Colorado Ag Water Alliance

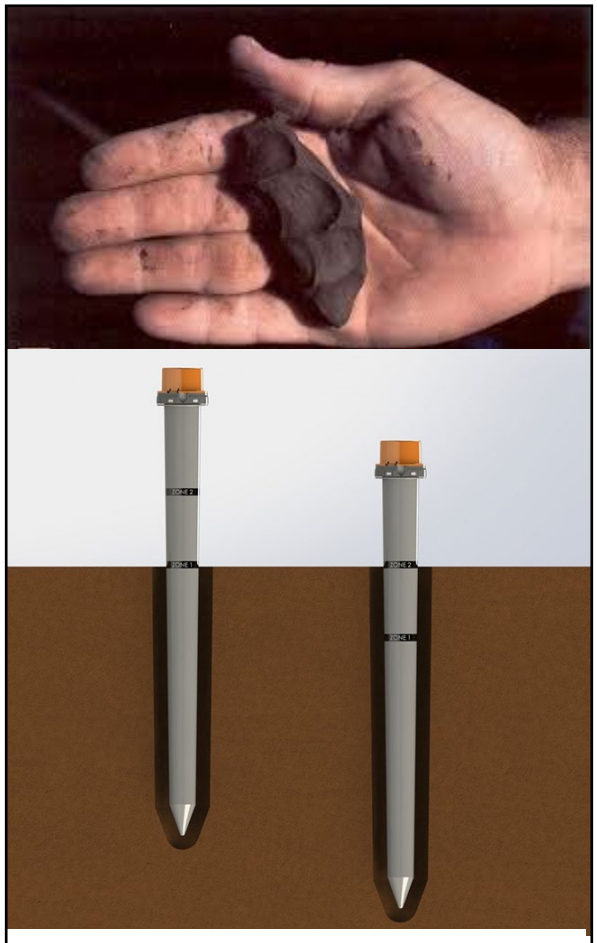
Blueprint: Irrigation Scheduling

The Drought Resilience Project

Over the past few years, the Colorado Ag Water Alliance (CAWA) has been providing funding directly to farmers and ranchers around the state of Colorado to implement Drought Resiliency Projects. Producers submitted applications to CAWA, that identified their drought issues, the proposed solution, and what data would be collected to determine if the solution was successful. Funded projects tended to fall into the following categories: irrigation improvements, livestock, alternative crops, and soil health. Blueprints are being developed based on results of successful projects to outline lessons learned from the projects and more importantly, the potential to scale up. We hope that our lessons can provide some guidance to others interested in implementing these practices. The focus of this blueprint is on irrigation scheduling.

What is irrigation scheduling?

Irrigation scheduling is a process to determine the correct frequency and amount of water to apply to a crop through irrigation. The tools to manage irrigation scheduling can range dramatically from observation to advanced technologies. The most common method for irrigation scheduling is visual cues (wilting, leaf curling) and feel (taking a soil sample by hand after digging into the ground to estimate the moisture content). There are many different advanced technologies that act as a "thermostat" for irrigation like soil moisture probes (tensiometers and capacitance sensors), neutron probes, and satellites.



How to estimate soil moisture by feel and appearance, and diagram of soil moisture probes.

Most of these different technologies have either a desktop or mobile application that presents the data to the user in many different forms. While some irrigation technology is new, the basic technology of using sensors to help measure the soil moisture and evapotranspiration of the crop is decades old. In discussions with staff from Colorado State University and vendors for different sensor technologies, it is estimated that only 3-5% of irrigators in Colorado use any advanced irrigation scheduling technology.

Where does irrigation scheduling technology not make sense?

It is important to note that there are many situations where irrigation scheduling does not make either practical or economic sense for an irrigator to use. While there may be some advantages to using irrigation scheduling in these situations, they don't provide a great opportunity for scaling up the practice and having a large impact on efficiency and conservation.

Short irrigation season: In many places throughout Colorado, agricultural producers only have irrigation water for a short period of time. Irrigation water may only be available for a few weeks to a few months. Many with limited irrigation water are growing grass hay and benefit by not only providing enough irrigation water for the crop but overirrigating to fill up the soil profile with water. Many producers will remark, "I only receive water for such a short time and need to use all of it."

Irregular irrigation deliveries: In some larger ditch and irrigation systems, it can be very difficult to implement irrigation scheduling if the ditch company has its own schedule for deliveries. Some delivery systems go through "rotations" or "partitions" throughout the season, and that schedule may conflict with the needs of the crop. Producers will often use water when it is their "turn" because they are not sure when they will get water again in the rotation.

