PENNSYLVANIA AGRICULTURAL CONSUMPTIVE WATER USE STUDY

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SUSQUEHANNA RIVER BASIN COMMISSION

The Susquehanna River Basin Commission was created as an independent agency by a federal-interstate compact* among the states of Maryland, New York, Commonwealth of Pennsylvania, and the federal government. In creating the Commission, the Congress and state legislatures formally recognized the water resources of the Susquehanna River Basin as a regional asset vested with local, state, and national interests for which all the parties share responsibility. As the single federal-interstate water resources agency with basinwide authority, the Commission's goal is to coordinate the planning, conservation, management, utilization, development and control of basin water resources among the public and private sectors.

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EXECUTIVE SUMMARY

Background

From July 2002 to December 2005, the Susquehanna River Basin Commission (Commission) undertook a review of management options to address the need for compensation for agricultural consumptive water use in the Pennsylvania portion of the Susquehanna River Basin. Commission regulations require operations to compensate for their consumptive water use during times of critical low flows. In recognition of the economic and operational burdens the compensation options imposed on individual farmers, the Commission, in 1992, temporarily suspended the consumptive water use regulations as they apply to agricultural operations.

In 2002, the Commission completed a study investigating the feasibility of providing dedicated water storage at the George B. Stevenson Reservoir (Stevenson Reservoir) to offset agricultural consumptive water use. The Stevenson Reservoir is owned by the Pennsylvania Department of Conservation and Natural Resources. The conclusion from that study, which was conducted pursuant to a grant agreement with the Pennsylvania Department of Environmental Protection (PADEP), was that the water storage project was not feasible, thus resulting in the need to evaluate alternatives to address compensation for agricultural consumptive water use in the Pennsylvania portion of the Susquehanna River Basin. The Commonwealth of Pennsylvania, again through a grant agreement with the PADEP, funded this second study of management options.

Need for Study

Like all other consumptive water uses, the consumptive use of water by agriculture has the potential to adversely affect aquatic resources and habitats of the basin and can impact other water users. The objective of the Commission's consumptive water use regulation is to mitigate these potential impacts by requiring users to make up for or otherwise compensate for their consumptive use during periods of low flows. Water users can achieve compliance by relying on storage or use other water sources, provided they do not further diminish inflow to the river systems of the Chesapeake Bay. In this way, water is added to the system to offset or compensate for losses related to the consumptive water uses. Water users who cannot secure makeup water can choose to discontinue water use during critical low flow periods or pay a fee to the Commission. The Commission utilizes such fees to develop water storage for release during critical low flow periods. It is the desire of the Commission and the Commonwealth to develop a compliance program on behalf of the agricultural community as a whole in lieu of requiring compliance by individual farmers and operators.

Study Objective

The objective of the study was to identify and evaluate water management options that could satisfy regulatory requirements for agricultural consumptive water use in Pennsylvania.

An important first step in this study was to quantify the amount of agricultural consumptive water use for which compliance is needed. Although there are many agricultural operations in Pennsylvania, not all are subject to Commission consumptive water use regulations. Use that was occurring at the time of the Commission's formation in January 1971 is exempt from regulation. Similarly, operations that consume less than 20,000 gallons per day (gpd) (as a 30-day average) are exempt, as specified in Commission regulations. Likewise, projections of future use were made to ensure that any recommended solutions can offset enough use to remain viable through 2025. Finally, it was essential to understand at what times during the year different agricultural operations consumptively use water so that the appropriate management options are assured to be available when and where the offsetting water is needed.

Using the information on quantity of water needed, along with the seasonal nature and location data, the Commission examined multiple options for securing a source (or sources) of water that can be made available to, and operated by, the Commonwealth and/or the Commission. The analysis considered the availability of the water during the critical low flow periods, the proximity of the water sources to areas of intensive agricultural consumptive use, and the ease or difficulty of implementing a project and the associated costs.

Quantity of Consumptive Use

Based on work done in 2002 under contract to the Commission by the Department of Agricultural Engineering at the Pennsylvania State University, and assuming the occurrence of a 50-year drought, Commission staff developed estimates of agricultural consumptive water use offset needed during low flow periods. The need for offset was adjusted to reflect only that quantity of water subject to Commission regulatory authority, factoring out estimates of pre-1971 uses, as well as estimates of the use by smaller, exempt agricultural operators. Finally, the need for offset water for agriculture was evaluated considering the difference in timing when agricultural consumption peaks (late spring/early summer) and when low flows historically occur most frequently (mid summer/mid autumn).

Considering the monthly distribution of agricultural consumptive water use and the expected timing of the need for offset (based on the typical annual hydrologic cycle), Commission staff concluded that a net volume of 4,900 acres-feet (ac-ft) of water, provided at a maximum rate of approximately 15.7 million gallons per day (mgd), is needed to appropriately offset the agricultural consumptive water use in the Pennsylvania portion of the Susquehanna River Basin. It is estimated, based on an analysis of existing hydrological records at 10 different United States Geological Survey (USGS) gages throughout the basin, that this offset would occur for an average of 11 days once every 8 years.

Management Options

Commission staff investigated five distinctly different management options that could potentially provide water to offset the consumptive use of water by agriculture in the Pennsylvania portion of the Susquehanna River Basin:

Surface Water Storage Sites: Commission staff identified and evaluated existing federal, state, municipal, and privately owned impoundments that could offer storage capacity for downstream flow augmentation. Existing unused (abandoned) water bodies and the construction of small farm ponds were also considered.

Aquifer Storage and Recovery Methods: Aquifer storage and recovery (ASR) is the generic name for any method that provides subsurface water storage via artificial recharge. In such projects, water would be banked during times of surplus and then discharged to augment stream flows during times of need.

Wetlands: Commission staff surveyed existing wetlands throughout the basin and investigated the capacity of the wetlands to recharge aquifers.

Water Conservation/Water Recycling/Best Management Practices: Commission staff investigated the potential water savings offered by water use innovations. Although not a direct offset of agricultural consumptive water use, water-saving techniques can compliment other initiatives by decreasing the amount of water consumptively used, thus lessening the impact of consumptive use on the water resources of the basin.

Regulatory Incentives: The Commission reviewed and evaluated existing regulatory incentives and regulatory programs, along with developing potential incentives to minimize consumptive use of water in the agricultural sector.

Evaluation of Management Options

For the purpose of gauging the suitability of the various management options in meeting the agricultural offset need, each option was rated with respect to the quantity of water it was able to provide, the proximity of the water to the drainage basins in need, and the expected benefits or impacts to water quality, habitat, and recreation. Factors such as the ease or difficulty of implementation, the long-term sustainability of the options, and expected relative costs were also assessed. Numerical ratings of the key factors were determined for each management option. A summary rating for each option was then tallied using a composite of the outcomes of the ratings for key factors, and was used to rank the options and identify those that are most favorable for meeting the needs of Pennsylvania's agricultural community.

Summary of Findings

The Commission concluded that using a combination of pumping from underground mine pool storage and using storage at public and privately owned surface water impoundments was the preferred method of providing the quantities of water necessary to offset agricultural consumptive use in Pennsylvania.

A third part of the selected plan involves the support for water conservation/water recycling/best management practices (BMPs) at agricultural operations. Although these initiatives would not directly offset consumptive losses, they would reduce that portion of agricultural consumptive use not subject to the Commission's consumptive loss regulation.

Implementation of Selected Plan

The Commission found that using a combination of pumping from underground mine pool storage and the use of storage at publicly and privately owned surface water impoundments is the most feasible and cost-effective solution for offsetting the consumptive use of water by Pennsylvania agriculture, provided that a funding mechanism can be secured to insure a steady revenue stream to fund the ongoing operational readiness of the selected components. In order to implement this portion of the plan, further work is needed to develop the specific details and operational arrangements at each location (mine pool or surface water impoundment). The scope of work for this study did not include this detailed work as part of this feasibility level study.

Recommendations

The study includes the following recommendations:

1. The Commission, in cooperation with the Commonwealth of Pennsylvania, should implement the necessary projects to provide the 15.7 mgd of water necessary to offset agricultural consumptive water use in the Susquehanna River Basin in Pennsylvania.

2. The Commission, in cooperation with the PADEP, Office of Mineral Resources, other appropriate agencies, and independent owners, should perform technical investigations of underground mine pool sites that have the greatest potential for flow augmentation. For each site considered, the studies should evaluate factors including, but not limited to, the quantity of water available; the interconnectivity of the underground mine pool with nearby surface water bodies; the proximity of the underground mine pools to the agricultural consumptive water use; the quality of water available, including its potential to improve downstream water quality; the treatment requirements; and the cost to implement.

3. The Commission, in cooperation with the PADEP, Office of Mineral Resources, other appropriate agencies, and independent owners, should perform technical investigations of flooded mine sites that have the greatest potential for flow augmentation. For each site, the studies should evaluate factors including, but not limited to, the quantity of water available; the interconnectivity of the underground mine pool with nearby surface water bodies; the proximity of the flooded surface mine to the agricultural consumptive water use; the quality of water available,

including its potential to improve downstream water quality; the treatment requirements; and the cost to implement.

4. The Commission, in cooperation with the Pennsylvania Fish & Boat Commission, Pennsylvania Game Commission, Department of Conservation and Natural Resources, other appropriate agencies, and independent owners, should perform technical investigations of state-owned water impoundments that have the greatest potential for flow augmentation. For each site that is considered, the studies should evaluate factors including, but not limited to, the quantity of water available; the proximity to the sources of agricultural consumptive water use; the potential to improve downstream water quality; potential impacts on habitat, recreation, and other current uses of the impoundment; physical improvements required to enable the releases of water; and cost.

5. To implement the recommendations of this study, the Commission should continue to work cooperatively with the Pennsylvania agricultural community, including the major farm organizations, the Pennsylvania Department of Agriculture, and other agricultural interests who are members of the Commission's Agricultural Water Use Advisory Committee.

6. The Commission should make the appropriate changes to the current suspension of its consumptive water use regulations, as it applies to agricultural operations, as part of an omnibus revision to the Commission's *Regulations and Procedures for Review of Projects*.

Additional recommendations that would be beneficial to the water resources of the basin:

1. The wetland location analysis tool developed as part of this study should be used to more effectively locate sites for wetland construction and restoration.

2. Susquehanna basin farmers should be encouraged to consult with the appropriate agencies, including the United States Army Corps of Engineers (USACE), Natural Resource Conservation Service (NRCS), New York State Department of Environmental Conservation (NYSDEC), PADEP, Maryland Department of the Environment (MDE), and Maryland Department of Natural Resources (MDNR), when considering wetland construction and restoration activities.

3. The agricultural community should support water conservation and water recycling BMPs in the Commonwealth in the interest of water sustainability.

4. Regulatory incentives for farmers to employ soil and water conservation practices should be used along with other incentives to encourage water storage, water recycling, water conservation, and water quality improvements that result in environmental and societal benefits.

1.0 INTRODUCTION

1.1 Purpose of Study

The purpose of the study was to undertake a review of management options to address and offset, to the maximum extent possible, the consumptive use of water by agricultural operations in the Pennsylvania portion of the Susquehanna River Basin. Water is *consumptively used* whenever the amount of water returned to the basin is less than the amount withdrawn. Examples of water uses that are dominantly consumptive (i.e., most of the water is not returned to the basin) include irrigation, evaporative cooling, and bottled water.

The study was performed by the Susquehanna River Basin Commission (Commission) for the Pennsylvania Department of Environmental Protection (PADEP) under a grant provided by PADEP.

