MARKET TRANSFORMATION OF IRRIGATION SCHEDULING IN WASHINGTON

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ABSTRACT

Washington State University is implementing a Scientific Irrigation Scheduling (SIS) Project that is being funded by the public utility districts through the Northwest Energy Efficiency Alliance (1998 through 2000). Scientific irrigation scheduling is defined as the use of crop evapotranspiration data and soil moisture sensors to accurately determine when and how much to irrigate. The project goal is market transformation. In other words, scientific irrigation scheduling will become a common practice that does not require continual government subsidy to be maintained. A 50% adoption rate will be a key indicator of market transformation in scientific irrigation scheduling.

Surveys were conducted during 1997 and 1998 to determine the status of and direction for scientific irrigation scheduling in Washington. According to the survey results, private consultants were contracted to perform irrigation scheduling on nearly 300,000 acres per year. Conservation Districts, county extension, and the National Resource Conservation Service have assisted producers in scheduling irrigation on an additional 15,000 acres per year. Individual Farm enterprises reported scheduling another 55,000 acres of irrigation on their own. The combined effort has resulted in a 17% adoption rate of scientific irrigation scheduling on an acreage basis.

Survey results also indicated that potatoes and tree fruit account for more than half of the acreage being scheduled. The main reason producers were willing to pay for irrigation scheduling is to insure the quality of high-value crops. Energy savings became important when water needed to be lifted a considerable distance; however, water conservation, high yield, fertilizer savings, and non-point pollution reduction were considered secondary benefits. Center-pivots were the most likely irrigation systems to be scheduled and a considerable proportion of

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drip and solid set sprinklers were scheduled, but a very small proportion of furrow systems and set-move sprinklers were scheduled. Of the producers who irrigated farms smaller than 1,000 acres, 75% of the survey respondents have personal computers and 50% have modems but less than 5% are using their computers to schedule irrigation.

Since computers and communication technology are available "on-farm," Washington Irrigation Scheduling Expert (WISE) has been developed as a web-linked and user-friendly software tool that brings together all the pieces needed to implement irrigation scheduling. WISE, soil moisture sensors and other tools will be promoted via traditional demonstration and educational methods but with a different emphasis. Instead of offering irrigators a free service, cooperators will be encouraged to produce their own irrigation schedules from the onset of their involvement with the SIS project and agricultural supply companies will be encouraged to add irrigation scheduling to their services. The goal of this paper and presentation is to document the status, tools, and progress of market transformation in Washington's SIS Project.

INTRODUCTION

The definition of Scientific Irrigation Scheduling (SIS) is deciding when and how much to irrigate based on physical measurements that estimate crop-water use and the soil-water status. The goal of the Scientific Irrigation Scheduling Venture in Washington is market transformation. Market transformation is an adoption process by which a product or procedure becomes a common and accepted practice that is supported by private enterprise without continual government subsidy. A 50% SIS adoption rate will be a key indicator of market transformation in Washington.

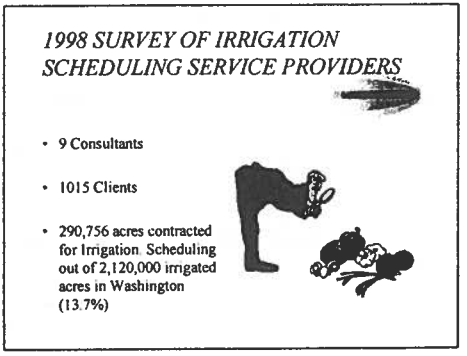
The process of transferring SIS technology to growers began over thirty years ago according to Shearer and Vomocil (1981) and Fereres (1996). These efforts have been effective in conserving water/energy (Shearer and Vomocil,1981; Dockter,1996 and Alam et al., 1996), improving crop yield/quality (Lyford and Schild, 1981; Silva and Marouelli, 1996; and Tacker et al., 1996) and reducing non-point pollution (Boesch et al., 1981; Klocke et al., 1996; and Nguyen et al., 1996). In addition, many Agricultural Consultants in the western United States have established successful irrigation scheduling businesses similar to the one described by Salazar et al. (1996).

