

**WEST VIRGINIA DIVISION OF NATURAL RESOURCES  
WILDLIFE RESOURCES SECTION**

**Proposed Dunkard Creek Fish and  
Mussel Restoration Plan**

---

---

**8/25/2011**



**Abstract – Fish, mussels, and mud puppy salamanders in Dunkard Creek, Monongalia County, West Virginia were decimated in September 2009 by golden algae (*Prymnesium parvum*) toxins. Water quality conditions at the time of the kill were characterized by high conductivities and chlorides from deep mine discharges. This document outlines the West Virginia Division of Natural Resources’ plan to monitor and restore the stream’s aquatic diversity and the values it supported prior to the kill.**

**Authors:**

David I. Wellman, Jr.  
Assistant District 1 Fisheries Biologist  
PO Box 99  
Farmington, WV 26571  
(304) 825-6787  
[David.I.Wellman@wv.gov](mailto:David.I.Wellman@wv.gov)

Janet Clayton  
Wildlife Biologist – Malacologist  
Elkins Operation Center  
Ward Road, P.O. Box 67  
Elkins, WV 26421  
(304) 637-0245  
[Janet.L.Clayton@wv.gov](mailto:Janet.L.Clayton@wv.gov)

Frank A. Jernejcic  
District 1 Fisheries Biologist  
PO Box 99  
Farmington, WV 26571  
(304) 825-6787  
[Frank.A.Jernejcic@wv.gov](mailto:Frank.A.Jernejcic@wv.gov)

Electronic copies of the **Proposed Fish and Mussel Restoration Plan for Dunkard Creek** can be downloaded from the Fishing link at the WVDNR website: [www.wvdnr.gov](http://www.wvdnr.gov)



**Table of Contents**

List of Figures ..... 4

List of Tables ..... 4

Background ..... 5

Goal ..... 14

Objectives ..... 14

    Fish..... 14

    Mussels ..... 14

    Mudpuppies ..... 15

Strategies ..... 15

    Fish Community Assessment ..... 15

    Smallmouth Bass Restoration ..... 16

    Muskellunge Restoration..... 16

    Mussel Restoration..... 17

    Mudpuppies ..... 19

    Annual Reports..... 19

Timeline ..... 19

    Fish Community..... 19

    Smallmouth Bass ..... 19

    Muskellunge..... 19

    Mussels ..... 19

    Mudpuppies ..... 20

Estimated Budget..... 20

Citations..... 21

**List of Figures**

Figure 1. Map of Dunkard Creek.....5  
Figure 2. General representation of the life cycle of freshwater mussels. ....10  
Figure 3. Stressed mud puppy observed on Dunkard Creek during kill event. ....15

**List of Tables**

Table 1. Dunkard Creek fish species collected by WVDNR. ....8  
Table 2. List of mussel species planned for restoration in Dunkard Creek.....13  
Table 3. Estimated budget for restoration of fish and mussel populations in Dunkard Creek. ...20

## Background

Dunkard Creek, a tributary of Monongahela River, meanders easterly for 33 miles from the West Virginia Fork headwaters near St. Leo in western Monongalia County before exiting the state one mile south of Mt. Morris, Pennsylvania (Figure 1). About three miles of this low gradient (2.6 feet/mile) reach meanders in Green County, Pennsylvania. After leaving West Virginia, Dunkard Creek flows approximately 20 miles in Pennsylvania to Monongahela River.

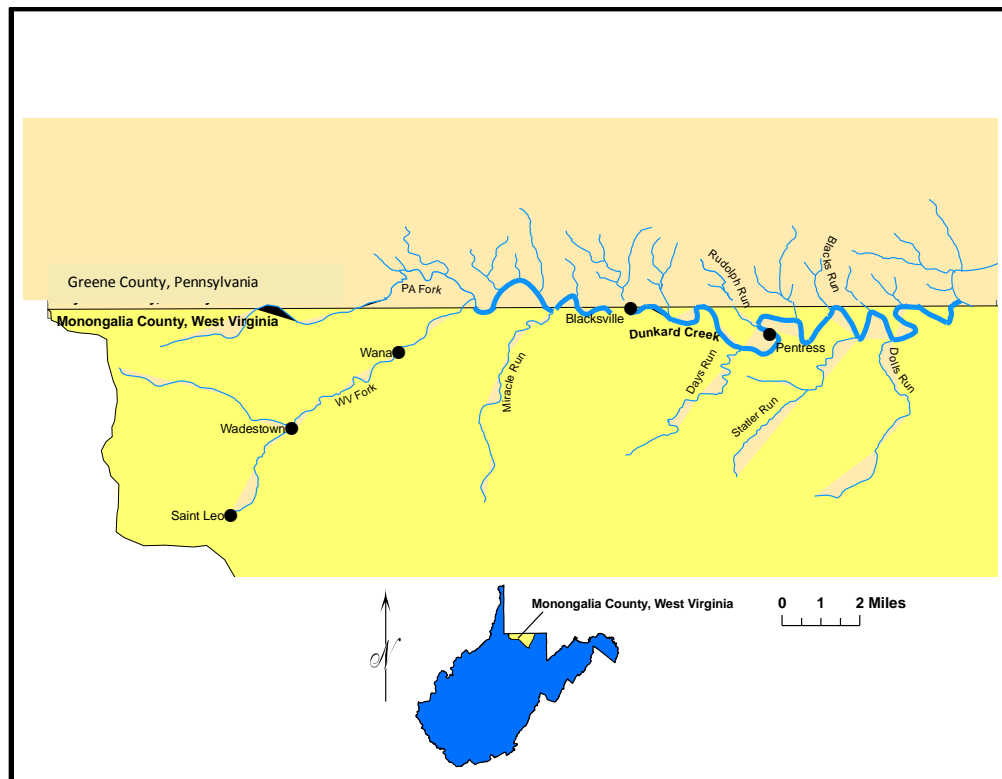


Figure 1. Dunkard Creek flows through Monongalia County, West Virginia and Greene County, Pennsylvania.

