# M.E.R.G.E

## Monongahela Enrichment River Guide for the Environment

Bridget O'Neill Kelsey Moxey Doug Rowland

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## Mission Statement

The Monongahela Enrichment River Guide for the Environment is a plan to improve water quality in the Monangahela Watershed. The goal is to collaborate with Pennsylvania, West Virginia, and Maryland to produce a water budget, improve current river infrastructure to be more efficient, safe, and green, and to encourage water quality by 2035.

•By 2017, create a water budget consolidating data from all three states into one dataset that determines where water is coming from, the quality of that water, and where the water is going

•By 2035, replace or improve critical infrastructure with green building practices

•By 2035, reduce TDS, metals, and acidity and increase oxygen levels by 20%

## Characteristics of the Monongahela Watershed

The Monongahela River is a major tributary to the Ohio River. Its drainage area is 7,340 square miles and spans across three different states, Pennsylvania, West Virginia, and parts of Maryland. The river is 128 miles long and flows north due to sloping topography and low setting valleys in the northern part of the watershed carved by glaciers (Three Rivers Quest, Pennsylvania Environmental Council). The Monongahela watershed is divided into 6 sub-watersheds shown in Figure 1. Table 1 displays the relative sizes of each sub-watershed in square miles, with the Youghiogheny having the greatest drainage area.

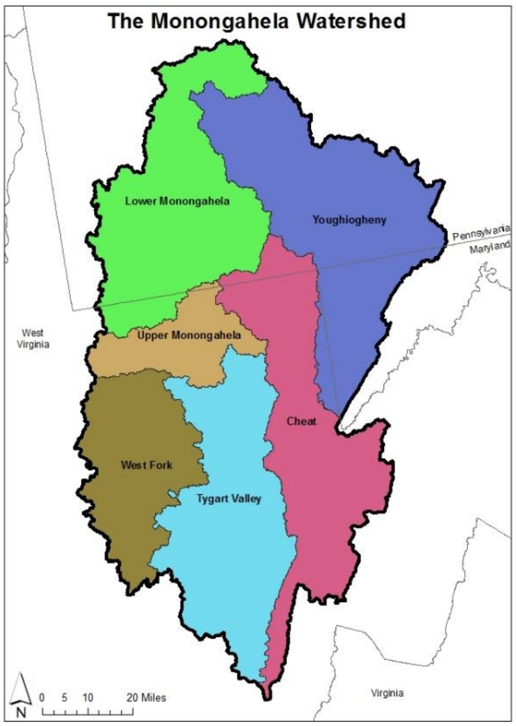


**Figure 1:** Delineation of sub-watersheds of the Monongahela River Watershed. (This figure was created in ArcMap 10.1 with data from USGS).

| Sub-watershed | Area (miles$^2$) |
|---|---|
| Cheat | 1410 |
| Lower Monongahela | 1450 |
| Tygart Valley | 1380 |
| Upper Monongahela | 463 |
| West Fork | 877 |
| Youghiogheny | 1740 |

**Table 1:** Areas of each sub-watershed of the Monongahela watershed. Data acquired from Three Rivers Quest.

Native Americans named the river Monongahela, meaning crumbling or falling banks (monriver.org, 2007). This justifies the highly erodible, poorly drained soils in the Allegany Mountains in the Eastern half of the watershed, predominantly the Cheat River and portions of the Youghiogheny. The western half contains well drained, fertile soils of the Appalachian Plateau (Army Corps of Engineers, 2012). A small portion in the southeastern area of the watershed is located in the Valley and Ridge province. Even though the entire watershed has a humid temperate climate, the varying physiographic regions differ in annual precipitation amounts due to elevation fluctuations. Mountainous terrain in the southeast receives an average of 55 inches of rainfall annually. The middle portion of the watershed receives an average of 43 inches of precipitation annually, where the northern portion accumulates an average of 39 inches (Pennsylvania Environmental Council).

## History

The Monongahela watershed experienced a unique transformation over time as humans altered its landscape. Until the 1600's, Native American tribes freely roamed the land using the area as their hunting grounds as the glaciers receded (monriver.org, 2007). During the 1600's and 1700's, indian traders and colonial outcasts expanded into the territory where many bloody battles were fought between the Native Americans for land (monriver.org, 2007). Finally permanent settlements were established by the mid 1700's near Point Marion and Morgantown, West Virginia. The settlers discovered the river's potential for navigation where river settlements emerged to transport agricultural products like dry whiskey. Due to its shallow waters, barges were built to transport cargo to Pittsburgh and even as far as New Orleans as the traveled down the Mississippi (monriver.org, 2007).

