Water Conservation Measures in West Virginia

Prepared for
West Virginia Department of Environmental Protection

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Abbreviations

DEP	West Virginia Department of Environmental Protection
DNR	West Virginia Department of Natural Resources
DOE	U.S. Department of Energy
EPA	United States Environmental Protection Agency
FGD	Flue gas desulfurization
HUC8	8-Digit Hydrologic Unit Code
ICPRB	Interstate Commission on the Potomac River Basin
LQU	Large Quantity User
MD DNR	Maryland Department of Natural Resources
NRCS	Natural Resources Conservation Service
U.S.	United States
USDA	United States Department of Agriculture
USGS	United States Geological Survey
HVAC	Heating, ventilation and air conditioning

Units of Measurement

gal/kWh	Gallons per kilowatt hour
gal/y	Gallons per year
Mgal/y	Million gallons per year

1 Introduction

Water is an invaluable, limited natural resource. The sustainable management of this resource through conservation is essential to protecting current and future human and ecosystem demands. Variables such as changing climate, regulatory, and economic environments are likely to put supplies under greater pressure in the future, making efficient water use practices even more important. Fortunately, there are a number of conservation practices being implemented across West Virginia. This project identifies projects and practices underway in West Virginia or activities being implemented elsewhere that may be applicable in West Virginia to: 1) reduce the amount of consumptive use, 2) improve the efficiency of water use, 3) provide for reuse and recycling of water, 4) increase the supply of water, and/or 5) increase groundwater recharge.

This evaluation was conducted based on the ten major types of large quantity uses in West Virginia; namely, 1) agriculture and aquaculture; 2) chemical; 3) industrial; 4) petroleum; 5) mining; 6) public water supply; 7) recreation; 8) hydroelectric power generation; 9) thermoelectric power generation; and 10) timber. . Conservation practices associated with hydraulic fracturing are also included.

West Virginia Department of Environmental Protection's (DEP) Large Quantity User (LQU) database contains descriptions of implemented and planned water conservation programs. An analysis was conducted to categorized type of user-reported conservation programs. The conservation programs were grouped into three categories (**Table 1**):

1) improving water use efficiency through implementation of use reduction methods or equipment (category 1 method),
2) reusing or recycling water on-site (category 2 method), and
3) reducing water loss due to leaks and unaccounted water (category 3 method).

Table 1. Number of water conservation plans by category and type.

Use type	Conservation category 1	Conservation category 2	Conservation category 3
Agriculture/ aquaculture	0	3	1
Chemical	5	2	0
Frack Water	0	1	0
Hydroelectric	0	0	0
Industrial	6	0	2
Mining	26	22	2
Petroleum	3	1	1
Public water supply	15	3	37
Recreation	12	0	1
Thermoelectric (coal)	1	3	0
Timber	2	1	0

Table 2 lists the number of large quantity users by water use type and 8-Digit Hydrologic Unit Code (HUC8) that reported water conservation plans. The majority of plans, 71 percent, were created for withdrawals in the public water supply and mining sectors. The hydroelectric sector has no reported water conservation plans. **Table 3** lists the reported amount of water saved by these conservation plans. The chemical and mining sectors report the largest water savings from implementation of the conservation plans, over 400 million gallons per year (Mgal/y). **Table 4** provides a list of HUC8 watershed codes and the name of the watershed. **Figure 1** provides a map of HUC8 watersheds and the approximate location of large quantity users with conservation plans.

The following sections evaluate conservation practices that may be applicable to each water use type as well as document conservation practices by the categories described above currently underway by the large quantity users in West Virginia.

Table 2. Number of large quantity users with water conservation plans, "--" indicates no users with identified conservation plan.