1.2 Background/Need for Study

The need for this study was based on both the potential adverse impacts caused by consumptive water use of agricultural operations and the regulatory requirements of the Commission. Both of these needs are discussed below.

An earlier study by Gannett Fleming, Inc. (2002), on behalf of the Commission, assessed the potential to develop water storage for agricultural consumptive loss makeup in the Commonwealth-owned George B. Stevenson Reservoir in Cameron and Potter Counties. This study concluded during its initial phase of investigation that developing surface water storage was technically infeasible and economically unjustified. Therefore, the present study was initiated and investigated a wide range of different management options that, individually or in combination, could possibly lead to an acceptable industry-wide/global solution to the Pennsylvania agricultural consumptive use problem, rather than focusing on compliance at the individual farm operation level.

1.2.1 Impacts of Agricultural Consumptive Use

Like all other consumptive uses, the consumptive use of water by agriculture has the potential to negatively affect the aquatic resources and aquatic habitats of the source waters. Water consumed directly reduces the quantity of streamflow in the vicinity and downstream of the withdrawal point. Nearby downstream users may also be impacted. Water withdrawn from groundwater resources and subsequently consumed has the potential to impact surrounding groundwater users, as well as reduce the amount of groundwater feeding surrounding surface water streams. The reduction of the groundwater contribution to streamflow (base flow) results in reduced streamflow during low flow periods. In some instances, large agricultural groundwater withdrawals may induce infiltration from adjacent surface water streams.

Conversely, the consumptive use of water by agricultural operations is a necessity in order to maintain operations during low flow periods. Simply stopping the consumptive use of water by agricultural operations during low flow periods would certainly have drastic impacts to human and livestock health and welfare, as well as to economic interests of the Commonwealth.

Therefore, it is in the Commonwealth's best interests to develop compensation or mitigation for agricultural consumptive water use during critical low flow periods.

1.2.2 Commission Consumptive Loss Makeup Regulation

The Commission regulates certain consumptive water uses that have come into existence since January 23, 1971, the effective date of the Susquehanna River Basin Compact. Its regulations apply to operations that consumptively use more than 20,000 gallons per day (gpd) (based on a 30-day average). Such operations are required to compensate in some manner for their water use during times of critical low flows. The goal of the compensation is to restore the streamflow to the levels that would occur if the regulated consumptive use projects were not in operation. The stress to habitat and downstream users would then be the same as if there were no upstream consumptive uses, and consumptive use would not worsen the impacts of a naturally occurring drought. Under Commission regulations, projects must compensate for consumptive use when the flow at a specified stream gage falls below predetermined low flow thresholds. The Commission commonly selects as a threshold the Q7-10 flow (the average minimum streamflow expected for 7 consecutive days once every 10 years, on average) or Q7-10 plus the amount of consumptive use at the point of taking, but local conditions can dictate that a different, more protective threshold be established. Compliance options include complete discontinuance of consumptive use, releases from an approved source (pond, lake, mine pool, etc.), imposition of conservation measures, and payment of a consumptive use fee to the Commission to provide compensation on behalf of the project sponsor.

1.2.3 Suspension of Regulation for Agricultural Industry

Although many agricultural operations exceed the regulatory threshold for consumptive water use, the Commission took action several times from 1992 through 1995 to temporarily suspend its regulation of consumptive water use for agricultural uses in recognition of the economic burden that consumptive use compensation options imposed on individual farmers. In 1995, when the Commission's comprehensive package of regulatory revisions was adopted, the suspension of the regulation as it pertains to agriculture was extended indefinitely until such time solutions are identified and implemented. Commission staff and the Commission's Agriculture Water Use Advisory Committee (comprised of individual farmers and representatives of agricultural industry groups and agencies) were charged to develop an industry-wide solution to the problem in lieu of asking for compliance by individual farm operations. The Commission has been studying options to assist the farm community in developing reasonable and sustainable solutions to compensate, to the fullest extent practicable, for impacts of consumptive water use. This study is the culmination of the latest efforts to develop such a solution.

1.3 Scope of Study

The scope of study focused on developing a comprehensive solution to the Pennsylvania agricultural consumptive water use in the Susquehanna basin, rather than requiring consumptive loss compliance by each individual farm operation. The details of the study scope are contained in Annex A (complete Scope of Work). Major elements of the scope of study are summarized below.

1.3.1 Geographic Area

This study focused on those management options that could be implemented in the Pennsylvania portion of the Susquehanna River Basin (see Figure 1-1). Approximately 20,950 square miles, or 76 percent of the entire Susquehanna River Basin, are located in Pennsylvania.

1.3.2 Determination of Jurisdiction

An important task of this study was to identify Pennsylvania agricultural operations in the Susquehanna River Basin that are subject to Commission regulations and, therefore, require compensation for consumptive water use during low flow periods. Operations subject to regulation are those that: (1) began after the Susquehanna River Basin Compact was executed in 1971; and (2) use in excess of the Commission's regulatory threshold of 20,000 gpd. After examining the data on agricultural water use in the Pennsylvania portion of the basin, the Commission determined that 785 agricultural operations are likely to be subject to the Commission's consumptive loss makeup regulation. This study focused on meeting the compliance need for only those operations.

1.3.3 Level of Detail

This study was intended to provide a reconnaissance level assessment, complete with an economic impact analysis, of a number of management options that could address agricultural consumptive water usage. The study was to identify those options, or combination of options, that had the most potential to offset the quantity of water currently being consumed by agriculture in the Pennsylvania portion of the Susquehanna River Basin. Taking action on the study's recommendations will require more in-depth analysis of specific projects and funding for the implementation of the selected plan.

1.3.4 Participants

During the course of the study, Commission staff worked with personnel from the United States Army Corps of Engineers (USACE), PADEP, Pennsylvania Department of Conservation and Natural Resources (DCNR), New York State Department of Environmental Conservation (NYSDEC), United States Department of Agriculture's (USDA's) Natural Resource Conservation Service (NRCS), Pennsylvania Department of Agriculture, and the Commission's Agriculture Water Use Advisory Committee. Additionally, technical investigative subcontracts were executed with Moody Associates, Gannett Fleming, Inc. (Dam Section) and Gannett Fleming, Inc. (Economic Rates Section).

Figure 1-1. Susquehanna River Basin and the Six Major Subbasins

2.0 TYPES AND QUANTITY OF AGRICULTURAL CONSUMPTIVE WATER USE

2.1 Types of Consumptive Use

The consumptive use of water is, as defined in the Commission's *Regulations and Procedures for Review of Projects*, "the loss of water from a ground-water or surface water source through a manmade conveyance system (including such water that is purveyed through a public water supply system), due to transpiration by vegetation, incorporation into products during their manufacture, evaporation, diversion from the Susquehanna River Basin, or any other process by which water withdrawn is not returned to the waters of the basin undiminished in quantity." Similarly, in the same referenced publication, agricultural water use is defined as "water use associated primarily with the raising of food or forage crops, trees, flowers, shrubs, turf, aquaculture and livestock."

The consumptive use of water by agriculture can occur wherever agricultural water use occurs. However, during the course of this study and in studies conducted by others, the most prevalent, and the largest agricultural consumptive water uses are related to crop irrigation and animal husbandry operations. It is important to note that water associated with processing of crops (washing of crops, the preparation of foodstuffs from crops, etc.) is not considered to be an agricultural consumptive use but rather an industrial (food) processing consumptive use, even though the operation may take place on the farm lot itself. These non-crop/non-livestock types of consumptive uses were not considered as part of this study. A good example of this distinction is the growing and preparation of tomato products. The water used to irrigate the crop in the field is considered to be an agricultural consumptive use, while the water used to process the harvested tomato into various juice, fruit, or sauce products is considered to be an industrial consumptive use.

2.2 Quantity of Consumptive Use

The total annual amount of water (in acre-feet [ac-ft]) consumed by agricultural operations, assuming the occurrence of a 50-year drought (based on precipitation deficit statistical analysis) has been estimated (Table 2-1), based on a study performed by Penn State University's Department of Agricultural Engineering (Jarrett and Hamilton, 2002), for the Commission. A 50-year recurrence interval was selected as the "critical period" for the study because that recurrence interval is the generally accepted standard for water supply reservoir analyses.

An estimate of agricultural consumption by state is also shown, although reliable data was not available for the purpose of apportioning agricultural consumptive use between states within the interstate subbasins. In the absence of necessary data, it has been assumed that the amount of agricultural consumptive use in the Pennsylvania portions of Subbasins 1 and 2 is approximately offset by the Maryland agricultural consumptive use that is contained in the Subbasin 6 totals (New York is Subbasins 1 and 2 summed, Pennsylvania/Maryland are Subbasins 3, 4, 5, and 6 summed). Therefore, the Pennsylvania/ Maryland combined total in the tables following represents the total Pennsylvania agricultural consumptive uses in the Susquehanna basin for the years indicated.

Table 2-1. Estimated Annual Agricultural Consumptive Use

Location	Year 1970 Total Consumption	Year 2000 Total Consumption	Year 2025 Estimated Total Consumption
Subbasin 1	11,760 ac-ft	12,392 ac-ft	9,601 ac-ft
Subbasin 2	3,350 ac-ft	3,035 ac-ft	2,766 ac-ft
Subbasin 3	5,163 ac-ft	5,684 ac-ft	5,830 ac-ft
Subbasin 4	5,404 ac-ft	6,001 ac-ft	5,931 ac-ft
Subbasin 5	6,057 ac-ft	8,445 ac-ft	9,679 ac-ft
Subbasin 6	24,899 ac-ft	34,691 ac-ft	39,413 ac-ft
Susquehanna Basin	56,633 ac-ft	70,248 ac-ft	73,220 ac-ft
New York	15,110 ac-ft	15,427 ac-ft	12,387 ac-ft
Pa./Md. Combined	41,523 ac-ft	54,821 ac-ft	60,853 ac-ft

For reference, a complete copy of the Jarrett and Hamilton (2002) report is included as Annex B to this report. It contains detailed discussions of all the source data used, irrigation estimate methodologies, livestock consumptive usage methodologies, predictive methods for both crop and livestock estimates, along with detailed analyses of precipitation deficiencies and the statistical methods used to determine the 50-year drought deficits in the various subbasins.

2.3 Post-Commission Compact Use/Amount Regulated by Commission

Again, based on the work done in 2002 by Penn State, the following tabulation (Table 2-2) gives an estimate of the total annual amount of water (in ac-ft) that would be subject to the existing Commission consumptive loss makeup regulation. Taken into consideration are estimates of pre-Compact (1970) uses, which are not subject to Commission regulations, as well as estimates of the amount of water consumed by smaller agricultural users that would fall below the 20,000 gpd regulatory threshold.

Table 2-2. Estimated Annual Regulable Agricultural Consumptive Use

Location	Year 2000 Estimate of Regulable Usage	Year 2025 Estimate of Regulable Usage
Subbasin 1	2,426 ac-ft	2,236 ac-ft
Subbasin 2	298 ac-ft	329 ac-ft
Subbasin 3	1,282 ac-ft	1,310 ac-ft
Subbasin 4	404 ac-ft	414 ac-ft
Subbasin 5	1,086 ac-ft	1,201 ac-ft
Subbasin 6	4,593 ac-ft	5,090 ac-ft
Susquehanna Basin	10,089 ac-ft	10,580 ac-ft
New York	2,724 ac-ft	2,565 ac-ft
Pa./Md. Combined	7,365 ac-ft	8,015 ac-ft

The Pennsylvania/Maryland combined number for the year 2025 (Table 2-2; 8,015 ac-ft) is only 13.2 percent of the Pennsylvania/Maryland combined year 2025 estimated total consumption shown in the previous table (Table 2-1). It is significantly less for the following two reasons.