Though historically impacted by coal mine drainage, Dunkard Creek's fish and mussel populations were more diverse than most streams of comparable size in northern West Virginia (Dan Cincotta, WVDNR pers. comm.). Approximately three miles upstream of the mouth of Dunkard Creek in Pennsylvania, acid mine drainage (AMD) continues to negatively impact water quality and, at times of low flow, may prevent fish moving from Monongahela River into Dunkard Creek.

In September 2009 a toxic event occurred on Dunkard Creek that devastated the fish, mussel, and mudpuppy salamander populations (hereafter referred to as the kill). The West Virginia Department of Environmental Protection (WVDEP) determined that the kill was ultimately caused by toxins produced by golden algae (*Prymnesium parvum*). Golden algae are typically found in brackish waters of coastal states and were not previously monitored in West Virginia. In several states golden algae are responsible for annual fish kills (Sager et al. 2008). At the time of the event, elevated stream conductivities (5,000 – 51,000  $\mu\text{S}/\text{cm}$ ) and chloride

levels (>4,000 mg/l) from deep mine discharges into Dunkard Creek allowed golden algae to persist. How golden algae were introduced into Dunkard Creek will likely never be determined.

The Consol Energy, Inc. (Consol) Blacksville No. 2 deep mine discharge significantly influenced the water quality of Dunkard Creek at the time of the 2009 fish and mussel kill. Due to water quality violations, Consol entered into an agreement with the WVDEP, the U.S. Environmental Protection Agency, and the U.S. Department of Justice, to provide the West Virginia Division of Natural Resources (WVDNR) funding to restore Dunkard Creek's aquatic community. The WVDNR intends to use these monies to restore the fish and mussel populations of Dunkard Creek to pre-kill levels if possible. This document outlines the proposed WVDNR restoration approach.

### The Fish Population

The WVDNR conducted 18 fish surveys in Dunkard Creek between 1959 and 2009. Survey data indicated that the fish population was stressed during the 1960s, but significant improvements were observed from the 1980s through the late 1990s. Species richness (the number of species collected) and standing crop (the number of fish per acre) had increased between 1982 and 1998 by 29% and 318%, respectively. A total of forty-four fish species have been collected, making Dunkard Creek's fish community one of the richest in the state for a stream of its size (Table 1). Thirteen of these fish species are considered game fish.

Recovery of fish communities can be difficult to determine due to their dynamic nature. However, many studies have shown fish to be resilient following catastrophic events such as drought (Larimore 1959, Baylor and Osborne 1993), floods (Roghair et al. 2002, Wellman 2004), and toxic spills (Olmsted and Cloutman 1974). Minnows, darters, and juvenile sport fish (i.e. black bass) have shown higher rates of recovery than older and larger individuals (Olmsted and Cloutman 1974, Niemi et al. 1990, Roghair et al. 2002). More specifically, juvenile bass have demonstrated more mobility than adults, resulting in quicker recovery rates (Olmsted and Cloutman 1974). Recovery times are greatly influenced by the location of potential colonizers (Warner and Fenderson 1962, Detenbeck et al. 1992, and Pearsons et al. 1992). Fortunately, Dunkard Creek had several tributaries not impacted by the golden algae toxin and that served as refugia for minnows, darters, juvenile bass and smaller suckers. Since the Dunkard Creek kill was caused by golden algae toxins and not by physical alteration of the stream channel or watershed, it is anticipated that the fish community, especially forage fish (i.e. minnows, suckers), will be resilient and rapidly recover. However, some major fish kills caused by golden algae have required considerable stocking effort by state agencies and several years for sport fish populations (i.e. largemouth bass, smallmouth bass) to recover (Sager et al. 2008).

Prior to the 2009 kill, smallmouth bass (*Micropterus dolomieu*) were abundant in Dunkard Creek and popular with local anglers. This plan proposes to re-establish the smallmouth bass population through stocking, implementing a new protective regulation, and annual monitoring. The other favorite recreational species with Dunkard Creek anglers was the muskellunge (*Esox masquinongy*). Though native to the Monongahela River drainage (Goldsborough and Clark, 1908), the WVDNR began stocking muskies in Dunkard Creek to enhance the fishery in 1964. As a result, the Dunkard Creek musky fishery was held in high

regard by avid musky anglers in both West Virginia and Pennsylvania. Limited reproduction was documented by the Pennsylvania Fish and Boat Commission in 2005 (R. Lorson, PAFBC pers. comm.). Unfortunately, the 2009 kill also devastated the musky population. This plan proposes to re-establish the musky fishery through stocking, utilizing the existing 30 inch size limit regulation, monitoring, and angler catch reports.

