EVALUATION OF THE BEST MANAGEMENT PRACTICES AGRICULTURAL WATER CONSERVATION PROGRAM

FINAL REPORT

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Eduardo Bautista, Ph.D.

USDA-ARS Arid Land Agricultural Research Center

Peter Waller, Ph.D.

The University of Arizona, Dept. of Agricultural and Biosystems Engineering

Prepared with the assistance of

Abigail Roanhorse

The University of Arizona, Dept. of Agricultural and Biosystems Engineering

1 EXECUTIVE SUMMARY

The Arizona State Legislature authorized in 2002 (A.R.S. § 45-566.02) a water conservation program for the agricultural sector based on best management practices (the BMP Program). The program is voluntary and an alternative to the conservation program that has been in operation since 1980 based on allotments (the Base Program). The statutory objective of the Program is to "provide an alternative conservation program that is designed to be at least as effective in achieving water conservation as the Base Program." The BMP Program requires farm operators to adopt conservation practices from a menu of approved practices and, in exchange, removes the allotment limitation. The program was initially approved on an interim basis, subject to review based on data collected during the 3rd management period of the Groundwater Management Act.

The Arizona Department of Water Resources (ADWR) entered into an agreement with the USDA-Agricultural Research Service- Arid Land Agricultural Research Center (ALARC, formerly U.S. Water Conservation Laboratory) to conduct a study of the BMP Program. The objective of the study was to examine the design and initial implementation of the Program based on initial outcomes. Data for the study were provided by BMP Program documents, BMP and Base Program records compiled by ADWR, and data obtained through interviews of Program participants and non-participants. Twenty-one enrollees and three non-participants were interviewed as part of this study.

Evaluation results indicate that the BMP Program is meeting the statutory objective of providing an alternative conservation program. Enrollees view the Program favorably and are benefiting from it. BMP farms are representative of Central Arizona agriculture, in terms of farm size, their crop mix, tenure structure, and farm technology. Motivations for participation are varied. A few operators were acutely constrained in comparison with other operators under the Base Program and now have access to a more flexible water supply. Others had complicated reporting requirements under the Base Program and have no reduced that reporting workload. Others want to pursue production alternatives that have been profitable in recent years, but which have higher water demands than their historical crops. For most, the BMP Program reduces the risk of depleting flexibility credits and, thus, of future water constraints.

Levels of participation are reasonable if one considers the following factors. A substantial amount of land in the AMAs is not being farmed and not all IGFR acreage is subject to Base Program regulations. Urban pressure and land tenure characteristics of farms in Central Arizona do not allow many producers to plan long-term and is limiting enrollment largely to the Pinal AMA, where the economy is largely agricultural-dependent. Many operators have historically accumulated flexibility credits and have little or no incentive for participation. Not all farms in the AMAs have improved irrigation infrastructure and, therefore, do not qualify for the Program

Participation will increase slowly for the above mentioned reasons. Changes to Base Program allotments could induce further participation, but participation will likely continue

to be limited to operators who qualify with their existing infrastructure and management practices. Responses from both BMP participants and non-participants suggest that farm operators will not make substantial investments or changes to farming practices just to qualify for the Program. Even if the investment may be economically justified, uncertain land tenure (lease duration, urban pressure, or the potential for a farm sale) may discourage farm operators from making long-term investments. Physical shortages in water supplies are more likely to induce farm improvements.

With respect to the statutory objective of equivalent water conservation to that achieved under the Base Program, current indications are that, first, enrolled operators are implementing the agreed practices. The effectiveness in the application of those practices cannot be evaluated based on the available data. A second finding is that annual water use for the BMP farms is, on the average, the same as it was in the Base Program. The same data indicates, however, that annual water use already exceeded the allotment by about 20% in the 3 years prior to BMP Program. This finding is applicable only to the sample of BMP farms, and not the general IGFR population in the AMAs. Current trends in agricultural water use in the AMAs can be easily explained by current agricultural economic incentives, which until recently had been encouraging producers to plant alfalfa and other water-intensive forages. These incentives and trends, in turn, can be largely explained by an increasing population in the state. Recent reductions in milk demand and prices (Beard Rau et al., 2009) will likely cause a drop in demand for forage crops and, therefore, for water.

Interviewees manifested uncertainty about future BMP Program benefits. A few respondents were pessimistic about the economic viability of agriculture in Central Arizona. Predictions are that the CAP will begin to experience shortages as early as 2011 and, therefore, a few operators in those areas anticipate that those shortages will ultimately negate Program benefits. Certainly, this is an issue that needs to be considered when promoting the Program, especially a farm requires infrastructural improvements. A related concern is about cropping changes induced by the BMP Program, to water-intensive crops, and the implications for other farmers in a district if CAP supplies become scarce. Interviewed operators were uncertain about how to measure long-term Program success.

A discussion of long-term program success requires an examination of the BMP Program objectives relative to water management objectives of the AMA. The water management objective of the Pinal AMA is to preserve agriculture for as long as economically possible. Several BMP participants stated during the interviewees that the Program enhances the profitability of their farm, by allowing them to grow crops that they would not likely pursue otherwise. Hence, the BMP Program is compatible with the Pinal AMA water management objectives, especially if average water use does not change. The Phoenix AMA objective is to achieve safe yield by 2025. In this case, the Program and AMA objective is less compatible, especially if the Program encourages a more permanent shift in cropping patterns toward water-intensive crops.

Evaluation results do not provide indications that participation is being hampered by enrollment procedures and reporting requirements. Although glitches were experienced during the early days of the Program, enrollment appears to be a straightforward process, if the farm qualifies. Reporting requirements do not appear to be onerous to the participants, partly because the Program does not impose strict record-keeping requirements.

The BMP Program has design features that ensure that most producers will comply with all or part of their agreement. Structural BMPs have to be in place at the time of enrollment and the list of approved management practices includes many practices that are in common use. Operators who are adopting a BMP for the first time may fail to comply with that part of the agreement if the benefits of that BMP are perceived to be low relative to their cost. Similarly, operators may neglect the documentation requirements of the Program, if they are perceived to be costly.

Participants are complying with reporting requirements. The data generated by the annual report and audit suggests that operators are, for the most part, complying with their agreements. The verification procedures have resulted in the separation of one farm from the Program. The facts surrounding this example suggest that the official policy is unclear about essential reporting requirements, how that information will be used to assess compliance, and how ADWR will proceed if non-compliance is suspected. These uncertainties have the potential to undermine future compliance and Program credibility.

Evaluation results also suggest uncertainties in the implementation of BMPs as a result of unclear definitions and the use of substitute practices. Program rules allow the Program Manager to authorize substitute practices, but without clear guidelines. This can have adverse implications for enrollment, enforcement, and Program credibility.

Monitoring uncertainties and BMP implementation issues discussed above are partly Program implementation issues. Those problems can be resolved based on more rigorous application of current policy or by clarifying existing administrative policies. However, this report also concludes that uncertainties are partly the result of Program design. The BMP approach requires guidelines and/or standards to guide the implementation of BMPs, their documentation, and for compliance evaluation. The Arizona BMP Program lacks those guidelines and, thus, a priority for ADWR and the Advisory Committee should be their development.

Major recommendations emerging from this study are:

- ADWR and the Advisory Committee need to develop a policy statement that defines BMP Program philosophy, objectives, participant expectations, benefits to the AMAs relative to their water conservation goals, and measures of success.
- ADWR and the Advisory Committee need to either develop a comprehensive set of BMP Program guidelines or revise the existing BMP Worksheet and practice definitions.
- ADWR and the Advisory Committee need to seek the authority to conduct periodic reviews and updates of the BMP worksheet (and guidelines if they are developed).
- ADWR needs to update its policy document on enforcement procedures.
- ADWR needs to dedicate staff time to field audits or needs to modify the audit process to reduce staff requirements.

- ADWR needs to track water use relative to the allotment for both the BMP and Base Programs

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4 INTRODUCTION

The Arizona State Legislature authorized in 2002 (A.R.S. § 45-566.02) a water conservation program for the agricultural sector based on best management practices (the BMP Program[1]). The BMP Program is voluntary and an alternative to the conservation program that has been in operation since 1980 based on allotments (the Base Program). The BMP Program requires farm operators to adopt conservation practices from a menu of approved practices and, in exchange, removes the allotment limitation. The Program was initially approved on an interim basis, subject to review based on data collected during the 3rd management period of the Groundwater Management Act.

The Arizona Department of Water Resources (ADWR) entered into an agreement with the USDA-Agricultural Research Service- Arid Land Agricultural Research Center (ALARC, formerly U.S. Water Conservation Laboratory) to conduct a study of BMP Program. This report summarizes the findings of the study, which examines the initial response of the farming community to the program, program implementation, and initial implications for water conservation. The study was completed subsequent to action taken by the Arizona legislature, which extended the BMP program into the 4th and 5th management periods.

[1] This report will refer to the Best Management Practices Program as the BMP Program or simply the Program.

5 BMP PROGRAM BACKGROUND

The BMP Program was developed in response to historical challenges by the agricultural community to water supply constraints imposed by the Base Program. Additional motivations were current concerns about its effectiveness, including measurable impacts on water conservation, and the administrative burden to ADWR and the agricultural water rights holders (Meghdal et al., 2008). The Base Program is one of the provisions established by the Groundwater Management Act (GMA), which has regulated groundwater use in the State of Arizona since 1980. The following paragraphs provide details on the Base Program and the GMA that are relevant to this study.

The GMA identified hydrologic regions with severe groundwater overdraft and designated them as Active Management Areas (AMAs). Four AMAs were originally established in 1980 (Phoenix, Pinal, Tucson, Prescott) and a fifth in 1994 (Santa Cruz) when the Tucson AMA was split. Except for the Pinal AMA, the water management objective of each AMA is to attain safe yield by the year 2025. For the Pinal AMA, the objective is to maintain the agricultural economy as long as it is economically feasible while preserving water for future non-agricultural uses. These objectives are expected to be met through the implementation of Water Management Plans to be carried out in five management periods (1980-1990,1990-2000, 2000-2010, 2010-2020, 2020-2025). These plans impose water conservation requirements for cities, industry, and agriculture that affect both surface and groundwater use. Key provisions for the agricultural sector include:

- A prohibition on the expansion of irrigated acreage in AMAs and INAs.
- A restriction on irrigation to lands with certificates of Irrigation Grandfathered Rights (IGFRs[2]). IGFRs were established based on lands that were historically irrigated five years prior to the enactment of the GMA.
- A requirement to measure all pumping from groundwater wells discharging more than 35 gpm and to report all agricultural water use[3].
- The establishment of a conservation program based on maximum annual groundwater allotments (the Base Program).

The Base Program annual allotment (AA) (in Ac-ft) is the product of the irrigation water duty (ID) (Ac-ft/Ac) and the irrigation duty acres (DA) (Ac) $AA = ID \times DA$ (ADWR, 1999). The Irrigation Duty is defined as the ratio of the irrigation requirement (IR) and the

[2] In the following discussion, the acronym IGRF will refer to both the irrigable land and the irrigation grandfathered right appurtenant to that land.

[3] IGFRs with less than 10 irrigable acres and that are not part of a larger farming operation are not required to report

assigned irrigation efficiency (*E*). *E* is an estimate of the fraction of applied water that is beneficially used for crop production and salt leaching.

Allotments were determined based on historical water use to minimize the immediate economic impact to existing water users. Historical water used was calculated based on the crops grown on an IGFR during the period 1975-1979 and on the peak irrigated acreage (the duty acres) for the same period . The duty acres are less than or equal to the irrigable acres, which are the total number of acres legally available for irrigation on an IGFR. The GMA aimed to achieve increasing levels of conservation with time by decreasing the values of *E* and, thus, the allotment. Those *E* values were set by ADWR for the 1st management period based on areas of similar farming conditions and adjusted case-by-case based on irrigation technologies, field slopes, and soil characteristics (Meghdal et al., 2008). The initial *E* values were in the range 0.50-0.70 and were projected to reach 0.85 by the 3rd management period.

The GMA instituted groundwater flexibility accounts to provide flexibility in the water supply of an IGFR given variations in weather and cropping patterns. The flexibility account is credited when the annual water use is less than the allotment and is debited in the opposite case. There is no cap to the amount of credits that can be banked in the flexibility account but an IGFR owner is out of compliance with the GMA and subject to a fine when his cumulative debits are greater than half the yearly allotment. Credits can be used at any future time, or transferred to other IGFR holders (but only in the year after which they were accumulated[4]). Transferred credits can be used to meet demands for the current year or offset debits from previous years.

Agricultural water users in the AMAs often depend on both ground and surface supplies. Because the GMA aims to encourage the use of renewable resources and preserve groundwater for emergencies and future needs, use of both types of supplies count against the allotment. Hence, areas that were entirely dependent on groundwater prior to the enactment of the GMA and that subsequently gained access to Central Arizona Project (CAP) supplies cannot, accumulate groundwater credits by using surface supplies only. At the same time, the flexibility account is not debited for any use of surface water in excess of the allotment. For systems with commingled supplies, debits to the flexibility account are calculated based on the volume of groundwater use in excess over the allotment using a "stacking order"[5] (ADWR, 1999).

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[4] The flexibility account provisions have been modified over the years. Currently, transfers are allowed to other IGRFs operated by other landowners in the same irrigation district, or to IGFRs in another district but in the same subbasin if the IGFRs are owned or leased by the same operator.

[5] If during a given year use exceeds the allotment and all water is from surface supplies, then the debit to the flexibility account is 0 ac-ft. If water use is entirely from groundwater, then the flexibility account is debited for all the excess (total use - allotment). If the supply is commingled, then surface supplies are debited first, followed by groundwater, next by the unused portion of the decreed and appropriative water available to the user, and finally by tail water and effluent. Except for groundwater, all other sources can only be debited up to the allotment. CAP water received by irrigation districts under the Underground Water Storage, Savings and Replenishment Program (in-lieu water) is counted as groundwater.

Some agricultural water users perceive the Base Program as unequitable and unfair and have challenged the program over the years (Megdal et al., 2008). IGFR holders with relatively small irrigation duties and duty acres (relative to their irrigable acreage) have limited flexibility in adapting the cropping patterns to changing economic incentives. Other users feel that landowners who had already made improvements to their irrigation systems were penalized with smaller assigned irrigation efficiency values. IGFR holders have also contested the target 0.85 irrigation efficiency value, which was supposed to be adopted for calculating the irrigation duties during the 3rd management period (Jacobs and Holway, 2004). That target was set under the assumption that water users would adapt to gradually decreasing allotments by adopting level-basin irrigation and other modern irrigation technologies. However, a study commissioned by ADWR during the 2nd management period (CH2M Hill, 1995) concluded that irrigation system improvements were uneconomical under conditions of the mid-1990s and that irrigation water suppliers had limited capacity to deliver the high flow rates required for the operation of modern level-basin irrigation systems.

At the same time that some agricultural water users have objected to the Base Program, average annual allotments have historically exceeded the average water use in all AMAs and has resulted in an accumulation of flexibility credits (CH2M Hill, 1995; GWMC, 2000; Needham 2005; Needham and Wilson 2005; Jacobs and Holway, 2004; Megdal et al 2008). According to Needham (2005) and Needham and Wilson (2005), the accumulated flexibility credits presently represent nearly six times the annual allotment for the average IGFR. These authors also concluded that weather together with water and commodity prices, were the only significant factors explaining water use patterns by agriculture in the AMAs since the enactment of the GMA and, therefore, that the Base Program was not affecting water use in the sector.

The accumulation of flexibility credits has been attributed to a variety of factors (Needham and Wilson, 2005; Jacobs and Holway, 2004). First, duty acres were calculated based on the peak acreage and not the average acreage for the period 1975-79. Since the historical period selected for the calculation of duty acres also corresponds to the period of highest historical irrigated acreage in the state, the allotments of many IGFRs were calculated based on peak historical demands. Land utilization rates, and therefore water demands, dropped substantially in Central Arizona during the 1990s as a result of Federal set-aside programs, agricultural credit limitations, and low crop prices induced. Those idled acres continued to accrue credits. An early economic study (Cory et al., 1992) suggested that the high price of groundwater was already inducing efficient irrigation in the Phoenix AMA, irrespective of the allotments imposed by the GMA. Those results likely apply as well to the Pinal and Tucson AMAs, where water prices are comparable or higher. Finally, Jacobs and Holway (2004) also state that agricultural water demands have decreased as a result of more efficient irrigation technologies and practices.

The feasibility of an 0.85 irrigation efficiency target remained an unresolved issue when the 3rd Management Plan was promulgated. Instead, an alternative voluntary conservation program, the Historic Cropping Program, was introduced. This program reduced the assigned irrigation efficiency to 0.75, but also reduced the allowable flexibility balance debits (to 25% of the allotment) and capped the accumulated flexibility credits (to 75% of

the allotment). No IGFR has been enrolled in that program. A Base Program for the period was finally approved by the Arizona Legislature in 2002 (A.R.S §45-566) which reduced the efficiency target to 0.80. The revised Base Program was approved together with the Best Management Practices (BMP) program (A.R.S §45-566.02), and both were added as an amendment to the 3rd Management Plan (ADWR, 2003).

In the amendment to the 3rd Management Plan, ADWR states that the purpose of the BMP program is to "provide an alternative conservation program that is designed to be at least as effective in achieving water conservation as the Base Program." Neither A.R.S §45-566.02 nor the amendment to the 3rd Management Plan specify how conservation program effectiveness will be measured in relation to the Base Program. Also, neither document specifies the enrollment requirements of the program, list of approved practices, and oversight and compliance rules. Those were subsequently developed by ADWR and the BMP Program Advisory Committee. The Advisory Committee was formed in 2002 by an executive order of the Arizona Governor and consists of representatives of agricultural and municipal interests as well as relevant state agencies. The BMP Advisory Committee, together with ADWR, is also responsible for assessing the effectiveness of the program and for suggesting improvements.

The BMP program was initially established on an interim basis, subject to review at the end of the 3rd management period. Subsequent legislation, Senate Bill 1577, has already extended the program into the 4th and 5th management periods (Megdal et al., 2008).

6 BMP PROGRAM FEATURES

To qualify for the BMP Program, farms must adopt physical and management conservation practices from a menu of approved practices. Enrollment is based on a point system structured around four categories of BMPs (Table 1). Definitions for the approved BMPs are provided in Appendix 11.1. Each category has a maximum 3 point allowance, which is intended to balance infrastructural with management practices in determining the eligibility of a farm. A total of 10 points are needed for enrollment.

A minimum 1 point is awarded under Category 1 (Water Conveyance) when 50% of the farm that is supplied with lined channels, pipelines, and drainback systems while the maximum 3 points are awarded when the percentage is 100%. The points awarded under Category 2 (Farm Irrigation Systems) are calculated based on the point value assigned to a system type and the percentage of land irrigated with that system. Point values are: (1) for gravity systems with an engineered uniform grade but with no mechanism for recovering tailwater losses; (2) for pressurized irrigation systems or, alternatively, with gravity systems with a uniform grade and tail water recovery systems, and; (3) for low-pressure sprinkle, drip, and level basin irrigation systems. A minimum of 2 points is needed in this BMP category to qualify for the program. Conveyance and irrigation system improvements need to be in place at the time of enrollment and need to be supported by farm plan maps.

Practices in Category 3 (Irrigation Management) deal with the questions of when and how much water to apply while practices in Category 4 (Agronomic Management) deal with soil and crop management, which indirectly impact water use over the entire season. Most of the listed practices must be applied annually, but they can be changed from year-to-year depending on specific needs and conditions. Some practices need to be applied over at least 20% of the BMP farm acreage. The large number of practices (12 for Category 3 and 8 for Category 4) provide operators with significant flexibility in meeting the 10 point requirement. In addition, operators can petition ADWR to approve management practices specific to their operation as best management practices.

TABLE 1.BMP POINT SYSTEM

BMP Category	Description	Minimum Points	Maximum Points
1	Water Conveyance System	1	3
2	Farm Irrigation System	2	3
3	Irrigation Water Management	1	3

4	Agronomic Management	1	3

Commercial farms often consist of multiple IGFRs. The BMP Program allows operators to enroll multiple IGFRs as a single farm unit, but those IGFRs must be no more than half-a-mile from each other. Only IGFRs that are in compliance with the Base Program can be enrolled. The IGFR flexibility account is frozen at the time of enrollment, but is activated again if the IGFR is subsequently de-enrolled.

Like Base Program operators, BMP Program participants must file an annual water use report with ADWR. Unlike the Base Program, in which users need to keep track of the source of water used in each IGFR and file individual reports for each water right in a farm unit, BMP farm operators with multiple IGFRs can use their combined allotment anywhere on the farm and document their water use in a single report. However, they must also file an additional report, the Schedule BMP, and are subject to an audit to verify compliance with the agreement. The Schedule BMP report identifies the practices carried out during the year, and changes to the conveyance and irrigation systems of the farm. Audited farm operators need to document the use of BMPs on the farm during the year and/or demonstrate the practice on the field.

Commercial farms often consist partly or totally of leased land. For leased land, the operator only needs to obtain an affidavit from the land owner authorizing him/her to enroll the IGFR in the program. Additional IGFRs can be subsequently added to an existing BMP farm. Similarly, an IGFR can be removed from a BMP farm if there is a change of ownership or lease status. In either case, the modified BMP must still meet the point-system requirements.

BMP farms are expected to stay in the program at least until the end of the 3rd management period and can become ineligible to re-enroll if they leave the program without a valid reason.

7 BACKGROUND TO THE EVALUATION

The USDA-ARS Arid Land Agricultural Research Center conducted the evaluation in collaboration with the Department of Agricultural and Biosystems Engineering of the University of Arizona, under an agreement with ADWR. Since the report is advisory to ADWR and the BMP Advisory Committee, evaluation objectives were developed with extensive input from both. The objective was defined as evaluating the design and implementation of the program based on initial outcomes[6]. It was also made clear that the evaluation did not seek to assess BMP Program worth as a water conservation policy.

The study was designed around five principal questions presented by ADWR, namely:

1) Did the Program attract a reasonable number and variety of participants? Were the number of enrolled operators, Irrigation Grandfathered Rights, Irrigation Acres, the location of enrolled lands, and the crop mixes produced reasonably representative of Central Arizona Agriculture?

2) What motivated growers to enroll?

3) Given their program experience, how do enrolled growers evaluate the advantages and disadvantages of the Program?

4) How has crop mix, crop acreage, and water use changed for participants since enrolling in the program and how do those changes, if any compare, with changes in central Arizona agriculture?

5) Are the Worksheet practices applied effectively? Is the verification process effective and cost-effective?

These questions were answered partly through an analysis of ADWR and public records, and partly through data collected through interviews with a sample of BMP participants and of farmers who elected to stay in the Base Program. Background literature, and ADWR and public records were initially reviewed to develop an understanding of issues relevant to the BMP program and to develop tentative answers to the principal research questions. A framework for the field study, consisting of a set of hypotheses for each principal research question, was developed based on this initial understanding of the issues. A questionnaire was developed based on these hypotheses. The study framework and the questionnaire were reviewed by the BMP Advisory Committee. Based on their input, adjustments were made to the scope of the research hypotheses and to the language and/or format of the questions.

The initial version of the questionnaire consisted of a large number of open-ended questions. Because of Advisory Committee concerns over the scope of the issues to be

[6] Mark et al. (2000) define four evaluation categories. This study is main concerned with the broad objective of "program and organizational improvement." However, the study also contains elements of "program worth" and "oversight and compliance."

examined and the duration of the interviews, most open-ended questions were rewritten as multiple choice questions. Several types of multiple-choice questions were included in the survey. Yes/No type questions were used to examine issues where we wanted unambiguous answers from the respondents. An example of a Yes/No question is the following:

E1. Did concerns over your Base Program allotment factor into your decision to enroll this farm in the BMP program?

With some questions, we explored the degree to which the respondent agreed/disagreed with a statement using a scaled answer. An example is:

E2. Prior to enrolling in the BMP Program, did your Base Program allotment constrain your crop mix and acreage decisions on this farm?

a. Never

b. Occasionally

c Half the time

d. Most of the time

e. All of the time

Some multiple-choice questions were developed to accept one or more possible answers that were identified from the background research. An example of such a question is:

E3. What administrative difficulties did you encounter when you enrolled? (Select all that apply.)

a. None.

b. IGRs were out of compliance with the Base Program

c. ADWR's IGR records were out-of-date

d. Obtaining signed affidavits

e. Obtaining records/information required for the BMP worksheet

f. Other

Finally, some questions presented the respondents with a set of mutually exclusive answers. Our expectation was that respondents would select only one of those answers but we did not prevent the interviewees from selecting two or more of those answers. An example of this type of question is the following:

E4. What is your assessment of the BMP Program's long-term impact.

a. The program will encourage farmers to adopt water-conservation practices and technologies.

b. *Participation in the program will be limited to producers who have made past investments in technology and management practices.*

c. *Participation will be limited to farmers with flexibility credit problems or are concerned about eroding flexibility credits.*

d. *A declining agricultural economy in Arizona will make the program irrelevant.*

e. *No opinion.*

f. *Other*

Where applicable, as in the previous example, multiple-choice questions allowed the respondents to not answer the question (No Opinion) or to provide an alternative answer (Other).

ADWR provided contact information for all BMP operators. All enrollees were contacted and asked to participate in the survey and over half responded. In the end we were able to interview 21. Obtaining contact information for non-participants proved more difficult, because of irrigation district concerns over their customers' privacy. We contacted three non-participants through referrals from BMP operators who participated in the survey.

Interviews were conducted face-to-face and generally lasted between half and one hour. While conducting the interviews we elicited additional discussion of issues raised by respondents, with the goal of capturing the nuances of their responses.