The start of the industrial revolution in the 1800's completely altered the watershed as a series of 16 locks and dams were built into the river to widen and deepen the channels for improved boat passage. During this time, mining productions emerged in the area, attracting workers to mine coal and steel. The last lock and dam were finished by the early 1900's, allowing full passage along the river. By this time, acid mine drainage infected the rivers, leaving the water extremely polluted. In 1907, the worst mining disaster occurred in Monongah, WV killing over 360 men (Pennsylvania Environmental Council). This period decimated the watershed's water quality with record low fish populations in the 1960s (monriver.org, 2007). Even after a series of public policies and notions, the Monongahela river ranked ninth on America's Most Endangered Rivers list in 2010 (Table 2; Pennenvironment, 2010). In 2013, the Monongahela river gained positive publicity when it was granted Pennsylvania's "River of the Year" award to applaud and raise awareness of the conservation efforts taking place (Pennsylvania Department of Conservation and Natural Resources, 2013). In recent years, fracking has become an issue in the Monongahela River watershed.

## Land Use

The land use distribution of the Monongahela is represented in Figure 2. Forests dominate the landscape, covering roughly 60% of the watershed's area (US EPA, 2002). However, 400 square miles of this land is allocated to timber companies for logging. Agricultural activities in the region are situated in the western portion of the watershed due to its fertile soils where 20% of the land is dedicated to this land use. The remaining estimated 10% of the watershed is dedicated to urban land use (US EPA, 2002). A majority of the urban area is situated in the northern part of the watershed near Pittsburgh, Pennsylvania, however river towns and cities are prevalent in the southern portion. Morgantown, West Virginia is also developed with impervious surfaces. Mining and other industrial activities are also a part of urban land use.

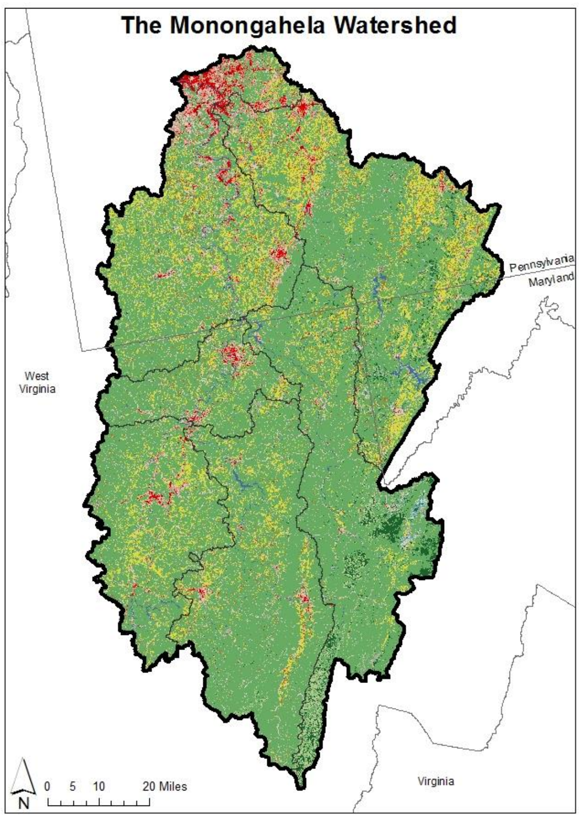


**Figure 2:** A representative land use map of the Monongahela River Basin. Red areas are developed land, yellow areas represent agriculture, green areas are forests, blue areas represent water bodies. (Map created with ArcMap10.1 using data provided from USGS NLCD)