HUC8	Agriculture / aquaculture	Chemi cal	Hydro-electric	Indus trial	Min ing	Petrol eum	Public water supply	Recrea tion	Thermo-electric (coal)	Timber	Frack Water
02070001	--	--	--	--	--	--	3	1	--	--	--
02070002	--	--	--	--	--	--	1	--	1	--	--
02070003	--	--	--	--	--	--	1	--	--	--	--
02070004	2	--	--	3	--	--	5	--	--	--	--
02070007	--	--	--	--	--	--	--	2	--	1	--
05020001	--	--	--	--	2	--	2	--	--	--	--
05020002	--	--	--	--	1	1	--	--	--	--	--
05020003	--	--	--	--	--	--	--	--	1	--	--
05020004	--	--	--	--	--	--	4	1	1	1	--
05020005	--	--	--	--	1	--	--	--	--	--	--
05020006	--	--	--	--	--	--	1	--	--	--	--
05030101	--	--	--	--	--	1	2	1	--	--	--
05030106	--	--	--	--	--	--	7	--	--	--	--
05030201	--	2	--	--	--	1	3	--	--	--	1
05030202	--	2	--	3	--	--	3	1	--	--	--
05030203	1	--	--	--	--	--	1	--	--	--	--
05050002	--	--	--	1	1	--	3	--	--	--	--
05050003	--	--	--	--	--	--	2	2	--	--	--
05050004	--	--	--	--	--	--	2	2	--	--	--
05050005	--	--	--	--	7	--	2	--	--	--	--
05050006	--	--	--	--	4	--	3	--	--	--	--
05050007	--	--	--	--	1	--	1	--	--	--	--
05050008	--	1	--	--	--	--	1	1	--	--	--
05050009	--	--	--	--	14	--	1	--	--	--	--
05070101	1	--	--	--	6	--	1	--	--	--	--
05070102	--	--	--	1	--	--	--	--	--	--	--
05070201	--	--	--	--	4	--	2	1	--	--	--
05070204	--	--	--	--	1	--	--	--	--	--	--
05090101	--	1	--	--	1	--	--	--	--	--	--
05090102	--	--	--	--	2	--	1	--	--	--	--
Total	4	6	0	8	45	3	52	12	3	2	1

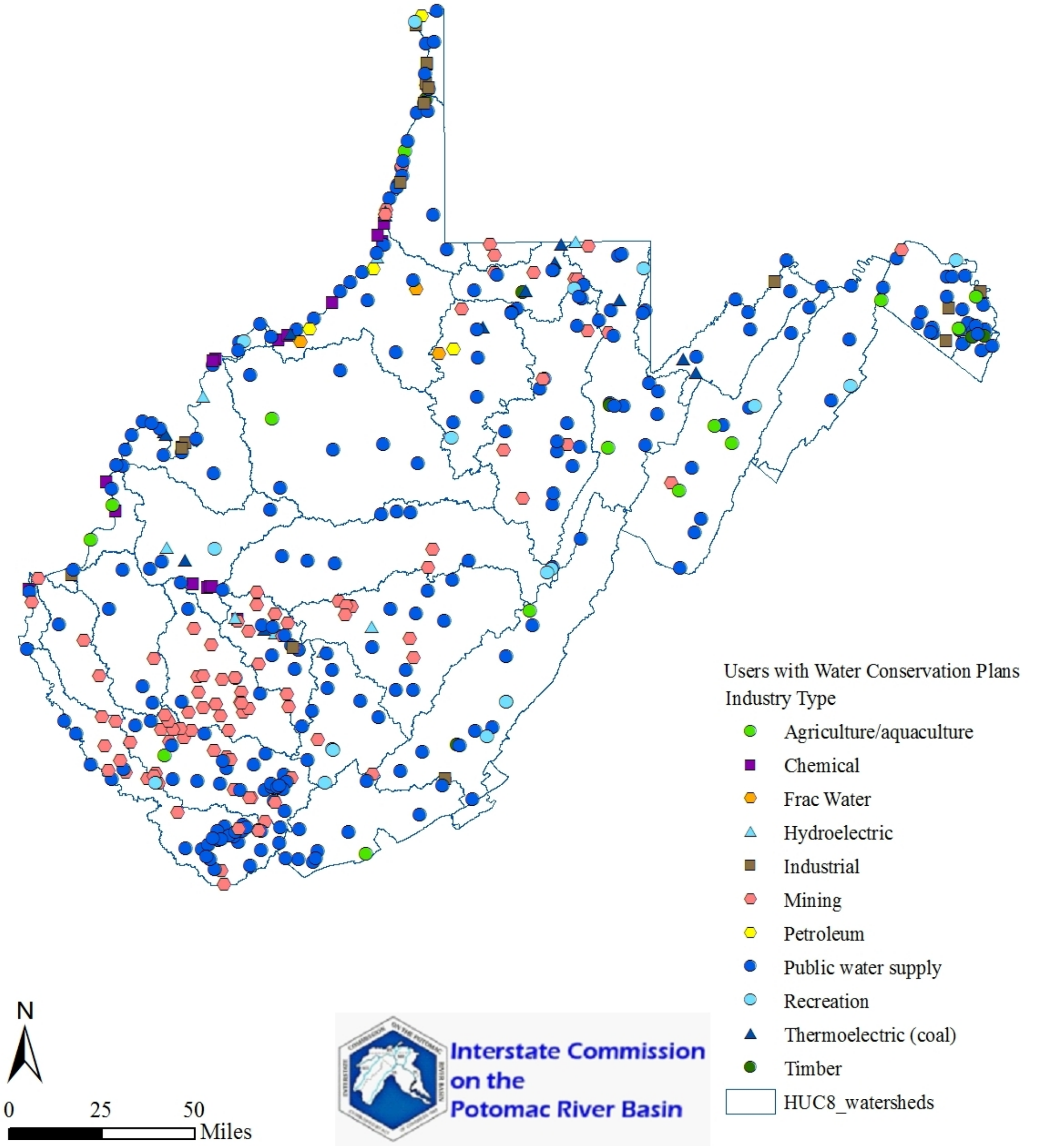
Table 3. Annual water saved by large quantity users with water conservation plans by industry type and HUC8 watershed. Units are in Mgal/y. "-- " indicates no conservation plans.