However, there are also documented difficulties in transferring SIS technology to growers. Clyma (1996) believes there has been a decrease in the practice of SIS. Shearer and Vomocil (1981) reported that most of the successful SIS programs in Oregon disbanded once the programs were no longer offered as free services. Koegelenberg and Lategan (1996) from South Africa believe that only consultants

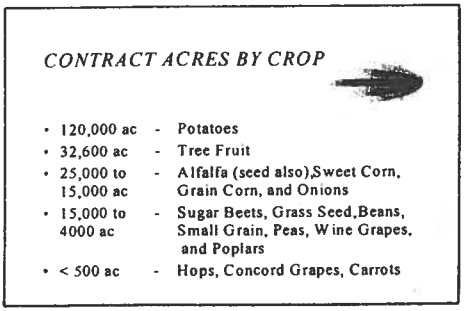
can apply the technical expertise necessary to implement irrigation scheduling correctly. Buchleiter et al. (1996) reported a combined savings of $23.7/ha in water, energy and labor on a 1700 ha farm in Kansas at a cost of $8.00 /ha. However, an attempt to sell similar SIS services to neighboring Kansas farms was unsuccessful at this level of return.

As for the future of SIS technology transfer, Howell (1996) states that there has been little change in SIS theory and methodology over the last twenty-five years; however, there have been significant changes in information technology that need to be applied to update SIS practices. Lamacq et al (1996) found that growers schedule irrigation on a whole farm basis and not strictly by the requirements of individual fields. This research suggests that the SIS techniques that we promote must be applicable to the entire farming system. Shearer and Vomocil (1981) remind us that adoption of fertilizer and weed control practices required sustained and concentrated support by both industry and educational institutions to accomplish market transformation.

STATUS OF IRRIGATION SCHEDULING IN WASHINGTON



Ag. consultants who provide irrigation scheduling services participated in a telephone survey prior to the 1998 growing season. In Washington, nine consultants responded to the survey that required forty-five minutes of phone time; however, most spent about two hours talking about their business. The combined effort from these nine firms resulted in over 1,000 clients and nearly 300,000 acres contracted for irrigation scheduling. This acreage represents 13.7% of Washington's 2,120,000 irrigated acres.



Potatoes were the crop most likely to be scheduled by a professional service and tree fruit was the next highest. Together they account for more than half the acreage scheduled professionally. Alfalfa, sweet corn, grain corn, and onions were scheduled at between 25,000 to

15,000 acres each. From 15,000 to 4,000 acres each of sugar beets, grass seed, beans, small grain, peas, wine grapes, and poplars were being scheduled. Very little professional irrigation scheduling is being performed on hops, concord grapes, and carrots.

Center-pivot irrigation systems were the most likely to be contracted for irrigation scheduling at 217,000 acres. Solid set and drip (includes micro spray) were the next largest group at 30,000 acres each, while very little irrigation was being scheduled professionally under furrow and set move systems. These survey results were also compared to the irrigation system acreage in Washington State as reported in the Irrigation Journal. Nearly, fifty percent of center-pivot acreage was being scheduled by professional services. This seemed unduly high and perhaps the total center pivot acreage is under reported. However, center-pivots are predominantly used to grow potatoes, the most scheduled crop, and water application can be easily controlled under center-pivot irrigation. Both solid-set sprinkler and drip irrigation had a higher percentage of professional irrigation scheduling than furrow and set-move sprinklers, possibly because they are extensively used on high-value crops such as vines and tree fruit and they are also easy to automate.

CONTRACT ACRES BY IRRIGATION SYSTEM

Furrow	Set Move	Solid Set	Pivot	Drip
Survey				
9850	3900	30,601	216,905	29,300
State				
510,00	800,000	200,000	475,000	100,000
1.9%	0.5%	12.2%	45.7%	29.3%

Most irrigation-scheduling consultants use the hand/feel method to compare with their soil moisture monitoring devices. The most prevalent monitoring device was the neutron probe, used by five of the nine consultants. Three of the consultants used gravimetric sampling in shallow rooted crops where a neutron probe might not be as effective. In addition, several consultants were promoting one of the less conventional methods of soil-moisture monitoring: Aqua-Flex, Aqua-Tel, Time Domain Reflectometry (TDR), and Frequency Domain Reflectometry (FDR).

SOIL MOISTURE MONITORING

Hand/Feel	9 out of 9
Neutron Probe	5 out of 9
Gravimetric	3 out of 9
Aqua-Flex	1 out of 9
Aqua-Tel	1 out of 9
TDR	1 out of 9
FDR Troxler Sentry	1 out of 9

EVAPOTRANSPIRATION

• On-site Weather Station	2 out of 9
• PAWS Weather Station	8 out of 9
• AGRIMET Weather Station	6 out of 9
• Historical	2 out of 9
• Change in Soil Moisture	2 out of 9

Most irrigation scheduling providers rely on a combination of PAWS and AGRIMET weather stations to estimate crop ET. Two of the consultants set up on-site weather stations for clients to calculate ET right on their property. Two consultants indicated that they used the change in water content measured at their soil moisture monitoring sites to adjust predicted ET rates. Seven out of nine consultants use a combination of present soil moisture status and predicted ET to calculate operation times for clients' irrigation systems.