**Influential Policies and Mandates**

| Year | Regulation/Policy | Purpose |
|---|---|---|
| **1937** | Federal Flood Control Act | Funded construction of dams to prevent flooding in Ohio Valley |
| **1937** | Pennsylvania Clean Streams Law | Establishes water pollution is a public nuisance |
| **1972** | Federal Water Pollution Control Act | Restore and maintain the chemical, physical, and biological quality of the nation's waters |
| **1977** | Federal Surface Mining Control and Reclamation Act | Mandated that mining companies restore the original contours of the land with topsoil and correct problems with past mining operations (i.e. acid mine drainage) |
| **2005** | Federal Energy Policy Act | Excludes hydraulic fracturing to be regulated under the Federal Water Pollution Control Act. |
| **2011-2012** | U.S. Army Corps of Engineers Initial Watershed Assessment (IWA) | Created an IWA to implement a watershed assessment management plan for the Monongahela River watershed |

**Table 2:** This table lists a series of applicable federal and state regulations that affect the Monongahela River Watershed. Data in the table is gathered from (Pennsylvania Environmental Council, monriver.org, and U.S. Army Corps of Engineers).

## Related Organizations

*3 Rivers Quest*

This organization is a part of West Virginia University that focuses on monitoring water quality of the streams and tributaries within the Monongahela watershed as well as the Allegheny and Ohio rivers. They have grassroots volunteer programs to involve citizens in measuring basic water quality parameters such as temperature, pH, and conductivity. They also sample for detailed water chemistry and river flow to measure parameters like Total Dissolved Solids.

*Pennsylvania Organization for Watersheds and Rivers (POWA)*

Focuses on all watersheds of Pennsylvania to advocate for protection, restoration and enjoyment of water resources by conducting programs to enhance stewardship, leadership, communication and action. They also help issue the “River of the Year” award with the Pennsylvania Department of Conservation and Natural Resources.

*Pennsylvania Environmental Council (PEC)*

A non-profit organization established in 1970 tailors to three needs of Pennsylvania's environment: watersheds, energy and climate, and trails and recreation. They are a leading stakeholder in Pennsylvania as they partner with POWA. One of their projects tailors to the towns along the Monongahela River. This “Monongahela River Towns” project focuses on the beautification of outdoor and recreational areas along the river. They aid towns with trail restoration and maintaining a “green” label.

*West Virginia/ Pennsylvania Monongahela Area Watersheds Compact*

This compact is part of the Monongahela Basin Watershed group who are primarily concerned with fracking in the Monongahela River Basin. They also affiliate themselves with projects along the tributaries of the Monongahela. They work with other watershed stakeholders to advocate for policy changes to protect the health of the rivers.

*Upper Monongahela River Association*

Primarily centered in West Virginia, this organization works with other stakeholders to ensure the navigable waterways of the Upper Monongahela. They show major interests in promote boating activities along the Monongahela and its tributaries. This organization also shows concern over fracking in the Marcellus shale within the watershed. In addition, they are a stakeholder in the West Virginia/ Pennsylvania Monongahela Area Watersheds Compact.

## Water Impairment:

The water quality of the Monongahela River was categorized as “impaired” for potable water use by the Pennsylvania Department of Environmental Protection (DEP) in 2012. This grade was assigned due to elevated levels of sulfate in the river. The DEP conducts analysis of river quality every two years and officially lifted the status of impaired drinking water in 2014 due to improved conditions within the Monongahela (Vidonic). This however is only one step in a long process to restore the river quality of the Monongahela. Water quality within the watershed is currently degraded by urbanization and the effects of industries such as mining and fracking. As recently as 2010, many of the streams within the watershed have been listed as impaired due to industrial and urban affects (see Figure 3). Efforts to improve water quality are often slowed and constrained because the watershed lies within three different states. The following section describes problems within the watershed that impair streams and problems that hinder restoration efforts.

