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EVALUATION OF BONNEVILLE POWER ADMINISTRATION'S SCIENTIFIC IRRIGATION SCHEDULING PROGRAM

Final Report

Prepared for:
Bonneville Power Administration

Prepared by:

Stuart Schare, Director
Deborah Swarts, Managing Consultant

Navigant Consulting, Inc.
1375 Walnut St.
Suite 200
Boulder, CO 80302

303.728.2500
www.navigantconsulting.com

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Executive Summary

Bonneville Power Administration (BPA) offers a variety of energy efficiency incentive programs that allow its member utilities to assist their retail customers in utilizing energy more effectively, thus reducing power costs for all BPA customers. Among the current offerings is a **Scientific Irrigation Scheduling (SIS) program,** which promotes a type of irrigation water management (IWM) that can be used by growers of agricultural products to improve irrigation water management. The **SIS Light program** was created to encourage lower-volume growers to participate by allowing a shorter time commitment and reducing reporting burdens.

This report describes Navigant Consulting's findings on regional irrigation practices and use of SIS in particular. It also presents an assessment of the SIS program and identifies opportunities for improvements in program design and delivery. Major evaluation research activities included the following:

1. Conduct a review of program documentation and secondary literature
2. Conduct interviews with BPA staff, participating utilities, and service providers
3. Review SIS Calculator
4. Evaluate cost-effectiveness of SIS Program using ProCost

Participation and Energy Savings

Since the latest iteration of the SIS program that began in 2006, the number of participating utilities has grown from two to eight, and the enrolled acreage has increased from roughly 63,000 acres to nearly 250,000 acres as of 2009. Energy savings are initially determined using the SIS calculator, a spreadsheet tool developed to estimate savings based on a variety of inputs including crop type, water source, pump type, and other parameters discussed in Section 3.2.5. Table E-1 summarizes the program savings using the SIS calculator for all participating acreage since 2006.

Table E-1. SIS Calculator Savings

Calendar Year	# Utilities	# Acres	Savings (MWh)	Average Savings (kWh per Acre)
2006	2	63,011	16,816	266.9
2007	5	131,542	26,302	200.0
2008	5	198,061	37,530	189.5
2009	7	253,331	43,307	171.0
2010 to date	8*	154,725*	35,369*	228.6
Total		**800,671**	**159,325**	**199.0**

* Does not include Grant County PUD for 2010 since final values were not available due to evaluation and reporting timelines.

Source: BPA: Summary of utilities' annual SIS reports, as compiled by BPA and provided in file "SIS summary.xls" Due to 3-year measure life requirement (cost-effectiveness purposes), these savings are not equal to those reported in the PTR system or to the Northwest Power and Conservation Council.

For the SIS program, output from the calculator is transferred to the Planning, Tracking, and Reporting (PTR) system which adjusts for line losses. SIS savings are recorded in the first year and are required to be sustained over the three-year measure life. Consequently, only additional, "incremental" acreage is reported in the subsequent two years of participation. After three years, the contract on the original acreage expires and the savings from additional acreage can be booked as new savings.

For SIS Light, savings are deemed at 220 kWh/acre per year. However, to keep the 3-year program design consistent, for one year of participation in SIS Light, a deemed savings value of 73 kWh/acre (roughly one-third of the annual deemed savings value) is entered into the PTR system for each of three years. Thus, savings from the calculator (see Table E-1) are different from those reported in the PTR system. Table E-2 provides the PTR database-reported savings as of October 1, 2010. Total savings reported to the Northwest Power and Conservation Council are nearly 60,000 MWh.

Table E-2. PTR Savings

Calendar Year (SIS applied)	Fiscal Year (Savings Booked)	# Utilities	PTR Database Savings (MWh)
2006	2007	2	18,098
2007	2008	5	6,103 †
2008	2009	5	12,091
2009	2010	7	21,369
2010	2011	8	Fiscal Year 2011 reporting not available
Total			**57,661**

† Only four utilities reported savings in the PTR system in 2007.
Source: BPA: PTR database summary and "SIS summary.xls" spreadsheet

In 2010, potatoes represented nearly one-quarter of the acreage under management for the program. Poplar, sweet corn, and peas combined accounted for nearly an additional 40% of the program acreage in 2010.

Findings

Irrigation Practices and the SIS Program

The evaluation and market research conducted for this investigation addressed a variety of issues covering both a regional irrigation practices market characterization in general and BPA's SIS offering in particular. Findings on *regional irrigation practices* relate to irrigation of farms in the Northwest (Washington, Oregon, Idaho, and Montana) and do not necessarily pertain to SIS practices or BPA's SIS program. *SIS program findings* are specific to BPA's program offering, including both SIS and SIS Light.

The regional market was found to be dependent upon available incentives in order to continue and expand the use of SIS. This was due to the combined cost of services and implementation exceeding the budget of a typical grower. Participating growers have responded positively to the use of SIS, indicating better crop quality and reduced consumables. This has contributed to increased awareness of the practice as growers inform each other of positive results.

The utilities and service providers value the program highly and plan to continue participation, but they indicated confusion over program rules (such as how savings accrue over three years), found reporting to be a burden, and expressed concerns about the program's long-term stability due to interruptions in the past. A summary of findings is provided in Table E-3.

Table E-3. Summary of Findings of Regional Irrigation Practices and the SIS Program

Regional Irrigation Practices	
Baseline Irrigation Practices	Irrigation practices vary widely, commonly including either irrigation-based on crop-specific USDA recommendations or physical inspection of surface soil conditions.
Use of Moisture Meters	Where SIS is performed, the most common type of moisture meter is a neutron probe, which is removed annually and reused by service providers. Telemetry probes are more expensive but can reduce the operating/labor costs associated with obtaining moisture readings.
Factors Affecting Adoption of SIS Practices	The likelihood of a grower implementing SIS practices is influenced by a variety of factors such as service provider availability, crop value, and the water source, the latter two of which directly influence SIS economics.
Economic Barriers	The cost of SIS is a major barrier, and in particular lack of access to financing for SIS equipment or services.
Free Ridership	There is little indication that SIS practices are being widely adopted in the absence of incentives, and thus free ridership is likely low. The introduction of SIS through BPA and other programs has helped to establish service providers, without whom many farmers would not have the option to use the SIS technology without investing in moisture meters and training.
Non-energy Benefits	Non-energy benefits are not directly recorded by service providers, but a qualitative understanding of the technology allows growers to understand that with better management of their water use, other positive influences will occur during their growing season (particularly for potatoes and wine grapes).
SIS Program Practices	
Incentives	The cost-sharing provided by the program through direct financial incentives is an essential benefit without which most growers located within the service territories of the utilities' surveyed would not be able to afford the investment in SIS.
Measure Life	The vast majority of SIS applications last for only a single growing season despite the required contract between BPA and the participating utilities for a three-year measure life.
SIS Light	The SIS Light program offering has not provided a sufficiently distinct and understandable alternative to SIS, and its participation requirements are not being strictly enforced.
Utility Understanding of SIS & SIS Light Programs	Utilities' understanding of program rules and requirements is limited, particularly with respect to SIS Light and its delayed booking of savings.
SIS Energy Savings Calculator	Both the utilities and service providers indicated that although it was not an ideal tool, the calculator is better than anything else they had encountered.
Marketing and Recruitment	The majority of the utilities rely on service providers, including water management and conservation districts, to contact growers and educate them about the services
Administration and Reporting Requirements	The utilities' primary complaint about program administration was the timing of the reporting.

Source: Navigant Consulting

Cost-effectiveness

The cost-effectiveness assessment performed for this program evaluation focuses primarily on measure-level benefits associated with SIS applications on farms in the Northwest. The range of savings values estimated with the SIS calculator illustrates the high variability of savings according to factors including required pump height, climate, and soil quality.

ProCost model runs performed for this analysis indicated a benefit-cost ratio for SIS of 1.3, suggesting that for a typical farm in the region, benefits outweigh costs. If the non-energy benefits are excluded, the ratio drops to 0.9. Including non-energy benefits (which is appropriate for Total Resource Cost (TRC) testing), SIS is cost-effective at the measure level, assuming a one-year measure life, savings of 200 kWh/acre, and a cost of $13.56/acre annually. If energy savings are less than approximately 130 kWh/acre, SIS is no longer cost-effective.

For a true regionally appropriate benefit-cost test, the impacts of program administrative costs and additional benefits (e.g., risk mitigation) would also be included. However, at this time the appropriate values for these inputs are still under review.

Recommendations

As requested by BPA, the evaluation "provides recommendations for methods to improve program delivery of SIS program (including SIS Light)." The recommendations are based on findings from secondary research, interviews, the calculator review, and the cost-effectiveness assessment. Recommendations are grouped into four categories covering the following topics:

1. Program structure and incentives
2. SIS Energy Savings Calculator
3. Program outreach
4. Program administration

A summary of the recommendations is provided in Table E-4, which also indicates whether the recommendation is a "Quick Fix" that can be addressed unilaterally and relatively easily by BPA, a "Strategic or Technical Effort" that may require a matter of months to implement, or a "Longer-Term Structural Change" that may require a longer period and/or coordination with the Regional Technical Forum (RTF) or utilities.

Table E-4. SIS Program Recommendations

Recommendation	Timeframe/Complexity		
	Quick Fix	Strategic or Technical Effort	Longer-Term Structural Change
Program Structure and Incentives			
R1. Reduce the required measure life to one year for some or all SIS applications.		✓	
R2. Merge SIS Light into SIS offering.	✓		
R3. Reduce the deemed savings value for SIS Light from 220 kWh/acre/year to 200 kWh/acre/year (if SIS Light is continued).	✓		
R4. Maintain the SIS program and incentives without interruption.	✓		
R5. Assess practical and political feasibility of a tiered system of incentives based on value to the region.		✓	
R6. Limit or modify incentives to account for systematic free ridership.		✓	
R7. Convene a task force to develop the new tiered incentive structure and eligibility requirements.	✓		
SIS Calculator			
R8. Add estimates of primary and secondary pumping effects in Columbia Basin.			✓
R9. Acquire available existing research on actual savings from SIS implementation to adjust SIS Calculator savings estimates.		✓	
R10. Modify calculator inputs to reduce the possibility of data entry error.	✓		
R11. Revisit SIS impacts for perennial crops such as fruit trees.			✓
R12. Review Oregon State University data when available.	✓		
Program Outreach			
R13. Improve marketing and education to utilities.	✓		
R14. Promote the program in districts relying primarily on groundwater.		✓	
R15. Expand service provider network to reach underserved areas.			✓
Program Administration			
R16. Develop a master database of SIS program participation data.			✓
R17. Enhance internal BPA staff coordination regarding program design, administration, and field services.		✓	

Source: Navigant Consulting

1 Introduction

Bonneville Power Administration (BPA) offers a variety of energy efficiency incentive programs that allow its member utilities to assist their retail customers in utilizing energy more effectively, thus reducing power costs for all BPA customers. Among the current offerings is a **Scientific Irrigation Scheduling (SIS) program,** which promotes a type of irrigation water management (IWM) that can be used by growers of agricultural products to improve irrigation water management.

The terms SIS and IWM are often used interchangeably, or one or the other is sometimes preferred by various organizations or individuals. The United States Department of Agriculture (USDA) uses the term IWM, while BPA and many Northwest area organizations generally use SIS. For this report, the term SIS has been adopted except when referring to USDA-funded programs.

When used properly, SIS provides information on when to irrigate and how much water to apply, as well as how to appropriately apply water to satisfy crop water requirements while avoiding plant moisture stress. The lower water use reduces electrical pumping costs for both the grower. These electric savings are the primary rationale for the SIS program, although non-electric benefits such as savings on water, fertilizer, and labor, as well as improved crop quality can be significant as well.

This report describes Navigant Consulting's findings on regional irrigation practices and use of SIS in particular. It also presents an assessment of the SIS program and identifies opportunities for improvements in program design and delivery. The report is organized as follows:

Section 1: Introduction, including a program overview and specific objectives of the evaluation

Section 2: Methodology, including secondary research, interviews, review of the program savings calculator, and approach to cost-effectiveness analysis

Section 3: Findings on regional irrigation practices and BPA's SIS program

Section 4: Cost-effectiveness analysis of SIS measures

Section 5: Summary and Recommendations

1.1 Program Overview

BPA has been offering the current SIS program since 2006 with the goal of promoting efficient energy use in the agricultural sector. BPA had previously offered other IWM or SIS related programs as early as 1986. In 2006 and 2007, significant research was conducted to understand the market, and develop a calculator to estimate savings from individual fields. In 2006 the

Regional Technical Forum (RTF) approved the SIS deemed calculator as an appropriate method to estimate SIS savings. To make the offering cost-effective, a three-year measure life was required.

The latest iteration of this program offering (including both **SIS and SIS Light)** helps utilities provide an incentive to growers for using moisture meters to precisely determine the amount of water needed for irrigation of their crops.