Irrigation scheduling is beneficial in many ways, but consultants were asked which benefits motivated clients to pay for their services. When clients were pumping from deep wells or lifting water long distances from rivers, water and energy conservation were important because operating expenses could be lowered significantly. Another key reason to pay for irrigation scheduling was improved crop quality. For many high-value crops, quality is the key to better price and proper irrigation is an important factor in maintaining high quality. Pressure to reduce agricultural pollutants was not described as an important reason to pay for irrigation scheduling even though environmental issues are becoming more prevalent.

KEY REASONS CLIENTS PAY FOR IRRIGATION SCHEDULING

• Short of Water	1 out of 9
• Save Water	3 out of 9
• Save Energy	4 out of 9
• Reduce Pollutants	1 out of 9
• High Yields	3 out of 9
• Crop Quality	7 out of 9
• Save Fertilizer	2 out of 9
• Size of Farm	1 out of 9
• Crop Value	2 out of 9
• Reduce Agronomic Problems	0 out of 9

Seven of the irrigation scheduling providers said their business was expanding slightly to moderately and those who said their business was not growing wanted to keep the business at its present size but felt they could expand if they desired. In addition to this favorable business climate among existing consultants, new irrigation scheduling ventures are getting started that utilize some of the newer soil-moisture measuring

THE BUSINESS CLIMATE

- Growth of business - 7 out of 9 expanding
- Identified 3 new firms offering irrigation scheduling
- A 1 to 1 benefit ratio to non contracted acreage

technology. Overall, consultants felt an additional acre benefited from every acre under contract.

1997 IRRIGATION SCHEDULING SURVEY OF WASHINGTON STATE PRODUCERS

- 199 Surveys Returned
- 105,000 Acres out of 2,120,000 Irrigated Acres in Washington

The SIS provider survey gives a picture of irrigation scheduling in Washington State from the consultants' perspective. Individual Grower's are also scheduling irrigation for themselves.

In the July 1997 issue of the *Washington Irrigator Newsletter*, a survey of scientific irrigation scheduling practices was included. Of those receiving the newsletter, 199 surveys were returned by Washington irrigators. representing 105,000 acres of Washington's 2,120,000 irrigated acres.

SELF-IMPLEMENTED SCIENTIFIC IRRIGATION SCHEDULING

	by acreage
• Use ET and Soil Sensors	77%
• Professional Scheduling Service	14%

Scientific irrigation scheduling (SIS) is defined as the use of both soil moisture sensors and crop evapotranspiration (ET) data to determine when and how much to irrigate. According to this definition, SIS is being practiced on 77% of the reported acreage. This high percentage is probably not representative of the entire state because those who practice SIS are more likely to return a survey than those who are not as interested in SIS. However, professional consultants were only responsible for implementing SIS on 14% of the survey acreage. Therefore, the survey represents the perspectives and practices of irrigators who implement SIS on their own.

IRRIGATION SYSTEMS USED IN IRRIGATION SCHEDULING

• Furrow	Set Move	Solid Set	Pivot	Drip
• Irrigation Systems being Scheduled in Survey				
• 7%	10%	9%	71%	3%
• Irrigation Systems in Washington				
• 24%	38%	10%	24%	4%

Most SIS is being implemented with center pivot irrigation (77%). Furrow, set-move sprinklers, solid-set sprinklers, and drip are each less than 10% of the SIS acreage. However,

solid-set sprinklers and drip systems only account for 10% and 4% of the irrigated acres in Washington, respectively. Therefore, irrigation of solid-set and drip systems is being scheduled at a higher rate than furrow and set-move sprinklers systems that account for 24% and 38% of Washington's irrigated acres, respectively.

The farm size of survey respondents varied from 2 to 24,000 acres. It was assumed that a producer with 24,000 acres would have a different perspective on irrigation scheduling than one with 2 acres. Therefore, the survey data was split into two groups: producers with more than 1,000 acres (large) and those with less than 1,000 acres (small).

