



Source Water Protection Plan
McDowell County Public Service District
Bartley Water System
PWSID 3302434

McDowell County, West Virginia
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EXECUTIVE SUMMARY

This Source Water Protection Plan (SWPP) is being developed for the McDowell County Public Service District (PSD) - Bartley System. This SWPP is being developed in accordance with Senate Bill 373.

The McDowell County PSD Bartley System is a state regulated public utility and operates a public water system serving the areas of Bartley, English, Atwell and Raysal, West Virginia. The Bartley System serves 1,018 residential customers. The Bartley System does not provide water to nor purchase water from any other system at this time. However, the City of War is developing a project to purchase water from the Bartley System in the near future.

The Bartley System obtains raw water from the Bartley Well which is under the influence of surface water. The water treatment plant has a treatment capacity of 240,000 gallons per day and pumps approximately 7 hours per day producing an average of 180,000 gallons per day. The Bartley System maintains six (6) treated water storage tanks totaling 788,000 gallons of treated water and has no raw water storage. Currently, the water system is experiencing 26.5% unaccounted for water. however, the McDowell County PSD is conducting leak detection and making necessary repairs, to reduce unaccounted for water.

The Bartley System currently maintains a 500 kW stationary generator. The generator can connect to 600 amp emergency transfer switch and provide power service to the raw water intake and treatment facility. The McDowell County PSD has a 50 kW portable generator that can provide power service to all of the booster stations in the distribution system.

In accordance with Senate Bill 373 the Bartley System currently has sufficient treated water storage in the event that the primary water source is contaminated. It is recommended to install an early warning monitoring system. Four (4) alternatives were evaluated in this Source Water Protection Plan (SWPP).

Backup Intake

Little Slate Creek has adequate supply to provide the average water demand for the Bartley System. The backup intake would be located on Little Slate Creek approximately 5 miles downstream of the water treatment plant and will require 26,000 linear feet of 6 inch raw water line from the intake to the water treatment plant.

Interconnection

The Bartley System is currently not interconnected with another system. The City of War system is located approximately 3.6 miles to the east of the Bartley System. The interconnection will require 19,000 linear feet of 6 inch pipe and a 600 gpm booster station. The City of War will be decommissioning their water treatment plant and purchasing water from the Bartley Water System in the near future.

Treated Water Storage

Bartley System currently has 788,000 gallons of treated water storage available. The maximum production in 24 hr period over the past year for the utility was 240,000 gallons per day. Senate Bill 373 requires two (2) days of storage based on maximum production in the past year. To satisfy the required storage capacity, the Bartley System needed 480,000 gallons of storage. Thus, the current system meets the required treated water storage capacity with 788,000 gallons of treated water storage.

Raw Water Storage

The Bartley System currently has no raw water storage available. Senate Bill 373 requires two (2) days of raw water storage equal to the maximum plant production in the past year. To satisfy the required storage capacity, the Bartley System needs 480,000 gallons of storage.

PURPOSE

The goal of the West Virginia Bureau for Public Health (WVBPH) Source Water Assessment and Protection (SWAP) program is to prevent degradation of source waters which may preclude present and future uses of drinking water supplies to provide safe water in sufficient quantity to users. The most efficient way to accomplish this goal is to encourage and oversee source water protection on a local level. Every aspect of source water protection is best addressed by engaging local stakeholders.

The intent of this document is to describe what the Bartley System has done, is currently doing, and plans to do to protect its source of drinking water. Although this water system treats the water to meet federal and state drinking water standards, conventional treatment does not fully eradicate all potential

contaminants, and treatment that goes beyond conventional methods is often very expensive. By completing this plan, the McDowell PSD acknowledges that implementing measures to prevent contamination can be a relatively economical way to help ensure the safety of the drinking water.

What are the benefits of preparing a Source Water Protection Plan?

- Fulfills the requirement for the public water utilities to complete or update their Source Water Protection Plan.
- Identifies and prioritizes potential threats to the source of drinking water; and establishes strategies to minimize the threats.
- Plans for emergency responses to incidents that compromise the water supply by contamination or depletion, including how the public, state, and local agencies will be informed.
- Plans for future expansion and development, including establishing secondary sources of water.
- Ensures conditions to provide the safest and highest quality drinking water to customers at the lowest possible cost.
- Provides more opportunities for funding to improve infrastructure, purchase land in the protection area, and other improvements to the intake or source water protection areas.

BACKGROUND: WV SOURCE WATER ASSESSMENT AND PROTECTION PROGRAM

Since 1974, the Federal Safe Drinking Water Act (SDWA) has set minimum standards on the construction, operation, and quality of water provided by public water systems. In 1986, Congress amended the SDWA. A portion of those amendments were designed to protect the source water contribution areas around groundwater supply wells. This program eventually became known as the Wellhead Protection Program (WHPP). The purpose of the WHPP is to prevent pollution of the source water supplying the wells.

The Safe Drinking Water Act Amendments of 1996 expanded the concept of wellhead protection to include surface water sources under the umbrella term of “Source Water Protection”. The amendments encourage states to establish SWAP programs to protect all public drinking water supplies. As part of this initiative, states must explain how protection areas for each public water system will be delineated, how potential contaminant sources will be inventoried, and how susceptibility ratings will be established.

In 1999, the WVBPH published the West Virginia Source Water Assessment and Protection Program, which was endorsed by the United States Environmental Protection Agency. Over the next few years, WVBPH staff completed an assessment (i.e., delineation, inventory and susceptibility analysis) for all of West Virginia’s public water systems. Each public water system was sent a copy of its assessment report. Information regarding assessment reports for the Bartley System can be found in **Table 1**.

STATE REGULATORY REQUIREMENTS

On June 6, 2014, §16.1.2 and §16.1.9a of the Code of West Virginia (1931) was reenacted and amended by adding three new sections designated §16.1.9c, §16.1.9d and §16.1.9e. The changes to the code outline specific requirements for public water utilities that draw water from a surface water source or a groundwater source influenced by surface water (GWUDI).

Under the amended and new codes, each existing public water utility using surface water or ground water influenced by surface water as a source must have completed or updated a source water protection plan by July 1, 2016, and must continue to update their plan every three years. Existing source water protection plans have been developed for many public water utilities in the past. If available, these plans were reviewed and considered in the development of this updated plan. Any new water system established after July 1, 2016 must submit a source water protection plan before

they begin operation. A new plan is also required when there is a significant change in the potential sources of significant contamination (PSSC) within the zone of critical concern (ZCC).

The code also requires that public water utilities include details regarding PSSCs, protection measures, system capacities, contingency plans, and communication plans. Before a plan can be approved, the local health department and public will be invited to contribute information for consideration. In some instances, public water utilities may be asked to conduct independent studies of the source water protection area and specific threats to gain additional information.

SYSTEM INFORMATION

The Bartley System is classified as a state regulated public utility and operates a public water system serving the areas of Bartley, English, Atwell and Raysal, West Virginia. A public water system is defined as:

“Any water supply or system which regularly supplies or offers to supply water for human consumption through pipes or other constructed conveyance, if serving at least an average of twenty-five individuals per day for at least sixty days per year, or which has at least fifteen service connections, and shall include:

- i. Any collection, treatment, storage and distribution facilities under the control of the owner or operator of the system and used primarily in connection with the system
- ii. Any collection or pretreatment storage facilities not under such control which are used primarily in connection with the system.”

A public water utility is defined as, “any public water system which is regulated by the West Virginia Public Service Commission.”

For purposes of this source water protection plan, public water systems are also referred to as public water utilities. Information on the population served by this utility is presented in **Table 1** on the following page.

Table 1 – Population Served by the McDowell Public Service District, Bartley System

Administrative office location:		HC 31 Box 436J Welch, West Virginia 24801	
Is the system a public utility, according to the Public Service Commission rule?		Public Utility PSD	
Date of Most Recent Source Water Assessment Report:		July 2010 By Bureau for Public Health	
Date of Most Recent Source Water Protection Plan:		2011	
Population served directly:		1,010 Residential; 1,018 Total	
Bulk Water Purchaser Systems:	Bartley System	PWSID Number	Population
	N/A		
	N/A		
Total Population Served by the Utility:		3,185 as of June 2015	
Does the utility have multiple source water protection areas (SWPAs)?		Yes	
How many SWPAs does the utility have?		14 PWSID Annual Report	

WATER TREATMENT AND STORAGE

As required, the Bartley System has assessed their system (e.g., treatment capacity, storage capacity, unaccounted for water, contingency plans) to evaluate their ability to provide drinking water and protect public health.

Table 2 contains information on the water treatment methods and capacity of the utility. Information about the water sources from which the Bartley System draws water can be found in **Table 3**.

Table 2 – McDowell Public Service District, Bartley System Water Treatment Information

Water Treatment Process (List in order)	<p>Raw Water Intake</p> <p>↓</p> <p>Wells</p> <p>↓</p> <p>Pre-CEP</p> <p>↓</p> <p>Filters</p> <p>↓</p> <p>Chlorine</p> <p>↓</p> <p>Clear Wells</p> <p>↓</p> <p>High Service / Transfer</p>
Current Treatment Capacity (gal/day)	252,000
Current Average Production (gal/day)	180,000
Maximum Quantity Treated and Produced (gal)	252,000
Minimum Quantity Treated and Produced (gal)	100,000
Average Hours of Operation	7hrs
Maximum Hours of Operation in One Day	24 hrs
Minimum Hours of Operation in One Day	5 hrs
Number of Storage Tanks Maintained	6 Caretta-105,000 RTGB- 53,000 Turkey-125,000 Groundhog- 200,000 Bartley- 180,000 Plainville- 125,000
Total Gallons of Treated Water Storage (gal)	788,000
Total Gallons of Raw Water Storage (gal)	n/a

Table 3 – McDowell Public Service District, Bartley System Water Sources

Surface Water Sources

Intake Name	SDWIS #	Local Name	Describe Intake	Name of Water Source	Date Constructed/ Modified	Frequency of Use (Primary/ Backup/ Emergency)	Activity Status (Active/ Inactive)
-	-	-	-	-	-	-	-

Table 4 – McDowell Public Service District, Bartley System Groundwater Sources

Groundwater Sources

Does the utility blend with groundwater?					No				
Well/Spring Name	SDWIS #	Local Name	Date Constructed/ Modified	Completion Report Available (Yes/No)	Well Depth (ft)	Casing Depth (ft)	Grout (Yes/No)	Frequency of Use (Primary/ Backup/ Emergency)	Activity Status (Active/ Inactive)
Bartley		Bartley	1970's	No	180'	180'	Yes	Primary	Active

(C) - Constructed

(M) - Modified

DELINIATION

For surface water systems, delineation is the process used to identify and map the drainage basin that supplies water to a surface water intake. This area is generally referred to as the source water protection area (SWPA). All surface waters are susceptible to contamination because they are exposed at the surface and lack a protective barrier from contamination. Accidental spills, releases, sudden precipitation events that result in overland runoff, or storm sewer discharges can allow pollutants to readily enter the source water and potentially contaminate the drinking water at the intake. The SWPA for surface water is distinguished as a Watershed Delineation Area (WSDA) for planning purposes and the Zone of Critical Concern (ZCC) for regulatory purposes.

The WSDA includes the entire watershed area upstream of the intake to the State of West Virginia border or a topographic boundary. The ZCC for a public surface water supply is a corridor along streams within the watershed that warrant more detailed scrutiny due to its proximity to the surface water intake and the intake's susceptibility to potential contaminants within that corridor. The ZCC is determined using a mathematical model that accounts for stream flows, gradient, and area topography. The length of the ZCC is based on a five hour time-of-travel of water in the streams to the water intake, plus an additional one- quarter mile below the water intake. The width of the zone of critical concern is one thousand feet measured horizontally from each bank of the principal stream and five hundred feet measured horizontally from each bank of the tributaries draining into the principal stream.

For groundwater supplies there are two types of SWPA delineations: 1) wellhead delineations, and 2) conjunctive delineations, which are developed for supplies identified as groundwater under the direct influence of surface water, or GWUDIs. A wellhead protection area is determined to be the area contributing to the recharge of the groundwater source (well or spring) within a five year time of travel. A conjunctive delineation combines a wellhead protection area for the hydrogeological recharge and a connected surface area contributing to the wellhead.

Information and maps of the WSDA, ZCC, and Wellhead Protection Area for this public water supply were provided to the utility and are attached to this report. See **Appendix A**. Other information about the WSDA is shown in **Table 5**.

Table 5 – Watershed Delineation Information

Size of WSDA (Indicate units)	729.91 Acres
River Watershed Name (8-digit HUC)	Big Sandy-Guyandotte 5070201
Size of Zone of Critical Concern (Acres)	554.84 Acres
Method of Delineation for Groundwater Sources	Hydrogeologic mapping
Area of Wellhead Protection Area (Acres)	175.07 Acres

PROTECTION TEAM

Communities with successful protection plans form a protection team to help develop and implement the plan. A protection team provides a broader level of oversight and should include individuals familiar with protective strategies. Team members should include: water supply staff, including the manager and designated operator; a Local Emergency Planning Commission (LEPC) representative; a local health department representative; local government officials; and affected citizen representatives. If any of these representatives are not available to participate on the protection team the water utility should document the effort to engage them and the reason why they were not available. In addition, other local stakeholders may be invited to participate on the team or contribute information to be considered. These individuals may be emergency response personnel, local decision makers, business and industry representatives, land owners (of land in the protection area), and additional concerned citizens.

The administrative contact for Bartley System is responsible for assembling the protection team and ensuring members are provided the opportunity to contribute to the development of the plan. The acting members of the Protection Team are listed in **Table 6**. The Protection Team reviewed the system's Source Water Assessment Report, included as an attachment for this report, the existing Source Water Protection Plan, as well as newly collected threat data to make informed decisions on threats, protective measures, and implementation actions. The Protection Team will be responsible for updating the source water protection plan continually and documenting their efforts to engage local stakeholders. To find out how you can become involved as a participant or contributor, visit the utility website or call the utility phone number provided in **Table 6**.

Table 6 – Protection Team Member and Contact Information

Name	Representing	Title	Phone Number
Mavis Brewster	General Manager, McDowell County	PSD Manager	
Jerry Stepp	McDowell County PSD Board Chairman	Chairman of PSD Board	
Elden Green	McDowell County PSD Board Member	PSD Board Member	
Carson Hill	McDowell County PSD Plant operator for Bartley	Plant Operator Bartley System	
Steve Bowman	McDowell County PSD Field supervisor	Field supervisor	
JJ (James) Rose	County Inspector with Health Dept.	Inspector with Health Dept.	
Teresa VanDyke	911 Center Director	Director of McDowell 911	
Jennifer Wimmer	County Administrator	McDowell County Administrator	
Harold McBride	County Commission President	McDowell County Commission President	
Cecil Patterson	County Commission	McDowell County Commission	
Gordon Lambert	County Commission	McDowell County Commission	
Clif Moore	State Delegate & Assistant County Administrator	State Delegate & Assistant County Administrator	
Date of first protection Team Meeting	August 2015		
Efforts to engage local stakeholders and explain absence of required stakeholders:		Called local stakeholders and placed ads in Local Newspapers.	

Potential Significant Sources of Contamination

This source water protection plan provides a complete and comprehensive list of the potential sources of significant contamination (PSSC) contained within the wellhead protection area, based upon

information obtained from the Department of Environmental Protection (WVDEP), the WVBPH, and the Division of Homeland Security and Emergency Management. Additionally, the consultants completed a review of aerial imagery and a windshield survey to identify PSSCs not contained in the databases listed above and to confirm the accuracy of the databases. A facility or activity is listed as a PSSC if it has the potential to release a contaminant that could potentially impact a nearby public water supply, and it does not necessarily indicate that any release has occurred.

WVBPH provided a database of PSSCs located in their SWPA. These data are organized into two types: 1) SWAP PSSCs, and 2) Regulated Data. SWAP PSSCs are those that have been collected and verified by the WVBPH SWAP program during previous field investigations to form the source water assessment reports and source water protection plans. Regulated PSSCs are derived from federal and state regulated databases, and may include data from WVDEP, US Environmental Protection Agency, Division of Homeland Security and Emergency Management, and out of state data sources.

Confidentiality of PSSCs

A list of the PSSCs contained within the SWPA should be included in the source water protection plan. However, the exact location, characteristics and approximate quantities of contaminants shall only be made known to one or more designees of the public water utility and maintained in a confidential manner. In the event of a chemical spill, release or related emergency, information pertaining to any spill or release of contaminant shall be immediately disseminated to any emergency responders reporting to the site of a spill or release. The designee(s) will be identified in the communication plan section of the source water protection plan.

PSSC data from some agencies (ex. Division of Homeland Security and Emergency Management, WVDEP, etc.) may be restricted due to the sensitive nature of the data. Locational data will be provided to the public water utility. However, to obtain specific details regarding contaminants, (such as information included on Tier II reports), water utilities should contact the local emergency planning commission or agencies, directly. Maps and lists of the PSSCs and regulated site locations are provided in **Appendix A**.

McDowell County PSD Bartley System PSSCs

The McDowell County PSD Bartley System protection team verified intake locations and reviewed the delineated area (SWPA) to verify the existence of PSSCs previously identified, identify any new

PSSCs, and to gain local knowledge of the presence of PSSCs not listed on the original or updated inventory or in regulated databases and not easily detected. Reviews of aerial photography, windshield surveys, and interviews with source water protection team members have been completed, and all potential sources of contamination discovered during this process are included in **Tables 7** and **8** below.

WVBPH guidance documentation **Appendix C** was utilized to prioritize sources based on WVBPH risk ratings. All sources with a relative risk to surface or groundwater greater than or equal to 4.0 was included in the list of priority sources **Table 7** and those with a risk less than 4.0 are included in the list of non-priority sources **Table 8**. Priority and non-priority sources are documented on maps included in **Appendix A**.

The WVBPH guidance document **Appendix C** encourages each system to perform a risk assessment for local facilities, and to adjust risk ratings for sources as needed to make sure they accurately reflect the local contaminant sources. The WVBPH guidance document assigns a risk of 4.5 to groundwater and surface water from Superfund Resource Conservation & Recovery Act Facilities (RCRA). However, the risk for the facility type was less than 4.0 for the only RCRA facility within the wellhead protection area for the McDowell County PSD Bartley System—the Bartley Water Treatment Plant. The WVBPH guidance document assigns a risk of 1.4 to groundwater and 1.5 to surface water for water treatment plants. Thus, in this SWPP the only RCRA site is included in the list of non-priority facilities.

In addition, the Source Water Protection Team for the Bartley system decided to include a gas station that is located outside of the SWPA.

The PSD and its Source Water Protection Team will continue to assess potential risks to the source water and make adjustments to the plan as needed.

Table 7. High Priority Potential Significant Sources of Contamination

Map Code	Site name	Site Description	Comments	Information source(s)	ASTs
C-18	Hillbilly Market Gas Station	Not priority according to BPH guidance, but Source Water Protection team suggested it be a priority source	Outside SWPA	Not previously identified	0
C-23	Exxon Station Pumps Still There - Closed	Historic gas station		SWAP	0
I-23-1	West Virginia Properties Inc	Coal mine		HPU	0
I-23-2	Starco Energy Inc	Coal mine		HPU	0
I-23-3	D D S Leasing Inc	Coal mine		HPU	0
I-23-4	D D S Leasing Inc	Coal mine		HPU	0
I-40-1	Dominion Transmission Inc, Olga Coal Co.,	Conventional oil and gas well	API 047-00317	ERIS wells	0
I-40-2	Dominion Exploration & Production, Alawest, Incorporated	Conventional oil and gas well	API, 047-02222	ERIS wells	0
I-40-3	Classic Oil & Gas Resources Inc, Heartwood Forestland	Conventional oil and gas well	API, 047-02202	ERIS wells	0
I-40-4	Dominion Transmission Inc, Olga Coal Co.	Conventional oil and gas well	API, 047-00261	ERIS wells	0
I-40-5	EQT Production Company, Brenton Production District	Oil and gas well	AST contains brine water, related to oil and gas well, but not	AST, AST with Chemicals, SWAP	1

			near a well in the ERIS wells database, well is noted in SWAP and DS data		
I-47-1	Bartley Mine Dump	Coal refuse structure, AML	The AML polygon, AML PAS polygon, and Coal Impoundments polygon all overlap	AML PAS, AML polygon, Coal Impoundments Refuse Structures	0
I-47-2	Bartley (Barker) Burning Refuse Pile	AML refuse area	The AML polygon and AML PAS polygon overlap	AML PAS, AML polygon	0
M-17	Norfolk And Southern Railroad Tracks	Railroad Tracks and Yards	Approximately 25 feet from well	SWAP	0
NA	Residences	Unsewered single family homes	93 total single family residences exist in the source water protection area	Includes small farms, pastures, cropland, barns	NA

Table 8. Non-Priority Potential Significant Sources of Contamination

Map Code, if applicable	PSSC Count	Category	Site name or description	Comments
C-43-1	1	Commercial	Benton Ward, Equipment and auto repair shop	
NA-1	1	Municipal	Water supply well, McDowell Bartley Well Number 1	Identified by source water assessment program
M-5-1	1	Municipal	Bartley Water Treatment Plant	Location for this facility varies across source water assessment program, NPDES, and RCRA databases. This facility is indicated by multiple points on the map in Appendix A.

Prioritization of Threats and Management Strategies

It may not be feasible to develop management strategies for all of the PSSCs within the SWPA. The identified PSSCs can be prioritized by potential threat to water quality, proximity to the intake(s), and local concern. The highest priority PSSCs can be addressed first in the initial management plan. Lower ranked PSSCs can be addressed in the future as time and resources allow. **Tables 7** and **8** above list the high priority and lower priority PSSCs and **Table 9** outlines management strategies that the system will implement to protect its source water.

Table 9. Reason for Concern for Highest Priority PSSCs or Critical Areas

PSSC or Critical Area	Reason for Concern
Underground coal mine	<p>The active mining results in heavy equipment traveling and working on site. Oils, grease, diesel, and other automotive fluids can migrate to groundwater if spilled on the surface and not properly contained. Increased effects of water treatment for acid mine drainage are concerns of the water system.</p> <p>Underground mines also require constant pumping of groundwater from the mine itself to the surface which can expose surface waters to heavy metals and cause erosion, as well as increase conductivity and decrease pH.</p>
Abandoned mine lands	<p>Acid mine drainage can infiltrate to the groundwater source and surface water resources. If not properly treated acid mine drainage from mine lands may impact the pH, iron, and manganese levels in the water.</p>
Oil and gas wells	<p>Gas wells of any type, when properly drilled in accordance with their permits; do not pose an imminent danger. Potential drilling into Marcellus Shale gas reserves are a concern. Fracturing fluids and brine water produced as byproducts of the drilling process could impact the water source if drilling occurs through the aquifer and regulations/best management practices (BMPs), such as casing and grouting, are not followed. Water haulers may pull water from surface water sources. If they are not aware of flow limits for when they can pull from the river they could compromise the quantity of water or mix contaminated water into the source particularly at lower flows. Also, road cuts to access gas well sites may create erosion issues that can cause increased sediments and turbidity in surface waters. Drilling into non-Marcellus formations is also a concern due to the potential for spills of drilling mud or produced water, which is typically stored onsite in aboveground storage tanks.</p>
Abandoned gas station	<p>Abandoned gas stations are likely to contain underground storage tanks (USTs). USTs, particularly those at historic sites, may leak and contaminate groundwater sources.</p>

PSSC or Critical Area	Reason for Concern
Railroad tracks	The railroad tracks run parallel to the source water. An accident on the railroad or leaks from standing train cars may result in spills into the water supply.

Implementation Plan for Management Strategies

The McDowell County PSD has considered management strategies to address potential contaminants within the source water protection area for the Bartley system. Additionally, the utility's Source Water Protection Team has developed implementation plans, including responsible personnel and timelines, for each strategy. The implementation plan and potential cost of each strategy were estimated and are presented in **Table 10**. Proposed commitments and schedules may change, but should be well documented and reported to the local stakeholders. The Source Water Protection Team will meet as needed to assess and update the implementation plans for each management strategy.

Aquifer protection and the development of an emergency response strategy

An aquifer protection management program will be developed for the entire SWPA with the cooperation of neighboring towns, McDowell County, and state agencies. The protection and management efforts will focus on obtaining additional information on the inventoried potential sources of significant contamination to further evaluate their risk.

McDowell County PSD is currently working with the McDowell 911 Center to create an Emergency Response Plan (ERP). The McDowell 911 Center is adding an annex to its Emergency Operations Plan that covers response to source water contamination.

References on ERPs can be found here: http://www.nesc.wvu.edu/plan_ahead4.cfm

Backup generators

In the event of a power outage that affects the water treatment plant, a generator is necessary for power. The McDowell County PSD currently has a backup generator for the Bartley System.

Emergency planning and coordination

The McDowell County PSD will communicate with the local fire department, county emergency services, and the county health department concerning potential threats to the source water from highway spills and other potential material releases. Communication will occur on a regular basis so that these agencies are aware of the boundaries of the SWPA, are in frequent communication with one another, and are prepared in the event of an emergency.

Fence well and well cap integrity

The McDowell County PSD will ensure that the Bartley well head continues to be secured within a fence.

McDowell County PSD will ensure that all well casings are properly grouted and that the wells are fitted with a properly sealed well cap. At least quarterly, the McDowell County PSD will check for well cap integrity to ensure a proper seal is maintained to prevent entry of contaminants during flood conditions.

Future development and Land Use Changes – Maps and inspection of SWPA

McDowell County PSD will monitor proposed land use changes, with a focus on coal mines and oil and gas wells, to determine if any adverse effects on short- or long-term water quality may occur. When permit applications are submitted to WVDEP and forwarded to the PSD, the PSD will review the application and contact the permittee if the PSD determines that the site has the potential to impact source water quality.

Careful observation of source water sampling data can help determine if land use changes that have occurred are impacting water quality or quantity. McDowell County PSD will also regularly physically inspect the SWPA.

McDowell County PSD will provide updates on areas served and SWPAs to the McDowell County Planning Commission or other appropriate county agency to make them aware of the location of proposed developments in relation to the water supply source.

An example of a letter that can be sent to make initial contact with entities proposing development is included in **Appendix A**.

Pharmaceutical disposal

McDowell County currently operates a drug take back program that allows residents to return their used medications. These medications will be disposed of properly so that they do not make their way into the source water.

McDowell County PSD will share information with the public on its website about the importance of properly disposing of medications and where the take back programs are located.

Information on pharmaceuticals and brochures that can be distributed can be found here:

<http://www.nesc.wvu.edu/waterwedrink/education.cfm>

Properly treat human wastewater within the Source Water Protection Area

The McDowell County PSD participated in the McDowell County Wastewater Coalition, a coalition of individuals; non-profits; and federal, state, and local governments and agencies that came together to address local concerns about water quality in the early 2000s. Among other accomplishments, the Coalition published a county-wide wastewater treatment plan.

Since then, the McDowell County PSD hired an engineering firm to write a Preliminary Engineering Report to help the PSD identify workable strategies for addressing unsewered areas. Engineering work will need to be completed before site-specific solutions can be designed.

Table 10. Priority PSSC Management Strategies

PSSC or Critical Area	Management Activity	Responsible Protection Team Member	Status/Schedule	Estimated Cost
All	Aquifer Protection and the Development of an Emergency Response Strategy	McDowell County PSD staff and McDowell 911 Center	In process	Staff time
All	Emergency planning and coordination	The McDowell County PSD employees and local emergency responders	The McDowell County PSD will communicate with local emergency responders quarterly	Minimal additional cost
All	Fence well and well cap integrity	The McDowell County PSD employees	In place, will check at least quarterly	Minimal
All	Future Development and Land Use Changes	McDowell County PSD employees	Review of coal mine and oil and gas well permits is ongoing. Updates to local agencies will occur at least annually.	Moderate staff time to develop process, then minimal staff time

All	Backup Generators	McDowell County PSD	In process	High upfront cost of purchase and ongoing maintenance, minimal staff time.
Unsewered residences	Properly treat human wastewater within the Source Water Protection Area	McDowell County PSD employees	Engineering firm has been secured for Preliminary Engineering Report.	Moderate staff time
	Pharmaceutical disposal	McDowell County PSD employees	McDowell County PSD will include information on their website starting in January 2016	Minimal staff time

Education and Outreach Strategies

The goal of education and outreach is to raise awareness of the need to protect drinking water supplies and build support for implementation strategies. Education and outreach activities will also ensure that affected citizens and other local stakeholders are kept informed and provided an opportunity to contribute to the development of the source water protection plan. McDowell County PSD Bartley System has created an Education and Outreach plan that it has either already implemented or plans to implement in the future to keep the local community involved in protecting their source of drinking water. This information is described below and can be found in **Table 11**. Supporting documents can be found in **Appendix A**.