The original plan for data analysis was to identify key themes from the responses to open-ended questions. Because of the change in the questionnaire format, survey questions were tabulated and summarized. These summaries, together with the respondents' informal comments, were then used to identify those key themes.

The research hypotheses provided the framework for organizing the research findings. However, this framework was modified while writing the report, as it became evident that some hypotheses were interrelated and could be combined and reorganized.

8 EVALUATION RESULTS

8.1 QUESTION 1: DID THE PROGRAM ATTRACT A REASONABLE NUMBER AND VARIETY OF PARTICIPANTS? WERE THE NUMBER OF ENROLLED OPERATORS, IRRIGATION GRANDFATHERED RIGHTS, IRRIGATION ACRES, THE LOCATION OF ENROLLED LANDS, AND THE CROP MIXES PRODUCED REASONABLY REPRESENTATIVE OF CENTRAL ARIZONA AGRICULTURE?

This section provides an enrollment summary for the BMP Program and examines the geographical distribution, size, tenure structure, production system, and irrigation technology of enrolled farms. An objective is to contrast the BMP farms with farming operations in Central Arizona and to determine if the program has attracted a diverse group of farms and operators or, instead, a particular type of operation. Another objective is to discuss two factors that affect participation, namely urban encroachment and farm tenure characteristics. Additional factors that influence participation will be examined in Section 8.2.

8.1.1 ENROLLMENT IN THE BMP PROGRAM, IN TERMS OF NUMBER OF FARMS, ACRES, AND LOCATION IS REPRESENTATIVE OF LAND USE PATTERNS IN CENTRAL ARIZONA.

Sixty-nine farms and nearly 41,000 acres have been enrolled in the BMP Program since 2004. Because of changes in ownership and land use, present enrollment (November 2008) totals 66 farms 153 IGFRs, and 36,651 acres (Figure 1). Most sign-ups occurred in the first year of the program. While new enrollments declined rapidly during 2005-07, they rebounded in 2008 when five new farms were added. Several farm operators have signed up more than one farm so the 66 farms represent 41 operators only. As indicated by the graphs, participation is limited to the Pinal and Phoenix AMAs, with the former contributing over 80% of the enrolled farms and acreage. Since 2006, all new BMP farms have been contributed by the Pinal AMA. Two factors that play a key role in determining the geographical distribution of enrolled farms, the land potentially available for enrollment, and the proximity to urban areas, are discussed next.

Figure 2 illustrates the acreage potentially available for enrollment by AMA. The graph (based on 2005 data) shows the total IGFR acreage of each AMA, and the split between exempt, idle, and non-exempt land. Land in the exempt category includes single-IGFR farms with 10 or less irrigable acres (Small Acres), which are not required to report water use, and waterlogged (WLA) lands located in the western part of the Phoenix AMA, which are exempt from the GMA conservation requirements. These lands are not candidates for

enrollment, as are idle lands. The non-exempt category includes IGFRs in the BMP Program and in the Base Program, which are shown separately in the graph.

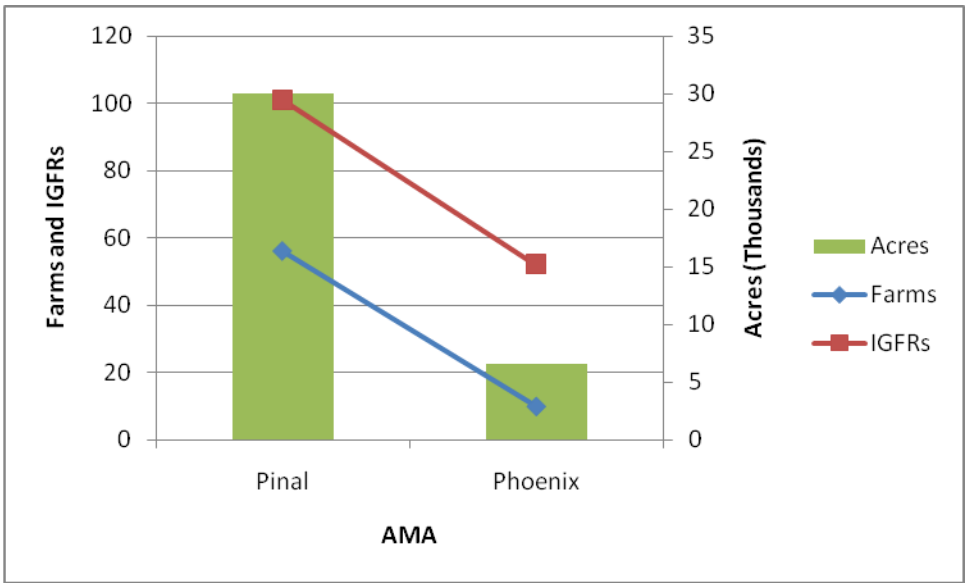

FIGURE 1. ENROLLED FARMS, IGFRS, AND ACREAGE BY AMA

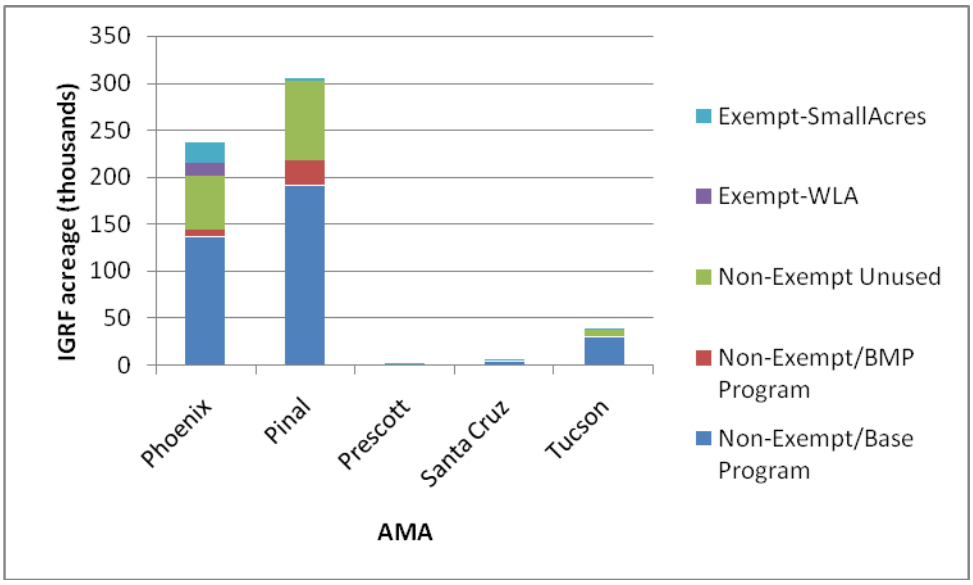

FIGURE 2. IGFR ACREAGE IN THE 5 AMAS, 2005

The Pinal AMA accounts for 52% of the total IGFR acreage in the state (nearly 305,000 acres), 70% of which is used and subject to the full conservation requirements of the GMA. Because of this acreage and an economy that is largely dependent on agriculture, the Pinal AMA was expected to contribute the largest share of program participants. The IGFR surface of the Phoenix AMA is also substantial (nearly 240,000 acres), and the value of agricultural production in the area is relatively high[7], but 40% of the area is exempt or idle, and the area is undergoing rapid urbanization, as will be discussed further below. The Tucson AMA has only about 37,000 IGFR acres. While that irrigable surface has remained stable in recent years, the AMA that has accumulated substantial flexibility credits (GWMC, 2000). Both the Prescott and Santa Cruz have a small irrigated acreage with mostly small farms and were not expected to participate in the program. In summary, the data of Figure 2 shows that the BMP program has attracted about 12% and 5 % of the acreage of non-exempt, non-idle land in the Pinal and Phoenix AMAs, respectively. This acreage represents 8% and 3% of the number of IGFRs available in those AMAs.

A second factor explaining the geographical distribution of BMP farms is urban pressure and the resulting uncertainty in the planning horizon of farm operators. The BMP Advisory Committee anticipated limited participation in areas under intense urban pressure, and a similar concern was expressed in a recent evaluation of AMA Management Plans conducted by the Water Resources Research Center of the University of Arizona (Megdal et al 2008). Population has more than doubled since 1980 in the Phoenix metropolitan area, where the population growth has averaged 2.4% per year for more than 10 years (MAG, 2005). As a result, a considerable amount of agricultural land has been converted to urban and industrial uses. State-wide, nearly137 thousand IGFR acres were retired for non-irrigation uses[8] during the period 1998-2007, with the Phoenix AMA accounting for 83% of that acreage and the Pinal AMA for 14%. Figure 3 summarizes that information for selected irrigation districts in the Phoenix and Pinal AMAs, respectively (irrigation district acronyms are defined in Table 2). In the graph, the OTHER category represents the data for the Tucson, Prescott, and Santa Cruz AMAs. All districts with BMP farms are included in the graph. Irrigated land conversions in the Phoenix AMA peaked in 2002, and were led by SRP. Since that year, conversions have been occurring also in the Pinal AMA, mostly in the MSIDD service area, and propelled Pinal County to be ranked as the 6th fastest growing county in the United States in 2007 (The Future at Pinal, 2007).

[7] According to the 2002 Agricultural Census Data (NASS, 2002), the market value of agricultural products sold by Maricopa County farms exceeded that of Pinal County farms by 75%. Most of the Phoenix AMA irrigated acreage is in Maricopa County, with a small portion in Pinal County, while all of the Pinal AMA is in Pinal County.

[8] IGFRs need to be retired with ADWR in order to convert the irrigated agricultural land to urban and other uses. The reported data includes urbanized IGFRs, IGFRs extinguished for Assured Water Supply Credits, and for non-irrigation water supplies. Partially retired acreage is not included in the data.

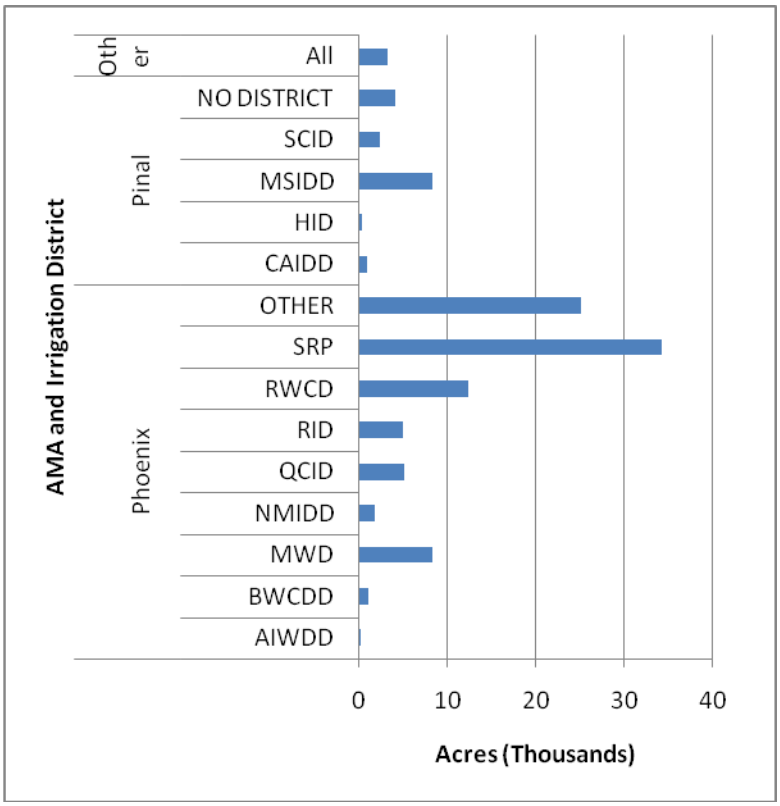

FIGURE 3. EXTINGUISHED IGFR ACREAGE IN THE AMAS, 1996-2007

TABLE 2. TABLE 2. SELECTED IRRIGATION DISTRICTS IN THE PHOENIX AND PINAL AMAS

Acronym	Name
AIWDD	Adaman Irrigation Water Delivery District #36
SRP	Salt River Project
RID	Roosevelt Irrigation District
MSIDD	Maricopa-Stanfield Irrigation & Drainage District
HID	Hohokam Irrigation &Drainage District
NMIDD	New Magma Irrigation & Drainage District
RWCD	Roosevelt Water Conservation District
QCID	Queen Creek Irrigation District
MWD	Maricopa Water District
CAIDD	Central Arizona Irrigation & Drainage District
SCID	San Carlos Irrigation & Drainage District

Figure 4 summarizes the acreage and farm enrollment by AMA and irrigation district. The BMP Program attracted farms from all four irrigation districts in the Pinal AMA, but only from three in the Phoenix AMA. Participation in the Phoenix AMA is restricted to irrigation districts not subject to intense urban pressure (see Figure 3) – AIWDD, RID on the west end of the AMA and NMIDD, on the east end. Similarly, in the Pinal AMA, the district under most urban pressure, MSIDD, is the one with fewest participants.

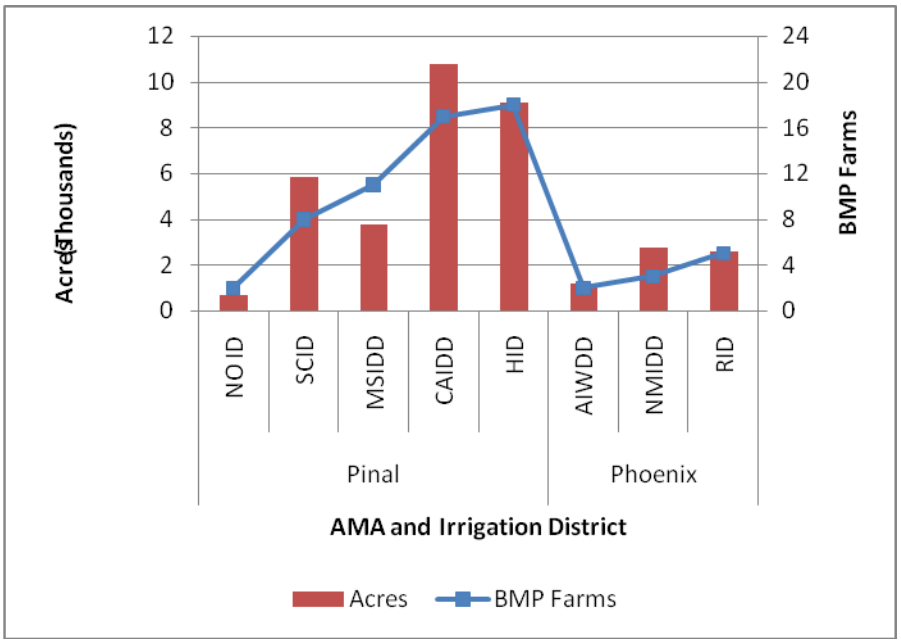

FIGURE 4. ENROLLED ACRES AND FARMS BY AMA AND IRRIGATION DISTRICT

8.1.2 ENROLLED FARMS ARE REPRESENTATIVE OF CENTRAL ARIZONA COMMERCIAL FARMS RELATIVE TO FARM SIZE, NUMBER OF IGFRS, AND OWNERSHIP STRUCTURE

Figure 5 summarizes the distribution of BMP farms and acres by farm size category. The graph uses the size categories employed by the Census of Agriculture (NASS, 2002). Half of the enrolled farms have less than 500 IGFR acres and those farms represent a fifth of the acreage. The other half of the farms, with more than 500 IGFR acres, represents 80% of the enrolled acreage. The largest share of farms (42%) and acres (52%) correspond to the 500-999 acre category. This size distribution can be contrasted with the corresponding distribution for farms in Central Arizona (represented by the combined statistics of Maricopa and Pinal Counties reported by the 2002 Census), which is illustrated in Figure 6. Excluded from the graph are farms with less than 10 acres which, as was explained earlier, are exempt from Base Program requirements and are not targeted for enrollment by the

BMP program. The farm size distribution for the two counties is bimodal, with the first mode in the 10-100 acre range and the second in the 500-999 acre range (Figure 5). This second mode matches the single mode in the BMP farm distribution. For Maricopa and Pinal Counties, farms with more than 2000 irrigated acres represent 7% of the farm population and account for nearly half the acreage. Only one BMP farm is in that category, and that farm accounts for 7% of the enrolled acreage.

Overall, these results show good agreement between BMP farm size distribution and the corresponding distribution for Central Arizona farms. The BMP population under-represents the lower end of the Central Arizona farm population; however, the Program may not want to target small farms for enrollment. Small farms represent a small fraction of the water used in the AMAs[9]. They can benefit from the water supply flexibility offered by the BMP program, but the administrative costs for ADWR is the same as for a large farm. Farms on the upper end of the distribution, which represent a very large share of the AMA agricultural water use, are also underrepresented. Their share of water use can increase substantially if a large number of those farms enroll in the BMP program seeking to switch to more water intensive crops, independently of how efficiently that water is used.

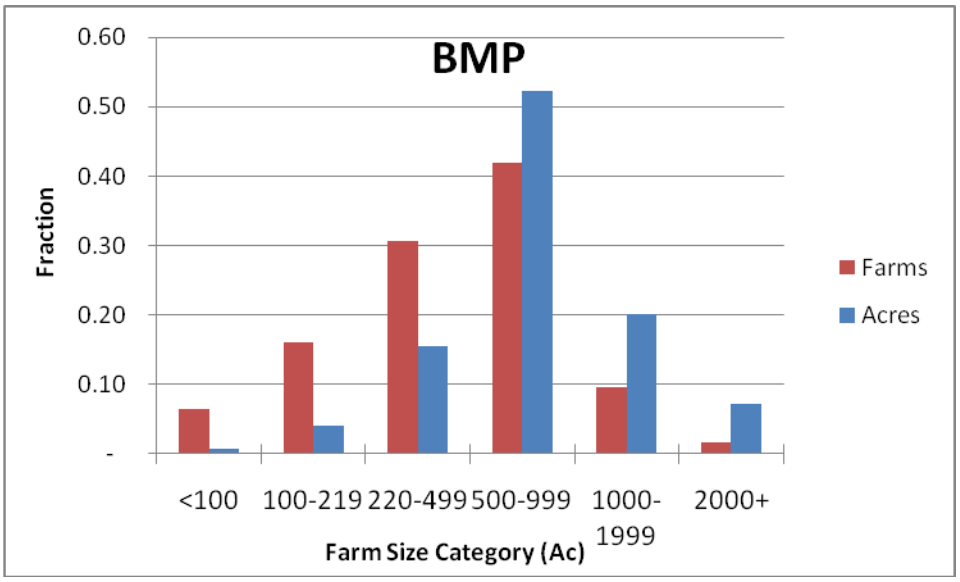

FIGURE 5. DISTRIBUTION OF BMP FARMS AND ACRES BY FARM SIZE

[9] Deva and Frisvold (2005) analyzed 2003 Farm and Ranch Irrigation Survey data for Arizona and noted that farms that used more than 500 acre-feet of water accounted for 97% of the reported applied water in the state. Considering that the average application rate for Arizona farms is nearly 4.5 ft, farms with less than 100 acres fall in the lower end of the water application distribution.

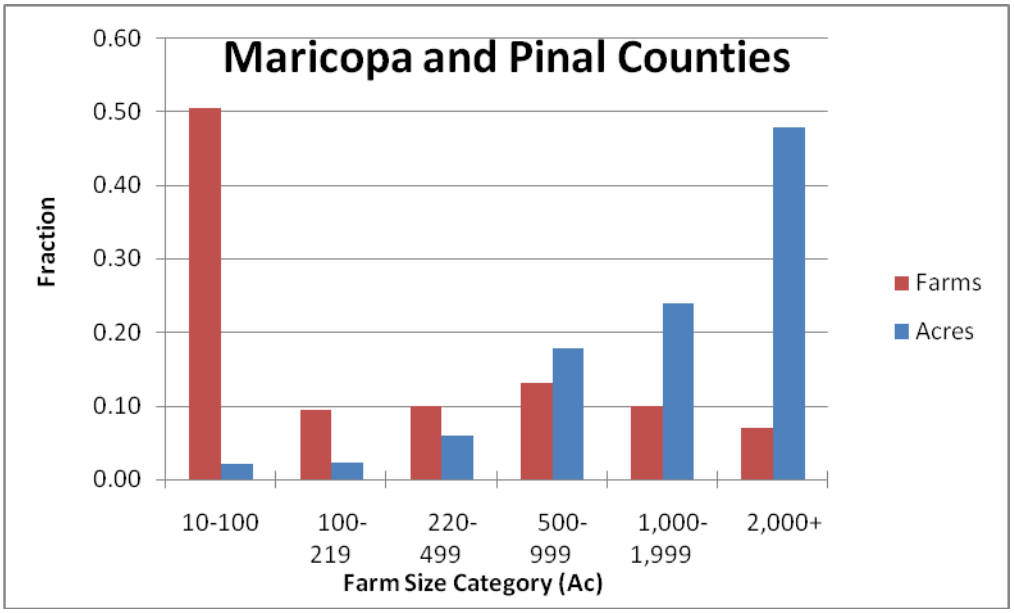

FIGURE 6. DISTRIBUTION OF FARMS AND IRRIGATED ACRES IN MARICOPA AND PINAL COUNTIES BY FARM SIZE CATEGORY, MARICOPA AND PINAL COUNTIES (NASS-2002 CENSUS OF AGRICULTURE).

As indicated before, the BMP Program rules were developed to facilitate the enrollment lands with leased lands, which are typical of commercial farms in Arizona. The farm tenure characteristics of BMP farms and of farms in Maricopa and Pinal County are illustrated in Figure 7 and Figure 8, respectively. The graphs show the fraction of farms that are fully owned versus farms that are partly owned (owned and leased land) or entirely leased; also displayed in the graphs is the average farm size for each category. Results are presented separately by AMA and county because of interesting contrasts between the BMP and county data. These comparisons exclude data from the New Magma Irrigation and Drainage District (NMIDD), which is located within the boundaries of the Phoenix AMA and also of Pinal County. Fully owned farms represent 40% of the BMP farms in the Phoenix AMA, but 70% of all farms in Maricopa County. The data also indicates a large difference in average size, nearly 350 acres for the BMP farms vs. 90 acres for the county level data (the average size for part owned/leased farms is in closer agreement, however). In contrast, the breakdown between owned and part owned/leased farms is essentially the same for the Pinal AMA BMP farms as for Pinal County data; average farm sizes by tenure category also do not differ by much between the two data sets.

One factor that helps explain these differences in tenure structure is that, in comparison with the Pinal AMA, typical commercial farming operations in the Phoenix AMA consist of a large number of IGFRs. BMP farms in the Phoenix AMA (excluding NMIDD farms) includes an average of 6.5 IGFRs (3.7 for owned farms vs. 8.8 for partly owned/leased farms). In contrast, BMP farms in the Pinal AMA average 1.7 IGFRs (1.3 for owned and 2.1 for part owned/leased). The number of IGFRs per farm may also contribute to limit the

participation of Phoenix AMA farms in the BMP Program - with more leased IGFRs, the farm operator faces greater difficulties in securing the needed affidavits.

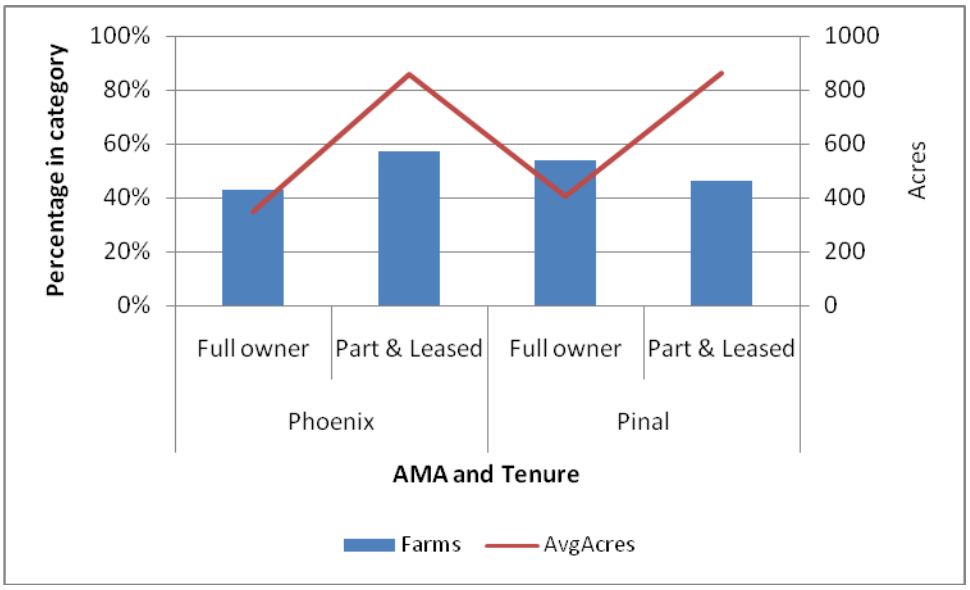

FIGURE 7. TENURE CHARACTERISTICS OF BMP FARMS BY AMA

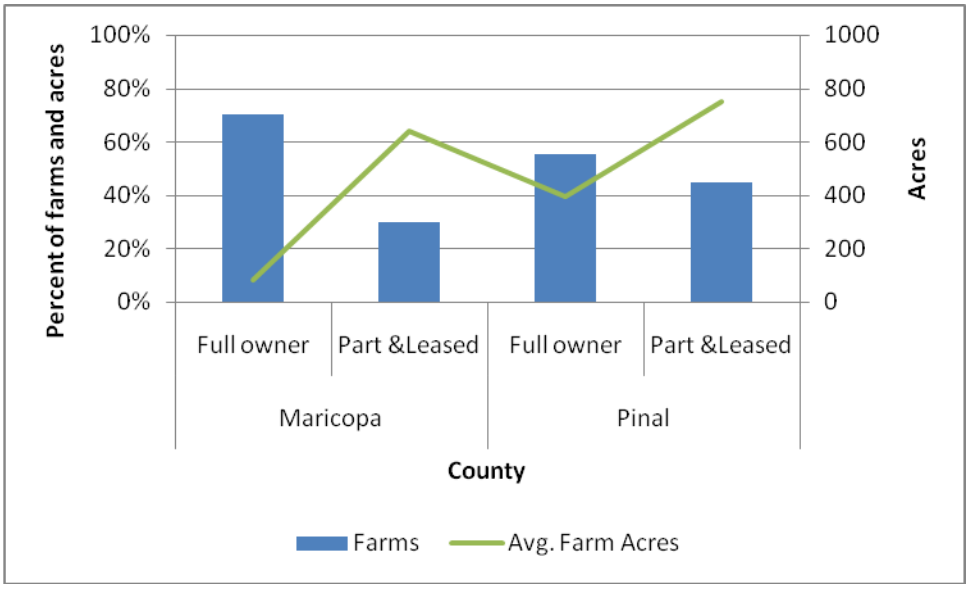

FIGURE 8. TENURE CHARACTERISTICS OF MARICOPA AND PINAL COUNTY FARMS, 2002 AGRICULTURAL CENSUS

While the BMP Program allows operators to enroll multiple IGFRs as a single farm, not all operators with multiple IGFRS can do so, either because the IGFRs are not contiguous (more than half a mile from each other) or because they are operated with different partners. The 2002 Agricultural Survey data does not provide data that could be used to characterize the fraction of the farm operator population that operates multiple farms. Nevertheless, Figure 9 is presented to illustrate the fraction of operators that enrolled more than one farm (25%).