FARM SIZE MAKES A DIFFERENCE

	# Surveyed	Total Acreage	Average Acreage
SMALL under 1000 ac.	182	26,852	147
LARGE over 1000 ac.	17	77,973	4589

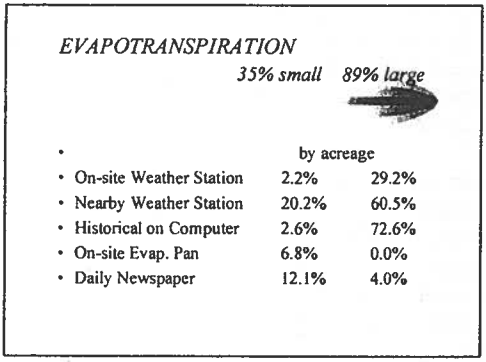
Both large and small operators reported high utilization of the feel/appearance method (above 79% by acreage) to determine the status of soil moisture. As for sensors, both groups were most likely to use a neutron probe and least likely to use Time Domain Reflectometry (TDR). However, the rate of sensor utilization was much greater in the large farm group. As an example, the neutron probe was being used on 80% of the acreage in the large farm group and on only 20% of the acreage on smaller farms. Private companies are presently marketing many new soil moisture sensors and the types of sensors used in Washington may change drastically.

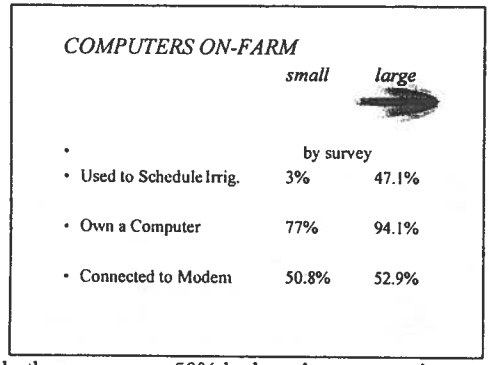
SOIL MOISTURE MONITORING

	small	*large*
	by acreage	
• Hand/Feel	79.1%	94.4%
• Neutron Probe	19.8%	80.5%
• Tensiometers	13.5%	41.0%
• Gravimetric	9.0%	33.0%
• Moisture Blocks	3.1%	1.5%
• TDR	0.0%	1.5%

Crop evapotranspiration (ET) is another important tool in Scientific Irrigation Scheduling. Again, large farms reported greater use of ET information than the

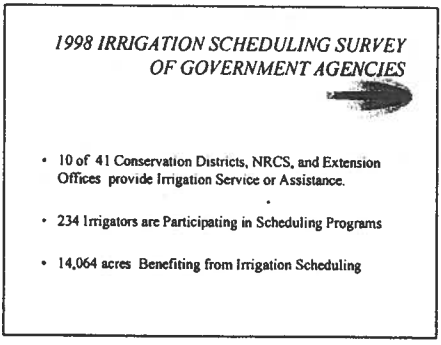
smaller farms, 90% versus 35% by acreage, and the sources of ET were also quite different. The small farm group predominantly used nearby weather stations, daily newspapers, and on-site evaporation pans, while the large farms used ET from computer software, nearby weather stations, and on-site weather stations.





Finally, computers help producers implement irrigation by providing access to crop ET, processing soil moisture readings, and forecasting operation times for irrigation systems. The survey revealed that 77% of the small operators owned computers but only 3% used them to schedule irrigation. On the large farms, 94% owned computers and 47% were used for SIS. In both groups over 50% had modem connections.

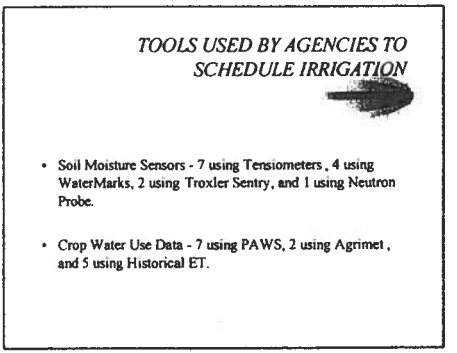
The newsletter survey shows how producers are implementing SIS for themselves. Yet it does not reveal how producers have learned to incorporate SIS into their operations. The final survey explains one of the mechanisms by which irrigation scheduling technology has been transferred to producers.