The **SIS program** is available to all member utilities and can accommodate farms of any size. Utilities are required to sign a three-year contract with BPA, stating the minimum number of acres they will enroll in the program during the period. Savings are estimated using the deemed calculator; first year savings are reported in total while only incremental savings are reported in the second and third years.

The **SIS Light program** was created in 2009 to encourage lower-volume growers and additional utilities to participate by allowing a shorter time commitment and reducing reporting requirements. This program is designed with a one-year measure life. However, because the program required a three-year measure life to be cost-effective, utilities in the SIS Light Program report one-third of the deemed savings each year. The deemed savings are based on previous program average savings from the SIS calculator. This results in the same average expected savings after a three-year period regardless of a utility's choice of SIS program type. The incentive amount is the same as for the SIS program, but only farms under 1,000 acres are eligible to participate in SIS Light. Table 1 summarizes major differences between the two programs.

Table 1. Comparison of SIS and SIS Light

Program Attribute	SIS	SIS Light
Contract Length	3 years	No Contract required
Incentive	$6/acre/year	$6/acre
Farm Size	Any	<1,000 acres
Savings Calculation	Use deemed SIS Calculators and submit to BPA.	Use SIS Calculators and submit to BPA.
Savings Reporting	First year report is total amount in the deemed calculator, Years 2 and 3 are incremental savings only.	Reported annually at one-third of deemed savings level, 73 kWh/acre/year
PTR Reporting	Uses custom project proposal for first year and completion reports each of three years. Uses additional calculator for PTR system reporting in years 2 and 3.	Reported as deemed measure into PTR system

Source: BPA

Both offerings require participating utilities to provide an annual program report to BPA, including participation details and SIS calculator outputs for each grower in the program. The SIS calculator is used to supply much of the quantitative data required for these reports. In most cases, service providers produce the reports on behalf of the growers and utilities.

Since the current program began in 2006, the number of participating utilities has grown from two to eight, and the enrolled acreage has increased from roughly 63,000 acres to nearly 250,000 acres as of 2009. Energy savings for reporting purposes are initially determined using the SIS calculator, a spreadsheet tool developed to estimate savings based on a variety of inputs including crop type, water source, pump type, and other parameters discussed in Section 3.2.5. Table 2 summarizes the program savings using the SIS calculator for all participating acreage since 2006.

Table 2. SIS Calculator Savings

Calendar Year	# Utilities	# Acres	Savings (MWh)	Average Savings (kWh per Acre)
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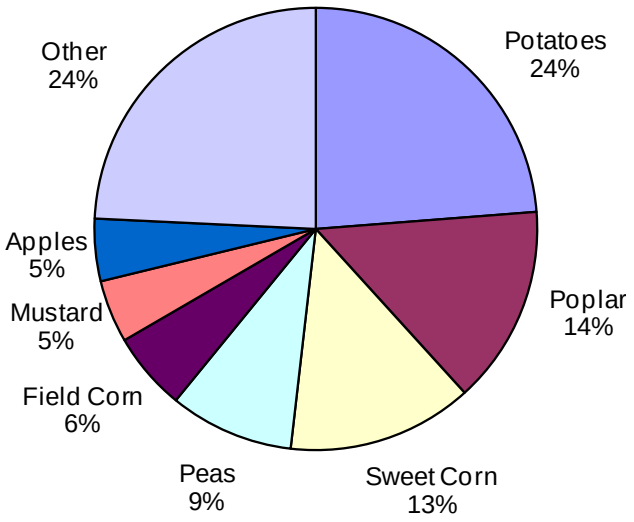
† Only four utilities reported savings in the PTR system in 2007.

Source: Source: BPA: PTR database summary and "SIS summary.xls" spreadsheet

In 2010, potatoes represented nearly one-quarter of the acreage under management for the program. As shown in Figure 1, poplar, sweet corn and peas combine for nearly 40% of the program acreage in 2010. The "other" category includes crops with less than 4% of the acreage, including onion, alfalfa, winter grain, dry beans, spring grain, wine grapes, bluegrass seed, and cherries.

Figure 1. Program Acreage by Crop Type



Source: BPA, CropType Summary_2010.xls spreadsheet

1.2 Objectives of this Evaluation

The SIS program was last evaluated by BPA in 2007,[1] and BPA now believes that the program can be improved through an updated evaluation of the program rules and processes, informed in part by interviews with participating utilities and service providers. The purpose of this evaluation is to review the current BPA SIS program delivery methods, savings, RTF decisions, and cost-effectiveness, and to provide recommendations for improvements or changes to future SIS program offerings. The scope includes research into the current market for SIS (e.g., baseline practices, need for incentives) and recommendations for updates or improvements to the SIS calculator, which was developed during the 2007 evaluation.

In order to meet these objectives, the specific components of the evaluation included:

- Update the regional market characterization, including baselines and current practices, through interviews with utilities and service providers.
- Identify baseline irrigation practices and SIS implementation costs and barriers for growers.
- Estimate program and measure cost-effectiveness.
- Identify opportunities for program improvements, including identification of any issues with crop types, program design, measure lifetime, planning, or tracking.
- Assess the status of the new SIS Light offering and its reception by utilities and service providers.

In addition, in its Statement of Work BPA identified ten specific questions to be addressed by this evaluation. These questions, which address issues such as irrigation practices, the economics of SIS, and the details BPA's SIS Program, are discussed throughout the Findings section (see Section 3) and are summarized in Section 3.3.

[1] *Impact Evaluation of Columbia Basin Pilot Irrigation Water Management Project*, Quantec, January 23, 2007.

2 Methodology

In its Statement of Work, BPA requested an evaluation of the current SIS program, including a review of program literature; interviews with BPA staff, utilities, stakeholders, participants, and non-participants; a review of the SIS Calculator; and a cost-effectiveness analysis.

Following a project initiation meeting, the evaluation team developed a work plan to address the specific concerns and interests of BPA staff such as the addition of interviews with service providers in place of participating and non-participating growers. Ultimately, the following activities were undertaken in performing this evaluation:

1. **Conduct a review of program documentation and secondary literature.** Navigant reviewed the available program documentation, previous program reports, the 6th Power Plan, and U.S. Department of Agriculture (USDA) data.
2. **Conduct interviews with BPA staff, participating utilities, and service providers.** The literature review was used to inform open ended discussions with BPA staff. This information was then incorporated into the design of interview guides for participating utilities and service providers. Interviews with these parties were conducted both by phone and in person. USDA Natural Resources Conservation Service (NRCS) staff working with the Environmental Quality Incentives Program (EQIP) were also interviewed.
3. **Review SIS Calculator.** Navigant reviewed the SIS Calculator and examined its algorithms to determine its functionality. Interviews were also used to evaluate user satisfaction with the tool.
4. **Evaluate cost-effectiveness of SIS Program using ProCost.** The Northwest Power and Conservation Council (Council) tool ProCost was used with outputs from the SIS calculator and data from the literature review to determine the cost-effectiveness of SIS under different conditions.

2.1 Review of Program Documentation and Secondary Literature

Navigant reviewed the previous SIS evaluation report and the SIS Calculator along with several regional data sources. These included:

Regional Studies and Guides

- *6th Power Plan*, Northwest Power and Conservation Council, 2010.
- *Washington State Irrigation Guide*, USDA, 1997

Research Reports

- *2007 Census of Agriculture, Farm and Ranch Irrigation Survey (2008), Vol. 3, Special Studies, Part 1.* USDA, July 2010.
- *Irrigation Water Management (IWM) Value Analysis Workbook*, Columbia Basin Ground Water Management Area (GWMA), 2003
- I*mpact Evaluation of Columbia Basin Pilot Irrigation Water Management Project*, Quantec, 2007
- *A Study of Irrigation Scheduling Practices in the Northwest Phase II: Measurement of Water and Electricity Impacts*, Quantec, 2005
- *A Study of Irrigation Scheduling Practices in The Northwest*, KEMA-XENERGY, 2003

SIS Program Documents and Tools

- *Energy Efficiency Implementation Manual*, BPA, 2009
- Quantec/BPA SIS Calculator Releases 2.0 and 3.0
- PTR Contract Calculator, built into PTR

2.2 *Conduct Interviews with SIS Stakeholders*

The primary source of new data for this program review came from interviews with BPA personnel, staff of utilities with SIS programs, and irrigation consulting service providers. This review was originally intended to contact growers directly, however after discussions with BPA personnel this was determined to be cost prohibitive. In order to obtain a statistically significant sample of growers it would have been necessary to contact a large number of participants. Attempts to obtain lists of growers from utilities were met with limited success. Service providers have direct contact with all individual growers and collect the field data for them, so this information was used in place of direct grower input, with recognition that their answers are potentially biased. Table 4 summarizes the personnel interviewed as part of this review.

Table 4. Interviewees

Category	Description	Interviewees
BPA Staff	BPA Staff	3
Utilities (12 total)	SIS Utilities	6
	SIS Light Utilities	4
	Utilities Not Yet Participating	2
Service Providers (9 total)	Commercial Service Providers	5
	Water Management and Conservation Districts	3
	Industry Experts	1
USDA EQIP Staff	USDA EQIP Staff	2
Total		**26**

2.2.1 BPA Personnel

Navigant researchers discussed the SIS and SIS Light programs at length with several BPA staff members. These discussions were not formal interviews, but rather open ended discussions with personnel familiar with the programs.

BPA personnel also provided Navigant with copies of select previous SIS reports, which are stored in hardcopy form at BPA's Walla Walla, WA office location, from where the program is largely administered. The reports that were reviewed by Navigant were complete and included the required data. BPA also provided a summary spreadsheet summarizing by year the utilities participating, the acreage under SIS management, and the SIS calculator savings. The complete data from individual reports—broken out by farm, crop type, and other parameters—only became available for 2010 at the end of the time period for this review, and thus were not included in the analysis other than the presentation of acreage by crop type in Figure 1 above.

2.2.2 Utilities

Navigant interviewed representatives from all twelve utilities participating in the SIS and SIS Light programs. Two of these utilities had not yet begun offering programs to their customers. The interviews were based on an interview guide developed in conjunction with BPA evaluation staff, included in Appendix A, and took approximately one hour to complete. Two interviews were performed in person while the remaining interviews were conducted by phone. Discussions with utility staff indicated a wide range in level of involvement across various utilities. Some of the utilities were actively engaged with the program and provided expansive answers to the interview questions. Other utilities left almost all program activities up to the service providers, and were not as familiar with some of the technical details of SIS implementation.

2.2.3 Service Providers

Service providers administer SIS services for growers. In the case of commercial service providers, this is done both on behalf of utilities offering SIS incentives and for any growers performing SIS outside of the BPA funded programs. Some water conservation and management districts also administer SIS services, although they are doing so only in conjunction with utilities offering SIS programs. When service providers administer SIS services for growers participating in utility incentive programs, the service providers produce program reports use the SIS Calculator to determine savings for the growers.

Eight service providers and one industry expert were interviewed as part of the program assessment. Two of the service providers were conservation districts, one was a water management area, and the remaining five were commercial providers. All interviewed service providers interviewed indicated a deep involvement with the program.

2.2.4 USDA EQIP Program Personnel

USDA offers some SIS, which they term IWM, funding through their EQIP program. The EQIP program provides funding to start new agricultural practices on individual farms. IWM is only one portion of the EQIP program. A point system is used to score proposals from growers in each district. Each district then chooses the top scoring proposals up to level of funds available, and enrolls the selected growers for a pilot period during which funding is provided to start using new practices. After two years the funding is discontinued for that grower.

Navigant interviewed USDA personnel administering the EQIP program in two districts, with one interview conducted in person and the other by phone. Relevant to the USDA's role with SIS, it should be noted that one district indicated that growers were expected to inform them if they were receiving SIS funding and that this would be deducted from the EQIP IWM incentive. The other district indicated that IWM funds could not be provided in conjunction with BPA funded SIS incentives. Both districts indicated that it had been many years since anyone had received any outside SIS funding for their EQIP project.

2.3 Review SIS Calculator

As a part of this program review, Navigant Consulting reviewed the SIS Calculator in detail. The SIS calculator is an Excel spreadsheet tool used to determine savings for each location at which an incentive is issued through either the SIS or SIS Light offering. Because the calculator is the primary tool used in determining savings for the program it is an important part of determining if the SIS program is cost-effective. In order to assess the SIS Calculator, Navigant reviewed the available documentation, examined the prescriptive inputs and performed parametric entries to ensure consistency. The review included:

- Review of the use and application of the SIS Calculator in order to understand inputs and outputs

- Examination of input tables and algorithms used by the SIS Calculator and comparison to other available data
- Performance of sample runs of savings calculations to verify operation of the SIS Calculator
- Identification and troubleshooting of any inconsistencies in the SIS Calculator outputs

2.3.1 SIS Calculator Inputs

In order to calculate energy savings, the SIS calculator requires certain inputs which can vary greatly between growers and between utility service territories. The most significant inputs to the calculator include:

- Utility, including geographic area
- Crop type
- Soil type
- Irrigated acreage
- Lift height between water source and irrigation equipment
- Irrigation system type
- Discharge pressure
- Pump type and size

2.3.2 SIS Calculator Outputs

The SIS calculator produces a summary report (available in table format) which includes both the input information and a number of calculated values, including:

- Energy savings
- Water savings
- Cost data

The calculator outputs are determined by inputs and certain assumptions which are based on USDA and water conservation district data. The model uses USDA recommended water application levels by crop and soil type. In addition, the algorithm assumes 10% savings based on USDA water requirements for the crop and area.