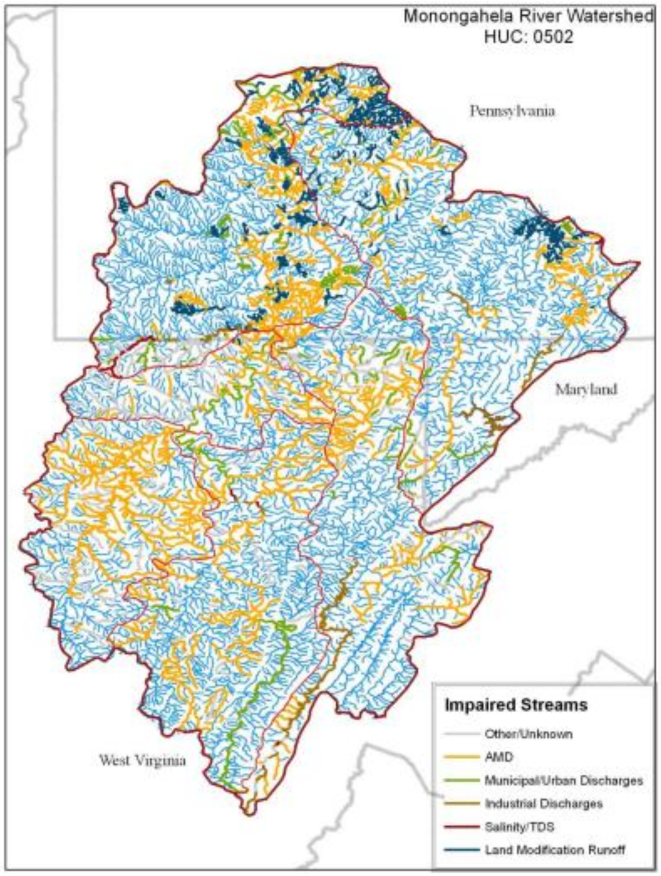


**Figure 3.** A map of impaired streams categorized by the 2010 State Water Quality Reports. (Army Corps of Engineers, 2012)

## Problem 1: Lack of Interstate Cooperation

Located within southwestern Pennsylvania, north-central West Virginia, and western Maryland, the Monongahela watershed is positioned within portions of nine congressional districts. The watershed sits within five congressional districts in PA, three in WV, and one in MD (see Figure 4; Army Corps of Engineers, 2012**)**. Currently, there is no interstate water regulatory committee to set standards for water quality, permitting, or enforcement **(**Army Corps of Engineers, 2012). The lack of interstate cooperation allows for the possibility of upstream source areas to pollute downstream areas, in another district or state, due to the downstream area having different standards.

Without interstate regulation, upstream areas also have no limits on water withdrawal that can affect downstream areas. The quantity of water withdrawn from streams is largely unregulated and is at risk to show negative consequences such as excessive withdrawals, which can affect water quantity and quality. With increasing populations and industrial needs for water, water withdrawal can create drinking shortages and low water flow conditions which increase the effects of pollution.