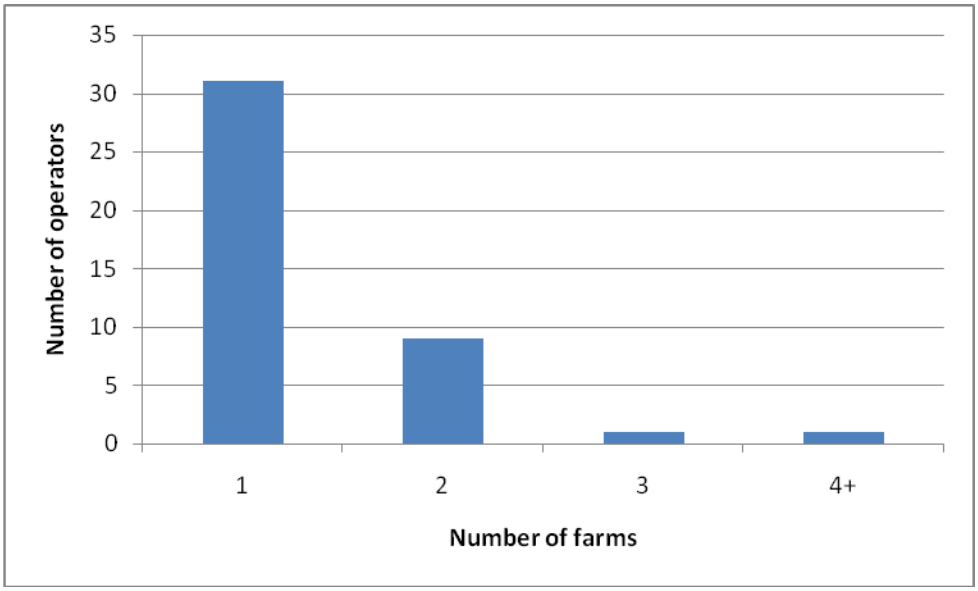

FIGURE 9. NUMBER OF FARMS OPERATED BY A BMP FARM OPERATOR

8.1.3 THE CROP MIX OF ENROLLED FARMS IS REPRESENTATIVE OF CENTRAL ARIZONA AGRICULTURE

Crop mix data for the BMP farms was collected through the farm operator interviews. As indicated before, we conducted 21 interviews so the data presented herein represents a sample of BMP farms. The operators were asked to identify their main production activity and, in addition, the mix of crops that they typically grow.

With one exception, all of the interviewed operators grow more than one crop. The crops reported by the operators are mostly typical of Central Arizona farms - alfalfa, cotton, corn, barley and wheat (Figure 10). These crops represented nearly 90% of the harvested crop acreage in Maricopa and Pinal Counties in 2002 (NASS, 2002). Of the 21 interviewed operators, 17 identified alfalfa and/or cotton as their main crop.

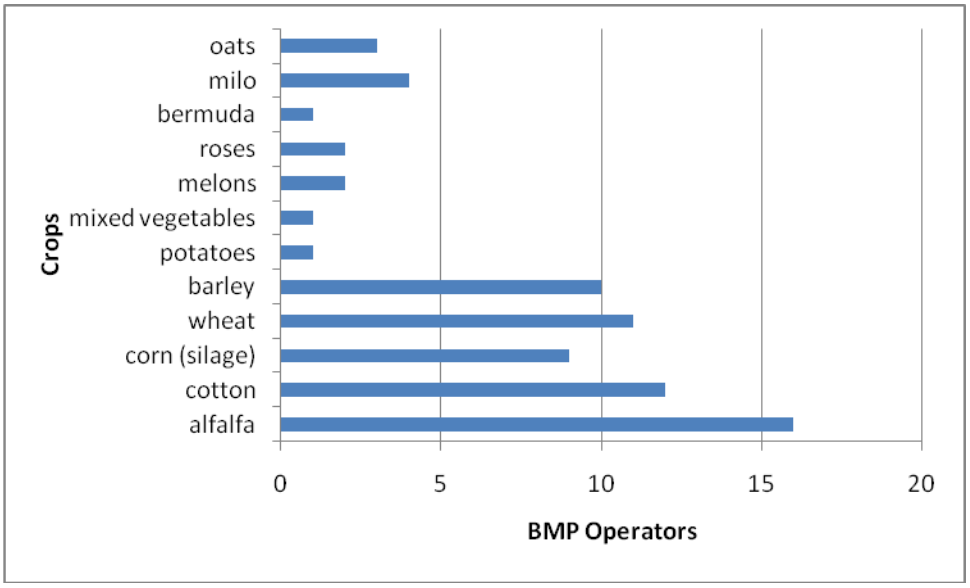

FIGURE 10. CROPS GROWN BY INTERVIEWED BMP FARM OPERATORS

8.1.4 ON-FARM IRRIGATION TECHNOLOGIES AND IRRIGATION MANAGEMENT PRACTICES OF ENROLLED FARMS ARE REPRESENTATIVE OF CENTRAL ARIZONA AGRICULTURE

A summary of the BMP enrollment worksheets is provided in Figure 11-Figure 13. The graphs show the percentage of participating farms that agreed to implement a particular BMP. Category 1 results (conveyance system) are not reported in these graphs because most of the enrolled farms reported conveyance systems consisting entirely of lined channels or pipelines (the average score for all farms is 2.95, with a minimum value of 2).

Ninety-seven percent of the enrolled acreage is irrigated with surface irrigation systems (Figure 11). The sum of all the values in the Figure 11 exceeds the total number of BMP farms because several farms utilize more than one on-farm irrigation method. Level basin systems are the most common method of water application by BMP farms. Those systems are defined as gravity systems with a row fall of less than 0.2 feet of total fall in the direction of irrigation and with no runoff losses. Results for Category 3 (irrigation management) and 4 (agronomic management) are similar to those presented for irrigation systems in that some practices are used by most participants, while others are used by fewer farm operators or none at all. Such is the case of BMP 3-12, use of computer models for irrigation scheduling.

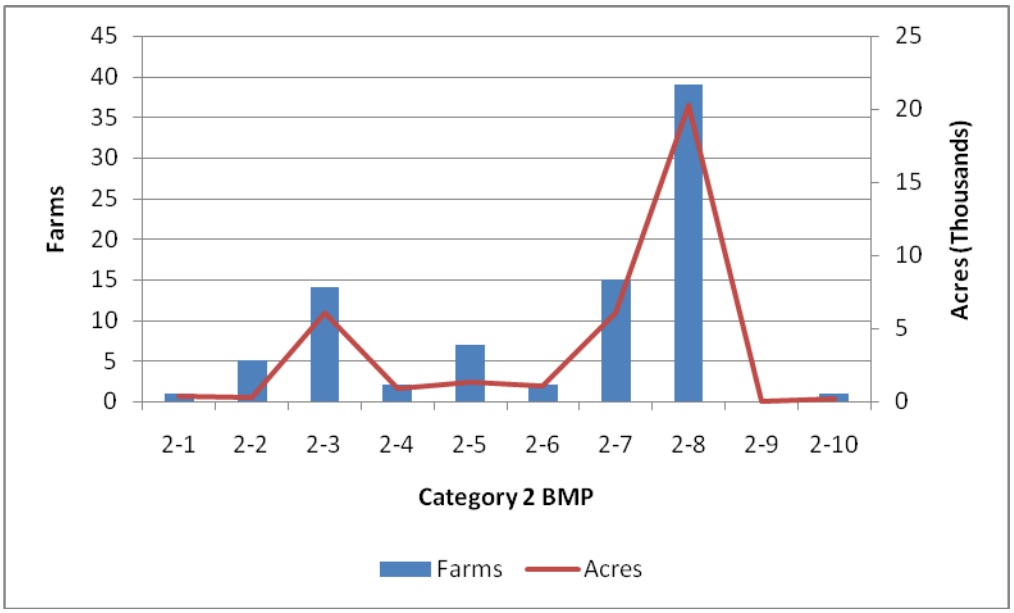

FIGURE 11. IRRIGATION SYSTEMS (CATEGORY 2) USED BY BMP FARMS AND ACRES SERVICED BY EACH IRRIGATION SYSTEM TYPE

KEY

2-1 Slope systems without uniform grades with tailwater reuse

2-2 Uniform slope systems without tailwater reuse

2-3 Uniform slope systems with tailwater reuse

2-4 Uniform slope systems within an irrigation district that recaptures and redistributes return flows

2-5 Modified slope systems

2-6 High pressure sprinkler systems

2-7 Near level systems

2-8 Level systems

2-9 Low pressure sprinkler systems

2-10 Trickle irrigation systems

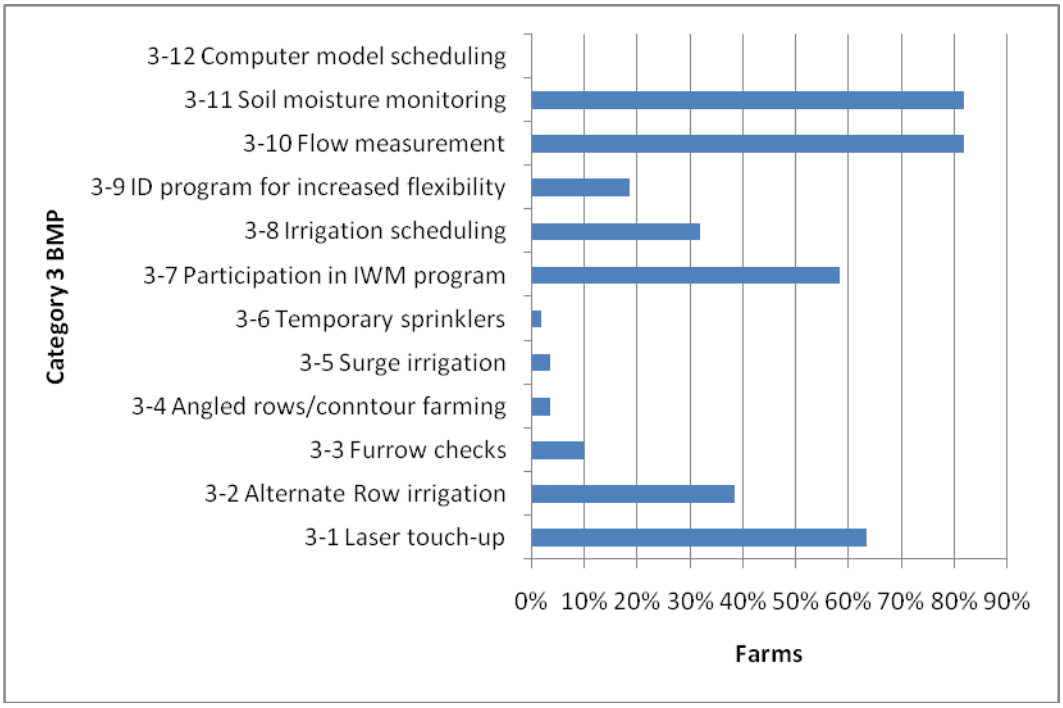

FIGURE 12. IRRIGATION MANAGEMENT PRACTICES (CATEGORY 3) USED BY BMP FARMS

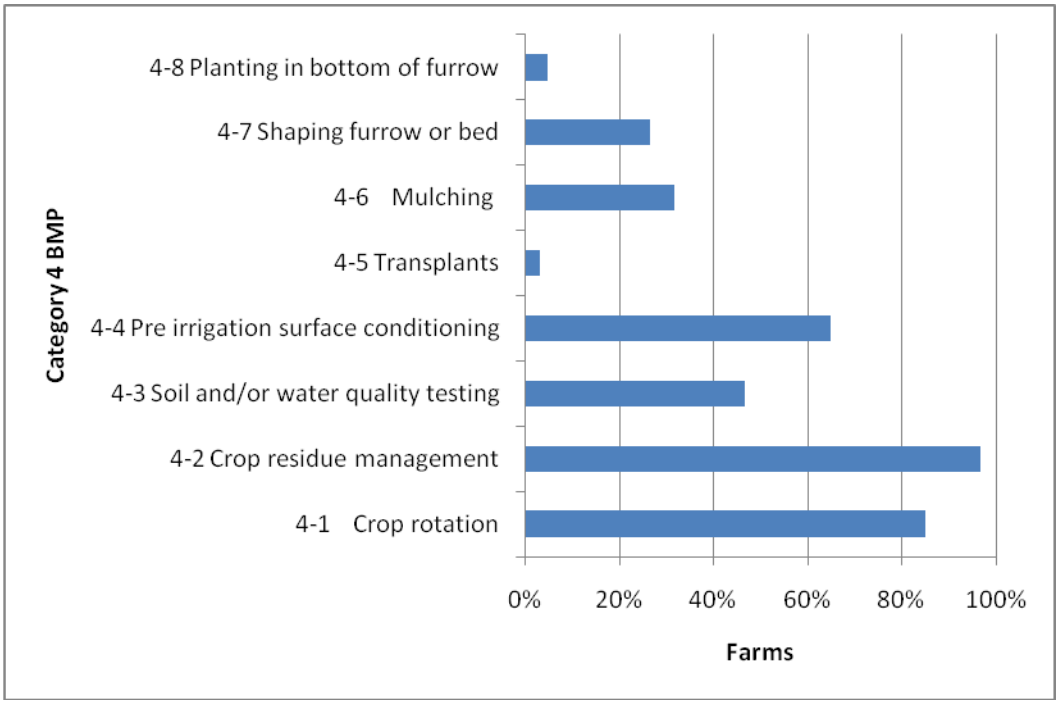

FIGURE 13. AGRONOMIC MANAGEMENT PRACTICES (CATEGORY 4) USED BY BMP FARMS

Limited data are available that can be used to contrast the irrigation technology and management practices of BMP farms with the farm population of Central Arizona. The 2003 Farm and Ranch Irrigation Survey (FRIS, 2003) provides data that can be used to characterize irrigation systems at the state level, but distinguishes gravity methods only as furrows, borders/basins, and uncontrolled flooding. The high proportion of BMP acres irrigated with gravity methods is consistent with the percentage (90%) of gravity irrigated acreage reported for Arizona by the survey. The data also provides an estimate of the acreage serviced with lined channels and other improved conveyance systems. According to those data, 87% of irrigated acreage is equiped with improved conveyance systems. Therefore, it is not unreasonable to assume that such type of systems are widely used throughout the Phoenix and Pinal AMAs.

Table 36 of the FRIS provides data on the use of irrigation scheduling practices. Those data indicate that most farm operators in Arizona schedule irrrigations using visual crop indicators and personal (fixed) calendars, neither of which are included in the list of approved BMPs. Instead, operators for 80% of the BMP farms agreed to conduct soil moisture monitoring and 30% to use of irrigation scheduling/management services[10]. This suggests a higher level of management by the BMP operators in comparison with the general population. Sixty percent of the BMP farms signed up with BMP 3-1 Laser Touch-up. This is consistent with the large number number of acres that have been laser-leveled in the state (nearly half the irrigable acreage, according to Table 37 of the FRIS).

Because of difficulties in characterizing the use of the approved BMP practices by farms in Central Arizona, we asked the interviewed operators to compare their BMP practices with the practices of other farm operators in their area. Figure 14 sumarizes the responses by BMP category (Cat1 – Conveyance; Cat2 – Irrigation System; Cat3- Water Management; Cat4 – Agronomic Management). Most operators responded that their BMPs were used by more than half or all farmers in the area. A comment made about this question by several respondents was "everybody here is doing their best to manage their irrigation water." In contrast, a few respondents indicated that their practices were not widely used or not used at all by their neighbors. Note in Figure 14that the responses for categories 1 and 2 are more scattered than for categories 3 and 4. Hence, most of the perceived differences are in the category of conveyance and irrigation systems. Although the survey did not explore these responses in more detail, several of these operators noted that they have high capacity ports on their farms which provides them with greater flexibility and control than traditional systems that use siphon tubes to divert water to a field.

[10] Mostly the Irrigation Management Service (IMS) and Water Conservation Management Program (WCMP), both of which are cooperative programs providing irrigation assistance to farm operators

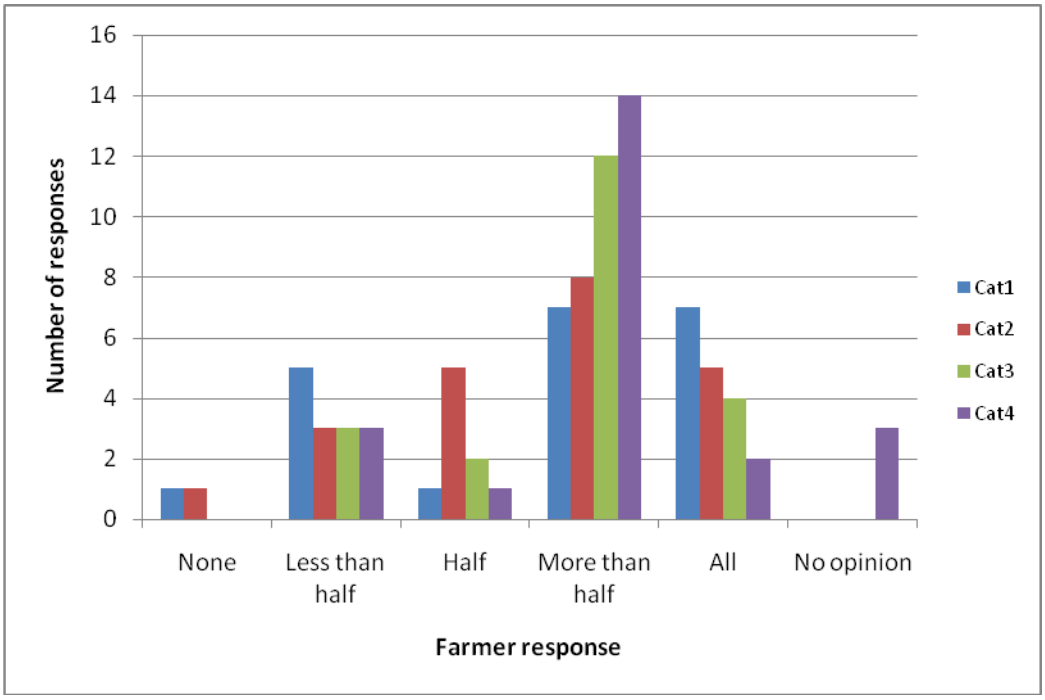

FIGURE 14. BMP FARM OPERATOR ASSESSMENT OF THE USE OF BMPS BY OTHER OPERATORS IN THEIR AREA

8.1.5 DISCUSSION

Since a limited number of non-participants were interviewed, the study was unable to determine if producers in the AMAs are widely aware of the BMP Program and if this impacts participation. All interviewed non-participants were aware of the Program and were unable to qualify or decided not to participate, as will be discussed later. The Program was promoted by ADWR, the irrigation districts, IMS/WMCP, the conservation districts, and others. Most participants stated that they received information about the Program from more than one of these sources. Still, some respondents suggested that other producers were not aware of the BMP Program.

Since ADWR did not establish targets for enrollment, the answer to question of whether levels of participation are reasonable is subjective. A substantial amount of land in the AMAs is not being farmed and not all IGFR acreage is subject to Base Program regulations. Urban pressure and land tenure characteristics of farms in Central Arizona do not allow many producers to plan long-term and is limiting enrollment largely to the Pinal AMA, where the economy is largely agricultural-dependent. Not all farms in the AMAs have improved irrigation infrastructure and, therefore, do not qualify for the Program. In addition, and as will be discussed in the following section, many operators have historically accumulated flexibility credits and have little or no incentive for participation. Given these considerations, participation appears to be reasonable. Furthermore, participation will likely increase slowly for the same reasons.

8.2 QUESTION 2. WHAT MOTIVATED GROWERS TO ENROLL?

The BMP Program removes the allotment limitation and provides an alternative procedure for reporting water use. Presumably, these incentives provide economic benefits to participants. Those participants vary in their farm resources (e.g. soil types, slope, water sources, delivery rate and rules, and irrigation technology), production objectives (crop mix and acreage), and management skills. Hence, they are impacted in different ways by the Base Program rules and may expect different benefits from the BMP Program. Numerous recent studies have examined the response of agricultural producers to conservation policies, including participation in voluntary resource conservation programs, the adoption of conservation practices, and the response to conservation subsidies (Marshall, 2004; Kuehne et al., 2008; Prokopy et al., 2008; Rosenberg and Margerum, 2008; Atari et al., 2009; Greiner et al., 2009; Sattler and Nagel, in press). Those studies have concluded that the response is affected only in part by the impact on farm income; perceived risks, transaction costs, attitudes toward conservation, social networks within the farming community, and other extrinsic and intrinsic factors are additional motivating factors that sometimes override financial considerations. This chapter examines the range of factors that motivated BMP farm operators to enroll. The analysis relies on data obtained through the survey and data provided by ADWR.

The issue of motivation was initially examined during the survey by posing the open-ended question "What was your motivation for enrolling?" Table 3 summarizes the responses along with the number of times that a particular theme was mentioned. Most interviewees offered very specific and concise responses; this suggests they had well-defined objectives when they joined the program. A few operators mentioned several motives. Several responses required some interpretation. In particular, several operators responded with the statement "water conservation." Based on the follow-up discussion, we interpreted those responses as "promoting water conservation", which was the language used by some respondents, The answers of Table 3 mostly confirmed our expectations about motivating factors. Those issues were examined more specifically through a series of multiple-choice and yes/no questions that are discussed in the following sections.

TABLE 3. RESPONSES TO THE OPEN-ENDED QUESTION "WHAT WAS YOUR MOTIVATION FOR ENROLLING?"

Response	Count
Increase water availability	7
Low water duty	2
Always over allotment	1

Freeze flexibility credits	3
Running out of flex credits	1
Avoid purchasing flex credits	1
Crop mix changing to more water consuming crops	1
Double cropping	1
Better utilize the land, reduce idle land	1
Freedom to plant what you want	1
Simplification of reporting process	2
Less paperwork	1
BMPS already in place	1
Help the agricultural community and ADWR	1
Promote water conservation	5

8.2.1 PRODUCERS' HISTORICAL WATER DUTIES AND FLEXIBILITY CREDIT BALANCES ARE FACTORS THAT INFLUENCE THEIR DECISION TO PARTICIPATE IN THE BMP PROGRAM

This hypothesis was analyzed first by analyzing allotment and flexibility credits data for all farms enrolled during 2004-2006. These data are compiled by ADWR for individual IGFRs. Since BMP Program farms consist of one or more IGFRs, the analysis aggregates the IGFR data for each farm.

The water entitlement per acre of irrigable land varies among enrolled farms because allotments are a function of the historical water use and the ADWR-assigned irrigation efficiency. Figure 15 illustrates the differences in irrigation duty ID (total farm allotment divided by the total farm duty acres) at the time of enrollment. The average ID for all farms is 4.13 ft, but values range from 2.9-5.6 ft. Most farms have an ID of 3.5-4.5 ft, but three had less than 3.5 ft. These differences are due to variations in the crops that were grown on those lands during the historical period 1975-80 (irrigation requirement values for the enrolled IGFRs range from about 2.3 to 3.9 ft) and in the assigned irrigation efficiency value, which range from 0.7 to 0.8. Differences in the entitlement are more acute when considering the allotment in relation to the irrigable acres of each farm. IGFR duty acres were determined based on the maximum number of acres cultivated during the historical period. For some farms, limited groundwater supplies dictated the land utilization rate (the ratio of cropped to irrigable acres) during that period. Some of those farms now have

access to CAP supplies and, therefore, could regularly plant a larger fraction of their irrigable acreage with a larger entitlement. For the enrolled IGFRs, the ratio of duty acres to irrigable acres ranges from 0.54 to 0.97. As a result, the irrigation duty per irrigable acre, which is identified in Figure 15 as EID (effective irrigation duty), ranges from slightly less than 2 to 5.3. The average EID for all farms is 3.6 ft or 0.5 ft less than the average ID, and 15 of the farms have an EID less than or equal to 3.5 ft.