2.4 Evaluate Cost-Effectiveness of SIS Program Using ProCost

ProCost is a spreadsheet-based tool produced and maintained by the Council. The tool was designed to estimate the system level benefit-cost ratios of energy efficiency measures, aid in program design, and develop conservation supply curves. Navigant used ProCost to calculate the benefit-cost ratio for SIS under various conditions and assumptions in order to determine cost-effectiveness. For a measure to be considered cost-effective, the associated benefit-cost ration as determined by the Total Resource Cost (TRC) test must be at least 1.0, with higher ratios considered preferable.

The primary inputs to the ProCost tool are:

- Energy savings (kWh/acre/year)
- Measure's effective useful life (EUL) (years)
- Capital Cost ($/acre)
- Annual O&M ($/acre)
- Non-Energy Value ($/acre/yr)
- Annual load profile
- Program administrative costs

3 Findings

The evaluation and market research conducted for this investigation address a variety of issues covering both a regional irrigation practices market characterization in general and BPA's SIS offering in particular. Findings are based upon interviews as discussed in Section 2 and are organized into the following broad topic areas:

- Regional irrigation practices
- SIS program findings
- 10 questions posed by BPA in its statement of work

The Navigant research team recognizes that much of the qualitative data contributing to these findings was provided by utilities and service providers whose role in the program (as direct or indirect recipients of BPA incentives) may influence their responses. The researchers did not detect explicit bias on the part of respondents. However, the assessment recognizes that the perspectives of these market actors must be considered in forming conclusions based on the collective responses.

3.1 Regional Irrigation Practices

Findings on regional irrigation practices relate to irrigation of farms in the Northwest and do not necessarily pertain to SIS practices or BPA's SIS program. Findings are grouped into the following categories:

1. Baseline practices and use of moisture meters
2. Use of moisture meters
3. Factors affecting adoption of SIS practices
4. Economic barriers
5. Free ridership
6. Non-energy benefits

3.1.1 Baseline Irrigation Practices

Based on interviews with utilities and service providers, **baseline irrigation management practices vary widely, commonly including either irrigation based on crop-specific USDA recommendations or physical inspection of the surface and subsurface soil conditions.** In its most basic form, soil sampling consists of performing a visual or physical inspection of surface conditions. In some cases, growers may actually dig somewhat deeper into the soil to get a better idea of moisture conditions. This does not provide as detailed information about the moisture conditions at the actual root depth as SIS using moisture meters. In addition, it may be done less on a less regular basis, and so it could be less reliable than SIS.

3.1.2 Use of Moisture Meters

Where SIS is implemented, there are a few different types of moisture meters and related consulting services provided by the local service providers in each area. Services are tailored to grower preference and requirements, although different service providers may have their own preferences and areas of expertise.

Types of Meters

The most common type of moisture meter used for SIS is a neutron probe. This device is inserted into pre-made tubes in the field by a licensed professional to record moisture levels for the soil present. Since the neutron probe includes a radiation source, only a licensed individual is permitted to operate it. This data is then analyzed and added to additional information for that field, such as crop type, soil type and weather patterns. This then provides the grower with a precise recommendation for the quantity of water to provide to the crops. Throughout the growing season, tubes are left in the ground, but the neutron probes are removed when not immediately in use. At the end of the growing season, the tubes and the meters are removed and serviced.

Another method of metering uses real time telemetry probes which are inserted in the ground and left there for the growing season. They read moisture data from the soil every minute, or at another preset interval, and send the information via radio waves to a database which the grower can access in real time. This allows for the grower to have a constant wireless connection to the information needed to monitor the field's needs. Telemetry is not as widely used as the neutron probes.

One of the water conservation districts has provided probes directly to growers. Other utilities have tried providing growers with meters in the past, but have found that they were incorrectly used or lost because the grower had other priorities during the growing season. These are typically tensiometer type probes which can be operated by a small grower without the help of a service provider. Water mark sensors can also be used in this manner, and in some cases growers have sent soil samples to consultants for testing by baking of the soil to assess moisture content.

Cost of Meter Services

Most service providers will tailor their level of service to the needs to the farmer. For neutron probes, a service provider may only visit the field once or twice a week to take readings and to reduce charges to the grower for their services. For real time telemetry, the grower has constant information from their field but may rely on the service provider to provide the information that they need to perform their farming activities. The typical cost per acre for metering varies depending on the type of crop, acreage, and service being used. Service providers that rely on neutron probes quoted a cost per acre of $6.50 to $18.00 or more for their services; a service provider using real-time telemetry (tensiometer probes) charges a flat rate fee of around $1,500

for one year of service in a typical 125 acre circle. The range of costs associated with neutron probes is determined by the number of visits to a particular field that are required per week; this could be from 1 to 3 site visits per week.

Loss and Reuse of Meters

There is approximately a 10% damage rate for the metering equipment per year. Telemetry type meters are only used to serve multiple crops in the same season when the field is double-cropped, such as with peas in the spring and sweet corn in the summer. In these cases, the meters are removed during the harvest of the first crop and then reinserted for the planting of the second crop. The housings for neutron probes are left in the ground for crops which do not require replanting, such as orchards or perennial crops. In these cases, probes can also be permanently installed if appropriate.

3.1.3 Factors Affecting Adoption of SIS Practices

The likelihood of a grower implementing SIS practices is influenced by a variety of factors such as crop value and the water source, both of which directly influence SIS economics. Other important influences include grower familiarity with SIS practices and the availability of service providers.

Crop Value

Crop value and the likelihood of implementing SIS practices are directly related. *Farms harvesting crops with a high market value and profit margin which require detailed irrigation records, specifically potatoes and wine grapes, generally tend to use some form of SIS for their fields.* It is important for these crops to have detailed irrigation records, as some buyers require records. For example, Simplot and Lamb Weston require records from potato growers in order to better assure the quality of the product they are receiving. Also, some growers use irrigation records as a sales tool for potential buyers. For lower value crops, farmers commonly cannot generate sufficiently significant cost savings from SIS to justify the required financial investment.

Water Source/Cost

Growers in areas with ground water conservation districts tend to be highly concerned with water use and are more likely to practice SIS. These regions have made strong pushes to reduce water use and the SIS programs have become an important part of their approach to achieving this goal. Although water conservation districts remain primarily concerned with water use, and BPA is interested in energy savings, it is in these areas where the greatest energy savings are achieved because of pumping lift.

Contrastingly, areas relying primarily on river water are generally much less concerned with reducing water use—with one utility indicating that customers were not charged for water consumption at all in the area. Utilities in river watersheds are generally more concerned with

energy savings and customer service than with water savings; however, the energy savings from SIS in these areas are significantly lower due to minimal pumping requirements.

Some growers are concerned that the states may see the water savings as a benefit to the state and could reduce the farmers' water rights.

SIS Practices and Growers

Growers who are familiar with SIS practices are reported to be more inclined to use them as they begin to see the benefits from controlling water usage. According to several interviewees, growers who first start using SIS generally require two or three seasons to grow accustomed to the process and tend initially to continue over-watering. Service providers act as educators for new users of the technology and help growers to understand that the reduced watering does not reduce crop yields. Growers' feedback to the utilities and service providers about their experiences with SIS typically reflects satisfaction with the improved quality of their crops and appreciation for having someone to assist them with the equipment and monitoring procedures.

Service Provider Availability

SIS service providers play a key role in encouraging growers to use SIS practices and support for program requirements. The irrigation consultants in most areas have been providing SIS to their clients for many years. In some cases, the relationship between the utilities providing the SIS program and the service provider is established because the service provider is already active in the region and the utility uses their knowledge to structure their program and marketing needs. Most growers in the community are aware of the local irrigation consulting and have either used their services before or have been contacted by them to participate in various programs. Service providers also perform most of the work for the utility program application process as well as the final report.

Some of the utilities, particularly ones who had recently signed up for the SIS offering with BPA, indicated that a lack of service providers in the area had been a barrier to implementing SIS practices, both with and without the program offering. The service providers generally indicated that they are continuing to expand their client base. However, movement into entirely new regions is slow since they have no established customer base, available incentives, or grower familiarity with the practices.

Farm Types (Size and Ownership)

There are not reported to be significant relationships between farm size or ownership and the use of SIS on the farm's crops. Farms over 125 acres were more heavily marketed to by service providers, which increased implementation, but in general all growers are motivated by economics.

Farm size was not reported to significantly affect the probability of implementing SIS or requesting an incentive from the utility—at least across the range of medium to large farms.

However, size does appear to influence SIS adoption for the very smallest farms. Utilities and services providers both try to reach as many irrigated farmers in their service area as possible, but are often less successful with farms less than 125 acres because these farmers do not have the financial and physical resources to participate. (Note that SIS Light is targeted at farms 1000 acres or smaller.) In addition it is frequently more difficult for utilities to contact very small farms individually to discuss the benefits of SIS. Many of the utilities and service providers interviewed indicated that they would increase their marketing efforts to smaller farms and those with low-value crops if they had the resources available to do so, including higher incentives and more staff.

With respect to **farm ownership**, SIS participation is almost exclusively farms that are *corporately or family owned, as opposed to leased.* Few utilities have encountered instances where farmers who are leasing property are participating in the SIS program.[2] For those farms that are being leased, according to service providers, the use of SIS practices tends to follow the individual rather than the location; as a result, when the lease expires on the farm space, the farmer will most likely continue to use SIS at his new location while the original acreage likely will no longer use the practice. Service provider contracts tend to be with growers and not with the owners of the fields (unless the owners are also growing their own crops). Often, leased growers move between utility service districts from one year to the next; so even though they may have a contract with the service provider to continue SIS, they do not necessarily participate in the same utility's SIS program.

3.1.4 Economic Barriers

The cost of SIS is reported to be a major barrier, and in particular lack of access to financing for SIS equipment or services. Service providers charge growers based on the level of service that the grower needs in order to fulfill their metering requirements. For example, a grower may choose to use neutron probe metering but only have the service provider take a reading from their fields once a week as opposed to two or three times a week. This will change the amount the grower has to pay the service provider because they are paying for a reduced amount of service. Other variations come from different types of metering equipment, such as real-time telemetry, and from crop variations. In order for a grower to meet the standards required by their utility to apply for the incentive for SIS, they often have to pay service providers for a broad range of metering services and this can range from $8 to $20 an acre. This range of pricing is reported by utilities and service providers to be a strain for growers to meet the upfront cost of metering service.

[2] Only two interviewees indicated that they had encountered cases of a leased farm participating in the SIS program.

In regards to financing, banks lending to growers are reported by one utility to tend not have an understanding of the economic benefits of SIS implementation and consequently are reluctant to provide growers with loans for what may appear to be a non-traditional and non-essential service. Since growers operate heavily on loans for new equipment and services, the incentive programs provide a significant help in this area.

A trend that was observed by utility staff for growers to cope with economic struggles was the decreasing of acreage that growers would sign up for the program. This relieves some of the cost of doing SIS for the growers as they do not have to do the metering process for all of their acreage. This also means that the utility program is not losing individual growers that are signed up from year to year; they are losing acreage that is involved in the incentive program. The net result is that program savings are reduced.

3.1.5 Free Ridership

There is little indication that SIS practices are being widely adopted in the absence of incentives. However, it appears that *free ridership* may be occurring with some high value crops (particularly potatoes and wine grapes). For example, it is reported that many potato growers use SIS technology and practices even without incentives due to two factors: 1) the high value of the crop justifying the expense for relatively small increases in quality and 2) the specific irrigation data requirements from potato buyers.

The introduction of SIS through BPA and other programs has begun to transform the market for SIS services; with service providers available to implement the technology, it is now an option for farmers to use the SIS technology without investing in moisture meters and training. Therefore, even if incentives were removed, there would likely be greater use of SIS than if the program had never existed. It should be noted, however, that service providers reported that the acreage enrolled to use the technology would be greatly reduced without the incentives in place.

Due to the often expensive upfront cost of SIS, the elimination of incentives in the past reportedly caused some growers to reduce the portion of their acreage on which they conduct SIS practices or to eliminate it altogether. In other instances, growers have extrapolated the moisture data they receive on the acreage under SIS to the rest of their crops, therefore participating in the practice but not necessarily receiving detailed information for all acreage involved. This extrapolation does not necessarily lead to optimum water application as conditions can vary widely over the areas involved.