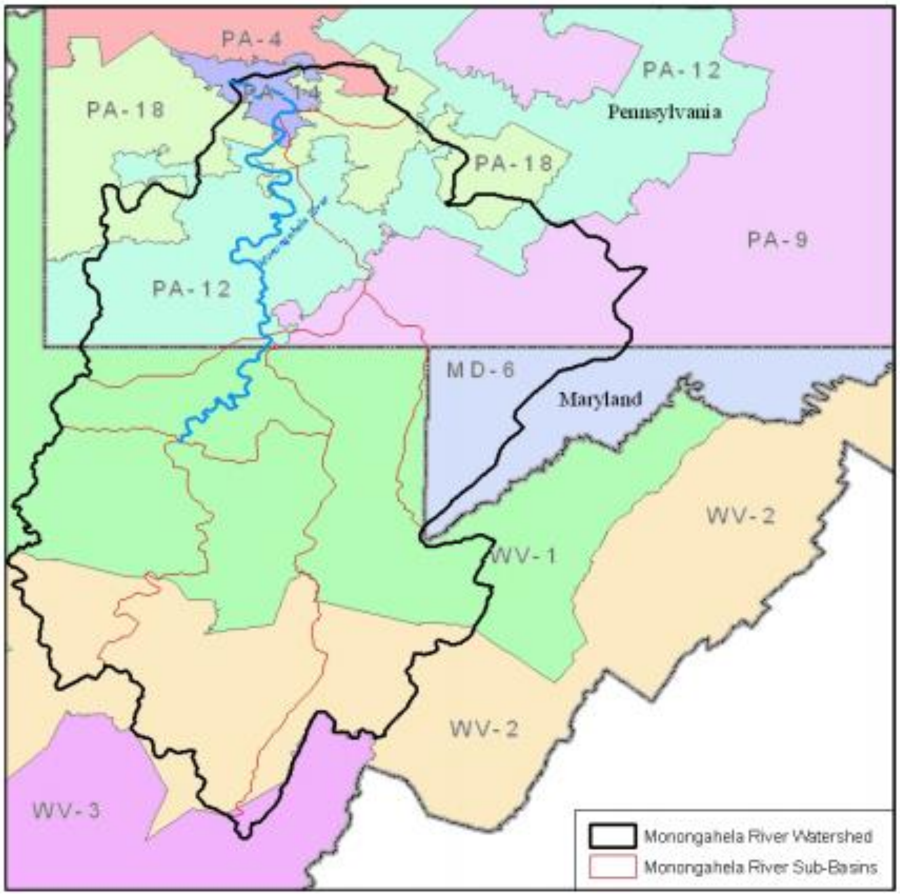


**Figure 4:** An overlay of the Monongahela Watershed over state boundaries and congressional districts
(Army Corps of Engineers, 2012)

## Problem 2: Urbanization

The Monongahela River has been an epicenter for development since the 1800s. The area historically has been rich in resources and the Monongahela has served as a source of water and transportation. These factors have contributed to urbanization along the Monongahela. Urbanization has directly affected the Monongahela in two ways: increased contaminants and channel alteration.

### Increased Contaminants

Urbanization generally negatively impairs watersheds by introducing contaminants more rapidly and directly to the river. This process occurs because urbanization leads to increased impervious cover which contributes to higher levels of runoff and flooding. Urbanization also introduces contaminants, such as fertilizer, garbage, heavy metals from car exhaust, pesticides, and others to the watershed (Albert et al 2015). These contaminants are more easily flushed to water sources due to the increase of impervious surfaces within the watershed. Seasonal effects of urbanization, such as road salt in winter and hotter runoff from heated impervious cover in summer, degrade the quality of the stream for aquatic life (Albert et al 2015).

Not only does the Monongahela experience these general effects of urbanization but is exposed to pollution from sewage due to combined sewer overflows. Combined sewer overflows (CSOs) are sewage systems that take in both sewage from buildings and runoff from storm drains. Both types of water are then transported through the sewers to be treated at a wastewater treatment plant. During storms, however, the mixed untreated water empties into streams through overflow outlets as sewage pipes become filled with rainwater runoff. CSOs differ from other sewage systems in which the sewage and the runoff are funneled into separate systems so that only the sewage is treated and runoff is returned to a stream. Pittsburgh, which is a large city along the Monongahela, was built with CSOs which empty into the Monongahela thus impairing the water quality during storms (Albert et al 2015).

### Channel Alteration

During the time of industrialization in the Monongahela region, the river was used as a source of transportation and still is today. In order to make the river more navigable, locks were constructed on the river to deepen and steady flow depth. A system of nine navigation structures are in place along the Monongahela from Fairmont, WV to Pittsburgh, PA **(**Army Corps of Engineers, 2012**).** These navigation structures maintain a minimum depth of nine feet in the river channel to make the river navigable **(**Army Corps of Engineers, 2012**).** Although locks serve to make the river navigable and to create backwater pools that can serve as reservoirs of water, these structures impair the water ecosystem by limiting sediment transport and aquatic diversity (US Army Corps 2014).

Culverts are another channel structure built as a result of urbanization that degrade the water quality of the Monongahela. Culverts are typically constructed cities or urban areas to bury streams underground to produce more land space for buildings and other urban structures. Culverts impair water quality by reducing the water's interaction with air and sunlight with decrease dissolved oxygen. Culverts also remove riparian habitats which can slow runoff and prevent erosion in urban areas (Albert et al 2015).

## Problem 3: Industry

The current main threat to the water quality of the Monongahela is industrial impacts from mining and natural gas fracking. These two industrial processes introduce pollutants to the stream which are extremely harmful to aquatic life and also require water withdrawal which endangers the drinking water supply.

### Acid Mine Drainage

The Monongahela Area has been affected by mining since the 1800s and resources are predicted to be plentiful for another 100 years of coal mining. The byproducts of mines greatly endanger streams. Pyrite or other iron sulfide minerals, exposed in coal mining, that become oxidized produce the formation of sulfuric acid. This acidic material is known as acid mine drainage (AMD). Streams with low buffer capacities cannot neutralize this acidic byproduct and thus become inhabitable for aquatic life such as fish, aquatic invertebrates, and benthic algae. Coal mining also can expose rivers to high levels of iron, manganese, aluminum, and sulfate. A USGS study used historical data to show streams near mining sites had elevated levels of sulfate. Over 2,390 miles of rivers were once classified as degraded in the Alleghany and Monongahela River Basins due to AMD. There is a downward trend in sulfate recently due to the Clean Air Act and other environmental regulations but there are still 2,685 abandoned mines known in the

Monongahela River Basin that could still be polluting the river and creating no-fish zones (Sams, 2000).