HUC8	Agriculture / aquaculture	Chemical	Hydroelectric	Industrial	Mining	Petroleum	Public water supply	Recreation	Thermoelectric (coal)	Timber	Frack Water
02070001	-	-	-	-	-	-	4.5	0.2	-	-	-
02070002	-	-	-	-	-	-	2.3	-	-	-	-
02070003	-	-	-	-	-	-	-	-	-	-	-
02070004	17.5	-	-	84.8	-	-	10.0	-	-	-	-
02070007	-	-	-	-	-	-	-	0.1	-	0.5	-
05020001	-	-	-	-	0.4	-	13.0	-	-	-	-
05020002	-	-	-	-	-	-	-	-	-	-	-
05020003	-	-	-	-	-	-	-	-	4.2	-	-
05020004	-	-	-	-	-	-	0.1	0.0	-	0.1	-
05020005	-	-	-	-	-	-	-	-	-	-	-
05020006	-	-	-	-	-	-	0.2	-	-	-	-
05030101	-	-	-	-	-	0.8	-	0.0	-	-	-
05030106	-	-	-	-	-	-	1.3	-	-	-	-
05030201	-	9.0	-	-	-	-	2.0	-	-	-	0.2
05030202	-	50.4	-	2.0	-	-	0.6	0.3	-	-	-
05030203	3.0	-	-	-	-	-	0.1	-	-	-	-
05050002	-	-	-	-	-	-	-	-	-	-	-
05050003	-	-	-	-	-	-	2.1	-	-	-	-
05050004	-	-	-	-	-	-	5.3	-	-	-	-
05050005	-	-	-	-	44.7	-	5.3	-	-	-	-
05050006	-	-	-	-	6.6	-	1.5	-	-	-	-
05050007	-	-	-	-	-	-	-	-	-	-	-
05050008	-	241.0	-	-	-	-	0.2	-	-	-	-
05050009	-	-	-	-	10.9	-	1.0	-	-	-	-
05070101	-	-	-	-	-	-	4.1	-	-	-	-
05070102	-	-	-	0.2	-	-	-	-	-	-	-
05070201	-	-	-	-	9.1	-	0.8	8.0	-	-	-
05070204	-	-	-	-	0.6	-	-	-	-	-	-
05090101	0.0	-	-	-	29.0	-	-	-	-	-	-
05090102	-	-	-	-	0.0	-	-	-	-	-	-
Total	20.6	300.4	-	87.0	101.3	0.8	54.3	8.5	4.2	0.6	0.2

Table 4. List of HUC8 watershed codes and watershed names.

HUC8	Watershed Name
02070001	South Branch Potomac
02070002	North Branch Potomac
02070003	Cacapon
02070004	Potomac Direct Drains
02070006	Shenandoah Hardy
02070007	Shenandoah Jefferson
02080201	James
05020001	Tygart Valley
05020002	West Fork
05020003	Monongahela
05020004	Cheat
05020005	Dunkard
05020006	Youghiogheny
05030101	Upper Ohio North
05030106	Upper Ohio South
05030201	Middle Ohio North
05030202	Middle Ohio South
05030203	Little Kanawha
05050002	Upper New
05050003	Greenbrier
05050004	Lower New
05050005	Gauley
05050006	Upper Kanawha
05050007	Elk
05050008	Lower Kanawha
05050009	Coal
05070101	Upper Guyandotte
05070102	Lower Guyandotte
05070201	Tug Fork
05070204	Big Sandy
05090101	Lower Ohio
05090102	Twelvepole

Figure 1. Large quantity users with water conservation plans.



2 Agriculture and Aquaculture

2.1 Aquaculture

Conservation in aquaculture projects involves making beneficial use of water that would otherwise be discharged to streams with a lower level of treatment and thus potentially reducing demands on other water sources. In certain instances the water being used is presently unsuitable for other out-of-stream uses and even has to be treated prior to use in aquaculture. A number of projects demonstrate the potential of using water from underground mines in West Virginia and surrounding states for aquaculture

(Semmens and Jacobs 2012; Semmens and Miller 2010; Miller 2008). These projects have shown aquaculture with mine water to be an economically viable opportunity (D'Souza et al 2003).