Table 1. Dunkard Creek fish species collected by WVDNR during 18 surveys from 1959 through 2009.

Common Name	Scientific Name	Fish Family	Forage/Game Fish
brook silverside	<i>Labidesthes sicculus</i>	Atherinidae	Forage
black redbhorse	<i>Moxostoma duquesnei</i>	Catostomidae (Sucker)	Forage
golden redbhorse	<i>Moxostoma erythrurum</i>	Catostomidae (Sucker)	Forage
northern hog sucker	<i>Hypentelium nigricans</i>	Catostomidae (Sucker)	Forage
quillback carpsucker	<i>Carpiodes cyprinus</i>	Catostomidae (Sucker)	Forage
silver redbhorse	<i>Moxostoma anisurum</i>	Catostomidae (Sucker)	Forage
white sucker	<i>Catostomus commersonii</i>	Catostomidae (Sucker)	Forage
gizzard shad	<i>Dorosoma cepedianum</i>	Clupeidae (Herring)	Forage
bluntnose minnow	<i>Pimephales notatus</i>	Cyprinidae (Minnow)	Forage
central stoneroller	<i>Camptostoma anomalum</i>	Cyprinidae (Minnow)	Forage
common carp	<i>Cyprinus carpio</i>	Cyprinidae (Minnow)	Forage
creek chub	<i>Semotilus atromaculatus</i>	Cyprinidae (Minnow)	Forage
emerald shiner	<i>Notropis atherinoides</i>	Cyprinidae (Minnow)	Forage
ghost shiner	<i>Notropis buchmanii</i>	Cyprinidae (Minnow)	Forage
mimic shiner	<i>Notropis volucellus</i>	Cyprinidae (Minnow)	Forage
minnow hybrid	<i>Cyprinid hybrid</i>	Cyprinidae (Minnow)	Forage
rosyface shiner	<i>Notropis rubellus</i>	Cyprinidae (Minnow)	Forage
sand shiner	<i>Notropis stramineus</i>	Cyprinidae (Minnow)	Forage
silverjaw minnow	<i>Notropis buccatus</i>	Cyprinidae (Minnow)	Forage
spotfin shiner	<i>Cyprinella spiloptera</i>	Cyprinidae (Minnow)	Forage
striped shiner	<i>Luxilus chrysocephalus</i>	Cyprinidae (Minnow)	Forage
stonecat	<i>Noturus flavus</i>	Ictaluridae (Catfish)	Forage
banded darter	<i>Etheostoma zonale</i>	Percidae (Perch)	Forage
blackside darter	<i>Percina maculata</i>	Percidae (Perch)	Forage
fantail darter	<i>Etheostoma flabellare</i>	Percidae (Perch)	Forage
greenside darter	<i>Etheostoma blennioides</i>	Percidae (Perch)	Forage
johnny darter	<i>Etheostoma nigrum</i>	Percidae (Perch)	Forage
logperch	<i>Percina caprodes</i>	Percidae (Perch)	Forage
rainbow darter	<i>Etheostoma caeruleum</i>	Percidae (Perch)	Forage
variegate darter	<i>Etheostoma variatum</i>	Percidae (Perch)	Forage
bluegill	<i>Lepomis macrochirus</i>	Centrarchidae (Sunfish)	Game
green sunfish	<i>Lepomis cyanellus</i>	Centrarchidae (Sunfish)	Game
largemouth bass	<i>Micropterus salmoides</i>	Centrarchidae (Sunfish)	Game
longear sunfish	<i>Lepomis megalotis</i>	Centrarchidae (Sunfish)	Game
pumpkinseed X green sunfish	<i>Lepomis (gibbosus X cyanellus)</i>	Centrarchidae (Sunfish)	Game
pumpkinseed	<i>Lepomis gibbosus</i>	Centrarchidae (Sunfish)	Game
rock bass	<i>Ambloplites rupestris</i>	Centrarchidae (Sunfish)	Game
smallmouth bass	<i>Micropterus dolomieu</i>	Centrarchidae (Sunfish)	Game
spotted bass	<i>Micropterus punctulatus</i>	Centrarchidae (Sunfish)	Game
muskellunge	<i>Esox masquinongy</i>	Esocidae (Pike)	Game
flathead catfish	<i>Pylodictis olivaris</i>	Ictaluridae (Catfish)	Game
yellow bullhead	<i>Ameiurus natalis</i>	Ictaluridae (Catfish)	Game
sauger	<i>Sander canadensis</i>	Percidae (Perch)	Game
freshwater drum	<i>Aplodinotus grunniens</i>	Sciaenidae (Drum)	Game



## The Mussel Population

Prior to the kill, Dunkard Creek supported the most diverse and abundant mussel population remaining in the entire Monongahela River watershed (Janet Clayton, per. com.). Historically, 20 species of mussels were known to inhabit Dunkard Creek. Three species reported by Ortmann in 1911 and 1919 (purple wartyback (*Cyclonaias tuberculata*), black sandshell (*Ligumia recta*) and clubshell (*Pleurobema clava*)) have not been observed since. Dunkard Creek supported the last known snuffbox (*Epioblasma triquetra*) population within the entire Monongahela watershed. Although this genetic stock is now believed lost, this species is currently proposed for federal listing as endangered, bypassing the candidate status.

