EVALUATION OF WATER MANAGEMENT ALTERNATIVES, USING INTEGRATED LAKE BASIN MANAGEMENT PRINCIPLES: A NORTH AMERICAN CASE STUDY

THESIS

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by

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EVALUATION OF WATER MANAGEMENT ALTERNATIVES, USING

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ABSTRACT

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SUPERVISING PROFESSOR: WALTER RAST

This study uses two management guidelines, namely Integrated Lake Basin Management (ILBM) and the Integrative Participatory Approach, in combination, to address some of the issues affecting the Marsh and Rock Creek watersheds in Adams County, Pennsylvania. The major objective of this study was to evaluate the feasibility of management suggestions developed during the creation of the Marsh and Rock Creek Critical Area Resource Plan (CARP) (being developed as a requirement of the Pennsylvania Act 220). A modified version of a stakeholder-consensus based methodology, developed by Corazón de la Tierra, which uses ILBM principles as a base reference, was used to achieve this objective. The methodology specifically required all relevant stakeholders (citizens, political figures, local businesses, etc.) to participate in several facilitated meetings and workshops, with the underlying goal of obtaining a rating (from 0-10), by consensus, on a series of questions directed at evaluating the feasibility of various management suggestions in the context of what are known as ILBM governance

pillars; namely, institutions, finances, stakeholder support, technology, information and policy. The scores for each pillar were then summed for each management suggestion, leading to a score between 0 and 60 (with 60 being the most feasible option to accomplish). The most technologically-advanced management programs received the lowest scores (primarily 30 or below), while the communication, monitoring and education programs received higher scores (primarily 45 or above). The basis for the scores for each of these pillars are discussed, as well as suggestions made for future refinements to this methodology. The scores resulting from this study will be used, in combination with a technical analysis, to determine which management suggestions will be included in the CARP and, in turn, the Pennsylvania State Water Plan.

CHAPTER I: INTRODUCTION

1.1 STATEMENT OF PROBLEM

Freshwater is arguably our most critical natural resource. All life depends on it in some manner, and it provides multiple life-supporting services to humans, including drinking water supply, irrigation, recreation and hydropower. Unfortunately, of the 1.386 million km^3 of water that exists on Earth, only 2.5% of it is fresh. Further, nearly three-quarters of that quantity is either locked up in the form of snow and ice, or else buried deep underground. In fact, less than 0.8% of the global freshwater supply is readily available for easy humans use from surface water sources like lakes and streams (Postel 1996).

Now, in theory, there is still enough readily available freshwater to support a total of 20 billion people over the globe. Unfortunately the resources are unevenly distributed spatially and temporally, leading to major pressures being put on these water systems (Burnstein 2002). This situation has been exacerbated by continuing economic development. There has been a tenfold increase in water use globally over the past century, and in our efforts to maintain economic growth, we have contributed to the deterioration of water resources through increasing sediment loads, increasing pollution through pesticide and fertilizer use and wastewater inputs, overfishing, over-abstraction and various other activities. As a result of such actions, virtually no country in the world

has been unaffected by the environmental issues associated with economic growth (Jackson 2001, Burnstein 2002).

Although our awareness of these problems makes the need for management evident, the actual management of surface water sources is not as simple as cleaning up the water body or restricting water withdrawals. Freshwater resources are interconnected, meaning the activities in one region often can cause problems in another region. For example, over-pumping an aquifer for irrigation purposes could lead to the drying up of a stream in an area located farther away; wastewater discharges into an upstream river could cause downstream lake eutrophication problems; deforestation of a mountainside could lead to erosion and sediment loading into a lake located in a downstream valley (ILEC 2005). Based on these realities, therefore, it is important to be aware that the management of a water system requires basin-wide integration of water-using or water-impacting sectors that are often separated on the basis of their resource needs. Ecological systems such as forests, groundwater, and rivers, as well as societal systems such as municipalities and counties, must all be managed collaboratively if any successful results regarding their sustainable use, and that of the life-supporting ecosystem goods and services they provide to humans, are to be accomplished (UNESCO 2003, ILEC 2005).

To complicate the matter, many national borders have been established without consideration of their shared water resources. This has led to over 40% of the world's population being located in an international watershed, as well as complicating factors in terms of municipalities or counties. In addition, there often are language barriers or political conflicts that can hinder collaborative efforts to manage surface water systems

for sustainable use, all of which represent problems that must be overcome order to ensure the water resource is managed and utilized in a sustainable manner (Burnstein 2002, ILEC 2005).

1.2 PURPOSE OF THESIS

The aforementioned issues, particularly those related to economic development and political boundaries, have been particularly evident in the combined Marsh and Rock Creek watershed in the Washington, D.C. area. As a result, the watershed has been designated a Critical Water Planning Area (CWPA), which is defined as a "*significant hydrologic unit where existing or future demands exceed, or threaten to exceed, the safe yield of available water resources*," under the Pennsylvania Act 220 (DEP 2006). As a result of this designation, the Marsh and Rock creek watersheds must develop a Critical Area Resources Plan (CARP) consistent with the guidelines of Act 220. As a part of the CARP development, several steps have already been identified, as illustrated in Figure 1.

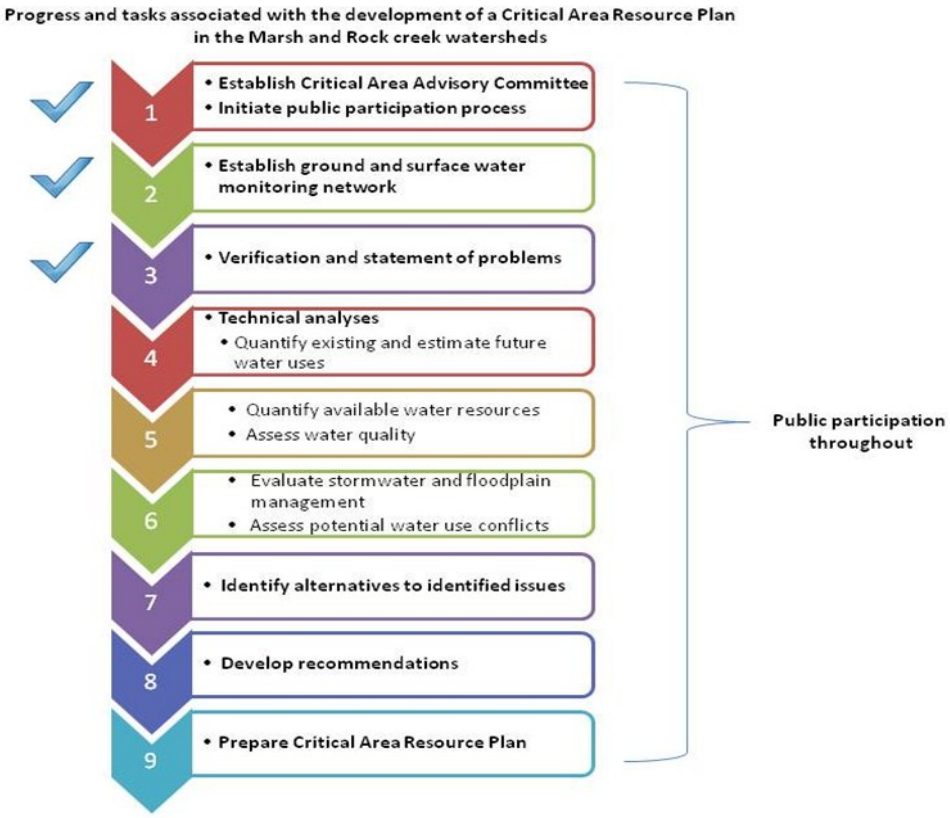


Figure 1. Nine steps to development of the Critical Area Resource Plan (CARP); The checks represent steps that were completed prior to this study (ICPRB 2011).

The "Technical Analyses" phase, which highlights the major issues within the basin, through scientific investigation, was completed during the completion of this study. These analyses were used to provide insight into the "Identifying Alternatives to Identified Issues" phase of the project, where this study was incorporated.

A major purpose of this research was to develop and implement a logical methodology for identifying unfeasible management options. Accordingly, this research effort sought to utilize a water resources management platform called Integrated Lake Basin Management (ILBM) to assess management alternatives developed during the

CARP process. The study was also designed to help provide insight into the range of actions needed for effective basin management.

The specific objectives of this research project were to:

1) Disseminate information on ILBM to the key stakeholders in the Marsh and Rock Creek watersheds;

2) To work with the key stakeholders in the Marsh and Rock Creek watershed to create a list of management alternatives they believe will solve the issues identified in previously-completed scientific studies;

3) To develop a prioritized list of management options on the basis of their feasibility, through consensus-based rating of the ILBM governance "pillars"; and

4) To compile and disseminate information on the stakeholder participation management process in the Rock and Marsh Creek Watersheds so that future managers can be made aware of the issues that were encountered and how they were resolved.

This research was undertaken in collaboration with Corazón de la Tierra (a non-governmental organization whose activities focus on the Lake Chapala-Lerma River Basin in Mexico), the Interstate Commission for the Potomac River Basin (ICPRB), the Pennsylvania Department of Environmental Protection (DEP), and the Marsh and Rock Creek Critical Area Planning Advisory Committee (CAAC).

1.3 RELEVANCE OF STUDY

This thesis provides several contributions to both the scientific community and the Marsh and Rock Creek Watersheds. These contributions are as follows:

1) A clear, systematic methodology for communicating with stakeholders within a watershed about the feasibility of management options and decisions;

2) A prioritized list of management alternatives, based on their feasibility, which can be incorporated in the CARP and, in turn, in the Pennsylvania State Water plan;

3) A North American case study which can be added to the growing literature on the use of ILBM principles for the management of watersheds;

4) A substantive demonstration that ILBM principles are useful in river basins, as well as lake basins, the latter being the water systems for which the guidelines were originally developed; and

5) Insights into the challenges and possible solutions involved with stakeholder-based watershed management, thereby providing future watershed managers with relevant experiences and lessons learned.

CHAPTER II: BACKGROUND INFORMATION

2.1 LITERATURE REVIEW

2.1.1 Integrated Water Resource Management (IWRM)

Recognizing the need for water management interventions on a global scale, it is important to identify and implement feasible options. Context is very important for achieving this goal, because there is no blanket solution for addressing the problems affecting our global water resources. Rather, a responsible and proactive approach is necessary for each water body, in order to identify and implement sustainable and innovative solutions for addressing their individual problems as well as for meeting the needs of those that depend on them. In fact, several water system management frameworks have previously been developed to provide assistance and guidance to water managers, and other basin stakeholders. The first and most commonly-known guidelines are presented within the framework called Integrated Water Resource Management (IWRM). According to the Global Water Partnership (GWP), "*IWRM is a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems*" (Global Water Partnership, 2000). Further, IWRM relies heavily on the following four principles developed during the 1992 Dublin Conference (Global Water Partnership, 2003):

1) "Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment
2) Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels;
3) Women play a central part in the provision, management and safeguarding of water; and
4) Water has an economic value in all its competing uses and should be recognized as an economic good."

2.1.2 Issues with IWRM

The use of IWRM has subsequently gained much support in national forums, and with many water scientists and managers. However, IWRM has proven to be difficult to implement in real world settings, as evidenced by the literature that examines its application. Common complaints about the IWRM framework include:

1) Lack of mention or clear understanding of the principles that govern lake management, in contrast to river management. This is a major deficiency, since more than 90% of the liquid water on the surface of our planet is stored in lakes and reservoirs (International Lake Environment Committee 2005; Rast 2008).
2) A primary focus on the anthropogenic uses of water bodies (so-called ecosystem "provisioning services"), without also considering the underlying ecosystem "regulating services" that make them possible (Brichieri-Colombi 2008).

3) Lack of clear suggestions on how to proceed beyond the consideration of specific principles. Although IWRM has been preached by many as a comprehensive water resources management approach, the reality is that little specific guidance has actually been provided to date on how to most appropriately and effectively implement it (International Lake Enviornment Committee 2005; Turton et al. 2007; Goldina et al. 2008; Biswas 2008; Saravan et al. 2009; Thuo 2009; RSCE–Shiga University and ILEC 2011).

4) Little mention of the inherent unpredictability of nature, or the need for adaptive management (Galaz 2007; Van de Keur 2008; Moriarty et al. 2010). This is in addition to the promotion of formal, large-scale, top-down, engineered management approaches, in contrast to local, small-scale, adaptive approaches (Galaz 2007; Brichieri-Colombi 2008; Goldina et al. 2008; Moriarty 2010).

2.1.3 *Integrated Lake Basin Management (ILBM)*

In response to these and other reported shortcomings with IWRM for managing water systems, the International Lake Environment Committee (ILEC), more specifically their Scientific Committee, headquartered in Shiga Prefecture, Japan, developed a new, more comprehensive framework known as Integrated Lake Basin Management (ILBM). The ILEC Scientific Committee comprises a group of scientists and managers that focus on lake management and assessment, particularly as related to the sustainable use of these important water resources. ILEC's ILBM framework has been demonstrated to be applicable on a broader scale and context than IWRM, and attempts to address the various shortcomings that characterize application of IWRM.

In contrast to IWRM, ILBM takes into account the unique properties of lakes (both natural and artificial), compared to rivers and other water systems, including their management implications. These properties include:

1) An integrating nature – Lakes act as water storage ('pooling') systems, as they are sinks in which all inflowing waters (and pollutants carried in them) drain. Thus, they can be characterized as a reflection or 'barometer' of the negative impacts of human activities in their surrounding drainage basins.

2) Long water retention time – Because lakes are water storage systems, they can retain water for relatively long periods of time. Thus, even though appropriate and effective management programs may be implemented in a given situation, the target lake may not actually exhibit improved water quality for many years after a program is implemented. This could lead to the erroneous conclusion that the management program failed, when all it may have required was additional time for the positive effects to become visible.

3) Complex response dynamics – Because lakes do not necessarily respond to impacts (e.g., pollutant inputs) in a linear manner, their in-lake dynamics are often not predictable. Thus, implementation of cautious management programs, with trial and error (i.e., adaptive management), is often better than massive or complicated programs. As noted above, sufficient time also must be allowed for the effects of a given lake basin management program to become evident. (ILEC 2005)

ILBM also emphasizes the sustainability of all ecosystem services, ranging from Provisioning Services (e.g., fishing; water supply), to less recognized Cultural or Regulating Services (e.g., religious or aesthetic significance; nutrient cycling or climate regulation, respectively). Maintenance of these services is necessary not only for the health of a lake, but also for the individuals dependent directly or indirectly on the lake and its resources for their livelihoods and well-being. Thus, lake ecosystems, and the range of life-supporting goods and services they provide, must not be ignored (ILEC 2005; MEA 2005).

Another difference between ILBM and IWRM is that the former provides comprehensive and flexible guidelines for managers who wish to implement an integrated basin-wide water management approach, in contrast to the relatively more 'top-down' focus, and emphasis on water resources as a commodity, that generally characterizes IWRM. This is accomplished with the utilization of six governance "pillars," which comprise elements that must be developed and/or strengthened to effectively manage a watershed. These pillars, developed and subsequently applied by ILEC in a number of lake basins around the world, include the following:

1) Information – Monitoring and collection of information about a water body, its basin and its resources, including both scientific and traditional information sources;

2) Institutions – The organizations or entities that support and facilitate lake basin management;

3) Policy – The "rules of the game" developed within the context of lake basin management efforts that are supported by politicians and all relevant stakeholders, including the public and ideally the media;

4) Participation – Enhanced participation of all relevant stakeholders within a lake basin, as a means of ensuring development and implementation of comprehensive and feasible plans, as well as for gaining cooperation and support ("buy-in") from all those invested in the basin;

5) Technology – The use of technologies that can be utilized and maintained in a sustainable manner for all aspects of lake basin management (from cleanup to communication). It is also necessary, however, to ensure the technology is not simply treating the symptoms of the identified problems, as opposed to addressing their sources, since doing only the former will not ensure sustainable water resources. It also is important to recognize that some "soft" approaches also can be effective, examples being education, enhancing awareness, providing incentives, etc.

6) Finances – The availability and maintenance of a sustainable source of financing is necessary for all relevant projects directed to the improvement of a water body. (ILEC 2005)

2.1.4 Integrated Lentic/Lotic Basin Management (IL^2BM)

As a significant component of my study and analysis of the ILBM framework, I participated in several international workshops focusing on the application and usefulness

of the framework, and the needed improvements. Through participating in these meetings, it became clear the ILBM governance pillars, as well as the emphasis on context and ecosystem services, are not applicable solely to lake systems, otherwise known as 'still' or lentic water bodies. In fact, the principles were equally applicable to flowing (lotic) water systems such as rivers and streams. In response to this conclusion, members of ILEC's Scientific Committee have discussed changing of the title of the framework from Integrated Lake Basin Management (ILBM) to Integrated Lentic/Lotic Basin Management (IL^2BM), as a means of providing logical, scientifically-rigorous and easily understood principles that can be utilized by managers of both lentic and lotic water bodies, and even underlying groundwater aquifers. These water systems are hydrologically-linked in a given drainage basin, with significant assessment and management implications and so the idea is that they should be interlinked in a management framework. These proposed ILBM revisions and inter-linkages have not yet materialized in the literature, (although are currently in progress). Nevertheless, the governance pillars, as well as their emphasis on context, as incorporated in ILBM are still very useful in all water basins, which is one of the reasons it was applied to this study.

2.1.5 Issues with ILBM

Based on case studies and experiences to date in water systems throughout the world, ILBM has been demonstrated to be flexible and easily understood, providing a common platform for management discussions and actions (Kodarkar et al. 2009; Juarez-Aguilar 2010). It has been applied, for example, in India, Japan, Kenya, Malaysia,

Mexico, Nepal, and the Philippines, providing a wealth of information and experiences from which we can learn (ILEC 2005; Kodarkar et. al. 2009; Juarez-Aguilar 2010).

Application of ILBM, however, is also not without its problems. Developing appropriate means or indicators for gauging management progress, and for attempting to prioritize projects, for example, have been identified as issues to be addressed. More specifically, it is one thing to say "these are the pillars" to be assessed and addressed. It is, however, an entirely different thing to identify the strengths, weaknesses and relevance of each of these management pillars in a given lake basin situation.

2.1.6 Lake Chapala Case Study

To address some of these issues, a study involving the application of ILBM was completed in Mexico by a non-governmental organization known as Corazón de la Tierra. This organization developed a methodology involving a mediated workshop comprised of key lake basin stakeholders, for the purpose of obtaining a consensus-based analysis of the strengths of each of the above-noted governance "pillars." This methodology has proven useful in the analysis of three sub-basins in the larger Lake Chapala basin, in Mexico (Juarez-Aguilar 2011). The detailed steps used in this study include (Juarez-Aguilar 2010; Juarez-Aguilar 2011):

Step 1: Identifying key stakeholders within the basin.

In the context of this procedure, stakeholders refer to those with an invested interest in the management of the water body in question and its surrounding basin. A key stakeholder refers to representatives of each stakeholder group with significant

knowledge about the basin, and with a good standing in the stakeholder group they represent. This condition is important in order to be able to keep the workshop at a manageable size, while also ensuring concerted stakeholder interest and involvement. The key stakeholder should ideally be interested in participating in a collaborative effort with all other involved stakeholders. In addition, those who are involved should want the resulting management plan to succeed.

Identification of the key basin stakeholders can be done in various ways, depending on the familiarity of the implementing agency within the basin. The stakeholders in the lake Chapala Study were identified through communication with local citizens, utilizing knowledge acquired in the basin while implementing other projects and research into the industries/activities within the basin, as well as research into whom from the industries would be willing and interested in participating.

Step 2: Contacting Key Stakeholders and Securing their Participation

This is one of the key aspects of this research approach. In order for the procedure to be effective, all key stakeholders must be represented, and must participate in the relevant activities. This was done in the Lake Chapala basin through formal invitations, and informal follow-ups by email and telephone.

Step 3: Obtaining Background Information on the Basin and its Management.

The workshop conducted as a part of this methodology requires every workshop participant to have as complete of an understanding of the physical characteristics, problems, and current management regime of the basin, as possible. In order to achieve

this, the workshop host must collect the already-available information and data on the water system through literature reviews and interviews, as well as acquire the needed scientific information through monitoring or scientific studies, if they have not yet been performed. In the Lake Chapala Basin, Corazón de la Tierra conducted several studies to gain a better understanding of the three sub-basins in which they were working, in order to provide the workshop participants with the information they needed.