West Virginia University and a private mining company raised fish using water discharged from a mine water treatment system to demonstrate that treated mine water can be used to raise healthy fish for stocking public waters and for consumption. In fact, Miller (2008) asserts that some underground coal mines in Appalachia have desirable water quality characteristics for aquaculture (temperature, alkalinity, pH, and pathogen free). A mining company operating mines in West Virginia and Maryland worked in cooperation with the Maryland Department of Natural Resources (MD DNR) to construct and operate a trout rearing facility in the mine's acid-mine-drainage treatment system settling pond from January of 1994 through May 2007[1]. This facility produced trout used by MD DNR to re-stock the North Branch of the Potomac River and other streams in West Virginia and Maryland. There are several other commercial-scale facilities currently producing trout and other fish for fee-fishing and consumption.

2.2 Agriculture

Agricultural water use for irrigation and livestock represents a very small portion of the total water use in West Virginia. In 2007, there were 692,003 acres of harvested cropland in West Virginia. Of those, only 2,189 acres (0.3 percent) were irrigated. Water use for irrigated lands could be estimated with additional information on the crops grown in those areas.

Also in 2007, there were 370 dairy farms in West Virginia with 11,744 milk cows (USDA 2009). Milk cows can be estimated to generally use 35 gallons of water per day (Jarrett and Roudsari 2007); making the total daily water use by the dairy farms over 411,000 gallons. Despite the small agricultural water uses (when compared to other sectors), there are still opportunities for water conservation. Conservation opportunities associated with milk cows and irrigation are discussed below.

2.2.1 Dairy Farms

In 1997, 252 million pounds of milk were produced from milk cows in West Virginia, worth an estimated $38 million. Almost three-quarters of the milk was produced in Jefferson, Mason, Berkeley, Preston, Greenbrier, and Monroe counties (Baniecki and Dabaan 1999).

Water is used at dairy farms for livestock consumption, cooling milk and cows, and cleaning the facilities. Sufficient quantities of clean water are essential for these uses. Dairy operators may reuse water for multiple purposes to reduce the amount of water used. For example, once withdrawn from surface- or ground-water, the relatively cool water can be used to cool the milk just after collection. Cooling the milk prevents bacterial contamination. As a result of this process, the water is warmed. The warmed water can be used as 1) drinking water for the cows, subsequently increasing milk production; 2) washing the facilities; and 3) cooling water for the cows during the summer months. The portion of the water that is not consumed could be recycled again as long as the water quality is sufficient for the intended use (personal comm., JoBo Holstein Farm, 6/25/2012).

2.2.2 Irrigation

To conserve water, irrigation should assist in meeting the water needs of the plants without over-saturating. Over-saturation can cause a loss of irrigation water to groundwater percolation or to surface water runoff. Conservation practices appropriate for a particular application will be site-specific. A great deal of research is available to assist landowners in identifying options. For example, the Agricultural

[1] Mettiki Trout Farm, http://www.arlp.com/involvement/mettiki-trout-farm.htm, accessed 1/28/2013.

Water Conservation Clearinghouse[2] contains easily accessible information and tools on agricultural water conservation. Literature at this site is available on water conservation policy, recovery and recycling, economics, crop water use, cropping systems, drought tolerance, water conveyance and delivery, and supply and storage to name a few. Tools are also compiled in the Clearinghouse from numerous sources including irrigation schedulers, cost estimation tools, and water use estimators.

In general, ensuring that irrigation water is applied at the right times and in the right amounts saves money, energy and water. One method for conserving irrigation water includes switching from high and medium pressure systems to low pressure or drip irrigation (NRCS 2006). Drip irrigation slowly releases water directly onto or just under the soil, losing less water to evaporation than traditional types of irrigation due to limited wind exposure and reduction in opportunities for surface runoff. Watering at the coolest time of day can also reduce water lost to evaporation.

2.3 West Virginia Large Quantity Users

The LQU database lists 14 users in the agriculture/aquaculture use type. One is a commercial nursery which does not recycle water but does monitor and minimize the amount of water used, a category 3 conservation method. One aquaculture operation had water recirculation systems (category 1 method) in place but ceased operations in 2008. The other users are either commercial fish hatcheries or hatcheries producing fish for West Virginia Department of Natural Resources (DNR) stocking programs. Four of the users have identified water conservation programs utilizing recycled water (category 2 method) and reduction of losses through leaks or unaccounted water (category 3 methods) with a total reported savings of 21 Mgal/y. This represents a savings of 0.4 percent of the total annual reported agriculture and aquaculture withdrawals. Given the few large agricultural withdrawals, enhancing agricultural water conservation may require outreach to the small quantity water users.