Only four species of mussels are known to remain within the Dunkard Creek watershed, all upstream of the kill zone. Only two of these species, the giant floater (*Pyganodon grandis*) and the fatmucket (*Lampsilis siliquoidea*) are potentially abundant enough to provide a source of brood stock, but are found in only one small tributary. The other two species, fluted shell (*Lasmigona costata*) and threeridge (*Amblema plicata*), are not believed to be sustainable at current population levels.

Freshwater mussels provide a variety of ecosystem services that are critical to the health of aquatic systems. Healthy mussel communities help stabilize stream bottoms because the mussels burrow into the substrate. The mussel's shells provide stable habitat for aquatic insects. Mussels remove bacteria and excess nutrients from the water and recycle those nutrients to make food available for aquatic insects and fish. Freshwater mussels have historically helped keep creeks and rivers clean by filtering enormous amounts of water. Mussels also provide food for fish and mammals. Unfortunately, freshwater mussels are the nation's most imperiled animals.

Freshwater mussels have a unique life cycle in that they must attach to a host for a period of time, undergo metamorphosis, and then release as juveniles (Figure 4). While most mussels use fish as hosts, one mussel known from Dunkard Creek, the salamander mussel (*Simpsonaias ambigua*), uses the mudpuppy (*Necturus m. maculosus*). Unfortunately the mudpuppy population was also decimated during the kill and recovery of adequate populations must be documented before restoration of this mussel may be pursued. For natural recolonization to occur, fish hosts in the headwaters of Dunkard Creek must be infected by resident mussels, swim downstream and pass one dam before releasing mussel larvae into the restoration zone.

In contrast to the upper reaches of Dunkard Creek, the lower three miles of Dunkard Creek are impacted by AMD. There is also a very limited and recovering mussel population in Monongahela River. Host fish must be infected by one of the few mussels present in Monongahela River, traverse the Dunkard Creek AMD zone, and then release mussel larvae in

the restoration zone. Natural restoration of mussel beds in Dunkard Creek from either upstream or downstream sources is unlikely.

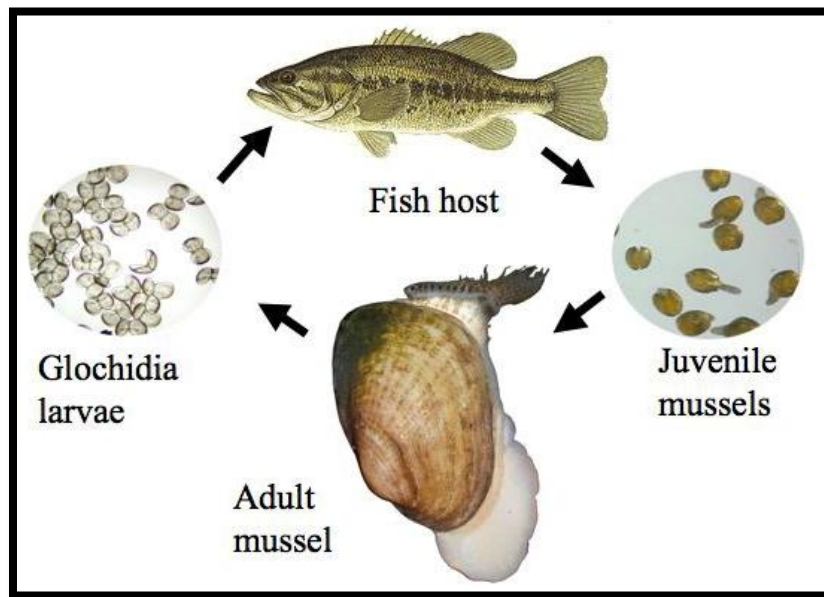


Figure 2. General representation of the life cycle of freshwater mussels.  
<http://molluskconservation.org/MUSSELS/Reproduction.html>

Over the next ten years attempts will be made to restore a stable and reproducing population of the 17 mussel species most recently lost from Dunkard Creek. The target number to restore per species is twice the estimated number killed, but with a minimum of 1,000 of each species representing three age classes. Goals were established based on the assumption that the number killed was significantly underestimated due to visibility, deep water, and buried mussels at the time of the assessment. Kill estimates will be re-evaluated after establishing the monitoring sites in 2011. Attempts will be made to collect mussel brood stock and fish hosts from watersheds closest to the Dunkard Creek watershed to ensure genetic integrity. Source streams in priority order include: Monongahela River and its tributaries, Allegheny River and its tributaries, and other tributaries of the upper Ohio River. The overall restoration strategy will involve limited translocation of adults from other streams. Mussels of adequate size will be tagged before release. Most active restoration will involve stocking of inoculated fish hosts until such time that juvenile grow-out facilities are identified or established.

Without active restoration, most mussel species are not expected to recover. The most direct restoration method is to relocate mussels to Dunkard Creek from other streams. This could, however, jeopardize source populations. Few sufficiently robust mussel populations remain within the Monongahela Basin. Streams that are still known to contain moderately diverse populations include: West Fork River, Hackers Creek, and Kincheloe Creek. None of the

populations are believed strong enough to supply adult animals for translocation though they may provide a source for brood stock. The Hackers Creek population has significantly declined in recent years. Surveys are planned for 2011 to assess the other two streams' potentials. The Allegheny River and its tributaries in Pennsylvania may provide some mussels for translocation and brood stock. Efforts will be made to coordinate with the Pennsylvania Fish and Boat Commission (PAFBC) to establish a plan as to which Pennsylvania streams would be best suited for providing each targeted species.