Not cost effective: For some irrigators, the benefits of irrigation scheduling may not outweigh the cost of the equipment. Irrigation scheduling equipment can range from $500 to $2,000 a field depending on the technology. If irrigation scheduling doesn't reduce labor or water costs, or increase efficiency and yield, then it would be difficult to justify the cost. For instance, CAWA funded one producer in Larimer County to use an irrigation scheduling system and received technical support. Even though the probes did help to show that decisions on irrigation correlated with the moisture probes, the producers did not see enough cost/ benefit to use them again.

Where does irrigation scheduling technology make sense?

Due to the reasons mentioned previously, there are situations where irrigation scheduling makes more sense than others.

Full supply of water: If the irrigator has a full supply of water in most years, they have the supply to make different choices. Irrigation scheduling in this case may help producers understand if they are over and under irrigating their crop and determine if pumping or other water associated costs (i.e. labor) could be saved.

On-demand water: To apply water according to the needs of the crop, an irrigator needs a consistent and reliable supply of water during the season. If water is available for a limited time

but a moisture probe says irrigation is not necessary, and irrigator may still apply water because they do not know when they will get water again. Alternatively, if a moisture probe says that irrigation is needed, it is possible the irrigator cannot even apply water if they want to because it isn't their turn to receive water or their water right is out of priority.

Expensive water and/or power costs: Irrigation scheduling equipment is an added expense. A common response from agricultural produces is that "a piece of equipment has to pay for itself." If the water an irrigator uses is more expensive because they are paying higher dues to their water provider or pumping fees, irrigation scheduling presents an opportunity to reduce costs. If they are paying for electricity to pump wells and run a pivot sprinkler, that provides an even further opportunity for irrigation scheduling to reduce the need to run equipment as often and lower costs.

When does irrigation scheduling lead to efficiency improvements?

In projects with irrigators, improved efficiency with irrigation scheduling was the most common result. The feedback we would hear more often than anything else was that irrigators felt that they applied the same amount of water during the season but were much more efficient and improved yields. While improved irrigation efficiency is highly likely, what is more important is that improved yields can cover the expense and labor of using irrigation scheduling technology.

When does irrigation scheduling lead to conservation improvements?

There is significant interest in improving irrigation scheduling to achieve water conservation. This is possible by reducing unnecessary irrigation applications and evaporation. Due to the logistics of many irrigation and ditch systems, it is difficult to conserve water that would have been consumptively used. However, there are situations where irrigation scheduling can lead to actual water conservation.

Groundwater: If an irrigator is pumping groundwater and reduces the amount of water they apply due to irrigation scheduling, the additional water they would have applied will stay belowground in the aquifer.

Pump from a reservoir: If an irrigator is using surface water delivered from an upstream reservoir and they apply less water due to irrigation scheduling, the additional water could stay in the reservoir.

How much water can be conserved through irrigation scheduling?

In general, studies have shown that non-beneficial evaporation from the soil or an irrigated crop can range from 20 – 40%. Irrigation scheduling is one of the rare methods that improves irrigation efficiency -- by reducing diversions – while also being a water conservation method. It is a water conservation method because it reduces soil evaporation and thus reduces

consumptive use. For the studies specific to irrigation scheduling, irrigators conserved water ranging from 5 – 25%. Read the sources below for more detail:

- Brad Udall and Greg Peterson, "Agricultural Water Conservation in the Colorado River Basin: Alternatives to Permanent Fallowing Research Synthesis and Outreach Workshops – Part 5: Irrigation Efficiency." Colorado Water Institute, Colorado State University. 2017.
- Colorado Ag Water Alliance, "Meeting Colorado's Future Water Supply Needs Opportunities and Challenges Associated with Potential Agricultural Water Conservation Measures." 2008.

The amount of water to conserve will depend significantly on the type of irrigation, soil, and experience of the irrigator. For example, in one project supported by CAWA, an irrigator using flood and furrow irrigation reduced the amount of water they applied by 40%. In another project, an irrigator using sprinkler irrigation in the San Luis Valley (an area that has been making water conservation efforts for decades now) reduced their pumping by 4.6% with irrigation scheduling.

Things to consider when implementing an irrigation scheduling project?