3 Chemical, Industrial, Petroleum, and Timber

Chemical, industrial, petroleum, and timber product processors or manufacturers account for 11 percent of the total withdrawals listed in the LQU database. These industries generally use water for uses such as boiler water, cooling, in-plant processes, equipment such as vacuum pumps, general washing, and fire protection. Water conservation opportunities include installation of air-cooled equipment and forced air cooling equipment in place of water-cooled equipment. Replacement of once-through cooling systems with recirculating cooling systems reduces water use if water-cooled systems are required. All possible opportunities for water recovery and reuse or alternative water supplies should be considered, such as filtration and membrane processes and capturing condensate drain water from cooling systems, or recycling of process water for boiler makeup water. Timber industry users are included in this group due to the similarities in water use practices to the other industries in this group.

A water conservation program should start with an audit or survey of existing water use within the facility. There are guidelines and examples available of water use audits or surveys from several sources (EPA 2011; NC-DENR 2009; GE Water 2007). A number of examples from across the country illustrate the types of conservation activities in this sector. Boiler operators remove built-up scale and other chemicals in boilers by expelling water from the boiler in a process called “blowdown”. This water is usually discharged due to its high chemical content. Automated boiler blowdown systems can reduce blowdown water losses by up to 20 percent and reduce the boiler’s energy use by 2 to 5 percent (NC-

[2] http://www.agwaterconservation.colostate.edu/Default.aspx, accessed 2/26/2013.

DENR 2009). Clean wastewater from other in-plant processes or equipment can be used as boiler makeup water reducing overall water use.

There are a number of case studies that could inform conservation practices for this sector in West Virginia:

- A glass manufacturer in North Carolina used water from air compressors and hydraulic fluid cooling water for boiler makeup. The reuse practice saved 8.5 million gallons of city water per year and was implemented for $3,000. Simple payback period for this modification was two months (NC-DENR 2009).
- A ConAgra potato processing plant in Idaho installed a tank, pump, and piping to capture compressor cooling water and reuses the heated water in the waste treatment plant. These changes had an equipment cost of $10,000 but an energy cost savings of $96,000 per year and 44.35 Mgal of water savings per year (GEMI 2007).
- A Roche pharmaceutical plant in Boulder, Colorado, upgraded the seal systems on two of six wastewater treatment system pumps and started using process water instead of city water for seal flushing on the other four pumps. The upgraded seals allowed the seal flush to be eliminated or replaced with used process water without any adverse effects on the pumps. Aggregate annual water savings were about 3.7 Mgal and $17,500 per year. With a total project cost of $23,300, the simple payback was 16 months (GEMI 2007).

Timber industry facilities listed in the LQU database are manufacturers of paper, wood, or timber-related products. As these manufacturers use water for similar processes such as making steam, processing raw materials, and cooling, the same types of conservation practices are applicable as for the other industrial users. One of the timber industry users reports that they installed air-cooled air conditioning units to replace their water-cooled units and implemented a water reuse system – the same types of systems applicable to other industrial users.

3.1 West Virginia Large Quantity Users

The LQU database lists 16 chemical users. Six of these users have conservation plans with a total savings listed as 300 Mgal/y or 0.2 percent of annual withdrawals. The LQU database lists 17 industrial users with 8 having conservation plans. Total water savings for these users is listed as 87 Mgal/y or 0.1 percent of annual withdrawals. The LQU database lists 6 petroleum users with 3 having conservation plans and total water savings listed as 800,000 gal/y or 0.1 percent of annual withdrawals. There are 7 timber users in the LQU with 2 users reporting having conservation plans with a total of 568,000 gal/y or 0.04 percent of annual withdrawals. Eighty-four percent of the responding chemical, industrial, petroleum, and timber users identified having category 1 conservation methods, 21 percent report category 2 methods, and 16 percent report including category 3 methods.

These groups of industries represent 11 percent of all water withdrawn as listed in the LQU database but were responsible for 67 percent of the water that was conserved. These industries are making investments in water conservation and efficiency that should be encouraged and expanded.

4 Coal Mining

Coal mining operations use water for washing and processing raw coal, separation of coal from rock, dust suppression on roadways, and potable uses for employees. In addition, underground coal mines in West Virginia use water for "cooling the cutting surfaces of mining machinery and for inhibiting friction-induced ignition of coal fines or gas" (Mavis 2003). Informal reports suggest, though, that the majority of water is used at coal mines for dust control (Mavis 2003). On average, coal mines use 50-59 gallons of water per ton of coal produced (USGS 2009). Mining activities, therefore, pose a significant opportunity for water conservation and reuse in the state. Two ways that coal mining-related water conservation activities can be implemented are by initiating programs to conserve and reuse water during the mining process and by finding ways to reuse mine pool water for other purposes.