### Fracking

Coal Mining was the dominant industry of the area for the past 200 years but more recently natural gas fracturing has grown in the area in the past 50 years and poses as another environmental threat. Natural gas fracturing, also known as fracking, is prominent in the area due to the Marcellus Shale Formation. Fracking uses a mixture of water and chemicals injected into the earth to break up rock to release natural gas. The wastewater from the fracking process is banned from being injected into ground storage by Pennsylvania regulations. More typically, water is shipped to other states to be disposed of or is paid to be processed by local wastewater treatment plants. These local facilities often are not equipped to treat the wastewater and often return polluted water to the streams. Biodegradable salts often are a main component of this wastewater and can heavily degrade water quality. In 2008, this briny water was noted to be corroding pipes and dishwashers (Griswold, 2011). In 2009, elevated levels of total dissolved solids from mining and methane operations contributed to a toxic algae bloom that caused a massive fish kill in Dunkard Creek, a stream in the Monongahela River Basin (Monongahela River). These events generated a response of stricter regulations for wastewater treatment and natural gas drilling which continue to evolve as more effects of the industry are studied.

Fracking also degrades water quality because the industry requires massive water withdrawals to support the amount of water needed for the fracking process (Griswold, 2011**)**. This withdrawals endanger drinking water because less water will be available in the river itself for potable use. In addition, withdrawing water puts the river at risk for low flow conditions which expose the river to pollution because less water is present to dilute harmful chemicals in the system.

## Strategies for Remediation

One of the greatest challenges for remediation in the Monongahela watershed is in its extent across the lines of three states (PA, WV, and MD). While the city of Pittsburgh, PA—which draws from the river for its municipal water supply—is arguably the biggest stakeholder in the quality of the river's water, West Virginia comprises a greater portion of the watershed's total area. Many potential sources of contamination reside in West Virginia as well. If sufficient interstate coordination is not achieved, watershed restoration runs the risk of squandering funds from one stakeholder without achieving tangible water quality and ecosystem restoration goals if the others fail to meet their targets.

### Initial Allocations

A simple but effective framework is needed for allocation of both responsibility and potential resources for restoration. This plan proposes a foundation based on a water budget within the Monongahela watershed in Pennsylvania. Accurate and reliable USGS gages providing free, high-resolution discharge data are conveniently in place along the Pennsylvania border. These provide an unbiased measurement of how much of the total water budget each state contributes. We propose the use of a water mass balance as a framework for assessing water availability, pollutant loads and subsequent fund allocation:

- Total discharge:

  030485152 Monongahela River @ Pittsburgh, PA

  Chosen as the outlet point since the municipality and population of Pittsburgh are the stakeholders with the largest risk in the Mongahela's water quality, and restoration of sufficient, high-quality flows here is a major goal of this management plan.

- Accurate estimation of West Virginia tributaries:

  03071600 Cheat River @Lake Lynn, PA -and-

  03063000 Monongahela River @ Point Marion, PA

- Accurate estimation of Maryland tributaries:

  03076850 Youghiogheny River @ Bridge, PA

State's hydrological contributions will be calculated as the percent of total discharge from tributaries in three states based on median annual discharge from the last five years. Pennsylvania water load to the Monongahela will be calculated as total (at site 030485152) minus the sum of loads at station ID's 03071600, 03063000, and 03076850 (USGS Water Data for Pennsylvania, 2015).

## Baseline Water Quality Assessment

After determination of each state's contribution to the Monongahela total discharge at the Pittsburgh gage, 20 subwatersheds on the order of < 50 $km^2$ will be targeted for baseline water quality and ecosystem assessment. These will be distributed across state lines based on percentage of discharge contribution to achieve as accurate of a picture of pollutant loading and ecosystem quality as possible. Additionally, study subwatersheds will be distributed to achieve as accurate a representation of primary land use/land covers as possible. The Pennsylvania Department of Environmental Protection, West Virginia Department of Environmental Protection, and Maryland Department of the Environment will conduct these surveys in their respective states with oversight in the form of random QA/QC by the USEPA to ensure reliable, consistent results. Surveys will be conducted quarterly for first three years to establish baseline conditions, followed by every year for the remainder of the study period to track progress. This comprises 29 samplings campaigns which, multiplied by 20 watersheds equals 580 total watershed samplings.