Although mussel propagation was begun in the early 1900s, it is still an incomplete and inexact science. Many host fishes have not yet been identified. Some mussel species are only known to use one species of fish while others are generalists and can transform on many species of fish. While all but one of the 17 species targeted for restoration have known hosts, nine use hosts not readily available commercially. Generally, artificial propagation of mussels entails several steps. Mussel brood stock must be collected, larval mussels (glochidia) must be extracted and attached to the appropriate fish host, and juvenile mussels collected and then stocked or moved to grow out within a hatchery. Stocking of newly transformed juveniles has shown very little success. In our West Virginia experience and that of others, most situations have involved augmenting existing populations and it is not known whether observed recruitment resulted from propagation efforts or natural reproduction. In both cases, recruitment has been low. Additionally, juveniles are very small and easily dislodged by currents and thus do not stay where placed. Hatchery grow-out appears to be the weakest link in artificial propagation other than finding suitable hosts for some species.

Juvenile mussels begin their life by pedal feeding. Their foot is covered with cilia and is used to bring food into the shell. As they mature, they switch from pedal feeding to filter feeding. Feeding juvenile mussels in the hatchery appears to be the key to survival. Facilities using the most natural water supplies appear to have the best success in propagating mussels to a stockable size. This would be the ideal situation for restoration of Dunkard Creek, but West Virginia does not have such a facility and restoration funds are inadequate to fund this approach to restoration. Our plans will circumvent this issue by directly stocking the infected host fish into Dunkard Creek. As main stem Dunkard Creek currently has no mussels, it will provide a unique opportunity to monitor the success of this restoration protocol.

All mussels are not created equal. There are two main brooding strategies. Short-term brooders typically have the period from egg fertilization to larval infestation occurring over a short period; females are generally gravid over a period of less than a month. Long-term brooders typically have the period from egg fertilization to larval infestation occurring over several months, including over the winter. Gravid females can be found over a period of several months. Most propagation efforts have historically involved mostly long-term brooders as it is much easier to collect gravid brood stock. Short-term brooders have to be regularly

assessed over time to find them at peak gravid condition. Gravidity is related mostly to stream temperature and has not been sufficiently documented for most species. It can fluctuate greatly depending on air temperature and flows. Short-term brooders are also more difficult to handle as they tend to readily abort when stressed. Recent research shows that glochidia that attach within 24 hours experience the best transformation success rate. For this reason, it is best to have the fish and mussels together when extracting the glochidia so that they can be quickly exposed to the host fish.

Table 2 provides a list of species targeted for restoration. Bluegill (*Lepomis macrochirus*) are readily available for purchase and will be the targeted fish host for those mussel species known to use them. Other confirmed fish hosts that have been collected from Dunkard Creek are listed for the other mussel species. The expected brooding period and brooding type is also provided. Non-commercially available fish hosts will be collected either by seining, trapping, or electrofishing and will require considerable effort.

Table 2. List of mussel species planned for restoration in Dunkard Creek with anticipated start date. Additional target dates will be established as improved water quality is ensured, water quantity issues are resolved, and brood stock sources are located. ds = downstream TBD = to be determined

Target Year to Start	Common Name	Scientific Name	Proposed Fish Host	Potential Source	Target Number to Restore	Reach to Stock	Brooding Period	Brooding Type
TBD	Threeridge	<i>Amblema plicata</i>	Bluegill	Pennsylvania	12,000	all	July	short
TBD	Pocketbook	<i>Lampsilis cardium</i>	Bluegill	Kincheloe Ck	6,000	all	Sept-May	long
2012	Fatmucket	<i>Lampsilis siliquoidea</i>	Bluegill	North Fk of WV Fk	2,600	all	Sept-May	long
TBD	Flutedshell	<i>Lasmigona costata</i>	Bluegill	Kinicheloe Ck, Salem Fk	3,600	all	Aug-May	long
2012	Fragile papershell	<i>Leptodea fragilis</i>	Freshwater drum	Monongahela	4,200	all	Sept-July	long
2013	Spike	<i>Elliptio dilatata</i>	Translocation	Pennsylvania	4,400	all	June-Aug	short
TBD	Snuffbox	<i>Epioblasma triquetra</i>	Logperch, Blackside Darter	?	1,000	all	Sept-May	long
TBD	Wabash pigtoe	<i>Fusconaia flava</i>	Creek chub	Pennsylvania	8,800	all	May-Aug	short
2012	Pink heelsplitter	<i>Potamilus alatus</i>	Freshwater drum	Monongahela, Upper Ohio	1,000	1, 2 (ds DOH)	May-Oct	long
TBD	Round pigtoe	<i>Pleurobema sintoxia</i>	Sptofin shiner, Bluntnose minnow, Central stoneroller,	Pennsylvania	1,000	1, 2 (ds Trinity)	May-July	short
TBD	Kidneyshell	<i>Ptychobranhus fasciolaris</i>	Rainbow Darter, Fantail darter	West Fk	6,500	1, 2	April-May	long
2012	Giant floater	<i>Pyganodon grandis</i>	Bluegill	North Fk of WV Fk	1,000	all	Aug-May	long
TBD	Salamander mussel	<i>Simpsonaias ambigua</i>	Mudpuppy	Pennsylvania	1,000	all	Oct-April?	long?
2012	Creepers	<i>Strophitus undulatus</i>	Bluegill	North Fk of WV Fk	1,000	all	April	long
TBD	Pistolgrip	<i>Tritogonia verrucosa</i>	Yellow bullhead, Flathead catfish	Upper Ohio	1,000	1, 2	May-July	short
2012	Paper pondshell	<i>Utterbackia imbecillis</i>	Bluegill	Left Prong New Ck Pond	1,000	all	April-Sept	long
TBD	Rainbow	<i>Villosa iris</i>	Bluegill	Pennsylvania, Booths Ck	1,000	1, 2	Sept-May	long