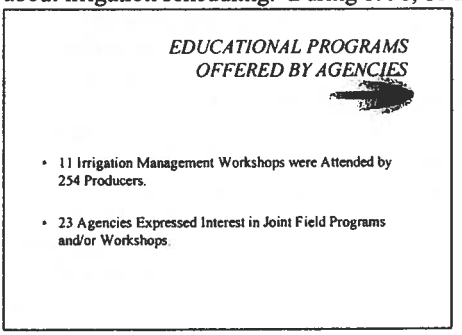
A telephone survey of government agencies involved in irrigation scheduling was conducted in the fall of 1998. A total of 43 National Resource Conservation Service, County Extension, and Conservation District offices were surveyed and 11 of these were conducting field programs in irrigation scheduling. In these programs, 234 clients were involved

effecting 14,064 irrigated acres.

The main irrigation scheduling tools used by government agencies are soil moisture monitoring and crop ET. The soil moisture sensors listed from most to least used are: tensiometers, granular matrix sensors, capacitance probes and the neutron probe. The sources of crop ET listed from most to least used are: PAWS, historical, and AgriMET.



Government agencies also provided educational opportunities for growers to learn about irrigation scheduling. During 1998, 11 irrigation scheduling workshops were conducted with a combined attendance of 254 irrigators. The 11 agencies already conducting irrigation scheduling programs said they were interested in a joint effort with the SIS Venture being implemented by WSU's Extension Irrigation Speacialist. An additional 12 agencies said they would like to start a joint irrigation scheduling program.



Five important conclusions from this survey are: 1) 9 consultants are scheduling the largest proportion of irrigated acreage (mostly high value crops), 2) a significant number of Washington producers are implementing SIS on their own, 3) large farming operations are making SIS a standard practice, 4) a majority of producers have the infrastructure for computer based irrigation scheduling but most are not using their computers for this purpose, and 5) 10 government agencies are helping producers implement irrigation scheduling and more agencies would like to start SIS programs). The combined effort has resulted in approximately 370,000 acres involved in SIS out of Washington's 2,120,000 irrigated acres. This amounts to an adoption rate of 17% by acreage and is a third of the way to the goal of 50% adoption for market transformation of SIS.

STRATEGY FOR SIS IMPLEMENTATION

Traditionally, most irrigation scheduling programs offer free or cost-shared services to help educate producers regarding new techniques. However, it was

determined that such a program would not have been effective for several reasons. First, providing free services would have competed with existing services and programs creating either redundant services or alienation of irrigation scheduling services providers. Another key factor in the decision was finite funds. The SIS grant from the Northwest Energy Efficiency Alliance provides funds for 1.3 full time equivalent employees which is not sufficient to provide SIS service to the entire state of Washington. But the argument against traditional methods was not simply bound by issues external to producers. It was also thought that if producers took an active role in SIS practices, the experience would allow them to make better decisions regarding if SIS was effective for them, if they were capable of doing it themselves, or if they saw hiring a consultant as being cost-effective. Getting the latest SIS tools in the hands of the producer would also help researchers and extension workers determine which methods were the most cost-effective and beneficial given the individual variables of different farms and farmers.

Therefore, a program was developed that would facilitate existing programs through traditional extension education, development of web pages and online computer programs to create SIS market transformation in the state rather than compete. This is being accomplished in three broad categories. The first is to cooperate with existing SIS promoters: regional extension agents, conservation districts, natural resource conservation services, public utility districts, ag chemical suppliers, irrigation equipment suppliers, and private consultants. Second, create marketing and technical tools to help existing SIS providers and encourage new companies to provide SIS services. Finally, establish educational and technical tools (including information technology) that allow producers to implement SIS on their own.

Technical and Marketing Tools for the Information Age:

The Washington Irrigation Scheduling Expert (WISE) Software is being developed to meet the needs of Washington Irrigators. WISE is written in JAVA with NetBeans DeveloperX2 components to allow cross platform operation and easy access to reference evapotranspiration (ET) from Washington's 59 Public Agriculture Weather Stations (PAWS). The graphical user interface is intuitive and will help the user input their field specific parameters such as crop type/timing, soil moisture and irrigation system specifications. WISE employs a short-term water balance that can be adjusted for soil moisture conditions. WISE is not a black box calculation of when and how much to irrigate since important steps are displayed and made apparent to the user. This feature also makes WISE an educational tool that teaches the principles of irrigation scheduling.

An alpha version of WISE was tested with irrigators during the 1999 growing season. A beta version was completed by the end of 1999 and this release is stable enough for use in 2000 growing season. Producers and SIS service

providers can download WISE from http:\\wise.prosser.wsu.edu. To make the most of WISE a PAWS internet account is highly recommended.

A SIS web site is also being developed. This site will provide access to PAWS, WISE, SIS service providers, newsletters, publications, presentations, event calendar, and a SIS list serve. The site is located at http:\\sis.prosser.wsu.edu.