First, all of the consumptive use that existed in 1970 (Table 2-1; 41,523 ac-ft) is considered to be grandfathered and not subject to regulation by the Commission (Table 2-1). This quantity is subtracted from the estimated total for 2025 (Table 2-1; 60,853 ac-ft) for a post-Compact increase from 1970 to 2025 in agricultural consumptive use of 19,330 ac-ft.

Secondly, the estimated post-1970 increase of 19,330 ac-ft includes all consumptive uses regardless of quantity. The Commission only regulates consumptive uses in excess of 20,000 gpd on a 30-day average. An analysis of water use data indicates that approximately 41 percent, or 8,015 ac-ft, are subject to Commission regulation. Because that quantity represents the best available estimate of the agricultural consumptive water use in Pennsylvania that is subject to Commission regulations, it will be referred to as the "regulable" agricultural consumptive water use.

2.4 Seasonally Adjusted Consumptive Use

The consumptive use of water by agriculture varies throughout the year, and is especially dependent on the water needs of the crops and animals being raised. The water needs for crops generally correspond with the growing season. The water needs (and consumptive use) for livestock are generally constant throughout the year. Precipitation in the basin is generally abundant during the spring months, tapers off during the summer and early fall, then peaks again in the late fall. Irrigation is used to augment the naturally occurring precipitation mainly during the summer months, particularly in years with precipitation deficits, when low flows are most likely to occur. In contrast, critical low flow conditions are known to occur most frequently during the late summer and early fall. Because peak agricultural water use and low flow periods do not always occur concurrently, Commission staff undertook an analysis to identify the portion of the water use that occurs during the time of year that low flows typically occur.

Using the Middle Susquehanna Subbasin (Subbasin 3) as an example, Table 2-3 shows the occurrences of low flow for the Susquehanna River at Wilkes Barre over 105 years of record. The occurrences are expressed both in terms of monthly occurrences of flows less than the 7-day 10-year low flow threshold and also in percentage of total occurrences. The data show that a significant majority of low flow occurrences, nearly 70 percent, take place in September and October. It, thus, becomes important to understand what quantity of water is consumptively used by agricultural operations during those months. Table 2-4 shows the monthly distribution of the year 2000 estimates for both total consumptive use and regulable consumptive use for both irrigation and livestock. These estimates are also expressed in terms of percent of total need.

The concurrence of agricultural consumptive use and critical low flows is graphically illustrated on Figure 2-1. Only the shaded portion of the consumptive use requires compensation. For this particular subbasin, approximately 61.5 percent of the total annual need (the amount of consumptive use from July through October) requires compensation. The previous estimates for the other subbasins can be reduced accordingly.

Similar computations were done for each subbasin, resulting in the final tabulation shown in Table 2-5. The reduction factor averaged about 35 percent over the 6 subbasins. The reduced amounts correspond to the amount of regulable consumptive use that occurs during periods of low flow, when consumptive use compensation releases would have to be made. They represent the amount of water actually required for release in order to compensate for regulable agricultural consumptive use. In summary, the 4,900 total ac-ft of Pennsylvania agricultural consumptive use estimated to be regulated by the Commission in 2025, 3,055 ac-ft, or nearly 63 percent of that total need, is located in the Lower Susquehanna Subbasin (Subbasin 6). This is followed by 850 ac-ft (17 percent) of need in the Middle Susquehanna Subbasin (Subbasin 3), 720 ac-ft (15 percent) in the Juniata River Subbasin (Subbasin 5), and 270 ac-ft (5 percent) of need in the West Branch Subbasin (Subbasin 4). Ideally, the elements of the selected plan should be located as close as possible to these subbasins of need, with the most need for facilities being in the Lower Susquehanna Subbasin (Subbasin 6).

Table 2-3. Q7-10 Occurrences at the Wilkes Barre Gage (Subbasin 3) for the Period of Record

Susquehanna at Wilkes Barre	**Q7-10 (days)**	**Q7-10 (%)**
January	--	0
February	--	0
March	--	0
April	--	0
May	--	0
June	--	0
July	3	1.2
August	40	16.3
September	108	43.9
October	64	26.0
November	31	12.6
December	--	0
Total	246	100.0

Table 2-4. Monthly Distribution of Agricultural Consumptive Use for Livestock and Irrigation for Subbasin 3 (Middle Susquehanna)

Subbasin 3	Total 2000 Irrigation (ac-ft)	Total 2000 Irrigation (%)	Total 2000 Livestock (ac-ft)	Total 2000 Livestock (%)	Regulated 2000 Irrigation (ac-ft)	Regulated 2000 Irrigation (%)	Regulated 2000 Livestock (ac-ft)	Regulated 2000 Livestock (%)
January	--	0.0	248	8.3	--	0.0	20	8.3
February	--	0.0	248	8.3	--	0.0	20	8.3
March	53	2.0	248	8.3	44	1.9	20	8.3
April	202	7.5	248	8.3	169	7.3	20	8.3
May	314	11.6	248	8.3	270	11.6	20	8.3
June	477	17.6	248	8.3	410	17.6	20	8.3
July	506	18.7	248	8.3	438	18.8	20	8.3
August	506	18.7	248	8.3	438	18.8	20	8.3
September	451	16.7	248	8.3	389	16.7	20	8.3
October	194	7.2	248	8.3	168	7.2	20	8.3
November	--	0.0	248	8.3	--	0.0	20	8.3
December	--	0.0	248	8.3	--	0.0	20	8.3
Total	2,703	100.0	2,976	100.0	2,326	100.0	240	100.0
July-Oct/Dec	1,657	613	1,488	50.0	1,433	61.6	120	50.0

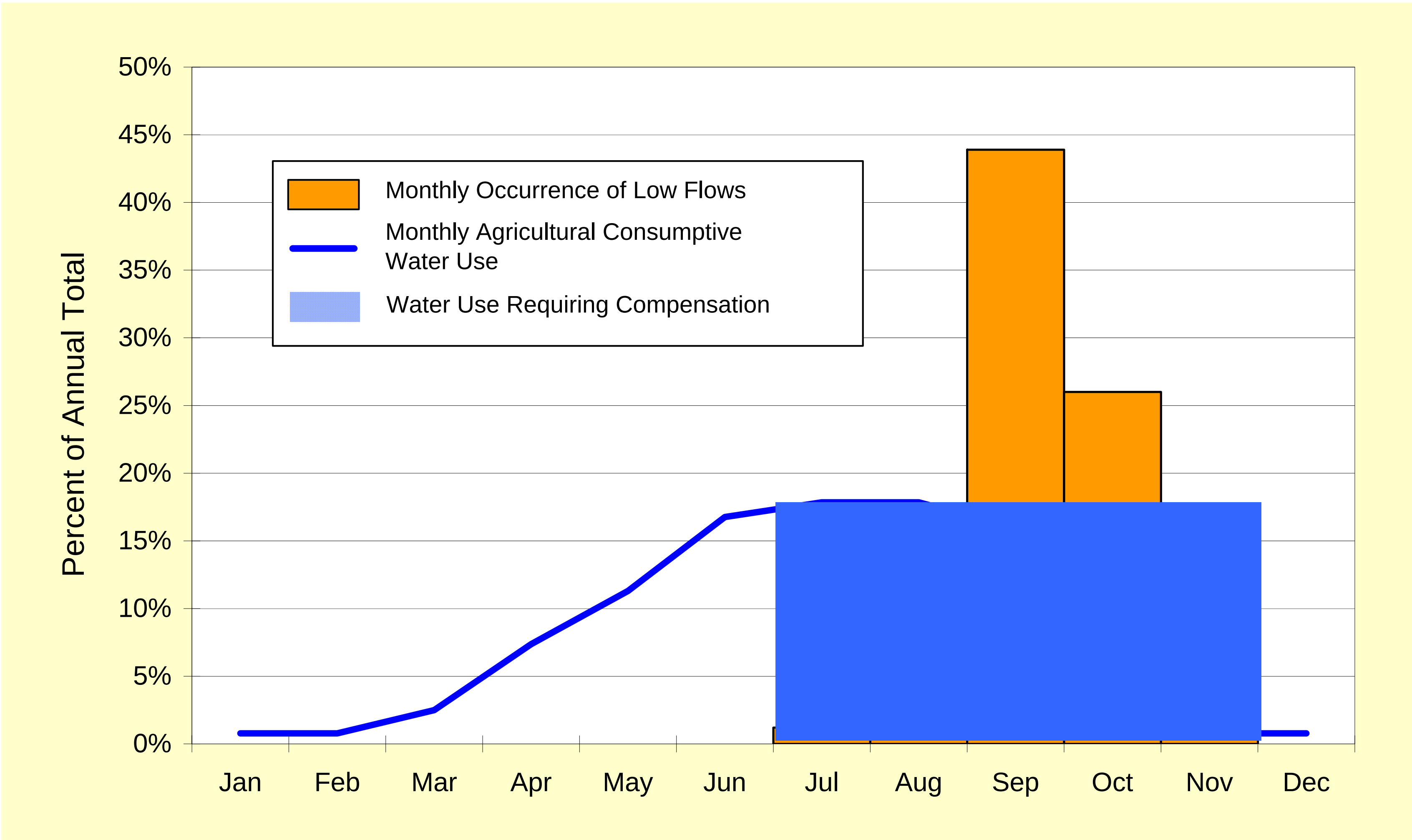

Figure 2-1. Monthly Distribution of Regulable Agricultural Consumptive Use and Q7-10 Flows, Middle Susquehanna (Subbasin 3)

Table 2-5. Estimated Regulable Agricultural Consumptive Use During the Period of Q7-10 Releases (July through October)

Location	Year 2000 Estimate of Regulable Usage	Year 2025 Estimate of Regulable Usage
Subbasin 1	1,941 ac-ft	1,789 ac-ft
Subbasin 2	238 ac-ft	263 ac-ft
Subbasin 3	833 ac-ft	852 ac-ft
Subbasin 4	263 ac-ft	269 ac-ft
Subbasin 5	652 ac-ft	721 ac-ft
Subbasin 6	2,756 ac-ft	3,054 ac-ft
Susquehanna Basin	6,683 ac-ft	6,948 ac-ft
New York	2,179 ac-ft	2,052 ac-ft
Pa./Md. Combined	4,504 ac-ft	4,896 ac-ft

3.0 EVALUATION OF MANAGEMENT OPTIONS STUDIED TO OFFSET PENNSYLVANIA AGRICULTURAL CONSUMPTIVE WATER USE

3.1 Evaluation of Management Options Considered

The Commission investigated five management options that could possibly be utilized singly or in combination to offset the consumptive use of water by agriculture in the Pennsylvania portion of the Susquehanna River Basin. The management options would focus on providing a global/industry-wide compliance mechanism to offset that quantity of agricultural consumptive water use that would be subject to the Commission's consumptive loss compensation regulation. The management options would not consider compliance by the individual agricultural operation because of the potential economic burden that may be placed on the individual farmer. The five management options investigated are: (1) Surface Water Storage Sites, (2) Aquifer Storage and Recovery Methods, (3) Wetlands, (4) Water Conservation/Water Recycling/Best Management Practices, and (5) Regulatory Incentives.

3.1.1 Evaluation Methodology

Each management option was reviewed with respect to the potential amount of agricultural consumptive use offset, and practical implementation issues. The full reviews are contained in reports (Annexes C through G of this report) and are summarized herein.