Step 4: Conducting Workshop

The workshop itself was conducted in four parts, as described below:

1) *Introduction to ILBM* - This portion is comprised of an explanation of the workshop and its purpose. Background on the ILBM approach also is provided to develop a common platform of understanding for workshop participants;

2) *Information Gathering* - Individual stakeholders introduce themselves and provide their perspectives on the key points in the basin history. The workshop host will have extensive knowledge of the basin (due to earlier preparation), and will be able to assist with dates and references as needed. The expectation is that this exercise will provide participants with a common understanding and knowledge platform upon which to base their discussions during the next portion of the workshop.

3) *Answering Questions* - Sixty questions were developed to provide insight into the state of each of the ILBM "pillars" within the basin. Their

response required a rating on a 0-10 scale (0 = there are no provisions; 10 = this portion of the pillar requires no work). In this part of the workshop, the participants must reach a consensus on the rating for each question. The expectation is that by involving the key stakeholders (who have already been provided a common platform and knowledge base), and requiring consensus, a significant portion of bias will be removed from the ratings. This is typically the portion of the workshop requiring the most mediation efforts.

4) *Problem solving* - The ILBM governance pillars requiring the most attention are identified on the basis of the consensus ratings for the above-noted questions. Agreed solutions to these identified problems are then sought, based on a full understanding of the basin and its relevant management issues. The expectation is that, by involving all relevant basin stakeholders, including regulators and citizens, the management suggestions resulting from the workshop will be feasible and, in turn, effectively and sustainably implemented.

Step 5: Distributing the results.

To ensure the results of the workshop are useful, they are then distributed to workshop participants so that they can be communicated to the stakeholder groups being represented. In addition, the conclusions should be published in some manner, in order to facilitate their access by any interested individuals or parties.

This ILBM-based methodology developed by Corazón de la Tierra proved very useful in the Lake Chapala Basin, both by helping to formulate clear, feasible, stakeholder-supported management suggestions, as well as encouraging stakeholder communication. This methodology can also be useful in other watersheds in which basin stakeholders and managers are trying to implement an Integrated Basin Management approach (Juarez-Aguilar 2010).

2.1.7 Stakeholder-Based Water Management

The Lake Chapala study conducted by Corazón de la Tierra, in addition to being a study in the application of ILBM, also is a case study in bottom-up stakeholder-based watershed management. Past literature has illustrated a tendency towards recommending "bottom-up" watershed management that is both comprehensive and involves all community members. Indeed, a 'participatory management' approach has become somewhat of a "buzz word" in the natural resource management community (Thomas 1995; McNeil et al. 2006; Ansel and Gash 2007).

The transition began with the literature highlighting the inherent unpredictability of nature, and how the traditional, top down, reductionist management methods are ineffective in protecting natural resources and the ecosystem services they provide (Holling 1978; Pahl-Wostl 2007 (A); Pahl-Wostl 2007 (B)). Thus, it is necessary to implement adaptive management regimes that are done in specific contexts and on small scales. This allows for incremental changes that can be completed quickly and efficiently (Susskind and Secunda 1998; Williams et. al. 2009; Innes and Booher 2010).

Through the various attempts that have been made in collaborative adaptive management, it has become clear that specific conditions must exist in order for the projects to be successful, including (McNeil et al. 2006; Ansel and Gash 2007; Susskind et al. 2012):

1) Trust amongst stakeholder groups;
2) Continuous involvement of key stakeholder groups in the decision-making process;
3) Support from scientific community for consultation, but not for decision-making; and
4) Clear and systematic guidelines on how to proceed.

The previously discussed methodology developed by Corazón de la Tierra, and which constitutes the basic structure of this thesis, attempts to meet some of these challenges by applying a clear and systematic approach for discussing basin water management issues, as well as the solutions needed to remedy or mediate them.

2.2 STUDY AREA

2.2.1 Location

This study was completed in the Rock and Marsh Creek watersheds in Adams County, Pennsylvania, with the support of the ICPRB and DEP. The two watersheds are located on the southern border of Pennsylvania (Figure 2).

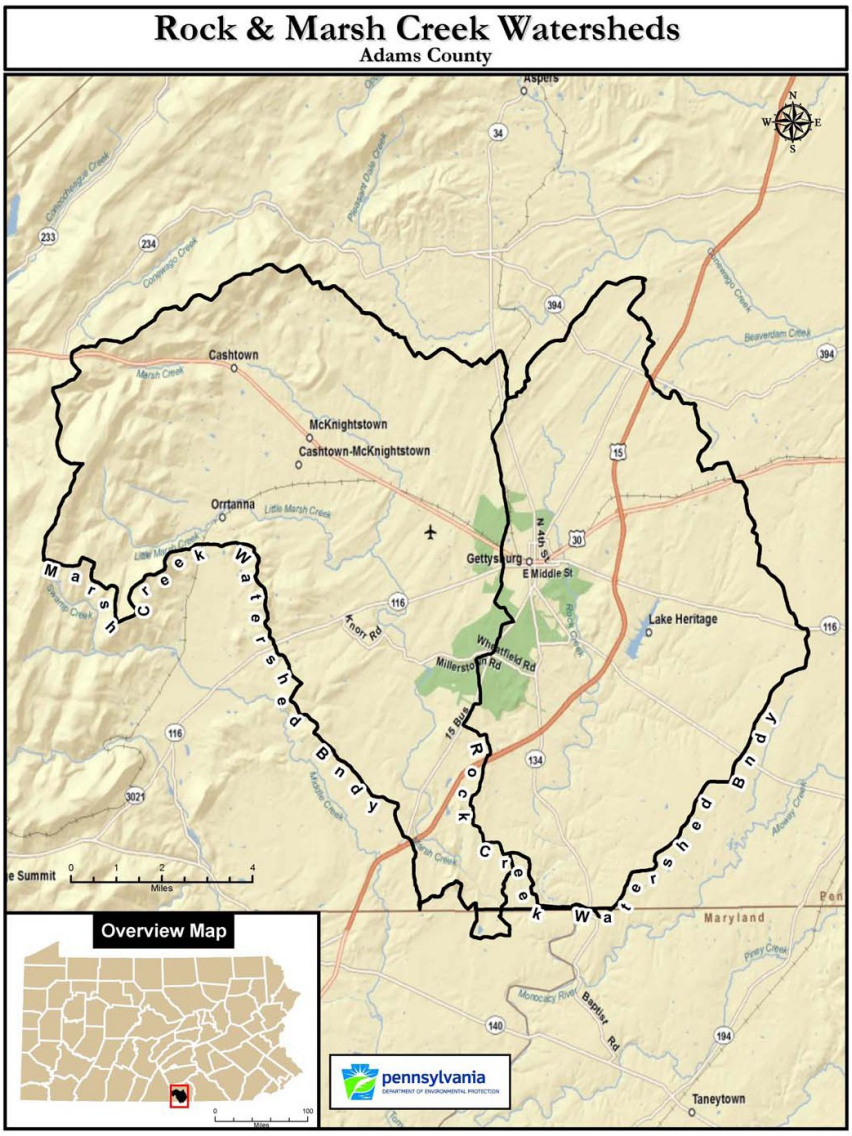


Figure 2. Map showing Rock and Marsh Creek within Pennsylvania (DEP 2009).

The combined Marsh and Rock Creek watersheds are divided into five sub-watersheds, including Upper Rock Creek, Lower Rock Creek, Upper Marsh Creek, Little Marsh Creek and Lower Marsh Creek (Figure 3). The data presented in the current section (Section 2.2: Study Area) refer to these sub-watersheds.

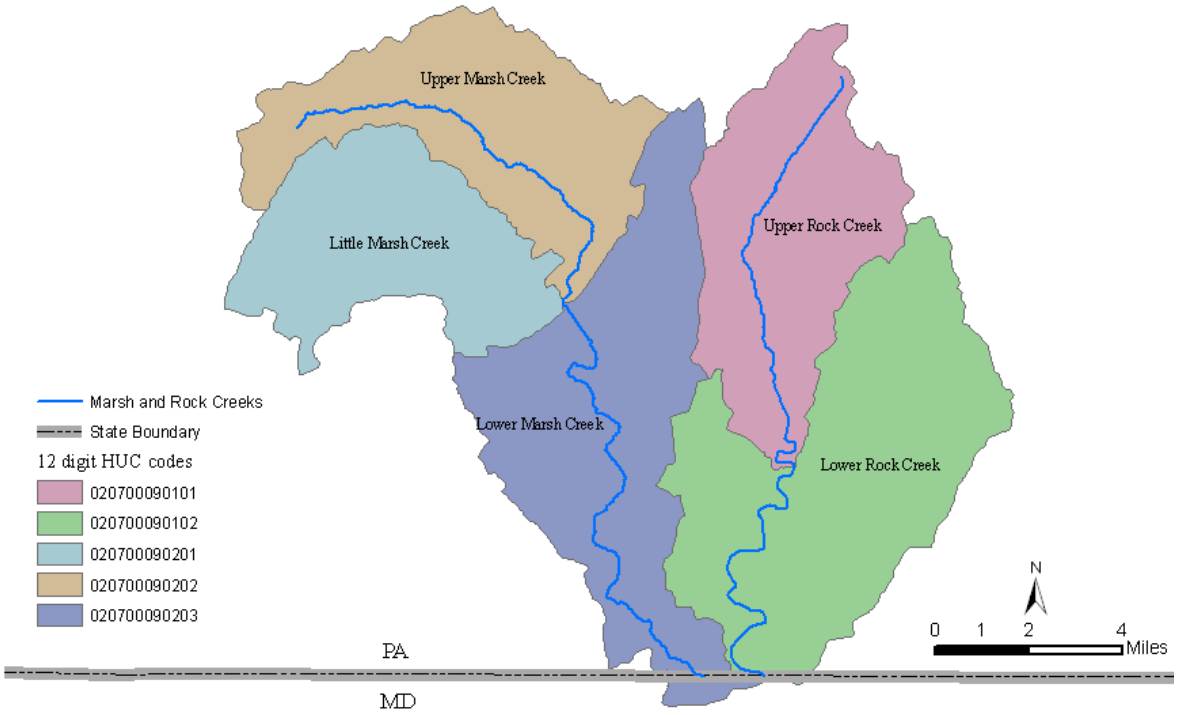


Figure 3. Map showing the location of the five sub-watersheds (with their Hydrological Unit Code) referenced in this study (ICPRB 2011).

2.2.2 Land Use

The Marsh and Rock Creek watersheds are composed of varying topography, including forest, shrub and grassland, although agriculture represents the majority of the land use (Figures 4 and 5). Each sub-watershed also contains a small amount of impervious cover, with the highest portion being in the Lower Marsh Creek, which has an average of 2.1% impervious cover per 30 by 30 grid. The smallest portion of impervious surface is in the Little Marsh Creek, with an average of 0.9% (Figure 6) (ILBM(E) 2011).

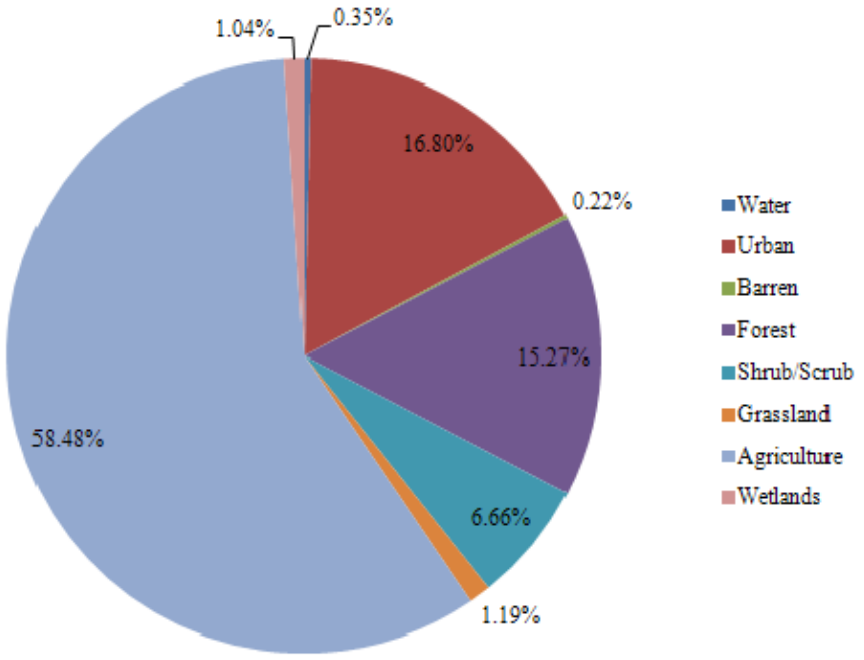


Figure 4. Land uses in Rock Creek watershed (ICPRB(E), 2011).

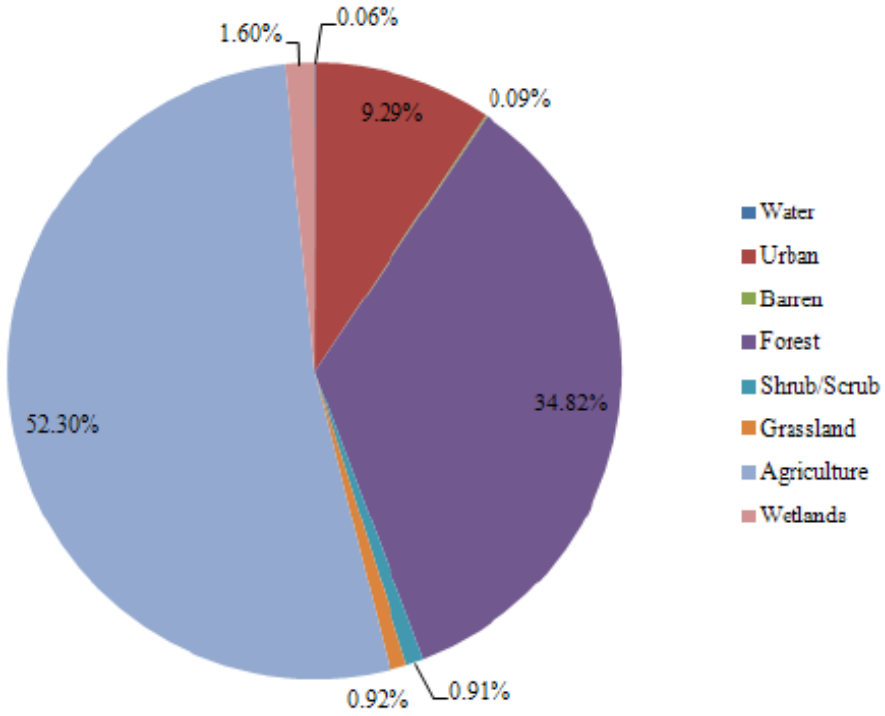


Figure 5. Land uses in Marsh Creek watershed (ICPRB(E) 2011).

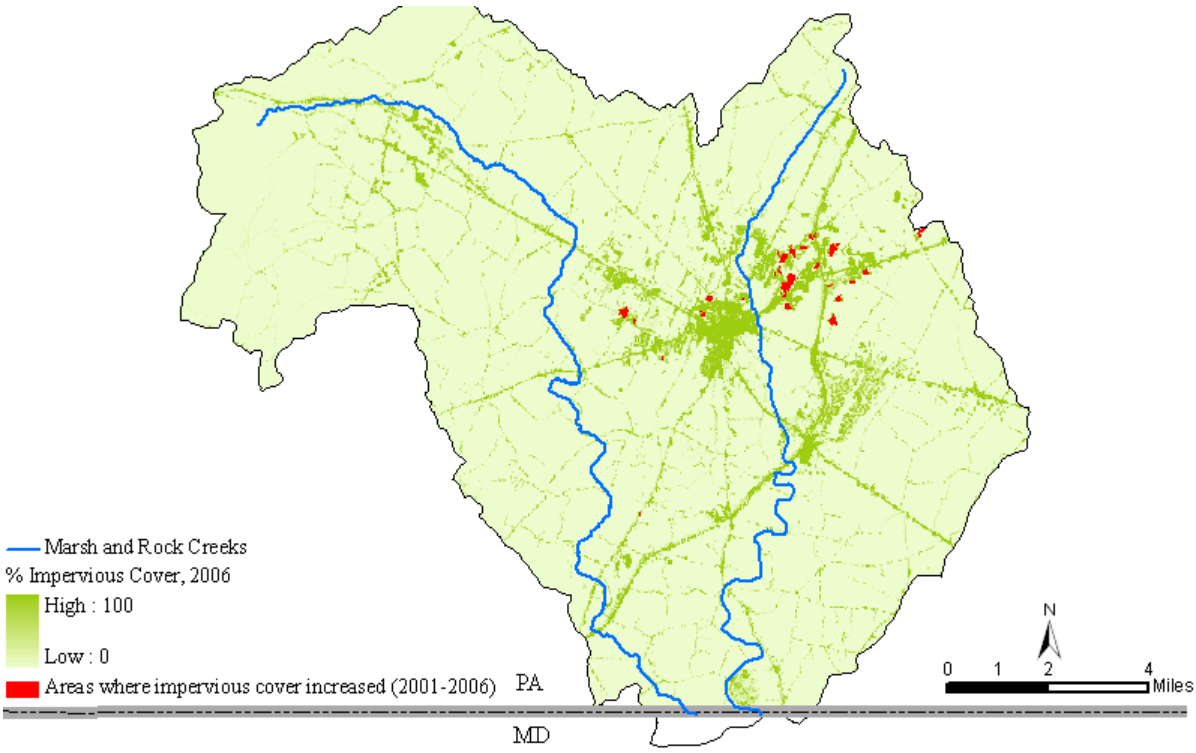


Figure 6. Impervious cover in Marsh and Rock Creek Watershed (ICPRB(E), 2011).

2.2.3 Water Availability/Uses

The water budget of the Marsh and Rock Creek watershed, based on accumulated data from 1997 – 2010, is represented schematically in Figure 7.

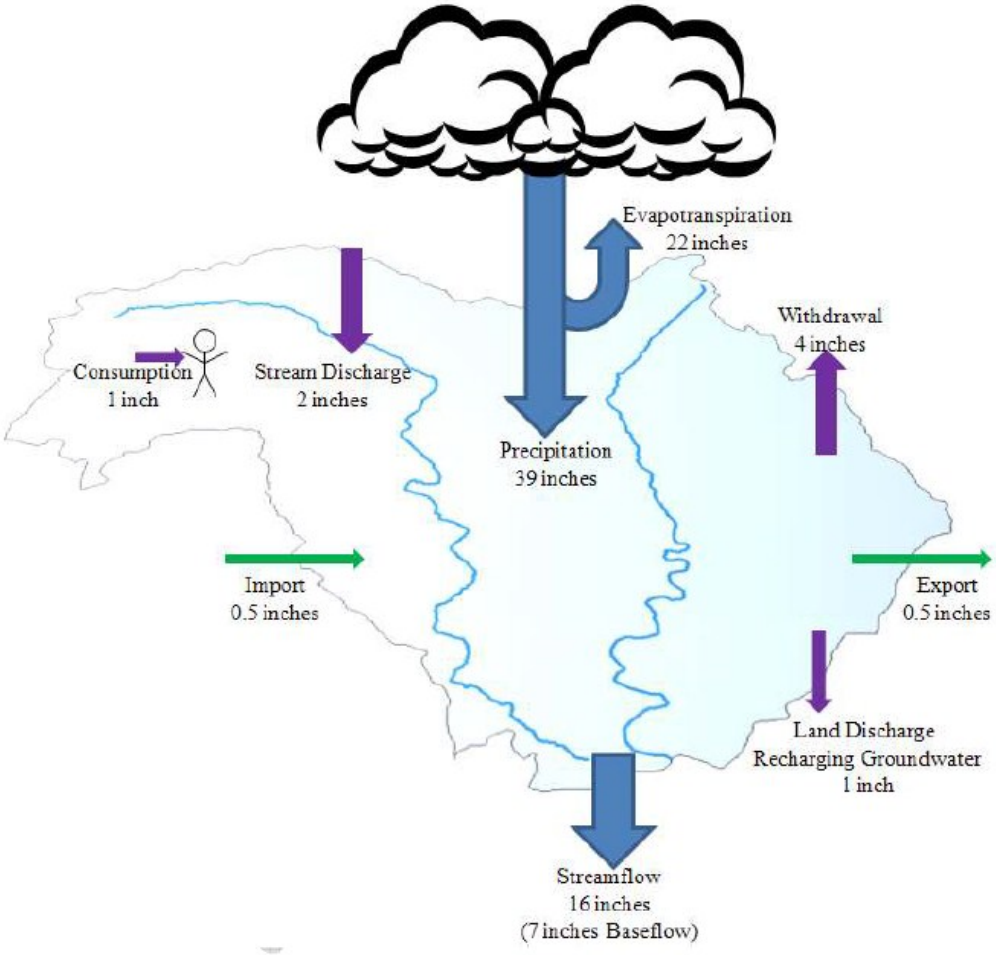


Figure 7. Water budget schematic for the Rock and Marsh Creek watersheds (ICPRB (B) 2011).