To the extent that agricultural land without SIS equipment is being managed according to farm-specific SIS data, there may be benefits realized from the application of SIS that are out of proportion to (larger than) the acreage where SIS is being applied. This practice may also be occurring on farms participating in BPA's SIS program and thus may lead to spillover savings

that are not accounted for in BPA's records of program acreage. The available information is anecdotal, however, and cannot reliably be used to augment estimated program savings.

Some utilities also expressed an intention to continue to fund the program out of their own budgets even if funding from BPA was withdrawn. One utility has already developed a procedure for funding the SIS program during years when BPA does not offer the SIS program, noting that the utility will continue to provide a version of the SIS program because it "is good for growers and it is important to support best business practices."

3.1.6 Non-energy Benefits

Non-energy benefits are not directly recorded by service providers, but a qualitative understanding of the technology allows growers to make decisions knowing that with better management of their water use, other positive influences will occur during their growing season. All utilities and service providers indicated that they used the SIS Calculator to estimate savings, however, this does not include non-energy benefits beyond water savings. From a qualitative perspective, the non-energy benefits most commonly cited include increased crop quality due to appropriate water application and decreased fertilizer use due to less water pushing nutrients through the soil beyond the plant root zone.

3.2 SIS Program Findings

SIS program findings are specific to BPA's program offering, including both SIS and SIS Light. Findings are grouped into the following categories:

1. Incentives
2. Measure life
3. SIS Light
4. Utility understanding of SIS and SIS Light programs
5. SIS Calculator
6. Average savings from SIS
7. Marketing and recruitment
8. Administration and reporting requirements

3.2.1 Incentives

The cost-sharing provided by the program through direct financial incentives are reported by both service providers and utilities to be an essential benefit without which most growers located within the service territories of the utilities' surveyed would not be able to afford the investment in SIS. Though many farmers are aware of the benefits of SIS, meeting the required financial investment to participate in the SIS program is difficult. Due to the recent poor economy, some participants have dropped the use of SIS because of difficulty securing adequate funding to pay for the metering services. Typically, at the beginning of the year, growers secure financing for expected farm expenses for the year, then repay the bank loans

with the profits. Several utilities and service providers reported that many growers find it difficult to secure the upfront backing for SIS without having a cost-sharing incentive in place.

3.2.2 Measure Life

The vast majority of SIS applications last for only a single growing season despite the required contract between BPA and the participating utilities for a three-year measure life. Energy efficiency practices and measures have limited lifetimes, typically varying from a few years to greater than 10 years, depending on how long related equipment is expected to be used prior to removal or failure. In the case of SIS, the measure life is determined by how long the SIS equipment (specifically moisture meters) remains installed and in use. With a few notable exceptions such as fruit orchards and other perennials, however, crops tend to have a single-season lifetime in any given field. Therefore, the program requirement for a three-year measure life appears to be incompatible with industry practices.

Further anecdotal evidence against a three-year measure life was presented by utilities who claim difficulty in attracting growers to commit to three-years of participation due to the fact that the land for many crops is leased and acreages changes annually.[3]

Utilities are generally delivering their committed acreage each year, but it is at varying locations and they find it difficult to predict how many acres will be involved each year. A one-year program would provide utilities with greater flexibility in enrolled acreage, and it would reduce the difficulty of tracking what acres are being reported under the program. SIS Light, a variation of the standard SIS offering, was introduced in part to address the problems created by the three-year requirement; however, the success of this program alternative has been mixed (see discussion of SIS Light, below).

3.2.3 SIS Light

The SIS Light program offering has not provided a sufficiently distinct and understandable alternative to SIS, and its participation requirements are not being strictly enforced. SIS Light was created with the intention of having a simplified program for farms under 1,000 acres. However, currently each participating utility is signed up to deliver either SIS or SIS Light, but not both. This suggests that for a given utility the program is limited only one size range of farms—or else the eligibility requirements of SIS Light are being overlooked. A few utilities indicated that although they liked the idea of a one-year program, that they were not willing to adopt it (or could not persuade growers to participate) because of the perception that SIS Light

[3] It is not a coincidence that utilities reported that virtually all participants in their programs are growers who own their own land (family-owned or corporate). Growers who lease land face the dual barrier of both single-season crops and also the possibility, if not likelihood, of moving to new land each year, often in a different utilities service territory.

provides reduced savings credits (whereas in practice the credits from participation are equal to the SIS program if equal acreage is conducted by the utility).

Based on the utility interviews conducted for this evaluation, there are *two main disconnects between BPA's intent with the SIS Light program and the utilities' understanding of it:*

1. *Farm size limitations are not being enforced, nor are they clearly understood by the utilities.* It is uncertain exactly how many of the participants fall into this category, but of the three sample files obtained for this review from SIS Light programs, one was for a farm larger than 1,000 acres. One utility staff member called the 1,000 acre limit on the SIS Light program a "nuisance" and indicated that it is often treated as a technicality to be worked around. It is not clear to what extent BPA staff are aware of the ineligible participation.

2. *The utilities do not clearly understand how annual savings are reported.* All of the utilities interviewed about SIS Light indicated a belief that the program provides reduced savings credits, even though it is designed to credit the same savings as the SIS program if the utility conducts the same amount of acreage.

Overall, awareness and understanding of SIS Light are limited among utilities and nearly non-existent among service providers. Only some of the utilities are aware of SIS Light at all, and they lack a complete understanding of the savings calculations and acreage limitations. However, all the utilities indicated that they would prefer SIS Light's one-year commitment, which would better reflect actual practices.

3.2.4 Utility Understanding of SIS and SIS Light Programs

Utilities' understanding of program rules and requirements is limited, particularly with respect to SIS Light. During the interview process, Navigant encountered instances where utility staff was either unable to articulate the specifics of the program or they gave descriptions of the program that did not correlate with documented program requirements. A representative of one utility that had not yet participated in any SIS program said that the company would sign up for SIS Light because, as he describe it, "SIS is a three year program and the growers get paid on the third year" and they want to avoid a situation where growers change hands and the one working the land in the third year gets paid but the growers from the first and second years do not. All utilities who were aware of SIS Light mentioned the three-year commitment of SIS versus the one-year commitment of SIS Light as the notable difference between the two programs. The 1,000 acre requirement of SIS Light was not understood by utility staff, if they were even aware of it.

3.2.5 SIS Calculator

The SIS calculator, described above in Section 2.3 of the Methodology, is a custom tool used to estimate savings from SIS applications. **Both the utilities and service providers indicated that**

although it was not an ideal tool, the calculator is better than anything else they had encountered. Below are findings regarding use of the calculator, the appropriateness of its savings assumptions, and the validity of its algorithms.

Use of the Calculator

There are only a few utilities whose internal staff use the calculator to complete the savings information as most utilities leave the reporting to the service providers. Representatives from the utilities that do use the calculator themselves admit that it is often challenging to enter the data and provide the necessary calculations. This may be because of the inexperience of the utility staff in understanding the necessities of the calculator since they are often not involved in the direct application of SIS and may not be familiar with its intricacies. For the service providers that are familiar with the tool and have observed its evolution over the years, they agree that the current version is much improved over the first version.

Savings Estimates

The SIS calculator allows for inputs of crop type, soil type, pumping height, pump type, pump horsepower, water applied, and discharge pressure. It contains data on soil drainage from multiple sources, as well as suggested data on water application by crop type. Much of this data is from the USDA databases, but data from more local sources such as Oregon State University (OSU) are also included.

Since there is significant data available on current water application once SIS is implemented, and on recommended water application from USDA, the only major assumptions being made by the software are 1) what the grower would have done in the absence of SIS methodology and 2) the percent reduction of water use due to SIS. The package currently assumes that USDA recommendations would have been followed, which is consistent with the baseline findings of this evaluation and provides for a relatively conservative savings estimate since actual practices without SIS may be, on average, less efficient than those recommended by USDA because it is reported that growers tend to overwater. It should be noted, however, that the greatest source of uncertainty may lie in the fixed estimate used by the calculator that savings are 10% of recommended water use according to USDA guidelines. Previous studies found savings between 10 and 12%.[4] This may be a conservative value, as one interviewee reported studies showing savings of 17% within his service territory, and the industry expert interviewed indicated up to 20% savings.

[4] Irrigation Scheduling Practices in the Northwest Phase II Report, Quantec, 2005.

Updates/Improvements

Overall, the utilities and service providers strongly supported keeping the calculator as it currently is. They would prefer that it remain unchanged rather than modified for minor potential improvements. However, it would simplify the overall program savings calculations to include primary and secondary pumping savings in the calculator output; these savings must currently be added outside of the calculator. Since the inputs to the calculator include both location and water source, this should not require any changes to user inputs. The additional savings could be listed separately from the current tertiary savings in the output to prevent confusion.

Some service providers with orchard crops in their client base indicate that the calculator does not appropriately reflect the crops or the irrigation systems used for that grower profile, particularly because the type of irrigation systems are different and the crops are perennial rather than annual. This possible shortfall in the calculator algorithms may be remedied through review of the overall savings estimate, as discussed above and included in the recommendations section of this report.

In addition, there are several additional areas for improvement in the calculator:

1. Version 2 of the calculator was "locked" to edits and used a Macro for calculations. Removal of the Macro in Version 3 has improved usability, but it has left the cells unlocked, which could result in errors if a user makes changes to the cells.

2. Several of the inputs, "Water Level in Soil Profile (%)" and "Effective Precipitation Adjustment Factor (%)", are entered in percentages (enter 100 for 100%), whereas "Attainable Application Efficiency (%)" is entered as a fraction (0.8 entered for 80%). This inconsistency could lead to data entry errors with significant impact on the results.

3. A pop-up menu appears if the user enters a value outside of the allowed range, stating "The value should be within the suggested range listed in the cell above. The range above represents the lower and upper bounds of efficiency for this system type." If the value entered is within the expected range, no additional details or instructions are provided. This allows users control over a value that they generally do not have any data to support.

Alternatives to the Calculator

There are currently no viable alternative to using the SIS calculator. OSU has been developing a website to provide growers with a significant amount of information, including water and energy savings from the use of SIS practices. The OSU website is not yet operational and could not be reviewed for comparison, but it is expected to eventually provide a good source of comparison for the SIS Calculator.

3.2.6 Average Savings from SIS

In 2008 BPA found an average savings of 220 kWh/acre based on the average of the SIS Calculator savings from 2006-2008. This value was used as the deemed savings value for the SIS Light program. However, the value appears to have been based on a straight average of the three years' per-acre savings. Calculating a more appropriate weighted average (total savings divided by total acres) for 2006-2008 yields a savings estimate of 205 kWh/acre per year. Using all available acres at the time of this report, the average is now 200 kWh/acre, including 2009 and 2010 to date.

3.2.7 Marketing and Recruitment

The majority of the utilities rely on service providers, including water management and conservation districts, to contact growers and educate them about the services since they are familiar with both grower needs and the available services. In addition, the service providers have a financial incentive to increase market participation in SIS practices and so are motivated to expand its usage. The utilities relying on water conservation districts to administer the program leave marketing activities to the conservation districts, which have the directive to reduce water consumption.

3.2.8 Administration and Reporting Requirements

The utilities' primary complaint about program administration was the timing of the reporting. In particular, this last year was the High Water Mark year and both a report and an addendum had to be filed. Utilities generally accepted that this was unavoidable, but it does introduce a burden, particularly on smaller utilities with limited staff. The majority of the paperwork, which consisted of reports, was actually written by service providers and provided by them to both the utilities and BPA. These reports included details of SIS implementation for each participating grower and SIS Calculator outputs showing savings for those growers.

3.3 Summary Responses to "Ten Questions" Posed by BPA

In its Statement of Work for this evaluation, BPA requested that "in addition to information on general market climate and practices," the research should target responses to a set of ten questions that had been identified as areas of interest by BPA staff. Many of these questions are answered and explained indirectly in the discussions earlier in this chapter. A concise response to each question is provided in Table 5 below.

Table 5. Summary of Key Findings

Key Question	Summary
1. **Are there differences in the practices between small/medium and large farms?**	**There are no significant differences reported in SIS implementation between farms of varying sizes,** although the smallest farms (<200 acres) are less likely to perform SIS since they are limited by cost and physical resources. Larger farms tend to have the staff available to assist with SIS practices as well as the financial means to pay for the upfront costs of implementation. Service providers may tailor their assistance to the needs of the grower, such as offering to take fewer weekly meter reads for a small farm to keep costs down.
2. **How many growers are now doing SIS on their own (true nonparticipants)?**	**There are few growers implementing SIS without participating in a cost sharing program.** Potato farmers are the only group consistently reported by survey respondents as using SIS regardless of whether incentives are offered; this is due to the relatively high value of the crop and the requirements of buyers for proper irrigation records to guarantee product quality. Proper water application at specific times during growth of potatoes can enhance the sugar content and that can influence the quality of the ultimate food product (e.g., French fries).
3. **How many past or current participants have expanded the use of SIS to other crops on their own?**	**There is little evidence to indicate that the presence of spillover via participants in BPA's SIS program expanding use of SIS, or former participants continuing SIS, without incentives.** However, some growers may use SIS on one section of their farm, and then extrapolate the data they receive to their other crops and mimic watering procedures. Thus, participation may generate water savings that are not captured in program records. Therefore savings may be higher than reported.
4. **What crops are most commonly chosen for SIS and for what reasons (market value, crop quality, etc)?**	**The crops that have the highest market value as well as the need for consistent crop quality (e.g., wine grapes) are the most commonly chosen crops for SIS.** In general, the most common crops are potatoes, alfalfa, corn, wheat, and peas. The applicability of this generalization varies according to the geographic area where the crops are grown. For example, cherries are common in the Dalles Irrigation District but not in other regions.
5. **What happens to the soil moisture meters at the end of the season? Do they reuse them even if they don't get BPA incentives?**	**Soil moisture meters are generally removed and serviced for re-use at the end of the growing season, although they will typically not be used in the same fields.** They are only kept in place in situations where the crops do not change on an annual basis, such as with orchard trees. Thus, while the meters themselves typically are re-used, there is unlikely to be any spillover resulting from "leftover" meters remaining in place after incentives have been terminated. That is, service providers re-use the meters and therefore the costs are included/integrated into their cost of service.