A balanced, consistent, and impartial semi-quantitative evaluation of all management options was performed using a common set of performance criteria. This evaluation facilitated a reasonable and fair comparison among the options for the purpose of identifying their potential to offset agricultural consumptive use of water. The options having the highest potential were identified for formulation of a management plan.

3.1.2 Evaluation Criteria

Each management option was independently assessed according to the following criteria. The criteria were established in four key areas: consumptive use offset, benefits and impacts, implementation issues, and economics. As listed below, each of the major criteria had specific topics or issues that were considered in assessing the degree to which the criteria were addressed.

A numerical rating from 1 to 10 was assessed for each of the 4 major set of criteria under all options and a summary rating, having a maximum of 40, was then established. The ratings, by major criteria, represent the range of expected outputs and results from low or very inefficient (e.g., a rating of 1) to high and very efficient (e.g., a rating of 10). Technical data was used to the extent possible for setting the ratings, with professional judgments also playing a key role.

The complete detailed assessment of each option is contained in Annex H to this report. A summary of the evaluations is presented in Section 3.7.

The evaluation criteria are summarized below:

CONSUMPTIVE USE OFFSET

Water Quantity

Amount of additional water input/amount of water conserved
Percent of agricultural consumptive use need addressed

BENEFITS AND IMPACTS

Water Quantity

Location (watershed versus subbasin versus basinwide)
Reliability (will option be "available" during low flow times)

Water Quality

Environmental

Fish and wildlife/habitat
Recreation/aesthetics
Hydrology
Land use

Other Factors

Sustainability (short-term only or long-term also)
Socioeconomic
Secondary benefits

IMPLEMENTATION ISSUES

Feasibility

Technical issues
Physical issues

Responsible Party (individual user versus third-party effort)

Legal Considerations Regulatory Considerations/Permits Required

Other Factors

Property owner issues
Public perception/public input
Political concerns

ECONOMIC EVALUATION*

Assumptions

Commission Costs

Project Costs

Initial cost
Operating and maintenance costs
Replacement costs (if necessary)
Average annual cost
Unit cost

SUMMARY RATING (summarizes findings, assess feasibility, and assign overall numeric rating to each option)

NOTE: An in-depth economic evaluation of all options, especially project costs and the determination of average annual costs, is contained in Annex I.

3.2 Review and Evaluation of Management Options

3.2.1 Surface Water Storage Sites

This portion of the overall study focused on the use of water stored in existing surface water bodies (impoundments and lakes) to offset the consumptive use of water by agriculture in the Pennsylvania portion of the Susquehanna River Basin. The existing surface water bodies were identified through a Geographic Information System (GIS)-based analysis. Ten databases of surface water bodies in Pennsylvania were evaluated with respect to accuracy and completeness. Of these, two were chosen for use in this study: the United States Environmental Protection Agency's (EPA's) National Hydrography Database and the most recent PADEP Dam Safety database. The two databases were cross-referenced and combined into a master database of surface water bodies in the Pennsylvania portion of the Susquehanna River Basin. To insure completeness, all possible water bodies that exceeded 10 acres were included in the analysis process. This resulted in approximately 750 water bodies being identified. Early in the analysis, it was decided that only surface water bodies 15 acres or larger would be considered as having significant potential to offset agricultural consumptive use. A final screening for all water bodies with a surface area of 15 acres or greater was performed, resulting in 512 water bodies being included in the master surface water body database. Each of the 512 water bodies was located on a United States Geological Survey (USGS) topographic map.

An assessment of the maximum potential drawdown was assigned to each water body, depending on its ownership category, its location within its respective watershed, and its use as derived from either the PADEP database or based on visual inspection of the USGS topographic map. This drawdown potential, coupled with the surface area of the water body, formed the basis for the estimate of the volume of water that could theoretically be contributed by each surface water body to offset agricultural consumptive use.

3.2.1.1 Impoundments

Review Summary

This category included those existing surface water bodies created by man-made flow barriers (i.e., impoundments) having a release works. They are owned or controlled either publicly or privately.

All identified water bodies were further assessed using 50 acres as the threshold size to provide a meaningful contribution. There were 29 publicly owned or controlled water bodies and 35 privately owned water bodies identified (Figures 3-1 and 3-2) ranging from 1,590-acre Glendale Lake in Cambria County to 51-acre Briar Creek Lake in Columbia County. Water bodies owned by municipal public water supply authorities or the federal government were not considered to have a high potential because of water availability issues in the case of public water supply situations and the costs of further investigative studies in the case of the federal reservoirs.

Many of the identified impoundments are principally used for recreation and do not have a mandated minimum release requirement in their PADEP dam safety permit. They are normally operated to maintain a constant (full) level. During periods of low flow, outflows are less than the inflows because of evaporation from the lake surface. If, during low flow periods, these lakes were operated so that the outflow from the impoundment was equal to the inflow, the natural evaporative losses would come from lake storage rather than from reduced outflow (which is the most prevalent method of maintaining lake levels during times of low inflow). The increased streamflow (equal to the evaporative losses) could be credited to offsetting the consumptive use of water by agriculture.

The impoundment at Gifford Pinchot State Park in York County, Pennsylvania, provides a good example of how the "inflow-outflow" release option would work. According to the PADEP Dam Safety database, there is no mandated low flow release requirement at this recreational impoundment. The impoundment has a surface area of 340 acres and a contributing drainage area of only 17.5 square miles. During times of low flow (below Q7-10), it is estimated that this impoundment would have an inflow of approximately 3.5 cubic feet per second (cfs) (0.2 cfs per square mile [csm] times 17.5 square miles). During August, it is estimated that evaporation alone from the reservoir is approximately 2.5 cfs, leaving only 1 cfs available for release downstream if pool level is held steady. By simply releasing an amount of water equal to the inflow plus the August evaporative loss for the duration of the Q7-10 event, as described above, an additional 2.5 cfs (5 ac-ft per day) of water could be available to offset the consumptive use of water by agriculture. This would result in a pool drawdown of approximately 1.6 feet for the impoundment at Gifford Pinchot State Park at the end of the 106-day period of record Q7-10 event.

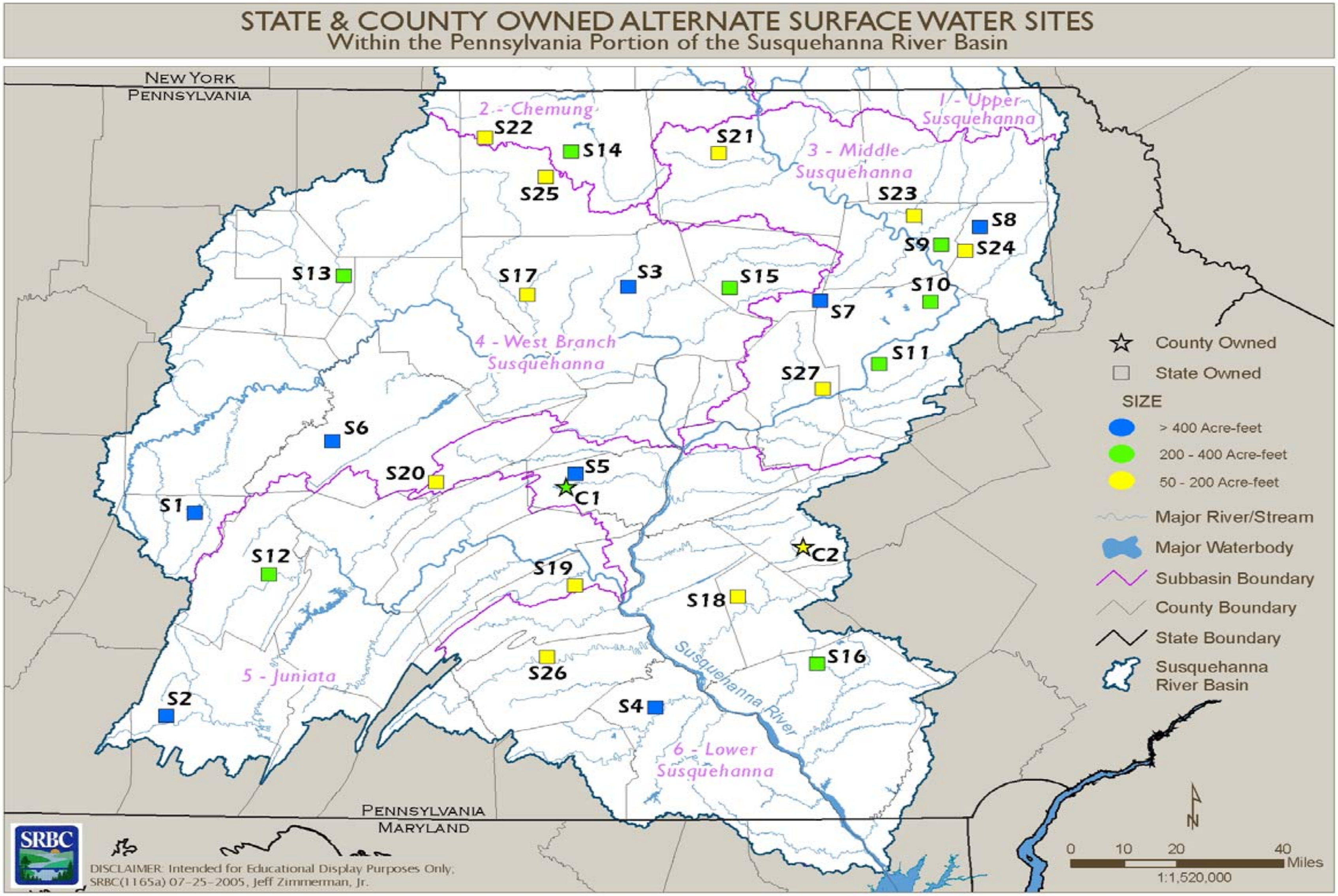

Figure 3-1. Publicly Owned Surface Water Bodies in the Pennsylvania Portion of the Susquehanna River Basin with 50 Acres or More of Surface Area