The largest components of the water budget are represented by precipitation, evapotranspiration, and stream flow, being an average of 39, 22 and 16 inches per year, respectively. Marsh and Rock Creek both have relatively high evapotranspiration rates of 68% and 50%, respectively (ICPRB(B) 2011).

Marsh and Rock creek represent the headwaters to the Potomac River, and discharge into the Monocacy River. The two creeks are primarily designated for fishing

uses (Figure 8), but are also used extensively for agriculture (including irrigation for orchards and wheat, as well as livestock), industry, commercial uses, mining, golf courses, and domestic water supply (Figure 9). These two waterways are also heavily used for non-withdrawal purposes, including tourism, birding, fishing and boating (ICPRB (B) 2011).

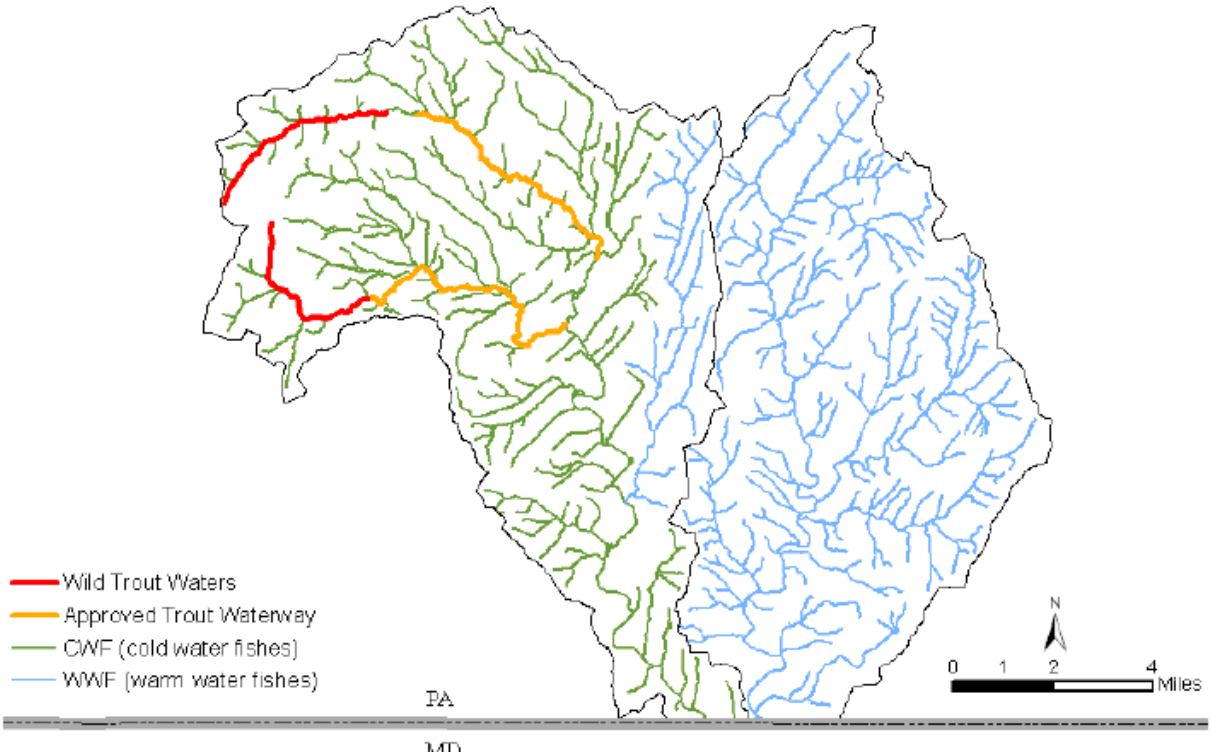


Figure 8. Map of waterway designations in Marsh and Rock Creek watershed (ICPRB 2011).

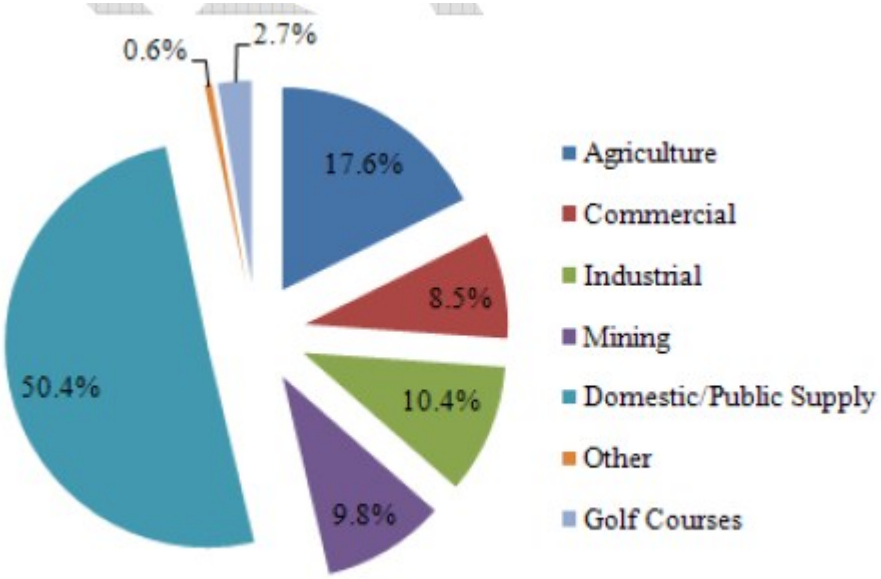


Figure 9. Water withdrawal use distribution in the Marsh and Rock Creek watershed (ICPRB (C) 2011).

Seasonal water stresses in the Marsh and Rock creeks occur mostly during the summer (Table 1), largely due to lower stream flows, higher evapotranspiration and higher water use. In both the upper and lower Rock creek sub-watersheds, water withdrawals exceed inputs during the summer. As a result, the creeks often exhibit periods during the summer when they go dry (DEP 2009). In addition, according to historical data, all the sub-watersheds water withdrawals exceed the 7Q10 (the lowest stream flow for seven consecutive days that would be expected to occur once in ten years) in every season. Further, the population is expected to increase in this region (Table 2), which is likely to exacerbate the problem (ICPRB(C) 2011).

Table 1. Average seasonal consumptive withdrawals in Marsh and Rock Creek watershed (gal/season) (ICPRB (B) 2011).

	Fall	Winter	Spring	Summer
Upper Rock Creek	32,805,233	18,316,510	33,159,785	37,828,315
Lower Rock Creek	36,160,220	16,476,006	36,104,395	43,246,888
Little Marsh Creek	35,175,800	14,334,191	34,535,136	50,184,533
Upper Marsh Creek	25,103,706	6,050,716	24,596,345	32,438,124
Lower Marsh Creek	44,992,448	25,458,612	45,149,971	65,219,270

Table 2. Projected CWPA population growth in percentage since 2000 (ICPRB (C) 2011).

Data Source	2010	2020	2030
ACOPD, 2011	7.5	22.4	29.3
DEP, 2006	20.5	44.9	52.4

2.2.4 Water Quality

Water quality degradation in the Marsh and Rock creek watersheds is due largely to pesticide use in the watershed, as well as nutrients from septic systems, agricultural runoff, residential runoff, and development. There has also recently been increased concern about pharmaceutical contamination. As a result, many Marsh and Rock creek segments and tributaries are impaired (Figure 10). There are many proposed development projects in the watershed because of projected population growth, which also could lead to further impairment of the waterways (Figure 11) (ICPRB(D) 2011).

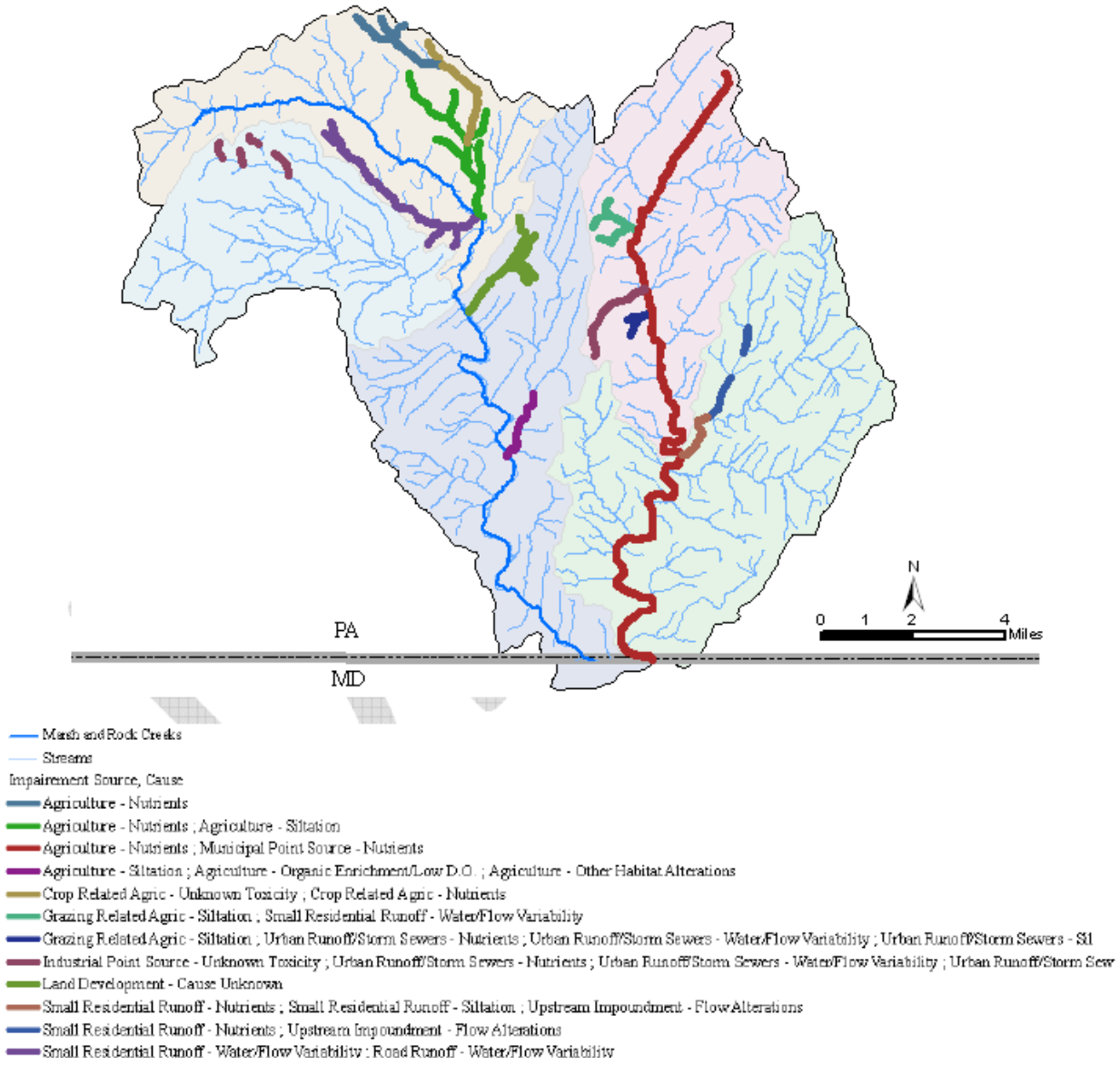


Figure 10. Impaired waterway locations and causes in the Marsh and Rock Creek Watersheds, based on eMapPA data(ICPRB (D) 2011).

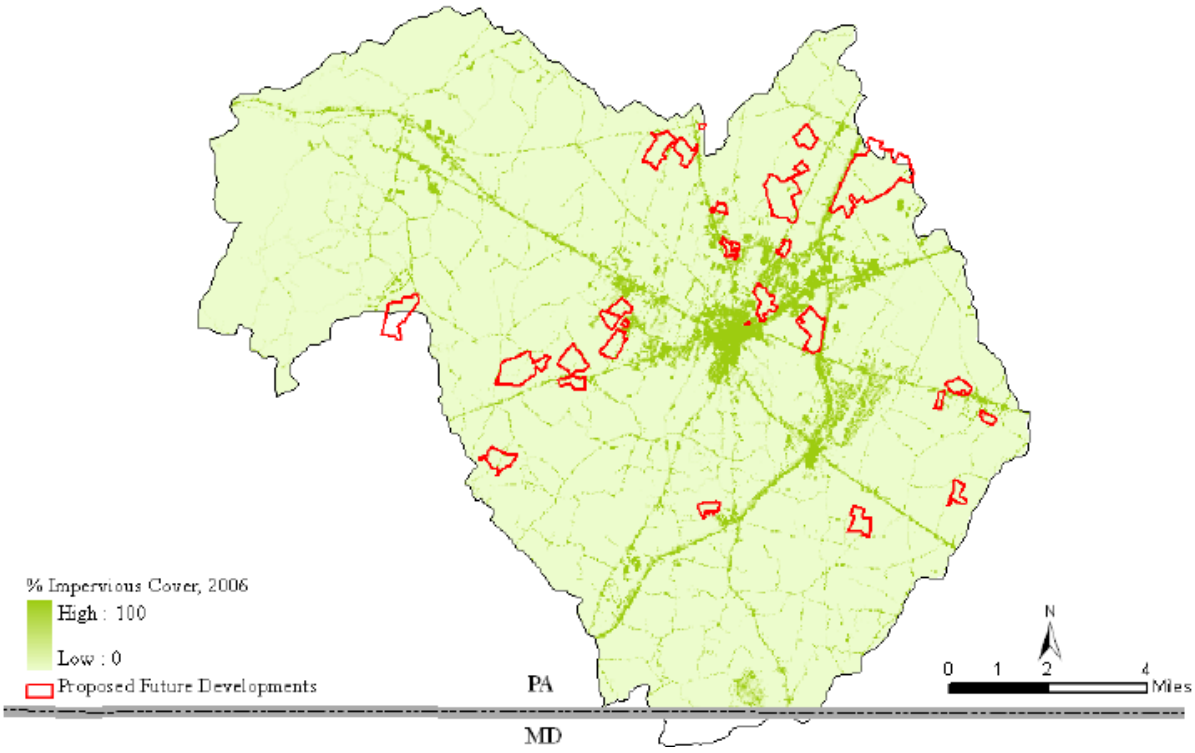


Figure 11. Map of proposed development sites in the Marsh and Rock creek watersheds (ICPRB 2011).

2.2.5 Critical Water Planning Area Designation

As mentioned in Section 1.2 (Purpose of Thesis) of this thesis, as part of Act 220, enacted in 2002, an act requiring investigation of the state of Pennsylvania's water resources, and development of a state plan, the combined Marsh and Rock Creek watersheds were nominated and designated a 'Critical Water Planning Area' (CWPA). A CWPA defined as a "*significant hydrologic unit where existing or future demands exceed, or threaten to exceed, the safe yield of available water resources*" (DEP 2006). The two watersheds were combined in this designation because they are hydrologically connected as the headwaters for the Potomac River basin (which provides water supply to Washington, D.C.), and because the populated area surrounding the borough of

Gettysburg lies in both watersheds, resulting in their exhibiting similar water withdrawal (wells drying up) and pollution issues (DEP 2009).

CHAPTER III: METHODOLOGY

The methodology used to achieve the goals of this research project was based on an analysis and the application of the methodology created by Corazón de la Tierra (previously discussed in section 2.1.6). This methodology was used because it not only provides clear, understandable steps to successfully conduct stakeholder consensus-based research (Juarez-Aguilar 2011), but also because many of the initial steps in this methodology had already been undertaken in the Marsh and Rock Creek Watershed. All revisions made in the application of this methodology were completed in consultation with ICPRB and communications with Corazón de la Tierra.

The complete procedure in the undertaking this study is outlined in the following sections. It is important to note that all the steps encompassed in the methodology created and applied by Corazón de la Tierra are included in this procedure, although each step was modified, as needed, to better address the Marsh and Rock Creek context.

Step 1: Identify key stakeholders within the basin.

This portion of the research was completed prior to the initiation of my study. The stakeholders included individuals from each school district, from the two universities located in the watershed, from all municipalities, state elected officials (or their representatives), conservation/environmental groups, public water suppliers, from the

county planning offices, all sectors of agriculture (cattle, wineries and orchards), major industries and others with knowledge of the study site (community members).

Step 2: Contact Key Stakeholders and Secure their participation

Each of the identified key stakeholders was contacted individually by ICPRB through email, telephone calls and personal visits and asked to join the CAAC before the beginning of this study. Each group participated in some capacity, either through their direct participation or sending an appropriate representative, or was kept informed on the study activities separately from the meetings. Each CAAC meeting normally comprised 30 -35 participants. For a list of the stakeholder groups as well as the organizations represented on the CAAC please refer to Appendix A.

Step 3: Obtain background Information on the Basin and its Management.

ICPRB conducted several studies evaluating water availability, current and future water uses, stormwater and floodplain management, and water quality. The results of these studies were distributed to the CAAC, and the committee was asked to voice their opinions and problems with any of the distributed information. An electronic blog was also created in order to facilitate discussion between participants beyond the organized meetings.

Step 4: Workshop (Including preparation)

The workshop was the portion of the research in which most of the study activities were focused. It was comprised of three separate meetings with the CAAC, as well as several other steps. Each of these steps is described below:

1) *ILBM Background Presentation* –A two-hour meeting took place on October 12, 2011, for the purpose of explaining how this study would be conducted, explaining how it could benefit the CAAC, and providing background information on ILBM as a platform for assessing basin management. This was completed through a PowerPoint presentation (Appendix B), followed by a discussion, and subsequent vote on whether or not the CAAC were interested in this research project. The group unanimously voted to participate in the project.

   This portion was done separately from the rest of the workshop, in order to give the participants a chance to ask questions about ILBM and the proposed project, as well as to ensure all the participants were interested in the project (an important factor for ensuring full stakeholder participation).

   The questions and discussions during this meeting were recorded for reference material.

2) *Discussion and Information Gathering* – In order to prepare for the next meeting, every participant needed to be fully aware of the studies that were previously completed by ICPRB, in order to be fully informed of the potential problems in the area. To facilitate this goal, the studies were posted on the CWPA blog, as well as distributed to all participants through email. A summary of the issues in the CWPA also was completed (Table 4 in Section 4.1), in order to ensure each participant received a good overview of the problems and background in a short, easy-to-read version. The steps involved

in the workshop were also posted on the blog and distributed individually, and discussions on the process, as well as any questions about the process, were encouraged. This step involved the completion of several meetings, conference calls and emails with key stakeholders.

3) *Management Solution Brainstorming Session* – This was a two-hour meeting was conducted on January 11, 2012, for the purpose of collecting management suggestions the committee concluded were needed to solve the problems identified previously by the committee and the ICPRB study (Table 4 in Section 4.1). A list of management suggestions that had already been collected was compiled and distributed before the meeting by email, with the committee then being requested to add any additional management suggestions they deemed important. The completed list contained 42 management suggestions (Tables 5-10 in Section 4.1). The merits of the management suggestions, however, were not discussed during this workshop.

   The discussion and management suggestions were recorded throughout the brainstorming session.

4) *Preliminary Analysis of Management Suggestions/Question development* – In order to facilitate discussion of the management suggestions, a preliminary analysis of each individual suggestion was conducted and compiled in a succinct, straight-forward document that was distributed to the committee for review. The preliminary analysis contained an explanation of the management

suggestions, the costs associated with the project, and a preliminary idea of how the program could help better manage the watershed (Appendix C).

In addition, six questions aimed at determining the feasibility of the management suggestions were developed in collaboration with ICPRB (Table 3). Research into how the questions should be worded, as well as how to score each of the responses, was conducted prior to the development of the questions. Leading questions were avoided by passing the questions through a committee for this purpose. In addition the questions and the answer responses were completed in a gradient with clear definitions so as to avoid misunderstanding and bias in accordance to social science research (Singleton and Straits 2005; Podsakoff et al. 2012).

Each question was based on one of the ILBM "pillars," and was meant to receive a consensus-based rating from 0-10. Each question was phrased in a way that was relevant to the goals of the CAAC. It is important to note that, because each program has to be voluntarily implemented according to Act 220 guidelines, the questions attempted to reflect the feasibility of the programs in this context.

Table 3. Questions produced in collaboration with ICPRB to evaluate program feasibility in the context of the ILBM "pillars".