Key Question	Summary
6. What is the true measure life of SIS?	**One year.** In practice, growers (and the service providers assisting them) generally use moisture meters and SIS practices for single-year cycles on a given crop. Utilities meet their three-year commitments to BPA by re-enrolling growers each year (many with new crops and/or new locations) or enrolling previously non-participating growers such that the total acreage addressed by the utility programs is sufficient to fulfill obligations to BPA.
7. What is the annual incremental savings?	Varies greatly with crop and water source. BPA's deemed value of 220 kWh/acre per year was based on an unweighted average of savings in 2006 through 2008. The weighted average savings, based on all data provided to BPA through September 2010, is 200 kWh/acre per year.
8. Are there other non-energy benefits that can be quantified that are not currently? (e.g., better crop, less mold, fungus etc, better nutrient management)	**Most non-energy benefits are not quantified by service providers but they are verbalized by growers who note the changes in crop quality when properly using SIS.** One benefit that could be quantified is the presence of fertilizer in the soil. Over-watering can push nutrients through the soil and away from the roots of the crops. With better water management, less fertilizer is needed during the growing season.
9. What is the SIS program offer relationship with USDA rebates?	**The USDA's EQIP program only applies to growers in their first attempts at IWM, and after a few years of participating, growers no long qualify for EQIP funding. This is often the point when growers sign up to participate in the SIS program**—in order that they can continue to receive cost sharing for their efforts.
10. Do some organizations (e.g., Lamb Weston, etc) require accurate irrigation records and IWM?	**Yes. Simplot** is a large agribusiness firm that purchases raw foods to create processed meals and they require irrigation records from their contracted **potato farmers**. Some **wine grape** buyers also require irrigation records because the amount of water supplied to the grape vines during their growth can alter the quality and flavor of the grapes. Anecdotal evidence suggests that growers of several other crops are now using irrigation records as a sales tool for potential buyers.

4 Cost-effectiveness

The cost-effectiveness assessment performed for this program evaluation focuses primarily on measure-level benefits associated with SIS applications on farms in the Northwest. The information provided can be used by BPA to assess which crops or regions may provide the greatest benefits from incentives that encourage additional acreage to be farmed using SIS practices. It can also form the basis of additional analysis, incorporating BPA program costs and sensitivity analyses, to determine whether the SIS program is cost-effective with an assumed measure life as short as one year

Program cost-effectiveness is a measure of how much the SIS program's benefits exceed the costs, either in levelized dollar terms or, more commonly, as a benefit-to-cost ratio. Identification of benefits and costs implicitly requires that the assessment assign values according to one or more perspectives—the most common being an all-inclusive perspective that accounts for all stakeholders including BPA, growers, service providers, and non-participating customers. This "regional" perspective is captured in the Total Resource Cost test. Other viewpoints of interest include those focused solely on BPA (Program Administrator test) and on participating growers (Participant test).[5]

In all of these examples, the assessment is performed over an established period of time typically corresponding to the period the program is expected to operate. At a minimum, the analysis horizon usually spans at least the life of a program measure, since the continuing benefits of the measure can be realized without additional upfront capital costs or infrastructure investment.

On an incremental measure basis, the costs include the capital and operational costs of implementing SIS. Incentives and program administration costs are not considered for the measure-level analysis. Benefits include the savings from reduced electrical pumping needs and non-energy benefits which, in this case, are primarily the cost savings from reduced use of fertilizer. These relevant cost and benefit categories are provided in Table 6.

[5] For a discussion of these and other commonly used cost-effectiveness tests, see *California Standard Practice Manual,* California Public Utilities Commission, 2001.

Table 6. Costs and Benefits for Measure-Level Analysis

Cost Categories	Sources of Regional Benefits
Capital cost for meters	Reduced electrical pumping (both system and on-farm pumping)
Operational costs of soil moisture measurement and reporting/communication	Cost savings from reduced use of fertilizer

Costs may vary between SIS applications and are difficult to state with certainty, but they are fairly straightforward and can be obtained through secondary research and the experience of growers and service providers implementing SIS. By default ProCost assumes 20% of total measure cost for program costs, which is also used in calculations for this report.

Estimation of benefits is more complex and uncertain due to the fact that the most direct benefit—reduction in irrigation water consumption—is difficult to measure due to uncertain baseline conditions (i.e., even if water consumption is measured, it is not known with certainty how much water would have been used in the absence of the SIS measures). And it is the reduction in water requirements for irrigation that provide the principal electricity benefits through reduced pumping needs both on the farm and at regional pumping stations. A related uncertainty in estimating benefits stems from identification of the type of pumping (if any) used to provide irrigation water to grower using SIS and the corresponding energy requirements on the basis of acre-inches saved.

Below is a discussion of the factors influencing benefits of SIS followed by an analysis of estimated energy savings using the SIS calculator for a variety of crop types and sub-regions. The SIS calculator is designed to determine savings due to reductions in water use with SIS. It specifically includes only tertiary pumping energy, which is used to distribute water on a farm, not primary and secondary pumping. In the Columbia Basin there is a significant amount of pumping energy used for both primary and secondary pumping, and this must be added in separately from the SIS Calculator. Primary pumping in this region is from Lake Roosevelt to Banks Lake reservoir[6] and secondary pumping accounts for distribution from there throughout the region[7].

[6] Primary pumping is estimated to use 1,085 kWh/acre-ft, and 20% in-field savings are assumed per "User's Manual V2_022007.doc"

[7] Secondary pumping is estimated to use 230 kWh/acre-ft, and 20% in-field savings are assumed per "User's Manual V2_022007.doc"

4.1 *Influences on SIS Benefits*

The purpose of this section is to confirm that the SIS Calculator appears to appropriately estimate energy and water savings based upon a variety of inputs and assumptions. This review also characterizes how estimated savings can vary with these parameters. The analysis provides a foundation upon which program improvement recommendations are based.

4.1.1 Water Source

The lift height from the water source to an irrigated field is the primary determining factor as to how much pumping energy is used for water transport. For the Columbia River Basin, the main source for water is the use of deep wells, and in the past growers could pump practically as much water as needed. Now, due to a critical ground water shortage, according to water conservation district personnel, all growers in the ground water districts must implement some form of water conservation as mandated by the regional Watermaster. For most areas where water has become a growing scarcity, the increase in Irrigation Water Management practices has been driven by this basic need for water conservation.

Outside of the Columbia River Basin, where water is more commonly supplied from river or other local surface sources, growers are not required to engage in water conservation activities. In some utility districts there is still no charge for irrigation water, beyond on-farm pumping costs.

Table 7 shows the breakdown of water source in the Northwest. As shown, nearly half of irrigation water comes from relatively shallow local surface source, with the two remaining quarters nearly equally divided between river and well water. Pumping lift requirements range from near zero for river/gravity feed sources to more than 100 feet of lift, on average, for wells. A weighted average of pumping gives a typical lift of 42 feet, which was used for the estimates of energy savings using the SIS calculator.

Table 7. Northwest Irrigation Water Distribution[8]

Water Source	Acres Irrigated	Acre-Feet Applied	% Water Applied	Average Pumping Lift
River/Gravity Feed	1,767,379	3,458,820	26%	0
Ground/Surface	3,188,741	6,240,472	47%	27
Wells	1,959,888	3,633,106	27%	108
Total	6,916,008	13,332,398	100%	42

Source: USDA

[8] USDA Census of Agriculture, *2008 Farm and Ranch Irrigation Survey*, updated July 2010.

4.1.2 Soil Type

In addition to water source, the cost-effectiveness of SIS is determined by how much water would need to be applied to a crop. This value is determined by a combination of crop type and soil type. While different crops require different amounts of moisture at different depths, how well the soil maintains moisture also varies. The water holding capacity of arable soil varies from a high of 2.4 in/ft for clay loam and silt loam to a low of 0.75 in/ft for fine sand.[9] The higher the water retention of the soil, the better water retention, and therefore less water needs to be applied for irrigation. In general, higher water retention soils are preferred for growing and very little irrigated acreage is in extremely sandy soil. Although SIS would be more cost-effective in lower water retention soils because of increased irrigation, and therefore pumping, requirements, average B/C estimates overall assumed a higher water holding capacity since this is more common.

4.1.3 Crop Type

For crops that have a high market value[10] it is often cost-effective for growers to implement SIS practices. Because the relatively high cost of implementing SIS is offset by the profit margin of the high value crops, it is more economically viable for growers to use it in these cases. It is also cost-effective for crops that have sensitive water requirements, such as wine grapes and potatoes. Since the amount of water applied to these crops at different stages of growth can dramatically affect their quality, it is quite important to appropriately measure the amount of water used to grow these crops.

One service provider was focused solely on cherries. This was one of the few crops that did not use center pivot irrigation, as it is impractical for trees. Fruit crops have a high value and, unlike most other crops, remain in the same field for many years. Because of the high value of the crop and year-to-year certainty of its acreage, SIS tends to be highly cost-effective for the grower. However, due to small fields (e.g., 20 acres) the cost per acre is extremely high. Since the service providers charge growers annually, however, the year-to-year costs of SIS do not change for the growers.

The crops for which SIS saves the most energy are those which have the highest water requirements. Alfalfa is a particularly water intensive crop which is commonly chosen for SIS.

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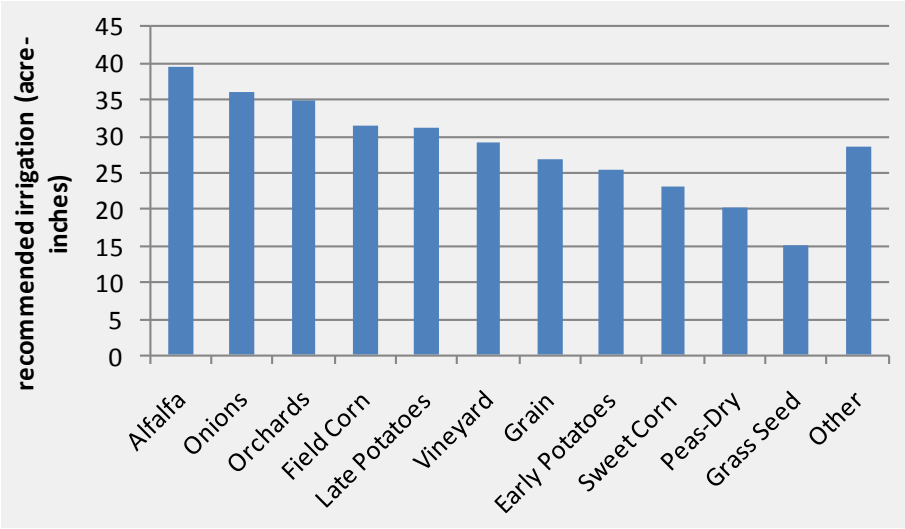
[9] Sand alone has a water holding capacity of 0.25 in/ft. However, that is not included in this analysis because it is not expected that agricultural crops will be grown in sand.

[10] The perception of what is a high value crop varies regionally. In the Northwest high value crops consist primarily of fruits, nuts, and vegetables as well as corn and alfalfa. In the current areas of BPA's SIS program offering, the most common of these are potatoes and alfalfa; however wine grapes, cherries, corn, and various root vegetables are also receiving incentives under the program. Each utility or service provider emphasizes the high value crops most commonly grown in their own service territory.

Potatoes are not as water intensive. Grass seed is the least cost-effective choice as it has low water use, however this is not a common choice for SIS because of its low crop value. Figure 1 shows the different recommendations for water application by crop. The lower the water use, the less cost-effective SIS is, because of the relatively low pumping requirements with minimal water application.

Figure 2. Typical Irrigation Gross Water Requirement per Season, Weighted by Acreage & Region



Source: USDA and others[11]

4.2 Benefit-Cost Testing

In order to establish measure level cost-effectiveness, benefit-cost testing was performed using the ProCost tool developed by the Council. Key inputs are as follows:

- **Energy savings** are assumed to be the 200 kWh/acre incremental energy savings from representing the average savings for the SIS program for the past several years as calculated by the deemed calculator.