Information dissemination via website and other methods

The McDowell County PSD will provide source water protection information on its website.

Information will be provided on source water protection in general, and specific information will be provided on the McDowell County PSD, such as the SWPA. Publicizing SWPA maps (even without including restricted information such as the exact location of PSSCs) will help people contemplating future development know whether or not the development will be in a sensitive area.

Information will also be included on the local pharmaceutical take back program, including a description of its importance in source water protection.

Information will also be provided that describes proper septic maintenance and that encourages community members to install septic systems or cluster systems or to hook up to wastewater line extensions.

Similar information will be provided at booths at public events, including the McDowell County Fair.

Informational brochures can be found at the following links:

<http://www.sourcewaterpa.org/wp-content/uploads/2013/03/Clearfield-MA-SWPTAP-Pharma-Disposal-Brochure.pdf>

<https://www.wvdhhr.org/oehs/eed/swap/documents/Posters/Farming%20-%20SWAPArea.pdf>

School curricula

The McDowell County PSD will work with the local school system to incorporate source water activities into the school curricula. The McDowell County PSD has participated in the Solid Waste Authority's Project WET, although it is currently not active. Project WET provides water resource education materials and training workshops.

Resources for students can be found at the following links:

<http://water.epa.gov/learn/kids/drinkingwater/index.cfm>

<https://www.wvdhhr.org/oehs/eed/swap/documents/Posters/PotentialImpacts.pdf>

Partner with watershed and civic groups

The McDowell County PSD will partner with local watershed associations, should any be formed that overlap with the SWPA. Watershed groups have a similar goal of protecting water resources and may have volunteers that can integrate source water protection into their efforts. They may also have additional knowledge and capacity for water quality monitoring or creating outreach materials.

Public meeting

The McDowell County PSD held a public meeting on August 11, 2015, introducing the SWPP and soliciting feedback for this management plan.

Consumer Confidence Report

The McDowell County PSD publishes a Consumer Confidence Report (CCR) annually, as required by the Safe Drinking Water Act. The CCR is made available to all water customers. The CCR describes the source water for the system, the levels of contaminants in the source water, the EPA safe contaminant levels, and information about *Cryptosporidium*.

The following paragraph may be used as a template for future CCRs:

The McDowell County PSD is committed to protecting its drinking water sources. The drinking water for Bartley comes from a well. This updated Source Water Protection Plans (SWPPs) for Bartley in

2015, based on the requirements of Senate Bill 373. The SWPP includes physical actions to protect the drinking water sources such as fencing around the well head, and planning actions such as creating an emergency response plan. It also includes an assessment of potential sources of contamination. The SWPPs were developed by the PSD in collaboration with a local Source Water Protection Team, and with the involvement of the public. Please contact the McDowell County PSD to learn more about source water protection.

Communication with potential sources of significant contamination and facility owners

McDowell County PSD will communicate by mail with owners of potential sources of significant contamination sources and owners of regulated facilities, explain that they are operating within the SWPA, and emphasize the need to follow all regulatory requirements and Best Management Practices (BMPs). This letter will also request that recipients share information with the utility related to chemical storage, including substances, amounts, and Spill Prevention and Response Plans. The letter will also provide contact information so that the PSD can be notified immediately, and directly, in the case of a potential contamination event. McDowell County PSD will investigate what types of preventative pollution measures are being conducted by the industrial or commercial facilities located within the SWPA.

A template for a letter to be sent to businesses is included in **Appendix A**.

Table 11. Education and Outreach Implementation Plan

Education and Outreach Strategy	Description of Activity	Responsible Protection Team Member	Status/Schedule	Estimated Cost
Consumer Confidence Report	The McDowell County PSD publishes a Consumer Confidence Report (CCR) annually, as required by the Safe Drinking Water Act. The CCR is made available to all water customers.	McDowell County PSD employees and secretary	In place. CCR is published annually.	Minimal staff time
Information dissemination via website and other methods	The McDowell County PSD will provide source water protection information on its website.	McDowell County PSD employees	McDowell County PSD will have info up by January 2016	Staff time, printing costs.
School curricula	The McDowell County PSD will work with the local school system to incorporate source water activities into the school curricula.	McDowell County PSD employees	McDowell County PSD will begin to work with local schools by January 2016	Minimal staff time
Communication with potential sources of significant contamination and facility owners	McDowell County PSD will communicate by mail with owners of potential sources of significant contamination sources and owners of regulated facilities, explain that they are operating within the SWPA, and emphasize the need to follow all regulatory requirements and Best Management Practices (BMPs).	McDowell County PSD employees	McDowell County PSD will communicate by mail with owners of potential sources of significant contamination sources and owners of regulated facilities by January 2016	Mailing cost, minimal staff time

Partner with Watershed and Civic Groups	The McDowell County PSD will partner with local watershed associations, should any be formed that overlap with the SWPA.	The McDowell County PSD employees and watershed association staff or volunteer	The McDowell County PSD employees will reach out to potential partners after becoming aware of a new watershed organization that overlaps with the SWPA	Moderate staff time
Public meeting	The McDowell County PSD held a public meeting on August 11, 2015, introducing the SWPP and soliciting feedback for this management plan.	The McDowell County PSD	Public meeting was held August 11, 2015	Moderate staff time around the event

Contingency Plan

The goal of contingency planning is to identify and document how the utility will prepare for and respond to any drinking water shortages or emergencies that may occur due to short and long term water interruption, or incidents of spill or contamination. Utilities should examine their capacity to protect their intake, treatment, and distribution system from contamination. They should also review their ability to use alternative sources and minimize water loss, as well as their ability to operate during power outages. In addition, utilities should report the feasibility of establishing an early warning monitoring system and meeting future water demands.

Isolating or diverting any possible contaminant from the intake for a public water system is an important strategy in the event of an emergency. One commonly used method of diverting contaminants from an intake is establishing booms around the intake. This can be effective, but only for contaminants that float on the surface of the water. Alternatively, utilities can choose to pump floating contaminants from the water or chemically neutralize the contaminant before it enters the treatment facility.

Public utilities using surface sources should be able to close the intake by one means or another. However, depending upon the system, methods for doing so could vary greatly from closing valves, lowering hatches or gates, raising the intake piping out of the water, or shutting down pumps. Systems should have plans in place in advance as to the best method to protect the intake and treatment facility. Utilities may benefit from turning off pumps and, if possible, closing the intake opening to prevent contaminants from entering the piping leading to the pumps. Utilities should also have a plan in place to sample raw water to identify the movement of a plume and allow for maximum pumping time before shutting down an intake (See Early Warning Monitoring System). The amount of time that an intake can remain closed depends on the water infrastructure and should be determined by the utility before an emergency occurs. The longer an intake can remain closed in such a case, the better. Treated water storage capacity in the event of such an emergency also becomes extremely important. Storage capacity can directly determine how well a water system can respond to a contamination event and how long an intake can remain closed. Information regarding the water shortage response capability of Bartley System is provided in **Table 12**.

Response Networks and Communication

Statewide initiatives for emergency response, including source water related incidents, are being developed. These include the West Virginia Water/Wastewater Agency Response Network (WV WARN, see <http://www.wvwarn.org/>) and the Rural Water Association Emergency Response Team (see <http://www.wvrwa.org/>). The Bartley System has analyzed its ability to effectively respond to emergencies and this information is provided in **Table 12**.

Table 12 – McDowell Public Service District, Bartley System Water Shortage Response Capability

Can the utility isolate or divert contamination from the intake or groundwater supply?	No
Describe the utility's capability to isolate or divert potential contaminants:	N/A
Can the utility switch to an alternative water source or intake that can supply full capacity at any time?	No
Describe in detail the utility's capability to switch to an alternative source:	None
Can the utility close the water intake to prevent contamination from entering the water supply?	Yes
How long can the intake stay closed?	The intake can stay closed as long as the treated water storage is available. With current treated water storage the intake can stay closed 4 days. (See Note On Next Page)
Describe the process to close the intake:	Gate Valve
Describe the treated water storage capacity of the water system:	788,000 gallons at the time of this report, the Bartley System was operating at 22% treated water storage capacity.
Is the utility a member of WVRWA Emergency Response Team?	Yes
Is the utility a member of WV-WARN?	No
List any other mutual aid agreements to provide or receive assistance in the event of an emergency:	No

Note: In the event the primary source is contaminated, it is recommended that the Utility evaluate the water storage on hand at that time and determine that the alternative source is sufficient to sustain the water system for the duration of shutdown

It is suggested that, if the utility does not have the capability to divert contamination from the surface water intake, pre-cast concrete bases are constructed around the raw water intake to drop booms into the water and physically divert surface contaminants from entering the raw water intake.

Operation During Loss of Power

This utility analyzed and examined its ability to operate effectively during a loss of power. This involved ensuring a means to supply water through treatment, storage, and distribution without creating a public health emergency. Information regarding the utility's capacity for operation during power outages is shown in **Table 11**. The utility's standby capacity would have the capability to provide power to the system as if normal power conditions existed. The utility's emergency capacity would have the capability to provide power to only the essential equipment and treatment processes to provide water to the system.

Table 13 – Generator Capacity

What is the type and capacity of the generator needed to operate during a loss of power?		The emergency generator capacity for the treatment facility is 500 kW Stationary Generator. The raw water intake is on the existing Emergency Power.		
Can the utility connect to generator at intake/wellhead? If yes, select a scenario that best describes system.		Yes, 500kW Stand by		
Can the utility connect to generator at treatment facility? If yes, select a scenario that best describes system.		Yes, Auto transfer. Both plant and well		
Can the utility connect to a generator in distribution system? If yes, select a scenario that best describes system.		Yes, Booster and Ground Hog		
Does the utility have adequate fuel on hand for the generator?		Yes		
What is your on-hand fuel storage and how long will it last operating at full capacity?		Gallons	Hours	
		180	48 – 72 hours	
Provide a list of suppliers that could provide generators and fuel in the event of an emergency:	Supplier		Contact Name	Phone Number
	Generator	Cummings	David Rollins	304-769-1012
	Generator	Caterpillar	Walker-CAT	(304) 949-6400
	Fuel	Brewster Oil		304-875-3528
	Fuel	RT Rogers		(304) 466-1733
Does the utility test the generator(s) periodically?		Yes, Weekly		
Does the utility routinely maintain the generator?		Yes, Contract with Caterpillar.		
If no scenario describing the ability to connect to generator matches the utility's system or if utility does not have ability to connect to a generator, describe plans to respond to power outages:		N/A		

If a portable generator is available through the respective county’s 911 or Emergency Center, it is assumed the generator is available **only** for the utility for which this source water protection plan is prepared. If more than one utility in the county uses the portable generator during power outages, it is suggested that each utility procure a generator specifically to protect their system during a power outage.

Future Water Supply Needs

When planning for potential emergencies and developing contingency plans, a utility needs to not only consider their current demands for treated water but also account for likely future needs. This could mean expanding current intake sources or developing new ones in the near future. This can be an expensive and time consuming process, and any water utility should take this into account when determining emergency preparedness. The Bartley System has analyzed its ability to meet future water demands at current capacity and this information is included in **Table 14**.

Table 14 – Future Water Supply Needs for the Bartley System

<p>Is the utility able to meet water demands with the current production capacity over the next 5 years? If so, explain how you plan to do so.</p>	<p>Yes, Currently the water treatment plant is running at 70% capacity and no larger increases in customers are anticipated.</p>
<p>If not, describe the circumstances and plans to increase production capacity:</p>	<p>N/A</p>

Water Loss Calculation

In any public water system, there is a certain percentage of the total treated water that does not reach the customer distribution system. Some of this water is used in treatment plant processes such as backwashing filters or flushing piping, but there is usually at least a small percentage unaccounted. To measure and report on this unaccounted for water, a public utility must use the same method used in the Public Service Commission's rule, *Rules for the Government of Water Utilities*, 150CSR7, Section 5.6. The rule defines unaccounted for water as "the volume of water introduced into the distribution system less all metered usage and all known non-metered usage which can be estimated with reasonable accuracy."

To further clarify, metered usages are most often those that are distributed to customers. Non-metered usages estimated include water used by fire departments for fires or training, un-metered bulk sales, flushing to maintain the distribution system, backwashing filters, and cleaning settling basins. By totaling the metered and non-metered uses, the utility calculates unaccounted for water. Note: To complete annual reports submitted to the PSC, utilities typically account for known water main breaks by estimating the amount of water lost. However, for the purposes of the source water protection plan, any water lost due to leaks – even if the system is aware of how much water is lost at a main break – is not considered a use. Water lost through leaks and main breaks cannot be controlled during water shortages or other emergencies and should be included in the calculation of percentage of water loss for purposes of the source water protection plan. The data in **Table 15** is taken from the most recently submitted McDowell County PSD PSC Annual Report.

Table 15 – Water Loss Information

Total Water Pumped (gal)		65,700,000
Total Water Purchased (gal)		0
Total Water Pumped and Purchased (gal)		45,990,000
Water Loss Accounted for Except Main Leaks (gal)	Mains, Plants, Filters, Flushing, etc.	0
	Fire Department	0
	Back Washing	0
	Blowing Settling Basins	0
Total Water Loss Accounted For Except Main Leaks		2,300,000
Water Sold- Total Gallons (gal)		45,990,000
Unaccounted For Lost Water (gal)		17,410,000
Water lost from main leaks (gal)		0
Total gallons of Unaccounted for Lost Water and Water Lost from Main Leaks (gal)		17,410,000
Total Percent Unaccounted For Water and Water Lost from Main Leaks (%)		26.5 %
If total percentage of Unaccounted for Water is greater than 15%, please describe any measures that could be taken to correct this problem:		Increased inspection and leak detection and making necessary repairs.

EARLY WARNING MONITORING SYSTEM

Public water utilities are required to provide an examination of the technical and economic feasibility of implementing an early warning monitoring system. Implementing an early warning monitoring system may be approached in different ways depending upon the water utility's resources and threats to the source water. A utility may install a continuous monitoring system that will provide real-time information regarding water quality conditions. This would require utilities to analyze the data in order to establish what condition is indicative of a contamination event. Continuous monitoring will provide results for a predetermined set of parameters. The more parameters being monitored, the more sophisticated the monitoring equipment will be. When establishing a continuous monitoring system, the utility should consider the logistics of placing and maintaining the equipment and receiving output data from the equipment.

Alternately, or in addition, a utility may also pull periodic grab samples on a regular basis or in case of a reported incident. The grab samples may be analyzed for specific contaminants. A utility should examine their PSSCs to determine what chemical contaminants could pose a threat to the water source. If possible, the utility should plan in advance how those contaminants will be detected. Consideration should be given for where samples will be collected, the preservations and hold times for samples, available laboratories to analyze samples, and costs associated with the sampling event. Regardless of the type of monitoring (continuous or grab), utilities should collect samples for their source throughout the year to better understand the baseline water quality conditions and natural seasonal fluctuations. Having a baseline will help determine if changes in the water quality are indicative of a contamination event and inform the needed response.

Every utility should establish a system or process for receiving or detecting chemical threats with sufficient time to respond to protect the treatment facility and public health. All approaches to receiving and responding to an early warning should incorporate communication with facility owners and operators that pose a threat to the water quality, state and local emergency response agencies, surrounding water utilities, and the public. Communication plays an important role in knowing how to interpret data and how to respond.

The Bartley System has analyzed its ability to monitor for and detect potential contaminants that could impact its source water. Information regarding this utility's early warning monitoring system capabilities can be found in **Table 16** and in **Appendix B**.

Table 16 – Early Warning Monitoring System Capabilities

Does your system currently receive spill notifications from a state agency, neighboring water system, local emergency responders, or other facilities? If yes, from whom do you receive notices?		Yes, the District receives spill notifications from the WV Health Department.	
Are you aware of any facilities, land uses, or critical areas within your protection areas where chemical contaminants could be released or spilled?		Yes, Coal Mining and Gas Wells are with the zone of critical concern.	
Are you prepared to detect potential contaminants if notified of a spill?		Yes	
List laboratories (and contact information) on which you would rely to analyze water samples in case of a reported spill.	Laboratories		
	Name		Contact
	REI Consultants		(304) 255-2500
	WV Office of Lab Services		(304) 558-3530
Do you have an understanding of baseline or normal conditions for your source water quality that accounts for seasonal fluctuations?		Yes	
Does your utility currently monitor raw water (through continuous monitoring or periodic grab samples) at the surface water intake or from a groundwater source on a regular basis?		No	
Provide or estimate the capital and O&M costs for your current or proposed early warning system or upgraded system.	Capital	50,000	
	Yearly O&M	750	

<p>Do you serve more than 100,000 customers? If so, please describe the methods you use to monitor at the same technical levels utilized by ORSANCO.</p>	<p>No</p>
<p>Note: Complete appropriate Early Warning Monitoring form for your system in Appendix B (Line 71). WVAWC Can expedite water testing.</p>	

SINGLE SOURCE FEASIBILITY STUDY

If a public water utility's water supply plant is served by a single-source intake to a surface water source of supply or a surface water influenced source of supply, the submitted source water protection plan must also include an examination and analysis of the technical and economic feasibility of alternative sources of water to provide continued safe and reliable public water service in the event its primary source of supply is detrimentally affected by contamination, release, spill event or other reason. These alternatives may include a secondary intake, two days of raw or treated water storage, interconnections with neighboring systems, or other options identified on a local level. Note: a secondary intake would draw water supply from a substantially different location or water source.

In order to accomplish this requirement, utilities should examine all existing or possible alternatives and rank them by their technical, economic, and environmental feasibility. In order to have a consistent method for ranking alternatives, WVBPH has developed a feasibility study guide. This guide provides several criteria to consider for each category, organized in a scoring matrix. By completing the Feasibility Study, utilities will demonstrate the process used to examine the feasibility of each alternative. The Feasibility Study matrix is attached as **Appendix C**. Those alternatives that are ranked highest and deemed to be most feasible will then be the subject of a second, more in-depth, study to analyze the comparative costs, risks, and benefits of implementing each of the described alternatives. An alternatives analysis report providing these details is attached as **Appendix E**.

COMMUNICATION PLAN

The Protection Team for this water system has also developed a Communication Plan that documents the manner in which the public water utility, working with state and local emergency response agencies, shall notify the local health agencies and the public of the initial spill or contamination event and provide updated information related to any contamination or impairment of the source water supply or the system's drinking water supply. The initial notification to the public will occur, in any

event, no later than thirty minutes after the public water system becomes aware of the spill, release, or potential contamination of the public water system. A copy of the Source Water Protection Plan and the Communication Plan has been provided to the local fire department. The Protection Team will update the Communication Plan continually to ensure contact information is up to date.

Procedures should be in place for the kinds of catastrophic spills that can reasonably be predicted at the source location or within the SWPA. The chain-of-command, notification procedures and response actions should be known by all water system employees.

The WVBPH has developed a recommended communication plan template that provides a Tiered Incident communication process to provide a universal system of alert levels to utilities and water system managers. The comprehensive Communication Plan for the Bartley System is titled **Appendix C**.

The West Virginia Department of Environmental Protection (WVDEP) is capable of providing expertise and assistance related to prevention, containment, and clean-up of chemical spills. The WVDEP Emergency Response 24-hour Phone Number is 1-800-642-3074. The WVDEP also operates an upstream distance estimator that can be used to determine the distance from a spill site to the closest public water supply surface water intake.

Emergency Response

A public water utility must be prepared for any number of emergency scenarios and events that would require immediate response. It is imperative information about key contacts, emergency services, and downstream systems be posted and readily available in the event of an emergency. Information regarding this utility's Emergency Response Plan can be found in **Appendix C**. Several short forms are included and provide quick access to important information about emergency response. These should be printed and made available for reference by utility personnel. The following information should be included in the utility's Emergency Response Plan:

- Emergency Response Team
- Emergency Communication Equipment
- List of sensitive populations
- List of major users

- Personnel and property protection measures
- Planned training courses
- Resource inventory
- Repair and supply providers
- Procedures for specific emergency incidents

If this information is not included in the plan, the emergency response plan should be re-evaluated and updated to provide all important information. Contact the WV Department of Health and Human Resources (DHHR) SWAP program at (304) 356-4298 for guidance with this process.

CONCLUSION & RECOMMENDATIONS

This report represents a detailed explanation of the required elements of the Bartley System Source Water Protection Plan. Any supporting documentation or other materials that the utility considers relevant to their plan can be found in **Appendix F**.

This Source Water Protection Plan is intended to help prepare community public water systems all over West Virginia to properly handle any emergencies that might compromise the quality of the system's source water supply. It is imperative that this plan is updated as often as necessary to reflect the changing circumstances within the water system. The protection team should continue to meet regularly and continue to engage the public whenever possible. Communities taking local responsibility for the quality of their source water are the most effective way to prevent contamination and protect a water system against contaminated drinking water. Community cooperation, sufficient preparation, and accurate monitoring are all critical components of this Source Water Protection Plan, and a multi-faceted approach is the only way to ensure that a system is as protected as possible against source water degradation.










As shown in the Feasibility Matrix in **Appendix D** treated water storage is the selected alternative and is currently in place. The Bartley System currently has four days of treated water storage based on average production. It is recommend for the District to install an early warning system. An early warning monitoring system will give notification and increase response time if the Bartley Well is contaminated. A cost estimate is provided on the following page. Further explanations of the costs are provided in Appendix E.

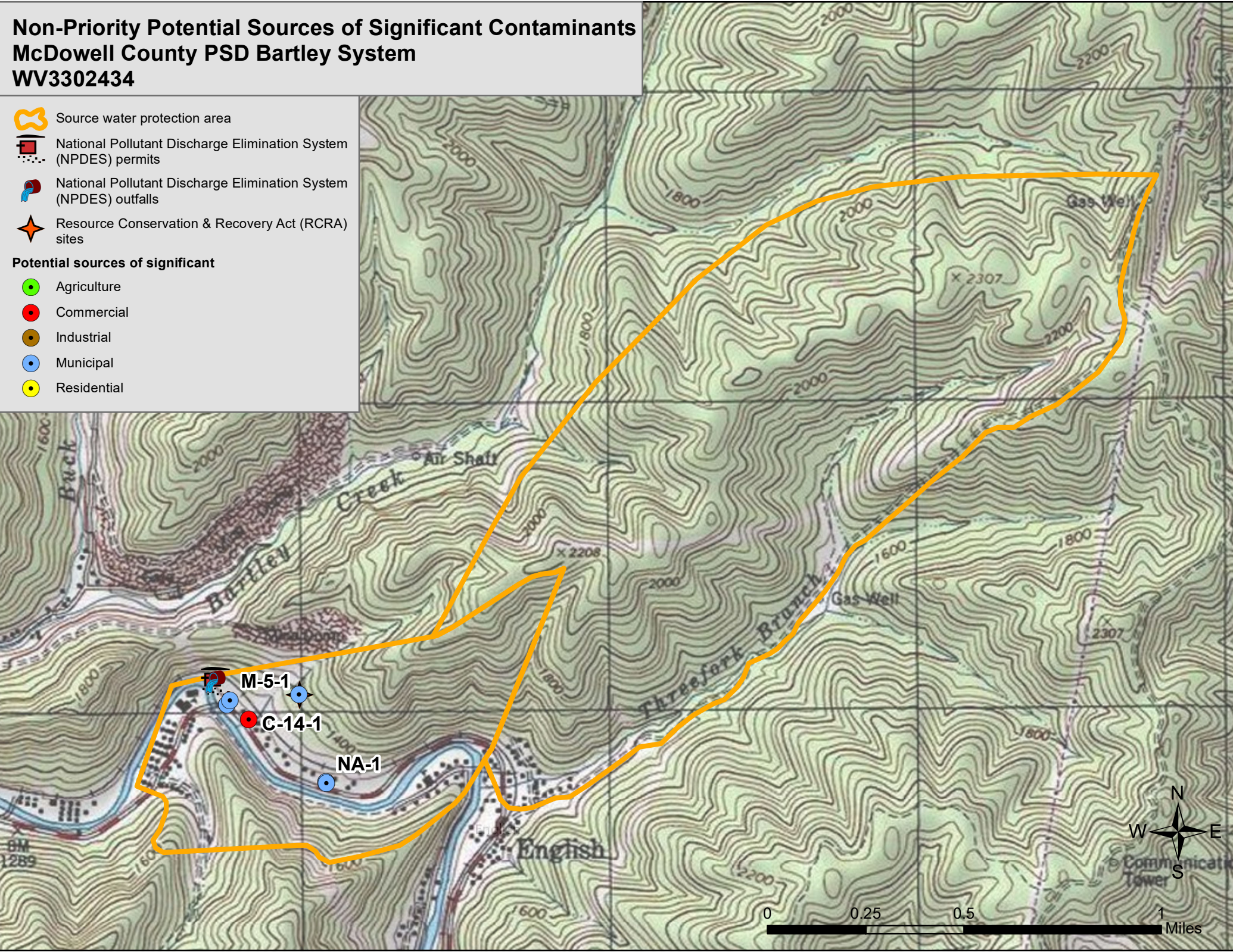
RECOMMENDED ALTERNATIVE COST ESTIMATE

Amount	Quantity	Item	Price
1	LS	Early Warning System	\$ 50,000.00
1	LS	Operation & Maintenance for Early Warning System	\$ 750.00
			TOTAL = \$50,750.00















APPENDIX A – FIGURES

Non-Priority Potential Sources of Significant Contaminants McDowell County PSD Bartley System WV3302434

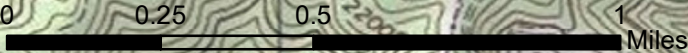
-  Source water protection area
 -  National Pollutant Discharge Elimination System (NPDES) permits
 -  National Pollutant Discharge Elimination System (NPDES) outfalls
 -  Resource Conservation & Recovery Act (RCRA) sites
- Potential sources of significant**
-  Agriculture
 -  Commercial
 -  Industrial
 -  Municipal
 -  Residential



Priority Potential Sources of Significant Contaminants McDowell County PSD Bartley System WV3302434

-  Conjunctive source water protection area
 -  Aboveground storage tank with additional chemicals
 -  Aboveground storage tank
 -  Hydrologic Protection Unit Mining and Reclamation permits
 -  National pollutant discharge elimination system (NPDES) permits
 -  Oil and gas wells
- Potential sources of significant contamination**
-  Agriculture
 -  Commercial
 -  Industrial
 -  Municipal
 -  Residential
 -  Coal refuse impoundments
 -  Abandoned mine lands polygons
 -  Abandoned mine lands problem areas

Residential sources (single family homes, NPDES septic seal permits) are not labeled.



[Contact name]

McDowell County PSD Bartley System

[Facility address]

Re: Protecting drinking water quality within the [Water System name] SWPA

Dear [XXX]:

The McDowell County PSD Bartley System is updating its Source Water Protection Program as mandated by Senate Bill (SB) 373, and is reaching out to facilities to open communication about protecting public drinking water supplies. Because your facility is located within the Source Water Protection Area (SWPA), we are also requesting certain information. The SWPA is the area surrounding a well that is likely contributing water to that well. The SWPA was established by the West Virginia Bureau for Public Health, as part of the Source Water Assessment and Protection Program to inventory the most likely potential sources of contamination.

SB 373 requires the SWPP to be a public, collaborative process. One of the requirements is for the utility to develop a management plan, which details actions to minimize potential threats to source water. One strategy included in McDowell County PSD's management plan is communication with facilities within the SWPA to educate them on source water protection efforts and to gather information from the facilities.

We encourage all facilities to follow all applicable regulations and Best Management Practices (BMPs) to minimize the chance of impact on our drinking water resources.