Through the projects we funded, there were many lessons in what it takes for an irrigator to successfully use irrigation scheduling to improve their farm or ranch.

Time: It can occur in one year, but often it can take multiple years for an irrigator to incorporate date from a soil moisture probe or other technology and using that data to change how they schedule irrigations. Irrigators will try a technology for one year, see little or no results, and then give up because they do not see a benefit to the cost. This is why it may be necessary to help cover the cost of irrigation scheduling for multiple years before an irrigator may see enough of a financial benefit to continue using something like a soil moisture probe.

Technical Support: The most significant obstacle we ran into was technical issues with soil moisture probes. Projects were more successful if the irrigator was receiving some sort of technical support from the manufacturer, an agronomist, or a consultant. There is no such thing as an "easy" soil moisture probe or a technology that doesn't require technical support. Soil moisture probes need to be properly calibrated to the soil in the field. It is often better to have a technician calibrate the probe. Many probes come with recommended settings for calibration based on soil type. These are often inaccurate and it is better to calibrate the equipment in the field with the soil. In one case, batteries for one probe were so unique they had to be ordered from China, and the irrigator couldn't use the probe for weeks during the middle of the season. In another situation, the equipment broke down and the companies nearest technician was in southwestern Kansas. It took over a month to get the equipment running again. Regardless of

the brand or technology, we recommend any irrigation scheduling project to have someone in the county or assigned to the project that can respond to issues within a day or two.

Easy to Read: For each type of irrigation scheduling technology, data can be presented in a variety of ways. Some problems we ran into:

- Some technology presents too much data, spreadsheets, and information that needs to be explained like soil water deficit or moisture content. Irrigators found this type of interface not helpful or difficult to use. One type of moisture probe simply said the moisture content of the soil, but irrigators found it difficult to know what to do based on this value.
- It was much better when data was interpreted on an app and shows an "area" on the graph that the soil moisture content needs to stay in. Some apps interpret the data based on the soil moisture content and consumptive use of the crop, and simply provide a color like red, yellow, and green (red = very dry, yellow = slightly dry, green = wet).
- When asked, irrigators would often spend a minute or less on an irrigation scheduling app reviewing information. They want something simple that they can easily look at and access from their phones. Technology that relied on a desktop was harder for irrigators to regularly check and they wouldn't keep up with it throughout the season.

Trusting the data: When an irrigator began using an irrigation scheduling technology, we typically heard concerns about trusting what the data says, especially if it was different than what an irrigator would normally do. Some irrigators expressed concern that if they followed the data from a soil moisture probe, that it would impact yields. The only solutions we found to address this distrust are time and a second opinion. As previously mentioned, it can take years for an irrigator to use data from soil moisture probes or other technology when making irrigation decisions. Often, they will spend an entire season just seeing how the data compares to what they would normally do, not making any changes and verifying that it is accurate. It did also help if an irrigator could get an agronomist or consultant to read the data verify its accuracy. At times, the irrigator would prefer a second opinion from someone who doesn't work for the company that is providing the technology. They believed they would get a more honest opinion from someone who did not work for the company providing the equipment.

Opportunities for scaling up irrigation scheduling projects in Colorado

Groundwater pumping: The best opportunity for irrigation scheduling is for irrigators that rely on groundwater. Irrigation water is on demand throughout the season, individual wells are metered, and the cost of irrigating (electricity and pumping fees) may make it cost effective to use technology. When irrigators rely on groundwater pumping, reduced pumping from irrigation scheduling can lead to water conservation.

Opportunities: Republican River Basin, Groundwater Management Districts and Rio Grand Basin Groundwater Subdistricts

Augmentation groups: Another great opportunity for irrigation scheduling is augmentation groups. Like irrigators who rely solely on groundwater, irrigation water is on demand throughout the season, individual wells are metered, and the cost of irrigating (electricity and pumping fees) may make it cost effective to use technology. Many of these augmentation groups are limited on augmentation supplies and looking for ways to reduce demand. For irrigators in augmentation groups, reduced pumping using irrigation scheduling can lead to water conservation.

Opportunities: South Platte augmentation groups, Central Colorado Water Conservancy District, Arkansas Groundwater and Reservoir Association, and Lower Arkansas Water Management Association

Surface water system with a reservoir: There may be opportunities with large districts that have distribution systems that are either piped and pressurized or lined, accurate deliveries made to each irrigator, and a reservoir "at the top of their system" that irrigators draw from. Many of these systems have a reliable and continuous supply of water and a reservoir they draw from. Depending on the system (and sometimes the location in the system), but irrigation scheduling can lead to water conservation by keeping water that would have been applied to fields in a reservoir.