- **Incremental costs** are based on the Northwest Power and Conservation Council's 6th Plan supply curves which estimate per acre cost at $13.56 each year. This is consistent with the service provider interviews conducted for this study and average in the range of $12 to $15 per year for the grower. This cost is taken to be a proxy for the true cost of SIS implementation, which would include capital costs of meters and actual implementation costs for the service providers.

[11] SIS_IWMCost_Effectiveness.xls, values derived from the Washington Irrigation Guide - USDA, NRCS, & WSU

- **Non-energy value** is derived from external avoided costs such as reduced fertilizer needs and embedded value of the water saved. A study conducted by the Columbia Basin GWMA showed that the expected reduction in fertilizer was 15 pounds per acre; the average cost of fertilizer was estimated at $0.40 per pound.[12] For the purposes of this evaluation, a benefit cost ratio was calculated both with and without the inclusion of this $6/acre, which is based on the Northwest Power and Conservation Council's estimates.

- **Measure effective useful lifetime (EUL)** was based on utility and service provider interviews, as described in the findings section of this report, and set to one year.

- **Annual load profile** associated with crop irrigation is provided in a dataset accompanying ProCost.[13]

These input values and their sources are provided in Table 8.

Table 8. ProCost Inputs for Measure Level Benefit Cost Analysis

Inputs	Value	Units	Source/Rational
Energy savings	200	kWh/acre/year	"Impact Evaluation of Columbia Basin Pilot Irrigation Water Management Project" Quantec, 2007
Capital Cost	$13.56	$/acre	Northwest Power and Conservation Council, 6th Power Plan Supply curves
Non-Energy Value	$6.00	$/acre/yr	Fertilizer - 15lb/ac @ $0.40/lb; "Impact Evaluation of Columbia Basin Pilot Irrigation Water Management Project" Quantec, 2007 and Northwest Power and Conservation Council, 6th Power Plan Supply curves
Measure EUL	1	years	Service provider interviews
Annual load profile	AgrIRRG	-	MC_LoadProfile - ProCost supporting file, Council

When run in ProCost, the inputs stated in Table 8 indicated a benefit-cost ratio for SIS of 1.3, suggesting that for a typical farm in the region, benefits are more than costs. If the non-energy benefits are excluded, the ratio drops to 0.9. Including non-energy benefits (which is appropriate for Total Resource Cost testing), SIS is cost-effective at the measure level, assuming a one-year measure life and 200 savings of kWh/acre and a cost of $13.56/acre annually. If the savings are less than approximately 130 kWh/acre, SIS is no longer cost-effective.

[12] Final Evaluation of GWMA Irrigation Scheduling Pilot Project, Quantec 2005

[13] The load profile spreadsheet "AgrIRRG" has the filename "MC_AND_LOADSHAPE_6P_USEME.XLS.

For a true regionally appropriate TRC, the impacts of program administrative costs and additional benefits (e.g., risk mitigation) would also be included. However, at this time the appropriate values for these inputs are still under review.

5 Summary and Recommendations

A summary of findings is presented below, followed by identification and discussion of recommendations for improvements to program design and delivery.

5.1 Summary of Findings

Navigant Consulting reviewed the available program literature, databases, customer satisfaction reports, and RTF decisions. This data was used to inform the interviews with utilities, service providers, and other industry experts. The regional market was reported to be dependent upon available incentives in order to continue and expand the use of SIS. This was due to the combined upfront cost of services and implementation exceeding the budget of a typical grower. Participating growers have responded positively to use of SIS, indicating better crop quality and reduced consumables. This has contributed to increased awareness of the practice as growers inform each other of positive results.

The utilities and service providers value the program highly and plan to continue participation, but they indicated confusion over program rules (such as how savings accrue over three years) and expressed concerns about the program's long term stability due to interruptions in the past. In particular, they do not like the uncertainties involved with a program that may not be renewed and find dealing with changes in reporting requirements or the SIS calculator to be burdensome.

A summary of major findings is provided in Table 9.

Table 9. Summary of Interview Findings

Regional Irrigation Practices	
Baseline Irrigation Practices	Irrigation practices vary widely, but commonly include either irrigation based on crop-specific USDA recommendations or physical inspection of surface soil conditions.
Use of Moisture Meters	Where SIS is performed, the most common type of moisture meter is a neutron probe, which is removed annually and reused by service providers. Telemetry probes are more expensive but can reduce the operating/labor costs associated with obtaining moisture readings.
Factors Affecting Adoption of SIS Practices	The likelihood of a grower implementing SIS practices is influenced by a variety of factors such as crop value and the water source, both of which directly influence SIS economics.
Economic Barriers	The cost of SIS is a major barrier, and in particular lack of access to financing for SIS equipment or services.
Free Ridership	There is little indication that SIS practices are being widely adopted in the absence of incentives, and thus free ridership is likely low. The introduction of SIS through BPA and other programs has helped to establish service providers, without whom many farmers would not have the option to use the SIS technology without investing in moisture meters and training.
Non-energy Benefits	Non-energy benefits are not directly recorded by service providers, but a qualitative understanding of the technology allows growers to understand that with better management of their water use, other positive influences will occur during their growing season.
SIS Program Practices	
Incentives	The cost-sharing provided by the program through direct financial incentives is an essential benefit without which most growers located within the service territories of the utilities' surveyed would not be able to afford the investment in SIS.
Measure Life	The vast majority of SIS applications last for only a single growing season despite the required contract between BPA and the participating utilities for a three-year measure life.
SIS Light	The SIS Light program offering has not provided a sufficiently distinct and understandable alternative to SIS, and its participation requirements are not being strictly enforced.
Utility Understanding of SIS & SIS Light Programs	Utilities' understanding of program rules and requirements is limited, particularly with respect to SIS Light.
SIS Calculator	Both the utilities and service providers indicated that although it was not an ideal tool, the calculator is better than anything else they had encountered.
Marketing and Recruitment	The majority of the utilities rely on service providers, including water management and conservation districts, to contact growers and educate them about the services
Administration and Reporting Requirements	The utilities' primary complaint about program administration was the timing of the reporting.

Source: Navigant Consulting

5.2 Recommendations

This section addresses BPA's request in its Statement of Work to "provide recommendations for methods to improve program delivery of SIS program (including SIS Light)." The recommendations are based on findings from secondary research, interviews, the calculator review, and the cost-effectiveness assessment, all of which were described above.

Recommendations are grouped into four categories covering the following topics:

1. Program structure and incentives
2. SIS Energy Savings Calculator
3. Program outreach
4. Program administration

A summary of the recommendations is provided in Table 10, which also indicates whether the recommendation is a "Quick Fix" that can be addressed unilaterally and relatively easily by BPA, a "Strategic or Technical Effort" that may require a matter of months to implement, or a "Longer-Term Structural Change" that may require a longer period and/or coordination with the RTF or utilities.

Table 10. SIS Program Recommendations

Recommendation	Timeframe/Complexity		
	Quick Fix	Strategic or Technical Effort	Longer-Term Structural Change
Program Structure and Incentives			
R1. Reduce the required measure life to one year for some or all SIS applications.		✓	
R2. Merge SIS Light and SIS into a single offering.	✓		
R3. Reduce the deemed savings value for SIS Light from 220 kWh/acre/year to 200 kWh/acre/year (if SIS Light is continued).	✓		
R4. Maintain the SIS program and incentives without interruption.	✓		
R5. Assess practical and political feasibility of a tiered system of incentives based on value to the region.		✓	
R6. Limit or modify incentives to account for systematic free ridership.		✓	
R7. Convene a task force to develop the new tiered incentive structure and eligibility requirements.	✓		
SIS Calculator			
R8. Add estimates of primary and secondary pumping effects in Columbia Basin.			✓
R9. Acquire available existing research on actual savings from SIS implementation to adjust SIS Calculator savings estimates.		✓	
R10. Modify calculator inputs to reduce the possibility of data entry error.	✓		
R11. Revisit SIS impacts for perennial crops such as fruit trees.			✓
R12. Review Oregon State University data when available.	✓		
Program Outreach			
R13. Improve marketing and education to utilities.	✓		
R14. Promote the program in districts relying primarily on groundwater.		✓	
R15. Expand service provider network to reach underserved areas.			✓
Program Administration			
R16. Develop a master database of SIS program participation data.			✓
R17. Enhance internal BPA staff coordination regarding program design, administration, and field services.		✓	

Source: Navigant Consulting

5.2.1 Program Structure and Incentives

R1. **Reduce the required measure life to one year for some or all SIS applications.** Growers are more likely to adopt SIS practices if the program requirements and incentive structure are aligned with the range of growing practices in the region. This includes lowering the measure life from its current three years to a single year to reflect the realities of seasonal farming practices and the transient nature of growers who lease farmland. In practice, the SIS program is routinely treated as a one-year engagement by growers, and it is primarily the utilities that must comply with BPA three-year requirement (see Section 3.2 of the Findings).

BPA's original rationale for the three-year measure life was one of cost-effectiveness: that three years were required to allow the annual savings to offset the annual costs.

R2. Merge SIS Light into SIS offering. Although the SIS Light program offering was created to provide utilities with a simpler program for farms less than 1,000 acres in size, it is not being treated that way. The utilities are primarily interested in it because of the one year commitment, but are often confused by the distribution of savings over a three year period. If the SIS program offering were shifted to a one year measure life and commitment (see previous recommendation), the SIS Light program could be eliminated and utilities encouraged to switch to the modified SIS offering. There may be some lesser benefits from SIS Light's reduced reporting requirements in the PTR, but if a one-year option is available through the full program, then there is relatively little need for a separate SIS Light offering.

R3. Reduce the deemed savings value for SIS Light from 220 kWh/acre per year to 200 kWh/acre per year (if SIS Light is continued). The deemed value was based on average SIS program savings estimated by the SIS calculator in 2006 through 2008. However, the value appears to have been based on a straight average of the three years' per-acre savings. Using a more appropriate weighted average (total savings divided by total acres) and incorporating all reported savings to date produces an annual savings value of 200 kWh/acre.

R4. **Maintain the SIS program and incentives without interruption.** Growers depend heavily on the SIS incentive to help defray their costs for irrigation water management. Without incentive programs use would likely drop significantly, with growers using fewer SIS measurement locations and trying to extrapolate data to additional fields. Fewer growers would likely participate as well, further reducing the overall use of the technology. Growers operate on a year-to-year basis and use bank loans to finance much of their operations. Banks are unfamiliar with SIS technologies and their benefits to farm operations and so do not loan on SIS equipment, making the incentive programs more indispensible to growers. In addition, there was a strong sentiment that discontinuing

and restarting the program (as was done in the past) created difficulties for growers and service providers who are more inclined to invest the initial capital for meters when they are confident that incentives will be available in future years.

R5. **Assess practical and political feasibility of a tiered system of incentives based on the regional value of the SIS applications.** On each farm and within each of the various regions within BPA's service territory there are different irrigation pumping requirements per acre of farmed land due to the water source, crop type, soil type, region/climate, and other factors.[14] Correspondingly, there are varying levels of electricity savings. Tiered incentives would be based on one or more of the above factors and would provide greater incentives for those growers whose use of SIS is associated with greater regional benefits. A simple structure is recommended, such as a matrix of two or three of the above attributes to create a finite number of combinations, each of which *could* have unique incentive value. For simplicity, a limited number of unique incentive values are recommended (e.g., low, medium, and high) and would be based *roughly* on the anticipated savings from SIS on a farm with the relevant attributes, as estimated by the SIS calculator.[15]

BPA could also allow for growers to apply for exceptions to the prescribed incentive level (i.e., receiving the next higher level of incentive) based on unique circumstances or soil with especially low water retention capacities. The burden of proof would rest with the grower. BPA would have to consider the potential administrative burden of allowing exceptions before incorporating this policy into the program.

R6. **Limit or modify incentives to account for systematic free ridership.** Growers of some high-value crops, particularly potatoes and grapes, often employ SIS practices even without the availability of incentives. Although the gross savings from SIS in these cases are likely to be high, the net impact on water and electricity use for the region may be low since the increase in acreage under SIS management is significantly less than the number of acres for which incentives are provided. This suggests that it may be

[14] For example, for a given amount of irrigation water, the onsite electrical pumping requirements of a farm using groundwater will vary according to the required lift, and the electrical pumping requirements for a farm using system irrigation water will depend on the water basin and the specific source of the water. Similarly, the amount of irrigation required (and therefore the pumping requirements) will depend on factors such crop type, soil type, and climate.