Consol will construct a reverse osmosis water treatment facility to treat and divert deep mine water now entering Dunkard Creek. The plant will be located at the head of Dents Run of Buffalo Creek, a tributary to Monongahela River entirely in West Virginia. This diverted discharge into Dents Run will reduce low flows in Dunkard Creek. The significance of this flow reduction is not yet known. The treatment facility is scheduled to go on-line in May 2013. With the lack of additional treatment until 2013 and the unknown effects of reduced flows, mussel restoration will not begin until 2012. In 2011, six monitoring sites will be established. Surveys will be conducted in the West Fork watershed to locate adequate brood stock, if possible, for future restoration efforts. Specific streams to be targeted include West Fork River, Hackers Creek, Kincheloe Creek, and Booths Creek. As all individuals targeted for propagation in 2012 are believed to be long term brooders, we will attempt to bring individuals into captivity during the fall of 2011 to be used for brood stock in the spring of 2012. Habitat requirements of the targeted species are such that individuals will be held at the WVDNR's Belleville complex or another suitable facility. Spring high flows typically make it difficult to collect brood stock just prior to inoculation.

## Goal

The goal of this plan is to restore<sup>1</sup> the aquatic community richness by re-establishing the diversity of fish, mussels, and mudpuppy salamanders to the levels existing prior to the 2009 event and to restore the recreational angling opportunities previously available.

## Objectives

### Fish

- Restore fish community richness to levels supportive of restoring mussel populations;
- Restore the smallmouth fishery and recreational opportunities for smallmouth bass anglers;
- Restore the musky fishery and provide anglers with quality size<sup>2</sup> muskies ( $\geq 30$  inches).

### Mussels

- Restore reproducing populations of 17 mussel species.

---

<sup>1</sup> Restoration, as defined in Hubert and Quist (2010), is the return of an ecosystem to its original, undisturbed state (e.g. prior to a major disturbance event).

<sup>2</sup> Quality size based on Proportional Stock Density length ranges defined by Gabelhouse (1984a). Quality size corresponds to approximately 36 - 41% of world record lengths for a specific fish species.

### Mudpuppies (Figure 3)

- Monitor by observation and, if necessary, facilitate natural restoration by transplanting mudpuppies from other populations if possible.



Figure 3. Stressed mud puppy observed on Dunkard Creek during kill event, September 10, 2009.

## Strategies

### Fish Community Assessment

Monitor fish abundance and richness through population surveys with standard parallel-wire electrofishing methods. This will aid in determining the adequacy of the forage fish base (i.e. minnows, suckers) to support a recreational sport fishery (i.e. smallmouth bass and muskies). In addition, survey results will determine the presence or absence of potential fish hosts vital to maintaining a viable and self-sustaining mussel community. Fish population surveys were conducted at Pentress in October 2009, immediately following the fish kill, and in July 2010. The October 2009 surveys yielded four species and 20 individual fish. In July 2010, 31 fish species and 2,180 individual fish were collected. The most recent surveys prior to the event were conducted in 2006 when 33 fish species and 6,039 individual fish were collected. Surveys will be conducted annually for the next five years at various stations along Dunkard Creek.

### **Smallmouth Bass Restoration**

Population surveys will be conducted in the summer or fall of 2011 to determine if the forage base is adequate to support a smallmouth bass population. If forage is sufficient, a program to stock hatchery-reared smallmouth bass will be initiated. Key program tasks are:

- WVDNR staff will conduct a fish health assessment to determine that all brood stock sources are free of deleterious bacterial pathogens and viruses. These assessments will be initially conducted in the Monongahela and Tygart rivers, two potential sources of smallmouth bass brood stock. Methods will follow standard protocols of the U.S. Fish and Wildlife Service (USFWS) Wild Fish Health Assessment Program.
- During the fall of 2011, 40 to 50 smallmouth bass (10 to 14 inches in total length) will be collected from the Monongahela or Tygart rivers. Fish will be transported to Palestine State Fish Hatchery in Wirt County. Adult smallmouth bass will be released into a hatchery pond, kept over winter, and allowed to spawn the following spring. Fingerlings (2-4 inches in total length) will be collected following pond drainage and stocked into Dunkard Creek at various West Virginia locations in late spring or early summer 2012. A maximum of 5,000 fingerlings will be stocked annually.
- Smallmouth bass will be stocked for three consecutive years beginning in 2012 and continue until 2014. Stockings will not occur in 2015 and 2016 to allow for the determination of successful reproduction. If successful reproduction does not occur, stockings will be conducted for an additional three years (2017 through 2020).
- Monitoring of smallmouth bass stocking success will be conducted through population surveys beginning in 2012 and continue through 2016, a five year period.
- A No Harvest angling regulation will be recommended for implementation in 2013 to facilitate adequate natural reproduction of stocked smallmouth bass. The regulation will be re-assessed after five years. Previous WVDNR age and growth data indicated that on average it takes three years for Dunkard Creek smallmouth bass to begin reproducing at a size of about 10 inches. A five year No Harvest regulation will allow the first two smallmouth bass stockings to reach sexual maturity before being allowed to be harvested.