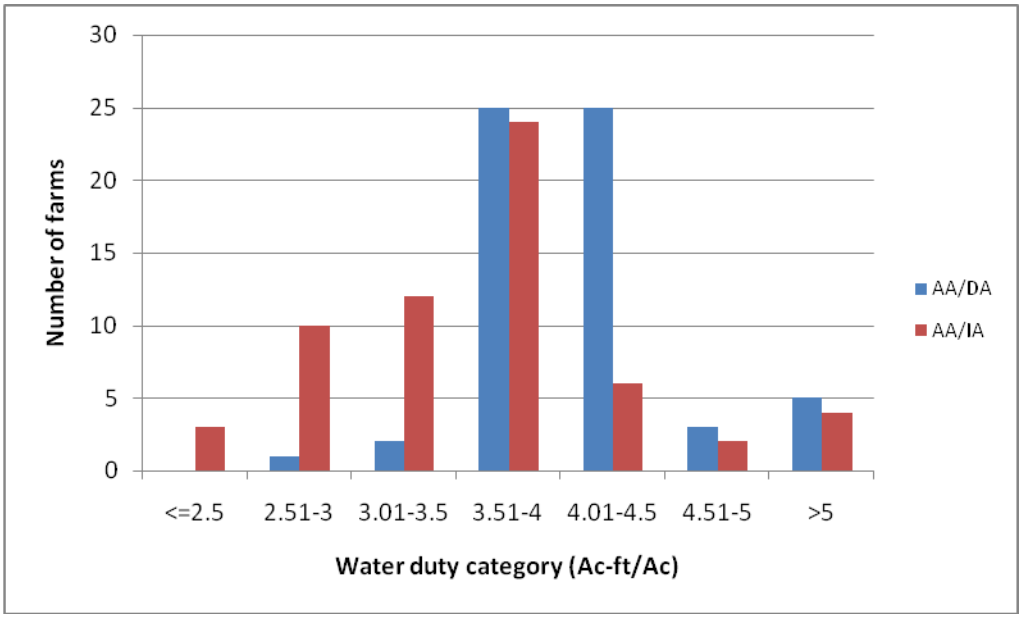

FIGURE 15. DISTRIBUTION OF BMP FARMS BY WATER DUTY, COMPUTED BASED ON DUTY AND IRRIGATED ACRES.

The flexibility account and mechanisms for transferring credits were instituted to provide operators with the flexibility to deal with short-term variations in cropping patterns and weather, but not necessarily with long-term variations. A large flexibility credit account provides some insurance against long-term changes in water demands, assuming the physical supplies are actually available. Figure 16 depicts the ratio of flexibility credits (at the time of enrollment) over the annual allotment (FC/AA) for the enrolled farms. The average FC/AA ratio for the BMP farms (3.72) is less than the AMA-average value (6.0) calculated by Needham (2005). Nevertheless, half of the BMP farms had at the time of enrollment a FC/AA ratio greater than 3.0 and nine greater than 6.0. Clearly, farms with a negative ratio were using water at the limit of their allotment when they enrolled.

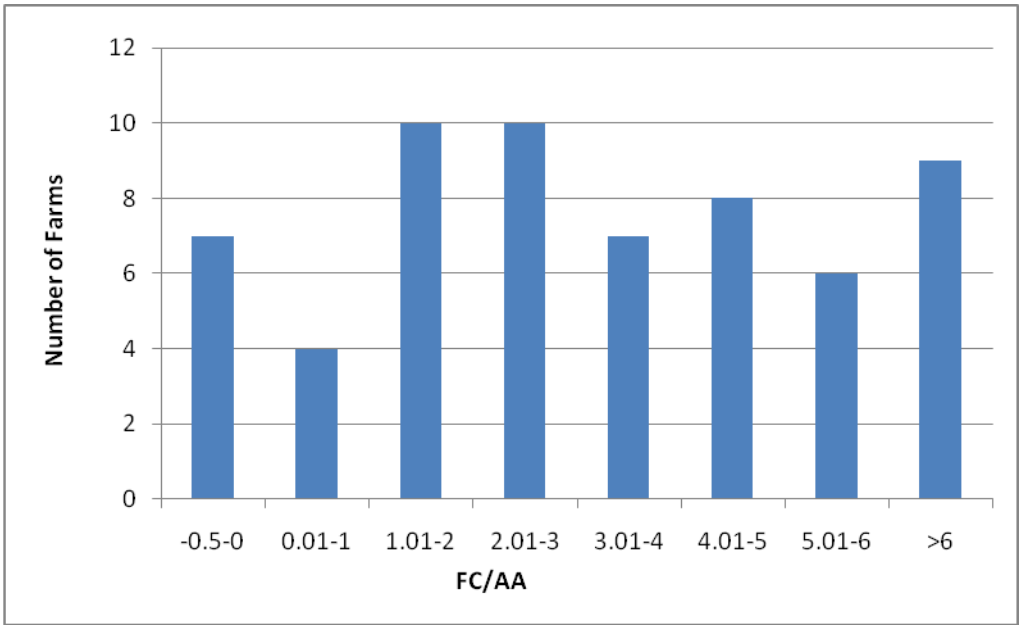

FIGURE 16. DISTRIBUTION OF BMP FARMS BY THE RATIO FLEXIBILITY CREDITS OVER ANNUAL ALLOTMENT.

As was explained before, the accumulation of flexibility credits has been attributed mainly to low land utilization rates; it is not surprising, therefore, that there is little correlation between the effective irrigation duty (EID) and the FC/AA data (Figure 17) for the BMP farms. The graph suggests a positive relationship between these two variables, but the scatter in the data is substantial. Hence, farms with a small EID have been able to accumulate credits while farms with the largest duties do not have the largest supply of credits. This does not imply that the farm operators with small irrigation duties have the same flexibility in making cropping changes as those with large duties, just that they work within the limitation of their allotment.

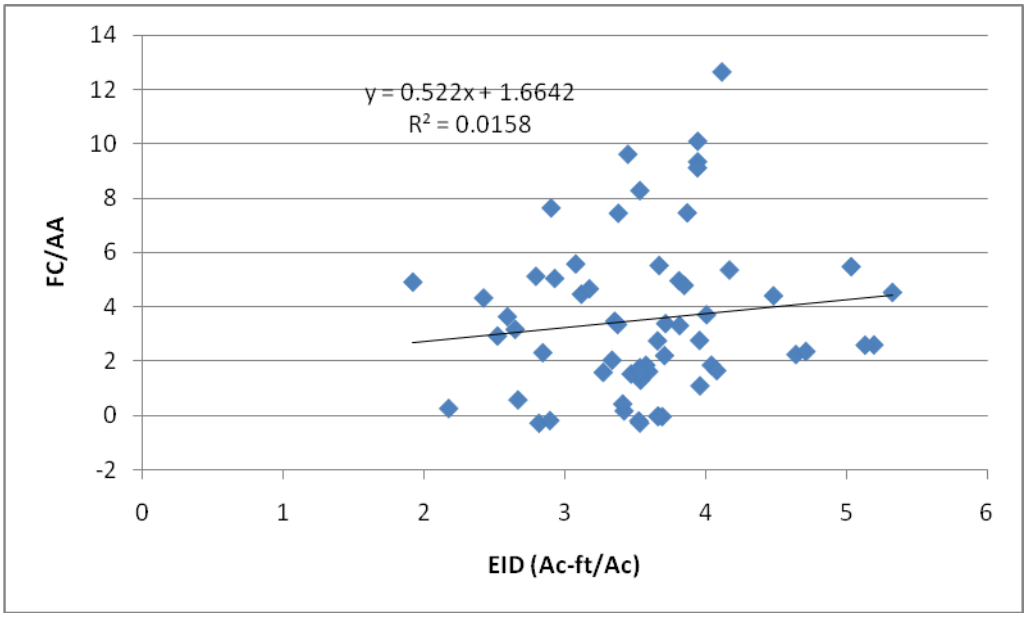

FIGURE 17. FLEXIBILITY CREDIT OVER ANNUAL ALLOTMENT RATIO AS A FUNCTION OF EFFECTIVE IRRIGATION DUTY FOR THE BMP FARMS

While few of the BMP farms enrolled with a negative flexibility balance, most saw their credits erode in the three years prior to enrollment. Figure 18 illustrates the ratio of the average credits or debits accumulated by the BMP farms 3 years prior to enrollment (COD3) over the annual allotment (COD3/AA). In the graph, parentheses are used to represent negative values [e.g.,(1)-(0.75)]. Only 30% of the farms accumulated credits during the 3 years prior to enrollment. For nine of the farms, the COD3/AA ratio is less than -0.5, meaning that their average annual debits during the period were more than half their allotment. These flexibility credit losses were most acute in Pinal AMA farms, in all likelihood as a result of increases in alfalfa acreage. Because the data is only for 3 years prior to enrollment, we cannot determine if the erosion of credits is a trend that has been ongoing for longer than 3 years and, if so, it the problem has become more acute in recent years. Note also that these data do not take into account flexibility credit purchases and only reflect the calculated credit or debit based on the reported water use. The available data indicates that a few operators eventually offset some of the debits with flexibility credit purchases but it is unclear whether those purchases occur regularly or are a response to recent increases in water demand.

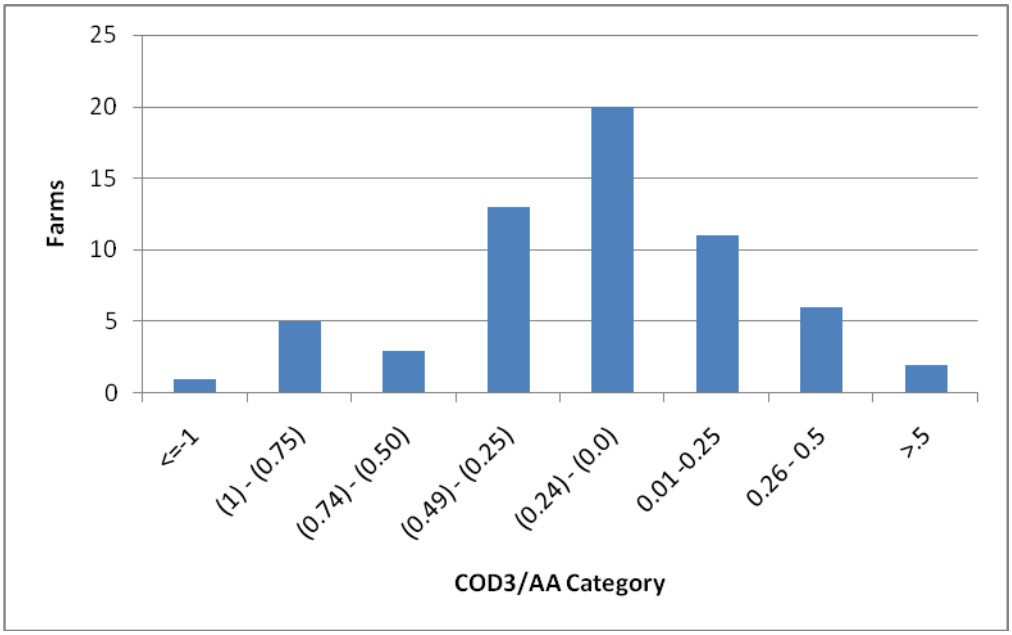

FIGURE 18. DISTRIBUTION OF FARMS BY THE RATIO OF AVERAGE CREDITS OR DEBITS 3 YEARS PRIOR TO ENROLLMENT OVER THE ANNUAL ALLOTMENT

In summary, the above presented data shows that allotments and flexibility credits varied substantially among BMP farms at enrollment time. Some enrolled farms may have been facing short-term water supply limitations at enrollment time, or were possibly anticipating limitations in the short- to medium-term. However, the data also suggests that many of the enrolled farms did not have those problems, as they had both a sizeable allotment and a large supply of credits.

Survey responses confirm the previous observations. During the interviews, we asked the operators if their Base Program allotment constrained their cropping decisions and if allotment concerns had been influential in their decision to enroll. Sixty percent of the respondents indicated that they were constrained half the time or more frequently (Figure 19), but the rest stated they had never been constrained by their allotment or only occasionally. While many of the operators did not feel constrained under the Base Program, almost all enrolled because of allotment concerns (Table 4[11]). Those farms potentially face future constraints with increases in the assigned efficiency value, especially if water use levels in the three years prior to enrollment are reflective of future water use levels.

[11] In this and similar tables, the first column presents a modified statement of the original question. For example, the first row contains a modified statement of the question associated with Figures 19. The second column is the number of responses that agree with the statement over the number of respondents who answered the question The number of responses is often less than the total number of interviewees because some questions did not apply to all operators and, in some cases, because some questions were accidentally skipped.

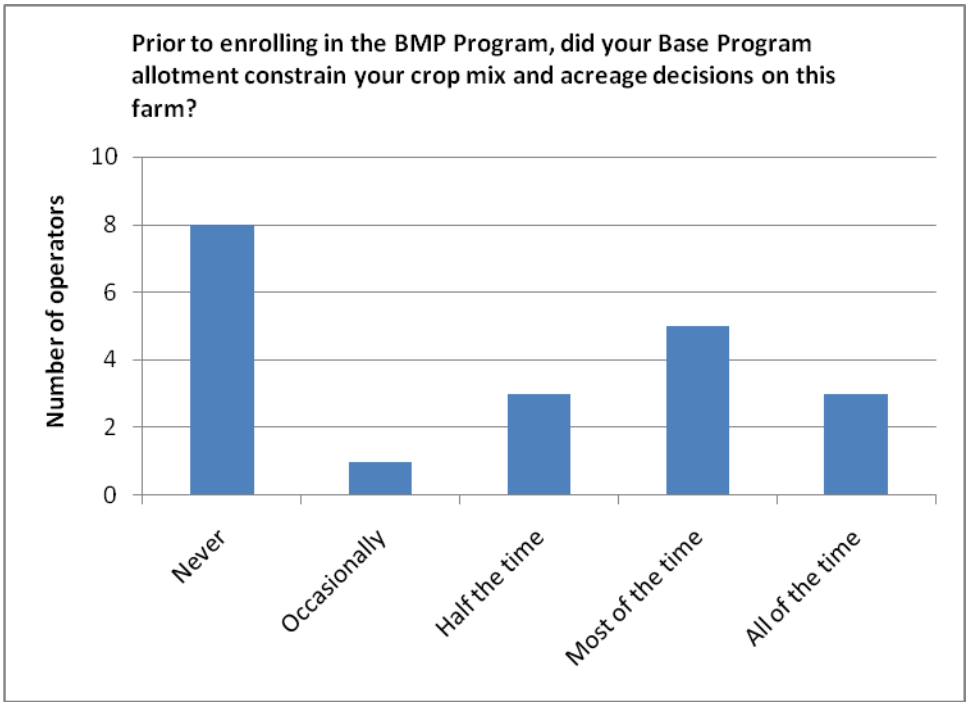

FIGURE 19. PERCEIVED IMPACT OF THE BASE PROGRAM ALLOTMENT ON CROP MIX AND ACREAGE DECISIONS FOR INTERVIEWED BMP OPERATORS

TABLE 4. INFLUENCE OF BASE PROGRAM ALLOTMENT AND FLEXIBILITY CREDITS ON THE DECISION TO ENROLL.

The Base Program allotment constrained the operator's crop mix and acreage decisions half or more than half the time	12/21
Base Program allotment concerns influenced the operator's decision to enroll in the BMP Program	18/20
The operator has been out of compliance with the Base Program at some time	2/20
Flexibility account concerns influenced the operator's decision to enroll in the BMP Program	8/20
At the time of enrollment, operator had concerns about freezing his/her flexibility account (s).	11/20

Producers were also asked if they had ever been out-of-compliance with Base Program rules (debits in excess of half the allotment) and if the balance of the flexibility account was a factor that influenced the decision to enroll. Only two of the producers had experienced compliance problems, and in both cases those problems were not recurrent. This suggests that the flexibility account, in fact, allows to adjust to short term variations in water

demands and, thus to operate within the allotment constraints, even for operators with limited allotments. Not surprisingly, 60% of the respondents did not enroll with flexibility account concerns. Moreover, more than half of the respondents indicated that at the time that they enrolled, they were concerned about having their flexibility account frozen. Evidently, these operators were considering the possibility that their water use would be less than the allotment while in the BMP Program and, therefore, would lose those credits.

The research team did not probe for details on how the Base Program rules limit the producers cropping decisions. However, the available data can be used to examine the relationship between the level of constraint reported by the operators (Figure 19) and their Base Program water supplies. Figure 20 depicts the average EID and FF/AA ratio for each respondent category of Figure 19. These values are relatively similar for all categories of respondents, from those who stated they were never constrained by their Base Program allotment to those stated they were always constrained. (Note that Figure 20 suggests that operators who were occasionally constrained have a much larger FF/AA ratio, i.e., a larger supply of flexibility credits. Since there is only one respondent in that category, the value is misleading). One interpretation of these data is that constraints are mostly a function of differences in demands among producers, which vary with crop mix, soils, and particularly with land utilization rates. For similar irrigation duty and flexibility credits relative to their allotment, a producer that plants most of his/her acreage on a regular basis would be expected to feel more constrained by the allotment than one who varies the acreage substantially from year-to-year. Crop acreage can also vary substantially if physical water supplies are scarce. In those cases, the allotment is not the factor that limits the producers' cropping decisions. In particular, farm operators in the San Carlos Irrigation and Drainage District can experience water shortages.

Overall, these responses indicate that while some respondents may be addressing present water limitations through the BMP Program, many are just reducing the risk of future constraints. During this part of the interview, the operators offered various comments that further support this conclusion. Some operators stated that their whole purpose in enrolling was to save their flexibility credits for future use. One did so in the expectation that the BMP program would not be reauthorized after 2010. Another commented to the question about constraints imposed by the allotment that water use was dictated by crop mix and acreage decisions, and not the other way around. If crop prices encourage operators to switch to more water intensive crops or expand their acreage, and thus increase their water use, then the operators will adjust their acreage or find the supplies (i.e., purchase or transfer credits). Others discussed the dependability of their long-term surface water supplies, especially those with farms receiving Central Arizona Project water. Producers are keenly aware that reductions in CAP water will necessarily have to be compensated by an increase in groundwater pumping to maintain the existing levels of production. While both surface and groundwater count against the allotment, the expectation is that with less surface water it will be more difficult to make due with the existing allotments (because surface water use in excess of the allotment is not debited).

As was explained in the methodology section, only three farm operators in the Base Program were interviewed. These operators were asked about their reasons for not participating in the BMP Program. Two of these respondents inquired about the Program

but found out they did not qualify based on their existing farm infrastructure. The third operator did no inquire but estimated that he did qualify for the Program and stated that, since his annual water use typically was less than his allotment, the Base Program worked well for him. Since he perceived no economic benefits, he chose not to participate in the Program. In addition, the operator expressed distrust of ADWR. Although this is only one example, it is reasonable to speculate that other farm operators elected not to participate for similar reasons.

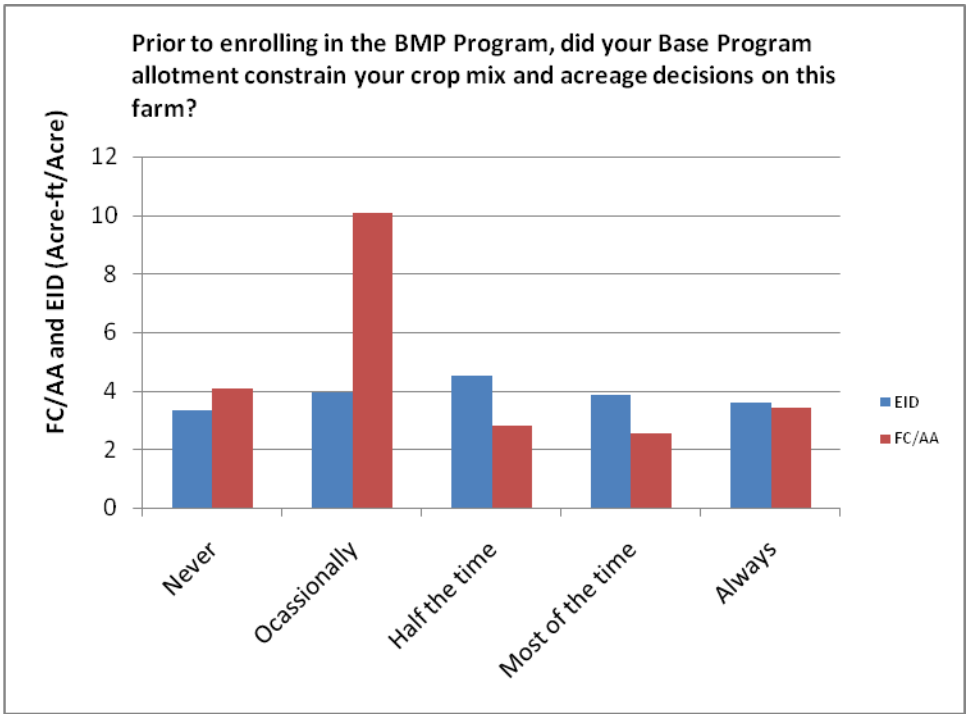

FIGURE 20. AVERAGE FC/AA AND EID INDICATORS FOR THE BASE-PROGRAM IMPACT CATEGORIES OF FIGURE 19

8.2.2 ENROLLED FARMERS ARE SEEKING TO ENHANCE THEIR ABILITY TO RESPOND TO AGRICULTURAL MARKET INCENTIVES WITH A MORE FLEXIBLE WATER SUPPLY

Most of the motivating factors cited by the interviewed operators in their response to the open-ended question (Table 3) express a concern over water supplies but others deal with changing production objectives, e.g., "changing crop mix", "double cropping", "freedom to plant what you want"," better utilize the land". As was explained before, limited irrigation duties and ratio of duty to irrigable acres limit the producers' ability to respond to market incentives. Although interviewee responses and comments suggest that some of the regularly purchase or transfer credits to deal with supply shortages, credits may not be available on a regular basis to everyone, especially in farming areas with high land utilization rates[12].

The survey asked the operators if changes had been made in crop mix and acreage during the previous three years, whether those changes had been facilitated by the BMP Program, and if future changes were planned that were being facilitated by the Program. Twelve of the respondents indicated they made changes in their crop mix and/or acreage over the previous three years. Those changes were attributed mainly to changes in crop prices, but also to other economic, agronomic, and management factors. However, only five of those respondents stated that the BMP program had facilitated those changes. Those operators increased their acreage of alfalfa, forages, or double crops, all of which are more water demanding that the traditional cotton and grain rotations. While those same respondents foresaw future changes with the help of the program, all other interviewees (75%) did not think the program would impact future cropping decisions. This again suggests that most BMP program participants are concerned more about the risk of future shortages than about present limitations.

While recognizing that a key incentive of the program is the removal of the allotment limitation, some respondents expressed concern about the impact that this would have on future water supplies for other operators in the same irrigation district. Those respondents were mostly concerned about BMP farms with increased alfalfa and double crop acreage and the consequent water use increase. At the time that the interviews were conducted, there were rumored reductions in CAP supplies to districts, and consequently on the supplies that those districts would provide to farm operators. Reductions to farm supplies were expected to be determined based on official allotments which evidently erases the

[12] The Pinal AMA Third Management Plan reports historical land utilization rates for irrigation districts in that area

flexibility advantage offered by the BMP program. While those reductions did not happen, they will certain occur in the future as urban demands increase[13].

8.2.3 ENROLLED FARMERS ARE SEEKING TO SIMPLIFY THEIR REPORTING WORKLOAD BY CONSOLIDATING MULTIPLE WATER RIGHTS

Monitoring agricultural water use under the Base Program rules imposes transaction costs on the water users and on ADWR. Under the Base Program, producers potentially face two recurrent transaction costs[14]. The first is the annual water use report, which all operators must file for each IGFR they irrigate. Evidently, the effort involved is greater for water users with multiple IGFRs than for those who farm only one IGFR. A second transaction cost is incurred whenever water is transferred from one to another. This affects both transfers between IGFRs farmed by the same operator (a transfer) or different operators (a purchase). Typically, such transactions occur when the operator has problems with the balance of his/her flexibility account. Independently of the administrative fees involved and the fines that can be incurred when these requirements are not met, operators need to invest time and effort to obtain the information, maintain the needed records, and prepare the required documents. Operators who purchase credits need to deal with additional monetary costs, and also with the problem of finding credits available for sale in a timely manner relative to farm planning decisions. The importance of these transaction costs are reflected in some of the answers presented in Table 3. As was explained earlier, the BMP Program still requires filing an annual water use report, but does not require the operator to track water uses separately for each IGFR operated within a farm unit. It also imposes a different type of transaction cost, in that operators need to maintain records to demonstrate their use of the agreed BMPs, and must respond to audit requests.

Survey results about the BMP reporting requirements as an enrollment factor are summarized in Table 5. As indicated in the table, some operators prepare their own reports, others hire consultants, while for others the irrigation district[15] takes care of that work. Evidently, districts that prepare the annual report spread the transaction costs over all operators in the district; hence, benefits from the BMP program, if any, would be difficult to measure. Interviewed operators reported paying consultant fees in the range $300 - $700. These fees seem modest and, therefore, it is not surprising that for these operators the BMP reporting procedure was not influential in their enrollment decision. The only operators

[13] When the CAP was built, CAP districts subcontracted for water with the Central Arizona Water Conservation Districts. Those long-term rights to water were waived in 1995 for rights to subsidized water available in a spot market (Wilson, 1997).