ILBM "Pillar"	Associated Question
Information	**Is the information needed to complete this project available?** 0 = None of the needed information is available. 3 = Some of the information needed is available but more studies need to be conducted. 5 = The information exists but needs to be compiled. 7 = The information exists and is partially compiled. 10 = The information exists and is compiled.
Funding	**Are there known funding sources which can support this project?** 0 = No funding opportunities exist for this project. 3 = Funding opportunities exist that could fund a portion of the project. 5 = Funding opportunities exist that could support the full project. 7 = The project is partially funded and funding opportunities exist to fund the rest. 10 = The project is fully funded.
Policies	**Do current policies (regulations, ordinances, etc.) support this project?** 0 = Current policies are against this project. 5 = There are no policies that support or inhibit this project. 10 = There are policies in place that permit or encourage this project.
Institutions	**Is there an institution who will take on and complete this project?** 0 = No institutions exist who can complete this project. 3 = Potential institutions may exist. 5 = Potential institutions exist but their institutional capacity is unknown. 7 = Institutions exist and have the capacity to complete the project. 10 = An institution or institutions can and have said they will complete the project.
Stakeholder Support	**Is there sufficient stakeholder support for this project?** 0 = No stakeholders are generally against or totally unaware of this project. 5 = Some stakeholders are in support and some are against this project. 10 = Stakeholders are generally in support of the project.
Technology (Timeframe)	**In what timeframe is the project likely to be complete?** 0 = 20+ years 3 = 10 years 5 = 5 years 7 = 3 years 10 =Less than 1 year

Two of the six ILBM governance pillars (policy and stakeholder support) were only given three scoring options, rather than five. This was done in the interest of conserving time during the workshop, due to the anticipation that extensive discussion would take place in these areas. This being said, the CAAC would be permitted to select a rating of 3 or 7 for both of these categories if a consensus could not be reached.

In addition, the technology pillar was changed to a question on timeframe. It was undertaken with the logic that the more extensive the technological fix, the longer the project would take. Further, the question on timeframe also was considered to be helpful in evaluating program feasibility.

5) *Personal Invitations to Participants* – In preparation for the workshop, each participant was informed of the workshop and its intended schedule by email and through the blog. Further, any participant not totally involved in the entire stakeholder process up until this workshop were sent a personalized email, and telephoned, in order to explain why their presence was needed at the workshop. This was done to ensure full participation, and also to attempt to ensure all bodies of knowledge and all opinions were 'on the table' during the consensus-based portion of the workshop. If a participant was unable to attend or to send a representative, the process was explained to them individually, and their input was taken through individual interviews and discussed during the workshop period (this only applied to three stakeholders).

6) *Answering Questions/ Feasibility Analysis* – This seven-hour, working lunch-mediated workshop was conducted on February 15, 2012 with the specific purpose of evaluating the management suggestions which resulted from the January 11, 2012 brainstorming session. It was structured in collaboration with ICPRB, with the purpose of making the most efficient use of the available time.

During the meeting, all participants (a total of 28) were asked to sign in, to allow the stakeholder groups present to be recorded. Each participant was also given an explanation of their role in this workshop as a representative of their respective stakeholder group. This was done to minimize the personal opinions of the stakeholder representatives biasing the overall results.

The next step of the workshop was to review each of the management suggestions and select the ones that were completely feasible, therefore meriting a "yes" (or 60) rating, and which ones were deemed completely unfeasible or unnecessary, thereby meriting a "no" (or 0) rating. To facilitate this rating exercise, the management suggestions were grouped into sections, based on the program objectives. After a section was read, the CAAC was asked to state whether they thought any of them merited definite "yes" or "no" designation. If a suggestion received neither designation, it was put in a "maybe" pile. The group was also asked to identify any management suggestions they felt were important so they could be flagged for early discussion.

When all the "maybe" management suggestions were determined (a total of 31), the group discussed each one of them, beginning with the flagged programs, in terms of the six aforementioned ILBM "pillar"-based questions (Table 3). The participants then reached a consensus on the rating for each question for each management suggestion. The group ultimately discussed and rated a total of 186 questions by the end of the workshop.

The ratings and associated discussions were recorded throughout the workshop.

7) *Problem solving* – Once the ratings had been accumulated, they were summed for each management alternative, resulting in each receiving a total score out of sixty. These scores were then used to prioritize projects, with the highest scores receiving the most priority and the lowest ones receiving the least. This prioritized list will be used in conjunction with a pending technical analysis to determine which programs will ultimately be recommended to the Pennsylvania State Water Plan.

Step 5: Distribute the results.

The scores were compiled and then distributed to the stakeholders via blog and email. A subsequent two-hour informal meeting was held on April 11, 2012 to discuss the information gained from the workshop, and how it was going to be used. At this meeting, the stakeholders voiced their opinions about the rating process and what they thought should have been done differently. The group also was asked if they agreed with the ratings, and if they thought they were accurate. A vote was also taken to see if the CAAC wanted to use the completed study now that they had received the results. The CAAC unanimously voted to use the study.

In addition to disseminating the information to the stakeholders, the information was also distributed to the Pennsylvania DEP.

CHAPTER IV: RESULTS AND DISCUSSION

4.1 RESULTS

The compiled list of issues that need to be addressed in the Marsh and Rock Creek Watersheds, based on past meetings and studies done by ICPRB, is presented in Table 4.

Table 4. Summary of issues identified through ICPRB scientific studies/CAAC discussions (ICPRB 2012).

Reference number	Issue summary
1	The average amount of water withdrawn in each CWPA sub-watershed on a daily basis in every season is greater than low flow conditions represented by 7Q10. Future growth is expected to exacerbate this problem, with an average maximum expected increase of 67% across all sub-watersheds by 2030.
2	Due to natural and anthropogenic conditions in the watersheds, water storage is limited. For example, the 13 public water suppliers have a total reported storage of 3,842,570 gallons (as of 2004 reporting). This represents only 2.3 days of average use. This issue is pervasive in the watersheds and is not limited to public water suppliers.
3	Impaired waterways exist in all five sub-watersheds of the CWPA. Actions taken in the watersheds should strive to maintain, if not improve, existing water quality conditions to prevent costly impacts to water users such as public water suppliers. **A)** Rock Creek is effluent dominated under low flow conditions. Sufficient quantities of water or a limited amount of pollutants should be maintained in the creek during low flow conditions to ensure the nutrient (and other pollutant) concentrations meet or exceed water quality requirements. **B)** Further the amount of effluent leaving the treatment plants should not exceed the capacity of the stream, causing deterioration of stream and habitat stability.
4	Uncontrolled storm water runoff affects Marsh and Rock creek water quality in terms of sediments, nutrients, erosion, and flooding. Proactive storm water management may reduce local and Chesapeake Bay water quality issues. Regarding storm water quantity, sufficient storm water is available to meet the water deficit in all seasons for the CWPA.
5	There is a lack of integrated, coordinated oversight and management of water resources at the CWPA scale that includes authority for implementation (due primarily to regulatory limitations at the state and county level); however, interest and concern in water resources management exists in the watershed and is evident by participation in the Adams County Water Resources Advisory Committee (WRAC) and the CAAC.
6	Data availability is a concern for the management of water resources in the Marsh and Rock creek watersheds: **A)** A significant portion of the water used in the Marsh and Rock Creek watersheds is currently estimated due to lack of available, reported water use data. **B)** Limited long-term surface and ground water level and quality data is available for assessment of water resources issues.

The management suggestions resulting from the past CAAC meetings, and from the brainstorming session on January 11, 2012, were compiled into a comprehensive table and sorted into categories on the basis of the type of management suggestion. The first set of management suggestions (Table 5) seek to increase water availability through either increasing water supply or reducing water demands. The reference numbers included in the table will be used later in this report.

Table 5. List of management alternatives suggested by CAAC categorized as relating to *Water Availability* (No.=management alternatives reference number; Type=management approach; Issue No.= issue reference numbers in Table 4; Sub-Watershed=sub-watershed the program applies to).

No.	Type	Management Alternatives	Issue No.	Sub-Watershed
1	Demand	Implement more water efficient irrigation practices.	1	All
2	Demand	Community water supply systems should perform a water audit at least once a year to control water loss	1,2	All but Upper Marsh
3	Demand	Seek, promote, and implement wastewater treatment system re-use, beneficial re-uses of wastewater.	4	All
4	Supply	Percolate water back into the ground from sewage treatment plants where feasible. Examples include the use of sand mounds, spray irrigation, constructed wetlands	1	All
5	Demand	New developments should include/incentivize water conservation equipment in homes when built.	1	All
6	Supply	Importation of water from Susquehanna Basin into GMA system through York Water.	1	Upper & Lower Rock, Lower Marsh
7	Supply	GMA may consider alternative means of conveyance from the augmentation well to the public water supply intakes to reduce consumptive loss	1	Upper & Lower Rock, Lower Marsh
8	Supply	Investigate use of quarries as water storage facilities, particularly in the diabase.	1	All
9	Supply	Creation of a new or rehabilitation of an old reservoir in/near the CWPA (ex. Birch Run)	1,2	TBD
10	Supply	New developments need to provide additional storage capacity.	2	All
11	Supply	Creation of additional agricultural ponds. Surface water ponds for agricultural irrigation should be the recommended practice over the use of wells.	1,2	All
12	Supply	Enhanced or additional treatment mechanisms should be developed to provide additional sources of water by further treating available surface and ground water sources.	1,3	All
13	Supply	Establish standardized passby for surface and ground water withdrawals to ensure the withdrawals do not de-water the streams.	1	All

The second set of management suggestions (Table 6) were specifically related to communications. They included education programs, encouraging collaboration between stakeholders, and other programs for the purpose of protecting the watershed in general, or for reducing water demands.

Table 6. List of management alternatives suggested by CAAC categorized as relating to *Communications*. (No.=management alternatives reference number; Type=management approach; Issue No.=issue reference numbers in Table 4; Sub-Watershed = the sub-watershed the program would applies to).

No.	Type	Management Alternatives	Issue No.	Sub-Watershed
14	Demand	Encourage communication between large water users on conservation measures being used within the community to foster idea sharing and long-term sustainability.	1	All
15	Protection	Develop a Strategic Communication Plan for the general public and targeted stakeholders (including all levels of education: school districts, colleges, universities), a marketing plan. Accent the positive of what can be done, such as the efficiencies that farmers have achieved to produce more with less. Because local grassroot support is needed for success, use the communication plan to develop a simple, comprehensive document for local people. The purpose of the document is to encourage participation in the protection of water quality, quantity, and conservation.	7	All
16	Protection	Enhance education in the CWPA on the following: -- Outreach and field trips for school age kids as well as municipal and elected officials to familiarize them with the watershed, including both the positives and negatives; and -- Stormwater education and outreach with organizations and the general public.	4,7	All

The third set of management suggestions are related to data collection (Table 7). Each of them is geared towards protection of the watershed.

Table 7. List of management alternatives suggested by CAAC which are categorized as relating to *Data Collection*. (No.=management alternatives reference number; Type=management approach; Issue No.=issue reference numbers in Table 4; Sub-Watershed=sub-watershed the program applies to).

No.	Management Alternatives	Issue No.	Sub-Watershed
17	Public water suppliers in the CWPA should prepare and get DEP approval for Source Water Protection Plans for all wells and surface intakes. Technical assistance is available from DEP and PGWA.	3	All but Upper Marsh
18	Monitoring of ILBM pillars and physical environment should be conducted to determine the effectiveness of implemented management recommendations, particularly installed systems/practices. The monitoring results should be utilized to adapt measure(s) to improve effectiveness.	3,4	All
19	Encourage/increase water use registrations and/or metering to more accurately understand the water uses in the watersheds for future water resources decision-making.	6a	All
20	Mason Dixon Utilities to fund a USGS (or similar) stream gage on Marsh Creek, if development proceeds.	6b	Lower Marsh
21	Installation of additional stream/staff gages and continued maintenance and operation of existing gages.	6b	Upper and Little Marsh in combination, all others individually
22	Encourage identification and documentation of wetlands. Develop municipal requirements for electronic submission of land development plans, inclusive of delineated wetlands that could be placed in a GIS wetlands layer.	6	All

The next set of management suggestions is related to policy and management (Table 8) and contains programs which seek to increase supply, decrease demand, and protect the watershed or all three. Each of the programs would apply to the entire watershed.

Table 8. List of management alternatives suggested by CAAC which are categorized as relating to *Policy and Management*. (No.=management alternatives reference number; Type=management approach; Issue No.=issue reference numbers in Table 4).

No.	Type	Management Alternatives	Issue No.
23	Protection	Establish groundwater protection ordinances for: well construction; geothermal wells; yield analysis (for large wells), need common methodology for municipalities to determine sustainable groundwater yields; water impact study (for large wells); and water quality protection, need inspections to ensure proper construction and testing of finished water to make sure treatment is adequate and well is functioning properly.	3,5
24	Protection	Encourage the adoption of a wellhead protection ordinance to protect water supply sources within the Critical Water Planning Area.	3,5
25	Protection	All municipalities in the CARP area should adopt and enforce ordinances recommended by the WRAC and Adams County government regarding: A) Lawn fertilizer; B) Stormwater management; C) Private well construction standards, including geothermal systems; D) On lot septic system maintenance; E) Water supply requirements for development; and F) Protecting and creating riparian buffers (need to create a model riparian buffer ordinance).	3,5
26	Protection	Encourage the development and maintenance of riparian buffers along designated greenways (including the Rock and Marsh creek greenways), as specified in the County Greenway Plan.	3,4,5
27	Protection	Adams County should provide funding for land preservation (purchasing conservation easements) targeting the Marsh and Rock creek watersheds.	3,4
28	Protection	Prepare a Joint Comprehensive Plan for the CWPA that includes sound land use policies and a strong water supply and protection component. Follow up with compatible zoning and SALDOs.	5
29	All	Fostering implementability of recommendations: A) Develop a list of projects requiring additional funding for future grant-seeking efforts; and B) Develop incentives or credits for implementation of practices.	5,7
30	Demand	Establish a water conservation program that can respond to water supply/demand conditions, especially for businesses and institutions affected by an influx of tourists (about 2 million) during summer months when water supply typically is low. Possibilities are: A) Encourage the adoption of water saving measures used in other tourist areas. The Chamber of Commerce and Visitors Bureau can help with this. B) Issue low water supply advisories when appropriate. The Water Management Council (see recommendation for establishment) could do this using data it collects. C) Adopt variable water and sewer rates based on water supply conditions (higher rates when supply is low). Municipal authorities may be able to do this.	1

Table 8 (Continued). List of management alternatives suggested by CAAC which are categorized as relating to *Policy and Management*. (No.=management alternatives reference number; Type=management approach; Issue No.=issue reference numbers in Table 4).

No.	Type	Management Alternatives	Issue No.
31	Protection	Create a Marsh/Rock Creeks Water Management Council. The Council would be composed of representatives from participating municipalities, municipal authorities and county government. It would be funded by contributions from those participating organizations and grants if available. It would function as a mini-ICPRB, but would contract out for technical expertise. It would do for all the participating municipalities and municipal authorities what would be impractical for individual entities to do. It could: A) Collect and analyze CARP area water supply data. B) Advise municipalities and municipal authorities in the CARP area about water allocation. C) Furnish technical advice on water resources issues. D) Serve as a central resource for inspections and permits required under municipal ordinances for water related matters.	5
32	Protection	Develop a local Marsh/Rock Creek Watershed Association that could facilitate coordination of volunteers to implement improvement projects.	5,7
33	Protection	Implement local drought preparedness activities including establishment of a CWPA drought advisory group.	5
34	Protection	Develop list of favorable areas for development, areas that are less sensitive. Put together an outreach team to demonstrate existing tools for choosing ideal development areas, logical water availability guidance tools.	1,7

The next set of management suggestions dealt with water quality (Table 9), with all attempting to protect the Marsh and Rock Creek water bodies. Number 38 in this chart is cross-categorized as a communications program.

Table 9. List of management alternatives suggested by CAAC which were categorized as relating to *Water Quality* (No.=management alternatives reference number; Type=management approach; Issue No.=issue reference numbers in Table 4; Sub-Watershed=sub-watershed the program applies to).

No.	Management Alternative	Issue No.	Sub-Watershed
35	Quantify maximum contaminant loads for pollutants of concern in impaired waterways by developing total maximum daily loads (TMDLs) for impaired reaches in the Marsh and Rock creek watersheds.	3	All
36	Implementation of sewage management districts where on-site septic systems are not managed by municipalities.	3	All
37	Install a filter or catchment near the outlet of Stevens Run to prevent debris from entering Rock Creek.	3	Rock Creek
38	Public water suppliers in the CWPA should participate in the Potomac Drinking Water Source Protection Partnership to leverage resources and enhance communications with other suppliers in the basin.	5,7	All but Upper Marsh

The final set of management alternatives are related to storm water management (Table 10), and seek to either increase water supply, decrease water demands, or a combination of both. All four are intended to apply to the full watershed.

Table 10. List of management alternatives suggested by CAAC which were categorized as relating to relate to *Storm Water Management* (No.=management alternatives reference number; Type=management approach; Issue No.=issue reference numbers in Table 4).

Ref No.	Type	Management Alternatives	Issue No.
39	Supply	Separate downspouts from storm drains by routing run-off to a pervious surface (lawn, rain garden, etc.).	1
40	Demand	Establishment of a storm water utility in the CWPA.	4,5
41	Supply/ Demand	Implementation of storm water management program(s). A) Continuation/expansion of the ACCD rain barrel and rain garden programs; B) Storm water run-off from impervious surfaces on golf course properties could be reused for landscaping purposes and/or to enhance infiltration through rain gardens and constructed wetlands; C) Promote use of warm season grasses whenever possible as a best management practice (e.g. golf courses); D) Implement efficient practices for control of runoff from agricultural land; -- Develop an Adams County specific storm water BMP manual; and E) Establish a collaboration with a developer in the CWPA to create a Low Impact Development (LID) showcase site to encourage environmentally sensitive development practices.	4
42	Demand	Implementation of storm water and gray water re-use program(s). Options include: A) Regional/neighborhood storm water ponds for grey water distribution; B) Collaboration between neighboring industries/companies to distribute grey water; C) Use of either rainwater or grey water for industrial processes such as product washing or cooling, rather than using ground or potable water; and D) Golf courses within the CWPA should be encouraged to use grey water for irrigation, wherever and to the extent possible.	4

The scores for each individual governance "pillar," as related to the study watersheds, as well as the overall score (sum of the pillar scores), for each management suggestion receiving a "maybe" designation during the workshop, are summarized below in Table 11.

Table 11. Scores given for each of the ILBM "pillars" for each of the management alternatives categorized as "maybe". The total is the sum of all the pillars. (Ref No. = number assigned to the program in Tables 4-10; TypeA = category of the program (A=Availability, C=Collection, DC=Data Collection, P/M = Policy and Management, Q=Quality and SW = Stormwater); TypeB = management approach (D =Reduce Demand, S =Increase Supply and P =Watershed Protection).

Ref No.	TypeA	TypeB	Policy	Financing	Information	Institutions	Stakeholders	Timeframe	Total
1	A	D	10	5	5	5	5	5	**35**
3	A	D	10	3	3	5	5	5	**31**
4	A	S	10	3	3	7	5	5	**33**
5	A	D	7	3	5	7	5	7	**34**
6	A	S	10	10	3	7	5	5	**40**
7	A	S	5	3	3	7	5	3	**26**
8	A	S	10	5	3	7	5	0	**30**
9	A	S	10	0	3	3	5	0	**21**
10	A	S	7	5	3	5	5	7	**32**
11	A	S	5	7	3	5	10	10	**40**
12	A	S	10	5	3	3	5	3	**29**
13	A	S	5	0	3	3	5	0	**16**
14	C	D	10	5	5	3	10	10	**43**
15	C	P	5	7	7	7	10	10	**46**
18	DC	P	10	5	10	7	10	10	**52**
19	DC	19	7	3	3	3	5	7	**28**
21	DC	P	10	5	10	7	10	10	**52**
22	DC	P	5	5	5	7	5	10	**37**
23 (A)	P/M	P	10	5	7	7	5	7	**41**
23 (B)	P/M	P	10	5	7	7	5	7	**41**
24	P/M	P	10	5	7	7	5	7	**41**
27	P/M	P	10	7	7	10	5	10	**49**
28	P/M	P	10	5	7	7	5	5	**39**
29 (A)	P/M	All	5	10	5	7	10	10	**47**
29 (B)	P/M	All	5	5	5	5	10	7	**37**
30	P/M	D	5	5	3	7	10	10	**40**
31	P/M	P	10	3	5	3	5	5	**31**
34	P/M	P	10	5	5	5	5	7	**37**
38	Q	P	10	5	10	7	10	10	**52**
41 (E)	SW	S/D	10	5	7	5	10	7	**44**
42	SW	D	5	5	3	7	5	5	**30**

The prioritized list (highest priority at the top) with the reference number, a condensed management alternative description, and the total score, is presented in Table 12. The programs with scores of 60 are those that received a "yes" designation, while those with scores of 0 are those that received a "no" designation.