McDowell County PSD is proud to have provided clean drinking water to the community that meets regulatory requirements. However, our past success should not prevent us from preparing for a future anomaly that may threaten the health and safety of our water customers. We are therefore requesting the following information from your facility:

1. Please identify any and all chemicals stored at your site or property that, if released to the water in any manner, may impact human health or the environment.
2. For every chemical listed for #1, please identify the maximum amount that may be stored at your site.
3. Please provide the current safety data sheet for every chemical listed for #1.
4. Please provide the Spill Prevention and Response Plan for your facility.

This information is for our planning purposes only. Information that is not already public will not be disseminated by McDowell County PSD.

We hope that you will keep McDowell County PSD in the communication chain in the unfortunate instance of an accidental release. If an accidental release occurs, in addition to contacting the state Spill

Response Hotline at 800-442-3974, please also immediately contact [relevant point of contact] at McDowell County PSD at [contact information].

If you have any questions regarding McDowell County PSD's Source Water Protection Program, please contact [contact information]. We thank you for your cooperation and look forward to continued collaboration to protect our drinking water.

[Contact name]
McDowell County PSD Bartley System
[Facility address]

Re: Protecting drinking water quality within the [Water System name] SWPA

Dear [XXX]:

As you may be aware, [the proposed activities] are located within the Source Water Protection Area (SWPA) for the McDowell County PSD Bartley System. The SWPA is the area surrounding a well that is likely contributing water to that well. The SWPA was established by the West Virginia Bureau for Public Health, as part of the Source Water Assessment and Protection Program to inventory the most likely potential sources of contamination.

McDowell County PSD Bartley System has completed a Source Water Protection Plan (SWPP), as required by Senate Bill 373. SB 373 requires the SWPP to be a public, collaborative process. One of the requirements is for the utility to develop a management plan, which details actions to minimize potential threats to source water. McDowell County PSD Bartley System's management plan includes contacting entities interested in development within the SWPA to educate them on source water protection and gather information about the planned development.

The McDowell County PSD encourages economic development within the community, but we want to see responsible development that protects our drinking water supply. We encourage all facilities to follow all applicable regulations and Best Management Practices (BMPs) in order to minimize the chance of impact on our drinking water resources. We ask to be a stakeholder and to be involved in discussions as development moves forward. We also seek to be a source of information on actions that this facility can take to protect drinking water.

If you have any questions regarding McDowell County PSD's Source Water Protection Program, please contact [contact information]. We thank you for your cooperation and look forward to continued collaboration to protect our drinking water.

APPENDIX B – EARLY WARNING MONITORING SYSTEM FORMS

Select and Attach the Appropriate Form for Your System:

Form A – Complete if you currently have an early warning monitoring system installed for a surface water source

Form B – If you do not currently have an early warning monitoring system installed for a surface water intake or are planning to upgrade or replace your current system, complete this form.

Form C – Complete if you currently have an early warning monitoring system for a groundwater source.

Form D – If you do not currently have an early warning monitoring system installed for a groundwater source or are planning to upgrade or replace your current system, complete this form.

Note: You may need to fill out and attach more than one form to your Protection Plan, depending on your current situation.

Appendix B – Form B

Proposed Early Warning Monitoring System Worksheet- Surface

Describe the type of early warning detection equipment that could be installed, including the design.
The early warning detection equipment that could be installed includes a level controller, display module, back panel, level & trough (see cost estimate by Hach Company in Appendix F, “Supporting Documentation”) along with conductivity, oil-in-water, ORP, and pH sensors
Where would the equipment be located?
Early warning monitoring systems would be located on the Tug Fork upstream of the Bartley Well and would enter the laboratory in the water treatment facility.
What would the maintenance plan for the monitoring equipment entail?
The proposed maintenance plan for the monitoring equipment shall consist of annual cleaning and/or exchanging of the probe(s) for the controller. Periodic calibration of the unit may also be required.
Describe the proposed sampling plan at the monitoring site.
Sampling of water quality data occurs every fifteen (15) minutes. The Bartley System would need to retrieve data from the “History” of the controller data collector twice per month.
Describe the proposed procedures for data management and analysis.
Data management for the early warning monitoring system consists of data points (up to 500 points or approximately six months per probe) being recorded in the “History” of the controller data collector. To access the “History”, the probe has to be plugged into the controller. Data is able to be removed via USB or through a local SCADA system.

Literature related to the development and design of early warning systems is provided on the following pages, courtesy of the American Water Works Association.

BY RICHARD W. GULLICK, LEAH J. GAFFNEY,
CHRISTOPHER S. CROCKETT, JERRY SCHULTE,
AND ANDREW J. GAVIN

Developing regional early warning systems

FOR US SOURCE WATERS



REGIONAL EARLY WARNING
SYSTEMS HELP IMPROVE
MONITORING CAPABILITIES,
FACILITATE COMMUNICATION
AMONG UTILITIES, AND REDUCE
RISKS TO PUBLIC HEALTH.

Early warning systems (EWSs) are used by water utilities to detect sudden changes in source water quality and are intended to provide information necessary to implement appropriate responses such as closing intakes or changing treatment methods. Rivers with several intakes over some distance are good candidates for multiple monitoring stations and coordinated data management and communication systems. In the United States, experience with such regional EWSs has largely been limited to the Ohio River and Lower Mississippi River. That situation has changed, however, with the recent development (or impending development) of regional systems on several other US rivers, including the Upper Mississippi, Schuylkill, Delaware, Allegheny, Monongahela, and Susquehanna. This article discusses the characteristics and ongoing development of these systems and the lessons learned through that process. These lessons may be applied to establish new regional EWSs on other rivers in the United States and elsewhere.

EWS OPERATIONS HAVE COMMON FUNCTIONS AND CHARACTERISTICS

Why EWSs are needed. Most raw drinking water sources are susceptible to disruptions in quality as a result of accidental, intentional, or natural contamination. To protect consumers from potentially harmful contaminants, avoid treatment process upsets, and ensure compliance with environmental regulations, utilities must respond rapidly to spills and other sudden pollution events and make appropriate adjustments in drinking water treatment and operations. The timely information provided by an EWS can help guide utility response decisions and ensure that such decisions reflect actual data and circumstances. EWSs are used mostly on riverine systems where water quality can change rapidly (as a result of a barge spill near an intake, for example); the systems are used less frequently for impoundments and rarely for groundwater.

Systems take various forms, serve several purposes. EWSs comprise a combination of frequent or continuous monitoring, other detection mechanisms, institutional arrangements, analysis tools, and response protocols. Certain components are common to all capable EWSs and include the following:

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- **Detection:** a monitoring mechanism to detect pollution events and/or a public or self-reporting program.

- **Characterization:** a means to confirm and more completely characterize the event.

- **Communication:** the dissemination of data and other information to utility personnel and other decision-makers and response actions to the public and other stakeholders.

- **Response:** actions taken to minimize the potential effect of the contamination event. Responses could include source containment and/or cleanup, closure of water intakes and use of alternate sources or storage, and treatment process modifications.

Early warning monitoring can be used to detect rapid deterioration in water quality resulting from accidental or intentional discharges of toxic and hazardous chemicals near an intake. Such events as large-scale boat spills, pipeline breaks, industrial accidents, and terrorist attacks may be low in probability but can have significant consequences for water supplies. EWSs are also useful for monitoring during extreme natural events (such as heavy rains and flooding and algal blooms) and somewhat predictable events (such as seasonal runoff of herbicides).

Furthermore, EWSs can serve as a pollution prevention tool by tracking spill events and garnering information (to warrant followup activities and actions by agencies or prevention activities at similar sites), detecting unauthorized waste discharges, and serving as a sentinel of river water quality. In this last capacity, EWSs may tend to increase the number of spills reported but decrease the total number of spills, perhaps because of greater diligence on the part of potential dischargers.

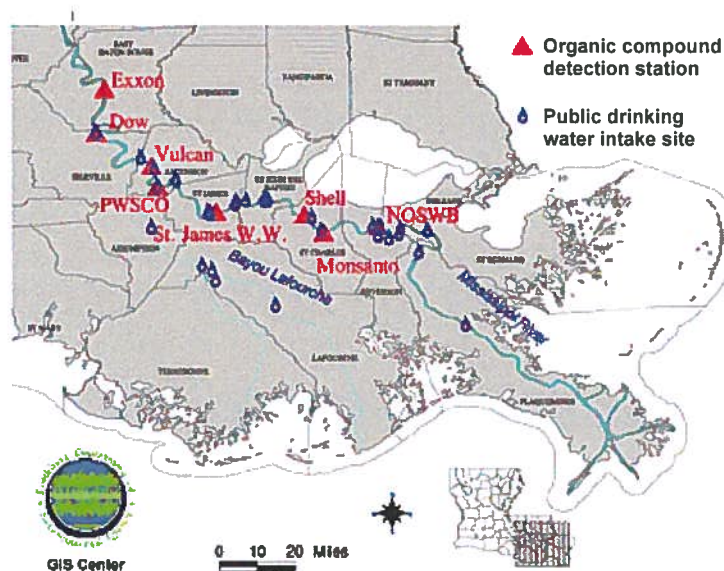
EWS scope depends on site-specific characteristics. Onsite early warning monitoring may be conducted by a single water supplier (e.g., a single instrument at an intake). However, source waters used by multiple water utilities (e.g., a large river) offer opportunities for

FIGURE 1 ORSANCO Organics Detection System stations on the Ohio River



ORSANCO—Ohio River Valley Water Sanitation Commission

FIGURE 2 Lower Mississippi River Early Warning Organic Compound Detection System



Source: Louisiana Department of Environmental Quality

cooperation and pooling of resources for development of integrated regional EWSs, including multiple monitoring stations, centralized data management and assessment, and coordinated information communication systems. This article uses the term “regional EWS” to refer to a system with multiple users and/or monitoring stations.

Most regional EWSs are developed in a phased approach that incorporates additional monitoring capability over time. Monitoring techniques range from relatively simple online measurements (e.g., pH, turbidity) to video surveillance to advanced analytical instrumentation to the use of living organisms as bioalarms. Gullick and colleagues (2003)

discuss EWS design for water utilities and the types of monitoring methods available; other references provide additional detail (Grayman et al, 2001; Gullick, 2001; Foran & Brosnan, 2000; ILSI, 1999). The sidebar on page 72 summarizes benefits provided by regional EWSs.

EXISTING SYSTEMS PROVE VALUE OF EARLY WARNING MONITORING

On many rivers, there is no systemic monitoring for sudden water quality changes, and no coordinated communication or central reporting system currently exists. Around the world, relatively few regional EWSs exist using monitoring, modeling, and communications in an integrated system to provide warning of contaminants in the source water. Several prominent systems (most of them located in Europe or Asia) were described in detail by Grayman and co-workers (2001) and summarized by Gullick and colleagues (2003). Many of these systems were developed in response to a specific contamination incident.

These systems are diverse but share some characteristics. They may vary greatly in their degree of complexity and in terms of the frequency of analysis and degree of automation. The more sophisticated networks include a coordinated monitoring, modeling, communication, and response program for an extended stretch of river. In all cases, some form of institutional structure coordinates efforts and communicates information so that appropriate actions can be taken.

Ohio River Organics Detection System. The most established regional EWS in the United States is led by Ohio River Valley Water Sanitation Commission (ORSANCO) on the Ohio River. The Ohio River is a source of drinking water for about 3 million people, and more than 25 million people live in the watershed. The river is also heavily industrialized in sections, serves a significant amount of commercial barge traffic, and has hundreds of municipal,



EWSs alert utilities of contaminants and allow them to initiate cleanups such as this one along the Schuylkill River following a chemical spill caused by a train derailment.

PHOTO: CHAD PINDAR, PHILADELPHIA (PA) WATER DEPT.

industrial, and combined sewer overflow discharges. The EWS includes 15 gas chromatograph stations at various locations to detect and monitor organic chemical spills (Figure 1). Data management and communications are coordinated by a single central office that communicates to utilities the nature of any detected spills or other changes in river water quality.

Most of the monitoring stations are operated by water utilities at their intakes; others are run by industrial facilities. These organizations provide labor and space for sampling and analysis stations; analytical instruments are purchased and maintained by ORSANCO. All stations analyze at least one sample a day. Using a centralized data-analysis system and state-of-the-science contaminant transport models, ORSANCO is often able to provide utilities with specific estimates regarding the concentration-distance-time profile of chemicals spilled in the river. This information helps water utilities decide when to close their intakes and/or how to respond with modifications in treatment processes.

Lower Mississippi River early warning organic compound detection system. Another regional EWS is located in Louisiana on a 128 mi (206 km) stretch of the Lower Mississippi River from Baton Rouge to New Orleans (Figure 2). The system includes eight gas chromatographs (operated by three water utilities and five industries) monitoring for volatile organic chemicals. Although there is

no central coordinating agency, the system is overseen by the Louisiana Department of Environmental Quality, which also provided financial support to purchase and maintain the gas chromatographs, accessories, and data-transmitting devices. The utility and industrial monitoring sites provide lab space and workers to analyze the samples. This system was inspired by the ORSANCO example and helps to protect the 1.5 million Louisiana residents who depend on the river for their drinking water supply (Grayman et al, 2001).

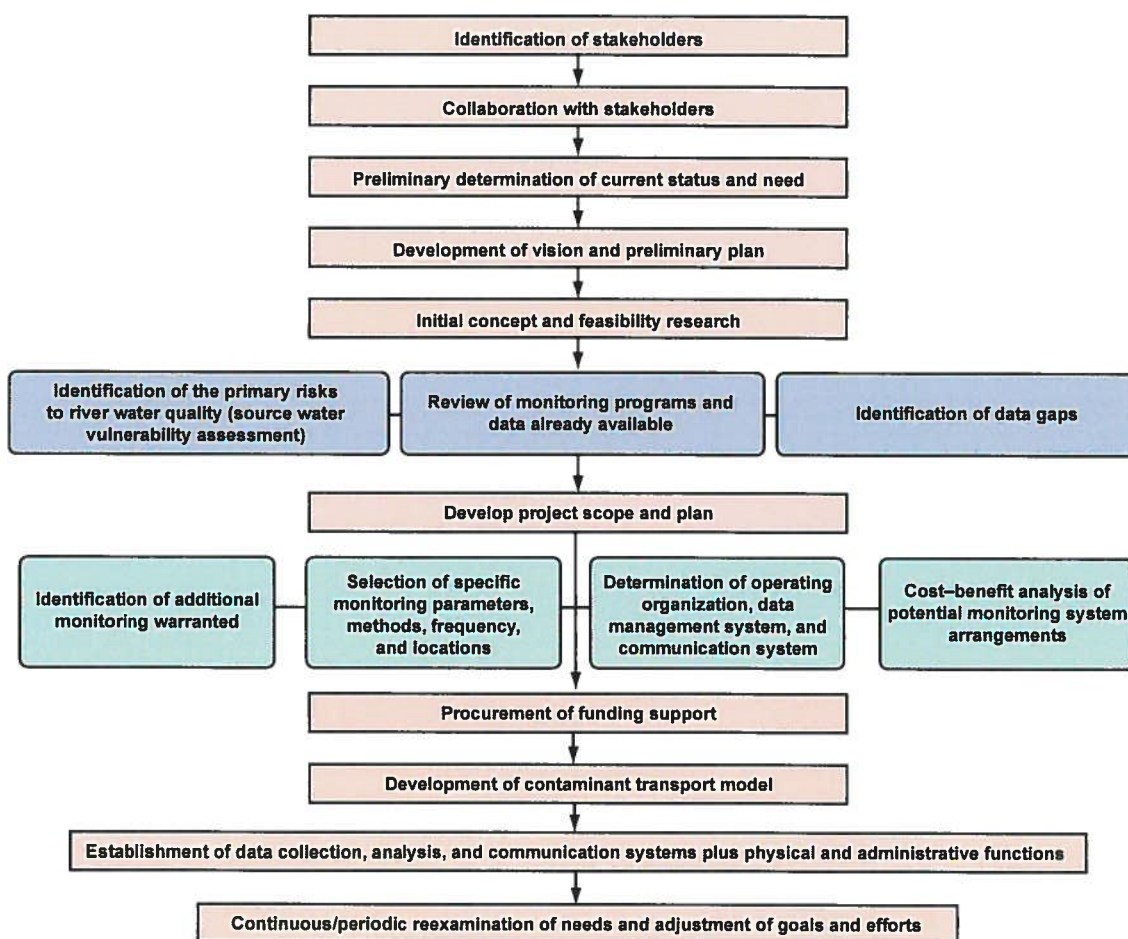
EARLY WARNING MONITORING IS ON THE RISE IN THE UNITED STATES

Interest in regional EWSs has increased in recent years, with systems currently in development for the Upper Mississippi, Schuylkill, Delaware, Allegheny, Monongahela, and Susquehanna rivers (Gullick, 2003). These systems are being designed to answer system-specific needs, and they reflect their individual locations and participating entities. However, the regional EWSs also have some characteristics in common. To some degree, each EWS was modeled after parts of the ORSANCO system, and each aspires to achieve these shared goals:

- Provide prompt notification of significant watershed events to downstream users.
- Provide information and tools to aid water suppliers in making decisions.
- Develop a framework to share information about water quality.
- Improve communication among water suppliers about water quality events.
- Improve communication between water suppliers and emergency responders.

The primary processes involved in the development of a typical regional EWS are shown in Figure 3. The following sections describe the monitoring and communication systems being developed as of April 2004 for the Delaware Valley, Upper Mississippi River, Allegheny and Monongahela rivers, and Susquehanna River.

FIGURE 3 Processes involved in the development of a typical regional early warning system



Delaware Valley (Schuylkill and Delaware rivers). The Delaware River Basin (Figure 4) drains an area of 13,300 sq mi (34,447 km²) in the states of New York, Pennsylvania, New Jersey, and Delaware. The Delaware River is the longest undammed river east of the Mississippi, stretching 330 mi (531 km) from its headwaters in New York state to the mouth of the Delaware Bay (PWD, 2002). The Schuylkill River is 130 mi (209 km) long and is the largest tributary to the Delaware River. Its basin drains an area of 1,900 sq mi (4,921 km²) in Pennsylvania.

The Delaware and Schuylkill rivers serve as the source water for more than 3 million people in southeastern Pennsylvania and southwestern New Jersey. Although both

rivers originate in rural areas, their confluence in the Delaware Estuary promoted the development of the urban, industrial, and shipping center that is the Philadelphia–Camden metropolitan area. Their location and upstream activities render the rivers highly vulnerable to water quality contamination events and ideal candidates for a source water EWS.

Utility spearheaded EWS development. The Philadelphia Water Department (PWD) operates the three drinking water treatment plants farthest downstream on the Delaware and Schuylkill rivers. The utility gained familiarity with both watersheds during development of the Source Water Assessment Program (PWD, 2002). While working with neighboring water suppliers, PWD identified the

need and gathered support for the development of a watershedwide EWS. In the aftermath of Sept. 11, 2001, and after five years of campaigning, PWD received a one-year, \$725,000 grant from the Pennsylvania Department of Environmental Protection (PADEP) to develop an EWS. Although the monetary resources were significant, the one-year time frame posed a significant challenge.

PWD sought stakeholder input. From the beginning, stakeholder involvement was an integral part of the EWS development. Even before the grant was awarded, PWD approached a select group of water utilities to gain their support, identify the overall goals of the EWS, and develop the basis for a proposal. After PADEP awarded the grant and

POTENTIAL BENEFITS OF REGIONAL EARLY WARNING SYSTEMS

A regional early warning system shared and supported by a group of water providers offers numerous benefits.

- Improved monitoring can detect sudden changes in river water quality.
- Identification of spills/releases that are unknown to the dischargers may help them to prevent similar releases in the future.
- Communication of contamination events to water utilities is improved.
- Better information on contamination events allows for better response decisions.
- The overall risk to the public from spill events is reduced.
- Water providers share more kinds of information, and communication among utilities is increased.
- Monitoring efforts on the river are better coordinated.
- The system can serve as a monitoring sentinel, thus promoting greater diligence on the part of potential dischargers.
- Public confidence in potable water quality is improved.
- Additional information provided by the system can help in responding to the press during spill events.
- A central data warehouse may be beneficial to researchers studying the river.
- Source water protection of a large river is complex and may not be feasible. Time, energy, and money may be better spent on reliable early notification systems and installation of water treatment processes to deal with potential contamination events.

Adapted from Gullick et al, 2003

the project was formally under way, PWD approached a broader group of stakeholders through a series of meetings, site visits, and surveys. This group included representatives from 14 water utilities along the main stem of the Schuylkill and Delaware rivers, county emergency management agencies, and regulatory agencies (e.g., PADEP) the New Jersey Department of Environmental Protection, and the US Environmental Protection Agency (USEPA), as well as other organizations such as the US Geological Survey (USGS), the Delaware River Basin Commission, and the US Army Corps of Engineers (USACE). This diverse group brought a wide array of experiences, capabilities, priorities, and needs to the EWS devel-

opment process. This in turn created both greater opportunities and significant challenges in meeting the varied expectations.

Input from the stakeholders helped to identify their needs and resources and enabled the design of an EWS that complemented existing emergency notification and response protocols. In addition, the stakeholder process identified the need for a system that could provide information and tools useful in the daily operation of a water treatment plant. This provision increases the overall value of the system and encourages users to become acquainted with the system as part of their routine operations.

System developed quickly. The Delaware Valley EWS was designed

to provide the infrastructure for a notification, communication, monitoring and data-management system that could expand and develop over time. The objectives during the first year of the project were to build a framework that would support emergency notifications, promote routine information-sharing, and demonstrate the potential for a watershedwide water quality EWS. The resulting EWS is a fully integrated computer-based system that includes three major components: a telephone-based notification system, a website and data-management system, and a water quality-monitoring network (Figure 5).

The telephone notification system is an off-the-shelf application that was customized for the Delaware Valley EWS. The telephony system accepts calls from emergency responders or water utility personnel, records event information provided via touch-tone responses to a standard question-and-answer process, and makes telephone and e-mail notifications. The telephony system is integrated with the EWS server and can forward event information to the EWS database and website.

The computer server, which houses the website, data-management system, and telephony system, is the core of the Delaware Valley EWS and the central location for all EWS information. The data-management system stores and organizes information about contamination events, water quality, and plant operational characteristics in an accessible format. The result is a unique and powerful tool that sets this EWS apart from others currently in operation.

The Delaware Valley EWS website provides a dynamic and interactive user interface to the database, allowing users to access and share event and water quality information in a centralized and secure location. Various user interface formats are available, including forms for reporting and viewing the details of a water quality event (Figure 6), maps to identify the location of an event (Figure 7), graphs that show water qual-

ity data (Figure 8), and a time-of-travel estimator (Figure 9). The estimator uses real-time flow data from USGS gauging stations to provide plug-flow travel time estimates for each intake based on river conditions at the time of the event. To provide additional boundaries on this rough estimate, the historical highest flow and lowest flow on record at the gauging stations are used with a hydrodynamic water quality model to provide estimates of the earliest and latest times it would take for the spill to reach a downstream intake.

The water quality monitoring network compiles both near real-time and historic water quality data. The near real-time portion of the network uses simple and readily available technology to transmit data from remote monitors to the EWS server on a set time interval. Continuous monitors are located at select water treatment plant intakes and USGS gauging stations. Real-time monitoring was initially limited to simple water quality parameters such as turbidity and pH, but the network will be expanded in future years as monitoring technologies advance and additional monitoring needs are identified. In addition to the near real-time data, utilities will submit the results of their routine operational monitoring, creating a historical database that can be compared with real-time data.

Automation was essential to system design. One of the great challenges in designing this system was meeting the requirement that it operate essentially unstaffed. This is a different approach from that taken by many existing systems, which use an organization to oversee the monitoring and notification process 24 hours a day, seven days a week. With the Delaware Valley EWS, once an event is reported via telephone or the Internet, the system automatically performs the time-of-travel estimations and notifies downstream users. System users then supplement the event description by reporting updates and additional information to the website. This inherent reliance on the users places the

FIGURE 4 Delaware River Basin



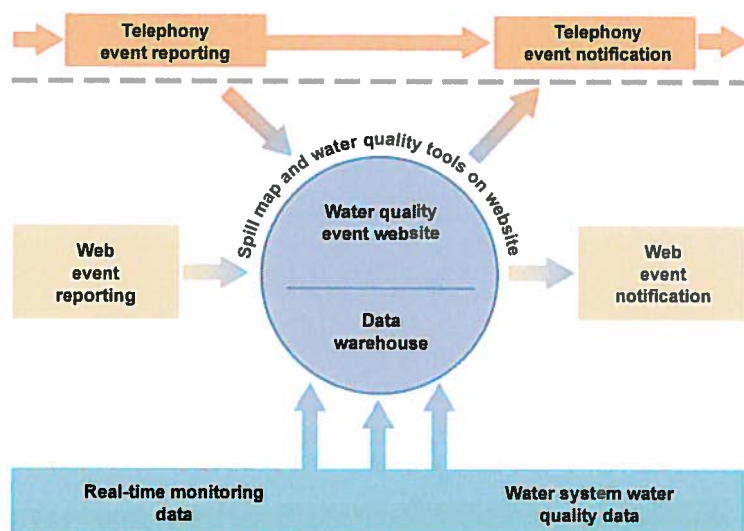
success of the Delaware Valley EWS firmly in their hands.

Steps were taken to ensure organizational sustainability. Maintaining stakeholder partnership will be crucial to the long-term success of the Delaware Valley system. A steering committee was formed to act as the EWS governing body and to promote sustainability by giving stakeholders a more active role in defining the future of the system to meet their needs. The steering committee will identify issues and make decisions to guide the system's future development and maintenance, as well as locate and allocate funding. The steering committee comprises the nine voting seats of participating utilities (Table 1). Government agencies and other organizations do not have voting seats but participate by serving in an advisory role. Steering committee meetings are open to all stakeholders.

Implementation demonstrated system's value. During the first three

months of EWS operation, seven water quality events of varying types and magnitudes were reported. Three events were associated with algal blooms or taste-and-odor events and their effects. One was related to high ammonia concentrations from road salt runoff affecting water treatment, and another was attributable to sewage main breaks spilling into the river. The final two events were related to spills—one a fuel spill of unknown origin and the other a tanker truck accident. The tanker truck accident in particular demonstrated the value of the Delaware Valley EWS. Initially the tanker truck was reported to have overturned on a bridge over the river just 3 mi (5 km) upstream of an intake, releasing approximately 100 gal (379 L) of diesel fuel into the river. During this event, the EWS was able to assist emergency response personnel and provide timely notification and pertinent data to downstream water sup-

FIGURE 5 Delaware Valley early warning system schematic



pliers so they could initiate their respective responses to the event with the best available information.

As system uses multiply, support for the Delaware Valley EWS grows.

The response and enthusiasm for participation in the Delaware Valley EWS have been positive, and more industrial users, water suppliers, and organizations are participating in the system as word spreads and users are trained. For example, a county health department requested that the system be expanded to include its entire county. The growing support for the EWS is due primarily to the potential of the system's alternative uses that indirectly benefit the day-to-day activities of participants. Examples of indirect uses being explored include: health departments turning to the EWS for help with investigating disease clusters related to recreational waterborne outbreaks, food and beverage manufacturers obtaining advance warning of potential water quality changes that might affect processing, water suppliers obtaining official reports to justify additional chemical costs (e.g., carbon addition) during events, emergency responders using EWS data to assist in documenting accidents, and recreational

events and users relying on the system for forecasts of water quality. As these potential multiple uses evolve, the usefulness and the long-term success and sustainability of the system increase.

Upper Mississippi River. The Upper Mississippi River refers to the approximately 1,300 mi (2,092 km) stretch of the Mississippi River from the headwaters to the confluence with the Ohio River at Cairo, Ill. (Figure 10). This definition excludes the Missouri River, the river's largest tributary. Other significant tributaries of the Upper Mississippi include the Illinois, Minnesota, St. Croix, Wisconsin, and Kaskaskia rivers (UMRBA et al, 2004).

A vital economic link for America's heartland, the Upper Mississippi River supports commercial navigation, water supply, recreation, wildlife, and waste-discharge assimilation. The river is a major transportation artery, and land use along its banks ranges from major metropolitan areas to rural farmland. A system of 29 locks and dams maintains a 9 ft (3 m) deep channel, allowing navigation as far upstream as Minneapolis, Minn. (UMRBA et al, 2004). The drainage area for the

Upper Mississippi River is approximately 189,000 sq mi (489,510 km²), primarily from the five states bordering the river (Minnesota, Wisconsin, Iowa, Illinois, and Missouri). The average flow of the river as it approaches Cairo is approximately 121 bgd (458 GL/d).