[14] Land sales and use change result in additional transaction costs

[15] MSIDD and CAIDD lease the wells from landowners, control all pumping, and therefore are for monitoring and reporting water use. In other districts, pumps are privately owned and operated.

who were motivated by the BMP reporting requirements were those who prepared their own report and, of these operators, all except one have to deal with a large number of IGFRs. In their follow up comments, some of these operators emphasized the importance of this program feature. With one exception, all of these respondents indicated that one day or less time was needed to prepare those reports. We did not follow up on these answers, so it is unclear if the operators considered the time and effort needed to compile the needed data when responding to this question.

TABLE 5. INFLUENCE OF WATER USE REPORTING PROCEDURES ON THE OPERATORS' DECISION TO ENROLL

Operator or a family member prepares the annual water use report	9/21
A consultant prepares the operator's annual water use report	5/21
The irrigation district prepares the operator's annual water use report	7/21
Simplified water use reports was a factor that influenced the operator's decision to enroll	6/20

Table 6 summarizes the results of selected questions related to the purchase of transfer of flexibility credits. Nine of the interviewed operators reported purchases (5) or transfers (4) of credits, but no operators reported both. Of the operators who purchased credits, only one did so frequently while the rest did so occasionally or rarely. Three stated that credits for sale were always/mostly easy to find but two that they were always hard to find. For farmers who transferred credits, most (3) found the process easy to deal with and only one stated that the process was somewhat difficult. These responses indicate transaction costs associated with purchases or transfers of credits are not uniform among water users. As a result, only 5 operators factored this issue into their decision to enroll.

TABLE 6. OPERATORS' EXPERIENCE WITH PURCHASE AND TRANSFER OF FLEXIBILITY CREDITS

While in the Base Program, the operator occasionally or regularly purchased flexibility credits	5/21
(For operators with multiple IGFRs) In the past, the operator has needed to transfer flexibility credits among IGFRs	4/16
Experience with flexibility credit purchases or transfers influenced the operator's decision to enroll in the BMP Program	5/9

8.2.4 PRODUCERS ARE LESS LIKELY TO ENROLL IF, IN ORDER TO QUALIFY, SUBSTANTIAL INVESTMENTS ARE NEEDED TO IMPROVE THE EXISTING IRRIGATION INFRASTRUCTURE OR IF SUBSTANTIALLY ALTERED IRRIGATION MANAGEMENT PRACTICES ARE NEEDED

Farms were expected to qualify for the program mostly based on existing BMPs, first because the list of approved BMPs includes practices that are not uncommon to Central Arizona agriculture, and second because conveyance and irrigation system upgrades are costly and generally need to be implemented over several years for average-sized farms. At the same time, for operators who were already considering upgrades for normal business reasons, the Program could provide an additional incentive to undertake such investments. A series of questions were posed to determine if operators made any physical improvements or management changes in order to qualify. To put these answers in perspective, questions were also asked about past irrigation infrastructure upgrades and/or changes to management practices, and also about other farming operations managed by the interviewees that are currently not enrolled in the BMP Program.

As expected, most producers qualified for the Program with their existing infrastructure and management practices (14/20) (Table 7). Of the two respondents who reported infrastructure upgrades (Table 7), one lined a canal section and added ports to his conveyance system, and the other re-leveled some fields. We did not ask for details on the magnitude of these investments or whether those improvements would have taken place without the Program. However, since those two individuals were already undertaking physical improvements to their farms (within the previous five years), it is likely that any upgrades induced by the BMP Program were in already in some level of planning at the time the Program was launched. Five operators reported changes to their irrigation or agronomic management practices that were made specifically to qualify, with one operator reporting as many as four practices (Table 7). From the follow-up questions, these operators appear to have limited experience with the newly adopted practices. Of the operators who reported no changes in their management practices, all indicated that their management BMPs were regularly used in their farming operation.

While only a couple of operators made physical upgrades to qualify for the program, most have made those improvements over the years, 9 of them within the last five years (Table 7). Somewhat surprisingly, fewer reported adopting irrigation or agronomic management BMPs during that same time period, although some of those who did discussed at great length changes that in their mind had helped them reduce their water use. In their follow up comments, several of these operators made it clear that water and related labor costs are overriding concerns and, thus, they are continuously seeking ways to improve their irrigation systems and management. However, at the same time that operators are concerned with more efficient water and irrigation labor use, they do not want to do so at the expense of increased management effort. This is reflected in the responses to questions about hypothetical required BMPs and if they would have chosen to participate in the

Program under those conditions (Table 7). Most respondents would have still participated in the program if required to install a flow measurement device at a point in the conveyance system where flows are split. Fewer would have participated if required to install some soil moisture measurement device and even fewer if the required BMP was the adoption of computerized scheduling. Some operators followed their responses with comments on their experience with these technologies. In their opinion, the benefits of a soil moisture monitoring device and, especially of computerized scheduling, are not perceived to outweigh the increased management effort.

TABLE 7. ADOPTION OF BMPS BY PROGRAM PARTICIPANTS

Operators who enrolled in the Program with their existing infrastructure and management practices	14/20
Operator made improvements to the farm conveyance and/or irrigation system to qualify for the Program	2/20
Operator adopted BMPs under categories 3 and 4 to qualify for the BMP program	5/20
Operator made significant improvements to the conveyance or irrigation system within the last five years	9/19
Operator made significant changesin rrigation and agronomic management to reduce water use within the last five years	6/17
Operators would install a measurement device at a location where flows split if required by the Program	16/19
Operators would adopt a computerized database of irrigation practices if required by the program	6/20
Operators would install a soil moisture sensor if required by the program	9/20

Overall, these responses support the idea that the BMP program may provide an additional incentive to carry out planned improvements, but by itself may not justify major improvements or even changes in management practice. Evidence of this is provided, first, by the responses of BMP operators who farm other properties not enrolled in the program (7/20). Three of those operators chose not to enroll those farms simply because they perceived no benefits - since those properties have a favorable allotment , they can continue to accumulate flexibility credits under the Base Program. An additional operator indicated the un-enrolled farm needed land improvements to qualify. Although that operator considered those improvements uneconomical given the benefits of the Program, he would reconsider if those improvements could be cost-shared. Landlord objections explain the other three un-enrolled properties. Additional evidence is provided by the responses of two of the non-BMP farm operators that were interviewed. Those respondents were interested in participating in the BMP program, but did not qualify with their existing

conveyance and irrigation systems. We inquired if they would consider making physical improvements to qualify. One respondents indicated that the needed the changes could not be economically justified, so they were unlikely to take place. The second operator was more enthusiastic about making improvements, but only if those improvements were cost-shared since he was leasing his land.

TABLE 8. IGFRS NOT ENROLLED IN THE BMP PROGRAM

Operators that farm IGFRs that are not enrolled in the Program	7/20
Operators who did not enroll IGFRs in the Program because there is not benefit	3/7
Operators who did not enroll IGFRS in the Program because the property does not qualify under the point system	1/7

8.2.5 PRODUCERS WITH LONG-TERM FARMING OBJECTIVES ARE MORE LIKELY TO ENROLL IN THE BMP PROGRAM; SPECULATIVE FARM LAND PRICES, URBAN SPRAWL, AND SHORT-TERM LAND LEASES ARE DISINCENTIVES TO ENROLLMENT

Past sections of this report have already discussed, albeit peripherally, the relationship between the planning horizon of producers and their decision to participate in the BMP Program. Most interviewed operators enrolled primarily with the goal of reducing the risk that future water demands will exceed their allotment and/or deplete their supply of flexibility credits. This is clearly a long term strategy. The fact that most enrolled farms are located in the Pinal AMA, and thus far from areas under intense urban pressure, suggests that farm operators with a short-term planning horizon would be less interested in the Program.

To further examine this issue, the interview explored issues related to the farm operators long-term farming plans (Table 9). The average age of the producers in the sample is 52 years, or slightly lower than the average reported in the 2002 Census of Agriculture (NASS, 2002). Hence, based on age, the average BMP producers could continue to farm for at least 10 years. In addition, nearly half of the respondents (9/21) have sons or daughters actively involved in the farming operation and some have children who are not involved yet because of their age. It is not surprising, therefore, that most respondents indicated that they or their children were planning to continue to operate the BMP farm for the foreseeable future or until retirement (14/21). This number is somewhat surprising if one considers that only six of the respondents own all of the land they farm (6/21) and that, of the 15 who don't, seven have short term leases. In addition, six of these interviewees with long-term farming plans expected part of their farm to be converted to non-agricultural uses in the near future. This line of questioning evoked comments from several operators about farming values and family ties to the farming lifestyle. Attachment to a farming lifestyle has been identified in

several studies as a key factor that influences the decision of agricultural producers to participate in conservation programs (Atari et al., 2007; Kuehne et al., 2008).

At the same time that most BMP operators have long term farming objectives, three operators stated they were planning to farm for five years or less and, thus, enrolled with a short-term planning horizon. Of these operators, one was expecting to retire, but two were threatened by urbanization. So despite the uncertainty of their situation, these two operators still chose to enroll their farm because of allotment and flexibility credit concerns.

Operators were also asked about the impact of the BMP Program on their year-to-year and long-term planning ability (Table 9). While most respondents (12/19) stated that the program enhanced their ability to plan in both, the short- and long-term, four indicated that the program only affected their year-to-year planning ability, and three thought the Program had no impact at all. Most of the operators who perceive a long-term planning benefit are also concerned with allotments but not necessarily with flexibility credits.

Of particular interest are the three operators who perceive no planning benefit. One of these individuals has both allotment and flexibility credit concerns, but is also threatened by urbanization and has a short-term planning horizon. Thus, whatever planning benefit the Program provides, it is undermined by external factors that may force him out of farming. The other two did not express allotment or flexibility account concerns, or any other BMP-related benefits for that matter. These are individuals who enrolled mainly to support the Program (to promote water conservation).

TABLE 9. RESPONSES TO QUESTIONS RELATED TO THE FARM OPERATORS' PLANNNING HORIZON

Average operator age (years)	52
Operators with a younger family members actively involved in the farming operation	9/21
Operator or a family member expect to operate the BMP farm for the foreseeable future or until retirement	14/21
Operator or a family member expect to operate the BMP farm for the five years or less	3/21
Operators who own all of their BMP farm	6/21
Operators with leased IGFRs, and at least one of those IGFRs has a short-term lease	7/15
Operator expects his/her farm to be converted to non-agricultural uses in the near future	8/19
The BMP Programs facilitates year-to-year and long-term planning for the operator	12/20

Overall, these responses support the hypothesis that most BMP enrollees have long-term objectives in mind, but they also show that the Program provides an alternative for operators with short-term objectives.

8.2.6 PARTICIPANTS TAKE PRIDE IN BEING PRIDE OF THE PROGRAM AND SEE THEMSELVES AS LEADERS IN THE AGRICULTURAL COMMUNITY RELATIVE TO WATER CONSERVATIONS ISSUES

The previous section mentioned that most enrolled operators have been carrying out improvements on their farm with the purpose of improving water management over the years, many in recent years. Because of their concern over water issues, many of these operators have been assumed leadership roles in their communities in activities related to water management, as indicated by the responses to a series of leadership questions (Table 10). Most of these operators (13/21) have been involved in the development of policies that affect water use, mostly as members of irrigation district boards. Similarly, most have participated in research and demonstration projects, many of them water related. While most operators felt uneasy when asked to compare themselves with fellow producers as water managers, most rated themselves as better or much better than average (12/21). Independently of the role that leadership characteristics may play in enticing producers to participate in the BMP Program, recent studies have suggested that producers involved in farming-related social networks have more access to information, are more open to innovations, and are more likely to respond positively to government-sponsored conservation initiatives and to experiment with conservation practices (Mathijs, 2003; Prokopy et al. 2008).

TABLE 10. RESPONSES TO LEADERSHIP QUESTIONS

Operators has been a member of farming -related organizations	16/21
As a member of farming-related organizations, operator has been involved in the development of policy affecting land improvements and/or agricultural water use	13/21
Operator has participated in University or USDA research or demonstration projects	14/21
Operators has been involved in research or demonstration projects directly or indirectly associated with water conservation	10/14

Operators feels recognized by fellow farmers for being a BMP farmer	4/21
Operators rates him/herself better or much better than the average water manager in their area	12/21

8.2.7 DISCUSSION

Previous sections examined separately various factors that were expected to influence the producers' decision to participate in the Program. It is of interest also to examine the combination of motivating factors and to characterize the interview sample in terms of these combined factors.

The responses to questions about allotment, flexibility account, the producers' experience with flexibility credit purchase or transfers as motivating factors were cross-tabulated. Results, which are summarized in Table 11, show that some participants pursued a objective when enrolling, while others were motivated by a combination of factors. Eight of the respondents stated that they enrolled only because of the allotment. Clearly, these individuals are concerned only with long term water supply problems. No operators enrolled solely because of flexibility account concerns. It makes senses that if individuals presently have a flexibility account problem, i.e. a short-term supply problem, they are also concerned about their allotment, i.e., their long-term water supplies. One operator enrolled only to avoid the transaction costs associated with flexibility credit purchase or transfer. The implication is that the operator has to undertake such transactions on a regular basis. Only three operators enrolled for all three reasons. Finally, 2 operators did not express concerns about allotments, flexibility balance account, or the transfer or purchase of credits. These individuals enrolled simply to support the Program.

TABLE 11. COMBINED MOTIVATING FACTORS FOR PARTICIPATION IN THE BMP PROGRAM

Allotment	8
Flexibility account	0
Purchase or transfer of credits	1
Allotment and flexibility account	5
Allotment/credit purchase	1
All	3
None	2

8.3 QUESTION 3. GIVEN THEIR EXPERIENCE WITH THE PROGRAM, HOW DO THE ENROLLED GROWERS EVALUATE THE ADVANTAGES AND DISADVANTAGES OF THE PROGRAM?

This section discusses the interviewees' views on BMP Program impact. It also discusses the administrative requirements of the Program and, from the interviewees' perspective, their impact on participation and program performance.

8.3.1 THE BMP PROGRAM IS PRODUCING SHORT TERM BENEFITS FOR THE ENROLLED PRODUCERS AND IS EXPECTED TO PRODUCE LONG-TERM BENEFITS

The BMP Program has delivered so far its anticipated expected short-term benefits. This was made clear by most interviewees while discussing their motivations for enrolling. Since the flexibility account is now frozen, BMP operators are no longer concerned with the balance of their account and do not have to transfer or purchase credits. As documented in Section 8.2.2, many of the interviewed operators were able to adjust their crop mix and acreage flexibly with their Base Program allotment. Operators who were constrained, however, have taken advantage of the BMP Program and made important cropping changes. Farm operators with complicated Base Program annual reporting requirements were emphatic in their approval of the BMP Program. In response to a question about impact, all of these respondents stated that their reporting workload had decreased substantially. As expected, operators form whom the irrigation district files their water use report perceived no benefit.

For farmers with a long planning horizon, the benefits that can be realized today with the BMP Program need to be balanced with the broader goal of water conservation, i.e., securing water resources for future use. Participants' perspectives on long term impacts were investigated, first with the multiple-choice question of Table 12. Although the responses to this question were meant to be mutually exclusive, half of the respondents (11/21) selected multiple answers. Thus, it appears that the selections for this question were not stated clearly and were misunderstood by the interviewees. For example, some operators responded (A) (the program will encourage other farmers to adopt conservation practices) in combination with (B) (participation will be limited to operators who made past investments in technology and management practices), some combined (A) with (C) (Participation will be limited operators with flexibility credit problems), and some combined (A) with (B) and (C). Ten respondents selected (A) only. These responses suggest that half of the interviewed participants are optimistic about the future of the program, and the other half are uncertain or pessimistic. Clearly, those who responded (D) or (F) are not very optimistic about the long-term prospects for the Program. Note that

nearly all of those individuals who responded with (A) (9/10), also stated earlier in the interview that most or all farms in their area had irrigation systems comparable or better than their own (see section 8.1.4). This would imply that if, in fact, the more like long-term impact of the Program will be to promote the adoption of conservation practices, then that impact would be limited.

Interviewees were asked next if ADWR should continue to promote the program despite its high administrative costs. Respondents were unanimous in their support of the Program although for somewhat different reasons. When asked to elaborate on their answer, some operators justified the Program on the basis of water conservation impacts. For these operators, the Program is creating awareness, and more importantly, actually providing incentives for making improvements to on-farm irrigation systems. In their opinion, operators who still need to make improvements cannot amortize those investments with their Base Program allotment. Other operators justified the Program on the basis of fairness. As was explained earlier, in the view of some members of the agricultural community, the GWMA allotments penalized farms with improved irrigation systems. Hence, the BMP Program rewards operators who made those investments. Most respondents discussed, however, the issue of farm profitability. For these individuals, the economic sustainability of their own farm or of irrigated agriculture in Central Arizona in general is in jeopardy and increased water supplies can mitigate that uncertainty. For example, one respondent stated that he thought the main purpose of the BMP Program was, in fact, to encourage producers to farm all of their acreage. Another stated his concern about the BMP Program disappearing, as he wouldn't be able to continue to farm if restricted to the Base Program allotment.

TABLE 12. OPERATORS' ASSESSMENT OF THE BMP PROGRAM'S LONG-TERM IMPACT

	Q. What is your assessment of the BMP Program's long-term impact?	
(A)	The program will encourage farmers to adopt water-conservation practices and technologies.	17/21
(B)	Participation in the program will be limited to producers who have made past investments in technology and management practices.	7/21
(C)	Participation will be limited to farmers with flexibility credit problems or are concerned about eroding flexibility credits.	8/21
(D)	A declining agricultural economy in Arizona will make the program irrelevant.	2/21
(E)	I don't have an opinion.	0/21
(F)	Other – Water supply limitations from the irrigation district will make the program irrelevant	1/21

The potential implications for broader water conservation objectives were discussed by only a few interviewees. One individual indicated that water use patterns would not change as a result of the Program because irrigation water uses are constrained by economic considerations. However, a few individuals expressed concern about wholesale changes in BMP farms from their traditional crop mix to alfalfa. In their view, this was not the original intent of the program and, thus, felt that some limits should be imposed, especially if water was physically scarce.

The issue of administrative costs was addressed by only a few of the interviewed operators. One respondent seemed surprised by our question and felt that the program had been designed to keep things simple and administrative costs low. Another participant contrasted the administrative costs of other BMP-based regulatory programs, both in agriculture and in other industries, and stated that costs could be reduced over time. Another operator stated bluntly that interviewed operators would express widespread support for the Program despite the administrative costs since they do not have to bear those costs. This was clearly a criticism of the way in which we asked the question and whether useful data could be derived from such a question. This respondent followed his comment with questions about enrollment and expressed some surprise at the number of enrolled farms, which he expected to be greater.

Operators were asked next to define program success. Respondents hesitated when answering this question, and responses typically were vague and in some cases no answer was provided. After some thought, some of the respondents reflected on the benefit to their farming operation (increase flexibility, less regulation, needed for long-term viability of agriculture). Many answers implied that the Program is successful by the fact alone that it creates awareness of water conservation. Again, a few respondents expressed concerns about the Program being abused, while others expressed concern over the benefits of the program being negated by physical water shortages. Finally, one respondent discussed the difficulties in verifying compliance with the Program. Overall, these responses made it clear that defining success for the Program is difficult.

8.3.2 ENROLLED FARMERS HAD LITTLE DIFFICULTY MEETING BMP ENROLLMENT REQUIREMENTS

Three administrative aspects of the program were investigated during the interviews. We asked participants about the enrollment process. We also investigated the BMP farm tenure structure and its impact on initial enrollment and on subsequent land transactions. Finally, we discussed with the respondents the Program annual reporting and auditing rules.

The first set of applications was submitted at enrollment workshops organized by ADWR in October 2003. Those applications were submitted without all of the required supporting documentation. After complete documents were submitted, ADWR denied admission to several of those farms[16], as they did not satisfy the enrollment requirements. In addition,

[16] ADWR did not keep records on these applicants that were denied admission. Mr. Michael Hanrahan, former BMP Program manager, estimated half-a-dozen of these cases.

some applications included IGFRs undergoing an administrative conveyance. Those applications experienced lengthy delays in the approval process because of the time needed to update pertinent records. Given these difficulties, ADWR decided to only accept applications with complete and up-to-date supporting documentation. This may explain why few interviewed operators reported problems with the enrollment process. Of 20 interviewed operators who dealt with the enrollment process (one operator acquired the lease after the farm had been enrolled), five stated that they encountered problems during enrollment. Specifically one had IGRs that were out of compliance, one had to deal with out-of-date ADWR records, two reported difficulties in getting affidavits signed by owner of leased properties, and one had difficulties obtaining records needed for the BMP Worksheet. The limited number of reported problems, and the fact that all of these issues were related to Program requirements, suggest a straightforward enrollment process, with no systematic challenges to the applicants. In addition, staff from the IMS and WMCP have facilitated the enrollment process for many applicants. Since the initial enrollments, the IMS and WMCP have played a very active role in the process by providing information and guiding potential applicants through the enrollment process. More than one interviewed operator acknowledged the efforts of the staff of these two organizations.

BMP Program rules were developed recognizing the fluidity of the agricultural land market of the state and the typical tenure structure of farming enterprises. Those rules allow farm operators to include leased IGFRs in their farm, and only require applicants to obtain a signed affidavit from the landlord. Once enrolled, operators can add an IGFR or de-enroll an IGFR from the farm, independently of whether the land is acquired or lost through a lease or an ownership change. Operators must file a new application when making these changes and the modified farm must continue to meet the point requirement. Of the 61 farms that enrolled in 2004-06, 31 did so with one or more leased IGFRs.

We asked interviewed operators about concerns they had about enrolling leased land in the Program. We also asked if the lease had created difficulties at the time of enrollment or subsequently. Nearly half of the operators who answered this question (6/13) expressed no initial concerns, even though some enrolled an IGFR with a year-to-year lease. For those who had concerns (7/13), the key concern was, of course, the uncertainty of the lease and whether they would be able to continue to farm on that property. One operator was concerned that without the leased property the rest of the farm would not qualify for the Program (farms with multiple IGFRs). While several (4) of these respondents were leasing IGFRs on a multi-year agreement, they were concerned about land being converted to non-agricultural uses in the near future. Difficulties encountered by participants while enrolling the leased properties were dealing with landlord concerns (2) and getting the required affidavits signed (2). Reported landlord concerns related to Program impacts on the ability to rent, transfer, or develop the land, and implications for the IGFR flexibility account if the farm used more water than its allotment. A couple of operators stated that they had not been able to add leased IGFRs to their BMP farm because of landlord objections.

IGFRs in 21 of the 61 farms enrolled in 2004-06 have been affected by an administrative conveyance or lease change. These changes include IGRFs that have been retired from the program, entirely or in part, ownership changes where the land is rented back to the BMP operator, and cases where a BMP farm is leased to a new operator. Two BMP farms were

de-enrolled from the program as a result of these changes, one because it was not farmed after being sold, and the other because it was converted to a non-agricultural use (housing). This large number of changes suggests that BMP Program rules do not interfere with land transactions, as was the intent when they were first developed.

This issue was further investigated during the interviews. Operators were asked if they had sold enrolled land or lost the lease for an enrolled IGFR. Of the six respondents who sold land, only one reported administrative difficulties created by the BMP Program. In that case, the sale involved part of an IGFR and ADWR took a long time to figure out how to the split the water use. We did not follow-up the question to determine if this created a problem for the sale itself or only for determining the flexibility balance of the portion that remained in the Program. Only one interviewed operator lost a lease but had been able to keep the rest of the farm in the Program. At least in one case, one operator expressed concerned that land use changes might force him out of the program. That operator enrolled a farm with a shared runoff recovery system in an area that is under intense urban pressure. If the farm with the shared recovery pit is sold, then the farm will no longer qualify for the program. According to the operator, other farm operators in the area have been encouraged to sell their land when they lose such type of facilities, because of the resulting difficulties in managing the irrigation water.

8.3.3 PROGRAM ANNUAL REPORTING AND AUDITING RULES WERE MADE CLEAR TO PROGRAM PARTICIPANTS AT THE TIME OF ENROLLMENT AND THOSE RULES ARE REASONABLE TO ENROLLEES

The BMP Program requires operators to verify their compliance with the enrollment agreement through their annual reports. ADWR verifies the credibility of the self-reporting mechanism through occasional audits. Few (3/21) of the interviewed operators reported problems with the annual reporting rules, even though nearly half of the respondents (10/21) stated that those rules had not been made entirely clear to them. Nearly a third (6/19) of the respondents who answered this question indicated they did not have those rules in-writing. Individuals who reported problems received notifications for failing to file an annual report. Operators were asked to comment on the effectiveness of the audit rules and to suggest improvements. Although no one described the process as unnecessary, a small number of respondents (4/21) described the process as intrusive. Two thirds (14/21) were comfortable with the process and, therefore, stated that the rules were both practical and effective. On the other end of the spectrum, a few respondents (3/21) indicated that although the process was practical, many BMPs were difficult to verify. These latter respondents commented on the importance of maintaining credibility for the Program and the need for audits. One respondent was concerned that no audits had been carried out in 2007. While responding to this question, operators commented again on their perceived need to impose some restrictions on alfalfa acreage for enrolled farms.