4.1 On-Site Conservation and Reuse

Mining operations can implement on-site water conservation activities and reuse water for multiple mining-related purposes. The amount of water used for dust suppression, being the major type of on-site water use, can be reduced through the addition of salts to the water. Specifically, magnesium chloride solution and calcium chloride are added to facilitate dust suppression (Mavis 2003). Over time, however, this process may have negative environmental impacts including increased salt loads in the soil, shallow groundwater, and local streams as well as associated impacts to fish, wildlife, and vegetation (EPA 2002).

Where possible, many coal mines reuse water for multiple on-site operations because of the sheer quantity of water needed and due to the economic incentives. Water reuse capabilities are determined by water quality requirements, water availability, and discharge considerations (Mavis 2003). For example, wastewater from the mine that is generated through seepage into the mine area can be reused for fire fighting and underground dust suppression. Other types of on-site wastewater that can be reused are the process wastewater and domestic wastewater.

4.2 Reuse by Other Water Sectors

Mine pool water can also be used for water supplies in other, non-mining sectors. There are an estimated 100,000 abandoned underground mines in West Virginia[3]. Although many of these are small and would likely not be an economically viable source of water, the larger mines may prove to be valuable additional supplies. For example, the National Mineland Reclamation Center mapped 130 underground coal mines in Pennsylvania and West Virginia with an estimated combined storage of 250 billion gallons (Veil et al. 2003).

Reuse of mine pool water for cooling in thermoelectric power generation plants has been recently investigated (Feeley et al. 2005; Donovan et al. 2004; Veil et al. 2003). As an example, Veil et al. (2003) evaluated the feasibility of using underground coal mine pool water for power plant cooling in Pennsylvania and West Virginia. This methodology was considered for the following types of power plants: steam electric power plants with closed-cycle cooling technology, closed-cycle cooling reservoir, and as a source of once-through cooling water. Donovan et al. (2004) found that there are several potential mines in the Pittsburg Coal Basin of northeastern West Virginia. The practicality of use is dependent on several factors such as the water quality characteristics of the mine water. Curtright and Giglio (2012) also suggested that mine water could be used in Marcellus Shale hydraulic fracturing activities.

Mine pool water may provide additional supplies for public drinking water, where water quality conditions are adequate. Loudoun Water in the Potomac basin is considering utilizing quarries as an

[3] Estimate developed by the West Virginia Geologic and Economic Survey.

additional source of water to meet anticipated water shortages. The water supplier would fill the quarry with Potomac River water during high flows and utilize the quarry water during times of low river flow. One quarry being considered for this purpose has a one billion gallon storage capacity (Black and Veatch 2008).

4.3 West Virginia Large Quantity Users

There are 102 mining users listed in the LQU database. Forty-five of these users report having water conservation plans in place. Of these users, 58 percent reported category 1 conservation methods, 49 percent reported category 2 methods, and 4 percent reported category 3 methods. The conservation measures include paving or applying chemical treatments to roadways for dust suppression, recycling water from settling ponds for coal preparation, and reduction of losses from leaking or malfunctioning equipment. A total of 101 Mgal/y, or 0.7 percent of annual withdrawals, is reported as being conserved by mining users. The other 55 percent of mining water users not reporting conservation programs may be an opportunity for additional outreach, education, and potential future water savings or reuse.

5 Public Water Supply

Public water suppliers withdraw water, treat it for human consumption, and deliver it to their customers. Water conservation methods available to public suppliers focus on water use efficiency in the distribution system and by their customers. Conservation methods include: conservation of water through leak detection in the distribution system and conservation programs to reduce use by customers (Templin et al. 1980).

5.1 Conservation in the Distribution System

Due to aging infrastructure, administrative and data handling errors, and problems with water metering, a significant portion of water for public supplies is "lost" or goes unaccounted (EPA 2009). Resources are available to assist public water suppliers in identifying losses in the system. For example, the American Water Works Association developed a free tool that identifies water losses and identifies parts of the system needing improvement (AWWA 2009).

5.2 Customer Education and Conservation

Conservation in the public water supply system has many benefits including using up to 20 percent less water, making additional water available for human and ecosystem uses (Penn State 2008). Conservation programs targeted to users of public water supplies include public education, retrofitting existing plumbing fixtures with low-flow fixtures, providing water conservation consulting services to industrial and commercial users, and implementing use-based rate structures (Templin et al. 1980).

Education and outreach to the general public promotes the use of in-home water conservation activities in people's daily lives – such as limiting showering time, not leaving water running during dish washing and teeth brushing, and purchasing water efficient appliances to name a few[4].

A Pioneer Institute study found that voluntary practices and education programs are less effective at conserving water than well-enforced mandatory programs, suggesting the need for additional water conservation policies (Olmstead and Stavins 2007).

[4] The Energy Policy Act of 1992 required that new toilets for homes must use 1.6 gallons per flush or less.