Opportunities: Dolores Water Conservancy District, Fire Mountain Canal, Grand Valley Water Users Association, Uncompahgre Valley Water Users Association, Palisade Irrigation District, Bostwick Park Water Conservancy District, North Sterling Irrigation District, and Fort Morgan Canal Company

Surface water: When working with surface water users, irrigation scheduling can improve efficiency but is unlikely to result in water conservation. However, two recent examples demonstrate how even improvements in efficiency can be meaningful.

One irrigator in Pueblo County relies on surface to flood irrigate using furrows for corn. With the help of irrigation scheduling, they were able to adjust form applying 51 inches of water to 31 inches without impacting yields. For the irrigator, this meant irrigating the field for a 16-hour set as opposed to a 24-hour set. In many ditch systems, if water is not applied to one field there is still water running in laterals. It doesn't just shut off. When the irrigator was done with the field using irrigation scheduling, they applied the water to the next field. While this doesn't result into any conserved water, this gain in efficiency can be incredibly meaningful for the producer. In water short years, the irrigator can keep more land under production and irrigate multiple fields according to the same schedule.

Another irrigator in Routt County uses "wild flood" irrigation on grass hay. This method of irrigation involves digging small ditches to spread as much water as possible over an irregular shaped field that is not level and can undulate. Western Colorado is dominated by this type of irrigation and it is difficult to even measure how much water is applied to a single field. This landowner has been irrigating this field for decades. He installed a moisture probe in a specific location in the field because he knows that when that part of the field is fully saturated with water, the rest of the field is also saturated. He doesn't "read" the soil moisture probe in a traditional sense. Instead, all he pays attention to is when the graph reaches a certain point. When he stops irrigating that field and shuts off the ditch, water flows downstream and is likely diverted by another water user. However, it saves him significant time using the moisture probe and by not overirrigating he is likely improving yields and has reported as much.

What can a scaled-up irrigation scheduling project look like?

Quantify past use: To know the impact of irrigation scheduling on the amount of water applied, it is helpful to know how much water has been applied to the field in previous years. Irrigation wells using groundwater and flowmeters are the best example that exists. We can easily look up pumping records in previous years and compare to any changes once irrigation scheduling begins. In general, irrigators have an idea of how many inches of water they apply to a field if they use a sprinkler, and that can be a helpful comparison. Also, if they have a sprinkler, historical data for the electricity to run the sprinkler is available and can be used to estimate how much water has been applied. Many flood irrigators do not necessarily measure the amount of water they apply in inches but time. It can take 12, 16, or 24 hours for them to irrigate a field sufficiently with siphon tubes, gated pipe, or seepage from laterals. Quantifying the amount of water applied in previous years in these situations can be very difficult unless the irrigator has kept detailed records.

Measurement: Throughout most of Colorado, individual fields do not have a measurement device (flume or flowmeter) and some irrigators may not know exactly how much water they apply to field. It can be difficult to schedule irrigation if an irrigator is not sure how much water is even being applied to a field. To be clear, there are ways they can determine how much water is applied without a measurement device. If they use a sprinkler, they can keep track of how much they apply every week. If they use siphon tubes, they can estimate the amount of water applied over a 24-hour period. If they use gated pipe, they can also estimate how much water is applied to a field. However, calculating the amount of irrigation water applied these ways is time consuming and burden to the irrigator. Ideally, fields with a measurement device are an easy and accurate example to quantify the amount of water applied to a field. It may be beneficial to pay for and install measurement devices for each field in a project if measuring the exact amount of water applied is necessary.

Provide support: Any new technology being introduced to agricultural producers needs to be supported with in-person technical assistance during the growing season. Equipment will need to be installed properly, problems addressed quickly, and data interpreted. It can be even more helpful to debrief after the end of the season, go over the data, questions from the producer, and discuss the season. It would be wise to be skeptical of any irrigation scheduling technology that insists technical support is not needed.

Multiple years: At previously stated, it can take multiple years for an irrigator to use data from irrigation schedule and change the way they irrigate. A project should last at least 3 years and more likely five to provide enough time for irrigators to use the technology over a period of time that will include normal, wet, and dry years. During this entire time, it will be necessary to provide technical support, not just in the first year.