8.3.4 DISCUSSION

The question of how to measure BMP Program long-term success was initially posed to the former BMP Program Manager and the Advisory Committee at one of their meetings. Based on participation and impact to participants, the Program appears to be meeting the objectives of A.R.S. § 45-566.02 and, thus, appear to be successful. However, if water shortages materialize as predicted (Blake, 2007), then BMP Program will offer few or no advantages to the participants relative to water supply but will still impose transaction costs on participants (implementation of BMPs and maintaining records to document those practices). In addition, changes in water supplies and unclear long-term expectations for the Program can create conflicts for BMP participants and ADWR. For example, concerns about changes in crop mix induced by the Program and whether that was the intent of the Program, may become more pervasive. BMP producers who are making those cropping changes may not be anticipating future water scenarios and may be confronting potential financial losses. Even the idea that the Program, in the long-term, may encourage producers to adopt water conservation technologies and produce actual conservation benefits may be misguided if the "saved" water is used to grow more water intensive crops or to increase land utilization rates (Schierling et al, 2006; Huffaker, 2008).

Given the uncertainty of future water supply scenarios and their implications, some discussion of long-term objectives and measures of success is necessary. Such discussion requires examining the BMP Program vis-a-vis the water management objectives of the AMA. The water management objective of the Pinal AMA is to preserve agriculture for as long as economically possible. Several BMP participants stated during the interviewees that the Program enhances the profitability of their farm, by allowing them to grow crops that they would not likely pursue otherwise. Hence, the BMP Program is compatible with the Pinal AMA water management objectives, especially if average annual water use does not change. The Phoenix AMA objective is to achieve safe yield by 2025. In this case, the Program and AMA objective is less compatible, especially if the Program encourages a more permanent shift in cropping patterns toward water-intensive crops.

8.4 QUESTION 4. HOW DID CROP MIX AND IRRIGATION ACREAGE AND WATER USE CHANGE FOR BMP FARMS DURING THE THREE YEARS AFTER ENROLLMENT AS COMPARED TO THE THREE YEARS BEFORE ENROLLMENT? IF THERE WERE CHANGES, DID THOSE CHANGES IMPACT WATER USE? FOR THE SAME TIME PERIOD, DID CROP MIX, ACREAGE, AND WATER USE CHANGE FOR NON BMP FARMS?

Data limitations narrowed the scope of this question relative to the initial research objectives. ADWR expected to generate crop acreage data for participating BMP farms from satellite imagery. Such information was made available for three years for farms in the Phoenix AMA but only for a single year for farms in the Pinal AMA. In addition to the limited number of years, inspection of that data revealed problems with crop classification and differences between the image-reported (planted and idle) and the official irrigation acres. The research team discussed with ADWR and the BMP Advisory Committee the possibility of requesting crop acreage data during the interviews. The consensus was that most operators would be reluctant to share such information because of privacy concerns. As a result, the analysis was confined to examining water use data compiled by ADWR for the BMP farms. Additional qualitative data were obtained during the interviews. We asked the operators a series of questions about their water use. The answers to these questions provide us with a qualitative measure of relative water costs and, therefore, whether water management is priority to the farming operation.

8.4.1 CHANGES IN CROP MIX OR ACREAGE BY BMP PARTICIPANTS, IF ANY, ARE CONSISTENT WITH OVERALL CHANGES OBSERVED STATE-WIDE

Section 8.2.2 documented changes in crop mix reported by the interviewed BMP operators, specifically increases in alfalfa, forage crops, and double cropping. These changes are consistent with changes in cropping patterns that have occurred in Central Arizona. Section 8.1.1 discussed the changes in population and land use patterns that have taken place in recent years in the Maricopa and Pinal Counties and how those changes are affecting participation in the BMP Program. Population growth affects land uses in lands that continue to be farmed. In particular, it has fueled an increased demand for dairy products. The impact on Pinal Country is a 535% increase in the number of dairy cows over the 1998-2006 period, accounting for most of the change in the dairy cow population of the state (NASS, 2008). Over the same time period, the acreage of alfalfa hay has increased over 230% in Pinal County and 132 % in Maricopa County (NASS, 2008). Given the change in agricultural acreage and the changes in cropping patterns, it is not surprising that a decrease in agricultural water use has been reported in irrigation districts in the Phoenix AMA closest to the metropolitan area but an increase in farming areas farther away (Hetrick and Roberts, 2004; Needham, 2005).

ADWR provided the research team with certified water use records for farms enrolled during 2004-2007. The data set includes records for the years 2001-2006. Because of the effect of weather and farm economic factors on water use, a before-after analysis requires data for the same time period and, preferably, time series of comparable length before and after. Those requirements are met only by farms enrolled in 2004, for which it is possible to compare data from 2001-2003 with data from 2004-2006. Complete water use records were available for 29 farms of the 38 farms enrolled in 2004.

The available records were used to calculate annual water use relative to the allotment (i.e., Relative Water Use –RWU). If RWU = 1, the reported water use matches the allotment. This index was derived by computing first the Water Use per Duty Acre (WUDA) [acre-ft/acre] for each farm and year. This calculation accounts for changes in the duty acres of a farm. RWU was then computed by dividing WUDA by the irrigation duty ID. For farms consisting of multiple IGFRs, a weighted ID value was computed. Average RWU were computed for the before and after periods, and then the difference between the two values, ΔRWU.

Figure 21 depicts the distribution of ΔRWU values for farms enrolled in 2004. The distribution is relatively symmetrical around the mean, with three fourths the values falling in the range $\pm$ 0.25. A paired t-test on these paired observations confirmed that mean is not statistically different from zero. Therefore, relative water use has not changed for the average farm as a result of the BMP Program[17]. Most of the computed ΔRWU values are small and can be explained by weather variations for the same cropping pattern or small changes in cropping patterns. Large reductions in water use are believed to be the result of land idling. In these cases, the producer would better off in the Base Program because flexibility credits would continue to accrue. Large increases in water use can be explained by changes in crop mix and acreage, which were reported by a few of the interviewed operators. An alternative explanation is that water applications have increases for the same cropping pattern. This possibility cannot be examined without crop and acreage data. Since water costs represent a substantial fraction of typical production costs of BMP operators (see Section 8.4.2), this alternative explanation seems unlikely.

[17] A before-after analysis was conducted using also the actual water-use data (instead of relative water use values). This limited the analysis to all farms enrolled in 2004 without acreage changes (N=26). From this analysis, the average change in water use was slightly less than - 30 ac-ft and not significantly different from zero.

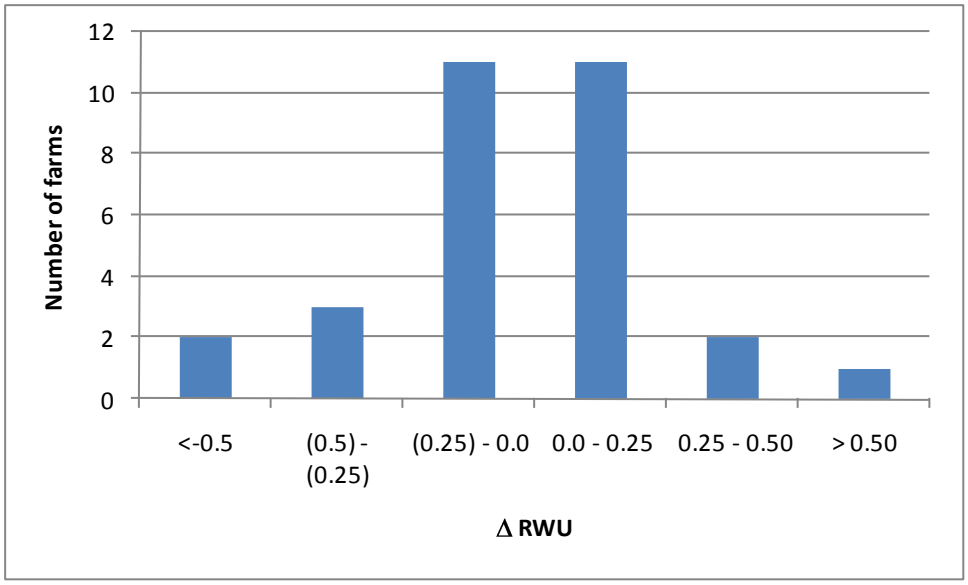

FIGURE 21. DIFFERENCE IN RELATIVE WATER USE BEFORE AND AFTER ENROLLING IN THE BMP PROGRAM FOR FARMS ENROLLED IN 2004.

While water use for the average BMP farm has not changed since enrollment, is has consistently exceeded the Base Program allotment (average RWU = 1.2) over the period of record. This result is consistent with findings presented in section 8.2.1, Figure 18, which show a loss of flexibility credits for the average farm. To further illustrate the trend in water use prior to enrollment, RWU was calculated for all farms in the data set with complete records (48 farms). The index was calculated using data from 2001-03 for farms enrolled in and 2004, 2001-04 for farms enrolled in 2005, and 2001-05 for farms enrolled in 2006. As with the results of Figure 21, the distribution of pre-BMP Program RWU values (Figure 22) is symmetrical around the mean value (1.25), with two thirds of the observations falling in the range 1.0 - 1.5. A mean value of 1.25 for this sample does not seem unreasonable if one considers that: 1) the flexibility account was instituted to enhance the producers ability to respond to market incentives over to short to medium term; 2) the average BMP farm had a flexibility balance of four times the annual allotment at the time of enrollment and could have continued to use water in excess of their allotment for several years, and; 3) crop prices had encouraged farmers in Central Arizona to increase their acreage of alfalfa and other water-intensive forages, as was discussed in previous paragraphs.

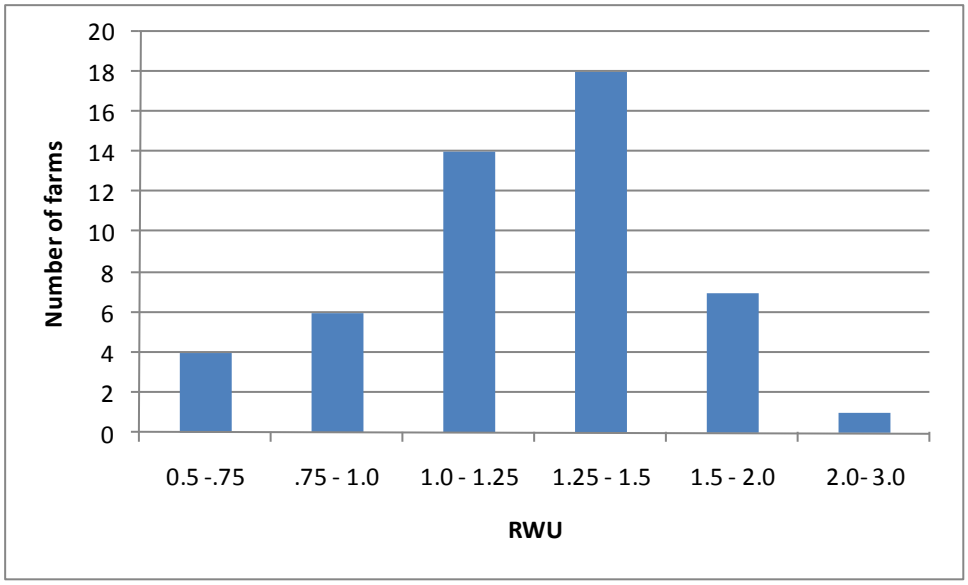

FIGURE 22. AVERAGE RELATIVE WATER USE PRIOR TO ENROLLMENT FOR BMP FARMS

Figure 22 also suggests cases of very high water use relative to the allotment prior to the BMP program, but those apparent outliers need to be interpreted with caution. As indicated in Section 8.2.1, there are substantial differences among farms in their irrigation duty and the ratio duty acres/irrigable acres. These differences can translate into large differences in RWU for the same water use, as illustrated in the hypothetical example of Table 13. Considering that farm operators with small effective irrigation duties (Farm B in the example) want to maximize their income and spread their fixed costs over as much irrigated acreage as possible just as much as farmers with a favorable effective irrigation duty (Farm A), those operators should be willing to exceed their allotment if they can procure that water and if that additional water can produce an economic benefit.

TABLE 13. RELATIVE WATER USE FOR HYPOTHETICAL FARMS WITH SAME WATER USE BUT DIFFERENT EFFECTIVE IRRIGATION DUTY

Variable	Farm A	Farm B
Irrigation Acres	100	100
Duty Acres	100	70
Irrigation Duty, Ac-ft/Ac	4	3
Effective irrigation Duty, Ac-ft/Ac	4	2.1
Water Use, Ac-ft	400	400
Water Use/Duty Acre	4.00	5.71
Relative Water Use	1.00	1.90

8.4.2 BMP PROGRAM PARTICIPANTS ARE STRONGLY AWARE OF THEIR WATER COSTS AND AIM TO REDUCE THOSE COSTS, IRRESPECTIVE OF GROUNDWATER REGULATORY PROGRAMS

Questions were asked to assess BMP farm operators' water costs and how closely operators track their water use and costs. Unit water costs and irrigation costs as a percentage of production variable costs vary considerably among BMP operators. In a few cases, water accounted for 50% or more of variable production costs. Given these differences in costs, operators can be expected to rank water differently in their farm management priorities. This is apparent from the responses to the last two questions of Table 14. A fourth of the respondents indicated they do not target a specific yearly application depth for their main crop while a third do not try to track water use and costs from year-to-year. Some operators commented that they did keep some records on water use but that those records were not very detailed. Others, as was indicated before, pay consultants to help them manage their water. One operator produced a record book with detailed information on water applications at the field level. One operator stated that he was not aware of his water costs, because a partner handles that aspect of the farming operation. While the data of Table 14 cannot be used to determine if the participants are "strongly aware" of their water costs, it should be clear that water management is a priority for those operators willing to invest time and/or money to track their water use.

TABLE 14. RESPONSES TO QUESTIONS ABOUT WATER USE AND COST

What is your average water cost, per acre-ft?	
<$20	
$20-$30	2
$30-$40	8
$40-$50	8
$50-$60	2
>60%	
Don't know	1
For your main crop, estimate your typical irrigation costs as a percentage of your variable production costs.	
<20%	1
20-30%	9
30-40%	4
40-50%	
50-60%	4
>60%	1
Don't know	2
For your main crop, do you have a targeted yearly water application, acre-ft/acre?	
Yes	16
No	5

Do you keep records that allow comparisons of annual water and irrigation management costs between years?	
Yes	13
No	7

8.4.3 DISCUSSION

These results support the findings of Section 8.2 regarding motivations for participation and also Needham's (2005) conclusions, that crop prices, water prices, and weather factors are the main drivers of agricultural water use in the AMAs, and not the Base Program regulations. The BMP Program has the potential to increase water use if participants make substantial changes to their cropping patterns, even if that water is used effectively. Only some participants are making those cropping changes. About half of the interviewed participants enrolled to reduce the risk of future water constraints or simply to support the Program. Other operators were relying on the flexibility account or the sale or transfer of flexibility credits to satisfy demands in excess of their allotment. Those operators were, to a lesser or greater degree, adapted to their Base Program allotment and were making their cropping decisions based on economic factors. That trend in water use has continued and will continue as long as that use is profitable or the water becomes physically scarce.

The analysis relies on a short period of record. The analysis does not deal either with water use by BMP farms in contrast with Base Program operators for the same time period. Given that economic incentives for producers will change with time, patterns of agricultural water use will also change. ADWR may want to track water use for both programs on an annual basis, to confirm that BMP Program water use is consistent with patterns of water use at the AMA level.

8.5 ARE THE WORKSHEET PRACTICES APPLIED EFFECTIVELY? IS THE VERIFICATION PROCESS EFFECTIVE AND COST-EFFECTIVE?

This section examines compliance and enforcement issues of the ADWR BMP Program. This section is organized as follows: Subsection 8.5.1 discusses first the concept of a BMP program, based on programs and plans described in various publications. This BMP concept is used as a reference for evaluating Program compliance and enforcement policies and procedures. This is followed by a discussion of Program characteristics relevant to the compliance problem (Subsection 8.5.2). Subsection 8.5.3 describes the monitoring instruments of the Program, a reporting form known as Schedule BMP and the audit process. Schedule BMP and audit reports were examined as part of the analysis. Findings from this part of the investigation are summarized in Subsections 8.5.4 and 8.5.5. These subsections examine the level of compliance with the verification requirements, if verification instruments providing evidence that BMPs are being applied, and the type of enforcement actions are taking place in cases of non-compliance. The last issue analyzed is whether Program monitoring instruments provide evidence that the BMPs are being applied effectively.

8.5.1 THE BMP CONCEPT

The concept of Best Management Practices has evolved as tool for promoting environmental protection through both voluntary and mandatory control measures. Generic definitions of BMPs are available at various websites[18]. A comprehensive guideline for the development of a BMP program is EPA (1993). Examples of BMP guidelines specific to agricultural water conservation are Waskom (1994), TSSWCB (2005), and FDACS (2006). Common characteristics of BMP programs suggested by these and other publications are the following:

- A BMP program has a well-defined policy statement that includes program objectives
- The program consists of a variety of control measures, which often need to be used in combination to deliver the expected impact.
- Application of each control measure is based on guidelines. Those guidelines, sometimes supported by technical standards, describe the sequence of activities essential to the proper application of the practice. This makes the BMP a "repeatable process."
- BMPs need to be customized to the particular condition and can change as scientific knowledge and/or experience dictates.

[18] For example, http://en.wikipedia.org/wiki/Best_Management_Practice; http://www.businessdictionary.com/definition/best-practice.html

- Checks and tests are needed to evaluate the effectiveness of BMPs
- Monitoring mechanisms are needed to assure compliance
- To be accepted by the user, BMPs need to be cost-effective

The BMP approach aims to promote the implementation of coordinated processes to prevent or at least mitigate externalities from production activities. These processes may include something as simple as maintaining facilities clean, or something as complicated as introduction of new technologies and associated management processes. If BMPs are not applied systematically, i.e. as part of a coordinated set of processes, they may produce limited or no benefits. For example, irrigation management research has shown that improved irrigation technologies and structures are sometimes implemented without improvements to irrigation management practices and, thus, produce limited conservation benefits (Clemmens et al, 2000; Bjornlund et al., 2009). Similarly, studies have shown that farmers can adopt conservation practices for soil and water while continuing to use detrimental practices (Napier, 2000).

The BMP approach also recognizes that benefits may be difficult to quantify. If inputs and outputs of the production activity cannot be quantified either for technical or economical reasons, then the alternative is to document the implementation of the BMP plan. This type of documentation is often seen as a mechanism for protecting production facilities against litigation.

Based on these elements, this report offers the following definition:

Agricultural water conservation BMPs are structural and non-structural control measures, or combinations of those measures, that have been proven by research and experience to produce water conservation benefits and that are cost-effective. Benefits include reduced applications, quality protection, reduced non-beneficial uses, and improved productivity. BMPs are based on repeatable procedures, customized for the particular conditions, and supported by tests and checks.

8.5.2 BMP PROGRAM CHARACTERISTICS RELEVANT TO THE COMPLIANCE PROBLEM

The question examined here is whether the BMP Program compels participants to apply the enrollment worksheet BMPs in an effective manner without the need for enforcement actions. This type of question has been the subject of extensive research by institutional scholars, especially in relation to the management of water and other common-pool resource systems (e.g., Ostrom, 1990; Easter, 1993; Marshall, 2004). Those studies recognize that institutional arrangements, in particular voluntary ones, are successful when they are partly self-enforcing. Participants will follow through with their agreements when compliance is expected to result in long-term benefits that outweigh the costs. At the same time, participants must trust that other participants are honoring their commitments. This can only happen if there is credible monitoring.

The BMP Program has design features that make it partly self-enforcing. A key one is that BMPs in Categories 1 and 2, which are costly long-term investments, need to be in place at the time of enrollment. Operators are locked into using those structural improvements for years, independently of whether they elect to enroll in the BMP Program or stay in the Base Program. Furthermore, the Program does not impose any performance requirements on any BMPs. Hence, the potential for non-compliance relative to BMPs in Categories 1 and 2 is very limited. Administratively, a BMP farm can become ineligible for the Program through a land sale or lease change if the modified farm does not meet the minimum point requirement. BMP operators are required to report such farm boundary changes and have a new worksheet score calculated.

The BMP Program recognizes that management, in addition to infrastructural improvements are needed for effective water use. The Program offers a large number of practices in Categories 3 and 4, to allow participants to enroll BMPs that are already in place (see Subsection 8.2.4). Presumably, practices that had been adopted prior to enrollment in the BMP Program were cost effective. BMP operators can be expected to continue to use those practice unless a better alternative can be found. For example, some operators re-level their fields on a regular basis because it improves irrigation system performance and water productivity. Operators who enrolled with BMP 3-1 (laser touch-up) can be expected to continue to re-level on a regular basis, unless there is a significant change in production practices or in the cost/benefit ratio of land-leveling practices (i.e., changes in water cost vs. cost of leveling equipment, labor, and fuel).

Not all participants enrolled with management practices that were in place and some practices are dependent on the crop mix of the farm. An operator who signs up a BMP that he is unfamiliar with may find out that the practice is more costly (either in actual money or in management effort) or the benefits more uncertain than originally expected. Non-compliance could occur in these cases, as the operator could reconsider the use of that BMP or apply it only in part. Irrigation scheduling is a good example of a technology that is not easily adopted by producers. Technology adoption research suggests this is a practice that is more likely to be successfully adopted when water costs are high, with permanent and/or high value crops, when using pressurized irrigation systems, and when producers have technical support (Leib et al., 2002). A producer using scheduling techniques for the first time could easily get overwhelmed with data requirements, especially since the data has to be obtained on a regular basis. BMP participants who practice it do so mostly with the assistance of consultants, who often provide other services besides irrigation management.

As was explained in the previous subsection, the BMP approach is often justified because production activities are difficult or costly to monitor. That is the case for many agricultural water management practices. Many of the management BMPs included in the worksheet are potentially difficult to observe by an auditor or another monitoring agent (e.g., IMS, /WMCP). For example, BMP 3-10 requires flow rates to be measured for each irrigation event on each field. This is a practice that can only be monitored in a practical manner by the farm operator. Self-monitoring mechanisms can be devised that can easily demonstrate the use of this practice. In contrast, some management practices can be easily observed by an external monitoring agent on the field if an audit is conducted at the right time of the

year. Thus, there is an incentive for complying with the agreed BMPs because some of those management practices are observable.

The BMP Program potentially reduces the water use reporting workload for some operators but in exchange participants have to document the use of their BMPs. The transaction costs of these reporting activities, entirely depends on the level of documentation required. As was explained before, BMPs may difficult to document and thus a BMP program may focus on documenting the process rather than the outcomes. Producers who benefit from the application of BMPs do not necessarily benefit from documenting the outcomes, and certainly not from documenting the process, unless the information is relevant to farm management decisions. Thus, operators may implement the agreed BMPs but neglect the documentation requirements. As will be discussed later, current documentation requirements of the BMP Program are largely non-intrusive and relatively easy to meet.

The institutional literature recognizes that non-economic factors provide additional incentives for compliance with agreements. In the BMP Program case, there are important factors to consider. As was indicated earlier, the BMP Program was developed in response to historical challenges to the Base Program. Participants who have invested effort in making the BMP Program a reality, would not want to undermine it. Producers are also aware of the growing urban population in the AMAs which will be demand a greater share of the CAP water supplies that they currently using, and that they benefit politically in any future water negotiations if they are perceived as responsible stewards of land and water resources. Producers with long-term objectives and who have children involved in the farming operation are concerned with the economic sustainability of the farm, which can be better achieved by using scarce/costly resources effectively (i.e,water conservation).

8.5.3 REPORTING AND AUDITING PROCEDURES

Applicants receive annual reporting instructions during enrollment. Operators confirm that BMPs in their enrollment worksheet are being applied using the form known as Schedule BMP (Appendix 11.2). In addition, operators confirm the enrolled IGFRs and report annual water use. Since the water use report is a requirement of the GMA[19], this discussion focuses solely on the Schedule BMP. In Sections 1 and 2 of the form, operators describe improvements to their conveyance and irrigation systems while Sections 3 and 4 are used to report management BMPs. Farming practices, and therefore BMPs, can change from year-to-year depending on crops and management objectives. Operators are allowed to make such changes, but if the BMPs are different from the ones checked in the enrollment worksheet, changes need to be explained. No supporting documentation needs to be filed.

Operators also receive information about the audit at enrollment time. Written instructions consist of a summary of evidencing procedures (Appendix 11.3) and the document "Agricultural BMP Program Proposed Enforcement Policy for Non-Compliance" (Appendix 11.4), which as the name suggest, outlines ADWR enforcement mechanisms. Evidencing

[19] ADWR issues a notice and imposes a fine when the responsible party fails to file such a report.

procedures are strictly qualitative and aimed only at verifying implementation, not technical effectiveness. Several options are available to operators for documenting their BMPs, including operator records, official records, receipts for services or equipment, possession of specialized equipment, photos, verification by IMS/WMCP, and even operator signed statements. Since these are only suggested methods, other methods are acceptable.

The BMP Program Manager notifies operators selected for an audit by mail and sets the audit date in consultation with the operator. The letter reminds the operator about needed documentation and directs operators to contact WMCP/IMS if there are questions about the auditing process and/or the needed evidence. Audits are conducted by the BMP Program Manager and an ADWR staff member, often with participation of IMS or WMCP. The audit team reviews the evidence but does not keep copies of documents. The team also drives around the farm and observes farm conveyance and irrigation systems. Based on the evidence, the Program Manager determines whether BMPs are being implemented as agreed and reports his findings in writing with copy to the operator.

8.5.4 ANNUAL REPORT FINDINGS

The Schedule BMP is easy to fill out. If no changes need to be reported, then operators can simply check boxes in the form. Explanations need to be provided only if the reported BMPs are different from those in the enrollment worksheet. Detailed examination of Schedule BMPs for a sample of farms revealed that some operators report the same BMPs every year. This is to be expected cropping plans, and therefore management practices, are relatively constant between years. Others make some changes from year-to-year, especially operators who enrolled with more management BMPs than needed to satisfy the point requirement. Operators who make changes do not always provide explanations, but many do. Overall, the reports suggest that the majority of operators are carrying out the agreed BMPs, and in some cases more than needed to satisfy the point requirement.