[15] Utilities in Texas follow the mandate of the Public Utility Commission of Texas by offering incentives for energy efficiency measures in direct proportion to the savings deemed to accrue from installation or application of the measures. Utilities may offer lower incentives, but the amount is capped at the avoided of the capacity and energy saved by the measure. See http://www.puc.state.tx.us/rules/subrules/electric/25.181/25.181.pdf.

appropriate to exclude certain crops from the program or to reduce the level of incentive available for specific crops. This would be consistent with the concept of tiered incentives (see above), which are intended to relate incentive levels to regional benefits. If a tiered incentive structure is adopted, crops with expected high levels of free ridership could be placed in an incentive tier lower than would otherwise be warranted based on their expected gross savings. At the extreme, a crop could be declared ineligible for incentives.

R7. **Convene a task force with a defined objective and timeframe to develop the new tiered incentive structure and eligibility requirements discussed in Recommendations R5 and R6 above.** Restructuring of incentive levels or eligibility requirements may warrant a decision-making process that involves stakeholders from both within and outside of BPA, including RTF members, utilities, growers, and service providers. Modifications to the existing program should be kept as simple and transparent as possible.

5.2.2 SIS Calculator

R8. **Add estimates of primary and secondary pumping effects in Columbia Basin.** The SIS calculator is generally a robust tool, to which the service providers and utilities have become accustomed. Its inputs are based upon data available at the time of its creation and its calculation algorithms are appropriate**.** The SIS Calculator could be modified to include the primary and secondary pumping savings in the Columbia Basin. Since the inputs to the Calculator include both location and water source this should be simple to implement. The savings should, however, be listed separately so they are not confused with the tertiary savings currently given by the Calculator.

R9. **Acquire available existing research on actual savings from SIS implementation to adjust SIS calculator savings estimates.** Many service providers believe that the program calculator does not accurately reflect savings for all crops under varying conditions. According to a representative of one of the Water Management and Conservation Districts, savings are substantially higher than those calculated by the program: by approximately 7% of USDA recommended irrigation levels (a 17% water reduction rather than the 10% reduction incorporated into the calculator), based on calculations made with approximately 15,000 field records. The calculator maintains a conservative estimate of savings and while this is appropriate in the absence of better data, the savings assumption could be adjusted upward in regions or applications types where more information is available.

R10. **Modify calculator inputs to reduce the possibility of data entry error.** The findings presented earlier in this evaluation identified three areas for improvement in how data

is entered and accepted in the calculator (see page 29). The fixes are straightforward could prevent erroneous savings estimates.

R11. **Revisit SIS impacts for perennial crops such as fruit trees.** Due to service provider concerns that the SIS calculator generated savings estimates for these crops seems particularly low relative to their trend data (see Findings section 3.2), a follow up analysis targeted specifically at these crops and associated irrigation effectiveness should be performed. However, it is possible that addressing the overall conservativeness of the savings estimate (recommendation above) may indirectly assuage this more specific concern as well.

R12. **Review Oregon State University data when available.** Oregon State University is developing a website for comprehensive economic advice to growers, including savings and cost estimates for SIS. The website is not yet publically available, but it should be reviewed for comparison to the program and possible incorporation into SIS calculations when it becomes available.

5.2.3 Program Outreach

R13. **Improve Marketing and Education to Utilities.** There is a disconnect between many utilities' understanding of program requirements, such as measure life and farm size, and the official program design. BPA should focus on education of current participating utilities as to the actual requirements, and ensure that marketing materials, utility workshops, or other outreach clearly describes the most important elements, such as incentives for SIS Light (if it is offered in future incarnations of the program) where confusion may be preventing greater participation. Any changes to program rules, including a one-year measure life, tiered incentives, or limited eligibility, should be clearly and strongly communicated both to existing participants directly and in marketing and program outreach materials.

R14. **Promote the program in districts relying primarily on groundwater.** Because of the increased benefits from reduced pumping, it is most cost-effective for BPA and the region when SIS is implemented in groundwater areas with high lift requirements. Water use reductions are also more important in these areas and may result in significant cost savings to participating growers, thus providing growers with additional economic incentive to use SIS. Ideally SIS program promotion should be coordinated with service provider availability to ensure that interested growers have the assistance they need to undertake what may be a cost-effective but complicated endeavor. If a tiered incentive structure is adopted, growers in groundwater districts may be eligible for relatively high incentive levels, which would further encourage their participation.

R15. **Expand service provider network to reach underserved areas.** There appears to be an insufficient infrastructure for SIS services regionally, which may be limiting market penetration. The majority of utility service territories served by BPA do not currently offer the SIS program, and some recently enrolled utilities indicated a lack of available service providers in the area. There appears to be a correlation between utilities enrolling in the program and service providers in the area. Although some growers who receive SIS incentives on their land in one service territory do use these methods in other areas, service providers indicated that generally there is minimal participation outside of utilities with available incentives. BPA should assist service providers to expand their territories (possibly through training courses for technicians), or train new service providers in underserved areas, which would facilitate utilities' adoption of SIS program offerings.

5.2.4 Program Administration

R16. **Develop a master database of SIS program participation data.** The existing summary spreadsheets provide by BPA provide savings data by year and utility. However, review of program savings by crop and other parameters was difficult because program documentation is currently stored in hardcopy format in BPA's Walla Walla office. Creating a simple spreadsheet or database via online data entry for utilities to enter farm name, size, crop type and acres, and savings into would greatly simplify program review and tracking. Once developed and populated using existing records, the database would be relatively easy to update and maintain as part of utility filing procedures.

R17. **Enhance internal BPA staff coordination regarding program design, administration, and field services.** The knowledge of BPA field staff regarding the applications of SIS technology and typical program practices could be better utilized by BPA on a routine basis, outside the context of a program evaluation. For example, the fact that apparently ineligible farms are participating in SIS Light could be raised internally at BPA so that actions can be taken to either enforce or modify program parameters.-Where feasible, BPA should work to align program requirements with realistic conditions in the service territories.

NAVIGANT

Appendix A - Interview Guides

2010 SIS/SIS Light Program Evaluation

Utility Interview Guide

Contact Name:	
Contact Email:	
Company Name:	
Company Phone:	
Company Address:	
Today's Date & Time:	
Scheduled Date & Time:	
Interviewer:	
Notes:	

Note: Utilities are either involved in SIS OR SIS Light, not both. The noted questions should be asked as one or the other once the correct program is determined.

INTRODUCTION

Hello, my name is [INSERT NAME] with Navigant Consulting and I am contacting you on behalf of Bonneville Power Administration (BPA). We're conducting a study to gather information on your utility's implementation of BPAs scientific irrigation scheduling offering. I'd like to ask you a couple of questions about your involvement and understanding of the SIS market.

All information that you provide will be aggregated for statistical purposes and your comments will remain anonymous. Your response would help our efforts tremendously. The questions should take about 30 minutes – is this a good time to speak, or would you rather schedule a later time?

[*If an appointment, record the date/time of scheduled appointment in the box above, and thank the respondent]*

[*If now, skip down to interview questions]*

[If no, attempt to convert the person into a respondent. If they will not participate in the phone survey, thank the participant and terminate the phone call. Briefly describe why they wouldn't participate below]

General Questions Regarding the SIS Program Offering and the Irrigation Market

1. How long has [Utility Name] been offering Scientific Irrigation Scheduling to your customers? [seek answer in # of years, or year started; convert to # of years for data entry purposes]

    a. Does your utility also currently work with an Irrigation Water Management (IWM) program through another entity (e.g. Environmental Quality Incentives Program (EQIP) from USDA)? Has the utility worked with an IWM in previous years?

    b. If so, how is/was this different from the BPA SIS program? [**for each category below**]

        i. Payment structure

        ii. Savings estimates

        iii. Eligibility

    c. Do you see a relationship between SIS and other IWM incentives? If so, what are the advantages or disadvantages?

2. Why did you decide to offer the SIS program? [**check all that apply**]

    a. customer service

    b. cost savings

    c. mandated energy savings targets

    d. other

3. Are you offering BPA's standard SIS offer or the "SIS Light" version?

    a. Why did you choose to offer this version? [**Probe**]

    b. Are you aware of some of the key differences between the two variations of the program?

[**Probe for a few of the differences, probably reporting requirements, commitment term for utility, and savings reporting time period/true-ups.**]

4. Would you consider any of the elements of SIS to be standard practice among growers in your area? (i.e. outside the influence of the program)

    a. Are you aware of any growers that use SIS practices without seeking reimbursement or assistance?
    Probe:

        i. When farm ownership is family or corporate?

        ii. What crops are involved?

        iii. What size of farms?

        iv. Are growers using meters without tracking actual water use?

5. What types of crops are most commonly chosen for SIS? (list all that apply and some indication of most common ones)

6. Have you noticed any shifts in the irrigation management market over the past 5 to 10 years?

    a. More types of crops using SIS/IWM?

    b. More acreage being covered by SIS/IWM?

    c. Have growers themselves or trade organizations become ambassadors for the methods to other growers?

7. Do you have any data regarding the impacts of irrigation on local water resources? (aquifers, rivers, or reservoirs)

    a. Total capacity

    b. Utilization

    c. Future supply

    d. Plans for lean (drought) years

8. Do you have (or could you steer us toward a source for) trend data or projections relating to the retail cost of energy or water?

GROWERS

9. How do you recruit or attract growers to participate in the SIS program?

10. How many growers have been contacted about this program in your service area?

    a. What share (%) of these growers were already aware of IWM/SIS practices (acres or # farms?)?

    b. What share of these growers were already aware of your utility's rebate programs?

11. What is the target market for participants? (**Probe:** How do you determine which farms would be likely to participate? - acreage, crop, ownership, etc.)

    a. How many growers are currently participating?

    b. How many total growers have participated in SIS [or SIS Light] since beginning the program?

    c. What share of your target (growers and acreage %) market do you think is currently participating in the program?

    d. What do you think is preventing more growers from participating?

    e. Are there specific markets you feel are under-represented in the program? Why is that the case?

12. Are there differences in how your utility approaches or interacts with small (<40 acres)/medium (40-640 acres) or large (>640 acres) farms?

    a. Does SIS Light play a role in how your utility approaches and interacts with small, medium and large farms? If so, how?

    b. How does grower size affect the likelihood of participating in SIS programs?

    c. Do you see a connection between field ownership and implementation of IWM practices? (Private/family owned vs. corporate/Agra Business)

13. Do you find that implementation of SIS is more difficult with leased fields that have year to year crop changes? If so, how is implementation impacted?

SERVICE PROVIDERS

14. Does your utility work with SIS technology service providers? If so, which ones?
15. What is your utility's relationship with SIS technology service providers?
    a. What types of agreements do you have with them?
    b. How many are actively supporting your SIS program?
    c. How did you identify the provider(s) that are supporting the program?
16. How do prospective and participating growers interact with your utility and with the service provider(s)?
    a. Describe the utility's role and responsibilities
    b. Describe the service provider(s) role and responsibilities
        i. Reporting responsibilities? (reporting water use, energy savings, acres irrigated, etc.)
        ii. Maintenance requirements? (installation of meters, removal, etc.)
        iii. Marketing requirements?
17. In regards to the soil moisture metering equipment:
    a. What happens to the soil moisture meters at the end of the season? Are they reused?
    b. What is the rate of damaged/discarded meters?
    c. Do you track soil moisture meters from purchase to discard? If so, how?
    d. Do you hear of meters being used for multiple crops in the same growing season?
        i. In what circumstances?
        ii. Describe how this is done.

BPA-PROGRAM SPECIFICS

18. What are the strengths of the SIS [SIS Light] program?

19. What do you think are areas of improvement for the SIS [SIS Light] program?
    a. Contracting with BPA?
    b. Incentives?
    c. Calculator?
    d. **[SIS only]** Do you have any thoughts regarding the three year reporting of savings?
    e. **[SIS only]** Do you have any thoughts regarding the initial reporting of all savings followed by the two years of "true ups" to those savings?
    f. SIS Light Only – Do you have any thoughts regarding the requirement that farms are less than 1,000 acres in size?
    g. SIS Light Only – Do you have any thoughts regarding the deemed savings estimates and tracking of savings
    h. Do you have other ideas for improving communication between your utility and BPA, or between your staff and program participants?
    i. Do you think BPA is getting significant value out of their support for this program? Are there ways that program delivery could be changed to increase that value?
20. What types of retention rates have you seen among your participants?
    a. What share of those signed up are still participating?
    b. What are the reasons cited for dropping out of the program?
21. How many of your utility staff are involved in processing the applications and subsequent monitoring activities?
22. What do you see as the **primary** bottleneck in the incentive application process?
    a. Is this also the largest burden on administrative costs?
    b. If not, what is the largest burden on administrative costs?

23. Did your utility offer any IWM programs prior to SIS/SIS Light?

    a. If so, how did this differ from the current program?

24. Are there any additions to the current SIS/SIS Light program that you would like to see, such as emerging technology, or existing/proven technologies?

25. What three features of the program do you think are most attractive to customers? [If they offer services for both SIS and SISL, emphasize that this question if for the standard SIS program only]
    [Read full list and check top three]

    – Electric savings
    – Consumables (e.g. fertilizer) savings
    – Water savings
    – Improved crop yields/quality
    – Incentives
    – Operational convenience/cost reduction
    – Other_____

    a. Out of those features, which do you believe is the most important?

