampsilis abrupta (=orbiculata)*
Mussel, northern riffleshell	*Epioblasma torulosa rangiana*
Mussel, rayedbean	*Villosa fabalis*
Mussel, sheepnose	*Plethobasus cyphyus*
Mussel, spectaclecase	*Cumberlandia monodonta*
Mussel, snuffbox	*Epioblasma triquetra*

Mussel, tubercled-blossom pearly	*Epioblasma (=Dysnomia) torulosa torulosa*

Plants

Northeastern bulrush	*Scirpus ancistrochaetus*)
Harperella	*Ptilimnium nodosum*
Virginia spiraea	*Spiraea virginiana*

EPA has also concluded that an EPA action to approve the primacy of fish tissue criterion elements over water column criterion element is not likely to adversely affect the proposed, threatened and endangered species in the State of West Virginia. Construction of protective water quality criteria for the protection of aquatic life from the chronic adverse effects of selenium that relies on measures in fish tissue over measures in associated water when both data are available reflects the increased accuracy and precision of fish tissue measurements in discerning thresholds for adverse effects and protective levels.

EPA is also concluding its approval of West Virginia's deletion of the acute selenium criterion for the protection of aquatic life is not likely to adversely affect the proposed, threatened and endangered species in the State of West Virginia. Selenium is bioaccumulative and toxicity primarily occurs via dietary (chronic) exposure. Acute toxicity associated with selenium occurs only at very high levels, making an acute criterion unnecessary.

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