A few Schedule BMPs list fewer management BMPs than needed to meet the 10 point requirement (and, therefore, fewer than those included in the enrollment worksheet). A few have been returned blank but signed. Explanations generally are not provided in either of these cases. Without explanations, it is difficult to say if the operators are not carrying out the agreed practices, forgot to check the corresponding boxes, or had to deal with unanticipated circumstance. An example of the latter is an operator reported that no BMPs had been applied because the farm had been idled due to lack of water. This is clearly an extenuating circumstance. It can be argued that if the form required operators to re-compute their BMP score from their reported practices, it would compel them to provide explanations.

The official policy (Appendix 11.4) does not specifically address these situations. ADWR issues a violation notice if non-compliance has been established, such as when the operator fails to file a water use report. An incomplete or blank report does not constitute a violation, so the operator does not receive a notice[20]. ADWR deals with these cases[21], first,

[20] The policy is not definitive about what actions will be taken, only suggests enforcement actions.

by contacting the operator with a request to resubmit the Schedule-BMP. If the annual report package is submitted by a third-party reporting service, then the service provider is contacted. ADWR may also request IMS or WMCP to assist the operator in filling out the form, especially in cases where the operator is an IMS/WMCP cooperator. Finally, ADWR may resort to an audit. That approach has been used with one farm suspected of non-compliance, as will be discussed later.

The worksheet definitions require some BMPs to be applied over at least 20% of the irrigable acreage (e.g. BMP 3.1) or over the entire irrigation season (e.g. 3.11). The Schedule BMP does not remind operators about those requirements or require the operators to report how extensively/frequently the practice is used. As a result, it is difficult to say if the requirement is always being satisfied. For example, one operator checked BMP 4.1- Crop Rotation and 4.2-Crop Residue Management while also reporting that the entire farm was planted to alfalfa in two reporting years. Without an explanation, this information seems contradictory. While it is unclear if the enrolled agronomic BMPs were in use in this particular case, the operator was applying more water management BMPs than indicated in his worksheet. Questions raised by this example are: 1) How strictly does ADWR want to monitor compliance with the BMP definition, i.e., does it matter if the practice is not always applied over 20% of the surface or over the entire irrigation season. 2) How strictly should ADWR interpret these reports, especially when the information provided is incomplete and/or contradictory; 3) Should a formal administrative process be initiated if non-compliance is suspected, as a result of incomplete or contradictory Schedule BMP information? 4) What flexibilities exist (or not) in satisfying the BMP point requirement? The BMP Advisory Committee has discussed this last issue. The discussion recognized that most agronomic management BMPs are not applicable with a single perennial or multi-year crop and, therefore, that the point requirement is inherently difficult to satisfy in those cases. Still, a clear policy on this issue is not available and the BMP worksheet and other Program documents do not provide guidance to operators when dealing with these constraints.

Some reports identify improvements to the conveyance/irrigation system but that information is not used to update the worksheet score. Based on Program rules, the number of management BMPs needed to satisfy the worksheet score requirement could potentially be reduced with improvements to the physical infrastructure. On the other hand, the number of management practices could be increased with some changes to the irrigation system. For example, if an operator adds slope to surface irrigated fields (changes a system from level to near-level), will ADWR recalculate the worksheet score in response to the report and require additional management BMPs if the minimum point requirement is not met? Changes of that type were reported by interviewed operators.

8.5.5 AUDIT PROCESS FINDINGS

[21] N. Kilb, BMP Program Manager, ADWR, personal communication, 2010.

BMP Program audits were first conducted in 2006. Fifteen operators (17 farms) were audited during the period 2006-07. No audits were conducted in 2008 and it is unclear if any were conducted in 2009, although records indicate that at least one operator received an audit notification. Therefore, a first finding from the review of audit reports is that the process has lacked continuity. This problem is explained by the retirement of the BMP Program Manager (Mr. Michael Hanrahan), the time needed to recruit a new Program Manager (Mr. Nicholas Kilb), and the time needed by Mr. Kilb to get up-to-speed on the Program. For example, Schedule BMP reports submitted for 2007 were only scrutinized until late 2008. Complicating matters is that the BMP Program Manager, which previously was dedicated entirely to the Program, now has additional job duties. Given that audits require significant time and technical support, it has now become more difficult for the Program Manager to conduct those audits on a regular basis.

Audit reports do not contain supporting documentation but they describe the evidence provided by the operators. Table 15 categorizes the evidence descriptions contained in the available audit reports. The table is based on the categories shown in Fig. 2 but with one additional evidencing method, "Operator Statement." This refers to verbal statements provided by the operator without supporting documentation or a signed statement. The compilation shows that operators prefer three methods to evidence their practices, Possession of Specialized Equipment, Operator Statement, and WMCP/IMS Verification. It should be noted here that several BMP farms are WMCP/IMS cooperators, and that staff from those programs have an opportunity to either observe some practices or assist operators with the implementation of some practices. WMCP/IMS verification sometimes involves the presentation of records at the request of farm operators, but other times it is only a verbal statement that the BMPs have been observed. Hence, both Operator Statement and WMCP/IMS Verification can be considered testimonial information. In contrast, photos, personal records, agreements, and receipts for services can be considered formal records because the information needs to be collected and/or filed. The evidencing method Possession of Specialized Equipment requires the operator to display the equipment, but does not require either verbal statements or recorded data. Thus, it does not belong in either the testimonial or formal record categories. If the results of Table 1 are grouped according to these criteria, then over 50% of the BMPs have been evidenced using testimonial information, 27% based on possession of specialized equipment, while only 20% of the evidence consists of formal records.

Not evident from Table 15 is that most formal records were provided by a minority of operators who used them to document most or all of their practices. Those operators also reported more management BMPs than needed to satisfy the minimum point requirement. In contrast, some operators relied entirely on testimonial information and those operators generally reported only the minimum number of required BMPs. Hence, one interpretation of these results is that they reflect differences in record-keeping habits among operators. Another explanation is that results reflect differences in the level of adoption of BMPs. Farm operators with a comprehensive concept of BMPs would be more likely to apply various related water and agronomic management practices, systematically measure needed inputs and outputs, and record data. As an example, some operators who enrolled with BMP 3.10 keep detailed records o water applied, by irrigation event and even by field, and presented those records during the audit. Others reported using water measurements

to determine the cutoff time based on a target volume/depth of application. Without a record, it is difficult to say if this is a systematic or occasional practice. Others just reported that the District measures the flow. For these cases, water measurement is in all likelihood used to check water bills from the irrigation district, but it is less clear if it is used to make operational decisions on the field.

TABLE 15. EVIDENCING METHODS EMPLOYED BY AUDITED BMP OPERATORS

PRACTICE	Signed statement from Enrollee	Receipts and purchase orders	Agreements	Records, notes, certificates, or maps	Photo confirmation	Possession of specialized equipment	IMS or WCMP Verification	Anecdotal	TOTAL
BMP 3.1 Laser touch-up						6	6		12
BMP 3.2 Alternate row irrigation					2		4	1	7
BMP 3.3 Furrow checks							2		2
BMP 3.4 Angled rows									0
BMP 3.5 Surge irrigation	1							1	2
BMP 3.6 Temporary sprinklers					1				1
BMP 3.7 Participation in an educational IWM program							5		5
BMP 3.8 Participation in a consultant or I.D. sponsored irrigation scheduling service		1					2	1	4
BMP 3.9 Participation in an I.D. program to increase flexibility of water deliveries								2	2
BMP 3.10 Measure flow rates to determine the amount of water applied		2		1		3		3	9
BMP 3.11 Soil moisture monitoring		2				2	1	2	7
BMP 3.12 Computer-based modeling using meteorological data									0
BMP 4.1 Crop rotation				2			1	4	7
BMP 4.2 Crop residue management					2	5	2	4	13
BMP 4.3 Soil and water quality testing		1						3	4
BMP 4.4 Pre-irrigation surface conditioning						3	2	1	6
BMP 4.5 Transplants						1			1

BMP 4.6 Mulching		2						1	3
BMP 4.7 Shaping furrow or bed					1	4		1	6
BMP 4.8 Planting in bottom of furrow						1			1
TOTAL	1	8	0	3	6	25	25	24	92

Like the annual reports, the audit reports do not address the issue of how extensively or frequently a BMP is used. They only provide a brief description of the practice and evidencing method. For example, a typical narrative for BMP 3-1 is:

"Farm is on a corn-corn-alfalfa-alfalfa-alfalfa rotation. <Operator> stated that his FSA-certified records are on file…"

Again, from this information it is difficult to tell if the BMP was applied as intended. The amount of land that is rotated on an annual basis may have been discussed during the audit, but if it was, it was not recorded.

One farm failed the audit and, as a result, was separated from the program. After enrolling, the operator re-leveled his fields and planted the entire farm to alfalfa. These practices were the only BMPs reported in the Schedule BMP after the first enrollment year. Since alfalfa is a multi-year crop, no leveling or rotation occurred during the second year and the corresponding Schedule BMP form was returned blank. The farm was targeted for audit based on those annual reports and the lack of response to ADWR requests for an updated Schedule BMP. Since the operator was technically still in compliance, a notice was not issued prior to the audit. The audit confirmed the Schedule BMP reports provided by the operator, and therefore, that BMPs were not being applied as agreed. The operator did not appeal the de-enrollment decision, despite the cropping changes made on his farm.

Although the Schedule BMP provided indications of non-compliance after the first year, ADWR did not respond until after the second reporting year when the situation became more evident. ADWR acted swiftly and emphatically at that point. Questions raised by this example are: What are the specific actions that will trigger enforcement procedures? Will the same enforcement procedures be used when dealing with different triggers and/or levels of non-compliance? The official policy (Fig. 3) is not specific about these issues and hampers the Program Manager's ability to initiate an enforcement action without a high degree of certainty that the operator is not following through with the agreement.

8.5.6 WORKSHEET PRACTICES ARE APPLIED EFFECTIVELY - ENROLLMENT IS BASED ON A TECHNICALLY SOUND AND CONSISTENT INTERPRETATION OF THE PROGRAM BMPS.

Monitoring mechanisms of BMP programs, such as those advocated by EPA (1993), aim to establish that practices have been applied per program-defined guidelines. Some level of

record-keeping is needed to make that assessment[22]. Under this concept, it is not possible to evaluate if worksheet practices are being applied effectively, first because annual and audit reports do not provide data that can be used to determine how practices are applied and, secondly, because the Program does not have well-defined guidelines for its approved practices.

Issues that can be investigated based on the available data are whether practices reported in the audits match the Program's BMP definitions and, more broadly, if those definitions conform to standards employed by other conservation/BMP programs[23].

Differences between the stated and actual practices were noted when reviewing the Audit Reports and their corresponding enrollment worksheets and involve only a few practices. One difference involves BMPs 2-3 (Uniform slope system with tailwater reuse). The definition provided in the enrollment worksheet and in other publicly available Program documents states:

"Sloped fields that have been engineered to uniform grades with a constructed recovery system that allows for the reuse of water that runs off the end of the field after an irrigation event."

Four farms that signed up with BMP 2-3 actually have a sloping irrigation system with a blocked downstream end but no tailwater recovery system. The enrollment forms for the four farms are hand annotated to indicate that the system has no tailwater. Hence, these farms were admitted into the Program with a substitute practice, which Program rules allow the Program Manager to approve. The BMP Advisory Committee discussed early in 2004 the definition for BMP 2-3 and concurred with the decision to interpret sloping systems without tailwater as BMP 3-2[24]. Thus, ADWR and the Advisory Committee currently do not have the authority to modify the BMP list or definitions.

One issue that needs to be considered about this case is that differences between the defined and actual practice can generate negative perceptions about how ADWR interprets Program enrollment rules and perhaps even enforcement problems. In this case, blocked sloping irrigation without tailwater is a de facto approved practice, but publicly available documents do not include it. The BMP list cannot be modified under Third Management Plan rules without legal review, public noticing and hearings. Operators with such infrastructure, which is common in Central Arizona, may be discouraged from applying for admission to the Program if the available information leads them to believe that their farm would not qualify. A second consideration relates to standards. The irrigation literature recognizes the difference between systems with and without a tailwater recovery system. The latter systems have to be carefully managed to prevent water from overtopping berms and spilling water, or at least from ponding downstream , which can reduce crop yield.

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[22] In cases where it is technically and economically feasible, quantitative measures may be included.

[23] For example NRCS conservation standards, Arizona Cooperative Extension definitions, and definitions employed by BMP programs in other states.

[24] Minutes of the BMP Advisory Committee meeting, Feb., 24, 2004

Sloping irrigation systems without tailwater recovery have the potential to achieve high uniformity and application efficiency, however that potential cannot be achieved without substantial management. If not well managed, those systems can result in substantial deep percolation losses with consequent leaching of agrochemicals, particular for coarse-texture soils. A tailwater recovery system increases flexibility and, consequently, hydraulic performance of the irrigation system (Burt et al., 2000). Thus, the decision to give the same score to both systems is debatable.

Mulching (BMP 4-6) is another case where the definition differs from the practice. The definition refers to the use of plastic or a straw cover to reduce evaporation from the soil surface. Many farmers use the term mulching to describe the practice of incorporating manure or other organic matter to improve soil structure and tilth. Three of the audited operators enrolled with BMP 4.6, and in all cases, operators were applying manure. The BMP Advisory Committee has also discussed the definition for BMP 4-6 and agreed that use of organic matter is an approved practice. Issues of concern here are similar to those for BMP 2-3. The practice of manure application is not recognized in Program documents available to the public and it is debatable whether the BMP should be awarded the same score if applied according to the original vs. alternate definition. Use of a soil cover has a direct impact on water conservation, as it reduces bare soil evaporation and non-beneficial uses of water by weeds. It also protects the soil again erosion. Application of manure and organic matter has an indirect impact, as it impacts soil water storage and availability to the crop, and therefore, potentially affects water productivity. Furthermore, in order for practices to be considered as BMPs, they need to meet certain implementation requirements. Those requirements are outlined, for example, in the State of Arizona BMP guidelines for dust control from agricultural operations (GABMPC, 2008).

Another example of a practice differing from the definition is for surge irrigation, BMP 3.5. The Program uses the conventional definition of surge irrigation, which is the application of water by intermittent surges. This is not a common practice in Arizona and requires specialized hardware. Therefore, it can be argued that the practice is not a management practice but, rather, belongs in Category 2 of the enrollment worksheet. One audited farm reported this practice. From the report it is clear that the actual practice is cutback irrigation, in which the inflow rate is reduced after the water reaches the end of the field or some predetermined distance. It is a management-intensive practice that, in effect, improves hydraulic performance relative to irrigation with a constant inflow rate and could be included in the Program. Surge and cutback irrigation are typically used with open-ended systems and can produce some runoff. As with other practices, application of surge irrigation needs to follow guidelines, for example those provided in Waskom (1994). Example guidelines for cutback irrigation are in the Idaho Conservation Planner[25].

BMPs need to be based on practices tested by science and experience. As indicated before, guidelines or standards for current worksheet practices are available from a variety of sources. However, the Program is not explicit about which guidelines or standards it is using. The following paragraphs discuss particular examples of BMPs where worksheet

[25] Agriculture …Launching into the Future. Idaho OnePlan Conservation Planner. ftp://ftp-fc.sc.egov.usda.gov/ID/technical/pdffiles/collection_forms07.pdf

definitions differ from established standards or are unclear. Ultimately, standards need to be developed for all practices if ADWR and the Advisory Committee deem this issue of importance for enforcement purposes and for Program credibility. Such standards could also help promote the proper adoption of irrigation and agricultural technologies.

The lack of well-defined guidelines and technical standards for BMP Program practices is reflected in the definitions for low pressure vs. high pressure system sprinkler irrigation systems. The worksheet definitions differ from NRCS Irrigation Guide standards and also from definitions in Scherer et al (1999). Members of the BMP Advisory Committee have noted the discrepancy and recommended changing the definition. The enrollment worksheet still refers to low-pressure systems as systems operating at less than 10 psi, while other definitions allow pressures up to 35 psi. Again, this creates misunderstanding of Program requirements. Few farms have enrolled in the program with sprinkler systems so it is unclear if this definition has had any impact on enrollment. At the same time, sprinkler system performance depends not only on mainline pressure but also on pressure variation along the line and system maintenance. Hence, Florida's BMP Program (FDACS, 2006) requires regular monitoring of the system as part of the BMP, to ensure that pressure variations do not exceed tolerances.

BMP 3-9 (Participation in an irrigation district program to increase the flexibility of water deliveries) is a practice that eleven farms agreed to implement, even though the definition is vague about how the practice needs to be implemented. In principle, most irrigation districts allow a limited number of water order changes during a day and grant an unscheduled start only if they can match it with a stop order of similar magnitude. With this practice, audit reports state that the operator is able to negotiate the needed flow changes with the irrigation district, not that the operator is participating in a formal program. It is a practice that can translate into measurable water conservation. However, if the practice is available to the operator on an ad hoc basis only, benefits may be realized only occasionally.

A final example is from BMPs 2-7 and 2-8, near-level and level irrigation systems. The BMP worksheet defines those systems based on total fall in the direction of flow (< 0.2 ft for level and 0.2-0.5 ft for near-level). The definition for level systems is based on common leveling practices in Central Arizona and NRCS standards for land leveling and level irrigation systems. The NRCS standards define level systems as systems with zero slope, subject to the precision of the leveling operation with laser equipment. An NRCS standard for near level irrigation is not available[26]. The problem with the definition is that the stated fall translates into a different bottom slope, and different hydraulic performance characteristics, depending on the field length. Quarter-mile long fields are common in Central Arizona but, at least for the interviewed operators, some have shorter fields. No farms were identified from our interview sample with longer runs. According to some of the interviewed operators, they have found by trial-and-error that level-basin can perform poorly with ¼ mile runs, and thus some have put back a slight slope. Leveling is based on slope and not on fall and a typical value for near level is 0.003 ft/100 ft, which translates into a fall of about 0.5 ft per ¼ mile. What this all means is that the BMP definition can lead

[26] P. Khanal, USDA-NRCS, Personal communication

to an implementation different from the intended practice. This problem was brought up during an operator interview.

8.5.7 DISCUSSION

Operators are complying with reporting and auditing requirements of the BMP Program. Data generated by the annual report and audits suggest that participants are implementing the practices in their enrollment worksheet. Individual cases of non-compliance, which are few, should not be construed to reflect on the general state of Program compliance or effectiveness with which practices are applied. The data does not allow to establish if the practices are applied effectively, however. The data also suggests that there are important uncertainties in the verification procedures and worksheet practices that need to be resolved. Not addressing those issues will undermine program credibility.

The following list summarizes the problems that were discussed in previous paragraphs.

- Incomplete/blank Schedule BMP reports
- Justifications are sometimes not provided for cases where practices are not reported
- ADWR does not notify operators in cases where non-compliance is apparent
- From the Schedule BMP, it is unclear if the practice was applied as defined
- A worksheet score is not calculated as part of the Schedule BMP report
- Few formal records are being used to evidence practices during audits
- In a few cases, the implemented practice differs from the definition
- The Program Manager and the Advisory Committee have recommended updating BMP definitions, but such changes are not reflected in Program documentation
- Some practice definitions are unclear

Some of these problems stem from ADWR's inability to update the BMP Program list and definitions under the Third Management Plan. Problems can also be attributed to shortcomings with Program policy. Current policy does not clearly define: 1) what specific information is essentially needed for verification (and which type of alternative information is not acceptable); 2) how that information will be used to assess compliance, and; 3) how ADWR will proceed if non-compliance is suspected.

The uncertainty is also philosophical. Does a BMP program consist of a menu of approved practices and definitions, or of a plan in which one or more practices that needed to be applied in a coordinated manner? If the effective application of BMPs is critical to Program success, then the answer should the latter. Both enrollees and Program managers need clearer guidance about Program expectations and the guidelines or standards that will be used to evaluate the application of BMPs. The documentation developed for the Texas and Florida agricultural water conservation BMP Programs (TSSWCB, 2005; FDACS, 2006) reflect the view of BMPs as a process. Those guidelines define the practice, expected benefits, and provide guidance for implementation and documentation. A similar document is the Arizona PM10 BMP Program guidelines (GABMPC, 2008). ADWR and the Advisory Committee should consider developing such type of a document.

Even if the concept for the current BMP Program is not based on the idea of a structured process, ADWR and the Advisory Committee need to discuss the level of documentation needed to safeguard program credibility. Operators are being faithful in the information that is being reported, both through the annual report and the audit. However, lack of continuity in the auditing process, and the widespread use of testimonial and visual information and low level of formal record-keeping will eventually be questioned by Program critics and perhaps even by BMP participants concerned about Program abuse. While it is clear that stricter documentation requirements can negate transaction costs benefits initially offered by the BMP Program, it can also be argued that some operators already documented their BMPs, even prior to being into the Program. The implication is that a stricter documentation does not necessarily need to be onerous and can ultimately produce benefits to the producers.

ADWR and the Advisory Committee also need to develop a stronger policy document outlining enforcement actions. If annual reports suggest non-compliance and no administrative action follows, then operators who carry out all of their agreed practices will question their commitment to their agreement. Operators who are currently attempting to keep a record of their practices will likely see little value in doing so if others do not do the same. If an audit is unlikely, then there will be little concern for filing an accurate Schedule BMP or documenting practices for audit purposes. The ultimate outcome will be a weak audit process that happens infrequently and that entirely relies on testimonial information.

9 CONCLUSIONS AND RECOMMENDATIONS

This study concludes that the BMP Program is meeting the statutory objective of providing an alternative conservation program. The Program is producing benefits for the participants in the form of increased ability to change cropping patterns, reduced administrative workload relative to the Base Program, but mainly reduced risk of future water constraints. Participation is reasonable considering that the Base Program works well for some producers, factors that limit producers' long-term farming horizons, and program technical requirements. Initial indications are that average water use relative to the allotment for the enrolled farms has not changed subsequent to enrollment. Individual farms have experienced increased water use as a result of crop changes. Enrollment requirements are straightforward and are not hampering participation. Participants are satisfying the verification requirements and current verification procedures indicate that producers are implementing the agreed practices. However, the verification procedures do not provide evidence that BMPS are being applied effectively or even that they are being applied per the strict BMP worksheet definition. Documentation of practices is relying more on testimonial information and less on formal records. Audits were systematically conducted during the first two years of the Program, but no audits have been conducted in the last two years of the Program, largely because of BMP Program staff changes. Verification procedures have resulted in one farm being de-enrolled from the Program. Although there is no reason to believe that other operators are not fulfilling their agreements, the monitoring process is not strong enough to ensure continued program credibility, even among participants. Difficulties with verification are largely a function of the lack of Program guidelines for BMP implementation and documentation. Based on these findings, this report offers the following recommendations.

1) ADWR and the Advisory Committee need to discuss the philosophy behind the current BMP Program. Is the Program intending to promote BMPs as a collection of individual practices or as a set of processes? In the authors' opinion, if Program credibility and success depends on the effective implementation of worksheet BMPs, then the latter interpretation must be adopted. The outcome of that discussion should be a policy statement that defines BMP Program philosophy, objectives, participant expectations, benefits to the AMAs relative to their water conservation goals, and measures of success. That statement should be distributed to participants and made available to the general public.

2) If ADWR and the Advisory Committee conclude that the BMP Program must promote the effective implementation of BMPs, then they will need to pursue the development of comprehensive Program guidelines. Those guidelines must define the steps to an effective implementation for each BMP in its list of approved practices, and how accomplishment of that process will be assessed. It is important to reiterate that typical guidelines of BMP programs are qualitative and aim to mainly to ensure that recommended processes are applied in a structure manner. Those guidelines should be developed with the contribution of ADWR and non-ADWR technical experts, but grounded on the experience of farm operators and the experience with the current BMP Program. Whenever appropriate, the

guidelines may refer to technical standards. The University of Arizona-Cooperative Extension should take the lead in this development.

3) Even if ADWR and the Advisory Committee conclude that current BMP Program concept does not need to be modified, they will still need to undertake a review of the current BMP worksheet. That review should be conducted with input from ADWR and non-ADWR technical experts and producers. The objective would to determine: a) the adequacy of current BMPs; b) substitute practices that need to be officially incorporated into the worksheet (and practices that should not), and; c) which practice definitions need to updated. Practice definitions should be revised taking into account the practicality of verifying implementation per the definition. For example, the definition for BMP 3-1 (Laser touch-up) is:

"Annual re-establishment of precision laser grades to ensure good advancement of applied irrigation water. Must be applied to a minimum of 20 percent of the near level and level basin acreage irrigated the prior year."

This definition has implications for the fraction of BMP farm treated with the practice (>20%), when the practice was applied (prior year), and even about measurable impact (good advancement). If these requirements need to be satisfied by the BMP user, then they will have to be documented both by the participant and by ADWR.

Another important issue to address during the review is to define a set of agronomic BMPs for permanent or multi-year crops. Since the ultimate objective is the effective use of irrigation water, a reasonable compromise would seem to be simply to require additional water management practices.

4) ADWR and the Advisory Committee need to seek the authority under the Fourth Management Plan to conduct periodic reviews of the BMP worksheet (and guidelines if they are developed), to update it if determined to be necessary, and to make that information available to the general public. As explained before, BMPs need to be tailored to specific situations and be responsive to changes fundament knowledge, technology, economic incentives, and production systems.