5.3 West Virginia Large Quantity Users

The LQU database list 253 public water suppliers in West Virginia. Fifty-two of these users reported having water conservation plans. The majority of these public suppliers (71 percent) reported having conservation plans that include category 3 methods, detecting and repairing leaks within the distribution system. Also identified were category 1 measures (29 percent), specifically, water conservation measures by customers during periods of low supply, public education, and the installation of water use meters at customer facilities. Only 6 percent of public suppliers reported category 2 methods as part of their conservation programs. The total savings is 54 Mgal/y or 0.1 percent of annual withdrawals by all public water suppliers.

6 Recreation

Recreation users listed in the LQU database are primarily golf course resorts which include water uses for irrigation; food services; heating, ventilation, and air conditioning (HVAC); maintenance; and general potable use. Another category of users in the recreation category is ski resorts. In addition to using water for the same general uses as golf course resorts, ski resorts use water for snowmaking.

6.1 Conservation Methods

Conducting a water use audit should be the first step of any conservation program. Understanding where and how water is used will allow identification of conservation and/or reuse opportunities. There are many water saving opportunities in the resort setting. Guidelines and best management practices for conserving water in this sector have been developed by states and other organizations (FL DEP 2009; EPA 2004). Several organizations and states have developed best management practices specifically for golf courses (Irrigation Association 2010; Carrow et al. 2007; CT DEP 2006). New Hampshire has developed a fact sheet providing guidelines for water conservation for snowmaking (NHDES 2010).

Conservation methods by golf courses include installation of high efficiency irrigation control systems and equipment, a category 1 method. Some operators reported reducing the level of irrigation water to only keep the grass alive, not “lush and green” and operating the irrigation systems manually to deliver water only to the areas needing water, not the entire golf course (a category 2 type conservation method, reducing loses). Another potential water-saving opportunity on golf courses is wastewater reuse. A golf course and residential community in Pennsylvania evaluated diverting some of the treated water from its wastewater treatment system to fill the golf course irrigation ponds as a way to recycle water and reduce withdrawals from wells and surface water sources. The existing size of the community does not make the treatment system modifications economical yet, but when the community build-out is reached the builder is expecting to make this change to the system (personal comm., White Run Regional Authority System, 6/20/2012).

Ski resorts also present an opportunity for water conservation activities. An example of ski resorts implementing a water conservation method for snowmaking operations is at Ski Liberty in Pennsylvania. Ski Liberty uses surface runoff-fed ponds as the supply for snowmaking water and augments the natural surface precipitation runoff feeding the ponds by using highly treated wastewater from the facility’s treatment system. This reduces withdrawals from groundwater or other surface water sources (personal comm., Ski Liberty – PA, 2010).

6.2 West Virginia Large Quantity Users

Of the 20 recreation users, 12 reported having water conservation plans in place that included installation of improved irrigation systems or reducing irrigation by additional monitoring of course conditions (category 1 conservation methods). Other category 1 conservation measures included installation of high efficiency equipment and plumbing fixtures. The total water savings reported by these recreation users with conservation plans was 9 Mgal/y or 0.6 percent of annual withdrawals.

7 Hydroelectric Power Generation

Hydroelectric power generation is the largest use type in the LQU database representing 99 percent of the total average annual withdrawals. However, the withdrawals listed for hydroelectric power generation are almost completely non-consumptive with only a small amount of water lost to evaporation from the pool upstream of the dam at the generating facility. The majority of the hydroelectric plants are run-of-river facilities with relatively little storage in the pool behind the dam. None of the listed hydroelectric users reported conservation programs.

8 Thermoelectric Power Generation

Thermoelectric power generation uses large quantities of water (Gerdes and Nichols 2008) to produce steam to drive electrical power generating turbines, cool and condense the steam, provide boiler make-up water, use in flue gas desulfurization (FGD) technology, and other plant processes. One of the other processes that use significant amounts of water is carbon dioxide recovery systems. There are three basic types of cooling systems used in thermoelectric power plants: once-through, recirculating, and dry cooling. In a once-through system, water is drawn from the source, used to cool and condense the steam, and returned to the source. In a recirculating system the steam is passed through large cooling towers where the water is used to cool and condense the steam which is then captured in ponds and recirculated through the cooling tower. A much larger amount of the water is lost to evaporation so the consumptive loss in a recirculating system is greater than in a once-through system even though the amount withdrawn is smaller. A study by the U.S. Department of Energy (DOE) (Feeley et al. 2005) compared the water use per kilowatt hour produced in thermoelectric plants using once-through and recirculating cooling systems. The average withdrawal for once-through cooling was 37.7 gallons per kilowatt hour (gal/kWh) with consumption of 0.1 gal/kWh while the withdrawal for recirculating cooling was 1.2 gal/kWh with consumption of 1.1 gal/kWh produced (Feeley et al. 2005). Dry cooling systems pass the steam through air-cooled heat exchangers to cool and condense the steam. The only water used in this process is for boiler make-up water. Dry cooling systems use a larger amount of energy, generally need more area, and are more expensive than systems using water for cooling.