The Upper Mississippi River has 26 drinking water suppliers with a total of 29 intakes over an 874 mi (1,407 km) stretch from Minnesota to Missouri. Of these suppliers, 23 are community systems, and the remainder are industrial facilities (non-community systems). These 26 water suppliers combined provide approximately 360 mgd (1,363 ML/d) of potable water to almost 3 million people. There are three drinking water intakes between St. Cloud and the Twin Cities of Minneapolis and St. Paul in Minnesota. Then for a stretch of 370 mi (595 km) there are no drinking water intakes downstream until the Quad Cities (Davenport, Rock Island, Moline, and Bettendorf) of Illinois and Iowa.

Regional organization assumes project leadership. Initially the work to develop a regional EWS on the Upper Mississippi River was led by American Water, a privately owned water supplier with four intakes on the river (Gullick, 2001). With the support of Region 5 of the USEPA, the Upper Mississippi River Basin Association (UMRBA), an organization representing the five states bordering the river, eventually took over the lead for assessing the potential for a regional EWS. UMRBA then formed an official Upper Missouri River EWS scoping group to help explore design and operational issues. The group includes representatives of drinking water suppliers and state and federal response and drinking water programs.

Key stakeholders contribute to EWS development. Following American Water's first efforts to assess the potential for a regional EWS on the Upper Mississippi River, other entities have made important contributions to this collaborative effort. In addi-

tion to the water suppliers, UMRBA has been instrumental throughout the project. UMRBA coordinates the efforts of the Upper Mississippi River Hazardous Spills Coordination Group, composed of state and federal agencies that have various response-related roles on the river. Discussions were also held with many of the individual agency members of the spills group, including USEPA and USACE. Representatives from ORSANCO and a research project sponsored by the AWWA Research Foundation (Grayman et al, 2001) served as consultants and provided significant advice and input.

Coalition of water suppliers formed. Realizing that the support of the water suppliers on the river would be crucial to development of a regional EWS, American Water initiated steps early on to organize these providers into a coalition to better represent their collective interests. The first meeting of the Upper Mississippi River Water Suppliers Coalition was held in October 2001 in Davenport, Iowa. The primary goals of the coalition are to establish a formal communication network for the water suppliers on the river, develop a regional EWS, promote source water protection practices, provide educational opportunities for the membership and their consumers, develop working relationships with other river stakeholders, and serve as a resource clearinghouse for river water quality and related information.

Coalition members can include both public and privately owned water utilities as well as industries and other organizations that operate noncommunity water systems using the Upper Mississippi River as a source. State and federal agencies responsible for drinking water, river pollution, and spills response also participate in the coalition's meetings, although they are not official members of the coalition and have no voting powers.

A series of meetings and conference calls was held to initiate the

FIGURE 6 Sample Delaware Valley early warning system user interface screen for a hypothetical spill event—water quality event report form

The screenshot shows a web-based user interface for the Delaware Valley early warning system. It features a map of the Delaware Valley region on the right side, with a red star indicating a spill location. On the left, there is a data entry form with the following sections:

- Event Details:** Includes fields for "Event ID", "Event Name", "Event Date", "Event Time", "Event Location", "Event Type", "Event Status", and "Event Priority".
- Event Description:** A text area for "Event Description".
- Event Location:** A text area for "Event Location".
- Event Status:** A dropdown menu for "Event Status".
- Event Priority:** A dropdown menu for "Event Priority".
- Event Type:** A dropdown menu for "Event Type".
- Event Source:** A dropdown menu for "Event Source".
- Event Impact:** A dropdown menu for "Event Impact".
- Event Action:** A dropdown menu for "Event Action".
- Event Comments:** A text area for "Event Comments".

A red text box on the right side of the form contains the following text:

When a contamination event is entered online, an immediate email notification is sent to all downstream users providing detailed event information together with a model estimating the time at which the contaminant will reach a given downstream drinking water intake.

project. More stakeholders have become involved at each step of the process and particularly at each of the meetings. One primary focus for the water suppliers was to encourage the spills group and the relevant state and federal agencies (public water supply and hazardous spill-response divisions) to support development of a monitoring network. On more than one occasion, the water suppliers coalition and the spills group have met jointly, providing opportunities to exchange experiences, perspectives, and concerns.

Existing monitoring programs identified. One important early step in the process was to identify and describe the existing river water quality monitoring programs conducted by the water suppliers as well as federal, state, and local agencies to ascertain what information would be useful for early warning monitoring. This investigation showed that despite the existence of numerous water quality monitoring programs on the Upper Mississippi River, little monitoring was being performed that would be applicable to an EWS because of the types of parameters

monitored (primarily oriented toward Clean Water Act compliance or measurement of ecological health), the relatively low frequency of monitoring (e.g., once every two weeks or monthly), and the location of most of the monitoring stations substantial distances away from the water supply intakes (Gullick, 2001).

A survey of the water suppliers was used to identify the type and frequency of source water monitoring already being performed, as well as the primary risks to river water quality. Oil and petroleum products, bacteria, algae, ammonia, and pesticides (herbicides and/or insecticides) were identified as the most common contaminants of the source water. According to the water suppliers, the leading sources of contaminants on the river were barge and boat spills, industrial spills, low flows, wastewater treatment plants, and runoff. Transportation accidents were viewed as by far the biggest threat.

Despite these risks to water quality, however, the same survey indicated that little monitoring was being performed to provide advance warning of many of these contaminants.

The screenshot displays the 'Early Warning System' web application. The interface includes a top navigation bar with various icons and a sidebar on the left with categories like 'Home', 'Alerts', 'Reports', and 'Data'. The main content area is titled 'Early Warning System - Events - All Active' and features a table of active events. Each event entry includes a status icon (e.g., 'Active'), a location name, a description, a status (e.g., 'Confirmed'), and a date. Below the table, there is an interactive map showing the location of the selected event, with a red pin indicating the specific site. A text box on the right side of the map provides additional details about the event, including the date and time of the last update.

Event ID	Location	Description	Status	Last Update
1	1.10.10	problem with flow rate from the river into the treatment plant	Confirmed	2014-05-07 10:00:00
2	1.10.10	problem with flow rate from the river into the treatment plant	Confirmed	2014-05-07 10:00:00
3	1.10.10	problem with flow rate from the river into the treatment plant	Confirmed	2014-05-07 10:00:00
4	1.10.10	problem with flow rate from the river into the treatment plant	Confirmed	2014-05-07 10:00:00
5	1.10.10	problem with flow rate from the river into the treatment plant	Confirmed	2014-05-07 10:00:00
6	1.10.10	problem with flow rate from the river into the treatment plant	Confirmed	2014-05-07 10:00:00
7	1.10.10	problem with flow rate from the river into the treatment plant	Confirmed	2014-05-07 10:00:00
8	1.10.10	problem with flow rate from the river into the treatment plant	Confirmed	2014-05-07 10:00:00
9	1.10.10	problem with flow rate from the river into the treatment plant	Confirmed	2014-05-07 10:00:00
10	1.10.10	problem with flow rate from the river into the treatment plant	Confirmed	2014-05-07 10:00:00

From the "all active events" page, the user can view the status and summary of all water quality events, and by selecting a specific event, can instantly view the event location on an interactive map and review and update past reporting and risk level information.

Funding draws on a range of sources. Initial financial support came from American Water and UMRBA, primarily in terms of personnel to perform the first exploratory work. More recently, USEPA Region 5 has provided up to \$75,000 through a cooperative agreement with UMRBA to support the scoping effort and acquire monitoring equipment for a pilot station; USEPA has also provided additional contractor assistance

Work proceeds on data collection, analysis, and dissemination system. Data-management and communication-system options are still being developed as part of the scoping effort. In April 2003, the scoping group surveyed members of the suppliers coalition concerning information dissemination and spill notification. Seventeen of the 23 organizations with intakes responded, generally expressing strong interest in a secure, web-based system that would notify them of contamination, provide ongoing information during an incident, and afford an opportunity to exchange information concerning routine operations. Most respondents indicated a willingness to share their own monitoring and testing results with other participants in the system, assuming a reasonable level of security could be ensured. This would allow the utilities to exchange data on parameters for which they test either routinely or seasonally but that may not be part of the EWS pro-

Pilot program launched for Upper Mississippi River EWS. The EWS scoping group is currently coordinating implementation of a pilot monitoring station that is slated to include a multiparameter probe¹ for pH, turbidity, chlorophyll, conductivity, dissolved oxygen, temperature, and oxidation–reduction potential, as well as a continuous online fluorescence detector² for oil and petroleum products. The multiparameter probe was deployed in October 2003, and the initial experience with this equipment has generally been positive. Efforts are ongoing to address site and operating requirements related to the fluorescence detector. The scoping group's intent is to operate the pilot station for a sufficient period to gain operating experience over different conditions (winter temperature and ice conditions in the region can be particularly severe), identify threshold values for the various parameters, and evaluate alternative data-transmission options. Initially, the pilot station is transmitting data via satellite to a USACE website.

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ment. If this interagency approach for the pilot is successful, it may prove to be a model for the final design of a regional EWS for the Upper Mississippi River.

Potential monitoring locations considered. Facilities that may serve as monitoring locations for the Upper Mississippi EWS include the water treatment plants, existing USGS and state monitoring stations, USACE lock and dam locations, and industrial facilities such as power plants. Factors determining the selection of monitoring sites will include the locations of potential contamination sources in relation to the location of water supply intakes, the risk these sources pose, and the willingness of various entities to participate.

Cost estimates vary. One proposed network of nine monitoring locations was estimated to cost about \$550,000–\$600,000 in capital expenses, \$40,000–\$50,000 for system startup, and \$280,000–\$340,000 in annual operating costs (Gullick, 2001). This estimate included purchase of monitoring (multiparameter probe and fluorescence detector) and telemetry equipment, daily analysis of oxidant demand, seasonal daily immunoassay analyses for atrazine, sheds for housing equipment, operating costs for the data-management and communication systems, and other items. It also assumed in-kind support from the water suppliers with monitoring stations to perform analyses and report results. The EWS scoping group will develop a refined estimate that reflects experiences with the pilot station, recommended monitoring locations, desired information system features, and other factors.

Project moves forward. Bringing the EWS to fruition involves the following steps: (1) complete pilot program, (2) develop institutional structure (data-management center and communications system), (3) complete full-scale system design (including finalizing monitoring parameters, methods, locations, and frequency), (4) develop contaminant transport model, (5) obtain long-term funding,

FIGURE 8 Example of Delaware Valley early warning system user interface screen—water quality data query results

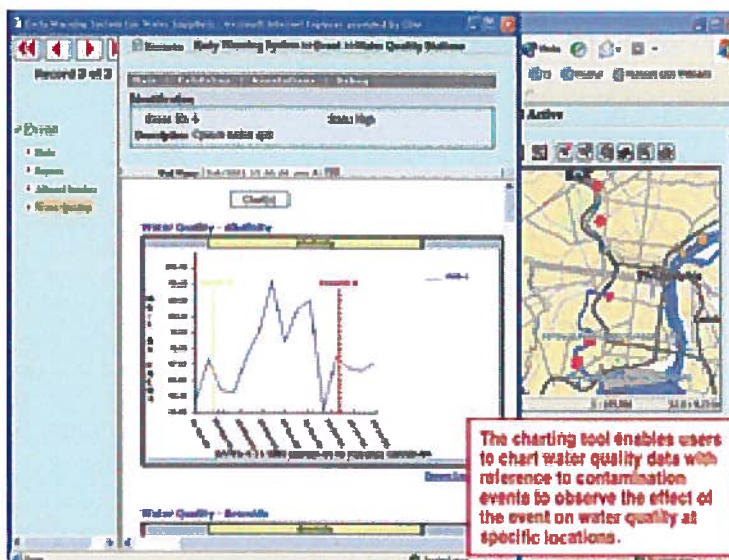
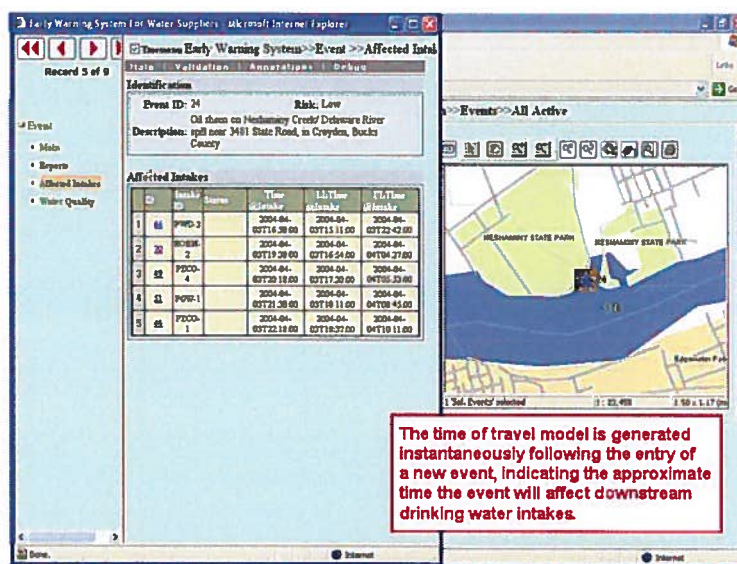


FIGURE 9 Example of Delaware Valley early warning system user interface screen for a hypothetical spill event—time-of-travel results



and (6) launch system setup and operation. Several of these efforts will take place concurrently.

Allegheny and Monongahela rivers. The Allegheny and Monongahela rivers converge at Pittsburgh, Pa., where they form the Ohio River.

The Allegheny River is 325 mi (523 km) long and drains 11,700 sq mi (30,303 km²). There are 16 water suppliers on the Allegheny River serving 637,000 people. The Monongahela River is 128 mi (206 km) long and drains 7,400 sq mi

(19,166 km²). The 15 water suppliers on the Monongahela main stem serve approximately 771,000 people, and 4 water suppliers on the Youghiogheny River tributary serve 201,000 people. A system of locks and dams on the rivers supports commercial navigation; reservoirs located in the watersheds provide flood control storage. Figure 11 shows the Ohio River Basin area with the Allegheny and Monongahela rivers highlighted.

As noted previously, ORSANCO has operated a regional EWS on the Ohio River for many years. This Organics Detection System, however, provides organics monitoring only on the extreme lower reaches of these two Ohio River tributaries (the Allegheny and Monongahela rivers). In January 2002, the PADEP approached ORSANCO requesting assistance in establishing regional EWSs on these rivers, and PADEP provided \$800,000 funding for system design and startup. Meetings held with drinking water utilities drawing from the Allegheny and Monongahela rivers found overwhelming support for the development and operation of a regional EWS.

System had to fit regional resources, capabilities. Initially envisioned as an expansion of the ORSANCO Organics Detection System, the Allegheny and Monongahela EWS evolved into an integrated source water monitoring network that would consider multiple parameters and host a secure website for the distribution of near real-time source water quality data. As part of the initial data-gathering effort, a suitability and susceptibility analysis of the drinking water utilities was conducted to evaluate each facility's needs and resources. The utilities located along the two river systems are relatively small; approximately 70% of the Allegheny and Monongahela river utilities serve 12,000 or fewer customers, with some serving as few as 1,000. Because utility plant personnel are already multitasking in their daily work, the addition or

FIGURE 10 Upper Mississippi River Basin



Source: USGS, 1999

installation of any monitoring equipment that required significant time to operate, maintain, or interpret would not be accepted or successful.

In contrast to some other developing regional EWSs, the Allegheny and Monongahela system focused on enhanced monitoring of source waters. In 2002, instrument tests evaluated available online technologies that would provide useful source water quality data, require minimal time to operate and maintain, and deliver readily interpretable results. Test results were favorable for four types of water quality monitoring instruments: (1) a multiparameter probe measuring temperature, pH, conductivity, dissolved oxygen, chlorophyll, and turbidity; (2) a fluorometer measuring hydrocarbons or chlorophyll; (3) a total organic carbon analyzer; and (4) a portable, autosampling purge-and-trap gas chromatograph with argon ionization detector. Data gathered from these instruments can be transmitted via the Internet to a project computer server, displayed near real time on the website and archived for later

assessment. Operation and maintenance time for this equipment was anticipated to be less than 1 hour per week.

A key step to the acceptance of this instrumentation was a demonstration of the proposed instruments to the water utilities. This helped allay concerns regarding the technical nature of the work required and the time commitment for operation and maintenance. Utility representatives provided input about which instruments they would be interested in supporting at their facility. This information provided the basis for the location and distribution of the monitoring equipment along the two rivers. Currently the Allegheny and Monongahela EWS has 11 monitoring locations operating a total of 7 multiparameter probes, 5 gas chromatographs, 3 total organic carbon analyzers, and 1 online fluorometer.

Another key component of the project was to foster the development of communications networks among the utilities. For several years, a communications network has existed on the Monongahela River for distribution of spill reports and spill information to downstream utilities. However, no such communication network existed on the Allegheny River. To answer this need, the Allegheny River Communication Network was organized during meetings of the Allegheny River utilities. The purpose of the group is to facilitate the exchange of spill and other water quality information of interest and concern to the drinking water providers.

This project has achieved and exceeded its initial goals. A state-of-the-art regional early warning system has been established that provides enhanced source water quality monitoring for multiple parameters, a mechanism for the distribution of these data in near real time via the Internet was developed, and a new communications network was created to facilitate information exchange among drinking water utilities using a common source water.

TABLE 1 Steering Committee for the Delaware Valley early warning system

Designated Voting Seats (Permanent)	Temporary Voting Seats (Annually Voted on by Membership)	Advisory Committee (Nonvoting)
Philadelphia (Pa.) Water Department	Trenton (N.J.) Water Works	Pennsylvania Department of Environmental Protection
Pennsylvania American Water Company (Hershey, Pa.)	Morrisville (Pa.) Municipal Authority	New Jersey Department of Environmental Protection
New Jersey American Water Company (Delran, N.J.)	Middlesex Water Company (Iselin, N.J.)	US Environmental Protection Agency
Aqua America Pennsylvania (Bryn Mawr, Pa.)	New Jersey Water Supply Authority (Clinton, N.J.)	Delaware River Basin Commission (West Trenton, N.J.)
	City of Pottstown (Pa.)	US Geological Survey

Susquehanna River. The main stem of the Susquehanna River flows 444 mi (715 km) from its headwaters at Otsego Lake in Cooperstown, N.Y., to the Chesapeake Bay. More than 20 public water systems within the Susquehanna Basin depend on the river as a source of drinking water; these systems serve in excess of 2.5 million people in New York, Pennsylvania, and Maryland. Twelve of these water suppliers draw from the main stem of the Susquehanna River in Pennsylvania. Figure 12 shows the Susquehanna River Basin and the location of some water suppliers participating in the EWS.

Commission spearheaded EWS development. Development of a regional EWS for these 12 water suppliers has been led by the Susquehanna River Basin Commission (SRBC), with the majority of funding provided by PADEP. In instigating the project, SRBC has taken a relatively progressive approach; many other regional EWSs have been developed because of requests from water suppliers to a basin commission (or association), as opposed to the basin commission initiating the effort. SRBC has a history of assisting water suppliers and has worked with Pennsylvania and Maryland since 1999 to develop Source Water Assessments (SWAs) required by the 1996 Amendments to the Safe Drinking Water Act. SWAs are designed to identify the susceptibility of water supplies to a variety of poten-

tial contamination sources and can provide information useful for establishment of source water protection and monitoring programs. SRBC also receives funds from USEPA to conduct water quality monitoring within its jurisdiction and assist with program coordination related to water quality issues.

Project scope defined. Initially, the EWS will extend only through the Pennsylvania part of the Susquehanna River Basin. However, SRBC and the states of New York and Maryland are engaged in discus-

sions to extend the EWS into those jurisdictions.

The scope of work for developing this regional EWS entailed six major tasks in the first year of development:

- Task 1—establish a steering committee of different stakeholders.
- Task 2—establish an EWS project database.
- Task 3—establish a communications network that would coordinate large spills through the Pennsylvania Incident Response System and promote data-sharing by water utilities on a secure website.

FIGURE 11 Allegheny and Monongahela rivers

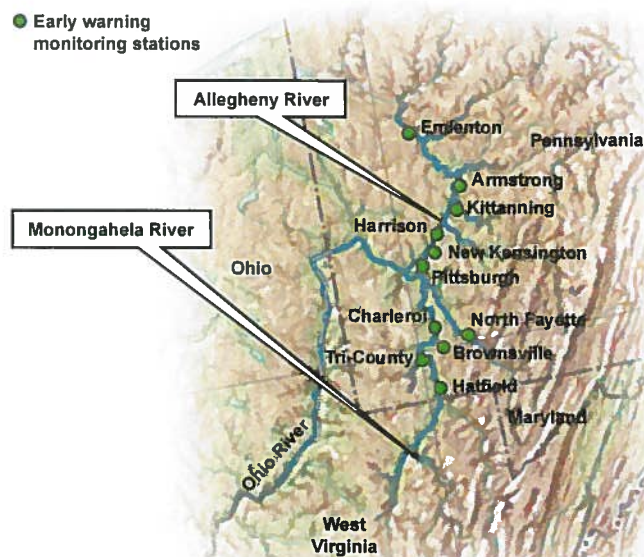
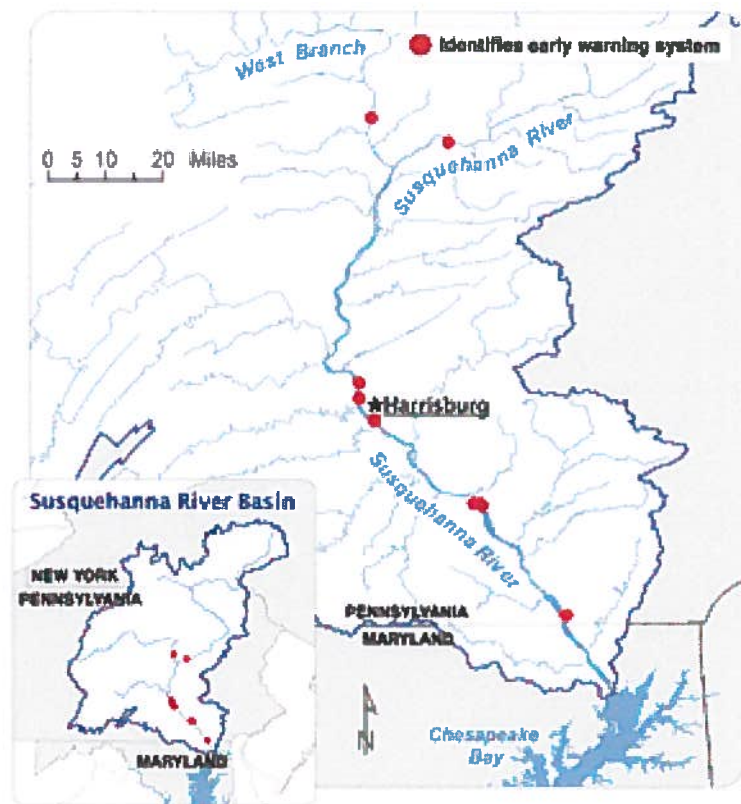


FIGURE 12 Susquehanna River Basin



- Task 4—design the full-scale monitoring system.
- Task 5—begin background work for development of a contaminant transport model.
- Task 6—assist water suppliers in connecting with other monitoring efforts (i.e., state and federal agency monitoring, citizen monitoring).

The initial phase of the project covered July 2002 through June 2003, during which time the framework for each of the six tasks was established. During the first year, three steering committee meetings were held, starting with a kickoff meeting in October 2002. Nine water suppliers have been active in the committee, assisting SRBC with decisions related to database and website design, monitoring data needs, emergency information needs, and contaminant information. Major efforts for the first year focused on establishing a website to

serve as a hub for project communications and developing the monitoring resources needed to promote data exchanges and serve as indicator parameters for possible contamination events.

Communications efforts take off. A secure website was established and became operational in July 2003, allowing water suppliers to exchange water quality information and view emergency response bulletins and summaries distributed by PADEP. In addition, other information from project databases was made available through the website. Information includes stakeholder directories, contaminant inventories, project maps, Internet links to river flows and dam releases, and a time-of-travel calculator.

During the first year, development of the Susquehanna EWS focused on three baseline parameters: temperature, pH, and turbidity.

By purchasing the equipment needed for online monitoring, SRBC increased the capabilities for five systems to provide real-time monitoring data for all three parameters. In addition, SRBC purchased a total organic carbon analyzer for another system that had existing online monitoring capabilities for the three base parameters. Beginning in July 2003, water suppliers started posting daily values to the website for temperature, pH, and turbidity. As of April 2004, three systems were posting data to the website at 4- to 6-hour intervals, and two more systems were expected to begin similar data posting soon.

Future plans focus on funding, system enhancement. In terms of future plans, SRBC will seek more stable funding for the operation and maintenance of the EWS and also investigate the potential for system enhancements and expansion. SRBC will be completing a study with USGS in December 2004 to characterize water quality and water velocity distributions across several transects of the Lower Susquehanna River. Because of the channel width and the presence of numerous islands and dams, the complex nature of the river presents challenges to establishing any sort of contaminant-tracking model. Study results should guide future model development efforts, as well as monitoring network enhancements.

LESSONS LEARNED OFFER ROAD MAP TO FUTURE EWS DEVELOPMENT

The development of regional EWSs in the United States has provided several lessons that can be applied to the successful establishment of similar systems on other rivers. These lessons center on securing strong water supplier involvement from an early stage, overcoming institutional constraints, obtaining initial funding for leading the project, and dealing with the sometimes very slow pace of a project of this magnitude.

Motivation for system development should not be driven by crisis. A specific chemical spill or release has been the initial impetus for development of several EWSs throughout the world. However, prudent utilities will not wait for an incident to occur on other rivers to provide incentive but instead will establish a system before occurrence of a large-scale contamination incident.

Stakeholder involvement can be the deciding factor in whether an EWS succeeds or fails. Cooperation between the affected water users, appropriate agencies, governments, and other stakeholders is critical to the development and operation of a successful regional EWS. In many instances, a variety of political jurisdictions may be involved, and EWS project leaders would do well to include input from these sectors.

Water supplier support is key. The most important collaboration within a regional EWS is that of the water providers themselves. Experience has shown that water utilities are the driving force and backbone for development of almost all regional EWSs, and their support and involvement are essential to EWS formation and operation. Without utility participation and endorsement, the project will likely not gain the necessary support from the applicable environmental agencies.

Limitations of water supplier resources must be recognized and reckoned with. Even if participating water providers offer strong conceptual support, their limitations of available time and money may prove an obstacle, and some suppliers may find it difficult to initially participate to the degree that they would prefer. The daily responsibilities of providing an adequate and safe drinking water supply for their communities keep many utilities (especially the smaller ones) fully occupied. Because of this, utility involvement in a long-term project such as a regional EWS may be sporadic. The successful EWS recognizes these limitations and makes the most of those resources that are available.

Individual leadership and institutional capacity must be developed.

Someone must take the initial action to organize stakeholders and start the planning process. An organization must be identified to coordinate and manage the overall system (it often helps to have a single organization serve as the overall system coordinator). Funding must be obtained and data-management and communications systems developed. The primary obstacle to successful development of regional EWSs are often these and other institutional considerations, as opposed to the technological limitations presented by the monitoring methods currently available. Strong stakeholder support, particularly from water suppliers and other water users, can help overcome these obstacles.

Funding helps ensure project stability. Adequate resources must be available in the early stages of the process to lead and perform the initial project work. Continued progress will depend on outside funding, and as many potential sources as possible should be considered. Involvement of key environmental agencies can help identify funding sources and secure funding for continued operations.

Phased approach allows time for project to evolve. A phased approach to launching a regional EWS helps ensure that planners and users are not overwhelmed by the potential complexity of the proposed system. Instead of trying to gather support for a complete advanced system, project leaders may want to start small to showcase EWS uses and benefits. The system can then be expanded and fine-tuned over time as conditions dictate.