The ultimate goal of these surveys is the development of statistical model to allocate pollutant loads to the Monangahela based on empirical data from subwatersheds and extrapolation to all unmeasured subwatersheds of the Monangahela with similar land use characteristics. An outside consultant will be hired for model development. The timeline for model development is immediately after establishment of the initial three year baseline assessment, with annual modification after sampling campaigns.

## Previous Studies

Water quality has long been of interest in the Monongahela basin due to mining and industrial contamination. In order to leverage historical datasets, we based our list of sampling analytes on those found in historical studies (EPA-STORET, 2015).

| ***Basic Water Quality Parameters*** | ***Metals*** | ***Pesticides, Solvents, & VOCs*** | ***Biology*** |
|---|---|---|---|
| **Alkalinity** and Hardness**;** BOD**; Chloride; DO;** DOC**; Fecal Coliform, Giardia & *E. Coli*;** pH**; Specific Conductance; $SO_4$, Temperature; Total N ($NH_4$, $NO_3$, $NO_2$, DON); Total P (Orthophosphorous); Total Suspended Solids**<br><br>**Discharge** | **Al, As**, Ba, Cd, Ca, **Cu**, **Fe**, **Pb**, Mg, **Mn**, **Hg**, **Ni**, K, **Se**, Ag, Na | Aroclor, **BTEX,** Cyanide, Dieldrin, Lindane, **MBAS,** Methoxychlor, Mirex, Nonachlor, DDD, DDT, Oxychlordane, Phenols | **Benthic macroinvertebrate survey** |

**Table 3:** List of analytes for baseline subwatershed survey. Bolded objects indicate those of highest importance given a previous assessment by the PA-DEP (Pennsylvania American Water Company, 2002).

Many watershed management plans have been faulted for excessive investment in initial assessments of watershed health, leaving insufficient funds for actual remediation activities afterward. The above table constitutes the initial, comprehensive list. If funding is found to be constraining, sampling will be reduced to the bolded parameters, which target the main concerns associated with resource extraction activity highlighted above.

## Mining Operations Census

State environmental departments will also be responsible for conducting a uniform, comprehensive census of all mining activities with the Mongahela watershed in their state, to be deposited to a central database. A central task force of environmental staff from each state will be created to coordinate this task. The resultant database will include number and type of operations, gallons day$^{-1}$ withdrawals from local waterways (including surficial aquifers with potential for a significant connection to local streams and rivers), wastewater discharges, status (active/inactive), and responsible companies/agencies. Pollutants associated with active and abandoned mine drainage and occult spills have been identified as the top concern for water quality in the Monongahela Watershed, so accurate quantification of these sources is a priority.

## TMDLs

Some TMDLs have been implemented in West Virginia for tributaries of the upper Monongahela. These include 31 iron, 28 aluminum, 26 manganese, and 22 pH limitations (US EPA, 2015).

| POLLUTANT | USE DESIGNATION | | | | |
|---|---|---|---|---|---|
| | Aquatic Life | | | | Human Health |
| | Warmwater Fisheries | | Troutwaters | | Contact Recreation/Public Water Supply |
| | Acute[a] | Chronic[b] | Acute[a] | Chronic[b] | |
| Aluminum, dissolved (µg/L) | 750 | 750 | 750 | 87 | -- |
| Iron, total (mg/L) | -- | 1.5 | -- | 1.0 | 1.5 |
| Selenium, total (µg/L) | 20 | 5 | 20 | 5 | 50 |
| Manganese, total (mg/L) | -- | -- | -- | -- | 1.0[c] |
| Chloride (mg/L) | 860 | 230 | 860 | 230 | 250 |
| Dissolved oxygen | Not less than 5 mg/L at any time | Not less than 5 mg/L at any time | Not less than 6 mg/L at any time | Not less than 6 mg/L at any time | Not less than 5 mg/L at any time |
| pH | No values below 6.0 or above 9.0 | No values below 6.0 or above 9.0 | No values below 6.0 or above 9.0 | No values below 6.0 or above 9.0 | No values below 6.0 or above 9.0 |
| Fecal coliform bacteria | **Human Health Criteria** Maximum allowable level of fecal coliform content for Primary Contact Recreation (either MPN [most probable number] or MF [membrane filter counts/test]) shall not exceed 200/100 mL as a monthly geometric mean based on not less than 5 samples per month; nor to exceed 400/100 mL in more than 10 percent of all samples taken during the month. | | | | |

[a] One-hour average concentration not to be exceeded more than once every 3 years on the average.