8.1 Conservation Methods

The DOE funded a project to evaluate the potential to extract water vapor from coal-fired power plant flue gases in order to reduce makeup water requirements for the plant's cooling water system (Folkedahl et al. 2006). The project concluded that although economic models indicate this technology can provide positive return on investment, it will take several years of development and continued focus on water resource management before these systems will yield the return that will make these systems attractive in the industry.

The use of freshwater in thermoelectric power generation may be reduced through the use of water in flooded and abandoned coal mines as a source of cooling water (Donovan et al. 2004). This is a potential future water conservation activity for West Virginia.

8.2 West Virginia Large Quantity Users

Thermoelectric power plants account for the second largest amount of withdrawals, after hydroelectric power generation, listed in the LQU database and have 15 users listed. The specific uses listed include cooling water, boiler make-up water, and service water for other plant processes. Three of the users reported having water conservation plans, all listing reusing or recycling water (category 2 conservation method) and one also listing the conversion to closed-loop type of cooling system (a category 1 method). These programs resulted in reported water savings of 4 Mgal/y which is less than 0.01 percent of total annual withdrawals of water at these three facilities.

9 Hydraulic Fracturing

9.1 Hydraulic Fracturing

Large amounts of water are used for hydraulic fracturing, or "hydrofracking," in the process of drilling gas extraction wells in the Marcellus Shale and other unconventional shale gas plays. Sand and various chemicals are pumped under high pressure into the well bore to create many micro-fractures in the shale rock holding the natural gas. These micro-fractures allow the gas contained in the rocks to be released and extracted through the well. Most of this injected water returns to the surface and is recovered, called "flowback water." During the extraction of natural gas from the well, additional "production water" is also extracted.

9.2 Water Reuse

In a recent trend in the gas exploration industry, most of this flowback and recovered water is being stored on-site, treated, and reused in fracking other wells. In a recent study for DOE, six of seven Marcellus Shale operators indicated they use all or some of the flowback and production water for fracking operations at other wells (Veil 2010). West Virginia Water Research Institute conducted a project under contract to DOE to evaluate technologies and develop and evaluate a mobile on-site treatment system. The system was designed to treat flowback and recovered water so it can be used for additional fracking operations (Ziemkiewicz et al. 2012). The resulting system was installed in a trailer-mounted shipping container and deployed at a Utica Shale well site in Ohio and a Marcellus Shale well site in West Virginia. Over 600,000 gallons of flowback water was treated at the two sites with 98.6 percent of the water being recycled (Ziemkiewicz et al. 2012).

9.3 West Virginia Large Quantity Users

The LQU database has three users with a use type of "frack water" located in watershed 05050002 West Fork and 05030201 Middle Ohio North. Only one of the users has reported having a conservation plan stating the water will be recycled and used in 30 other gas wells (category 2 conservation method) over a five-year period with a total savings of 225,000 gallons per year (gal/y) or 0.1 percent of annual withdrawals.

10 Summary

Implementation of water conservation and reuse activities in West Virginia may be an essential component of meeting the growing demands with the limited water resources. Fortunately, there are numerous methods for conservation and reuse in each water use sector, as evidenced by the available literature from the Mid-Atlantic region and across the country. Existing programs and opportunities for future conservation efforts in the state were identified through an evaluation of DEP's LQU database.

The database identifies 1) users by industry category, 2) user provided information on water conservation plans such as what conservation measures the plan includes, and 3) expected water savings produced by the plans. This analysis categorized the conservation plans by the types of measures they contained; 1) improving water use efficiency through use reduction methods or installing improved-efficiency equipment, 2) on-site water reuse or recycling, and 3) loss reduction due to leakage or waste. Water conservation methods applicable to each of the ten industry types, plus hydraulic fracturing, were reviewed. The number of users implementing conservation programs was identified. The reported savings resulting from these conservation plans was totaled.

Public water suppliers had the largest number of users reporting conservation plans with 52 users, followed by mining with 45 users reporting conservation plans. The industry reporting the largest total savings however was the chemical industry with 300 Mgal/y savings. Mining had the second largest with 101 Mgal/y total savings from conservation plans. In terms of the percentage of withdrawals saved by conservation plans, no industry reported total savings to be as much as 1 percent of the total reported withdrawals. In total, the conservation efforts of the large quantity users with conservation plans resulted in 578 Mgal/y of annual water savings. However, this is 0.03 percent of all withdrawals by large quantity users, so there are many more opportunities for additional water conservation.

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