Salesmanship emphasizes obvious and not-so-obvious benefits of EWS. Much of the early work in developing a regional EWS involves convincing various stakeholders that the system is needed and will provide substantial benefit in comparison with expected costs. It helps to clearly define the program and its uses so that beneficiaries understand what

they'll be getting and what they will need to do to participate in and benefit from the system. It can also help to emphasize less apparent advantages such as the coordinated communication and notification aspects of an EWS program.

Project team characteristics ultimately shape project outcome. If a regional EWS undertaking is to be successful, the core team leading the project must encompass certain characteristics. The numerous stakeholders participating in such a process (especially the many regulatory agencies and water suppliers) and the extensive institutional considerations involved may present challenges in resolving various views, priorities, and expectations. At times, the process of developing an EWS can be quite slow. Members of the project team must exhibit and maintain a high degree of motivation, determination, enthusiasm, patience, and perseverance. With these traits, the team can help prevent the project from coming to a standstill and lead it on a continuing course toward success.

WHAT DOES THE FUTURE HOLD FOR EARLY WARNING MONITORING?

The implementation of EWSs and regional EWSs within the United States is growing, and surveys by the AWWA Research Foundation indicate that most surface water users want these capabilities. It is anticipated that in the coming years, most major US river systems used as supplies for drinking water may develop these systems.

In the future, EWSs will likely become another part of routine activities for water systems in their multiple barrier approach. These systems will use extensively integrated information-management, data-management, and communication technologies that provide reliable and real-time information to all users as new technologies become available. The next generation of EWSs could include satellite communication, real-time monitoring technologies for

pathogens as well as chemical and biowarfare agents, neural networks for predicting events based on current conditions, and web-based applications—all integrated with next-generation personal communication devices such as cell phones and personal digital assistants.

Stakeholder challenges to regional EWSs may significantly decrease as more systems are developed and demonstrate a degree of reliability, trust, cooperation, and value. Ultimately, regional EWSs that were developed individually could be tied together. For example, the systems for the Ohio River, Allegheny and Monongahela rivers, Lower Mississippi River, Upper Mississippi River, Delaware and Schuylkill rivers, and Susquehanna River could potentially be linked to create a “super-regional” EWS. This would enable individual regional systems to share relevant information, take advantage of administrative economies of scale, and work together to secure funding.

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FOOTNOTES

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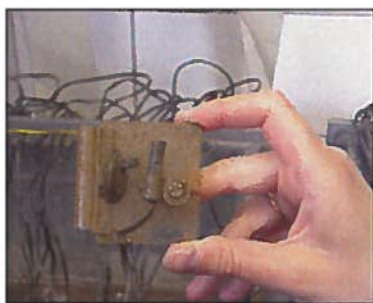
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DESIGN OF Early Warning Monitoring Systems FOR SOURCE WATERS

WITH EARLY WARNING MONITORING
SYSTEMS, WATER PROVIDERS
CAN RESPOND MORE QUICKLY
AND EFFECTIVELY
TO CONTAMINATION
OF WATER SUPPLIES.



This monitor uses a reed switch to detect whether the mussel's shell is open or closed. The mussels close their shells when sensitized by a toxicant.

Most raw drinking water sources are susceptible to a variety of disruptions in water quality as a result of accidental, intentional, or natural contamination. Rapid response to spills and other sudden pollution events is necessary to determine appropriate changes in drinking water treatment and operations in order to protect water consumers from potentially harmful contaminants, avoid treatment process upsets, and ensure compliance with environmental regulations. Early warning monitoring systems provide timely information on changes in source water quality so that knowledgeable response decisions can be made. Early warning systems can be a cost-effective mechanism for reducing risks, help boost public confidence in the water utility, and serve to encourage good practice and careful reporting on the part of dischargers.

Although the US Environmental Protection Agency (USEPA) does not mandate monitoring of raw water by water utilities, many utilities do so to some degree in order to (1) detect the existence of contaminants, (2) ascertain that existing treatment is adequate (and if not, to provide information that will help identify an appropriate improvement), and (3) provide real-time treatment process control. The monitoring data, however, are often limited regarding the number of parameters measured and the frequency of monitoring and may not be conducive to detecting spills and other sudden changes in water quality.

A 1999 survey of 153 water providers in the United States, Canada, and the United Kingdom found that a majority of utilities had experienced a significant source water contamination event in the past five years, adequate warning is not always available, the most serious perceived threats for the future are transportation accidents, and source water contamination is a significant issue that should be addressed through improved early warning systems (Grayman et al, 2001). The threats most commonly cited by drinking water utilities with intakes on rivers included spills of oil, petroleum, and chemical products from transportation accidents and pipeline and storage tank releases; insecticides and herbicides from agricultural runoff; and pathogens from untreated sewage discharges.

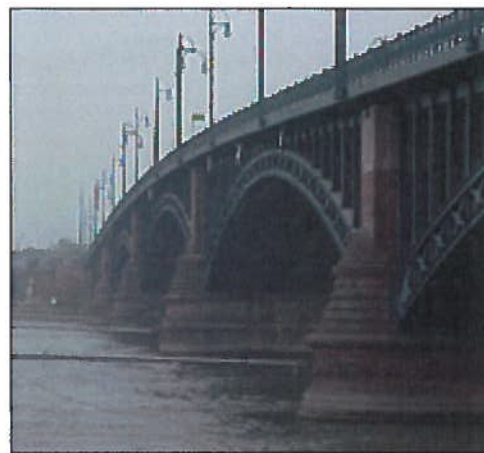
This article summarizes key results from two cooperative research projects (Grayman et al, 2001; Gullick, 2001). To examine the state of the art in

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early warning systems, these researchers surveyed utility practices and perceived needs for early warning and source water monitoring, performed a literature review of available monitoring methods, studied early warning systems around the world, examined case studies of monitoring practices at US utilities, developed a risk-based computer model for design and analysis of early warning systems, created a generic riverine contaminant transport model, and initiated development of an early warning monitoring network on the Upper Mississippi River. Though the principles of early warning monitoring apply to water quality changes from any source, this work focuses on source waters and does not directly address treated water in the distribution system or threats to the water supply infrastructure.

SYSTEM COMPONENTS AND CHARACTERISTICS DEFINED

Early warning systems include a combination of continuous or frequent monitoring, other detection mechanisms, institutional arrangements, analysis tools, and response mechanisms. They can be used to detect rapid deterioration in water quality resulting from accidental or intentional discharges of toxic and hazardous mate-



Multiple sampling ports on Germany's Rhine River are used to monitor water quality. The center two intakes monitor the general river water. The one close to shore represents and monitors the effluent of a large industrial complex located upstream on the same side of the river. The fourth intake is near the far shore to sample water that is primarily from an upstream tributary on that side of the river.

rials near an intake (e.g., low probability/high impact events such as large-scale boat spills, pipeline breaks, industrial accidents, terrorist attacks). They are also useful for monitoring during extreme natural events (e.g., heavy rains and flooding, algal blooms) and somewhat predictable events (e.g., seasonal runoff of herbicides). Early warning systems are used mostly on riverine systems where water quality can change rapidly (see example scenario in Figure 1), less frequently for impoundments, and rarely for groundwaters.

An ideal warning system features key components. The scope of an early warning monitoring program will depend on site-specific characteristics. Systems vary from a single instrument at an intake to large river systems with networks of sophisticated monitoring stations combined with

coordinated data management and information communication systems. Certain components, however, are generic to all good early warning systems and include the following:

- detection—a monitoring mechanism to detect pollution events and/or a public or self-reporting program,
- characterization—a means to confirm and more completely characterize the event,
- communication—a way to disseminate data to utility personnel and other decision-makers as well as to inform the public of response actions, and
- response—actions that minimize the potential effect of the contamination event.

An ideal early warning monitor would cover all threats, monitor continuously, provide warning in suffi-

FIGURE 1 Schematic example of an early warning system

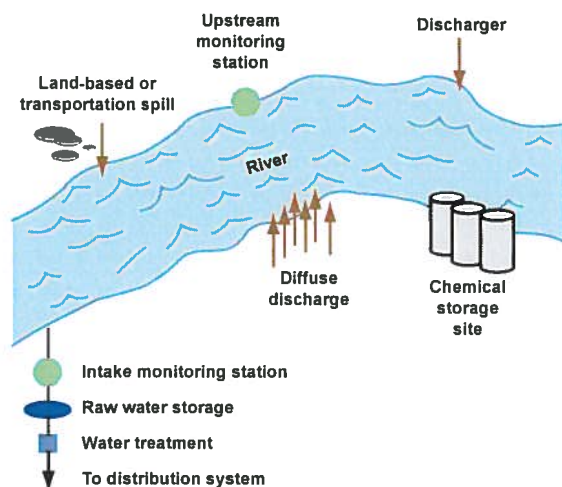
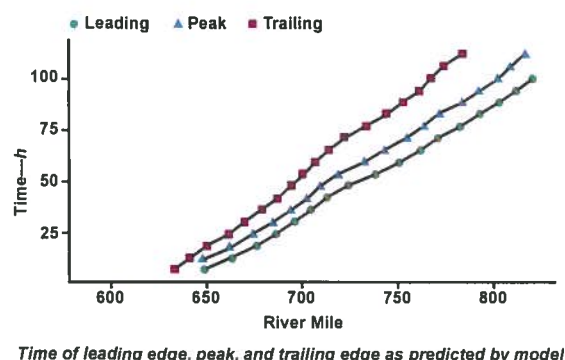


FIGURE 2 Example of riverine contaminant transport model output



Design Process and Components for Early Warning Monitoring Systems

- **Analysis of the need for early warning monitoring**
 - Preliminary vulnerability and susceptibility analysis
 - Review of available monitoring programs and data
- **Determination of program scope**
 - Selection of parameters to be monitored, monitoring methods, number and location of monitoring stations, and frequency of monitoring
 - Data management and interpretation
 - Cost-benefit analysis
- **Development of system organization and function**
 - Physical features
 - Administrative components
 - Response and communication plans
 - Funding
- **Implementation**
 - Monitoring program
 - Identification of response thresholds
 - Event confirmation procedures
 - Characterization of contamination
 - Data management, interpretation, and dissemination
 - Water quality modeling
 - Communication systems and plans
 - Response plans
- **System review and improvement**

cient time for action, give minimal false-positive or false-negative responses (such that the frequency of alarms is neither too high nor too low), be able to identify the source of contamination, be sensitive to water quality changes at regulatory levels, be reproducible and verifiable, require low skill level and training, allow remote operation, be affordable and robust, and function year-round (ILSI, 1999). Naturally, analysis of the system benefits, costs, and available resources may reduce the number of these characteristics that are applicable to specific situations, but the list provides guidance for development of such systems.

Monitoring techniques range from relatively simple online measurements of such parameters as pH and turbidity to video surveillance to advanced analytical instrumentation to the use of living organisms as bioalarms. Some methods (e.g., general water quality indicators such as bioalarms and dissolved oxygen [DO]) measure effects in the water, thus indicating that "something is not normal" but not necessarily what it is. Early warning monitors sometimes have less-sensitive detection levels than those of conventional monitoring, are often more qualitative and not compound-specific, and because they are concerned with identifying large changes in concentrations generally need less quality assurance/qual-

ity control (QA/ QC) than conventional or compliance monitoring.

DESIGN SHOULD BE INCORPORATED INTO OVERALL SYSTEM

Early warning systems should be viewed, designed, and operated as an integral part of the operation of the overall water supply system (including source water quality protection programs and monitors, as well as intake, storage, treatment, and distribution system characteristics) in order to minimize the risks associated with degraded drinking water quality under various cost and technology constraints. The key components and steps in development of an early warning monitoring system are summarized in the sidebar on this page.

The type and scope of the system to be developed should be guided primarily by the relative potential risks (source water vulnerability/susceptibility assessment), cost-benefit analysis, availability of resources and technical capabilities, and current treatment capabilities. In some water supplies, continuous monitoring of a select few parameters at, or just upstream of, the intake may be sufficient. In other cases, particularly on busy commercial rivers with numerous intakes and potential contamination sources, a more extensive and coordinated network may be appro-

priate. Some water utilities use early warning systems to assess the quality of multiple source waters in order to be able to continuously use the highest quality source of those available. Reducing the time between occurrence of an event and implementation of response actions is critical and is accomplished through selection of appropriate detection methods; prompt data review, confirmation, and event characterization; efficient communication infrastructure; and rapid relaying of information to decision-makers. The design of early warning monitoring systems has been discussed in the literature (Grayman et al, 2001; Gullick, 2001; Foran & Brosnan, 2000; ILSI, 1999). Sanders and colleagues (1983) examined the process for water quality monitoring system design, including statistical analyses for optimizing monitoring locations and frequency.

Vulnerability assessments help identify needs. The types of land and water uses and activities (e.g., industries, agriculture, transportation, and other commercial enterprises) located near a water source can be used to identify potential contamination scenarios, rank their relative potential occurrence and effect, and prioritize a list of pollutants of concern to be considered for monitoring. The vulnerability assessment can be used to determine not only the requirements

and scope of an early warning monitoring system but also the potential need for alternate raw water sources, treatment process alternatives, increased raw water or finished water storage capacity, and other system characteristics. Vulnerability assessments are already being performed for all US public water supply systems as part of the Source Water Assessment Programs (SWAPs) required of each state by the 1996 Safe Drinking Water Act (P.L. 104-182) (see www.epa.gov/safewater/protect.html). The SWAP requirements are separate and different from the security vulnerability assessments required of many water utilities by the US Bioterrorism Act of 2002 (P.L. 107-188) (see www.epa.gov/safewater/security/security_act.pdf).

Detection mechanisms determined by site and system characteristics. The decision of what parameters to monitor should be made on a site-specific basis and take into account both watershed and water supply system characteristics. The vulnerability assessment can provide a prioritized optimal list of parameters, which is then evaluated given practical, technical (including adequacy of available monitoring methods), resource, and budgetary constraints. A review of other existing monitoring programs for the source water (e.g., by state or federal agencies, industries, and other water suppliers) should be performed to capitalize on any potential synergies.

Range of monitoring methods are available. The primary mechanisms for detecting spills and other events include water quality monitors, self-reporting by the dischargers themselves, and sighting and reporting by the observing public or by public or private agencies and organizations. The most effective early warning systems combine all three means of detecting contamination events.

Because rapid, responsible self-reporting of spill events provides the most dependable detection method, regulations and protocols should be established and enforced to strongly encourage such actions. However,

the existence of and compliance with such laws vary significantly around the world. Reporting by spill-response personnel and other governmental agencies and organizations is the most common means by which many US utilities learn of source water contamination events. Public reporting is most effective with larger contamination events that have observable results (e.g., fish kills, oil sheens, odor) and events in more heavily populated areas. The effectiveness of this method depends on a population that has been sensitized to reporting such events. In Japan, for example, public reporting is the most common early warning method.

Some utilities use daily or more frequent visual inspection of source waters to monitor for gross visible pollutants such as oil sheens and algal blooms. Video cameras are sometimes used to aid in visually monitoring intake water and also to monitor upstream areas where large-scale accidents could occur (e.g., bridge abutments, highway or railway overpasses). Images can be sent directly to the treatment plant control room, and computerized image analysis technologies can be used to detect certain changes in the video images and then issue an alarm when something changes in the picture. Use of video cameras at night can be problematic, of course, and lights may be necessary to provide better 24-hour visual monitoring.

Water quality monitors include physical, chemical, radioactive, and microbiological analyses that can identify and quantify either a specific water quality parameter or a surrogate parameter selected to provide a conservative indication of the presence of a more harmful but more difficult to analyze contaminant. When surrogates are used, an adequate site-specific correlation should be established with the parameter of primary concern. In addition, biomonitoring techniques that use living organisms can be helpful in detecting general changes in water quality and toxicity. Available monitoring technologies are discussed later.



The "smell bell" test is being performed here on a sample from the River Trent in the United Kingdom. The smell bell test is an inexpensive method of physical analysis but requires trained personnel with good noses and usually is not performed more than once per shift or once per day.

Several factors influence location of monitoring stations. Monitoring systems should be installed far enough upstream from the point of water abstraction to allow for timely warning. On the other hand, monitoring stations located too far upstream will not provide coverage for pollution sources entering between the station and the intake. These somewhat conflicting considerations must be balanced with the available resources when water providers are determining the number and location of monitoring stations. If multiple water utilities use the same source (e.g., a river), they can take advantage of opportunities for cooperation and pooling of resources in terms of multiple monitoring locations.

Potential factors to consider in the selection of monitoring locations include the following:

- the location of potential contaminant sources,
- the river's flow rate (i.e., time of travel from major potential contamination sources to the intakes)
- the magnitude of mixing and dilution attributable to currents and hydrodynamic dispersion,
- consideration of all three spatial dimensions (e.g., how far upstream, where across the river, and how deep),

- the type of contaminants (e.g., contaminants such as floating oils may determine monitor depth),

- the monitoring instruments' response time and frequency of analysis and data review,

- the nature of the treatment process (i.e., what can the processes handle, how much time is needed to make any potential adjustments),

- precautions to protect the instrumentation from the elements,

- security to prevent vandalism,

- access to electricity,

- means of telemetry (e.g., cellular telephone or radio versus need to acquire access to telephone lines), and

- access for monitor maintenance and upkeep.

Attention must also be given to the potential for mixing (or lack thereof) of contaminants both laterally and vertically in a river. Field tracer dye studies can be used to help elucidate river-mixing patterns between potential outfalls and water supply intake(s). With a small or well-mixed system, a single monitor near the river's center or bank may be sufficient. In other instances, multiple intakes may be necessary to adequately characterize water quality across the river.

System efficacy depends on frequency of monitoring. The effectiveness of an early warning system improves as the monitoring frequency increases, and monitoring continuously via real-time online monitors is usually preferred. Longer times between samples can not only result in some short-duration events being missed but also delay the detection of the contamination event and the resulting mitigating actions. More-frequent analysis is suggested for monitors at intakes (given the lack of time between detection and entering the intake) as well as for faster

ivers and rivers with lower dispersion. For upstream monitoring stations, the analysis frequency should take into consideration the contaminant travel time from the monitoring location to the intake.

System only as reliable as its data. With any monitoring system, appropriate QA/QC measures are necessary to ensure reliability of the analytical data generated and foster confidence in the appropriateness of potential responses. Because early warning monitors are concerned with identifying substantial changes in concentrations, however, they generally require less QA/QC than conventional or compliance monitoring, and precision and consistency are more important than accuracy.

Modern technology simplifies data transmission. Data from automated onsite or remote monitoring stations are usually easily transmitted for immediate use via modern electronic information transmission (telemetry) technologies such as telephone (wire and cellular), radio waves, and satellite-based communications systems. Telemetry devices are discussed in the AWWA manual for instrumentation and control (AWWA, 2001).

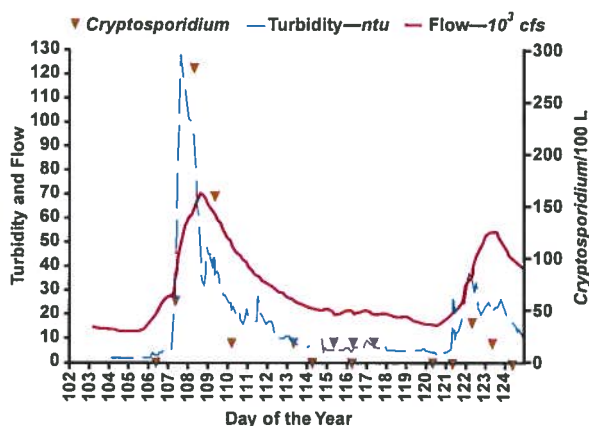
Risk-based models facilitate system design and analysis. Spill events are highly probabilistic occurrences, but major spills are relatively rare.

Minor spills are much more common yet generally have little effect. The recommended approach to designing and evaluating early warning monitoring is a systematic method that considers the highly variable, probabilistic nature of many aspects of the system. These aspects include the probability of spills, the behavior of monitoring equipment, variable hydrology, and the probability of obtaining information about spills independent of analytical monitoring.

Spill Risk, a risk-based model using Monte Carlo (probabilistic) simulation techniques, was developed to aid in the design and analysis of early warning monitoring systems (Grayman & Males, 2002; Grayman et al, 2001). This tool uses a one-dimensional advection-dispersion contaminant transport model for a single reach of river (no tributaries). Probabilities are assigned to different types of fixed and mobile spills and discharges. Numerous simulations are run with varying inputs, and the results are used to assess the impact reduction for a single water intake (in population exposure above preset limits) provided by a variety of alternative early warning system configurations. Specifically, the model can help to determine the optimum type, number, and location of monitors; the optimum frequency of analysis; and various response scenarios.

Response thresholds determined by variety of factors. Every early warning monitoring system should include predetermined response thresholds (i.e., an increase in response above normal fluctuations from baseline levels) that warrant identification as a contamination event and trigger additional action such as confirmation procedures, additional investigation and characterization of the event, and assorted

FIGURE 3 Variation in turbidity, river flow, and *Cryptosporidium* concentrations during spring sampling in the Delaware River



Source: LeChevallier et al, 1998

prospective response actions. Selection of response thresholds should take into consideration such factors as

- historical patterns of water quality;
- the actual or perceived threat from various levels of contamination or events;
- the toxicity of the chemical or pathogen being monitored, with consideration given to regulatory limits and advisories;

- the nature and size of the population exposed;
- the ability of the treatment processes to remove the contaminant;
- the sensitivity and specificity of the monitoring method;
- the potential for false-positive or false-negative monitoring results; and
- the type and severity of action that might be taken if the trigger level is exceeded.

Response thresholds should be set at a reasonable level such that they don't occur either too frequently (too many alarms can be problematic) or too rarely (i.e., serious events are missed). A contaminant that could have severe public health effects would warrant a more stringent action trigger level than would a less harmful contaminant. Federal or state standards may be used as a guide, although in some cases, a lower value may be desirable; if existing treatment processes are efficient for that contaminant, then perhaps a concentration somewhat higher may be acceptable.

Protocol needed to confirm initial monitoring results. Initial detection results should be confirmed because false-positives may be associated with monitoring instrumentation or incorrect public reports. The confirmation process may include thoroughly checking the result's QA/QC, resampling and repeating the analysis, and performing more-accurate or more-specific alternative methods of analy-

sis. Optimally, this step would not necessarily preclude or delay a necessary response action; any such delay should consider the immediacy of the situation, the potential magnitude of the event and corresponding possible effects (or perceived effects) on public health or the treatment systems, and the risks the water supplier is willing to take (if any), as well as other site-specific circumstances. If intakes can be closed with no substantial adverse ramifications, then it would be prudent to do so during the wait for event confirmation. To aid in confirmation, some advanced monitoring stations automatically take samples at fixed intervals and store these samples for a fixed period (e.g., 24 h); other stations are designed to take samples automatically when a monitor detects an unusual event. In either case, these samples can then be analyzed using standard tests to confirm and characterize the nature of the contaminant.

Characterization of contamination guides response. Characterization of a contamination event is imperative in order for the utility to predict with reasonable accuracy the event's effects on intake water quality over time. Contamination characterization is a six-step process:

- Step 1: Determine the specific contaminant(s) involved.
- Step 2: Identify the likely source of the contaminant (if unknown).

- Step 3: Determine the spatial and temporal variation in concentration in the source water.

- Step 4: Assess the dynamic behavior of the contaminant in the water body (mixing and decay behavior).

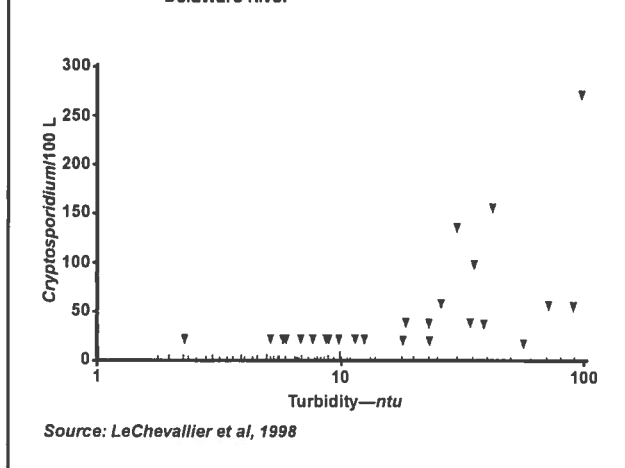
- Step 5: Predict the movement of the contaminant within the water body in order to predict both the time that the leading and trailing edges reach water intakes and the likely concentration.

- Step 6: Determine the effects on the waterway itself (e.g., fish kills).

Characterization of the contamination event is generally accomplished through sample collection, field and laboratory monitoring, instream tracking of the event, and use of mathematical models to predict the movement of the contaminants in the water body. Depending on the extent and severity of the event, the amount of field work and monitoring can vary significantly.

Predictions of the concentration-time-distance profile of a contaminant event can be developed to warn water users in advance of the time period when the contaminant will be at their intakes and what concentrations they will be subject to. Mathematical hydrodynamic contaminant transport models that are properly developed, calibrated, and operated can provide reasonable predictions in many cases. These models include a hydrological component that predicts contaminant transport via water flow and dispersion; often various contaminant fate processes are included as well. Models intended for use in rapid-response scenarios should be easy and quick to use, generate predictions with reasonable accuracy, and provide output that is easily interpreted. In addition to testing the model on a routine basis, water providers should establish protocols, train personnel, and set up a

FIGURE 4 Correlation of turbidity and *Cryptosporidium* in the Delaware River



General Research and Development Needs for Early Warning Monitoring Systems

- Development of a continuous monitor capable of detecting low levels of dissolved oil and petroleum products without significant limitations from chemical and physical interferences
- Continued development of rapid and automated sensors for established and emerging pathogens and biowarfare agents
- Development of sensors for simultaneous identification of multiple pathogens (combined biosensors)
- Improvements in sensor sensitivity
- Continuous, online, and remote-sensing monitors for a greater number of chemical parameters
- Improvements in electronic nose technology, especially for detecting odors in surface waters in which the complex chemical composition can create a combination of smells that make it difficult to monitor electronically
- Improvement of biological monitors through better means of sensing behavioral changes in response to sudden exposure to toxins
- Greatly improved technology exchange between the water supply industry and the many different industries developing innovative sensor technologies

fast mechanism for acquiring flow and velocity information. Current flow data for many rivers may be obtained electronically from US Geological Survey or US Army Corps of Engineers gauging stations; alternatively a flow gauge can be installed at the monitoring station.

Water quality models should be used as a guide to what may happen and are intended to supplement (but not replace) collection of actual real-time data as a source of information. Grayman and co-workers (2001) reviewed available models of varying complexity and also developed a one-dimensional Riverine Spill Modeling System that can be easily adapted for use for a wide range of rivers. An example output from such a model (Figure 2) identifies the expected time at which a spill will reach downstream locations.

Response actions and plans must be prepared ahead of time. Often, initial information about the nature and extent of a contamination event is

limited. A water utility must first determine whether to act immediately or delay action pending confirmation and additional information. When the warning has been triggered by monitoring at the intake, then the need for near instantaneous decision-making is more acute. Appropriate water supplier responses to changes in source water quality depend on the type and potential extent of contamination, efficacy of existing and available treatment processes, and projected risks to public health or treatment process efficiency. General guidance and operating policies for response activities for a range of possible contamination events should be operative before an event occurs. Policies may include taking immediate action, waiting until the contaminant event has been confirmed and the nature (extent, location, arrival time, etc.) of the event determined, or opting for a more complex action plan determined by the type and location of the warning.

Responses to mitigate the effects of a spill event can include (1) closure of water intakes and use of alternate sources or storage, (2) cleanup of the spill before it can affect water intakes, (3) adjustment of existing treatment processes or use of additional ones, and (4) public notification (e.g., boil-water notices). Closure of water intakes provides the most absolute barrier; for optimum effectiveness, this action should be guided by information from the early warning system to coincide with the period of highest concentrations. If the water intake can be closed for only a limited time period (e.g., a few hours), then this places a premium on accurate predictions of concentration. The availability of raw and finished water storage capacity can help facilitate intake closure. In some cases, the intake location can be switched to draw water from different depths or lateral positions within the same source. Bank filtration and ground-water injection-recovery systems provide for additional treatment and place an additional time lag between the surface water source and the treatment plant.