5) ADWR needs to update its policy document on enforcement procedures. The document needs to outline the verification process and clearly establish what level of documentation is expected from participants, how that information will be used to assess compliance, and administrative procedures that will follow in cases where non-compliance is suspected and in cases where non-compliance has been established. The Program Manager currently relies on phone calls to initiate an inquiry when non-compliance is suspected, but there is no record of such actions. This lack of records may make it easier for an operator to challenge a decision to separate a farm from the program if non-compliance has been established.

6) Audits need to be conducted with some frequency to ensure compliance; however current Program staffing limits the ability to conduct such audits. ADWR needs to find resources to support this activity but this may difficult to do under current State budgetary constraints. An alternative approach would be to modify the audit process. One suggested

approach is to require annual documentation of BMPs with the Schedule BMP. For operators who are already keeping records, this should not represent and additional burden. A sample of these documented Schedule BMPs could then be audited and farm visits would only be conducted in exceptional cases. Another alternative is to request audits at ADWR offices, which would be more onerous to enrollees.

7) The program is required by statute to achieve water conservation benefits equivalent to those of the Base Program. This study provides indications that water use has not changed on average for the enrollees. Future determination of the effectiveness of the BMP approach relative to the statutory requirement will require ADWR to track water use relative to the allotment over time, for both BMP operators and the Base Program population.

8) ADWR must continue to promote the BMP Program, but should not do so aggressively until some of the above issues are resolved. Some time will be needed to develop program guidelines (or a revised worksheet) and updated monitoring-enforcement policies.

10 REFERENCES

ADWR. 1999. Third Management Plan for Pinal Active Management Area 2000-2010. Arizona Department of Water Resources. Phoenix, AZ. http://www.azwater.gov/DWR/Content/Publications/files/ThirdMgmtPlan/tmp_final/default.htm

ADWR, 2003. Modifications To Chapter 4, Agricultural Conservation Program Third Management Plan Phoenix Active Management Area, Arizona Department of Water Resources, Phoenix Arizona. http://www.azwater.gov/AzDWR/Watermanagement/AMAs/ThirdManagementPlanModifications2.htm#Phoenix

ADWR. 2004. An Alternative Conservation Program for Irrigated Agriculture. Arizona Department of Water Resources. www.azwater.gov/dwr/WaterManagement/Content/AMAs/PinalAMA/presentations/BMP_Program.ppt - 2003-02-24

ADWR 2008. Permits, Forms, and Applications. Arizona Dept. of Water Resources. Accessed 2008. http://www.azwater.gov/dwr/Content/Find_by_Category/Permits_Forms_Applications/default.htm

Atari, D.O.A., Yiridoe, E.K., Smale, S., Duinker, P.N. 2009 What motivates farmers to participate in the Nova Scotia environmental farm plan program? Evidence and environmental policy implications. Journal of Environmental Management. 90 (2): 1269-1279

Beard Rau, A., Soenarie, A., and Jensen E. 2009. "A soured outlook for Arizona dairy industry." The Arizona Republic, Aug 3, 2009. http://www.azcentral.com/arizonarepublic/news/articles/2009/08/03/20090803dairyimpact0803.html

Bjornlund, H., Nicol, L., Klein, K.K.. (2009). The adoption of improved irrigation technology and management practices-A study of two irrigation districts in Alberta, Canada. Agricultural Water Management, 96 (1), pp. 121-131.

Blake, C. 2007. "Arizona faces potential water supply shortage from the Colorado River by 2011." Western Farm Press. Dec 1, 2007. http://westernfarmpress.com/mag/farming_arizona_faces_potential/

Burt, C. M., Clemmens, A.J. Bliesner, R.Merriam, J.L., and Hardy, L. 1999. Selection of Irrigation Methods for Agriculture. Prepared by On-Farm Irrigation Committee, Environmental Water Resources Institute, ASCE. American Society of Civil Engineers, Reston, VA

CH2M-Hill. 2005. Study and Evaluation of Irrigation Water Duties Established Under the Second Management Plan. Task A-4 Draft Report. Prepared by CH2M-Hill for the Arizona Department of Water Resources.

Clemmens, A. J., A. R. Dedrick, W. Clyma, and R. E. Ware. 2000. On-farm system performance in the Maricopa-Stanfield irrigation and drainage district area. Irrigation and Drainage Systems 14:93-120.

Cory, D. C., Evans, M. E., Leones, J. P., and Wade, J. C. 1992. The Role of Agricultural Groundwater Conservation in Achieving Zero Overdraft in Arizona. *Water Resources Bulletin*. 28(5): 889-901.

Deva, S. and Frisvold, G. 2005. Some highlights from the 2003 Farm and Ranch Irrigation Survey. Arizona Review 3(1): 16-19. Dept. of Agric. & Res. Econ. Univ. of Arizona, Tucson.

Easter, K.W. 1993. Economic failure plagues developing countries' public irrigation: An assurance problem. Water Res. Res. 29(7): 1913-1922.

EPA. 1993. Guidance Manual for Develop Best Management Practices (BMP). EPA 833-B-93-004. U.S. Environmental Protection Agency, Office of Water.

FDACS. 2006. Florida Agricultural Water Conservation. Best Management Practices. Florida Department of Agriculture and Consumer Services. Tallahassee, FL. http://floridaagwaterpolicy.com

FRIS 2003. Farm and Ranch Irrigation Survey (2003). Volume 3, Special Studies, Part 1 AC-02-SS-1, 2002 Census of Agriculture. National Agricultural Statistical Service, U.S. Dept. of Agriculture. http://www.agcensus.usda.gov/Publications/2002/FRIS/fris03.pdf

GABMPC 2008. "Guide to Agricultural PM10 Best Management Practices. Agriculture Improving Air Quality." 2nd Ed. Governor's Best Management Practices Committee. Arizona Detpt. Env. Quality, Phoenix , Arizona.

Greiner, R. Patterson, L., Miller, O. (2009). Motivations, risk perceptions and adoption of conservation practices by farmers. Agricultural Systems 99: 86–104

GWMC, 2000. Governor's Water Management Commission. Groundwater Issues: Allowable Groundwater Pumping. Final TAC Draft11-28-00

Hetrick J., Roberts, D. 2004. Trends in Non-Indian Agricultural Water Use Within the Phoenix Active Management Area. Proc. The Future of Agricultural Water Use in Arizona. The University of Arizona Water Resources Research Center and the Department of Agricultural and Resource Economics. April 28, 2004, Casa Grande, Arizona; http://cals.arizona.edu/AZWATER

Huffaker, R. (2008) Conservation potential of agricultural water conservation subsidies. Water Res. Res., 44 (7), art. no. W00E01

Jacobs, K.L., Holway, J.M. 2004. Managing for sustainability in an arid climate: Lessons learned from 20 years of groundwater management in Arizona, USA. *Hydrogeology Journal* 12 (1), pp. 52-65

Judkins, G. 2008. Declining Cotton Cultivation in Maricopa County, Arizona: An Examination of Macro and Micro-Scale Driving Forces. APCG Yearbook. 70: 1-26

Kuehne, G., Bjornlund, H., Cheers B. 2008. Developing irrigator types from clustered values. Water Science and Technology. 58(3): 587-595

Leib, B.G., Hattendorf, M., Elliott, T., Matthews, G. 2002. Adoption and adaptation of scientific irrigation scheduling: Trends from Washington, USA as of 1998. Agric. Water Manage., 55(2):105-120

MAG 2005. *Regional Report: A Resource for Policy Makers in the Maricopa Region*. Maricopa Association of Governments. http://www.mag.maricopa.gov/pdf/ cms.resource/Regional-Report-Final-web59556.pdf

Mark, M.M., Henry, G.T., and Julnes, G. 2000. *Evaluation. An Integrated Framework for Understanding, Guiding, and Improving Policies and Programs*. Josey-Bass Inc., San Francisco, CA.

Marshall, G.R. 2004. Farmers cooperating in the commons? A study of collective action in salinity management Ecological Economics 51 (2004) 271– 286

Mathijs, E. 2003 Social capital and farmers' willingness to adopt countryside stewardship schemes . Outlook on Agriculture 32 (1): 13-16

Megdal, S., Smith, A.A. and Lieu, A.M. 2008. *Evolution and Evaluation of the Active Management Area Management Plans*. Final Report. Water Resources Research Center, University of Arizona. Tucson, AZ.

NASS. 2002. 2002 Census of Agricultural. National Agricultural Statistical Service. U.S. Dept. of Agriculture. http://www.agcensus.usda.gov/Publications/ 2002/index.asp

NASS. 2008. Arizona Statistics. National Agricultural Statistical Service. U.S. Dept. of Agriculture. Accessed 2008. http://www.nass.usda.gov/Statistics_by_State/ Arizona/index.asp

Napier, T. 2000. Use of soil and water protection practices among farmers in the north central region of the United States. JAWRA 36(4): 723-735.

Needham, R.A. 2005. *An Impact Assessment of Water Conservation Policy in Agriculture: The Arizona Groundwater Mangement Act of 1980*. M.Sc. Thesis. Dept. of Agricultural and Resource Economics. University of Arizona, Tucson AZ

Needham, R.A. and Wilson, P.N. 2005 Water Conservation Policy in Arizona Agriculture: Assessing the Groundwater Management Act of 1980. Arizona Review. 3(1): pp13-16. Dept. of Agricultural and Resource Economics. University of Arizona, Tucson AZ

Ostrom, E. 1990. Governing the Commons. The Evolution of Institutions for Collective Action. Cambridge Univ. Press, Cambridge, UK

Prokopy, L.S., Floress, K., Klotthor-Weinkauf, D., Baumgart-Getz, A. 2008 Determinants of agricultural best management practice adoption: Evidence from the literature J. Soil and Water Conserv. 63 (5):300-311

Scheierling, S.M., Young, R.A., and Cardon, G.E. (2006). "Public subsidies for water-conserving irrigation investments: Hydrologic, agronomic, and economic assessment." *Water Res. Res*., 42 (3), art. no. W03428

Scherer, T.F., Kranz, W.Pfost, D. Werner, H, Wright, W.A., and Yonts, C.D. . 1999,Sprinkler Irrigation Systems. First Edition. MWPS-30 MidWest Plan Service. Iowa State University, Ames IA

The Future at Pinal: Making Choices, Making Place. 2007. Morrison Institute for Public Policy. School of Public Affairs. College of Public Programs. Arizona State University. http://www.asu.edu/copp/morrison/PinalReport.pdf

TSSWCB. 2005. Water Conservation Best Management Practices (BMP) Guide for Agriculture in Texas. Based on the Agricultural BMPs contained in: Texas Water Development Board. Report 362. Water Conservation Implementation Task Force. Texas State Soil and Water Conservation Board.

Waskom, R.M. 1994. Best Management Practices For Irrigation Management. Colorado State University Cooperative Extension Bulletin #XCM-173.

Wilson, P.N. 1997. Economic Discovery in Federally Supported Irrigation Districts: A Tribute to William E. Martin and Friends. *J. of Agric. and Res. Econ*. 22(1):61-77

11 APPENDICES

11.1 LIST OF APPROVED BEST MANAGEMENT PRACTICES AND PRACTICE DEFINITION

AGRICULTURAL BEST MANAGEMENT PRACTICES PROGRAM

BMP Category 1: Water Conveyance Systems

BMP 1.1 Concrete-lined ditch

Definition: A means of transporting water to farm fields via a concrete-lined ditch in order to minimize transmission losses through seepage.

BMP 1.2 Pipelines

Definition: Any type of low or high-pressure pipeline used to convey water to a farm field in order to reduce or eliminate water loss prior to the act of irrigation. Pipelines may be constructed of PVC, ABS, concrete, aluminum, and or steel.

BMP 1.3 Drainback system

Definition: Level irrigation system technology utilizing headland channel conveyance which is designed and maintained to "drain" excess water applications from one irrigated field to the next down gradient field.

BMP Category 2: Farm Irrigation Systems

BMP 2.1 Slope systems without uniform grades with tailwater reuse - (1 Point)

Definition: Sloped fields without uniform grades with a constructed recovery system that allows for the reuse of water that runs off the end of the field after an irrigation event.

BMP 2.2 Uniform slope systems without tailwater reuse - (1 Point)

Definition: Sloped fields that have been engineered to uniform grades with no means of reusing the water that runs off the end of the field after an irrigation event.

BMP 2.3 Uniform slope systems with tailwater reuse - (2 Points)

Definition: Sloped fields that have been engineered to uniform grades with a constructed recovery system that allows for the reuse of water that runs off the end of the field after an irrigation event.

BMP 2.4 Uniform slope within an irrigation district that captures and redistributes return flows - (2 Points)

Definition: Sloped fields that have been engineered to uniform grades enabling an irrigation district to collect the water that leaves a farm field after an irrigation event for distribution to another farm field.

BMP 2.5 Modified slope systems - (2 Points)

Definition: Sloped fields that have been engineered to uniform grades in the upper portion of the field, with the bottom portion generally having a field slope of 0.0 to 0.2 feet of total fall in the direction of irrigation. All irrigation water is retained on the field.

BMP 2.6 High pressure sprinkler systems - (2 Points)

Definition: Side-roll, linear, center-pivot, and solid set designs that operate at mainline water pressures of 10 pounds per square inch (psi) or more.

BMP 2.7 Near level systems - (2.5 Points)

Definition: Sloped fields that have been engineered to uniform grades between 0.2 to 0.5 feet of total fall in the direction of irrigation over the entire length of the field. All irrigation water is retained on the field.

BMP 2.8 Level systems - (3 Points)

Definition: Level border or level furrow system where the field slope may vary from 0.0 to 0.2 feet of total fall in the direction of irrigation over the entire length of the field. Either all irrigation water is retained on the field or a level drainback system is used.

BMP 2.9 Low pressure sprinkler systems - (3 Points)

Definition: Linear and center-pivot sprinkler designs that operate at water pressures measured at the high end of the mainline of no greater than 10 psi.

BMP 2.10 Trickle irrigation systems - (3 Points)

Definition: Pressurized drip or subsurface irrigation capable of applying precise amounts of water to the crop root zone (also referred to as drip irrigation).

BMP Category 3: Irrigation Water Management

BMP 3.1 Laser touch-up - (1 Point)

Definition: Annual re-establishment of precision laser grades to ensure good advancement of applied irrigation water. Must be applied to a minimum of 20 percent of the near level and level basin acreage irrigated the prior year.

BMP 3.2 Alternate row irrigation - (1 Point)

Definition: The practice of irrigating every other cultivated row during either single or multiple irrigation events to minimize the surface area of applied water. Annually, must be used on at least 20 percent of the acreage irrigated in row crops for at least one irrigation.

BMP 3.3 Furrow checks - (1 Point)

Definition: Manually applied or installed devices placed in rows to raise the water level in the row reducing the velocity to prevent erosion and enhance infiltration rates. Annually, must be used on at least 20 percent of irrigated acreage for at least one irrigation.

BMP 3.4 Angled rows/contour farming - (1 Point)

Definition: Annual practice of reducing row fall through row angling and/or contouring to enhance water advancement and infiltration rates. This practice may also minimize or eliminate tailwater runoff. Annually, must be used on at least 20 percent of irrigated acreage.

BMP 3.5 Surge irrigation - (1 Point)

Definition: The practice of applying irrigation water to a field by intermittent surges or pulses of water rather than by a continuous flow rate. The irrigation water advances down the field (or furrow), in stages, allowing uniform water penetration and avoiding tailwater runoff. A gradual sealing and soil conditioning occurs with each progressive surge allowing a more efficient water application. Annually, must be used on at least 20 percent of irrigated acreage.

BMP 3.6 Temporary sprinklers - (1 Point)

Definition: Utilization of portable, roller and/or solid set sprinkler system for meeting pre-irrigation needs, seedling germination to establish a crop, and/or pre-harvest irrigation for maintaining crop quality. This practice reduces water use when compared to conventional flood irrigation techniques that require excessive water applications for seedling germination and/or crop quality. Annually, must be used on at least 20 percent of irrigated acreage.

BMP 3.7 Participation in an educational irrigation water management program - (1 Point)

Definition: Enrollment in a private or Department sponsored educational irrigation water management program that includes irrigation water management topics such as soil water

replacement needs, application rates, and irrigation scheduling. Annually, must participate in such a program throughout the entire crop season.

BMP 3.8 Participation in a consultant or irrigation district sponsored irrigation scheduling service - (1 Point)

Definition: Enrollment in a consultant or Department sponsored irrigation scheduling service that provides recommendations on soil moisture monitoring, soil water replacement needs, irrigation application rates, and irrigation scheduling dates based on soil moisture monitoring or real-time evapotranspiration data. Annually, must participate in such a program throughout the entire crop season.

BMP 3.9 Participation in an irrigation district program to increase the flexibility of water deliveries - (1 Point)

Definition: Enrollment in a cooperative program set up by the irrigation district to assist a farmer with timely irrigation deliveries and shut off, constant flow rates, and other water order guidelines developed by the irrigation district. Annually, must participate in such a program throughout the entire crop season.

BMP 3.10 Measure flow rates to determine the amount of water applied - (1 Point)

Definition: Measure flow rates to determine the water application rate required for each irrigation event on each field for the purpose of achieving good application efficiencies.

BMP 3.11 Soil moisture monitoring - (1 Point)

Definition: Use of a number of accepted methods to monitor/measure soil moisture for the purpose of determining soil water replacement needs, application rates, and irrigation scheduling on each field (accepted methods may include core sampling, resistance blocks, neutron probe, tensiometers) throughout the entire crop season.

BMP 3.12 Computer based model using meteorological data - (1 Point)

Definition: Use of a computer based irrigation scheduling program that incorporates real-time meteorological data (e.g. AZMET) for the purpose of determining irrigation event schedules on each field throughout the entire crop season.

BMP Category 4: Agronomic Management

BMP 4.1 Crop rotation - (1 point)

Definition: Periodic rotation of crop types on a given farm field to ensure the non-degradation of soil tilth. Annually, at least 20 percent of the acreage irrigated the prior year needs to be rotated to a different crop.

BMP 4.2 Crop residue management - (1 point)

Definition: Incorporation of crop residue into the soil profile to increase soil nutrients, soil water holding capacities, and increase the available soil moisture to a crop. Annually, must be employed on at least 20 percent of the total irrigated acreage.

BMP 4.3 Soil and water quality testing - (1 point)

Definition: Annual soil testing to determine: 1) residual amounts of fertilizer, 2) soil salinity for leaching needs, and 3) water intake rates and water holding capacity. Soil testing is required on at least 50 percent of the irrigated acreage. Water quality testing for needs such as estimating leaching requirements or avoiding potential injury to crops. Testing must include a "blend" analysis of irrigation water used from all sources.

BMP 4.4 Pre-irrigation surface conditioning - (1 point)

Definition: Mechanical means (i.e. driving rows, soil torpedoes, etc.) by which rows or borders are prepared prior to an initial irrigation to smooth flow of water to avoid unwanted deep percolation during dry conditions or to enhance water advancement rates. Annually, must be used on at least 20 percent of irrigated acreage.

BMP 4.5 Transplants - (1 point)

Definition: Use of established seedlings transplanted into a field. This practice eliminates excessive applications of water to germinate crops in the field from seeds. Annually, must be used on at least 20 percent of irrigated acreage.

BMP 4.6 Mulching - (1 point)

Definition: Use of organic matter or plastic sheets to cover plant beds (plastic mulch) and/or use of plastic material laid over hoops suspended above the plant beds (floatable row covers) to reduce evaporation losses. Annually, must be used on at least 20 percent of irrigated acreage.

BMP 4.7 Shaping furrow or bed - (1 point)

Definition: Use of mechanical means such as a row former to make the bed profile more shallow to minimize time of infiltration and minimize the wetted surface area along the rows. Annually, must be used on at least 20 percent of irrigated acreage.

BMP 4.8 Planting in bottom of furrow - (1 point)

Definition: Practice of planting in the bottom of the furrow as opposed to planting along the top of the row bed to minimize impacts of salt build up and wetting (subbing) requirements for germination. Annually, must be used on at least 20 percent of irrigated acreage.

SCHEDULE BMP

ARIZONA DEPARTMENT OF WATER RESOURCES

BMP WORKSHEET REPORT

ANNUAL REPORT 2004

BMP Farm Unit No. _____

BMP Farm Unit Name: _____

PART 1 - Description of Water Conveyance System Improvements

Please describe the extent of each type of water conveyance system change or improvement implemented on the BMP Farm Unit during 2004. If no changes or improvements were made, please so indicate.

PART 2 - Description of Farm Irrigation System Improvements

Please describe the extent of each type of farm irrigation system change implemented on the BMP Farm Unit during 2004. If no changes or improvements were made, please so indicate.

PART 3 - Irrigation Water Management Practices Applied

Please check from the list below the types of irrigation water management BMPs that were applied on the BMP Farm Unit during 2004.

☐ BMP 3.1 Laser touch-up ☐ BMP 3.2 Alternate row irrigation ☐ BMP 3.3 Furrow checks
☐ BMP 3.4 Angled rows ☐ BMP 3.5 Surge irrigation ☐ BMP 3.6 Temporary sprinklers
☐ BMP 3.7 Participation in an educational irrigation water management program
☐ BMP 3.8 Participation in a consultant or irrigation district sponsored irrigation scheduling service
☐ BMP 3.9 Participation in an irrigation district program to increase the flexibility of water deliveries
☐ BMP 3.10 Measure flow rates ☐ BMP 3.11 Soil moisture monitoring ☐ BMP 3.12 Computer Scheduling
☐ Approved substitute BMP (note below)

Please indicate below if the BMPs checked are different than what was agreed to at time of enrollment into the BMP Program. If you are practicing different BMPs indicate your reasons for doing so.

PART 4 - Agronomic Management Practices Applied

Please check from the list below the types of agronomic management BMPs that were applied on the BMP Farm Unit during 2004.

☐ BMP 4.1 Crop rotation ☐ BMP 4.2 Crop residue management ☐ BMP 4.3 Soil and water quality testing
☐ BMP 4.4 Pre-irrigation surface conditioning ☐ BMP 4.5 Transplants ☐ BMP 4.6 Mulching
☐ BMP 4.7 Shaping furrow or bed ☐ BMP 4.8 Planting in bottom of furrow ☐ Approved substitute BMP

Please indicate below if the BMPs checked are different than what was agreed to at time of enrollment into the BMP Program. If you are practicing different BMPs indicate your reasons for doing so.

I hereby certify that the information contained in this report is, to the best of my knowledge and belief, true, correct, and complete.

X _____ _____
SIGNATURE Date

11.3 TABLE OF EVIDENCING METHODS

ADWR

SUGGESTED METHODS OF EVIDENCING THE ANNUAL APPLICATION OF AGRICULTURAL BMPs FOR BMP PROGRAM ENROLLEES

		Signed statement from Enrollee	Receipts and purchase orders	Agreements	Records, notes, certificates, or maps	Photo confirmation	Possession of specialized equipment	IMS or WCMP Verification
BMP 3.1	Laser touch-up	▲	▲				▲	▲
BMP 3.2	Alternate row irrigation					▲	▲	▲
BMP 3.3	Furrow checks					▲		▲
BMP 3.4	Angled rows					▲		▲
BMP 3.5	Surge irrigation	▲					▲	▲
BMP 3.6	Temporary sprinklers		▲			▲		▲
BMP 3.7	Participation in an educational IWM program			▲	▲			▲
BMP 3.8	Participation in a consultant or I.D. sponsored irrigation scheduling service			▲				
BMP 3.9	Participation in an I.D. program to increase flexibility of water deliveries			▲				
BMP 3.10	Measure flow rates to determine the amount of water applied				▲			▲
BMP 3.11	Soil moisture monitoring				▲			▲
BMP 3.12	Computer-based modeling using meteorological data				▲		▲	▲
	Substitute IWM Practice	--	--	--	--	--	--	--
BMP 4.1	Crop rotation				▲			▲
BMP 4.2	Crop residue management				▲	▲		▲
BMP 4.3	Soil and water quality testing				▲			
BMP 4.4	Pre-irrigation surface conditioning					▲		▲
BMP 4.5	Transplants	▲	▲					▲
BMP 4.6	Mulching		▲			▲		▲
BMP 4.7	Shaping furrow or bed					▲	▲	▲
BMP 4.8	Planting in bottom of furrow					▲		▲
	Substitute Agronomic Management Practice	--	--	--	--	--	--	--

Note: Evidencing requirements for Substitute BMPs will be determined after the BMP is approved by the Director

Agricultural BMP Program
Proposed Enforcement Policy for Non-Compliance

Philosophy

The Department expects BMP Program participants to implement the conservation measures as agreed to on the BMP enrollment form. In the event of non-compliance, the Department's preference for this Interim Program is to work cooperatively with the responsible party (usually the operator) to come into compliance in a timely and appropriate manner. In taking specific compliance action, the Department will consider the following:

- The severity of the infraction
- Whether it is the first, second or third offense
- Whether the infraction was self-reported
- Other reasonable extenuating circumstances

Responsible Party

In situations of non-compliance, the Department will seek to identify who bears responsibility for that non-compliance. The presumptive responsible party for compliance shall be the person or persons using groundwater pursuant to the enrolled rights (i.e., the operator).

Actions

The Department has developed proposed compliance remedies that include informational, educational and water management benefit components. The proposed compliance actions may include:

- Sending a notice of non-compliance to all parties
- Requiring a conservation audit/review
- Requiring 'extra' conservation measures
- Requiring a water management contribution
- De-enrolling the participant from the BMP Program for the duration of Third Management Period.

The Department also reserves the right to pursue civil penalties against the responsible party if the non-compliance is both serious and intentional.