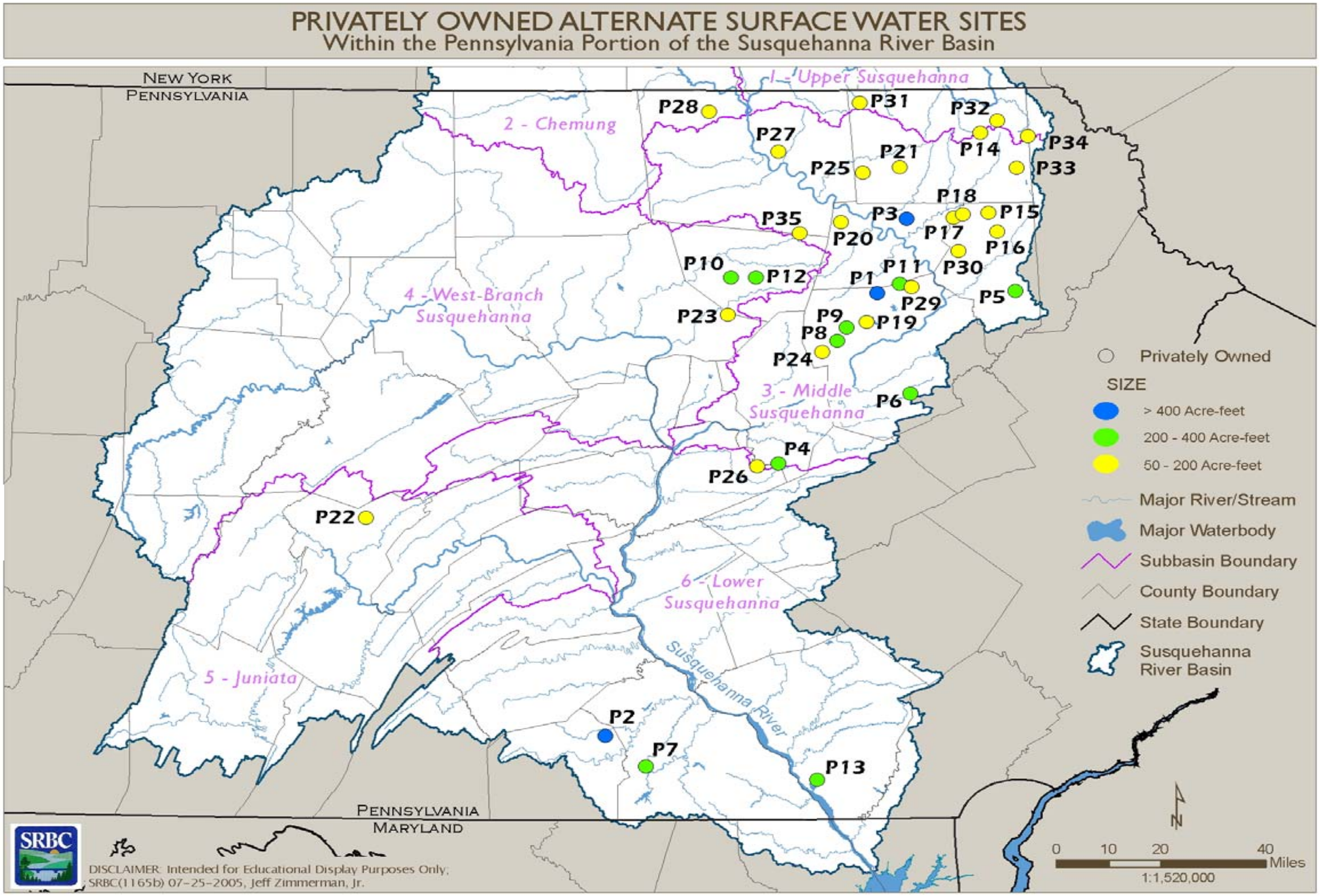

Figure 3-2. Privately Owned Surface Water Bodies in the Pennsylvania Portion of the Susquehanna River Basin with 50 Acres or More of Surface Area

Harvey's Lake, an impoundment in Luzerne County, Pennsylvania, provides another good example. According to the PADEP Dam Safety database, there is no mandated low flow release requirement at this recreational impoundment. The impoundment has a surface area of 640 acres and a drainage area of only 7.2 square miles. During times of low flow, it is estimated that this impoundment would have inflows between 1.5 and 2 cfs (0.2 csm). Yet during August, it is estimated that evaporation alone from the reservoir is approximately 4.3 cfs, leaving no flow available for release downstream if the pool level is held steady. By simply releasing an amount of water equal to the inflow plus the August evaporative loss for the duration of the Q7-10 event, as described above, approximately 4 cfs (8.5 ac-ft per day) of water could be available to offset the consumptive use of water by agriculture. This would result in a pool drawdown of approximately 1.4 feet for Harvey's Lake at the end of the 106-day period of record Q7-10 event.

Summary of Benefits and Implementation Issues

The utilization of this method of operation has the potential to more than offset all of the consumptive use of water by agriculture that could be regulated by the Commission. If all 64 such facilities could be utilized there would be approximately 9,900 acres of stored water. If the average drawdown during the 106-day period of record Q7-10 event was 1.5 feet, a total of 14,850 ac-ft (140 ac-ft per day or 45.75 million gallons per day [mgd]) of water would be released. Since the release required to fully offset regulable agricultural consumptive use during a Q7-10 flow event is 46 ac-ft (or 15 mgd), only 3,253.6 pool acres (approximately one-third of that available), or 0.5 foot of drawdown, would be required.

Implementation of this option would require no further in-depth hydrologic studies or additional permits for the discharge of the water, since waters would be released from existing facilities. However, facilities to measure the flow upstream (inflow) and downstream (outflow) of the impoundment would be required.

A complete copy of the report documenting the investigations related to this option is contained in Annex C.

Evaluation

The publicly owned impoundments scored 32 out of a possible 40 points overall, with relatively high scores under all 4 criteria headings.

The privately owned impoundments scored 25 out of a possible 40 points overall, with relatively low scores under Benefits/Impacts (5) and Implementation Issues (4). The low Benefits/Impacts (5) score was due to concern for possible negative impacts of drawdown on recreational use, aesthetics, and habitat. The low score for Implementation Issues (4) relates to concern for securing cooperation with private owners and for possible political difficulties.

The evaluations are summarized in Annex H.

3.2.2 Glacial Lakes

Description and Evaluation

This category focused on assessing the amount of storage that could potentially be withdrawn from natural lakes lying in glacially impounded depressions with areas exceeding 50 acres. These water bodies have no associated dam or release works, and are generally located in the glaciated northeastern portion of the basin. Some of these water-filled depressions have large surface areas, but are of unknown depth. Additionally, these glaciated depressions may or may not have a perennial stream flowing either into or out of the water body.

The ownership of these water bodies is currently unknown. There were 21 such water bodies identified, with pool areas ranging from 137.5 acres at a recreational area facility in Lackawanna County to 25 acres at a headwater pond in Susquehanna County. The estimated storage would range from 206 ac-ft to 37.5 ac-ft, for an assumed total drawdown of 1.5 feet. These water bodies have little or no inflow. Therefore, the rate of withdrawal will be equal to the August rate of evaporation.

Summary of Benefits and Implementation Issues

The utilization of natural, glacial lakes has the potential to offset a significant portion of the consumptive use of water by agriculture that would be regulated by the Commission. In all cases, for this storage to be utilized to offset agricultural consumptive use, portable pumping facilities would have to be brought to the site and the water withdrawn from the water body and discharged into the nearest watercourse. This could prove to be a challenge in some cases because of the remoteness of the water body from receiving streams. There would also be a requirement that the receiving stream be of sufficient size to be able to accept the flow. At each natural lake that would be utilized, pumping equipment would have to be secured, installed, and operated for the duration of the low flow period. This effort would be manpower intensive and require substantial coordination.

Since the use of the majority of these lakes is recreational, implementing this plan to offset the agricultural consumptive use may generate concern from both the owners and users. Additionally, a National Pollutant Discharge Elimination System (NPDES) permit for the discharge of the pumped water into an adjacent watercourse would almost certainly be required.

A complete copy of the report documenting the investigations related to this option is contained in Annex C.

Evaluation

The natural (glacial) lakes scored 19 out of a possible 40 points overall, with relatively low scores under Benefits/Impacts (5), Implementation Issues (2), and Economics (4). The low Benefits/Impacts (3) score was due to concern for possible negative impacts of drawdown on recreational use, aesthetics, and habitat. The low score for Implementation Issues (4) relates to concern for securing cooperation with private owners and for possible political difficulties. The low score for Economics relates to the cost of the required release works and the need to convey the water to a potentially remote receiving stream. The evaluations are summarized in Annex H.

3.2.3 Abandoned Quarry Pools

Description and Evaluation

Twelve abandoned surface mine pits filled with water were located by the GIS analysis process. These abandoned surface mine workings could hold substantially larger quantities of water because they are typically fairly deep (several tens of feet). There would generally be far fewer environmental and existing user conflicts that would limit the amount of allowable drawdown.

Pool areas ranged from 69 acres for an abandoned water supply "reservoir" in Schuylkill County to 15 acres at an abandoned quarry in Lancaster County. The corresponding storage ranged from 345 ac-ft to 75 ac-ft, assuming a total drawdown of 5 feet. Very likely, a few tens of feet of drawdown would be available, not only because these water bodies are typically very deep, but because there would be few, if any, environmental and existing user issues. A floating pump station would allow tens of feet of drawdown during the withdrawal of water. The rate of withdrawal would be minimally equal to the August rate of evaporation. Higher rates would be possible where testing demonstrated that drawdown in the aquifer would not negatively impact existing wells, streams, springs, and wetlands.

Summary of Benefits and Implementation Issues

The utilization of this category of surface water body has the potential to offset a small portion of the consumptive use of water by agriculture that would be regulated by the Commission. In addition, many of these water bodies are located in agricultural areas, allowing mitigation in the areas where consumptive water use by agriculture occurs. However, a number of issues would need to be addressed prior to implementation. Quarry pools often have water quality problems for which some treatment would be required. The quarry pools are excavations into local aquifers and are filled with groundwater. Tests would need to be performed to insure that the pumpage would not produce any drawdown interference with neighboring water users or negatively impact the receiving stream. Additionally, a constructed conveyance to the receiving stream and an NPDES permit for the discharge of the pumped water into the receiving stream would almost certainly be required.

A complete copy of the report documenting the investigations related to this option is contained in Annex C.

Evaluation

The abandoned quarry pools scored 14 out of a possible 40 points overall, with relatively low scores under Consumptive Use Offset (3), Implementation Issues (2), and Economics (4). The low score for Consumptive Use Offset relates to the limited available storage. The low score for Implementation Issues (4) relates to the need to convey water to a potentially remote receiving stream and the need for NPDES permitting. The low score for Economics (2) relates to the cost of conveying the water to a potentially remote receiving stream. The evaluations are summarized in Annex H.

3.2.4 Newly Constructed Small Impoundments (Farm Ponds)

Description and Evaluation

This category focused on assessing the amount of storage that could potentially be developed by constructing on-site storage (farm) ponds. It was assumed that the average constructed pond would be 3 acres in size and be able to be drawn down at least 5 feet. Even at the maximum amount of drawdown, less than 15 ac-ft of water per pond would be available to offset agriculture consumptive use. It was also assumed that ponds would be constructed "off-stream" and would be filled by runoff or pumping water from an adjacent perennial stream. This "off-stream" method of construction is preferred since it minimizes, but does not eliminate permitting requirements and environmental considerations. Primarily, constructing off-stream was preferred so that impacts to existing wetlands would be avoided to the maximum extent possible.

Summary of Benefits and Implementation Issues

The utilization of this category only has the potential to offset a very small percentage of all of the consumptive use of water by agriculture that would be regulated by the Commission. An important advantage is that this solution can be developed closest to the source of the problem, thus minimizing the local impacts of agricultural consumptive use.

There are several drawbacks to this option. First, according to several Commission Agricultural Water Use Advisory Committee members, the agricultural community believe that the amount of regulation and permitting necessary to construct a farm pond is overwhelming and not "worth the effort." A summary of the regulatory requirements pertaining to the construction of farm ponds is contained in Annex C. Second, the preferred method of off-stream construction necessitates taking valuable farmland out of production to serve as the site of the pond. Third, the ponds are typically used as a water supply for animals, limiting the amount of drawdown and the period over which the water could be used. Finally, the construction of farm ponds is the most costly surface water option that was investigated. It would take more than 325 such ponds to fully meet the agricultural consumptive offset. The economics of such an undertaking would be prohibitive, making the utilization of farm ponds not economically viable.

A complete copy of the report documenting the investigations related to this management option is contained in Annex C.