Communication systems and plans are key to the efficacy of early warning monitoring. The effectiveness of an early warning system relies on accurate and timely information being communicated to those responsible for making response action decisions. The emergency response plan should include detailed instructions for communication between appropriate parties, with decision-makers, and to other stakeholders and the public, as necessary. Means of communication to the various parties can include face-to-face meetings, telephone, facsimiles, e-mail, websites, electronic bulletin boards, the media, and other methods.

Cooperative networks make the most of resources. Although onsite early warning monitoring may be conducted by a single water supplier, source waters used by multiple water utilities (e.g., a large river) offer opportunities for cooperation and pooling of resources for development

TABLE 1 Select approaches for detecting chemical and radioactive threats to drinking water*

Threats	Approach†								
	High End			Middle			Low End		
	\$100,000s	Pros	Cons	\$10,000s	Pros	Cons	\$1,000s	Pros	Cons
Ions (salts)				IC	Fast, broad, sensitive		Ion probe	Sensitive	Selective
Metals	ICP-MS	Fast, broad ID, sensitive	Staff, lab	AAS Polarography	Fast, sensitive Fast, fairly selective	Staff, lab Selective	Ion probe	Sensitive	Selective
Polar organics	LC-MS	Broad ID	Staff, lab	LC TOC	Broad ID Broad ID	Staff, lab Lack of sensitivity	UV		Lack of sensitivity
Nonpolar organics	GC-MS	Broad ID	Staff, lab	LC	Broad ID	Staff, lab			
Volatiles, oil, hydrocarbons	GC-MS	Broad ID	Staff, lab	P&T-GC GC Fluorescence (oil, HC)	Broad ID Broad ID Broad ID	Staff, lab Staff, lab Interferences	Smell bell	Fast	Human testers
Specific compounds	GC-MS, LC-MS	Broad ID	Staff, lab				Immunoassay (pesticides)	Fast, specific	Staff
Biotoxics				Biomonitorst‡	Continuous, fast	Lack of specific ID			
Radiation				Tritium Gamma detector Beta or alpha detector	Fast, specific Fast, broad ID, available online Fast	Not available online Lack of specific ID Lack of specific ID, lab, evaporation step, not available online			

*Modified from ILSI (1999)

†AAS—atomic absorption spectrometry (furnace or flame), Broad ID—can monitor for many compounds simultaneously, GC—gas chromatography, HC—hydrocarbons, IC—ion chromatography, ICP-MS—inductively coupled plasma mass spectroscopy, ID—identification, LC—liquid chromatography, MS—mass spectrometry, P&T—purge and trap, Selective—monitors for a single compound, TOC—total organic carbon, UV—ultraviolet

‡Biomonitorst—fish, daphnids, mussels, algal fluorescence, and luminescent bacteria

of an integrated early warning monitoring network, including multiple monitoring stations, centralized data management and assessment, and coordinated communication systems. Case studies of such networks are reviewed later and have been discussed by other researchers (Grayman et al, 2001; AWWARF & CRS PROAQUA, 2002).

ANALYTICAL METHODS OFFER PROS AND CONS

Although the technology exists to monitor for regulated compounds in drinking water, it is neither technically nor economically feasible to monitor for all chemical and microbiological parameters. Utilities must consider the tradeoffs between costs and the range and type of monitors used. Selection of the specific methods for monitoring the parameters of concern should be based on a vari-

ety of factors, including method-response sensitivity (which should be compared with source water baseline levels), speed, desired frequency of analysis, available means of data development and retrieval, labor and maintenance requirements, initial and ongoing operating costs, and space availability. Potential water quality monitors include physical, chemical, radioactive, and microbiological analyses, as well as bioalarm systems that use living organisms to act as sensors for extreme changes in water quality. Many researchers have examined rapid or online monitoring techniques for the water industry (AWWARF & CRS PROAQUA, 2002; Frey et al, 2001; Grayman et al, 2001; Gullick, 2001; Dippenaar et al, 2000; Pollack et al, 1999; Reinhard & Debreau, 1999). The following sections offer a brief overview of select methods for early warning.

Some of the more common physical and chemical monitoring methods used in early warning systems include simple probes measuring various parameters (e.g., turbidity, pH, temperature, conductivity, DO, chlorophyll), relatively simple batch tests (e.g., immunoassays for herbicides), and more advanced monitoring for chemicals (e.g., fluorescence for oils and chromatography for oil and petroleum constituents, volatile organic chemicals, and phenols). Some of the primary surrogates used include turbidity, DO, odor, conductivity, and general measures of organic carbon content (e.g., oxidant demand, total organic carbon). However, some of the parameters that are easily and inexpensively monitored via online probes (e.g., temperature, conductivity, pH) provide little information on detecting many spill events (e.g., oil spills). Although the more

FIGURE 5 Schematic of a commercial flow-through fish biomonitor tank

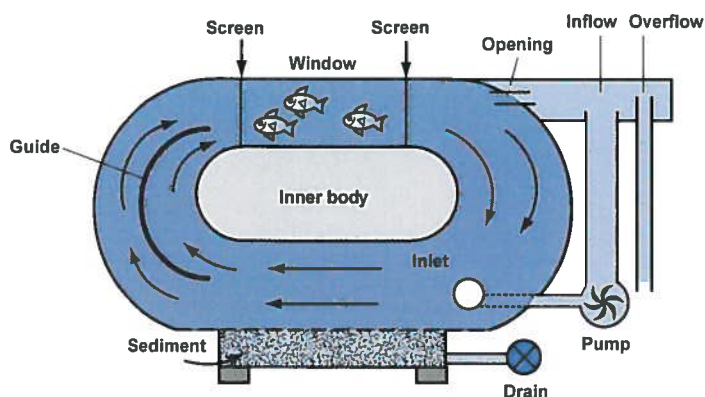
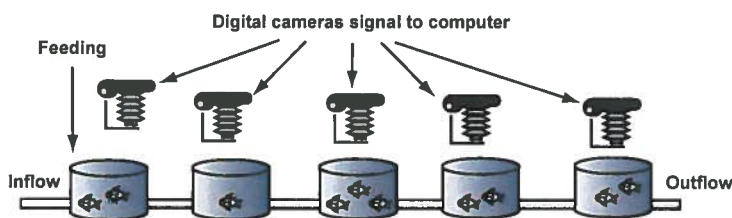


FIGURE 6 Schematic of fish-avoidance monitoring system in Osaka, Japan



advanced monitors are more expensive and require more maintenance and expertise, they are better at detecting many spill events.

Physical analyses offer speed, up-to-date information. Most physical monitoring methods are relatively rapid for most parameters (e.g., turbidity, conductivity, temperature, odor), and many can generate continuous real-time online data. Continuous online turbidity measurements are regularly used in treatment process-control application, and more expensive online particle counters are sometimes also used. Large increases in turbidity are frequently correlated with adverse changes in microbial water quality because both turbidity and microbial concentrations often increase substantially in surface waters during and after storm events because of surface runoff. Figure 3 shows an example of the correlation among increased river flow from storm events, turbidity, and the presence of the protozoan parasite *Cryptosporidium* (LeChevallier et al, 1998). High *Cryptosporidium* load-

ings at this location can typically be avoided by shutting an intake and using water from onsite storage when turbidity rises above a certain level (e.g., >15 ntu in Figure 4).

The presence of unusual odors can be a useful indicator for certain contamination events, including those resulting from algal by-products such as geosmin and methylisoborneol, phenols, petroleum products, and assorted volatile organics. One means for detecting odors is the "smell bell." Because it requires trained personnel with good noses, the smell bell test is not usually performed more than once per shift or once per day, thus limiting its use in early warning systems. Recent research suggests that it may soon be feasible to use electronic odor-sensing technologies ("electronic noses") that can operate continuously with less bias and greater repeatability and precision (Grayman et al, 2001).

Chemical analyses come in many forms, range of costs. Many standard chemical analyses can be used for early warning monitoring, and sev-

eral methods have been adapted for automated online applications and remote data access. Table 1 summarizes the relative costs as well as pros and cons for different early warning monitoring technologies for select chemical constituents.

Online analytical probes. Online analytical probes are relatively inexpensive, are easy to use, can provide continuous or nearly continuous monitoring with remote access to data, and are available from a variety of manufacturers. Ion-selective electrodes can quantify many inorganic ions including pH, elemental anions (e.g., chloride, bromide, fluoride, and iodide), ammonium, nitrite/nitrate, cyanide, certain metals (e.g., lead, cadmium, copper, aluminum, and manganese), and several other inorganic pollutants (Table 2). Probes are also available for turbidity, chlorophyll, and DO. Some manufacturers combine a variety of electrodes into one convenient and efficient multi-parameter instrument. Because probes can foul in many raw water environments, some models use self-cleaning systems to reduce maintenance requirements.

DO. The DO concentration is a major parameter for the survival of aquatic life and for early warning applications is typically measured with a simple online probe. A decrease in DO can indicate the presence of organic compounds from sewage or surface water runoff. In addition, diurnal fluctuations in DO can be indicative of the presence of algae; for this reason, DO is sometimes used in conjunction with chlorophyll and turbidity measurements to monitor for algal blooms.

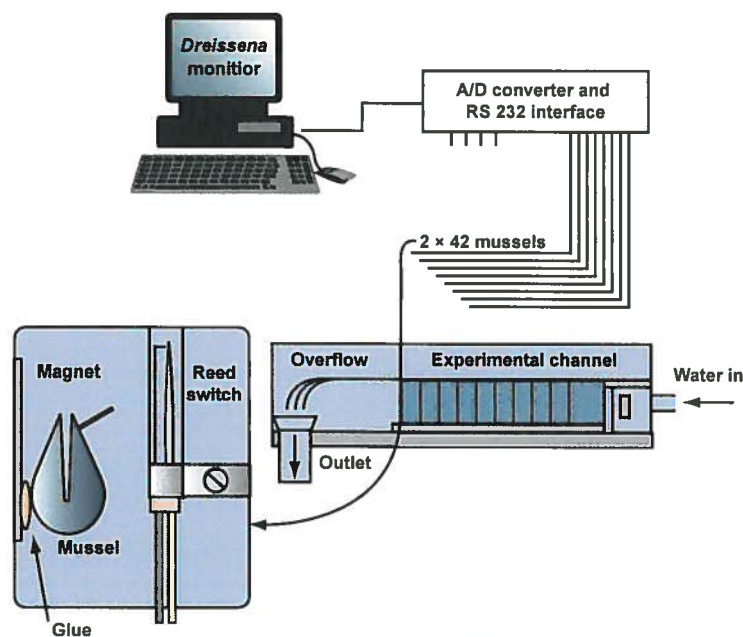
Nitrate and ammonia. Nitrate and ammonia/ammonium may be measured with a specific ion electrode; more sensitive but more expensive instruments for online colorimetric and ultraviolet (UV) analyses are also available. Both parameters may be indicative of agricultural pollution (i.e., fertilizers). Ammonia may come from sewage and animal waste discharges.

Metals. Ion-specific electrodes are available for certain metals, including lead, cadmium, copper, aluminum, and manganese. Anodic stripping voltametry-polarography is an excellent alternative for rapid analysis (<1–10 min) of low concentrations (nanogram-per-litre range) of certain metals and is used online at various monitoring stations in Europe. The instruments are priced in the range of \$10,000–\$17,000 and can detect four to six metals simultaneously; however, the method is restricted to amalgam-forming metals (e.g., cadmium, chromium, copper, lead, and zinc) and is subject to matrix interferences. Colorimetric methods are relatively inexpensive, typically apply to a single metal, and are subject to more interferences than more sophisticated methods. Atomic absorption spectrometry and plasma emission spectroscopy instruments are expensive and typically available only in commercial laboratories. One promising new technology, which has been applied to analysis of zinc, mercury, and cadmium, uses fluorescent molecules that react to specific metals in the presence of UV light (Bronson et al, 2001). Other developing methods for a variety of heavy metals include enzyme sensors and biosensors using genetically engineered microorganisms (Rogers & Gerlach, 1999).

General organic chemical parameters. Total organic carbon (TOC) and UV light absorption at 254 nm (UV₂₅₄) are general measures of organic content that can be performed in minutes and online. Though TOC is generally more sensitive and thus used more often for early warning, its natural variability in source waters is often greater than the concentrations of specific organics of concern. Simpler bench-scale test kits for organic carbon are also available.

Oxidant demand and oxidant residual. Oxidant demand can be a general indicator of organic carbon content and ammonia in the source water. Because many utilities practice preoxidation (i.e., addition of chlorine, chlorine dioxide, ozone, or per-

FIGURE 7 Schematic of a *Dreissena* monitor featuring two channels, each with 42 mussels



manganate) and use online monitors to measure downstream oxidant residual, the oxidant demand can be calculated if the oxidant dosage and flow rates are known. Of course, oxidant residual is not applicable to raw waters but can be a useful warning measure of changes in distribution system water quality if residual disinfection is used by the utility.

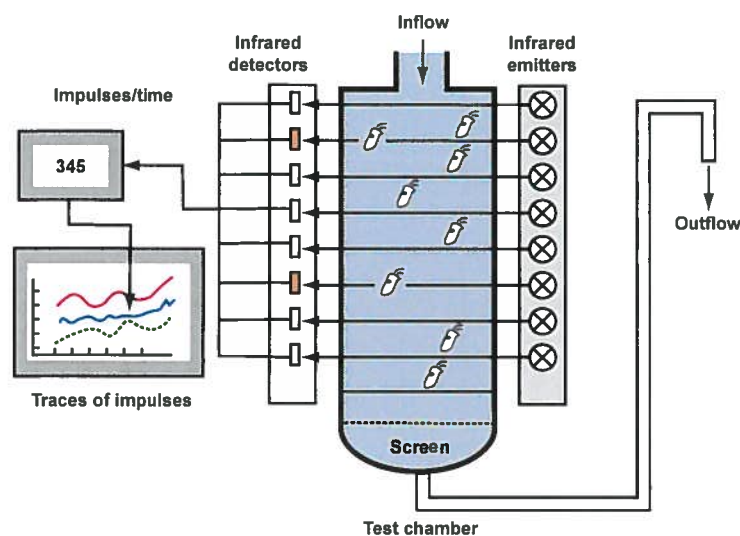
Oil and petroleum. The primary techniques for online oil monitoring use light-scattering for floating oil and fluorescence for dissolved oil although each method has its limitations (He et al, 2001). Common chemical and physical interferences (e.g., particles, detergents, and floating debris) can cause frequent false alarms and make it difficult to track an oil spill during rain events that increase turbidity. Most commercial oil-in-water monitors use light-scattering techniques and thus are primarily useful only for major spills (e.g., for a 0.33 mm [0.013 in.] or greater layer of floating product).

Fluorometry can be used for dissolved gasoline, diesel, jet fuel, and oil components (such as BTEX [benzene, toluene, ethylbenzene, and xylenes]), as well as chlorophyll from

algae. Continuous fluorescence oil detectors cost in the range of \$12,000–\$24,000, are very sensitive (low microgram-per-litre range in fairly clean water), and are used in several monitoring programs worldwide, although turbidity and humic substances can interfere. Although manual solvent extraction methods are labor-intensive, some European monitoring stations use an automated system for extraction and spectrophotometric analysis of total dissolved hydrocarbons (between 0.2 and 10 mg/L). Online monitors for low concentrations of oil need improvement. The introduction of genetically engineered microorganisms as biosensors for BTEX (Rogers & Gerlach, 1999) may prove useful in the future.

Organic chemicals. Manual and online gas chromatographs (GCs) range in cost from \$30,000 to \$50,000 and are used in several early warning systems worldwide to monitor for volatiles or other organic chemicals (including fuel oil components). Only a few stations use liquid chromatography, which costs in the range of \$50,000–\$100,000. Analyses can typically be performed in less than an hour by trained operators.

FIGURE 8 Schematic of original *Daphnia* monitor



Mass spectrometry (MS) is even more expensive and would be used primarily during the event confirmation step to provide accurate identification of organics in select samples. For some chromatography analyses, sample preparation can add significantly to the work required, and the necessary QA/QC can be more time-consuming than that for some of the simpler analyses.

Pesticides. Pesticide (herbicide and insecticide) contamination of surface waters is often seasonal because it primarily results from nonpoint source rainfall runoff from agricultural areas during periods of high pesticide application. The inexpensive batch ELISA (enzyme-linked immunosorbent assay) procedure, which is often used for the herbicide atrazine, takes approximately 40 minutes and compares reasonably well with GC-MS results for concentrations on the order of 3 µg/L, i.e., the level of the USEPA drinking water standard (Lydy et al, 1996).

Radioactivity. Early warning for radioactivity in surface waters may be applicable for facilities downstream from a nuclear power plant or other potential large source of radioactivity. Both gross radioactivity and specific radioactive substances may be measured. Tritium (hydrogen-3) may

be an especially good indicator for nuclear power waste because it behaves as a conservative tracer in water and would reach an intake prior to other radioactive constituents that have larger retardation factors. Monitoring stations on the Rhine River measure for total alpha, total beta, tritium, cesium-137, and strontium-90 activity (Grayman et al, 2001).

Advances make microbiological analyses more feasible for early warning use. Conventional methods of microbial analysis require a relatively long time period (e.g., hours or days) for isolation and reproduction (amplification) of the microbial species, and many tests are specific only to a single species or class of organisms. Because of these limitations, these analyses are not often used for early warning applications. However, significant recent advances in microbial monitoring and related technology offer increased sensitivity, specificity, and more-rapid analysis, including deoxyribonucleic acid (DNA) microchip arrays, rapid DNA probes, immunologic techniques, cytometry, laser scanning, laser fingerprinting, optical technologies, and luminescence (Grayman et al, 2001; Rose & Grimes, 2001; Foran & Brosnan, 2000; Quist, 1999; Rogers & Gerlach, 1999). Most of these

methods are still being developed or were only recently introduced. However, their use is likely to increase in the future. Relatively rapid existing methods for microbes are summarized in *Standard Methods* (1998) and Venter (2000).

Nucleic acid-based systems measure the genome of the organisms, which gives a high degree of specificity, but sample processing typically takes at least 2–4 hours. Several different kits are available for these tests. Rapid DNA probes are species-specific and use a robot-assisted microplate analysis of amplified samples of DNA (Quist, 1999). DNA microchip arrays are a developing technology that can detect and identify multiple microorganisms within 4 hours. Laser-scanning cytometry can be used to rapidly detect any organism for which there is a specific antibody, but the instruments are expensive.

Immunoassays use target-specific fluorescent antibodies that bind with an antigen of the target species, and test kits for a variety of pathogens are available that are relatively rapid, inexpensive, sensitive and simple to use (www.aoac.org/testkits/microbiologykits.htm).

Commercial methods^{1–3} for measuring bacterial counts within 8–24 hours are readily available. Thanks to recent advances, the potential analysis time for bacteria (e.g., total coliforms, *E. coli*, or heterotrophic plate counts [HPC]) has been reduced to 4–8 hours or less. For example, a new modification of method 9211C.1 (*Standard Methods*, 1998) using adenosine triphosphate bioluminescence allows quantification of HPC within minutes (Lee & Deininger, 1999).

The conventional tests for protozoan parasites such as *Giardia* and *Cryptosporidium* (USEPA methods 1622 and 1623) require extensive training and are too time-consuming for early warning monitoring applications. Commercial instruments are available that can provide for screening of protozoan parasites in aqueous samples, but the tests still take a few

hours because of sample preparation requirements.

When algae blooms are detected at their earliest stages, the algae can be treated in the reservoir before they grow out of control, thus reducing taste and odor problems and saving on treatment costs. Several commercial continuous monitors are available that rely on an online fluorescence detector to measure chlorophyll *a*, the principle photosynthetic pigment in all algae. Some probes costing ~\$5,000 combine these measurements with those for water clarity (turbidity) and oxygen to provide early warning of algal blooms. A more expensive and sophisticated system was used in Los Angeles, Calif., to detect algae in supply reservoirs and resulted in substantial cost savings for treatment chemicals (Morrow et al, 2000).

Biomonitor track pollutants through their effect on organisms. The sheer magnitude of the number of pollutants of concern and the inability to monitor many of them continuously or at all have led to the use of online biomonitor. Biomonitor measure the changes in the behavior or properties of living organisms resulting from stresses placed on them by the presence of toxic materials. Conceptually biomonitor are analogous to the canaries used by miners to detect the presence of toxic gases. Though biomonitor do not provide information on the specific contaminant or cause of the stress on organisms, they warn that something unusual in the water is affecting the organisms, thus warranting further investigation such as specific chemical analyses (Penders & Stoks, 1999). Some biomonitor respond rapidly to elevated concentrations of a wide range of toxic compounds, and some can also be used to assess low-level chronic contamination by persistent, bioaccumulative toxins (e.g., from xenoestrogens, biocides, pharmaceuticals, and pesticides).

Examples of biomonitor include the dynamic fish (Figures 5 and 6), mussel (Figure 7), and *Daphnia* or water flea (Figure 8) tests as well as

TABLE 2 Specific ion electrodes used in monitoring raw water

Ion	Type	Range—mg/L	Interferences*
Ammonium	PVC† membrane	0.1–18,000	K
Bromide	Solid state	0.4–80,000	S, I, CN
Cadmium	Solid state	0.01–11,000	Ag, Hg, Cu, Pb, Fe
Calcium	PVC membrane	0.2–40,000	Pb, Hg, Cu, Ni
Chloride	Solid state	1.8–33,000	S, I, CN, Br, OH, NH ₃
Copper	Solid state	0.0006–6,350	Ag, Hg, Cl, Br, Fe, Cd
Cyanide	Solid state	0.1–260	S, I, B, Cl
Fluoride	Solid state	0.02 to saturation	OH
Iodide	Solid state	0.006–127,000	S, CN, Br, Cl, NH ₃
Lead	Solid state	0.2–20,700	Ag, Hg, Cu, Cd, Fe
Nitrate	PVC membrane	0.5–62,000	I, CN, BF ₄
pH	PVC membrane	1–14 (pH units)	
Surfactant	PVC membrane	1–12,000	
Hardness	PVC membrane	0.4–40,000	Cu, Zn, Ni, Fe

*Ag—silver, B—boron, BF₄—tetrafluoroborate, Br—bromine, Cd—cadmium, Cl—chlorine, CN—cyanide, Cu—copper, Fe—iron, Hg—mercury, I—iodine, K—potassium, NH₃—ammonia, Ni—nickel, OH—hydroxide, Pb—lead, S—sulfur, Zn—zinc

delayed algal fluorescence and luminescent bacteria response. The dynamic tests involve measuring changes (typically via electronic means) in movement or physiological responses by an organism as it tries to avoid toxic chemicals in the water. Because different species respond to different chemicals to varying degrees, the simultaneous use of different types of bioalarms (including some from different trophic levels) is often recommended (Penders & Stoks, 1999; LAWA, 1998).

The generally preferred method seems to be the *Daphnia* monitors, especially the newer ones that use digital cameras and are capable of following the behavior of each daphnid. The newer mussel tests appear to be well-suited because of the large filtering capacity of the mussels, their sensitivity, and their longevity. The simpler bacterial tests using luminescent bacteria are promising methods to determine the toxicity of the river water. Likewise, the delayed fluorescence of algae can be measured relatively easily. Although algae and bacteria monitors are not currently in wide use, and more experience with these monitors is needed, neither of these facts should deter water suppliers from using them. A report of German field experiences rated the

dynamic *Daphnia* test as the first priority for developing a bioalarm station, followed in order by fluorescent algae, bacteria tests, and mussel monitors (LAWA, 1998). Fish monitors were not recommended primarily because the sensitivity was problematic and not reproducible (e.g., problems were encountered with both false alarms and the systems not responding to pollution events) (LAWA, 1998).

Very few biomonitor are in use in the United States, but dozens are operating in Europe (LAWA, 1998). Practically every station with a biomonitor uses a *Daphnia* test, but some also use fish, mussels, algae, and bacteria to test the water with organisms from different trophic levels. Japan and Korea have installed several of these systems, and the numbers are currently expanding. In the United States, USEPA research laboratories in Cincinnati, Ohio, are investigating the effectiveness of biomonitor at different trophic levels (Haught, 2000), and *Daphnia* toximeters were used for assessing source water quality during the 2002 Winter Olympics in Salt Lake City, Utah (Yates et al, 2002).

Purchase costs for these systems typically range from about \$10,000 to near \$50,000 and up. The manual

TABLE 3 Summary of advanced early warning systems around the world

River	Country	Administration	Monitoring Program	Comments	Websites
Ohio River	United States	ORSANCO (Ohio River Valley Water Sanitation Commission)	Organics Detection System (15 gas chromatographs)	Federal-state commission working with water utilities	www.orsanco.org
Mississippi River	United States	Louisiana Department of Environmental Quality	8 gas chromatographs for organics detection	Cooperative effort among the state, water utilities, and industries	www.deq.state.la.us/surveillance/ewocds/index.htm
Rhine River	Germany, Holland, Switzerland	International Commission for the Protection of the Rhine	9 international stations plus 20 national monitoring stations	Multinational early warning system; extensive use of biomonitors.	www.iksr.org
River Trent	United Kingdom	Severn Trent Water	1 station at intake	Provides real time warnings and historical database	
River Dee	United Kingdom	Hyder Lab and Sciences	3 stations	Cooperative effort among three water companies and government	
River Tyne	United Kingdom	Northumbrian Water Group	2 stations	Wide range of advanced monitors	
Llobregat River	Spain	Grupas Aguas de Barcelona	10 stations	Extensive network of automated monitors	
River Seine	France	SEDIF (Syndicat des Eaux d'Ile-de-France)	Automatic monitoring stations and samplers serving three plants	Combines sophisticated treatment, monitors, and early warning system	
North Saskatchewan River	Canada	EPCOR Utilities Inc.	2 stations located at intakes	Includes online monitors for chemical dosing decisions	
St. Clair River	Canada	ORTECH Environmental Inc.	1 monitoring station	Effective system in industrialized area since 1987	
Yodo River	Japan	Yodo River Water Quality Consultative Committee	Monitors at intakes	Cooperative effort among 10 water companies; unique monitoring systems	
River Han (and other rivers)	Korea	National Institute of Environmental Research	20 stations on four rivers	Combination of standard and advanced instruments and biomonitors	www.nier.go.kr
Danube River	Parts of 17 European countries	International Commission for the Protection of the Danube River	Mostly conventional monitors	Primarily a network for sharing spill information; 11-nation commission	www.icpdr.org
Moselle River	France and Germany	International Commission for the Protection of the Moselle and the Saar	Several advanced monitoring stations with chemical and biomonitors	Primarily agricultural area with good water quality	www.iksms-cipms.org
Elbe River	Germany and Czech Republic	International Commission for the Protection of the Elbe	17 monitoring stations	Significant improvement in water quality since the reunification of Germany	www.arge-elbe.de www.bafg.de/html/ikse/ikse.htm

batch bacteria tests can be the least expensive in terms of capital costs. The algae, *Daphnia*, and mussel tests are fairly comparable in expense (~\$20,000–\$40,000) and cost less than fish monitor units (LAWA, 1998; Stoks, 1998). Operating costs are fairly low for all these methods (except the luminescent bacteria test)

and primarily involve replacement organisms and electricity.

False-positive results can result from interferences from a variety of environmental factors other than contaminants (e.g., temperature changes or low oxygen). Data on the sensitivity and minimum detection limits of online biomonitors are relatively

limited, and the methods demonstrate a relative lack of sensitivity for some chemicals of interest. Other drawbacks include the high cost for more sophisticated biomonitors and maintenance requirements for the living systems. The interpretation of the signals from biological monitors is also an important consideration; as

this improves, the value of biomonitoring will likely increase.

New monitoring methods emerge, research and development needs identified. Electronic noses and rapid bacterial methods have been identified as areas in which developments are taking place, and the use of these as early warning systems is likely to increase. Selected general research and development needs are summarized in the sidebar on page 64. Numerous research projects by the AWWA Research Foundation and the Water Environment Research Foundation are investigating rapid and online monitoring technologies. Generally speaking, however, many of the advances in monitoring technologies occur from research in other scientific fields (e.g., the food and beverage industry, analytical chemistry, the sensor industry, and the military); these advances include biosensor and biochip technology, fiber optics, genetically engineered organisms, immunoassays, and microelectronics. Research on rapid and online monitoring systems for a variety of contaminants is being conducted by a number of US government organizations including the USEPA (Panguluri et al, 1999; Rogers & Gerlach, 1999) and the US Army's Joint Service Agent Water Monitor program (ILSI, 1999).