Traditional Education and Marketing Tools

Field demonstrations have become more focused since all on-farm experiments are driven by testing and perfecting SIS. Soil-moisture sensors marketed in Washington are being compared under different soils, irrigation systems and crops. These have been placed in locations across the state where cooperating organizations will use them in field days to promote SIS. The results from the sensor comparisons are also being used in SIS workshops.

SUMMARY OF SIS OUTREACH EFFORTS

- 29 Workshop Presentations with 1,278 Contacts
- 12 Field Day Presentations with 401 Contacts
- 24 Articles in Newsletters and Popular Press
- 8 Soil Moisture Sensor Comparison Sites
- 8 Cooperators demonstrating SIS
- 207 Contacts for Technical Assistance (one-to-one)

SIS cooperating farms are monitoring soil moisture with a sensor of their choice and generating schedules from WISE. The SIS project will provide free access to PAWS, teach cooperators how to use WISE and confirm their method of soil-moisture monitoring with neutron probe readings. The SIS project will also monitor their irrigation amounts and timing with a micro-logger. Each of these steps is intended to move cooperators toward self implemented irrigation scheduling or the realization that they should pay a service provider. Workshops on WISE and scheduling methods are also training and encouraging producers to implement SIS.

Finally, the written media is also utilized. Newsletters, articles, and a brochure have been published to educate and promote SIS. Other media formats such as television and radio may be utilized as the SIS project progresses.

Collaboration Strategy

Since the focus of the Washington SIS program and the way it is marketed has fundamentally changed, many cooperators will have the opportunity to learn self-implemented SIS in lieu of WSU providing free services to a few clients. Instead of marketing for an isolated WSU Program, the SIS project will seek to promote and prepare other provider organizations to participate in the market transformation process.

Since WSU will avoid duplicating existing programs, funds and engergies can be funneled into developing new tools to be shared with anyone interested in using or promoting SIS. Some of the ways the Washington SIS program can support partner organizations include the following:

- Listing on SIS Web Site along with SIS Information.
- One Advertisement/Article per year in "Washington Irrigator Newsletter."
- Use of Washington Irrigation Scheduling Expert Software and PAWS Data.
- Automated Monitoring of Irrigation System On Times at an affordable price.
- Client Training in SIS via Workshops and Field Days.
- WSU Technical Support of PAWS and WISE.
- Limited Field Support (WISE set-up and check-ups).
- Testing of Soil Moisture Sensors.

In addition, a brochure has been published which although developed and printed by WSU, is free to cooperating providers to use with prospective clients (either public or private). A space has been left blank to allow individual providers to personalize the brochure with a stamp or business card.

In return for such support, partner organizations will be required to:

- Provide Soil Moisture Sensors for Testing at WSU.
- Purchase a PAWS Subscription after their program is established.
- Receive Training in PAWS and WISE.
- Work with Clients to Monitor Soil Moisture and Produce Irrigation Forecasts.
- Organize and Set-up Irrigation Workshops and Field Days.
- Report Clients Assisted under SIS.

Each of these commitments is design to ensure reliable and scientific irrigation scheduling is dispersed to all participants.

RESULTS AND CONCLUSIONS

As of January 2000, Washington's agricultural service industries are showing signs of market transformation in SIS. Two of the nine existing SIS service providers plan to use WISE with some of their clients while another existing service providers will sell soil moisture sensing devices with SIS training for producers who desire to implement their own irrigation

MARKET TRANSFORMATION INDICATORS

- 1 of 9 existing SIS provider starting to sell sensors
- 2 of 9 existing SIS providers using WISE
- 6 of 8 new SIS companies selling sensors
- 4 of 8 new SIS companies providing field service
- 3 of 4 new SIS providers plan to use WISE
- 20 individual WISE software downloads

scheduling programs. Since the initial survey of SIS providers in the spring of 1998, eight more Washington based companies will start marketing SIS. Six of the eight are selling new soil moisture monitoring devices and four companies will provide on-farm scheduling services. Of the four companies planning to provide direct SIS service three intend to use WISE. WISE has also been downloaded by nearly twenty individuals.

Future SIS surveys should reveal the extent of SIS penetration into new markets. In many ways, the SIS market is being driven by new information technology that allows businesses to better serve their customers and by the need to reduce environmental degradation caused by irrigated agriculture. Therefore, the future looks bright for market transformation of SIS. Funding for the Washington SIS Venture was provided by the Northwest Energy Efficiency Alliance (NEEA).

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