Evaluation

The newly constructed farm ponds scored 12 out of a possible 40 points overall, with relatively low scores under Consumptive Use Offset (1), Benefits/Impacts (5), Implementation Issues (2), and Economics (4). The low score for Consumptive Use Offset relates to the very low storage volume that could be developed. The low Benefits/Impacts (5) score was due to concern for possible negative impacts of drawdown on recreational use, aesthetics, and habitat. The low score for Implementation Issues (4) relates to concern for securing cooperation with private owners and for possible political difficulties. The low score for Economics relates to the cost of the required release works and the need for a receiving stream. The evaluations are summarized in Annex H.

3.3 Aquifer Storage and Recovery Methods

The goal of this task was to identify methods which could be utilized to store water in the subsurface, or to identify artificial subsurface bodies of freshwater for subsequent release during periods of low flow. The task investigated an aquifer storage and recovery (ASR) method adapted to fractured bedrock aquifers; two methods of flooding unsaturated, unconsolidated surficial materials with small dams; and the withdrawal of water from flooded underground mines.

3.3.1 Classic Aquifer Storage and Recovery – Background

Description and Evaluation

ASR is a method of storing potable water in subsurface materials (aquifers), and recovering it when needed. The ASR method requires a source of potable water and a receiving body of permeable earth material (aquifer), into which the potable water is injected for storage. The receiving aquifer must have sufficient interconnected porosity to provide a useful amount of storage, and have either non-potable, somewhat salty water or no water. ASR has been most commonly developed in confined, unconsolidated aquifers in coastal plain and alluvial fan settings. Potable water is injected into a confined aquifer, where it displaces the existing saltwater or brine. Groundwater flow velocities in the confined aquifers are relatively low, so there is minimal drift of the injected body of freshwater and only a thin zone of diffusion mixing. The potable water is injected and stored during periods when water is plentiful, and withdrawn when it is needed during periods of drought. ASR in unconsolidated aquifers received minimal investigation because there are no candidate-receiving aquifers in the Pennsylvania portion of the Susquehanna River Basin. However, the review of the “classic” ASR concept led to the consideration of ASR methods adapted to fractured bedrock aquifers and unsaturated, unconsolidated surficial materials (glacial deposits and saprolite).

3.3.2 Aquifer Storage and Recovery – Fractured Bedrock

Description and Evaluation

In fractured bedrock ASR, storage is in confined, fractured bedrock aquifers containing brine, in contrast to a confined, unconsolidated coastal plain aquifer containing brackish water. These can be found in several areas in the Appalachian Plateau (located in the northwest part of the basin, primarily those areas north and west of Altoona, State College, and Williamsport), approximately 300-500 feet beneath stream valleys.

Summary of Benefits and Implementation Issues

ASR wells would be most applicable to the northern areas of the Susquehanna River Basin where brine-containing aquifers are found at relatively shallow depths (<500 feet). The total estimated costs to develop and operate for 10 years an ASR well, with an annual capacity of 30 to 60 ac-ft of water storage, would range from $1,660,000 to $2,010,000. Thirty to sixty ac-ft of water storage represent less than two percent of the total amount of storage needed to offset agricultural consumptive use.

A number of factors contribute to making this method prohibitively expensive and operationally intensive. The fractured bedrock aquifers have substantially lower permeability and interconnected porosity than their coastal plain counterparts. As a result, multiple injection/recovery wells will be required at each site. Stream water would be withdrawn, purified, and injected during wet periods during the years between low flow events. Once a site was filled to capacity, injection would cease and the facility would sit idle. The stored water would be recovered for release during Q7-10 events. The injection water must be essentially of potable quality in order to meet regulatory requirements for injection into the subsurface and discharge into streams, and to minimize the precipitation of minerals in the well bore and surrounding aquifer. Operation and maintenance would be required for the wells, pumps, and treatment plants.

A complete copy of the report documenting the investigations related to this management option is contained in Annex D.

Evaluation

The fractured bedrock ASR scored 13 out of a possible 40 points overall, with relatively low scores under all categories. The method offers minimal storage potential at relatively high cost and with significant operational issues. This method is deemed technically feasible, but impractical. The evaluations are summarized in Annex H.

3.3.3 Hybrid Aquifer Storage and Recovery – Impoundment Storage

Description and Evaluation

Water would be stored in highly permeable surficial materials such as glacial stratified drift, alluvial fans, saprolite, and colluvium. Surface dams would be constructed across headwater and upland valleys with unsaturated surficial deposits. The resulting impoundment would flood the adjacent unsaturated surficial material up to the level of the spillway. This method could be utilized in two areas of the Susquehanna River Basin: the glaciated section in the northeastern portion of the basin, and in the Piedmont physiographic province in Lancaster and York Counties where thick saprolite deposits are found in upland settings.

Summary of Benefits and Implementation Issues

This method, while somewhat costly, could potentially satisfy approximately 50 percent of the agricultural consumptive use need. This method would also deliver the augmentation flow to smaller tributaries that are located in agricultural areas: farmed areas in the northern plateau and the intensively farmed Lower Susquehanna Basin (Lancaster and York Counties).

Drawbacks include the large land area required, the high initial construction costs, and potential adverse environmental impacts. The water storage costs for surface impoundments are very dependant on the height of the dam. At minimal dam heights, storage costs are on the order of several hundred thousand dollars per ac-ft of storage. At maximum pool elevations, storage costs were on the order of $15,000 to $20,000 per ac-ft of storage. For minimal head dams with 10 feet or less of height and with 10 ac-ft or less of storage capacity, the costs will approach $150,000 per ac-ft. Low head dams of 10 to 30 feet height and from approximately 10 to 175 ac-ft of storage, costs will range between $30,000 and $85,000 per ac-ft. Moderate head dams with pools between 30 and 60 feet in height, storage costs will range between $15,000 and $30,000 per ac-ft. The estimated total storage volume ranges from approximately 105 to 250 ac-ft in the piedmont, for a maximum pool depth of 40 feet. In the glacial regions, storage volumes range from approximately 175 to 875 ac-ft, for a maximum pool depth of 60 feet.

A complete copy of the report documenting the investigations related to this management option is contained in Annex D.

Evaluation

The hybrid ASR method scored 23 out of a possible 40 points overall, with relatively low scores under Consumptive Use Offset (5), Implementation Issues (5), and Economics (5). The low score for Consumptive Use Offset relates to the limited available storage. The low score for Implementation Issues (4) relates to the need to operate and maintain a dam, reservoir, and release works. The low score for Economics (5) relates to the cost of construction and operation and maintenance costs for the dam and release works. The evaluations are summarized in Annex H.

3.3.4 Flooded Underground Mines

Description and Evaluation

Water in isolated subsurface voids such as underground mines could be utilized for flow augmentation. Groundwater currently in mine pools would be pumped during low flow periods and natural groundwater recharge would replenish the mine pool water during wet years. Pool water from coal mines would most likely require treatment prior to discharge. Abandoned underground coal mines account for the majority of prospective sites, but a few large non-coal sites are potentially available.

The best available information on the locations and water storage volumes of underground mine pools is mapping of acid mine drainage (AMD) discharges by PADEP (Figure 6 in Annex D). Of the 136 mapped AMD discharges, 67 are in the West Branch Subbasin in the Appalachian Plateau Physiographic Province, 66 are in the Middle Susquehanna Subbasin in the Ridge and Valley Physiographic Province, and 3 are located in the Juniata Subbasin in the Ridge and Valley Physiographic Province. All of these mine pools are located upstream of the Lower Susquehanna Subbasin, where most of the agricultural use occurs.

The numbers, dimensions, and locations of the mine pools associated with the AMD discharges are poorly known. However, the AMD discharges represent the natural recharge to the mine pool groundwater basin. The volume of the discharge is proportional to the size of the groundwater basin that is influenced by the mine void. Larger AMD discharges are associated with larger groundwater basins and larger mine pools. An example of a mine pool that is a flooded coal mine is the Barnes and Tucker mine pool. The PADEP Bureau of Mines estimates that approximately 7.5 mgd would be available from this mine pool complex, which is approximately 50 percent of the water needed to offset agricultural consumptive use in the Pennsylvania portion of the Susquehanna River Basin.

Non-coal underground mine pools are also known, although very little information is available. They are primarily limestone and sandstone mines. They are located in the Ridge and Valley and Piedmont Physiographic Provinces. Most of them are expected to be located in the Lower Susquehanna and Juniata Subbasins. The number of non-coal mine pools is expected to be much lower than the coal mine pools, but they will likely be of comparable size. The Bell Mine, located near Bellefonte, Pennsylvania, is an example of an abandoned underground limestone mine. A conservative estimate of the mine pool water storage is 1.234 billion gallons (3,785 ac-ft). This single mine pool could meet a substantial portion of the entire agricultural consumptive use makeup flow need. However, other sources of makeup flow are desirable in order to distribute the benefits of the releases.

Summary of Benefits and Implementation Issues

The utilization of water in mine pools appears to be the most promising of the methods considered. This low flow augmentation method could satisfy the entire agricultural consumptive use, low flow makeup need at relatively low cost. The treatment and use of mine water would have the added benefit of eliminating polluting acid mine discharges and improving stream water quality. The added benefit of cleaning up polluted streams would be attractive to local community and watershed organizations.

Costs to construct and operate a mine water treatment plant are highly variable and dependant upon the quality and quantity of the mine water to be treated. The coal industry cost range to operate an active chemical treatment plant is $0.15 to $0.50 per 1,000 gallons of water treated or $49.00 to $163.00 per ac-ft. These industry cost ranges do not include the cost to construct the treatment plant.

A study of AMD in the Tioga River watershed previously completed for the Commission evaluated the costs to both construct and operate for 15 years (i.e., 15-year present value cost estimate) AMD treatment plants for 10 AMD discharges. The 15-year present value costs ranged from $3.19 to $431.30 per ac-ft of water treated. The annual operating cost, excluding construction costs, ranged from a low of less than $0.01 per ac-ft for passive treatment, to a high of $323.48 per ac-ft for active treatment. The large cost range is due to the wide range for the quality and quantity of the mine discharges. Passive AMD treatment utilizes wetlands and other natural means to treat mine water. Active AMD treatment utilizes chemicals to treat the water. Passive treatment generally has lower annual operation and maintenance costs, but may not have lower construction costs than active treatment.

A complete copy of the report documenting the investigations related to this management option is contained in Annex D.

Evaluation

The flooded underground mine pools scored 33 out of a possible 40 points overall, with relatively high scores under all 4 categories. The available number of sites is limited, but their storage capacity is substantial, and the costs for construction of pumping facilities, operation, and maintenance are all relatively low. The evaluations are summarized in Annex H.

3.4 Wetlands

3.4.1 Wetland Construction and Restoration

Description and Evaluation

The potential contribution of wetlands to offset the consumptive use of water by agriculture is through increased recharge to the aquifer, and through the delayed release of overbank flows. Both of these act to increase streamflow and to delay the onset of Q7-10 flows. It has been widely claimed by wetland advocates that wetlands provide recharge to the groundwater flow system, and that the restoration and construction of wetlands results in increased recharge. Wetlands located on floodplains or floodplain marginal – toe of slope settings are, from a hydrogeologic point of view, in groundwater discharge areas.

Although wetland definitions vary somewhat among agencies and government programs, there is almost universal agreement to delineate wetlands by using a combination of: (1) hydrology, (2) vegetation, and (3) soils. Wetlands in the Susquehanna River Basin were identified on a broad scale using the National Wetlands Inventory. A GIS-based tool was developed to assist in locating areas for wetland construction and restoration projects.