SUCCESS OF EXISTING SYSTEMS MAY WIN NEW USERS

Case studies provide snapshots of monitoring applications. There are relatively few advanced early warning systems around the world that are extensive in size and scope, employ significant online state of the art monitoring equipment, and utilize monitoring, modeling, and communications in an integrated system to warn of contaminants in source water. Table 3 summarizes 15 prominent systems described by Grayman and colleagues (2001); taken together, these installations provide a fairly complete picture of the potential for early warning systems. Other research has documented case stud-

ies of online monitoring, some of which focus on early warning (AWWARF & CRS PROAQUA, 2002). These references include an evaluation of the successes and limitations of the systems.

There are both significant commonality and diversity among the systems. All of the systems depend on a combination of monitors, self-reporting, and/or public reporting. The monitoring systems used range from simple probes (e.g., pH, turbidity, conductivity) to advanced instruments such as GCs and UV monitors to biomonitoring. Many of the systems employ mathematical models to predict arrival times for a spill at downstream intakes. In all cases, some form of institutional structure coordinates efforts and communicates information so that appropriate actions can be taken. The impetus for several of these systems and networks has been an unfortunate large spill or release of a toxic or hazardous chemical.

Systems vary in their degree of complexity (Table 3). For example, the system on the River Rhine has nine international monitoring stations and 20 national stations monitoring for numerous parameters, including general water quality parameters, organic carbon indicators, nutrients, inorganics and metals, organic compounds (pesticides and volatile organics), and radioactivity. Other systems may contain only a single monitoring station. Systems also vary in terms of the frequency of analysis and degree of automation. Many of the systems are highly automated, with both alarm signals and maintenance performed remotely. The more sophisticated networks include a coordinated monitoring, modeling, communication, and response program for an extended stretch of river.

With a few notable exceptions (e.g., the Ohio River and Lower Mississippi River), US experience with advanced early warning monitoring systems and networks is limited, and many US water suppliers have little or no early

warning system in place. However, interest in early warning monitoring networks has increased in recent years, and such systems are currently being developed for the Upper Mississippi, Schuylkill, Delaware, Allegheny, Monongahela, and Susquehanna rivers (Gullick, 2003).

Future holds developments for early warning systems. A vision for the future of early warning monitoring systems would address the reduction of contamination events and a plan to mitigate the effects of unexpected discharges. Key elements would include (1) an active program for reducing the likelihood of the discharges, (2) an enforced set of regulations that strongly encourages self-reporting of any nonroutine discharges, (3) a monitoring system for detecting contaminants in the source waters, (4) a mathematical tool (model) for predicting the movement of a contaminant from its source to the water intakes, (5) a communications and organizational infrastructure for coordinating and disseminating information on the contaminant event, and (6) effective means for reducing the effects of the contaminant on the water system through intake closure, treatment, and use of raw or finished water storage or alternative sources.

This vision is looking brighter but has not yet been fulfilled. In some instances, early warning systems that include many of these elements have been implemented. However, most raw water sources continue to be vulnerable to contamination, and the water community still has far to go to safeguard water supplies. Ongoing research is expected to produce substantial advances in monitoring technologies in the near future.

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APPENDIX C – COMMUNICATION PLAN

COMMUNICATION PLAN

FOR THE

McDOWELL COUNTY BARTLEY SYSTEM

PWSID: # WV 3302434

Certified Operator: Carson Hill

Contact Phone Number:



Contact Email Address: mcdpsd@frontiernet.net

Plan Developed On: September 2015

Plan Update Due On: July 2016

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INTRODUCTION

Legislative Rule 64CSR3 requires public water systems to develop a Communication Plan that documents how public water suppliers, working with state and local emergency response agencies, shall notify state and local health agencies and the public in the event of a spill or contamination event that poses a potential threat to public health and safety. The plan must indicate how the public water supplier will provide updated information, with an initial notification to the public to occur no later than thirty minutes after the supplier becomes aware that the spill, release or potential contamination of the public water system poses a potential threat to public health and safety.

The public water system has responsibility to communicate to the public, as well as to state and local health agencies. This plan is intended to comply with the requirements of Legislative Rule 64CSR3, and other state and federal regulations.

TIERS REPORTING SYSTEM

This water system has elected to use the *Tiered Incident / Event Reporting System* (TIERS) for communicating with the public, agencies, the media, and other entities in the event of a spill or other incident that may threaten water quality. TIERS provides a multi-level notification framework, which escalates the communicated threat level commensurate with the drinking water system risks associated with a particular contamination incident or event. TIERS also includes a procedural flow chart illustrating key incident response communication functions and how they interface with overall event response / incident management actions. Finally, TIERS identifies the roles and responsibilities for key people involved in risk response, public notification, news media and other communication.

TIERS provides an easy-to-remember five-tiered **A-B-C-D-E** risk-based incident response communication format, as described below. **Table 1** also provides associated risk levels.

A = Announcement. The water system is issuing an announcement to the public and public agencies about an incident or event that may pose a threat to water quality. Additional information will be provided as it becomes available. As always, if water system customers notice anything unusual about their water, they should contact the water system

B = Boil Water. A boil water advisory has been issued by the water system. Customers may use the water for showering, bathing, and other non-potable uses, but should boil water used for drinking or cooking.

C = Cannot Drink. The water system asks that users not drink or cook with the water at this time. Non- potable uses, such as showering, bathing, cleaning, and outdoor uses are not affected.

D = Do Not Use. An incident or event has occurred affecting nearly all uses of the water. Do not use the water for drinking, cooking, showering, bathing, cleaning, or other tasks where water can come in contact with your skin. Water can be used for flushing commodes and fire protection.

E = Emergency. Water cannot be used for any reason.

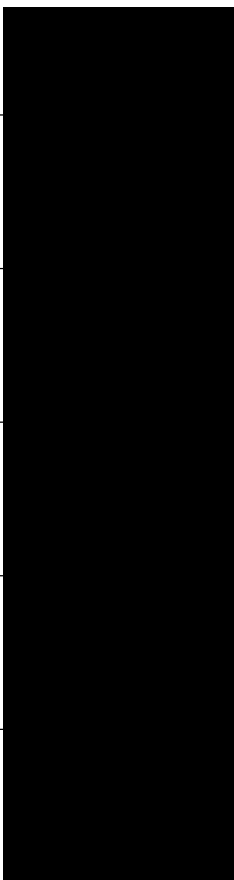
Table 1

Tier	Tier Category	Risk Level	Tier Summary
A	A nnouncement	Low	The water system is issuing an announcement to the public and public agencies about an incident or event that could pose a threat to public health and safety. Additional information will be provided as it becomes available.
B	B oil Water Advisory	Moderate	Water system users are advised to boil any water to be used for drinking or cooking, due to possible microbial contamination. The system operator will notify users when the boil water advisory is lifted.
C	C annot Drink	High	System users should not drink or cook with the water until further notice. The water can still be used for showering, bathing, cleaning, and other tasks.
D	D o Not Use	Very High	The water should only be used for flushing commodes and fire protection until further notice. More information on this notice will be provided as soon as it is available.
E	E mergency	Extremely High	The water should not be used for any purpose until further notice. More information on this notice will be provided as soon as it is available.

COMMUNICATION TEAM

The Communication Team for the water system is listed in the table below, along with key roles. In the event of a spill or other incident that may affect water quality, the water system spokesperson will provide initial information, until the team assembles (if necessary) to provide follow-up communication.

Table 2 – Water System Communication Team Members, Organizations, and Roles

Team Member Name	Organization	Phone	Email	Role
Mavis Brewster	McDowell PSD		mcdpsd@frontier.net.net	Primary Spokesperson
Jerry Stepp	Chairman McDowell PSD		N/A	Secondary Spokesperson
Steve Bowman	McDowell PSD		mcdpsd@frontier.net.net	Member
Teresa VanDyke	McDowell County 911		mapping@citlink.net	Member
Elden Green	McDowell PSD		mcdpsd@frontier.net.net	Member
Jesse Rose	McDowell County Health Department		Jesse.j.Rose@wv.gov	Member

In the event of a spill, release, or other incident that may threaten water quality, members of the team who are available will coordinate with the management staff of the local water supplier to:

- Collect information needed to investigate, analyze, and characterize the incident/event
- Provide information to the management staff so they can decide how to respond
- Assist the management staff in handling event response and communication duties
- Coordinate fully and seamlessly with the management staff to ensure response effectiveness

Communication Team Duties

The communication team will be responsible for working cooperatively with the management staff and state and local emergency response agencies to notify local health agencies and the public of the initial spill or contamination event. The team will also provide updated information related to any contamination or impairment of the source water supply or the system's drinking water supply.

According to Legislative Rule 64CSR3, the initial notification to the public will occur no later than thirty minutes after the public water system becomes aware that the spill, release or potential contamination of the public water system poses a potential threat to public health and safety.

As part of the group implementing the Source Water Protection Plan, team members are expected to be familiar with the plan, including incident/event response and communication tasks. Specifically, team members should:

- Be knowledgeable on elements of the Source Water Plan and Communication Plan
- Attend team meetings to ensure up-to-date knowledge of the system and its functions
- Participate in periodic exercises that “game out” incident response and communication tasks
- Help to educate local officials, the media, and others on source water protection
- Cooperate with water supplier efforts to coordinate incident response communication
- Be prepared to respond to requests for field investigations of reported incidents
- Not speak on behalf of the water supplier unless designated as the system’s spokesperson

The primary spokesperson will be responsible for speaking on behalf of the water system to local agencies, the public, and the news media. The spokesperson should work with the management staff and the team to ensure that all communication is clear, accurate, timely, and consistent. The spokesperson may authorize and/or direct others to issue news releases or other information that has been approved by the system's management staff. The spokesperson is expected to be on call immediately when an incident or event which may threaten water quality occurs. The spokesperson will perform the following tasks in the event of a spill, release, or other event that threatens water quality:

- Announce which risk level (A, B, C, D, or E) will apply to the public notifications that are issued
- Issue news releases, updates, and other information regarding the incident/event
- Use the news media, email, social media, and other appropriate information venues
- Ensure that news releases are sent to local health agencies and the public
- Respond to questions from the news media and others regarding the incident/event
- Appear at news conferences and interviews to explain incident response, etc.

INCIDENT / EVENT COMMUNICATION PROCEDURE

The flow chart in this section illustrates how the water system will respond when it receives a report that a spill, release, or other contamination event may have occurred. Key elements of the flow chart are described below.

Communication with agencies, the public, and the media during threat incidents

Upon initial notification of the incident/event, system managers and staff will collect information and verify the need for further investigation. If further investigation is warranted, and the initial facts support it, the water system spokesperson will issue a public communication statement consistent with the threat level. In addition, water system personnel and partners will be dispatched to conduct reconnaissance, a threat assessment, and a threat characterization, if present. This work may include:

- Verification of the incident/event type (spill, release, etc.)
- Location of incident/event

- Type of material(s) involved in spill, release, etc.
- Quantity of material involved
- Potential of the material to move, migrate, or be transported
- Relevant time factor(s) in the risk assessment (e.g., downstream movement rate)
- Overall level of risk to water system, whether low, moderate, high, or very high
- Development of the initial risk characterization

As the flow chart indicates, several iterative cycles will occur after the initial threat assessment, including communication with local agencies and the public, further investigation of the incident, possible implementation of the water system's contingency plan, and eventual elimination of the threat and a return to normal operations. Communication activities during this period will include:

- The initial release (i.e., Announcement, Boil Water, Cannot Drink, Do Not Use, or Emergency)
 - Sent to local health agencies, the public, and the news media within 30 minutes
- Notification of the local water system's source water protection and communication teams
 - If warranted by initial findings regarding the spill, release, or incident
- Notification of the WV Bureau of Public Health as required
- Periodic information updates as incident response information is received
- Updates to the applicable A-B-C-D-E advisory tier, as necessary

After the threat level is reduced, and operations return to normal, the water system staff, the communication and source water protection teams, and their partners will conduct a post-event review and assessment. The purpose of the review is to examine the response to the incident, relevant communication activities, and overall outcomes. Plans and procedures may be updated, altered, or adapted based on lessons learned through this process.

TIERS Flow Chart

Public Water Supplier Becomes Aware of Incident or Event

Conduct initial assessment to determine if the incident/event poses a risk to public health and safety.

Incident Poses Potential a Risk and Requires Notification within 30 Minutes

Public water supplier must issue notification to the public and local health agencies within 30 minutes of determining that incident poses a risk to public health and safety

Incident Does Not Pose a Risk No Further Investigation Is Needed

- Does not require notification to the public and local health agencies in 30 minutes.
- Should notify that known incident does not pose a risk.

Activate Incident Response

- Deploy incident assessment

Implement Contingency Plan if Necessary

- Replace/augment water source
- Adapt as necessary
- Communicate*

Threat Assessment and Characterization

- Incident/event type (spill, release, etc.)
- Location of incident/event
- Material(s) involved in spill, release, etc.
- Quantity of material
- Material movement/migration potential
- Time factor(s) in risk assessment
- Level of risk to water system
- Low, moderate, high, very high

Threat is Reduced or Eliminated Communicate*

Review Incident, Adapt Approach

- Incident response/investigation
- Communication activities
- Contingency operations

Threat Level Remains or Escalates- Communicate*

Return to Normal Operations

- Monitor any new developments
- Continue managing operations & source water protection program
- Communicate*

Communicate*

Constant communication with local agencies, public, and the media is critical throughout the entire process. The initial notification should include all pertinent information, depending on the TIERS level. Regular information updates should be provided. The **A-B-C-D-E** TIERS should be updated and explained as necessary.

Emergency Short Form 1

Emergency Communication Information

	Name	Phone Number	Email	
Designated spokesperson:	Mavis Brewster		mcdpsd@frontiernet.net	
Alternate spokesperson:	Jerry Stepp		N/A	
Designated location to disseminate information to media:	McDowell PSD Office, Coalwood WV.			
Methods of contacting affected residents:	Word of mouth	X	Posted notices	X
	Door-to-door canvassing	X	Radio	X
	Newspaper	X	Other	internet
Media contacts:	Name	Title	Phone Number	Email
	WVVA Bluefield	NBC	304-325-5487	News@wvva.com

	Name	Emergency Phone	Alternate Phone	Email
Local Police	McDowell County Sheriff	304-436-8526	911	
Local Fire Department	Raysal Volunteer Fire Department	304-967-7484	911	
Local Ambulance Service	McDowell County Ambulance Service	304-436-3877	911	
Hazardous Material Response Service	DEP	1-800-642-3074		Rusty.T.Joins@wv.gov

Emergency Short Form 2

Key Personnel

	Name	Title	Phone	Email
Key staff responsible for coordinating emergency response procedures?	Mavis Brewster	McDowell PSD Manager		mcdpsd@frontiernet.net
	Jerry Stepp	Chairman of McDowell PSD		N/A
Staff responsible for keeping confidential PSSC information and releasing to emergency responders:	Mavis Brewster	McDowell PSD Manager		mcdpsd@frontiernet.net
	Jerry Stepp	Chairman of McDowell PSD		N/A
Other communities that are served by the utility:	Bartley, English, Atwell and Raysal West Virginia			
Major user/sensitive population notification:	Name	Emergency Phone	Alternate Phone	
	Riverview High School	304-436-8441		
EED District Office Contact:	Name	Phone	Email	
	Beckley Office	304-256-6666	John.PB.Stafford@wv.gov	
Downstream Water Contacts:	System Name	Contact Name	Emergency Phone	Alternate Phone
	City of Iaeger		304-938-5171	
Are you planning on implementing the TIER system?		Yes		

Emergency Short Form 3

Emergency Response Information

List laboratories available to perform sample analysis in case of emergency:	Name	Phone
	REI Consultants	304-255-2500
	Analabs	1-800-880-6406
	WV office of Lab Services	304-558-3530
Has the utility developed a detailed Emergency Response Plan in accordance with the Public Health Security Bioterrorism Preparedness and Response Pan Act of 2002 that covers the following areas?	No Bioterrorism Plan has been developed.	
When was the Emergency Response Plan developed or last updated?	N/A	

Emergency Short Form 4

State Emergency Spill Notification

1-800-642-3074

Office of Emergency Services

<http://www.wvdhsem.gov/> Charleston, WV- (304) 558-5380

WV Bureau for Public Health Office of Environmental Health Services (OEHS)

www.wvdhhr.org/oehs

Charleston, Central Office (304) 558-2981

Beckley, District 1 (304) 256-6666

St. Albans, District 2 (304) 722-0611

Kearneysville, District 4 (304) 725-9453

Wheeling, District 5 (304) 238-1145

Philippi, District 6 (304) 457-2296

National Response Center - Chemical, Oil, & Chemical/Biological Terrorism

1-800-424-8802

WV State Fire Marshal's Office

1-800-233-3473

West Virginia State Police

1-304-746-2100

WV Watch – Report Suspicious Activity

1-866-989-2824

DEP Distance Calculator

<http://tagis.dep.wv.gov/pswcheck/>

APPENDIX D – SINGLE SOURCE FEASIBILITY STUDY

Feasibility Matrix		McDowell County Public Service Bartley System					PWSID: 3302434						Date: 42277					Completed By: The Thrasher Group Inc.				
Alternative Strategy Description	Economic Criteria					Technical Criteria							Environmental Criteria						Final Score	Total Capital Cost	Comments	
	Operation and Maintenance Costs	Capital Costs	Total	Total %	Weighted Total	Permitting	Flexibility	Resilience	Institutional Requirements	Total	Total %	Weighted Total	Environmental Impacts	Aesthetic Impacts	Stakeholder Issues	Total	Total %	Weighted Total				
Backup Intake	3.0	2.7	5.7	94.4%	37.8%	2.8	3.0	2.7	2.7	11.1	92.8%	37.1%	3.0	2.5	2.3	7.8	87.0%	17.4%	92.3%	2.6 million	Backup intake on Little Slate Creek	
Interconnect	3.0	2.7	5.7	94.4%	37.8%	2.8	3.0	2.7	2.7	11.1	92.8%	37.1%	3.0	2.5	2.3	7.8	87.0%	17.4%	92.3%	1.5 Million	Interconntion with the City of War	
Treated water storage	3.0	3.0	6.0	100.0%	40.0%	3.0	3.0	3.0	3.0	12.0	100.0%	40.0%	3.0	3.0	3.0	9.0	100.0%	20.0%	100.0%	\$0.0	Treated Water Storage	
Raw Water Storage	3.0	3.0	6.0	100.0%	40.0%	3.0	3.0	3.0	3.0	12.0	100.0%	40.0%	3.0	2.0	2.3	7.3	81.5%	16.3%	96.3%	\$713,375.0	Raw water Storage Tank	
Other-	0.0	0.0	0.0	0.0%	0.0%	0.0	0.0	0.0	0.0	0.0	0.0%	0.0%	0.0	0.0	0.0	0.0	0.0%	0.0%	0.0%	\$0.0	None	

Scoring:

- 0 – Not feasible. Criterion cannot be met by this alternative and removes the alternative from further consideration.
- 1 – Feasible but difficult. Criterion represents a significant barrier to successful implementation but does not eliminate it from consideration.
- 2 – Feasible. Criterion can be met by the alternative.
- 3 – Very Feasible. Criterion can be easily met by the alternative

APPENDIX E – ALTERNATIVES ANALYSIS

ANALYSIS OF ALTERNATIVES

McDowell County Public Service District Bartley System currently has one alternative source of water supply in the event that the primary water source becomes contaminated.

1. Backup Intake

The Bartley System surface water intake located on Tug Fork River is currently the primary source of water supply. There is one (1) source of water supply large enough to supply sufficient capacity – Little Slate Creek. The mouth of Little Slate Creek is located approximately 26,000 feet Downstream of the existing water treatment plant surface water intake on the Tug Fork River.

The stream flow of Little Slate Creek was found using the USGE maps. The data is calculated below:

$$4 \text{ cubic feet per second} * \left(\frac{448.83 \text{ gpm}}{1 \text{ cfs}} \right) = 1800 \text{ gpm}$$

The minimum required capacity for the treatment facility is 600 gallons per minute, which is satisfied by the Little Slate Creek. Thus, the construction of a backup intake located on Little Slate Creek located in Raysal, WV downstream of the Bartley Water Treatment Plant will include 26,000 feet of 6” raw water line from the intake to the water treatment facility will be considered in the feasibility analysis. A cost analysis is provided in Appendix F, “Supporting Documentation”.

2. Interconnection

The Bartley System is not currently interconnected with another utility. The City of War is the closest utility, however the City of War is in the process of decommissioning their water treatment plant and will begin purchasing water from the McDowell PSD Bartley System.

If the Bartley System active water source is the Tug Fork River. The City of War source of raw water is the Tug Fork River. The City of War is upstream of Bartley System so if the Tug Fork was contaminated downstream of the City of War, the City of War would be a viable option. If the Tug Fork River is contaminated upstream of the city of War then the interconnection would not be a viable option. At this time no other interconnection is possible. The interconnection was considered in the feasibility analysis.

To Interconnect the Bartley System with the City of War it requires 19,000 linear feet of 6 inch water line and 600 gpm. A cost analysis is provided in Appendix F, “Supporting Documentation”.

3. Treated Water Storage

The Bartley System treated water storage capacity for the system consists of six (6) water storage tanks totaling 788,000 gallons. On average, the water treatment facility produces 180,000 gallons per day of water. The maximum produced by the water treatment facility from July 2014 to July 2014 was 240,000 gallons per day, according to monthly operating reports provided by the utility.

The minimum required treated storage capacity, according to Senate Bill 373, is equal to two (2) days of

system storage based on the plant's maximum level of production experienced within the past year, and the maximum required is equal to five (5) days of the average production, according to WVBPH standards requiring 20% turnover per day.

The minimum required treated water storage capacity for the system would be:

$$240,000 \text{ gallons per day} * 2 \text{ days} = 480,000 \text{ gallons}$$

Therefore, the system currently meets the maximum required treated water storage capacity. Thus, this alternative will not be considered in the feasibility analysis.

4. Raw Water Storage

The Bartley System does not have any raw water storage capacity for the system.

As mentioned in Section #3, the water treatment facility produces 180,000 gallons per day on average and has a maximum production of 240,000 gallons per day.

The minimum required raw storage capacity, according to Senate Bill 373, is equal to two (2) days of system storage based on the plant's maximum level of production experienced within the past year, and the maximum required is equal to five (5) days of the average production, according to WVBPH standards requiring 20% turnover per day.

The minimum required raw water storage capacity for the system would be:

$$240,000 \text{ gallons per day} * 2 \text{ days} = 480,000 \text{ gallons}$$

Therefore, the system currently does not meet the minimum required raw water storage capacity. Thus, the construction of a 491,000 gallon raw water storage tank will be considered in the feasibility analysis.

A cost analysis is provided in Appendix F, "Supporting Documentation".

Feasibility Matrix		McDowell County Public Service		PWSID: 33032434		30-Sep-15		Matrix Completed By:		The Thrasher Group Inc.	
Bartlev System											
Criteria	Question	Backup Intake	Feasibility	Interconnect	Feasibility	Treated Water Storage	Feasibility	Raw Water Storage	Feasibility	Other-	Feasibility
Economic Criteria											
What is the total current budget year cost to operate and maintain the PWSU (current budget year)?		\$1,388,805.00		\$1,388,805.00		\$1,388,805.00		\$1,388,805.00		\$1,388,805.00	
O and M Costs	Describe the major O&M cost requirements for the alternative?	Labor, Power Materials for Maintenance	3	Labor, Power Materials for Maintenance and purchase of treated water	3	Labor, Power Materials for Maintenance	3	Labor, Power Materials for Maintenance	3		0
	What is the incremental cost (\$/gal) to operate and maintain the alternative?	\$0.00	3	\$0.00	3	\$0.00	3	\$0.00	3	\$0.00	0
	Cost comparison of the incremental O&M cost to the current budgeted costs (%)	0.00%	3	0.00%	3	0.00%	3	0.00%	3	0.00%	0
O and M-Feasibility Score			3.0		3.0		3.0		3.0		0.0
Describe the capital improvements required to implement the alternative.		Construction of a backup intake on Little Slate Creek		None		Done		Construction of new 491,000 gallon tank		None	
Capital Costs	What is the total capital cost for the alternative?	2.6 million	2	1.5 Million	2	0	3	\$713,375.00	3	\$0.00	0
	What is the annualized capital cost to implement the alternative, including land and easement costs, convenience tap fees, etc. (\$/gal)	\$0.00	3	\$0.00	3	0	3	\$0.00	3	\$0.00	0
	Cost comparison of the alternatives annualized capital cost to the current budgeted costs (%)	0.00%	3	0.00%	3	0.00%	3	0.00%	3	0.00%	0
Capitol Cost-Feasibility Score			2.7		2.7		3.0		3.0		0.0
Technical Criteria											
Permitting	Provide a listing of the expected permits required and the permitting agencies involved in their approval.	ACOE, USFW,WVDNR, WVDEP,WVSHOP, County FloodPlain	3	ACOE, USFW,WVDNR, WVDEP,WVSHOP, County FloodPlain	3	Done	3	ACOE, USFW,WVDNR, WVDEP,WVSHOP, County FloodPlain	3		0
	What is the timeframe for permit approval for each permit?	ACOE (90 days) .USFW (60 days),WVDNR (60 days), WVDEP (90 days) ,WVSHOP (60 Days), County FloodPlain (90 days)	3	ACOE (90 days) .USFW (60 days),WVDNR (60 days), WVDEP (90 days) ,WVSHOP (60 Days), County FloodPlain (90 days)	3	Done	3	ACOE (90 days) .USFW (60 days),WVDNR (60 days), WVDEP (90 days) ,WVSHOP (60 Days), County FloodPlain (90 days)	3		0
	Describe the major requirements in obtaining the permits (environmental impact studies, public hearings, etc.)	Environmental Impact Studies	3	Environmental Impact Studies	3	Done	3	Environmental Impact Studies	3		0
	What is the likelihood of successfully obtaining the permits?	Good	2	Good	2	Done	3	Very Good	3		0
	Does the implementation of the alternative require regulatory exceptions or variances?	No	3	No	3	Done	3	No	3		0
Permitting-Feasibility Score			2.8		2.8		3.0		3.0		0.0
Flexibility	Will the alternative be needed on a regular basis or only used intermittently?	Intermittently	3	Intermittently	3	Done	3	Intermittently	3		0
	How will implementing the alternative affect the PWSU's current method of treating and delivering potable water including meeting Safe Drinking Water Act regulations? (ex. In the case of storage, will the alternative increase the likelihood of disinfection byproducts?)	No Impact	3	No Impact	3	Done	3	No Impact	3		0
Flexibility-Feasibility Score			3.0		3.0		3.0		3.0		0.0
Resilience	Will the alternative provide any advantages or disadvantages to meeting seasonal changes in demand?	Yes	3	Yes	3	Done	3	no	3		0
	How resistant will the alternative be to extreme weather conditions such as drought and flooding?	Drought may limit withdrawal capacity	2	Drought may limit withdrawal capacity	2	Done	3	Yes	3		0
	Will the alternative be expandable to meet the growing needs of the service area?	Yes	3	Yes	3	Done	3	Yes	3		0
Resilience-Feasibility Score			2.7		2.7		3.0		3.0		0.0

Criteria	Question	Backup Intake	Feasibility	Interconnect	Feasibility	Treated Water Storage	Feasibility	Raw Water Storage	Feasibility	Other-	Feasibility
Institutional Requirements	Identify any agreements or other legal instruments with governmental entities, private institutions or other PWSU required to implement the alternative.	None	3	The Mcdowell PSD will need an purchase agreement with the City of War WV	3	Done	3	None	3		0
	Are any development/planning restrictions in place that can act as a barrier to the implementation of the alternative.	No	3	No	3	Done	3	No	3		0
	Identify potential land acquisitions and easements requirements.	WV DOH Right of Way	2	WV DOH Right of Way	2	Done	3	Property availability on site for storage tank	3		0
Institutional Requirements-Feasibility Score			2.7		2.7		3.0		3.0		0.0
Environmental Criteria											
Environmental Impacts	Identify any environmentally protected areas or habitats that might be impacted by the alternative.	None	3	None	3	Done	3	None	3		0
Environmental Impacts-Feasibility Score			3.0		3.0		3.0		3.0		0.0
Aesthetic Impacts	Identify any visual or noise issues caused by the alternative that may affect local land uses?	Yes, construction of a backup intake would cause temporary noise issues.	2	Yes, construction of a interconnetion would cause temporary noise issues.	2	Done	3	Yes, construction of a storage tank would cause temporary noise issues. The visual issues would remain once the tank is constructed	2		0
	Identify any mitigation measures that will be required to address aesthetic impacts?	Construction will need to be completed as quick as possible	3	None	3	Done	3	Tank construction will need to be completed as quick as possible	2		0
Aesthetic Impacts-Feasibility Score			2.5		2.5		3.0		2.0		0.0
Stakeholder Issues	Identify the potential stakeholders affected by the alternative.	Water customers and land owners	2	Water customers and land owners	2	Done	3	Water customers and land owners	2		0
	Identify the potential issues with stakeholders for and against the alternative.	A rate increase may occur	2	A rate increase may occur	2	Done	3	A rate increase may occur	2		0
	Will stakeholder concerns represent a significant barrier to implementation (or assistance) of the alternative?	None	3	None	3	Done	3	No	3		0
Stakeholder Issues-Feasibility Score			2.3		2.3		3.0		2.3		0.0
Comments		Backup intake on Little Slate Creek		Interconntion with the City of War		Treated Water Storage		Raw water Storage Tank		None	

Instructions: Using the expanded instructions in the "FEASIBILITY STUDY GUIDANCE DOCUMENT", complete the white and gray input cells. Rank each criteria based on the evidence provided and best professional judgement. Rank the criteria 0-3, assuming 0=not feasible and 3=most feasible. The password to edit fillable cells is "swap".