[b] Four-day average concentration not to be exceeded more than once every 3 years on the average.

[c] Not to exceed 1.0 mg/L within the five-mile zone upstream of known public or private water supply intakes used for human consumption.

Source: 47 *CSR*, Series 2, *Legislative Rules, Department of Environmental Protection: Requirements Governing Water Quality Standards*.

**Table 4:** Primary toxic pollutants and levels of concern identified by the WV-DEP in the Upper Monongahela (Tetra Tech, 2014).

An ancillary goal of this watershed management plan is to develop a synergy with extant national regulations, using their data to target our efforts in local waterways when possible, and in turn sharing any data collected by the states for augmenting federally-imposed regulations. We hope that our efforts will expand into the Cheat River Watershed (a Monongahela tributary in West Virginia) as well as the lower Monongahela in Pennsylvania, where TMDLs are currently not imposed (US EPA, 2006).

## Funding for Remediation

Considering the association of most contamination within the watershed with resource extraction, funding will be sought under brownfield and superfund programs through the US-EPA. Application for financial support will be based on subwatershed assessments and hydrologic budgets outlined above, with a focus placed on remediation of mining sites. Avenues through which we will apply include:

- EPA Brownfield Area-Wide Planning Pilot Program
- Targeted Brownfield Assessments
- Superfund where applicable

(EPA Brownfields and Land Revitilization, 2015; EPA Superfund, 2015).

Should EPA funding be acquired, specific allocations will be determined on baseline sampling and associated pollutant load models outlined above, with oversight by the EPA to mitigate state bias. The remainder of the financial burden (after EPA funds exhausted) to meet targeted reductions and TMDLs will fall on state governments

Additional consideration will be given to levying fines on agents responsible for improper resource extraction protocols pursuant to individual states' regulations. Some of these fines can be directly diverted to remediation efforts.

## Cleanup

Targets identified for the most urgent contamination and potential for effective cleanup strategies include:

- Abandoned mine drainage
- Urban stormwater runoff along transportation corridors, especially combined sewer overflows near Pittsburgh
- Industrial spills

(Pennsylvania American Water Company, 2002).

A synthesis of impaired subwatersheds' primary pollutants, along with the mine census and brownfield targets will allow us to choose sites for the most cost-effective remediation. One engineering consultant firm will be selected to conduct remediation in order to maintain efficiency and cross-site consistency unless it is found financially advantageous to hire different contractors for each state or site.

Explicit engineering solutions we hope to pursue include:

- Identification and regrading of drainage pathways from abandoned mining operations to limed retention ponds for sequestration of acidity, metals and sediment
- Retrofitting of aging urban stormwater controls, with a specific focus on CSOs
- Installation of biofiltration swales along transportation corridors

Additionally, some funding should be diverted to a small team for increased oversight and monitoring of active mining operation to ensure compliance with regulations on volumetric water withdrawals and to mitigate occult spills.

## Summary of Long-Term Goals and Solutions

| ***Long Term Goal*** | ***Regulation or Engineering Strategy*** |
|---|---|
| Reduce withdrawals for industrial/mining operations by 25% where flow volume is impaired | *Increased oversight of mining operations by state regulatory agencies* |
| Mitigate occult dumps and/or spills from mining/industrial activity | *Divert portion of cleanup funds to implementing BMP's for mines (retention ponds, bioreactors, lime treatments, etc.)* |
| Divert CSO and urban runoff from direct discharge to Monongahela tributaries | *Allocate portion of cleanup funds for improvement of urban stormwater controls (retention ponds, vegetated swales, and armored spillways) particularly around Pittsburgh metropolitan area* |
| Catalog all active and discontinued mining operations to address future pollutants and incorporate into progress reports | *Development of interstate committee for census of mining operations* |

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