### **Muskellunge Restoration**

Population surveys will be conducted in the summer or fall of 2011 to determine if the forage base is adequate to support a musky population. If forage is sufficient, a program to stock hatchery-reared muskies will be initiated in the following year. A musky stocking program will not be initiated until the forage base is adequate for both smallmouth bass and muskies. Key program tasks are:



- Approximately 10 muskies (five females and five males) ranging in length from 34 to 36 inches will be collected from Buckhannon or Tygart rivers during spring. Fish will be transported to Palestine State Fish Hatchery in Wirt County where the fish will be spawned and young-of-year muskies placed into hatchery ponds until early fall. Advanced fingerlings (10 - 12 inches) will be collected following pond drainage and stocked into Dunkard Creek at various locations in early fall. A maximum of 400 advanced fingerlings will be stocked annually.
- Musky stockings will occur for three consecutive years and then will cease for at least two years. Population surveys will be conducted during these two years to determine stocking success and musky density.
- Musky population surveys will be conducted with standard boat electrofishing gear used in other known musky streams.
- Musky angler reports (i.e. WV Husky Musky Club, Muskies, Inc. and local anglers) will be used to aid with evaluating musky restoration.
- The statewide minimum length limit of 30-inches will be in effect for Dunkard Creek muskies.

### **Mussel Restoration**

Monitoring of mussels will include the following:

- Establish six permanent monitoring stations (2011).
- Establish a baseline of extant mussel species and numbers (2011).
- Refine kill estimates developed immediately following the kill by more extensive and intensive surveys (including excavations) (2011).
- Track restoration success by conducting quantitative surveys in 2015, 2018, 2021 and 2026.
- Conduct annual timed surveys to adaptively guide development of annual work plans (2012-2021).

Relocate adult mussels from sources to provide assurance of genetic compatibility. Sources may include:

- The Allegheny and Monongahela rivers and their tributaries and other Upper Ohio River tributaries.
- Salvage mussels from Pennsylvania. Efforts will be coordinated with PAFBC to identify potential opportunities for salvaging mussels that would be impacted by projects on Pennsylvania rivers.
- Mussels from beds in West Virginia that are sufficiently robust to support removal and translocation. Surveys will be required to assess potential to remove mussels. Besides the upper Monongahela River, potential sources include (in declining suitability) West Fork River, Kincheloe Creek and Hackers

Creek. Hackers Creek has been subject to increasing stress and is the least likely source.

#### Collect and release adult mussels

- Secure individuals of the spike (*Elliptio dilatata*) for release in 2013.

#### Methods of securing, inoculating, and releasing host fish will include:

- In 2012, 50 to 200 freshwater drum will be collected and inoculated with fragile papershell and pink heelsplitter glochidia. The host fish will be released into Dunkard Creek.
- Four mussel species (snuffbox, Wabash pigtoe, round pigtoe, and pistolgrip) utilize various darters, shiners, chubs and catfish as hosts (Table 2). Appropriate fish hosts will be collected, inoculated and released into Dunkard Creek. Scheduling these mussel species for restoration is dependent on securing brood stock, identifying brood stock holding facilities, success in securing sufficient numbers of host fish, and several other factors that must be resolved relative to brooder type and host fish.
- Coordination between WVDNR and commercial hatcheries and/or WVDNR hatcheries will be conducted to provide host fish for inoculation. Currently, plans are to purchase bluegill for hosting glochidia for four species (fatmucket, giant floater, creeper, and paper pondshell) in 2012.
- Secure, and hold as necessary, brooding mussels of fatmucket, giant floater, creeper, paper pondshell, fragile papershell and pink heelsplitter for a 2012 mussel release.
- In future years, secure, and hold as necessary, brooding mussels of the remaining species where the exact timing will depend on assessment of and response to 2011 – 2013 activities.
- All activities above will be dependent on availability and access to appropriate numbers of identified fish and mussel species. Access is often dependent on flow conditions, which can vary widely and unpredictably. A synopsis of mussel restoration activity, sources, host fish etc. is found in Table 2.

#### Determining impact of reduced flow on mussels:

- As part of the settlement agreement with Consol, treated deep mine water which was previously discharged into Dunkard Creek will be pumped to a treatment plant located in the Buffalo Creek watershed in Marion County. The pumping of water out of the Dunkard Creek watershed will represent an inter-basin transfer of water, and could have a negative impact on low flows in Dunkard Creek. The WVDNR will attempt to evaluate the effect of the inter-basin transfer on low flow events and evaluate whether riffle species of

freshwater mussels will have sufficient water during low-flow periods for survival prior to stocking mussels on riffle habitat.

### **Mudpuppies**

Informally monitor mudpuppy population as an adjunct to fish and mussel monitoring. Indications are that populations will naturally recover during the restoration period. However, should recovery appear to be delayed, translocations of mudpuppy brood stock will be initiated if possible. A formal assessment of mudpuppy recovery will be made in 2016.