- Scoring:
- 0 – Not feasible. Criterion cannot be met by this alternative and removes the alternative from further consideration.
- 1 – Feasible but difficult. Criterion represents a significant barrier to successful implementation but does not eliminate it from consideration.
- 2 – Feasible. Criterion can be met by the alternative.
- 3 – Very Feasible. Criterion can be easily met by the alternative

Matrix Explanation

The alternative analysis matrix evaluates the utility's ability to implement each of the additional sources outlined. Alternative sources are evaluated for economic, technical and environmental feasibility. The matrix uses a 0-3 rating system, with 3 being very feasible and 0 being not feasible. Each category has sub questions to develop an average for the alternative. Once all areas are evaluated, a final feasibility score is given for each of the alternatives for use in determining which option will best suit the utility needs.

Economic factors evaluated in the matrix include all information needed to fund the alternative source. The matrix considers the current utility budget available per the latest (2014) annual report, operation and maintenance costs for each alternative, and the capital needed to construct each alternative. Supporting documentation is included in Appendix F of the report which provides a breakdown of costs for each alternative that are used as capital costs in the matrix. The economic feasibility of each alternative is compared on a cost per gallon ratio. This ratio is determined by dividing the capital cost of the improvements by the total number of gallons of water produced per year. An average of the economic feasibility factors is then calculated and entered into the overall feasibility matrix found in Appendix D.

Technical criteria evaluated include permitting, flexibility, institutional and resilience factors. Permitting costs are included in all supporting documentation for each alternative source. The permitting factors included the permits that would be needed to construct the alternative source for the utility. An additional environmental factor is the feasibility of obtaining each permit. Permits were rated from 3 to 0 based on the difficulty of obtaining the permits for the project. Depending on the project area, some permits may be very difficult and costly to obtain. Flexibility factors evaluate the ability of the alternative to be used as a permanent source of water or if it can only be used on a temporary basis. The intake and interconnections can be used as both temporary and permanent sources. The alternatives' ability to help the utility during seasonal or population increases is also evaluated in the resilience factors. The alternatives that can produce additional water were rated as 3, or very feasible. Additional criteria evaluated are easements and right of ways that will need to be acquired to construct the alternative source. For interconnections and intakes right of way would be needed to lay the new waterline. The feasibility of attaining the right of way was evaluated. All technical criteria was averaged and also entered into the feasibility summary in Appendix D.

Environmental aspects for each alternative include impacts, aesthetics and stakeholders. Environmental impacts included any areas in the proposed alternative source area that are protected. Areas that are protected would have a low feasibility because the impacts could be large if the project were constructed. Aesthetics factors were noise, visual impacts and mitigation measures that could affect the projects feasibility. The aesthetic factors relate to the stakeholders factors. The stakeholders' portion of the environmental criteria involves the community and their acceptance of the new source alternative and the structures that will be constructed.

APPENDIX F – SUPPORTING DOCUMENTATION

EARLY WARNING MONITORING COST ESTIMATE

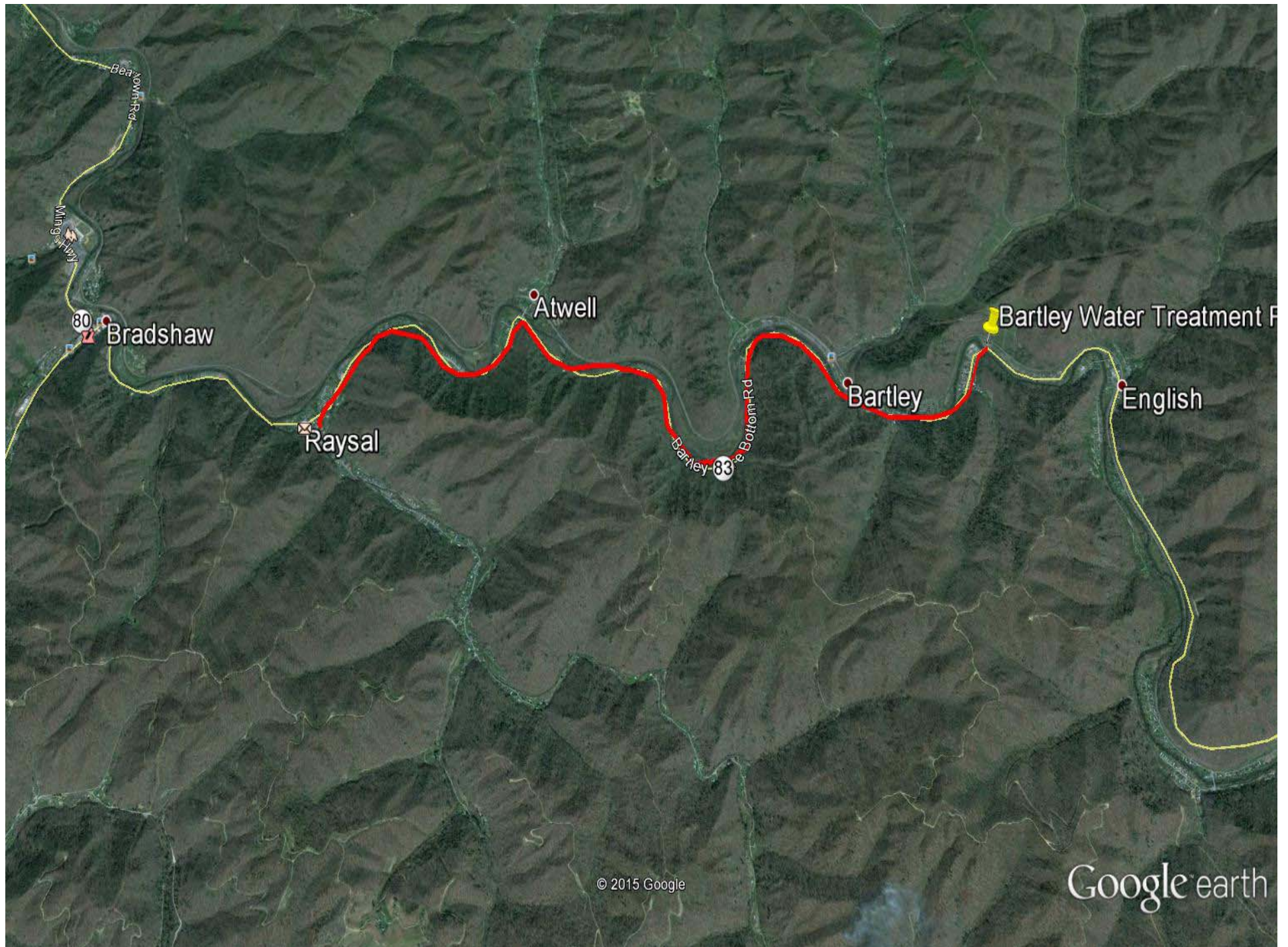
Qty.		Description	Unit Price	Total Cost
1	EA	Back Panel / Trough / Level (required)	\$ 4,350.00	\$ 4,350
1	EA	Probe Module SC1000 (6 sensors)	\$ 1,344.00	\$ 1,344
1	EA	Internal Card SC1000 (4 mA inputs)	\$ 879.00	\$ 879
1	EA	Display Module SC1000	\$ 2,770.00	\$ 2,770
1	EA	Conductivity Sensor	\$ 860.00	\$ 860
1	EA	FP360 SC Sensor, 500ppb, SS, 1.5 m Cable	\$ 17,480.00	\$ 17,480
1	EA	ORP Sensor	\$ 880.00	\$ 880
1	EA	pH Sensor, Ryton	\$ 800.00	\$ 800
1	LS	Installation	\$ 20,365.00	\$ 20,365
TOTAL =				\$ 50,000

OPERATION & MAINTENANCE COST ESTIMATE

Qty.		Description	Unit Price	Total Cost
1	LS	Annual O&M Cost	\$ 750.00	\$ 750
TOTAL =				\$ 750

In addition to the early warning system, the Bartley System should establish a baseline water quality for their sources.

Backup Intake



GPM of Existing Pump 600 GPM

Intake Pricing Parameters	Cost per GPM
If the GPM needed is Greater than or Equal to 1,000 GPM (12" Pipe)	\$ 1,500.00
If the GPM needed is between 700 GPM to 999 GPM (8" Pipe)	\$ 1,750.00
If the GPM needed is less than 700 GPM (6" Pipe)	\$ 2,000.00
Intake pricing includes acreage, pumps, screens, concrete, raw water well, electricity, etc.	\$ 1,200,000.00

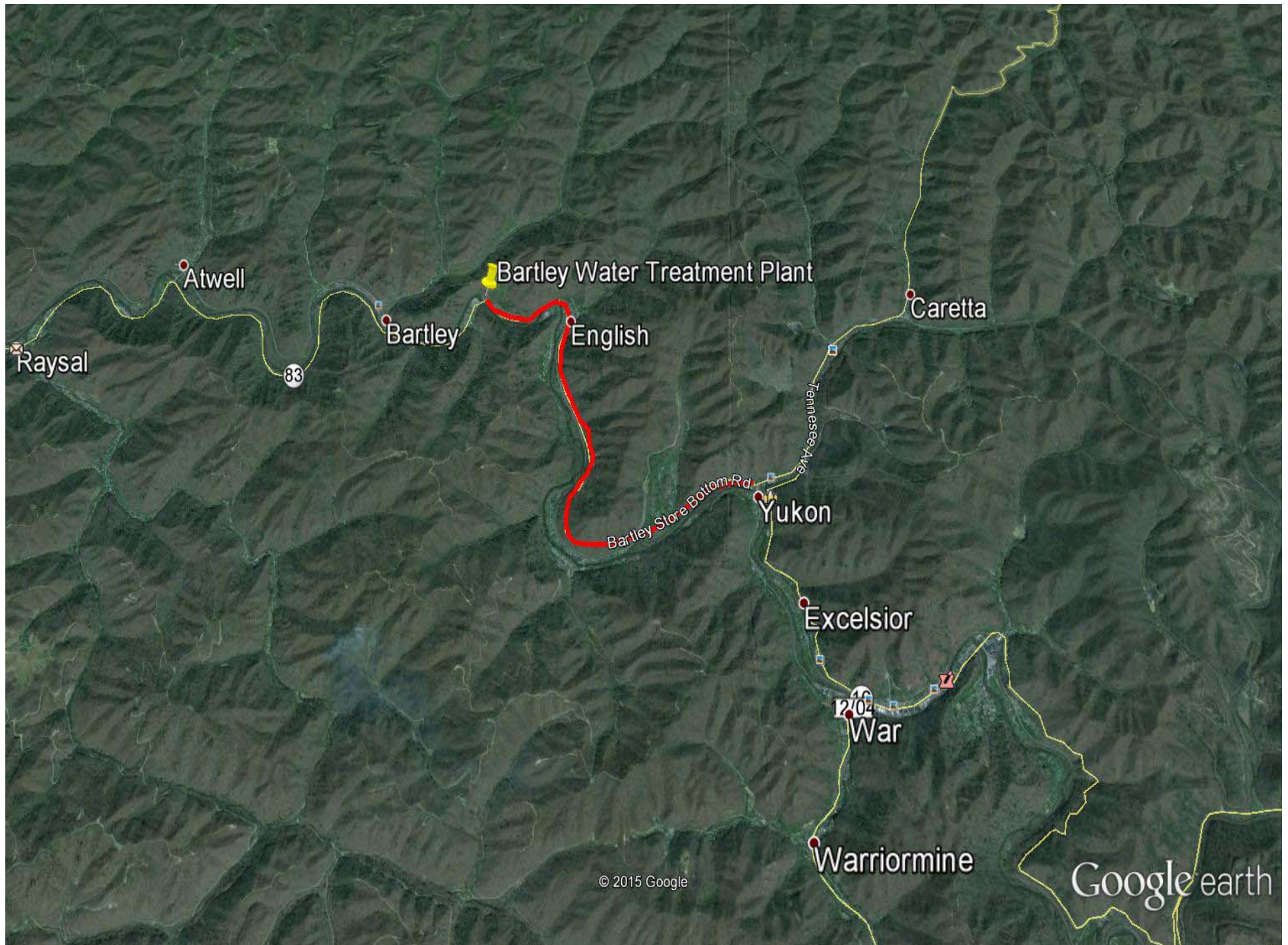
Additional Environmental Costs		
Mussel Survey	No	\$ -
Permits	Yes	\$ 7,500.00
		\$ 7,500.00

Piping Size	Cost per Foot	Footage	Totals
6" Pipe	\$ 34.00	26,000	\$ 884,000.00
8" Pipe	\$ 37.00	-	\$ -
12" Pipe	\$ 60.00		\$ -
			\$ 884,000.00

Totals	
Intake	\$ 1,200,000.00
Permitting	\$ 7,500.00
Piping	\$ 884,000.00
Additional Fees	\$ 522,875.00
Total Cost	\$ 2,614,375.00

Assumptions
Water will be taken from Little Slate Creek. Previous usages of the stream have confirmed the capacity to be adequate. According to the WVDNR, Little Slate Creek is not a mussell stream and does not require a survey to be completed during permitting. Permits required would include WV DEP, WV DNR, ACOE, WV SHPO, US FWS, WV DOH and County Floodplain. The piping route is included in the following page of supporting documentation. Additional fees are predicted to be 25% of overall cost. The fees include legal, engineering and accounting needs.

Interconnection



Pricing Parameters
If the GPM needed is Greater than or Equal to 1,000 GPM (12" Pipe)
If the GPM needed is between 700 GPM to 999 GPM (8" Pipe)
If the GPM needed is less than 700 GPM (6" Pipe)

Utility Information		
Existing Capacity	600	GPM
Footage Needed	19,000	LF

Price for First 1,000 LF					
Item	Unit	\$/Unit	Gate Valve (2)	Meter	Cost Per Foot
12" Pipe	LF	\$ 60.00	\$ 4,400.00	\$ 2,450.00	\$ 66.85
8" Pipe	LF	\$ 37.00	\$ 2,530.00	\$ 2,450.00	\$ 41.98
6" Pipe	LF	\$ 34.00	\$ 1,880.00	\$ 2,450.00	\$ 38.33

Additional Footage after 1,000 LF				
Item	Unit	\$/Unit	Gate Valve (1)	Cost Per Foot
12" Pipe	LF	\$ 60.00	\$ 2,200.00	\$ 62.20
8" Pipe	LF	\$ 37.00	\$ 1,265.00	\$ 38.27
6" Pipe	LF	\$ 34.00	\$ 940.00	\$ 34.94

Additional Costs	
Permitting (All)	\$ 7,500.00

Booster Station Cost		
GPM	\$/Gal	Total Cost
400+	\$ 950.00	\$ 570,000.00
100+	\$ 1,798.00	-
60+	\$ 2,750.00	0

Total Cost of Interconnection	
First 1,000 LF	\$ 38,330.00
Additional Footage	\$ 628,920.00
Permitting	\$ 7,500.00
Booster Station	\$ 570,000.00
Additional Fees	\$ 311,187.50
Total	\$ 1,555,938

Assumptions
One gate valve per 1,000 feet of additional water line.
Non-rocky conditions.
Additional Fees predicted to be 25% of overall cost. These include legal, engineering and accounting requirements.
Permits would include WVDEP, WVDNR, ACOE, WVSHPO, USFW, WVDOH and County Floodplain.
The piping route is included in the following page of supporting documentation.
Costs for each item include materials and labor.

RAW WATER TANK COST				
Gallons	Tank Dimension	Model Number	Cost	Cost Per Gallon
105,000	25.17'dia. x 28.43' sidewall height	AQUASTORE tank Model 25 28 - SSWT	\$ 155,000	\$ 1.48
209,000	30.77'dia. x 37.59' sidewall height	AQUASTORE tank Model 31 38 - SSWT	\$ 225,000	\$ 1.08
297,000	39.16'dia. x 33.01' sidewall height	AQUASTORE tank Model 39 33 - SSWT	\$ 285,000	\$ 0.96
438,000	47.55'dia. x 33.01' sidewall height	AQUASTORE tank Model 48 33 - SSWT	\$ 345,000	\$ 0.79
491,000	50.35'dia. x 33.01' sidewall height	AQUASTORE tank Model 50 33 - SSWT	\$ 365,000	\$ 0.74
607,000	55.95'dia. x 33.01' sidewall height	AQUASTORE tank Model 56 33 - SSWT	\$ 425,000	\$ 0.70
691,000	64.34'dia. x 28.43' sidewall height	AQUASTORE tank Model 64 28 - SSWT	\$ 470,000	\$ 0.68
816,000	69.93'dia. x 28.43' sidewall height	AQUASTORE tank Model 70 28 - SSWT	\$ 510,000	\$ 0.63
948,000	69.93'dia. x 33.01' sidewall height	AQUASTORE tank Model 70 33 - SSWT	\$ 555,000	\$ 0.59
1,025,000	72.73'dia. x 33.01' sidewall height	AQUASTORE tank Model 73 33 - SSWT	\$ 595,000	\$ 0.58
1,260,000	72.73'dia. x 33.01' sidewall height	AQUASTORE tank Model 73 33 - SSWT	\$ 695,000	\$ 0.55
1,453,000	97.91'dia. x 28.43' sidewall height	AQUASTORE tank Model 98 28- SSWT	\$ 790,000	\$ 0.54
1,601,000	97.91'dia. x 28.43' sidewall height	AQUASTORE tank Model 98 28- SSWT	\$ 870,000	\$ 0.54
1,789,000	103.5'dia. x 28.43' sidewall height	AQUASTORE tank Model 104 28- SSWT	\$ 945,000	\$ 0.53
2,026,000	120.29'dia. x 23.84' sidewall height	AQUASTORE tank Model 120 24- SSWT	\$ 1,052,000	\$ 0.52

COSTS OF ADDITIONAL ITEMS AND ASSUMPTIONS	
Access Road and Site Preparation	\$ 75,000
Yard Piping and Vault	13%
Bonds/Permits	\$ 20,000
Fencings	\$ 35,000
Engineering/Accounting/Legal Fees	25%
Level-Sensing and Measuring Equipment	\$ 10,000
Rock Excavation of Foundation (if encountered)	5%
ASSUMPTIONS: Cost are based on a standpipe glass lined tank. Price include access roads and site preparation (assuming land would need to be purchased for the tank site), telemetry, excavation in rock (% of Tank Cost), valve vault and piping (13% of tank Cost), fencing (Lump Sum). Does not include additional waterline from site to water system. Fees for engineering, legal and accounting services will be 25 percent of the overall project cost.	

TOTAL COST (INCLUDING ADDITIONAL ITEMS) OF RAW WATER STORAGE				
Gallons	Tank Dimension	Model Number	Cost	Cost Per Gallon
105,000	25.17'dia. x 28.43' sidewall height	AQUASTORE tank Model 25 28 - SSWT	\$ 403,625	\$ 3.84
209,000	30.77'dia. x 37.59' sidewall height	AQUASTORE tank Model 31 38 - SSWT	\$ 506,875	\$ 2.43
297,000	39.16'dia. x 33.01' sidewall height	AQUASTORE tank Model 39 33 - SSWT	\$ 595,375	\$ 2.00
438,000	47.55'dia. x 33.01' sidewall height	AQUASTORE tank Model 48 33 - SSWT	\$ 683,875	\$ 1.56
491,000	50.35'dia. x 33.01' sidewall height	AQUASTORE tank Model 50 33 - SSWT	\$ 713,375	\$ 1.45
607,000	55.95'dia. x 33.01' sidewall height	AQUASTORE tank Model 56 33 - SSWT	\$ 801,875	\$ 1.32
691,000	64.34'dia. x 28.43' sidewall height	AQUASTORE tank Model 64 28 - SSWT	\$ 868,250	\$ 1.26
816,000	69.93'dia. x 28.43' sidewall height	AQUASTORE tank Model 70 28 - SSWT	\$ 927,250	\$ 1.14
948,000	69.93'dia. x 33.01' sidewall height	AQUASTORE tank Model 70 33 - SSWT	\$ 993,625	\$ 1.05
1,025,000	72.73'dia. x 33.01' sidewall height	AQUASTORE tank Model 73 33 - SSWT	\$ 1,052,625	\$ 1.03
1,260,000	72.73'dia. x 33.01' sidewall height	AQUASTORE tank Model 73 33 - SSWT	\$ 1,200,125	\$ 0.95
1,453,000	97.91'dia. x 28.43' sidewall height	AQUASTORE tank Model 98 28- SSWT	\$ 1,340,250	\$ 0.92
1,601,000	97.91'dia. x 28.43' sidewall height	AQUASTORE tank Model 98 28- SSWT	\$ 1,458,250	\$ 0.91
1,789,000	103.5'dia. x 28.43' sidewall height	AQUASTORE tank Model 104 28- SSWT	\$ 1,568,875	\$ 0.88
2,026,000	120.29'dia. x 23.84' sidewall height	AQUASTORE tank Model 120 24- SSWT	\$ 1,726,700	\$ 0.85

TREATED WATER TANK COST				
Gallons	Tank Dimension	Model Number	Cost	Cost Per Gallon
105,000	25.17'dia. x 28.43' sidewall height	AQUASTORE tank Model 25 28 - SSWT	\$ 155,000	\$ 1.48
209,000	30.77'dia. x 37.59' sidewall height	AQUASTORE tank Model 31 38 - SSWT	\$ 225,000	\$ 1.08
297,000	39.16'dia. x 33.01' sidewall height	AQUASTORE tank Model 39 33 - SSWT	\$ 285,000	\$ 0.96
438,000	47.55'dia. x 33.01' sidewall height	AQUASTORE tank Model 48 33 - SSWT	\$ 345,000	\$ 0.79
491,000	50.35'dia. x 33.01' sidewall height	AQUASTORE tank Model 50 33 - SSWT	\$ 365,000	\$ 0.74
607,000	55.95'dia. x 33.01' sidewall height	AQUASTORE tank Model 56 33 - SSWT	\$ 425,000	\$ 0.70
691,000	64.34'dia. x 28.43' sidewall height	AQUASTORE tank Model 64 28 - SSWT	\$ 470,000	\$ 0.68
816,000	69.93'dia. x 28.43' sidewall height	AQUASTORE tank Model 70 28 - SSWT	\$ 510,000	\$ 0.63
948,000	69.93'dia. x 33.01' sidewall height	AQUASTORE tank Model 70 33 - SSWT	\$ 555,000	\$ 0.59
1,025,000	72.73'dia. x 33.01' sidewall height	AQUASTORE tank Model 73 33 - SSWT	\$ 595,000	\$ 0.58
1,260,000	72.73'dia. x 33.01' sidewall height	AQUASTORE tank Model 73 33 - SSWT	\$ 695,000	\$ 0.55
1,453,000	97.91'dia. x 28.43' sidewall height	AQUASTORE tank Model 98 28- SSWT	\$ 790,000	\$ 0.54
1,601,000	97.91'dia. x 28.43' sidewall height	AQUASTORE tank Model 98 28- SSWT	\$ 870,000	\$ 0.54
1,789,000	103.5'dia. x 28.43' sidewall height	AQUASTORE tank Model 104 28- SSWT	\$ 945,000	\$ 0.53
2,026,000	120.29'dia. x 23.84' sidewall height	AQUASTORE tank Model 120 24- SSWT	\$ 1,052,000	\$ 0.52

COSTS OF ADDITIONAL ITEMS AND ASSUMPTIONS	
Access Road and Site Preparation	\$ 75,000
Yard Piping and Vault	13%
Bonds/Permits	\$ 20,000
Fencings	\$ 35,000
Engineering/Accounting/Legal Fees	25%
Level-Sensing and Measuring Equipment	\$ 10,000
Rock Excavation of Foundation (if encountered)	5%
ASSUMPTIONS: Cost are based on a standpipe glass lined tank. Price include access roads and site preparation (assuming land would need to be purchased for the tank site), telemetry, excavation in rock (% of Tank Cost), valve vault and piping (13% of tank Cost), fencing (Lump Sum). Does not include additional waterline from site to water system. Fees for engineering, legal and accounting services will be 25 percent of the overall project cost.	

TOTAL COST (INCLUDING ADDITIONAL ITEMS) OF TREATED WATER STORAGE				
Gallons	Tank Dimension	Model Number	Cost	Cost Per Gallon
105,000	25.17'dia. x 28.43' sidewall height	AQUASTORE tank Model 25 28 - SSWT	\$ 403,625	\$ 3.84
209,000	30.77'dia. x 37.59' sidewall height	AQUASTORE tank Model 31 38 - SSWT	\$ 506,875	\$ 2.43
297,000	39.16'dia. x 33.01' sidewall height	AQUASTORE tank Model 39 33 - SSWT	\$ 595,375	\$ 2.00
438,000	47.55'dia. x 33.01' sidewall height	AQUASTORE tank Model 48 33 - SSWT	\$ 683,875	\$ 1.56
491,000	50.35'dia. x 33.01' sidewall height	AQUASTORE tank Model 50 33 - SSWT	\$ 713,375	\$ 1.45
607,000	55.95'dia. x 33.01' sidewall height	AQUASTORE tank Model 56 33 - SSWT	\$ 801,875	\$ 1.32
691,000	64.34'dia. x 28.43' sidewall height	AQUASTORE tank Model 64 28 - SSWT	\$ 868,250	\$ 1.26
816,000	69.93'dia. x 28.43' sidewall height	AQUASTORE tank Model 70 28 - SSWT	\$ 927,250	\$ 1.14
948,000	69.93'dia. x 33.01' sidewall height	AQUASTORE tank Model 70 33 - SSWT	\$ 993,625	\$ 1.05
1,025,000	72.73'dia. x 33.01' sidewall height	AQUASTORE tank Model 73 33 - SSWT	\$ 1,052,625	\$ 1.03
1,260,000	72.73'dia. x 33.01' sidewall height	AQUASTORE tank Model 73 33 - SSWT	\$ 1,200,125	\$ 0.95
1,453,000	97.91'dia. x 28.43' sidewall height	AQUASTORE tank Model 98 28- SSWT	\$ 1,340,250	\$ 0.92
1,601,000	97.91'dia. x 28.43' sidewall height	AQUASTORE tank Model 98 28- SSWT	\$ 1,458,250	\$ 0.91
1,789,000	103.5'dia. x 28.43' sidewall height	AQUASTORE tank Model 104 28- SSWT	\$ 1,568,875	\$ 0.88
2,026,000	120.29'dia. x 23.84' sidewall height	AQUASTORE tank Model 120 24- SSWT	\$ 1,726,700	\$ 0.85