Staff performed field studies in an attempt to identify the recharge potential of individual wetland sites in the Susquehanna River Basin. Four wetlands were investigated in the southern Susquehanna subbasin and one wetland in the western Susquehanna subbasin. Three of the wetlands were natural, and two were constructed/restored. All were located in floodplains or floodplain marginal – toe of slope positions, the most common wetland settings in the basin. Each wetland site had at least one deep–shallow piezometer pair. Open intervals were determined from the inferred permeability of the saturated materials encountered in hand-augered borings. Water levels were monitored continuously with digital recorders and transducers for a period of several months during the growing season. The monitoring results, in combination with site-specific observations of floodplain and valley side morphology, seepage and spring locations, open water and surficial stratigraphy from borings and streambank exposures indicate that these sites were consistently areas of groundwater discharge. Therefore, the construction or restoration of wetlands in these settings are not considered an effective means of offsetting the consumptive use of water by agriculture.

Summary of Benefits and Implementation Issues

The ability of wetlands to provide water storage and recharge specifically for flow augmentation during low flow periods is limited and could not be quantified on site-specific or basinwide scale. However, wetland construction and restoration can provide significant benefits to runoff detention and retention, water quality, fish and wildlife habitat, recreation, and aesthetics. Wetland values and benefits also support the underlying objectives of the Commission's project review regulations, are important to overall ecosystem health, and improve the resiliency of stream systems to drought and floods.

A complete copy of the report documenting the wetland management option analysis is contained in Annex E.

Evaluation

The wetlands management option scored 19 out of a possible 40 points overall, with relatively low scores under Consumptive Use Offset (1), Benefits (5), and Implementation Issues (5). The low score for Consumptive Use Offset relates to the insignificant available storage. Wetlands do not contribute significantly to the makeup of water used consumptively by agriculture in the Pennsylvania portion of the Susquehanna River Basin. They do, however, provide numerous water resource related benefits. The evaluations are summarized in Annex H.

3.5 Water Conservation/Water Recycling/Best Management Practices

3.5.1 Soil Conservation Plans

Description and Evaluation

Soil conservation plans are written to meet an allowable amount of soil loss (T) per year based on the soil type. Several factors are used in the Revised Universal Soil Loss Equation (RUSLE) to determine if soil loss limitations are being met in a particular field. These factors include: rainfall, slope, crop rotation, and crop management. Rainfall and slope are fixed factors in the equation while the crop rotation is typically picked according to the farmers needs. This makes conservation tillage (minimal cultivation methods) the easiest and most common way to meet soil loss restrictions. Although exposure of water to evaporation is not reduced with conservation tillage, infiltration into the soil is increased as runoff is decreased. There is an increased dependence on herbicides needed to control weeds that would likely result in some water quality degradation. Soil conservation plans may also contain other practices that promote infiltration of water, including strip cropping, waterways, diversions, terraces, and filter areas. With these practices implemented and no incorporation of manure, infiltration is enhanced and aquifer recharge is increased when a minimal soil moisture deficit is present. The result would be increased base flow during the early to mid summer months. During a dry year, this could delay the onset of a low flow event and the need to release water for consumptive use makeup. While the quantity of makeup water saved cannot be quantified, the savings are clearly beneficial from a water resource management perspective. Conservation plans are required for all farms as per Pennsylvania Chapter 102 regulations.

Summary of Benefits and Implementation Issues

Soil conservation plans have the benefit of increasing infiltration and improving water quality through controlling erosion and manure application by minimizing runoff. Conservation tillage may result in degraded water quality due to increased dependence on herbicides. The plans are easily implemented with minimal cost investment. However, the cost must still be picked up by the farmer and, thus, even a small monetary investment is significant. The plans do not contribute significantly to the makeup of water used consumptively by agriculture in the Pennsylvania portion of the Susquehanna River Basin. Therefore, this option did not receive further consideration.

Evaluation

The soil conservation option scored 21 out of a possible 40 points overall, with a very low score under Consumptive Use Offset (0). The low score for Consumptive Use Offset relates to the lack of contribution to available storage. Soil conservation does not contribute to the makeup of water used consumptively by agriculture in the Pennsylvania portion of the Susquehanna River Basin. It does, however, provide numerous water resource related benefits. The evaluations are summarized in Annex H.

3.5.2 Irrigation Initiatives

Description and Evaluation

The purpose of this study was to evaluate a number of irrigation-based best management practices (BMPs) that could be implemented to reduce consumptive water demand. Three areas for irrigation-water conservation were analyzed. They included:

1. Maximizing irrigation efficiency – existing equipment;

2. Maximizing irrigation efficiency – new/replacement; and

3. Smart irrigation systems.

The quantity of irrigation water in the Susquehanna River Basin was estimated in a study conducted by Dr. A. R. Jarrett, Pennsylvania State University. Jarrett estimated that in 2000 there was 29,006 ac-ft of irrigation in the Pennsylvania portion of the Susquehanna River Basin with 7,499 ac-ft subject to Commission regulation. Totals for the Susquehanna River Basin in 2000 were 31,706 base ac-ft, with 8,396 ac-ft regulable. For 2025, Jarrett estimated there would be 29,267 ac-ft of irrigation in the Pennsylvania portion of the Susquehanna River Basin with 7,710 ac-ft subject to Commission regulation.

One method of maximizing irrigation efficiency using existing equipment is the application of precise irrigation scheduling. Irrigation scheduling is used to apply the proper amount of water to a crop at the proper time. It is estimated that by precise irrigation scheduling, water savings of 10 to 20 percent can be realized.

Another promising method of maximizing irrigation efficiency with existing equipment is reduce the amount of irrigation water needed through the implementation of the no-till farming method. Using this method, farmers do not till fields before planting, but use heavy equipment to plant seeds right through the remnants of harvested crops. Crops grown using the no-till method require one-third the amount of water as crops grown in fields that have been plowed. At present, 2,800 ac-ft could be conserved if 50 percent of the regulable farms in the Susquehanna River Basin adopted the no-till method, with 2,900 ac-ft conserved in 2025. There are no upfront costs or annual operation and maintenance costs using the no-till method. However, a significant concern is that the resulting increased reliance on herbicides for weed control would likely cause some degradation of water quality. Until this water quality issue can be resolved, this method of consumptive use makeup cannot be recommended.

Irrigation efficiency can further be maximized by installation of new, more efficient irrigation equipment. Micro-irrigation includes irrigation methods characterized by the frequent application of water, in small flow rates, on or below the soil surface. The volume of water is applied directly to the root zone in quantities that approach the consumptive use of the plants. The root zone moisture content is thereby maintained near field capacity throughout the growing season, providing a level of water and air balance close to optimum for plant growth. Micro-irrigation systems employ dedicated water delivery equipment and “smart” controllers. Smart controllers regulate the amount of irrigation water based on a specific plant type’s water needs, a specific plant’s root depth, type of soil at the site (clay, sandy, etc.), plant microclimate (full or partial sun or shade), slope of landscape (flat or incline), irrigation method used (sprinkler, drip or bubbler), and daily weather conditions at the site. Replacing spray irrigation with “micro” irrigation systems would result in a 43 percent reduction in irrigation consumption due to the increased water application efficiency. Presently, an annual savings of 476 ac-ft, or about 10 percent of the regulable agricultural consumptive use, could be realized if 25 percent of the regulable farms in the Susquehanna River Basin install new micro-irrigation equipment, and 492 ac-ft could be saved in 2025. Micro-equipment can be installed for about $850 per acre of irrigated land.

Summary of Benefits and Implementation Issues

Micro-irrigation methods can be applied throughout the Susquehanna River Basin and are highly reliable. Less water would be lost to evaporation or over-application, making more water available for irrigation or other purposes, especially during droughts. The water savings would result in a reduction in regulable agricultural consumptive use of approximately 10 percent.

The widespread application of the no-till farming method could sharply reduce the amount of water used for irrigation, but would likely result in some degradation of water quality due to increased use of herbicides. Other means of weed control are currently being investigated and may resolve this issue. At present, the method cannot be recommended.

Installation of new “smart” irrigation equipment will result in greater operation and maintenance costs for irrigators. Irrigators also will need training to operate this new equipment. No permits would be required for any of the crop water conservation methods described in this report.

The use of “smart” irrigation systems would substantially increase irrigation efficiency and decrease agricultural consumptive use, and should be encouraged. However, the systems are expensive and will likely only be applied where there is an incentive such as water shortage, regulations, or a financial benefit. Without encouragement, the method is unlikely to contribute significantly to consumptive use makeup. Therefore, this management option did not receive further consideration.

A complete copy of the report documenting the investigations related to this management option is contained in Annex F.

Evaluation

The irrigation-related initiatives scored 19 out of a possible 40 points overall, with relatively low scores under Consumptive Use Offset (1), Benefits (5), and Implementation Issues (5). The low score for Consumptive Use Offset relates to the insignificant available storage. Wetlands do not contribute significantly to the makeup of water used consumptively by agriculture in the Pennsylvania portion of the Susquehanna River Basin. They do, however, provide numerous water resource related benefits. The evaluations are summarized in Annex H.

3.5.3 Animal Husbandry Initiatives

Description and Evaluation

Animal consumptive water use amounts to approximately 1,000 ac-ft per year, split between mainly dairy, swine, and poultry operations (several other operation types also contribute to this water used, including beef operations). This water use can be reduced by reusing water for various purposes, reducing spillage losses, maintaining animal comfort, and minimizing water exposed to evaporation.

For dairy operations, the consumptive uses are animal consumption, milk cooling, animal cooling, and facility cleanup. Of these uses, the only ones that require water treated to potable standards are the milk cooling process and cleaning milk house equipment. One way to conserve water is to reuse this water for animal watering and cooling. Approximately 29 gpd of water are used to cool the milk collected from one animal. This water can then be used to account for the 23 gallons consumed per animal per day and the 1.7 gallons per animal per day for evaporative cooling.

Implementing this process includes installation of a collection tank, transfer pipes, and pumps. This method has the most potential for reducing water use. Several of the larger operations have already implemented this practice. If the remaining farms that fall under the consumptive use regulations implement this water reuse, 156 ac-ft of water use or 0.03 percent of regulable agricultural consumptive use in the Pennsylvania portion of the Susquehanna River Basin would be saved annually.

Facility cleanup is another major water use, totaling 7 gallons per cow per day. Three and one-half gallons per cow per day of this value can be minimized by using lagoon water to wash out the free stall barns and alleyways. This type of system has many components that need to be worked out in the planning process of the entire operation. Therefore, the installation of such a system is most appropriate for farms that are in the planning stages for either initial construction or for a major addition, such as a milk house or holding facility.

Another consumptive use is evaporative cooling of animals. This water can be reduced by using recycled water, a more efficient form of cooling, or a different form of cooling. More efficient methods of cooling include cooling pads, which line the end of a barn, and cool air by pulling it across a saturated membrane. This method minimizes losses by recollecting water and recycling it back through the system. It does still utilize evaporative cooling and, therefore, still consumptively uses water.

Another method is to utilize the fact that air temperature several feet below the surface is fairly consistent throughout the year. Air forced through buried pipes is cooled during the summer and warmed during the winter. Piping this air into animal holding areas takes the place of evaporative cooling and saves money on cooling and heating. Keeping the animals cool also reduces their respiration rate, reducing the amount of water respired. This type of cooling is not being used on any operation in the Susquehanna River Basin at this time. If the farms falling under Commission consumptive use regulations, and not already using another method to reduce evaporative cooling, adopted this type of cooling, 33 ac-ft of water use would be saved annually.