Table 12. Prioritized list of management alternatives based on total scores determined during the workshop of February 15th 2012. The total is the sum of all the governance pillars (as shown in Table 11); the No. is the reference number assigned to the program in Tables 4-10; scores of 60 were "yes" programs and scores of 0's were "no" programs.

No.	Management Alternatives	Score
41 (A-D)	Implementation of storm water management programs not including the creation of a Low Impact Development (LID) showcase site.	60
25	All municipalities in the CARP area should adopt and enforce ordinances recommended by the WRAC and Adams County government (excluding lawn fertilizers and on lot septic systems).	60
2	Community water supply systems to perform a water audit once a year to control water loss.	60
16	Enhance education in the CWPA with outreach and field trips for school age kids as well as municipal and elected officials and stormwater education to organizations and general public.	60
17	Public water suppliers in the CWPA should prepare and get DEP approval for Source Water Protection Plans for all wells and surface intakes.	60
20	Mason Dixon Utilities funded USGS (or similar) stream gage on Marsh Creek.	60
26	Development and maintenance of riparian buffers along designated greenways (including the Rock and Marsh creek greenways), as specified in the County Greenway Plan.	60
32	Develop a local Marsh/Rock Creek Watershed Association that could facilitate coordination of volunteers to implement improvement projects.	60
33	Implement local drought preparedness activities including establishment of a CWPA drought advisory group.	60
34	Develop list of favorable areas for development, areas that are less sensitive. Put together an outreach team to demonstrate existing tools for choosing ideal development areas.	60
35	Quantify maximum contaminant loads for pollutants of concern in impaired waterways by developing TMDLs for impaired reaches in Marsh and Rock creek watersheds.	60
18	Monitoring of ILBM pillars and physical environment should be conducted to determine the effectiveness of implemented management recommendations, particularly installed systems/practices. The monitoring results should be utilized to adapt measure(s) to improve effectiveness.	53
21	Installation of additional stream/staff gages and continued maintenance of existing gages.	52
38	Water suppliers to participate in the Potomac Drinking Water Source Protection Partnership.	52
27	Adams County should provide funding for land preservation (purchasing conservation easements) targeting the Marsh and Rock creek watersheds.	49
29 (A)	Develop a list of projects requiring additional funding for future grant-seeking efforts;	47
15	Develop a Strategic Communication Plan for the general public and targeted stakeholders (including all levels of education: school districts, colleges, universities), a marketing plan.	46
41 (E)	Implementation of storm water management program(s): Establish collaboration with a developer in the CWPA to create a Low Impact Development (LID) showcase site to encourage environmentally sensitive development practices.	44

Table 12 (Continued). Prioritized list of management alternatives based on total scores determined during the workshop of February 15th 2012. The total is the sum of all the governance pillars (as shown in Table 11; the No. is the reference number assigned to the program in Tables 4-10; scores of 60 were "yes" programs and scores of 0's were "no" programs).

No.	Management Alternatives	Score
14	Encourage communication between large water users on conservation measures being used within the community to foster idea sharing and long-term sustainability.	43
23	Establish groundwater protection ordinances for: yield analysis (for large wells), to meet need for common methodology for municipalities to determine sustainable groundwater yields.	41
23	Establish groundwater protection ordinances for: water impact study (for large wells).	41 Water
24	Encourage the adoption of a wellhead protection ordinance to protect water supply sources within the Critical Water Planning Area.	41
6	Importation of water from Susquehanna Basin into GMA system through York Water.	40
11	Creation of additional agricultural ponds. Surface water ponds for agricultural irrigation should be the recommended practice over the use of wells.	40
30	Establish a water conservation program that can respond to water supply/demand conditions, especially for businesses and institutions affected by an influx of tourists (about 2 million) during summer months when water supply typically is low.	40
28	Prepare a Joint Comprehensive Plan that includes sound land use policies and a strong water supply and protection component. Follow up with compatible zoning and SALDOs.	39
29 (B)	Develop incentives or credits for implementation of best management practices.	37
22	Develop municipal requirements for electronic submission of land development plans, inclusive of delineated wetlands that could be placed in a GIS wetlands layer.	37
1	Implement more water efficient irrigation practices.	35
5	New developments should include/incentivize water conservation equipment in new homes.	34
4	Percolate water back into the ground from sewage treatment plants.	33
10	New development requirements to provide additional storage capacity.	32
3	Seek, promote, and implement wastewater treatment system re-use.	31
31	Create a Marsh/Rock Creeks Water Management Council. The Council would be composed of representatives from participating municipalities, municipal authorities and county government.	31
8	Investigate use of quarries as water storage facilities, particularly in the diabase.	30
42	Implementation of storm water and gray water re-use program(s).	30
12	Enhanced or additional treatment mechanisms should be developed to provide additional sources of water by further treating available surface and ground water sources.	29
19	Encourage/increase water use registrations and/or metering to more accurately understand the water uses in the watersheds for future water resources decision-making.	28
7	GMA may consider alternative means of conveyance from the augmentation well to the public water supply intakes to reduce consumptive loss	26
9	Creation of a new or rehabilitation of an old reservoir in/near the CWPA (ex. Birch Run)	21
13	Establish standardized passby for surface and ground water withdrawals to ensure the withdrawals do not de-water the streams.	16
36	Implementation of sewage management districts where on-site septic systems are not managed by municipalities.	0
37	Install a filter or catchment near the outlet of Stevens Run to prevent debris from entering Rock Creek.	0
39	Separate downspouts from storm drains by routing run-off to a pervious surface (lawn, rain garden, etc.).	0
40	Establishment of a storm water utility in the CWPA.	0

In order to determine what ILBM governance pillars seemed to be stronger or weaker, in terms of the management suggestion, an overall summary of each pillar was completed through a mean analysis, and the construction of a frequency diagrams for each pillar. The results of each of these analyses are presented below in Figure 12.

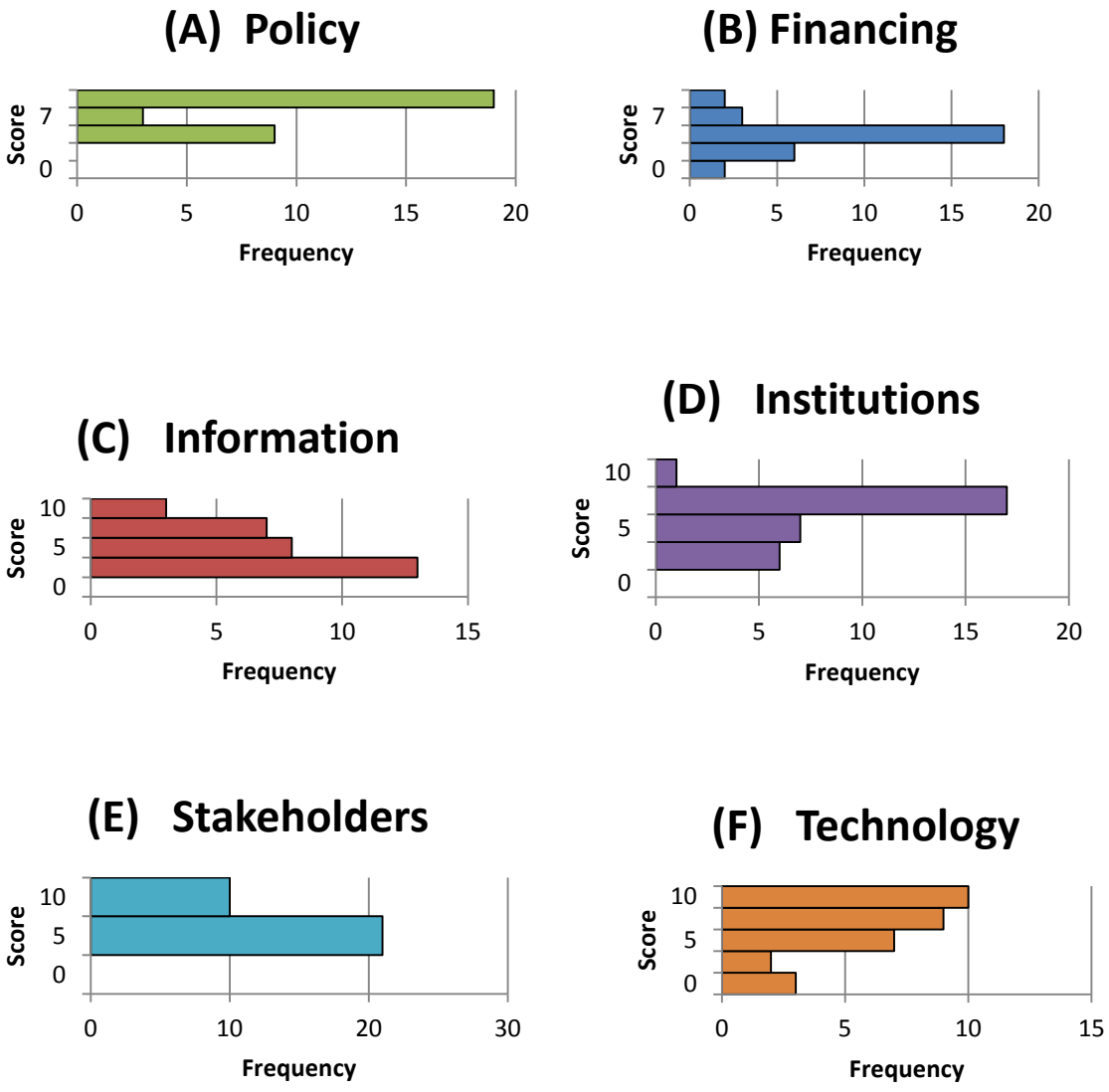


Figure 12. Frequency diagrams of the overall scores for each of the ILBM governance "pillars" (Mean values are as follows: (A) = 8.26; (B) = 4.81; (C) = 5.10; (D) = 5.87; (E) = 6.61; and (F) = 6.58).

4.2 DISCUSSION

4.2.1 Individual Scores

The programs at the top of the prioritized list (i.e., those with a score greater than 45) in Table 12 above were consistently the programs that were in the process of taking place, or one which could be quickly initiated. The creation of greenways in riparian areas, for example, is a project that had begun in other regions of Adams County, and could easily be campaigned to continue in the CWPA region.

The programs with scores between 30 and 45 contained a mix of programs which have or have not begun. For the ones already partially developed, there was often another component holding them back (e.g., stakeholder support; timeframe). The inter-basin transfer between the Susquehanna basin and the CWPA (ref no. 6), for example, has already been proposed, and is in the process of being permitted, it still received a score only in the mid-range (40), due to low scores in timeframe (5), stakeholder support (5) and information (3).

All programs receiving a score of 30 and below were either technologically too advanced (ref no. 7, 8, 9, 12, 37 and 39), required the creation of an entirely new institution or implementing agency (ref no. 36 and 40), or had little stakeholder support (ref no. 13 and 19), each resulting in a low score for all the governance pillars. The creation of a new reservoir near the CWPA (ref no. 9) had a very low score

due to the timeframe, lack of funding, lack of information and lack of stakeholder support.

It also was interesting to note that all the programs meant to increase availability (ref. no. 1-13) exhibited scores of 35 or less, with the exception of reference no. 6 (interbasin transfer) and reference no. 11 (creation of agricultural ponds), both of which had scores of 40. These are relatively low scores, indicating increasing water availability is neither considered feasible or desirable in this watershed by the CAAC. This type of opinion and understanding was supported by informal discussions which often took place in the stakeholder meeting groups. Many of the members of the CAAC were against the importation, or creation of more water resources, since they viewed this approach as being ineffective in dealing with the source of the problem (i.e., over-use), therefore being a waste of funds. The committee often supported the idea of reducing water demands through education and communication programs.

These kinds of results are also consistent with the fact that the CAAC was looking at each of these management suggestions with the understanding they needed to be voluntary. Since projects that attempt to increase water availability often involved inputting technological fixes or bringing in water from external sources (which can be costly), they often were not viewed as feasible.

Based on this logic, it was also interesting that all the communication projects (ref. no. 14-16) received scores of 43 or above (43, 60 and 46, respectively). Since these kinds of management projects require no technological advances, and can be done with small funding levels, they were generally favored with this scoring system.

The policy and management projects ranged between 30 and 47. This was likely because these kinds of projects require an existing institution to take them on, therefore being more difficult to accomplish on a voluntary basis. This being said, they nevertheless often received a high score because they are possible with current standards, and also had support from stakeholders in general.

4.2.2 Overall Analysis

When looking overall at the distribution of scores for all of the programs (Figure 12) in terms of the ILBM governance pillars, one can see that the policy pillar tends to be strong, with an average of 8.25, and a very high occurrence of tens ("current policies support the completion of this project"). This seems likely in Pennsylvania, where programs like Act 220 exist.

It is important to note, however, that the financing pillar had an average score of 4.81, with 5 being the most common score, ("funding opportunities exist to fund the full project, but have not been acquired"). This finding indicates that, even though the policies exist to help implement projects, the funding does not necessarily follow. Because funding opportunities do exist, however, for many of these projects, it seems fair to believe that many of these projects can be implemented if someone actively takes charge of them.

The "information" pillar had a mean score of 5, with the highest occurrence of scores taking place in the 3 to 5 range, meaning that "more studies need to be done" or that "the information may exist, but still needs to be compiled." This is an issue in the

Marsh and Rock Creek Watershed, being one of the reasons why management suggestion 18 and 21 (further monitoring and evaluation of environmental factors; increase in staff gage implementation) both received high stakeholder support scores (10) and high overall scores (52 for both).

The mean score for the institution pillar questions was 5.87, with 7 as the most common score (meaning that "the institutions exist and have the capacity to take on the projects but have not yet committed or expressed interest"). This indicates the institution pillar is strong, considering that many of these projects were developed only as a part of a brainstorming effort. The score not being 10 could be attributed to the fact that not all the institutions know about the projects being proposed. Thus, this rating may change as the management suggestions are published in the Pennsylvania State Water Plan. In addition, this scoring frequency may also relate to financing, meaning that if the financing were to become available to the institutions, they would likely take on the project.

Stakeholder support had a mean score of 6.61, with the highest occurrence of 5 ("some stakeholders were for the project and some were against the project"). This is a common answer, since stakeholder groups often may not agree. These results may indicate a flaw in the design of the question that involved reducing the scoring options from five to three. If time permits, future studies should exhibit more of a gradient (for example: 3 = approximately 25% of stakeholders are in support of this project, 5 = approximately 50%, etc.). This would provide more meaningful numbers in the rating process, and provide more information about the management suggestions.

The final pillar, technology, which was worded in terms of timeframe, had a mean score of 6.58, with high occurrences of 7 and 10, or "one" to "three year" projects. This indicates the CAAC was reluctant to propose long-term projects and, therefore, were likely already thinking of feasibility when brainstorming the suggested management alternatives. It is also important to point out that all projects that received a 0 or 3 score in technology ("ten year" or "twenty year" projects) also received a score less than 30, indicating this "pillar" question was particularly helpful in determining feasibility. This was not unexpected, since long-term projects are often very expensive, have high opposition from community members, and often require extensive studies (effecting the financing, stakeholder support and information pillars).

4.2.3 Successes and Challenges

On April 11, 2012, a presentation of the resulting prioritized list was completed, with the results receiving approval by the CAAC. A discussion of the study was also completed through a discussion, and a series of informal questions. This lead to the conclusions on where the successes and challenges were in this study. Overall, there were various successes within this project, including:

1) Successful communication of the applicability and efficacy of the ILBM approach to the stakeholders of Marsh and Rock Creek;

2) Prioritization of all of the management suggestions for the Marsh and Rock Creek Watersheds;

3) Creation of systematic methodology for discussing management projects in a timely and efficient manner;

4) Efficient and organized mediation of discussions between stakeholder groups within the CAAC; and

5) Successful dissemination of the information discovered in this study through the publication of this research thesis;

In addition to these successes, there also remain some challenges that were identified during the completion of this project. These challenges should, ideally, be anticipated and dealt with in future studies, prior to workshop completion. A list of these challenges and issues were developed throughout the process, and through discussions with the CAAC, and include:

1) Time management constraints

> The design of the workshop required the CAAC, in addition to doing the preliminary filtering of "yes" and "no" programs, to answer the same questions about 31 different management programs (the "maybes") all in one day. This adds up to a total of 186 questions needing to be answered, limiting the discussion to less than 2 minutes per question. This became tedious for the CAAC and somewhat frustrating by the end of the workshop. While the stakeholders recognized the need to get through things quickly, as well as the need to answer the questions, some wanted more time to discuss each program more thoroughly. Because it is

important in these types of efforts to cater to stakeholders needs, it is recommended that for future studies the workshop should be undertaken in several separate meetings. The first would be for the purpose of filtering yes and no programs, and the rest would be to discuss each management suggestion (the exact number of meetings would depend on the time left to do the project, and the number of management suggestions).

While the implementation of time constraints is crucial to keep everyone in the group on task, an increased time of three or four minutes per management suggestion, as well as a maximum time of two- and-a-half hours per discussion, would prevent workshop participant "burn-out" by the end of the discussion.

2) Question development

This is an area where the wording must be deliberately and carefully completed. Leading or confusing language can cause frustration on the part of the stakeholders, in addition to producing inaccurate results. There were a couple times during the workshop in which the meaning behind the ILBM "pillar" scores needed to be clarified. Ideally, this should not have been the case. A good way to mitigate this problem would be to allow the stakeholders to preview the questions and scoring before asking them to answer them. This would ensure that all participants understood the wording, and found the questions useful. The questions in this study were developed in collaboration with ICPRB, the consulting firm associated

with the CAAC. In retrospect, however, passing them through the committee itself would have been ideal.

3) Contributing components in addition to feasibility.

While this study was focused on feasibility, a suggestion made after the workshop was that it may have been useful to have included a few other components as well, including:

- A rating of the desire of the committee members/stakeholders to use the project -- This study assumed that if a management alternative was suggested, it represented something the committee would like to include in the recommendations, or that the stakeholder support pillar reflect the CAAC desire to completer the project. In reality, however, this was not necessarily the case. Thus, it may be a good idea to include a rating on this particular point in future efforts.

- An evaluation of the sustainability of the management suggestion -- It is obvious that feasibility should not be the only factor used to prioritize management suggestions. If that were the case, many persistent pesticides would seem to be ideal solutions to insect infestations, as opposed to properly planting sustainable crops for the region. While this issue was not in the scope of the present study, it is still important to note that some way of filtering out unsustainable programs should be included, when selecting between management

alternatives. One possibility could be the use of a sustainability rating system which leads to the exclusion of any program that does not receive a specific rating.

4) Ensuring all stakeholders are represented

In order for the results of this process to be accurate and unbiased, it is necessary for all the stakeholders to be represented during the workshop. While this workshop had a fairly complete array of stakeholder representation, there were still a few key players not at the table because of scheduling conflicts, or lack of interest. These included the economic development board, the university community and a few industries in the area. While some scheduling conflicts cannot be avoided in such efforts, an attempt at accommodating all of the stakeholders, as well as keeping them informed as to why the process is relevant to them, is very important. One means of addressing this problem would be to schedule meetings well in advance, and to make personal visits to the key stakeholders to explain why their presence would be of value.

5) Preventing a few people from taking over the conversation.

While this situation also is sometimes unavoidable, since some people are more forceful in expressing their opinion, it is still necessary to ensure that all the stakeholder groups get to voice their opinion, even with time constraints. In our workshop, although consensus was reached on all

questions, there was nevertheless a select set of people who voiced their opinions far more often than the rest of the group, and that tended to unduly dominate the discussions.

A way of mitigating this problem could be to seat people according to groups (i.e., Agriculture; Industry; Policymakers; etc.) and, in addressing each group, to ask if anyone from the group had something to add. This would help ensure each group is consulted on each question before moving on to the next.

While some of the aforementioned challenges are inevitable when working with a stakeholder group of over thirty people, the methodology used in this study nevertheless proved very useful in helping determine the feasibility of each suggested program. The hope is that this methodology, when properly applied, will help future watershed managers and consultants navigate the use of stakeholder-based watershed management challenges.

CHAPTER V: CONCLUSIONS

Surface water sources must be managed in a comprehensive and integrated manner in order to ensure their sustainable use. ILBM provides a useful platform for water managers and other stakeholders to develop such management plans. The method of consensus-based analysis used in this thesis has previously proven effective in Mexico, and was also very useful for the Marsh and Rock Creek sub-basins. The implementation and assessment of the ILBM platform in this study, as well as in other locations around the world, has highlighted considerable promise in helping water managers and stakeholders gather information, identify governance issues, prioritize management projects, and establish cooperation among those involved in effective management of the basin.