### **Annual Reports**

WVDNR will provide annual reports on the progress of the Dunkard Creek restoration efforts. These annual reports will be made available to the public on the WVDNR website ([www.wvdnr.gov](http://www.wvdnr.gov)) or by contacting the appropriate WVDNR personnel (contact information provided with list of authors).

## **Timeline**

### **Fish Community**

- 2009 – 2010: initial fish community population assessments have been completed
- 2011 – 2016: continue fish community population assessments

### **Smallmouth Bass**

- 2011: fish health assessment of brood stock
- 2011 – 2013: brood stock collection in the fall
- 2012 – 2014: fingerling stockings in the spring
- 2015 – 2016: determine stocking success

### **Muskellunge**

- 2013 - 2015: brood stock collection in the spring (activity timeline dependent upon forage population)
- 2013 – 2015: advanced fingerling stockings in the fall (activity timeline dependent upon forage population)
- 2016 – 2017: determine stocking success and density

### **Mussels**

- Monitoring will be conducted annually as discussed in the strategy section with more extensive monitoring conducted initially, every three to five years during the project, and at the project's conclusion.
- Initial restoration of seven mussel species will be attempted in 2012 and 2013. The mussel restoration project will be adaptively managed and scheduled based on results from those efforts.

- Evaluation of low flow events will be attempted in fall of 2011 to determine if riffle habitat will be available for riffle mussel species at low flows.

### **Mudpuppies**

- Informal monitoring will be conducted in conjunction with other surveying efforts each year. An assessment of the success of natural recovery of the mudpuppy population will be conducted in 2016. A decision will then be made that natural recovery is occurring or to augment restoration of the species.

## **Estimated Budget**

Table 3. Estimated budget for restoration of fish and mussel populations in Dunkard Creek.

Restoration Activity	Cost per Stocked Fish*	Estimated Number to be Stocked per Year	Cost per Year	Number of Years	Total Activity Cost
Musky stocking	\$4.72	400	\$1,888	5	\$9,440
Smallmouth bass stocking	\$1.72	5,000	\$8,600	5	\$43,000
Fish monitoring	--	--	\$9,600	5	\$48,000
Mussel monitoring	--	--	\$19,000	5	\$95,000
Mussel restoration	--	--		10	\$305,000
<b>Total</b>					<b>\$500,440</b>

\*Values provided by the American Fisheries Society Fish Replacement Cost updated to 2010.

## Citations

- Cairns, J., J. S. Crossman, K. L. Dickson, and E. E. Herricks. 1971. The recovery of damaged streams. *Association of Southeastern Biologist Bulletin* 18:79-106.
- Cairns, J., Jr. 1990. Theoretical basis for predicting rate and pathways of recovery. *Environmental Management* 14:517-525.
- Detenbeck, N. E., P. W. Devore, G. J. Niemi, and A. Lima. 1992. Recovery of temperate-stream fish communities from disturbance: A review of case studies and synthesis of theory. *Environmental Management* 16:33-53.
- Gabelhouse, D. W., Jr. 1984a. A length-categorization system to assess fish stocks. *North American Journal of Fisheries management* 4:273-285.
- Goldsborough, E. L. And H. W. Clark. 1908. Fishes of West Virginia. *Bulletin of the Bureau of Fisheries* 27:31-39.
- Hubert, W. A., M. C. Quist. 2010. *Inland Fisheries Management in North America, Third Edition* p 297.
- Larimore, R. W., W. F. Childers and C. Heckrotte. 1959. Destruction and re-establishment of stream fish and invertebrates affected by drought. *Transactions of the American Fisheries Society* 88:261-285.
- Niemi, G. J. P. DeVore, N. Detebeck, D. Taylor, A. Lima, J. Pastor, J. D. Yount, R. J. Naiman. 1990. Overview of case studies on recovery of aquatic systems from disturbance. *Environmental Management* 14:571-587.
- Olmsted, L. L. and D. G. Cloutman. 1974. Repopulation after a fish kill in Mud Creek, Washington County, Arkansas following a pesticide pollution. *Transactions of the American Fisheries Society* 1:79-87.
- Pearsons, T. N., H. W. Li, and G. A. Lamberti. 1992. Influence of habitat complexity on resistance to flooding and resilience of stream fish assemblages. *Transactions of the American Fisheries Society* 121:427-436.
- Roghair, C. N., C. A. Dolloff, and M. K. Underwood. 2002. Response of a brook trout population and instream habitat to a catastrophic flood and debris flow. *Transactions of the American Fisheries Society* 131:718-730.

- Sager, D. R., A. Barkoh, D. L. Buzan, L. T. Fries, J. A. Glass, G. L. Durten, J. J. Ralph, E. J. Singhurst, and G. M. Southard. 2008. Toxic *Prymnesium parvum*: A Potential Threat to U.S. Reservoirs. American Fisheries Society Symposium 62:261-273.
- Sedell, J., R. Hauer, C. P. Hawkins, and J. Stamford. 1990. The role of refugia in recovery from disturbance: modern fragmented and disconnected river systems. Environmental Management 17:711-724.
- Warner, K. and O. C. Fenderson. 1962. Effects of DDT spraying for forest insects on Maine trout streams. Journal of Wildlife Management 26: 86-93.
- Wellman, D. I. 2004. Post-flood recovery and distributions of fishes in the New River Gorge National River, West Virginia. Masters Thesis, West Virginia University, Morgantown, West Virginia.