26. [**If they offer services for both SIS and SISL**] How, if at all, do your answers change for the SIS Light program?

27. What features of the program do you think represent significant barriers to participation? [If they offer services for both SIS and SISL, emphasize that this question is for the **standard SIS program only**] [**Choose most important two or three**]

    – Inadequate incentives
    – Difficulty of installation
    – Difficulty of program documentation
    – No desire to apply since technology is standard
    – Other_____

    a. Which of these potential barriers do you believe is the most significant?

    b. For each of the barriers, what could be done to overcome them?

28. [**If they offer services for both SIS and SISL**] How, if at all, do your answers change for the SIS Light program?

29. What type of feedback do you receive from participants about the program? Are there aspects that they feel:

    a. Are particularly strong or helpful?

    b. Need improvement?

30. Do you have any previous documentation that would show historical SIS/IWM implementation trends or data from periods when incentives were either not offered or temporarily removed?

31. What could be done to increase participation?

32. What do you see as the best way to accurately track water use? **(**specifically flow rates**)** (**Determine if they do track water use and if they only do it with the SIS/IWM equipment.)**

33. Do you track or estimate any annual external costs or savings that might be attributable to SIS? (**Prompts**: fertilizer, herbicides)

34. What metrics does your utility use to track conservation achievements (energy and water savings) vs. administrative costs? (**Quantitative data - for example - $ spent over aMW reductions achieved --- if available.**)

35. Do you have any additional thoughts that you would like to share?

NAVIGANT

Service Providers

2010 SIS/SIS Light Program Evaluation

Service Provider Interview Guide

Contact Name:	
Contact Email:	
Company Name:	
Company Phone:	
Company Address:	
Today's Date & Time:	
Scheduled Date & Time:	
Interviewer:	
Notes:	

***Note: Questions in BOLD are high priority. Questions in *italics* are low priority and may be skipped if time is an issue. Other questions are normal priority. ***

INTRODUCTION

Hello, my name is [INSERT NAME] with Navigant Consulting and I am contacting you on behalf of Bonneville Power Administration (BPA). We're conducting a study to gather information on BPA and local utility scientific irrigation scheduling programs . I'd like to ask you a couple of questions about your involvement and understanding of the programs available and your interaction with SIS technology.

All information that you provide will be aggregated for statistical purposes and your comments will remain anonymous. Your response would help our efforts tremendously. The questions should take around 30-45 minutes – is this a good time to speak, or would you rather schedule a later time?

[*If an appointment, record the date/time of scheduled appointment in the box above, and thank the respondent]*

[*If now, skip down to interview questions]*

[If no, attempt to convert the person into a respondent. If they will not participate in the phone survey, thank the participant and terminate the phone call. Briefly describe why they wouldn't participate below]

IRRIGATION/SIS MARKET IN GENERAL

First, I'm going to ask you some general questions about your firm and the market for SIS/IWM. To try to clarify, we'll talk about the market for Irrigation Water Management, then use the word "SIS" for utility programs.

1. How is your firm involved in the implementation of Irrigation Water Management (IWM) (sometimes known as SIS)?
    a. What types of growers do you work with?
        i. Corporate or small farms?
        ii. Specific crops?
        iii. Size (acres)
    b. What types of irrigation systems do you primarily work with? (center pivot, etc.)
2. What crops are most commonly chosen for IWM? (**list all that apply and some indication of most common ones**)
3. Are you aware of certain organizations and/or crops that require accurate irrigation records? (Prompts: Lamb Weston & Simplot, or the buyers of wine grapes and potatoes)
    a. Does the value of the crop often correlate with the use of SIS? In other words, do more expensive crops require accurate irrigation records as opposed to less expensive crops?
    b. What do you see as the best way to accurately track water use? **(**specifically flow rates**)** (**Determine if they do track water use and if they only do it with the SIS/IWM equipment.)**

4. What type of moisture meter do you find is most common among growers? How does this vary among grower size, crop type, etc.?

    a. What happens to the soil moisture meters at the end of the season? Are they reused (i.e. left in place for multiple growing seasons or moved to a new location)?

    b. Are the meters serving multiple crops in the same growing season?

    c. What is the rate of damaged/discarded meters? [PERCENT?]

5. What, if any, mechanisms are in place to track the soil moisture meters from purchase to installation and eventual removal?

6. Do you see a connection between field ownership and implementation of IWM practices? (Private/family owned vs. corporate/Agra Business)

7. What are the differences in irrigation practices between small /medium and large farms?

    a. How do you define small vs. large farms (acreage)?

    b. How does size affect the likelihood of using IWM practices?

8. How is implementation of IWM made more difficult with leased fields (we understand they are more likely to be subject to crop changes from year to year)?

    a. Who typically owns the IWM equipment, the field owner or the lessee?

    b. What typically happens to IWM equipment when crops in a field changes?

9. What is the typical cost (in $/acre) for implementing IWM?

    a. Have you noticed any shifts in grower perception of the costs associated with IWM?

10. Do you know what the annual savings per acre from IWM for:

    a. costs (including fertilizers, etc.)?

    b. water?

    c. energy?

11. Have you noticed any shifts in the irrigation management market over the past 5 to 10 years? (**Prompts:** more types of crops using the methods; more acreage being covered by methods)?

    a. Would you consider any of the elements of IWM to be standard practice among growers in your area?

        i. If so, under what circumstances have you noted growers using IWM practices without seeking reimbursement or assistance?
        Probe:

            1. When farm ownership is family or corporate?

            2. What crops are involved?

            3. Are growers using meters without tracking actual water use?

    b. How have the reasons growers give for seeking your help in implementing IWM changed over time?

    c. What, if any, reasons do growers give for discontinuing their use of IWM?

SERVICE PROVIDER INTERACTION WITH SIS PROGRAMS

12. What local utilities do you work with in offering SIS programs for energy efficiency reasons?

13. Are you aware of BPA's offering of SIS to its public power utilities (be able to know from Q12 which are BPA and not --- Not BPA – Avista, Idaho Power, Northwestern, PacifiCorp, PGE, Puget Sound Energy, Chelan)—*CLARIFY THAT questions that follow are for public utilities only.*

14. What ACTIVIITES does your firm do related to SIS programs for BPA's offering? **(MAY NEED PROMPTS TO GET AT SPECIFIC ACTIVITIES)**

    a. Is there any difference in the growers you work with through the SIS programs? What types of growers do you work with?

    b. Are there differences in how you work with different growers (e.g., based on size, type of crop, etc)

15. For SIS programs specifically, what is the process you use to become involved in the installation and servicing of equipment for growers? [phone calls, personal visits, farm bureaus, trade associations, etc.?]

    a. What are your reporting responsibilities under utility programs? (reporting water use, energy savings, acres irrigated, etc.) To whom to you report (**presumably someone at the utility)**?

    b. What are your maintenance requirements under the program? (installation of meters, removal, etc.)

    c. Do you have any marketing requirements? (outreach to growers, etc.)

16. From your perspective, how has the cost of supporting SIS implementation changed in recent years?

17. What are the common differences in IWM practices for a grower who participates in a utility SIS program vs. a grower who implements IWM without receiving utility incentives?

18. How does grower participation in an SIS program differ between: Private/family owned farms and Corporate, Agra Business farms?

19. What feedback do you hear from growers regarding the hardware that must be installed to participate in a utility's SIS program (moisture meters, flow monitoring devices, etc.)?

20. [If they don't do both SIS and SISL] Are you aware that through BPA, utilities can offer two version of the SIS program – the standard program and SIS Light for farms less than 1000 acres?
    Yes / No / DK

    a. If yes, Can you identify the differences between the SIS and SIS Light programs? Explain. _____

21. Do you know of any additional irrigation water management programs available in your area? Do you participate or not?

22. (If they work with more than one utility) Does your method of program implementation vary by utility? How?

    a. What are the strengths and weaknesses of the different programs? [REMEMBER THAT YOUR ANSWERS ARE CONFIDENTIAL]

23. For BPA/public utility programs: if program type is unknown or if participating in just one (SIS or SIS Light); if participating in both, make sure to differentiate answers:

    a. *Do you do provide help with applications? (**Yes / No /DK**)*

        i. *If yes, does this vary by utility?*

    b. *Describe the implementation process for getting equipment to the grower and set up?*

    c. Describe the reporting process for collecting data from grower and providing it to the utility?

    d. Are you familiar with the SIS calculator? Do you find the SIS calculator to be an appropriate tool for reporting savings? Is something better you're familiar with?

    e. What other services do you provide related to the program?

24. *Do you market to growers in your service area about this program (these programs)? If so,*

    a. *How many growers have you contacted within the last year?*

        i. *regarding SIS*

        ii. *regarding SIS Light*

        iii. *regarding IWM practices in general*

    b. How many of these growers were already aware of utility SIS programs?

        i. Among small/medium growers (< 1,000 acres)

        ii. Among larger growers (>1,000 acres)

    c. Were they aware of the rebate programs or just the practice?

        i. Among small/medium growers (< 1,000 acres)

        ii. Among larger growers (>1,000 acres)

    d. What is the target market for participants? (i.e. How do you determine which farms would be likely to participate?)

    e. Are utility SIS programs missing a key piece of the market that could be influenced by incentives?

f. *What specific steps do you take to inform growers of SIS programs?*

g. *What % of growers you have contacted are currently participating in a utility SIS program?*

h. What share of your past or current participants have expanded the use of SIS to additional crops without the incentive?

   i. Do you continue to provide SIS/IWM services to these growers?

i. What share % of growers who formerly participated has since dropped out of the programs they were in?

   i. What are the reasons for growers dropping out?

j. Are there specific markets you feel are underserved?

25. *Do you know of any [emerging] technologies that you feel should be part of the SIS [SIS Light] program, which are not currently included?*

26. *What share of total SIS implementation costs are for program requirements? In other words, what share of costs are incurred only because of program requirements for data collection and reporting?*

27. What do you include in estimates of the annual savings for the grower?

- Operations and management
- Water costs
- External costs, i.e. fertilizer
- Improved crop quality
- Just use a "Rule of thumb"
- Not at all
- Other non-energy costs?
- Other_____

a. What do you think of the method of reporting savings for the programs?

28. What metric, if any, does your firm use to track conservation (energy and water savings)? (Quantitative data - for example - $ spent over a MW reductions achieved --- if available.)

    a. If savings and cost are tracked, are they reported to the grower directly?

    b. Do you have a way of aggregating farm specific data across a larger sample of your clients?

    c. If so, can you share that data with us?

29. [If more than 1 program] What share of your customers are in each of these program types

SIS	_____%
SIS Light	_____%
USDA (IWM)	_____%
Other_____	_____%
Other_____	_____%
Other_____	_____%
TOTAL	**%**

PROGRAM STRUCTURE/IMPROVEMENTS

30. From your perspective, what are the strengths of the BPA/public utility SIS programs?

31. **In what ways can BPA/public utility SIS programs be improved [If they offer services for both SIS and SISL, emphasize that this question if for the standard SIS program only]?**
    Probe:

    a. Any issues with the application process?

    b. Any issues with the payment structure for services?

    c. Do you feel the data reporting requirements are appropriate?

d. Do you feel the incentives are appropriate?

e. What aspects of SIS need new or increased incentives to improve adoption rates by growers?

32. [If they offer services for both SIS and SISL] In what ways can the *SIS Light* program be improved? **Probe:**

    a. Any issues with the application process?

    b. Do you feel the data reporting requirements are appropriate?

    c. Are the deemed savings values reasonable?

    d. Do you feel the incentives are appropriate?

    e. What do you think of the 1000 acre maximum size?

33. *What three features of the program do you think are most attractive to customers? [If they offer services for both SIS and SISL, emphasize that this question if for the standard SIS program only] [Read full list and check top three]*

    – *Electric savings*
    – *Consumables (e.g. fertilizer) savings*
    – *Water savings*
    – *Improved crop yields/quality*
    – *Incentives*
    – *Operational convenience/cost reduction*
    – *Other*_____

    Out of those features, which do you believe is the most important?

34. [If they offer services for both SIS and SISL] How, if at all, do your answers change for the SIS Light program?

35. **What features of the program do you think represent significant barriers to participation? [If they offer services for both SIS and SISL, emphasize that this question is for the standard SIS program only] [Choose most important two or three]**

    – Inadequate incentives
    – Difficulty of installation
    – Difficulty of program documentation
    – No desire to apply since technology is standard
    – Other_____

a. Which of these potential barriers do you believe is the most significant?

b. For each of the barriers, what could be done to overcome them?

36. Do you have any data regarding the impacts of irrigation on local water resources? (aquifers, rivers, or reservoirs) (**Y/N/DK**) (*If yes, probe for specific types of data collected*)

    a. Total capacity

    b. Utilization

    c. Future supply

    d. Plans for lean (drought) years

37. Do you have any additional thoughts that you would care to share?

Thank you for your time!