This research project has provided a useful case study from which those involved in the stakeholder workshops, and future basin managers, can learn. It has also added to the continuing stock of experience and 'lessons learned' being developed around the world in the application and evaluation of this comprehensive ILBM management approach, as well as contributed to the effective management of the Marsh and Rock Creek sub-watersheds of the Potomac River Basin.

APPENDIX A

List of all the stakeholder groups that were represented in, or in collaboration with, the Critical Area Advisory Committee (CAAC).

Stakeholder Category	**Specific Group**
County	Adams County Conservation District
	Adams County Department of Economic Development
	Adams County Chamber of Commerce
	Adams County Office of Planning
	County of Adams Department of Emergency Services
State	Pennsylvania Department of Environmental Protection
	2 House of Representative elected officials
	1 Senate official elected official
Federal	Gettysburg National Park
Conservation	Watershed Alliance of Adams County
	Strawberry Hill (Conservation Organization)
	Act 220 Regional Committee
Agriculture	Farm Bureau
	Mason Dixon Farms
	Adams County Winery
	Adams County Fruit Growers Association
	Biglerville Fruit Research Laboratory
	Knouse Foods
	Dairy Farmers
Industry	GenOn/ Formerly Reliant Energy
	Ski Liberty
	Knouse Foods
Local Knowledge	1 Citizen with a background in Engineering
	2 Citizens with a background in Geology/Hydrogeology
	1 Citizen with extensive water monitoring experience in the region
Public Water Supply	Rural Water
	Gettysburg Municipal Authority (GMA)
Development	Mason Dixon Country Club

APPENDIX A (continued)

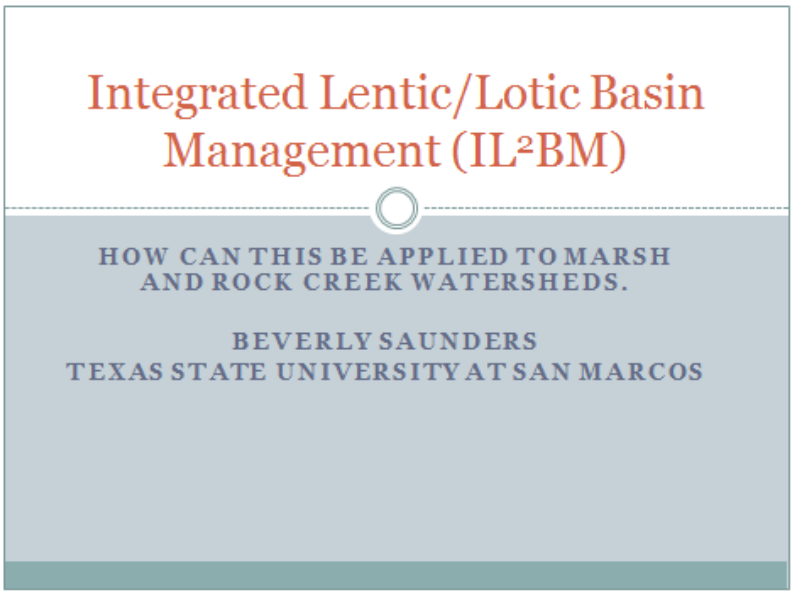
List of all the stakeholder groups that were represented in, or in collaboration with, the Critical Area Advisory Committee (CAAC)

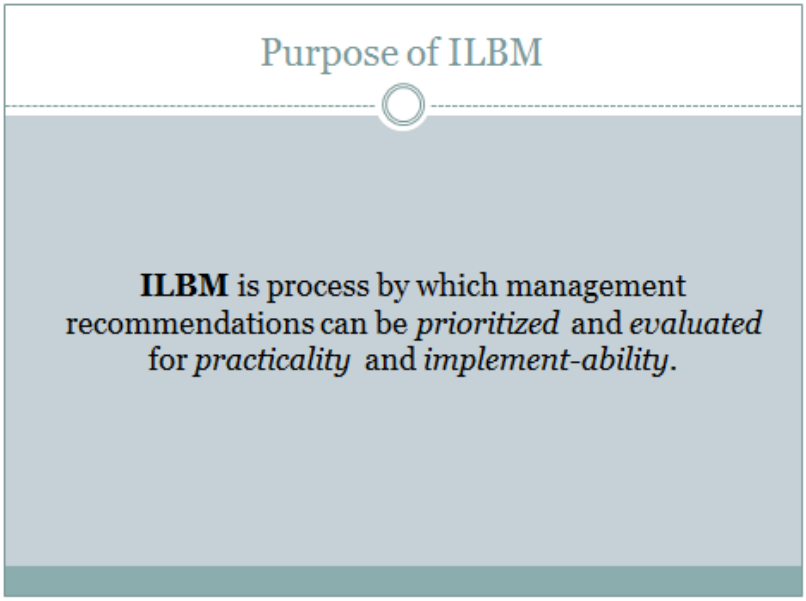
(NOTE: The percentages following the municipalities represent the percentage of the Critical Water Planning Area (CWPA) is contained within that municipality).

Stakeholder Category	**Specific Group**
Municipalities	Council of Governments
	Bonneauville (0.7%)
	Straban (12.7%)
	Liberty (0.1%)
	Butler (2.0%)
	Franklin (24.8%)
	Freedom (5.7%)
	Gettysburg (1.2%)
	Mount Joy (13.2%)
	Hamiltonban (3.0%)
	Mount Pleasant (5.6%)
	Highland (7.6%)
	Cumberland (23.5%)
Education	Penn State Extension Service
	Penn State University
	Gettysburg College
	Harrisburg Area Community College
	Conewago Valley School District
	Fairfield School District
	Littlestown Area School District
	Upper Adams School District
	Gettysburg Area School District

APPENDIX B

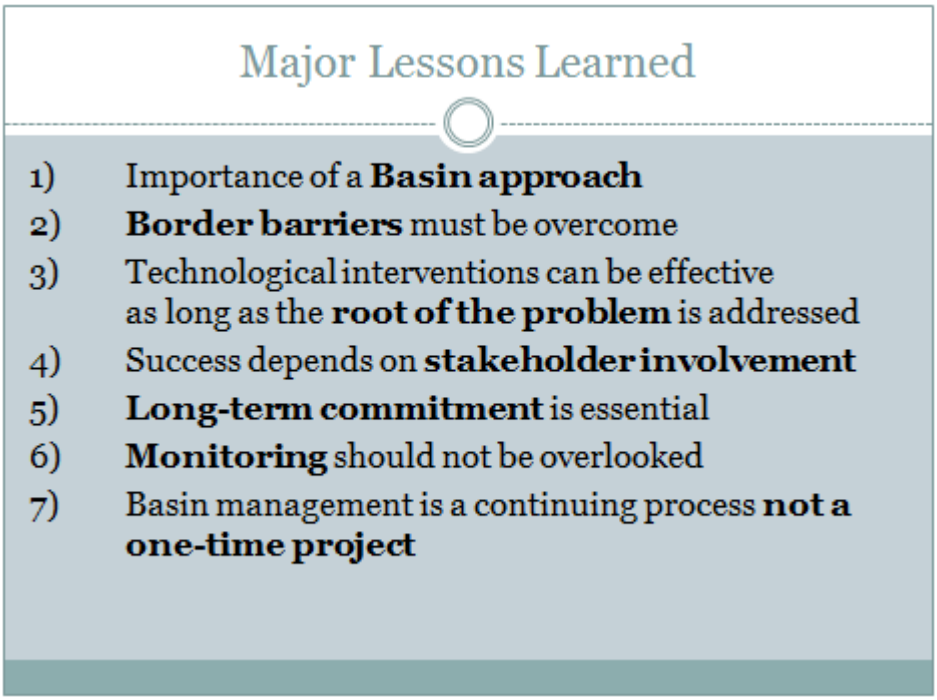
Integrated Lake Basin Management (ILBM) presentation given to the Critical Area Advisory Committee (CAAC).





APPENDIX B (Continued)

Integrated Lake Basin Management (ILBM) presentation given to the Critical Area Advisory Committee (CAAC).



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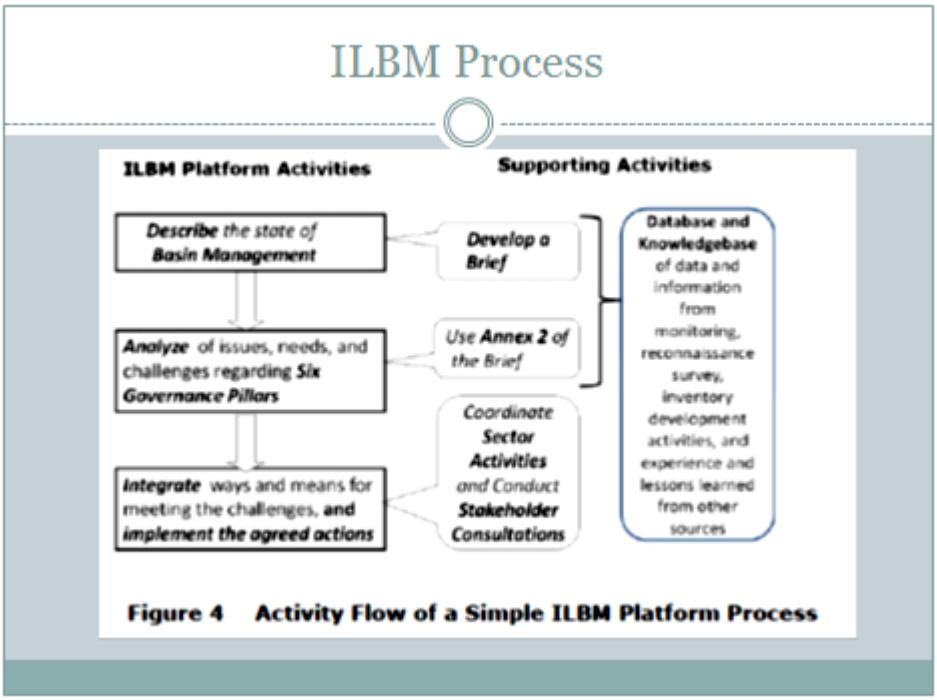
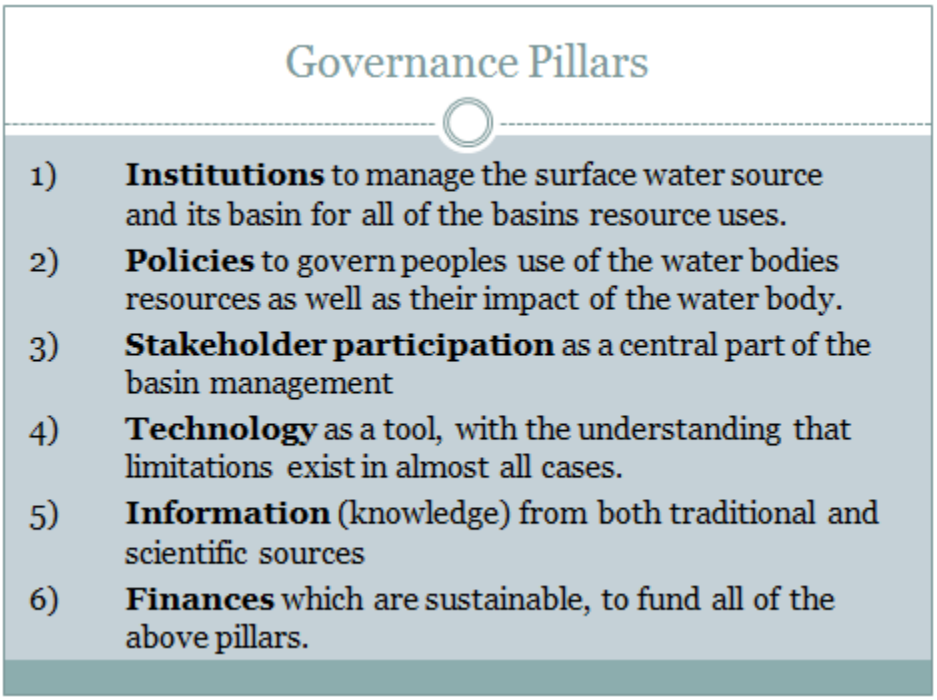
Integrated Lake Basin Management (ILBM) presentation given to the Critical Area Advisory Committee (CAAC).





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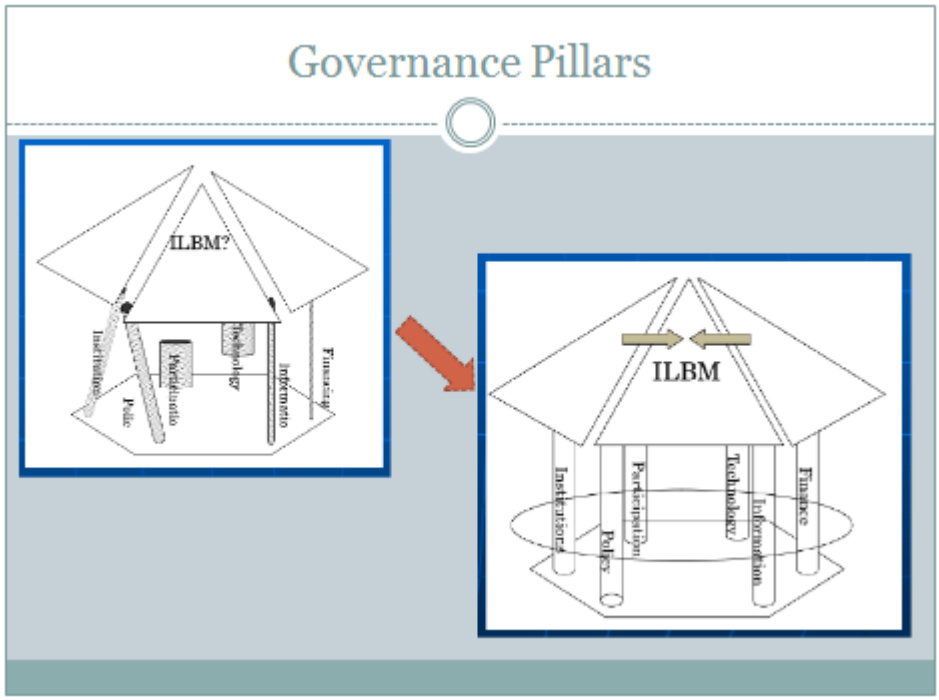

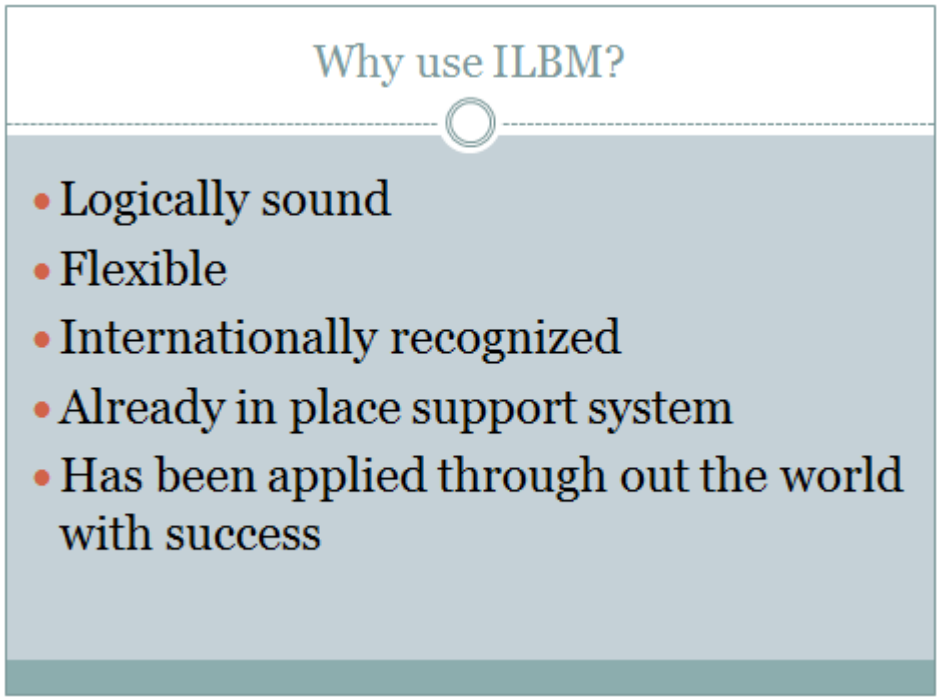

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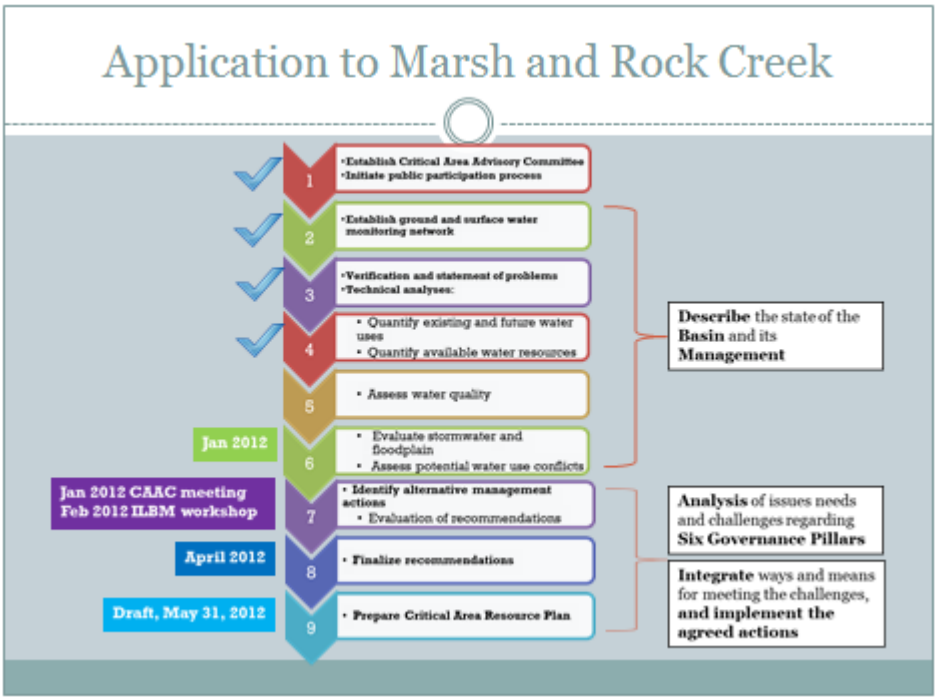