Animal water spillage accounts for about half of swine water consumption. Several methods exist to minimize these losses. Most of the water is lost due to animals bumping into stationary waterers. To minimize this problem, water swings can be installed allowing the waterers to move freely within a holding facility, avoiding the animals. Another way to minimize losses is to use water regulators to match the amount of water available with the amount of water required by a specific-sized animal. Additionally, water nipples can be used to keep water at an on-demand basis.

Most swine operations have some combination of these practices already implemented. If the remaining farms, falling under the Commission's consumptive use regulations, were to implement these practices, approximately 425 ac-ft of water would be saved annually.

Ultimately, all of the water used ends up exposed to evaporation in the fields, making it all consumptively used. Field evaporation can be reduced by promoting immediate incorporation of manure by plowing. Farm management practices such as manure incorporation are listed in the farm's soil conservation plan and nutrient management plan. The soil conservation plan is the determining factor for what type of plowing occurs on the farm. It is written solely to reduce erosion and any water infiltration benefits are secondary. Therefore, no water use reductions can be expected.

A final option to offset the amount of water consumptively used is to collect rainwater. Roof runoff can be collected in a cistern or within the lagoon in order to be available for future use in recycling, watering, or field application. This option is limited by the size of the storage facility.

Summary of Benefits and Implementation Issues

The main benefit of implementing various animal husbandry initiatives is an improvement in water quality. Animal husbandry initiatives support many of the underlying objectives of the Commission's project review regulations with respect to water conservation and beneficial use, but do not contribute significantly to the makeup of water used consumptively by agriculture in the Pennsylvania portion of the Susquehanna River Basin.

A complete copy of the report documenting the investigations related to this management option is contained in Annex F.

Evaluation

The animal husbandry initiatives scored 16 out of a possible 40 points overall, with a very low score under Consumptive Use Offset (1). The animal husbandry initiatives would not contribute significantly to the makeup of water used consumptively by agriculture in the Pennsylvania portion of the Susquehanna River Basin. They do, however, provide numerous water resource related benefits. The evaluations are summarized in Annex H.

3.6 Regulatory Incentives

3.6.1 General Permit and/or Permit by Rule

Description and Evaluation

Regulatory incentives involve the use of either a general permit or permit by rule to allow agricultural consumptive users to administratively comply with the Commission's consumptive use regulation. Individual approvals would not be made by the Commission. Instead, a project sponsor would implement (or join other agricultural users in implementing) certain conservation practices (often known as BMPs) that are set forth in a Commission "general permit" or "permit by rule" and, after doing so, would automatically be in compliance with the Commission's consumptive use regulation.

The compliance methods in lieu of consumptive use makeup could include soil, water, and wildlife conservation practices similar to those implemented under various programs administered by the USDA's NRCS, as specified in the general permit or permit by rule. None of these potential compliance methods would involve the makeup of water consumed by an agricultural consumptive user during periods of low flow.

Summary of Benefits and Implementation Issues

Regulatory incentives implemented through a general permit or permit by rule program do offer a number of potentially valuable benefits, including augmentation of base flows, improvement of water quality, enlargement of fish and wildlife habitat, soil and water conservation, and a host of other environmental and socioeconomic benefits. Regulatory impediments are often minimal or nonexistent for the installation and use of conservation practices, and the need for individual Commission approval of numerous agricultural consumptive use projects would be eliminated.

Nevertheless, there are a number of serious flaws associated with the use of regulatory incentives as a means of compliance with the Commission's consumptive use regulation including:

1. The inability of a regulatory incentives program to meet the primary objective of the Commission's consumptive use regulation (i.e., to provide one-for-one compensation for consumptive use during periods of low flow);

2. The difficulty and high cost of administering a general permit or permit by rule program for the estimated 600 agricultural consumptive use projects in the basin that are subject to the Commission's consumptive use regulation; and

3. The difficulty in dealing with operations that do not try to attain the general permit and also likewise do not implement BMPs.

A complete copy of the report documenting the investigations related to this management option is contained in Annex G.

Evaluation

The regulatory incentives option scored 12 out of a possible 40 points overall, with a very low score under Consumptive Use Offset (1). The low score for Consumptive Use Offset relates to the negligible contribution to the makeup of water used consumptively by agriculture in the Pennsylvania portion of the Susquehanna River Basin. It does, however, provide numerous water resource related benefits. The evaluations are summarized in Annex H.

3.7 Comparison of Management Options

A side-by-side summary comparison of the 12 management options (5 main categories with subcategories) was done through use of the numeric ranking values for each of the major evaluation categories, which are summarized in Table 3-1. The summary ratings ranged from 12 to 33, with only 4 of the 12 options receiving a score of more than 5 for meeting the goal of offsetting consumptive water use.

The comparison of the ratings for management options described above formed the basis for developing recommendations. An examination of Table 3-1 shows that the impoundments and the hybrid ASR mine pool options received the highest total ratings of 32 and 33, respectively. In addition, these 2 options scored well on each of the 4 main performance criteria, with ratings from 6 to 10, including a 10 rating in terms of meeting the priority goal of offsetting consumptive use.

The results of the ranking methodology indicated that a combination of two options, namely impoundments, and the hybrid ASR mine pools, would result in a management plan that would offset the most agricultural consumptive use and do so in the most beneficial and cost-effective manner.

Table 3-1. Summary of Numeric Ratings

Alternative	SW – Impoundments Public	SW – Impoundments Private	SW – Lakes	SW – Quarries	SW – Farm Ponds	ASR – Bedrock	Hybrid ASR – Unconsolidated	Hybrid ASR – Mine Pool	Wetlands	Soil Conservation	Irrigation Initiatives	Animal Husbandry Initiatives	General Permit/ Permit by Rule
CU Offset	10	10	8	3	1	3	5	10	1	1	1	1	1
Benefits/Impacts	7	5	5	5	5	4	8	6	5	7	5	5	5
Implementation	7	4	2	2	2	3	5	7	5	6	5	4	3
Economics	8	6	4	4	4	3	5	10	8	8	8	6	3
TOTAL	**32**	**25**	**19**	**14**	**12**	**13**	**23**	**33**	**19**	**22**	**19**	**16**	**12**

SW – Surface Water
CU – Consumptive Use

4.0 SUMMARY OF SELECTED PLAN

The evaluation of all 12 options studied indicated that a combination of existing surface water impoundments and underground mine pools would provide the most water to offset agricultural consumptive use in the most cost-effective manner.

For the surface water impoundments, GIS analyses and screenings indicated that there were 2 county-owned facilities, 27 Commonwealth-owned/controlled facilities, and 35 privately owned facilities that exceeded 100 ac-ft in estimated storage.

After the screening processes described above were completed, the utilization of the different components (surface storage and mine pool storage) was addressed.

One of the objectives of the selected plan was that it should provide as much consumptive use makeup water as close to the area where the water was being consumed as possible. By referring back to Table 2-5 in Section 2.4, it is noted that of the 4,900 total ac-ft of Pennsylvania agricultural consumptive use estimated to be regulated by the Commission in 2025, 3,055 ac-ft, or nearly 63 percent of that total need is located in the Lower Susquehanna Subbasin (Subbasin 6). This is followed by 850 ac-ft (17 percent) of need in the Middle Susquehanna Subbasin (Subbasin 3), 720 ac-ft (15 percent) in the Juniata River Subbasin (Subbasin 5), and 270 ac-ft (5 percent) of need in the West Branch Subbasin (Subbasin 4). Ideally, the elements of the selected plan should be located as close as possible to these subbasins of need, with the most need for facilities being in the Lower Susquehanna Subbasin (Subbasin 6). Additionally, Tables 1 and 2 in Annex C indicate whether or not the individual impoundment has (as per the PADEP Dam Safety database records) a required minimum release of water to the watercourse downstream of the impoundment. It turns out that only 5 of the 64 impoundments selected have mandated low flow releases. This implies that for the vast majority (92 percent) of the surface water impoundments selected, the maintenance of summer recreation pool levels may be maintained by reducing outflows, which could mean an impact to the downstream aquatic resources.

5.0 PREPARATION FOR IMPLEMENTATION OF SELECTED PLAN

In order to implement this portion of the plan, further work is needed to develop the operational details at the selected sites. The scope of work for this study did not include this detailed work as part of this feasibility level study. The work on the specifics of acquiring water from both the selected underground mine pools and the selected surface water impoundments needs to be continued. The Commission concluded from this study that such water utilization is feasible and is a cost-effective solution; the specific details and operational arrangements at each location (mine pool or surface water impoundment) need to be further identified and resolved. These details would include cost estimates specific to each location for the operational changes necessary to utilize the storage identified in this study. This detailed work would also consider how to utilize any “surplus” consumptive loss makeup water. It is possible that if all of the surface water and underground mine pool storage sites were developed to their fullest, the amount of water released into the hydrologic system may exceed the actual amount of agricultural consumptive makeup need required to comply with the Commission’s consumptive loss makeup regulation. In that case, the selected operational plan could either be refined to reduce the operational impacts on the various elements being utilized or compensation in excess of the regulated need could be made, recognizing that the actual consumptive use by Pennsylvania agriculture is much greater than the 4,900 ac-ft of usage subject to the Commission’s consumptive loss makeup regulation. Additionally, and more importantly, a funding mechanism needs to be secured to insure a steady revenue stream to fund the ongoing operational readiness of this portion of the final plan’s selected components.

Concurrent with the detailed work described above, the Commission, the Commonwealth, and the agricultural community through the Commission’s Agricultural Water Use Advisory Committee should develop an ongoing program to support and encourage the industry-wide implementation of the water conservation, water recycling, and BMP methods analyzed during the course of this study. While these alternatives do not directly provide consumptive loss makeup water, they are critical to the most efficient utilization of the water resources critical to the agricultural industry in Pennsylvania. For this reason, this recommendation is a key component of the selected plan.

6.0 RECOMMENDATIONS

The Commission investigated five distinctly different areas of management options that could possibly be utilized to offset the consumptive use of water by agriculture in the Pennsylvania portion of the Susquehanna River Basin. The Commission concluded that by utilizing a combination of two management options, the amount of consumptive use that can be regulated by the Commission could be completely offset in a cost-effective manner. The study includes the following recommendations:

1. The Commission, in cooperation with the Commonwealth of Pennsylvania, should implement the necessary projects to provide the 15.7 mgd of water necessary during low flow periods to offset agricultural consumptive water use in the Susquehanna River Basin in Pennsylvania.

2. The Commission, in cooperation with the PADEP Office of Mineral Resources, other appropriate agencies, and independent owners, should perform technical investigations of underground mine pool sites that have the greatest potential for flow augmentation. For each site considered, the studies should evaluate factors including, but not limited to, the quantity of water available; the interconnectivity of the underground mine pool with surface water bodies; the proximity of the underground mine pools to the agricultural consumptive water use; the quality of water available, including its potential to improve downstream water quality; any treatment requirements; and the cost to implement.

3. The Commission, in cooperation with the Pennsylvania Fish & Boat Commission, Pennsylvania Game Commission, DCNR, other appropriate agencies, and independent owners, should perform technical investigations of water impoundments that have the greatest potential for flow augmentation. For each site that is considered, the studies should evaluate factors including, but not limited to, the quantity of water available; the proximity to the sources of agricultural consumptive water use; the potential to improve downstream water quality; potential impacts on habitat, recreation, and other current uses of the impoundment; physical improvements required to enable the releases of water; and cost.

4. To implement the recommendations of this study, the Commission should continue to work cooperatively with the Pennsylvania agricultural community, including the major farm organizations, the Pennsylvania Department of Agriculture, and other agricultural interests who are members of the Commission's Agricultural Water Use Advisory Committee.

7.0 REFERENCES

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