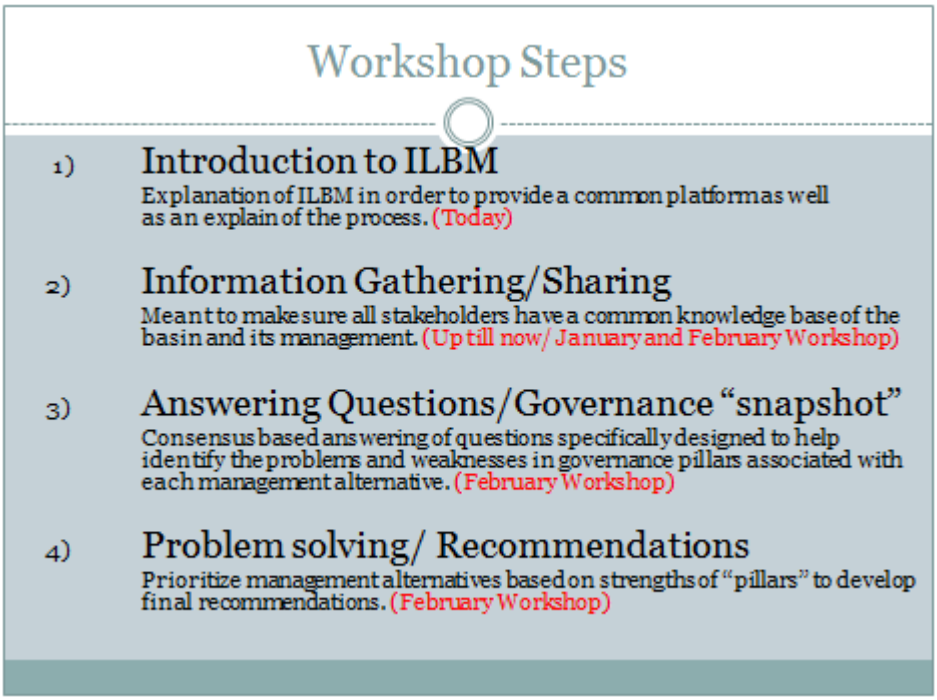

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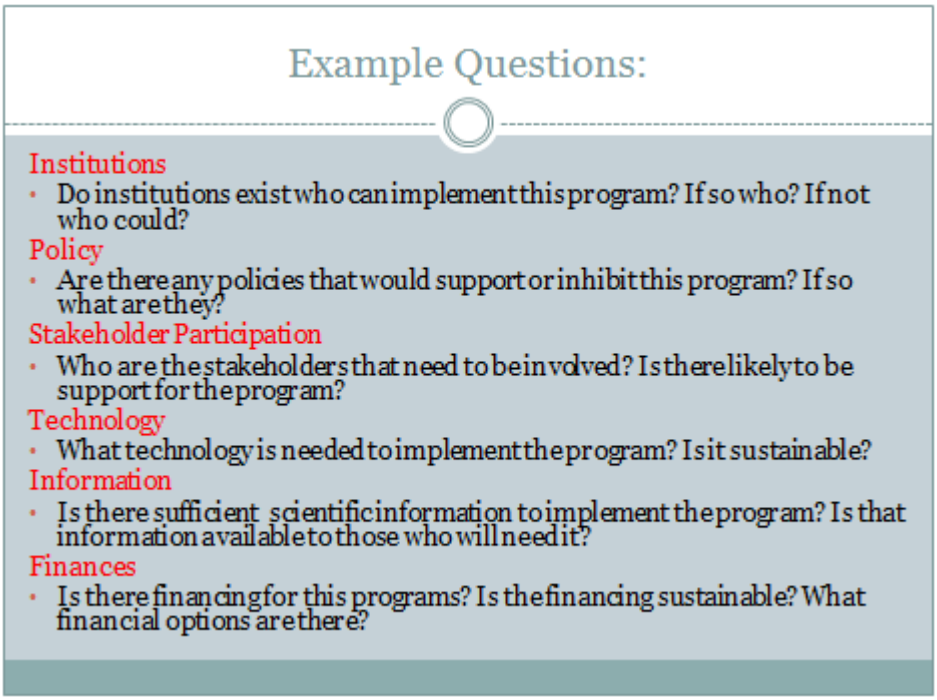

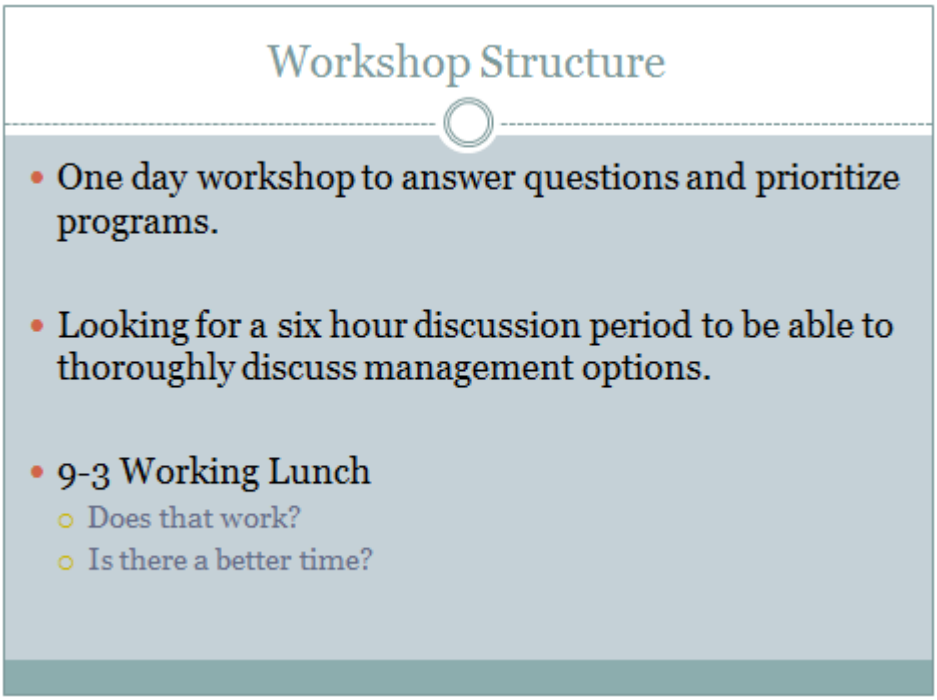

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APPENDIX C

Preliminary analysis of management alternatives. This document was compiled by Interstate Commission for the Potomac River Basin and distributed before the question answering workshop. Some of the research for the document was completed as a part of this study.

Preliminary Background Information
Management Alternatives Considered for Inclusion in the Marsh/Rock CARP
v.2/13/12

This document is intended to provide background information requested by the advisory committee and/or deemed appropriate during subsequent investigations. It is not intended to argue for or against any of the management alternatives, but only to provide some information to begin the discussions. Management alternatives deemed high priority at the February 15th workshop will undergo further investigation/evaluation over the coming months.

1. Implement more water efficient irrigation practices.

It was estimated that more than 350 million gallons of water were used for irrigation in the CWPA in 2010. Further, irrigation can be a highly consumptive process (82% consumptive on average, according to USGS). Use of efficient irrigation practices may reduce irrigation water use by 50-70% and the consumptive use of water by up to 25%[1].

One type of water efficient irrigation practice is drip irrigation. The initial costs of this system are high and can vary significantly site to site; however, one organization[2] gives a price range of $700 to greater than $1,500 per acre. The system needs to be maintained over time to prevent clogging of the drip lines. The cost and time associated with maintenance depends on initial water quality among other factors. Irrigators who utilize drip irrigation see some long term savings due to decreased water use.

The following are some water efficient irrigation strategies for residential or commercial applications according to the City of Santa Monica[3]:

- "Group plants with similar water requirements on common zones to match precipitation heads and emitters.
- Use drip irrigation for trees, shrub beds and areas of groundcover to eliminate evaporation losses.
- Choose low-volume, low-angle sprinklers for lawn areas.
- Select heads that fit the size and shape of the areas to be watered.
- Program automatic controllers for night irrigation to reduce losses due to evaporation and wind drift.
- Select controllers with adjustable watering schedules and moisture sensors to account for seasonal variations, and calibrate them during commissioning.
- Where possible, use graywater for irrigation. Use barrels at the bottom of rainwater leaders for manual irrigation of trees and shrubs.
- Place 3 to 5 in. of mulch on planting beds each spring to minimize evaporation."

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[1] http://www.smgov.net/Departments/OSE/Categories/Green_Building/Guidelines/Landscape/Water_Efficient_Irrigation.aspx

[2] http://www.lavwcd.org/irrigation.html

[3] http://www.smgov.net/Departments/OSE/Categories/Green_Building/Guidelines/Landscape/Water_Efficient_Irrigation.aspx

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2. Community water supply systems should perform a water audit at least once a year to control water loss.

As of 2010, almost 590 million gallons of water was used for public water supply in the CWPA. Controlling water loss in the supply system could reduce overall water use and enhance profitability of the system. A free tool is available through the American Water Works Association[4].

3. Seek, promote, and implement wastewater treatment system re-use, beneficial re-uses of wastewater.

According to the DEP Reuse of Treated Wastewater Guidance Manual[5], wastewater reuse activities require a Water Quality Management permit from DEP. If the activity includes stream augmentation, a NPDES permit is also required. The EPA states that[6], "factors that should be considered in an industrial water reuse program include:

- Identification of water reuse opportunities
- Determination of the minimum water quality needed for the given use
- Identification of wastewater sources that satisfy the water quality requirements
- Determination of how the water can be transported to the new use"

Additional CARP-related project efforts this spring and early summer are expected to identify specific re-use opportunities and applications in the CWPA. One resource available to assist in this effort is a 2012 book titled Water Reuse: Potential for Expanding the Nation's Water Supply through Reuse of Municipal Wastewater[7].

4. Percolate water back into the ground from sewage treatment plants where feasible.

According to the DEP Manual for Land Application of Treated Sewage and Industrial Wastewater[8], an applicant must complete and have approval for Act 537 sewage facility planning modules as well as obtain a Clean Streams Law Part II Water Quality Management permit for land application of sewage. When conditions prevent land application, seasonal discharges to surface waters are allowable, but require a NPDES Part I discharge permit.

5. New developments should include/incentivize water conservation equipment in homes when built.

Historic steps toward including water conservation equipment in homes included the EPA Energy Policy Act of 1992, requiring that all new toilets produces for home use must operate at 1.6 gallons per flush or less. Since then, many municipalities around the country have implemented water conservation programs that incentivize water conservation in homes and business in various ways. For example, Denver Water

[4] http://www.awwa.org/Resources/WaterLossControl.cfm?ItemNumber=47846&navItemNumber=48155
[5] http://www.elibrary.dep.state.pa.us/dswebGet/Document-72495/362-0300-009.pdf
[6] http://water.epa.gov/polwaste/nps/chap3.cfm
[7] http://books.nap.edu/catalog.php?record_id=13303#description
[8] http://www.elibrary.dep.state.pa.us/dsweb/Get/Version-48798/362-2000-009.pdf

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initiated a New Home Water Conservation Initiative Program that provides a financial incentive for builders/developers or homeowners who install water efficient devices. The City of Austin, Texas developed the 3C business challenge that labels a business as an Austin Green Business Leader if the business commits to reducing water use by 10%. The benefits for the business are positive perception from potential customers, reduced water and energy costs, and financial and technical assistance from the City of Austin.

6. Importation of water from Susquehanna Basin into the GMA system through York Water.

The application was originally submitted to SRBC approximately four years ago and is pending. The request is for a continuous connection that would be relied on in the long term. The original transfer request was for 300,000 gpd, with a peak transfer of 1 Mgd. As demands on GMA grow in the long term, the transfer amount may increase to 3 Mgd. The waters would be discharged into the Marsh/Rock watersheds, with the exception of those discharged through the Hunterstown WWTP. Discharges from the Hunterstown WWTP are made back to the Susquehanna Basin. Additional information is available in the meeting minutes of the 11/15/11 advisory committee meeting.

7. GMA may consider alternative means of conveyance from the augmentation well to the public water supply intakes to reduce consumptive loss.

In the Act 220 Critical Water Planning Area screening process, evaporation from the Marsh Creek pool above the dam at the GMA intake was estimated to be an annual average 37,900 gpd. This evaporative loss is 0.9% of the minimum passby flow required under GMA's withdrawal permit. The average number of days per year that the well was used to augment the natural flow from 2006 to 2010 was 55 days per year and the average daily discharge amount from the well was 0.5 Mgd. Applying the percent of evaporative loss to this discharge gives an average of 4,400 gpd of the augmentation water lost to evaporation (approximately 0.4% of GMA's average annual daily water use).

Conveying well water to the water treatment plant intake blends the harder groundwater with the stream water, reducing the amount of pretreatment required in the treatment plant.

8. Investigate use of quarries as water storage facilities, particularly in the diabase.

Several locations in the Potomac Basin experiencing or anticipating water shortages are considering quarries as an alternative for water storage. One example is Loudoun Water, who plans to withdraw water from the Potomac River during high flow conditions and store it in a quarry, where it can be treated for public water supply under low flow conditions. The first quarry that may be available for use by Loudoun Water has a one billion gallon storage capacity.[9] This is a long term water supply effort and may take years before operational, depending on the mining operations. The first of the mines under consideration for Loudoun water may be available in five years and the second may be operational sometime around 2030 or 2035. Two additional quarries that have been identified are longer term, future

[9] http://www.loudounwater.org/uploadedFiles/Loudoun_Water/Whats_Hot/Project%20Summary.pdf

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quarry options[10]. Unit costs of the Loudoun quarries range from 0.20 to 0.63 dollars per 1,000 gallons of safe yield[11]. Diabase areas in the CWPA may provide opportunities for water storage in the long term.

9. Creation of a new or rehabilitation of an old reservoir in/near the CWPA (ex. Birch Run)

Birch Run Dam was originally constructed in 1937 to create Chambersburg Reservoir on Conococheague Creek. In 2004, the reservoir was drained. The next year, Birch Run Dam was breached[12]. Prior to and since the breach of the dam, replacement of the dam has been under consideration (e.g. March 2000 Gannett Fleming Birch Run Dam Evaluation of Alternatives study).

Several other studies evaluated construction of reservoirs in or near the CWPA including a 2007 application prepared by Buchart Horn for water allocation by GMA for the proposed York Water connection and a 1995 water allocation application prepared by Gannett Fleming for GMA referencing a December 1977 water supply system improvement study by Gannett Fleming that identified several possible reservoir projects.

The Buchart Horn study evaluated a new reservoir in the headwaters of Conewago Creek, near Arendtsville. Negative aspects of this project that were cited in the evaluation include the location of PA State Route 234, parallel to the creek. Creating a new route would add significant expense and was determined to not be practical or affordable. Further, twice the distance of the interconnection pipeline required for the York Water interconnection would be required to connect this new reservoir with the GMA system, causing even greater expense. Overall, this option was evaluated as being "economically unfeasible."

The Gannett Fleming study evaluated several dam creation options, including one near Orrtanna and one near Caledonia (both on Marsh Creek), and creating an off-stream reservoir near Gettysburg. The Marsh Creek options were determined to be quite expensive because infrastructure would be required to cover the ten mile distance from the GMA system. Alternatively, the water could be discharged from the reservoir upstream and withdrawn at the existing treatment plant; however, other users could potentially take this water from the stream – not ensuring water availability for the GMA system.

The Gettysburg off-stream reservoir option, projected to hold 160 Mgal of raw water, would require approximately 50 acres of land and was determined to be difficult to implement and expensive.

10. New developments need to provide additional storage capacity.

14.5 Mgal of raw water storage is being proposed in association with the Mason Dixon Country Club. As an incentive for Mason Dixon Country Club, this additional storage allowed them a higher withdrawal

[10] According to the Central Water Supply Plan final report prepared for Loudoun Water by Black& Veatch in September 2008 (B&V project No. 161194)
[11] http://www.loudounwater.org/uploadedFiles/TM7_Jennings_Randolph_Lake%27s_Water_Supply_Costs.pdf
[12] Manuel, J.J. 2009. An investigation of the recently drained Chambersburg Reservoir in south-central Pennsylvania. Middle States Geographer 42:1-8. Accessed 2/9/12 at http://geographyplanning.buffalostate.edu/MSG2009/1_MANUEL.pdf

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rate during flows greater than 18.9 cfs[13]. Further, companies are now making available small and medium sized storage options with attention to cost, aesthetics, and water conservation[14]. PENNVEST Drinking Water State Revolving Fund "offers low interest loans with flexible terms to assist a variety of borrowers for construction, expansion, and maintenance of drinking water facilities (treatment plants, distribution mains, *storage facilities*), and improvements and upgrades to water quality systems[15]" {emphasis added}.

11. Creation of additional agricultural ponds.

Creation of agricultural ponds requires a permit from DEP under Chapter 105. This permit requirement is waived if "1) The contributory drainage area is less than or equal to 100 acres. 2) The greatest depth of water at maximum storage elevation is less than or equal to 15 feet. 3) The impounding capacity at maximum storage elevation is less than or equal to 50 acre feet."

NRCS provides funding through the Agricultural Management Assistance (AMA) program for new ponds to be used as irrigation water sources only. Ponds are typically funded as part of larger irrigation systems that include a pump and filter system, pipelines and sprinklers or emitters that deliver the irrigation water to the crop. NRCS will do the surveys and design for the pond itself and help the landowner with necessary permits. NRCS tries to avoid the need for specialized permits by keeping pond size and location within DEP's General Permit guidelines. The company supplying parts/materials performs the design for the irrigation system itself. NRCS engineers must review and approve the design before installation. In Adams County, various kinds of irrigation systems have been installed through this program, ranging from pond-fed trickle irrigation systems for orchards and vegetables to well-based pivot sprinklers for corn. Once an application is received through the AMA program, the process typically takes one to two calendar years for completion. Approximately 60-90% of the project cost is typically covered by the NRCS program, with the rest covered by the landowner. Relying on the AMA program for funding was not recommended by NRCS as the funding is not guaranteed. The program has not received much funding over the last couple of years. And, funding available through this project is expected to continue to decline in the future. Quoted and paraphrased sections from personal communication with NRCS in Gettysburg, PA (2/6/12).

12. Enhanced or additional treatment mechanisms should be developed to provide additional sources of water.

All public water suppliers in the CWPA solely utilize groundwater with the exception of GMA, who has a withdrawal on Marsh Creek in addition to groundwater wells in both Marsh and Rock creek watersheds. There are several stretches of surface water in the CWPA that are impaired for nutrients. Four (including GMA) of the thirteen public water suppliers in the CWPA are located within 0.5 miles of an impaired stream, indicating that a switch from groundwater to surface water would require treatment to remove these nutrients and microorganisms. Further, public water suppliers using surface water sources may be subject to different water treatment requirements than suppliers using ground water sources.

[13] http://files.dep.state.pa.us/RegionalResources/SCRO/SCROPortalFiles/MDU%20WA%20Pmt%20Report.pdf
[14] http://www.waterefficiency.net/WE/Articles/15578.aspx
[15] http://www.portal.state.pa.us/portal/server.pt/community/programs/9322/drinking_water_%28dwsrf%29/541747

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13. Establish standardized passby for surface and groundwater withdrawals to ensure the withdrawals do not de-water the streams.

DEP has the authority to establish passby requirements via the withdrawal permitting authority. For example, GMA has a passby requirement of 6.68cfs on Marsh Creek. The new Mason Dixon County Club withdrawal permit would requires a minimum passby of 18.9cfs.

Establishing a passby for individual withdrawals throughout the CWPA would require site-specific analyses to determine an appropriate passby amount.

14. Encourage communication between large water users on conservation measures being used within the community to foster idea sharing and long-term sustainability.

Numerous large water users in the CWPA have reported on water conservation measures being implemented at their location. Communication among these users may assist in transfer of knowledge and cost-effective ideas between large users. Perhaps there is an existing forum in the CWPA that would be appropriate for this type of dialogue.

15. Develop a Strategic Communication Plan for the general public and targeted stakeholders (including all levels of education: school districts colleges, universities), a marketing plan.

Communication on science-based topics such as water resources management requires thoughtful consideration in several areas, a couple of which are provided here. According to Christensen (2008)[16], the 7 C's of successful communication are that it be correct, clear, concise, comprehensive, compelling, concrete, and concentrated. Communicating with the general public requires an understanding of the target group and the most effective communications environment for that target group. For example, what is the general level of understanding of water resources issues in the general public in the CWPA? What type(s) of media outreach will be most effective in reaching the target group? There are many types of media outreach mechanisms including press releases, community meetings, word of mouth, the internet, etc.

16. Enhance education in the CWPA.

Several studies have been conducted on the link between environmental education and the correlation with action. The general consensus is that knowledge distribution alone is not sufficient to encourage action. Instead, a number of factors need to be addressed in order to encourage active participation of those being included in the education plan. The 3 steps proceed in a fairly linear fashion: 1) awareness of the problem, 2) knowledge of the issues, and 3) skills and knowledge of what actions that needs to be taken. Including these steps in a CWPA education campaign may enhance the local participation and

[16] Christensen, L.L. 2008. The Hands On Guide for Science Communicators: A Step-by-Step Approach to Public Outreach. O'Reilly Media. ISBN: 978-0-596-52234-6.

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subsequent actions taken by the community to improve the sustainability of water resources in the watersheds[17].

17. Prepare a Joint Comprehensive Plan for the CWPA that includes sound land use policies and a strong water supply and protection component. Follow up with compatible zoning and SALDOs.

Land use planning in Pennsylvania is implemented at the municipal level. Therefore, development, approval, and implementation a land use plan for the CWPA will require collaboration between all involved municipalities. It was also noted during a previous advisory committee meeting that development of this plan should include collaboration with county planning agencies on the vision and planned actions for the future of the county.

18. Public water suppliers should prepare and get DEP approval for Source Water Protection Plans for all wells and surface intakes.

A source water protection plan was prepared for the GMA surface water sources by ICPRB in 2003. That same year, DEP prepared a source water assessment of the GMA ground water supplies. Several resources are available in the CWPA to assist/guide other public water suppliers in the development of Source Water Protection Plans. ACOPD has a Water Supply and Wellhead Protection Plan[18]. PA Rural Water Association works with communities to develop source water protection plans[19]. PA DEP's Source Water Protection Assistance Program (SWPTAP) "provides no cost support to community water systems, individual municipalities with a community water system, or a group of adjacent municipalities to develop local Source Water Protection programs[20]."

19. Monitoring to evaluate effectiveness of implemented management recommendations.

Physical monitoring to determine effectiveness of implemented management recommendations is necessary to understand whether the practices are working as expected and provides the opportunity to adjust when necessary. At the CAAC meeting on 4/11/11, it was noted that monitoring is often not conducted and effectiveness often not evaluated for BMPs that have been implemented to date. Depending on the methods used, monitoring can be expensive. For example, USGS 2011 estimates to measure 12 sites in the CWPA seasonally for water quality parameters including preparation, reconnaissance, sample collection, and laboratory processing for field parameters, nutrients, major cations and anions, and total coliform and E. coli was over $70,000. Cost estimates for water quantity measurements by USGS are provided with management alternative #22. An alternative to USGS measurements is volunteer water quality monitoring, which is significantly less expensive and may be sufficient for screening purposes, but may be less desirable to serve as the basis for management decisions. A combination of volunteer and professional monitoring may be the most cost efficient approach to meet the needs of the CWPA.

[17] http://www.cbtrust.org/atf/cf/%7BEB2A714E-8219-45E8-8C3D-50EBE1847CB8%7D/Changing%20learner%20behavior%20-%20H%20and%20V.pdf
[18] http://www.adamscounty.us/LinkClick.aspx?fileticket=25QEY5dhGDE%3D&tabid=154&mid=524
[19] http://www.prwa.com/content/source-water-protection
[20] http://www.sourcewaterpa.org/?page_id=639

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Monitoring of the 6 ILBM practices is also important to understand whether the strength of the pillars is increasing. Resources are currently available to evaluate the ongoing effectiveness of the ILBM pillars.

20. Encourage/increase water use registrations and/or metering.

As regulated by DEP[21], water use registrations and reporting are required for "public water supply agencies and hydropower facilities, irrespective of the amount of withdrawal, and any person whose total withdrawal from one or more points of withdrawal within a watershed operated as a system either concurrently or sequentially exceeds an average rate of 10,000 gallons per day of water in any 30-day period. Those persons who obtain their water through an interconnection with another person in an amount that exceeds an average rate of 100,000 gpd in any 30-day period also must register. Registrants must annually report their water usage and other information and retain records for at least 5 years."

Collected water use data is then made available on the DEP website[22]. This data is valuable to managing water resources as it allows managers to understand how much water is needed and at what time of the year. Water used by those not required to report is estimated for water management purposes. In combination, these small users comprise a significant portion of the overall water use in the CWPA. Encouraging the smaller users to report their water use would benefit the management of water resources because it would allow for a snapshot of water uses based on actual data rather than estimates.

21. Mason Dixon Utilities to fund a USGS (or similar stream gage).

As part of the DEP withdrawal permit for the Mason Dixon Country Club, streamflow monitoring at a gage (with USGS approved methodologies) is required if the development proceeds.

22. Installation of additional stream/staff gages and continued maintenance on existing gages.

Streamflow and groundwater level measurements can be valuable assets to short and long term water resources management efforts. USGS is a reliable source for this type of data collection, analysis, and QA. Additionally, USGS data becomes available to water managers, decision-makers, and the public online through their website. For example, groundwater levels being collected by ACCD as part of the CARP project are QA'd by USGS and posted to their website[23]. Currently, USGS is sub-contracted through the CARP project to install, maintain, and operate 4 staff gages, develop rating curves at the staff gages, and QA the groundwater level data previously mentioned. The cost of performing these activities from 2010 – 2012 are provided below.

[21] http://www.pawaterplan.dep.state.pa.us/StateWaterPlan/WaterUse/WaterUse.aspx
[22] http://www.pawaterplan.dep.state.pa.us/StateWaterPlan/WaterDataExportTool/WaterExportTool.aspx
[23] http://groundwaterwatch.usgs.gov/countymaps/PA_001.html

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PROJECT ACTIVITY	FEDERAL FISCAL YEAR			Total by activity
	2010	2011	2012	
Installation of 4 staff plates	$9,452	$0.00	$0.00	$9,452
Operation and Maintenance of 4 staff plates	$1,000	$10,920	$11,920	$23,840
3 Miscellaneous streamflow measurements	$0.00	$1,006	$502	$1,508
Groundwater level data QA	$3,300	$3,200	$3,200	$9,700
PROJECT COST	$13,752	$15,126	$15,622	$44,500
ICPRB funding	$13,752	$12,186	$12,682	$38,620
USGS matching funds	$0.00	$2,940	$2,940	$5,880

23. Fostering implementability of recommendations.

Implementation of management recommendations may require funding and/or incentives. Having a prioritized list of projects that need funding will foster the ability to go after grants in a timely fashion when they become available. Further, providing incentives for implementation may encourage stakeholders to see the personal benefit of implementation. One outcome of the Feb 15th CARP workshop will be a prioritized list of management alternatives, which may serve as the basis of projects requiring additional funding.

Financing issues and alternatives for sustainable water infrastructure were recently presented in a report by The Johnson Foundation[24].

24. Establish a water conservation program that can respond to water supply/demand conditions, especially for businesses and institutions affected by an influx of tourists. Possibilities are:

1) Encourage the adoption of water saving measures used in tourist areas.

Collaboration with the Gettysburg Adams Chamber of Commerce or the Gettysburg Convention and Visitors Bureau may assist in identifying effective water saving measures for tourist areas. Other areas around the country have utilized a similar approach. For example, the Michigan Chamber of Commerce[25] published an explanation of indoor conservation efforts (low flush toilets and urinals), landscaping options (soil moisture sensors, drought tolerant plants, more efficient irrigation methods), and opportunities for water conservation through effective communication (incorporating water saving policies into training, posting conservation fliers) to name a few. This and other case studies from around the country may prove useful in developing a water conservation program in the CWPA.

2) Issues low water supply advisories when appropriate.

See # 28

[24] http://eponline.com/articles/2012/01/27/report-taps-into-innovative-financing-to-secure-future-for-sustainable-water-infrastructure.aspx
[25] http://www.in.gov/dnr/files/wa-michiganwaterconservation.pdf

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3) Adopt variable water and sewer rates based on water supply conditions (higher rates when supply is low).

A Pioneer Institute study[26] found that "price-based approaches to water conservation are more cost effective than non-price approaches." Further, "raising water prices can be politically very difficult; perhaps as a result, water demand management through non-price techniques is the overwhelmingly dominant paradigm in the United States. However, the cost-effectiveness advantage of price-based approaches is now very clear. Thus, it would be useful to generate discussion of the political advantage to be gained by demonstrating this potential cost savings. Where water rate-setting officials are constrained by law from raising water prices, during droughts or in general, a discussion of the real costs of these constraints would be useful."

25. Create a Marsh/Rock Creeks Water Management council. The council would be composed of representatives from participating municipalities, municipal authorities and county government.

Equitable implementation across the CWPA of several management alternatives identified in this document would likely require coordinated collaboration of agencies with authority for implementation (municipalities). An management alternative that may benefit from this council include those dealing with establishment of ordinances and land use planning (e.g. #31).

26. Develop a local Marsh/Rock creek Watershed association that could facilitate coordination of volunteers to implement improvement projects.

This association, as proposed, would function similarly to the WAAC – with a focus on the CWPA. The purpose is on-the-ground implementation and monitoring of practices through the use of volunteers.

27. Develop list of favorable areas for development, areas that are less sensitive. Put together an outreach team to demonstrate existing tools for choosing ideal development areas, logical water availability guidance tools.

A county-wide GIS-based shapefile and associated map was developed that identified suitable development areas, or "designated growth areas," in the Adams County Comprehensive Plan (2010). For additional insights into areas appropriate for development, one CAAC member suggested using mapping already available for Adams County to identify geologic areas were groundwater recharge is more (or less) likely to occur. Utilizing this information, the impact to recharge in the CWPA can be considered as a part of land use planning.

The Adams County Zoning Code (1990)[27] requires developments in areas which are not designated for moderate to high density levels must demonstrate that onsite sewer and water can be safely provided.

[26] http://www.hks.harvard.edu/fs/rstavins/Monographs_&_Reports/Pioneer_Olmstead_Stavins_Water.pdf
[27] http://www.co.adams.wa.us/documents/buildplan/zc.pdf

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28. Implement local drought preparedness activities including establishment of a CWPA drought advisory group.

Pennsylvania's system for declaring drought watches, warnings, and emergencies evaluates conditions at the county level. Due to the more "critical" conditions, it may be beneficial to evaluate drought status at the CWPA-watershed level. The current statewide program utilizes indicators such as precipitation deficit, streamflow, groundwater levels, and soil moisture to evaluate drought conditions. Numerous tools are available to assist with drought evaluation of these characteristics in the CWPA. Firstly, the DEP drought web page provides information on sources of information utilized in the evaluation of drought status[28]. These data sets are available to be monitored by interested parties in the CWPA prior to DEP evaluations or designations. Also, the USDA is working on a tool, ALEXI, to map evapotranspiration estimates and irrigation impacts on water use. Once available, maps will be posted online at http://www.drought.gov. The US Drought Monitor offers a look at current and future drought conditions. The program also monitors climate, seasonal, streamflow, and soil moisture outlooks across the country[29]. In addition to monitoring efforts, local outreach and education on drought conditions may include press releases and informing the public and water suppliers on beneficial, voluntary reductions in water use. Encouraging management programs that increase local preparedness, like the ACCD rain barrel program, may also enhance public awareness and encourage voluntary conservation of water during drought conditions.

According to Sue Weaver (DEP), the CWPA stakeholders should seek legal counsel on the scope of the authority to implement local drought preparedness activities. For example, declaration of a drought emergency is a formal declaration made by the governor. Local groups do not have this authority.

29. Quantify maximum contaminant loads for pollutants of concern in impaired waterways by developing TMDLs.

A number of waterways in Adams County do not meet the water quality criteria assigned for their respective designated uses (e.g. public water supply, contact recreation, etc.). Two TMDLs are currently being developed in Adams County including Plum Run and Beaverdam Creek. Any entity is able to petition DEP for development of a TMDL by submitting a form which can be obtained on the DEP website. DEP priority is given to certain watersheds, currently consisting of primarily nutrient and sediment problems. If DEP selects a watershed for development of a TMDL, DEP typically covers the costs of the work. Alternatively, a third party can pay to develop the TMDL and submit to DEP/EPA for approval.

The EPA has released a new tool to identify "who is discharging, what pollutants they are discharging and how much, and where they are discharging." The tool is available online[30] and uses permit and Discharge Monitoring Report data to calculate pollutant loadings in pounds per year.

[28] http://www.portal.state.pa.us/portal/server.pt/community/drought_information/10606
[29] http://droughtmonitor.unl.edu/
[30] http://cfpub.epa.gov/dmr/

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30. Public water suppliers in the CWPA should participate in the Potomac Drinking Water Source Protection Partnership of leverage resources and enhance communications with other suppliers in the basin.

The Partnership[31] is a voluntary association of water suppliers and government agencies focused on protecting drinking water sources in the Potomac River basin. This coalition of water utilities and management/regulatory agencies enables a comprehensive approach to protecting raw water supplies in the basin.

Through work groups and active discussion at meetings, the Partnership is identifying a strategy to carry forward source water protection as recommended by source water assessments prepared throughout the Potomac River basin. The Partnership now has 20 member organizations.

Participation is open to all, however, if able to pay an annual fee of 1) $300 or 2) $66 per average annual MGD is requested. An outreach event is planned for early April 2012 (date TBD) for anyone interested.

31. Establish groundwater protection ordinances.

Adoption of a number of groundwater protection ordinances has been proposed for the CWPA, including well construction, geothermal wells, yield analyses, water impact studies, and inspection of wells after construction to make sure treatment is adequate and the well is functioning properly. A model well construction ordinance is currently under development and review. Geothermal well ordinances have been developed and adopted in other areas of the commonwealth and are available for review and modification. One example of a model geothermal well ordinance is the Spring Creek Watershed Model Ordinance, presented at the 2010 Pennsylvania Water Symposium[32]. An intern from the University of the District of Columbia's Professional Science Masters in Water Resources Management, beginning March 2012, is scheduled to investigate alternative methodologies for determining sustainable groundwater yields if deemed important by the advisory committee. Results of the analysis would be presented at a spring or summer advisory committee meeting.

32. Encourage the adoption of wellhead protection ordinance to protect water supply sources within the Critical Water Planning Area.

Pennsylvania's Wellhead Protection Program was formally initiated, with approval from the EPA, in 1999. Recognizing the multiple levels of governmental authority and the diverse stakeholders involved in wellhead protection, DEP's focus is on "technical, financial, and educational assistance to facilitate the development of voluntary local Wellhead Protection Programs[33]." The Adams County Water Supply and Wellhead Protection Plan was developed in 2001 to "protect groundwater quality of public supply wells from potential contamination threats. Four pilot projects were completed for Abbottstown, Fairfield,

[31] http://www.potomacdwspp.org/index.php
[32] http://resources.cas.psu.edu/WaterResources/pdfs/Giddings.pdf
[33] http://www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/srceprot/source/WHPPOVER.htm

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Gettysburg, and Littlestown[34]." According to advisory committee members, a revision of this plan has been discussed although formal plans have not been made.

33. All municipalities in the CARP area should adopt and enforce ordinances recommended by the WAAC and Adams county government regarding: 1) Lawn fertilizer, 2) Stormwater management, 3) Private well construction standards including geothermal systems, 4) On lot septic system maintenance, 5) Water supply requirements for development and 6) Protecting and creating riparian buffers (need to create a model riparian buffer ordinance).

1) The current Adams County Comprehensive Plan does not currently provide guidelines on lawn fertilizers but mentions that lawn fertilizer is large cause of nitrate-related water quality issues. In addition, the Plan states that the use of fertilizer made from septic waste can cause bacterial issues in terms of surface and groundwater pollution.

2) In November, 2011 the Adams County Stormwater Management Plan[35] was prepared to meet the requirements of the Pennsylvania Storm Water Management Act (Act 167). The plan encourages the preservation of natural drainage patterns, groundwater recharge programs, the protection of streams designated with Exceptional Value of High Quality and natural storm water runoff regimes as well as the use of natural processes and BMPs. Also included in the plan are model ordinance provisions for adoption by municipalities in the county.

3) See #31.

4) The Adams County Water Supply and Wellhead Protection Plan[36], created in 2001, suggests the need for on-lot septic system ordinances which assure siting, maintenance, pumping and replacement of systems so as to minimize potential groundwater pollution. Alternatively the plan suggests municipalities create local sewer districts which charge each household a small annual fee. In return, the municipality takes responsibility for the maintenance and replacement of tanks (see #39).

5) See #31.

6) See #34.

34. Encourage the development and maintenance of riparian buffers along designated greenways (including the Rock Marsh Creek greenways) as specified in the Adams County Greenways Plan.

Riparian buffers have many benefits related to protecting water quality, enhancing aesthetics and recreation opportunities, slowing surface run-off, protecting stream health, and encouraging infiltration to name a few. The Adams County Greenways Plan[37] was completed in 2010 as one component of the Adams County Comprehensive Plan. It was created with the goal of "providing a vision and approach for establishing a comprehensive countywide greenway network that will protect Adams County's natural

[34] http://www.adamscounty.us/LinkClick.aspx?fileticket=kLYqwCxJmDk%3D&tabid=82
[35] http://www.adamscounty.us/LinkClick.aspx?fileticket=kLYqwCxJmDk%3D&tabid=82
[36] http://www.adamscounty.us/LinkClick.aspx?fileticket=25QEY5dhGDE%3D&tabid=154&mid=524
[37] http://adamscounty.us.dnnmax.com/LinkClick.aspx?fileticket=j-B2_YoMNWI%3d&tabid=154&mid=759

APPENDIX C (continued)
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and cultural resources for generations." Pilot projects for the Adams County Greenway have been identified, including one on Rock Creek. The greenway proposed for Rock Creek, located in portions of Gettysburg Borough, Straban Township, Cumberland Township, and Mount Joy Township would be 28.8 miles - 14.7 miles of which may include a trail. Information on the development of a riparian buffer ordinance is available on the WAAC website[38].

35. Separate downspouts from storm drains by routing run-off to a pervious surface.

Separating downspouts from storm drains can enhance infiltration, reduce surface run-off and associated flooding, and reduce pollutant transport. In Adams County, there is an incentive for on-site stormwater management for buildings less than 5,000 square feet as they are exempt from a permit if disconnected from the stormwater system (personal comm., CAAC).

36. Establishment of a stormwater utility in the CWPA.

According to EPA Region 3[39], more than 500 stormwater utilities are in operation across the country. These utilities utilize fees to cover the costs of stormwater management projects. Typical fees that a single family home may incur from these utilities averages about $11 per quarter. The establishment of a stormwater utility for financing of stormwater projects typically involves the following steps: 1) development of a feasibility study, 2) creating a billing system, 3) developing and implementing a public information program, 4) adopting an ordinance, 5) providing credits or exemptions, and 6) implementation.

In Florida, stormwater reuse utilities (a slightly different concept than a stormwater utility, discussed in the previous paragraph) are defined as non-potable "systems conveying water to a customer or customer base." The utility charges for the services provided; namely, the distribution of stormwater for reuse. Capital construction costs ranged from $0.30-$1.65 per gallon of source capacity depending on type and method of system. Technologies range from operational chlorination to reverse osmosis blending with reclaimed water. These utility systems were found to have lower pricing and cost requirements than either potable or wastewater utility systems. Quoted and paraphrased[40].

37. Implementation of a stormwater management program.

There are numerous opportunities for stormwater management in the CWPA, a number of which are listed on the management alternatives spreadsheet. And several practices are already in place. For example, ACCD conducts stormwater management activities across Adams County including rain barrels, county-wide planning, etc.

38. Implementation of stormwater and gray water re-use program.

Additional efforts this spring and early summer are expected to identify specific re-use opportunities and applications in the CWPA to be included in the CARP.

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[38] http://www.adamswatersheds.org/images/SOTW_Riparian_Buffer_Ordinace.pdf
[39] http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/upload/region3_factsheet_funding.pdf
[40] http://www.stormwater.ucf.edu/conferences/9thstormwatercd/documents/StormwaterReuse_PPT.pdf

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St. Petersburg, FL is one example of a municipality utilizing gray water re-use. "Domestic wastewater composed of wash water from kitchen sinks and tubs, clothes washers, and laundry tubs is called gray water (USEPA, 1989). Gray water can be used by homeowners for home gardening, lawn maintenance, landscaping, and other innovative uses. The City of St. Petersburg, Florida, has implemented an urban dual distribution system for reclaimed water for nonpotable uses. This system provides reclaimed water for more than 7,000 residential homes and businesses[41]."

39. Implementation of sewage management districts where on-site septic systems are not managed by municipalities.

Septic systems that are not functioning properly can degrade water quality, primarily by leaking nutrients into the surface or ground water. Some states in the Chesapeake Bay Watershed have even proposed banning septic systems in new housing developments for this reason[42]. One idea for the proper care and maintenance of septic systems in the CWPA, suggested by an advisory committee member and also found in the county Water Supply and Wellhead Protection Plan, is that municipalities create local sewer districts which charge each household a small annual fee. The municipality then accepts responsibility for the maintenance and replacement of tanks.

40. Encourage identification and documentation of wetlands.

One CAAC member noted that there is limited documentation of wetlands in the CWPA, suggesting that the majority of wetland mapping primarily includes ponds or water bodies. This recommendation is to development municipal requirements for electronic submission of land development plans, inclusive of delineated wetlands that could be placed in a GIS wetlands layer.

41. Adams County should provide funding for land preservation (purchasing conservation easements) targeting the Marsh and Rock creek watersheds.

According to one CAAC member, "The recommendation is to have Adams County provide funding for land preservation (purchasing conservation easements) targeting the Marsh and Rock Creek watersheds. Preserving the land will maintain water quality and increase infiltration by limiting impervious surface. By maintaining open space and thereby reducing development, there will be less stress on the water resources in the future. The Marsh Creek watershed is more critical than the Rock Creek watershed because it is a water source for Gettysburg Municipal Authority. The Marsh Creek watershed was targeted for preservation in the past with great success. PaDEP provided monies from a fine to fund easement purchases. The project received major awards from PaDEP and the EPA because of the protection afforded the watershed."

[41] http://water.epa.gov/polwaste/nps/chap3.cfm
[42] http://www.bayactionplan.com/2011/02/septic-solution-chesapeake/

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42. Install a filter or catchment near the outlet of Stevens Run to prevent debris from entering Rock Creek.

Debris has been noted in Stevens Run, near the confluence with Rock Creek in Gettysburg. Some type of debris removal device, such as a filter or a catchment, would assist in removing this debris before entering Rock Creek. This management strategy will require maintenance to remove the intercepted trash.

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