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CSU Extension - Small Acreage Irrigation Evaluation Instructions

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OVERVIEW

Introduction

This document is the companion to the latest release of the CSU Extension "Small Acreage Irrigation Evaluation" Excel™ spreadsheets[1] for evaluating small acreage land parcels that are *furrow* or *side-roll* irrigated. Contained within this document are instructions to perform a basic evaluation of a furrow or side-roll sprinkler irrigated land parcel with the corresponding spreadsheet. These are not intended to be bullet proof assessments, as especially furrow irrigation is an inexact art-form[2]. This manual and the accompanying spreadsheets are a guide only and will require at the minimum a fundamental understanding of irrigation evaluations and small acreage irrigation practices (in Colorado) if the output is be of use to the irrigator.

The algorithms for both the furrow and side-roll evaluations were synthesized from the two most significant irrigation evaluation authorities in the country:

- The Irrigation Association[3] (IA), which focuses more on lawn irrigation but has developed many of the distribution uniformity calculation techniques that can and are applied at the agricultural level.
- California Poly-Technical University[4] (Cal Poly) Irrigation Assessment literature. Cal Poly runs intensive irrigation assessment classes for all irrigation systems. Their literature includes most of the important extra analysis beyond distribution uniformity.

Evaluation Definitions

Why evaluate small acreage irrigation? The main reason is to identify where irrigation techniques could be improved to benefit the land manager's agronomic enterprise. While much can be learned – to the benefit of the evaluator – from comparison of one small acreage manger's irrigation management to another, the primary function of an evaluation is to facilitate the application of good irrigation water management (IWM). Most small acreage owners know some IWM but a well performed evaluation will help eliminate outstanding knowledge gaps. Some key results of interest to the land manager are reduced labor input and improved crop performance. It should be stressed *that while obvious maintenance issues are outstanding an evaluation will not provide any new information; resolve the maintenance issues before evaluating*.

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[1] As of Oct 10th 2010, "Small Acreage Audit Furrow v4.0 093010.xls" and "Small Acreage Audit Side-roll v1.4 100710.xls" are the latest versions.

[2] ITRC Paper No. P 98-003 On Farm Irrigation Management - The Shift from Art to Science Burt, Charles M., 1998.

[3] http://www.irrigation.org/certification/default.aspx?pg=draft_guidelines.htm&id=25

[4] http://www.itrc.org/classes/iseclass.htm

The evaluation is broken into two main areas that overlap to form a complete evaluation. The *snapshot assessment* is the physical measurement that occurs at the time of the evaluation. This provides the evaluator with a snapshot of how successful the irrigation system is at distributing water efficiently and uniformly throughout the irrigation area. The *seasonal assessment* is a more general overview of irrigation practices outside the scope of a one-time snapshot. The Excel™ spreadsheet provides a tool to bring these two evaluation areas together to give a more comprehensive assessment of the land managers irrigation system and IWM.

FURROW IRRIGATION EVALUATION

The following instructions are for furrow irrigation: gated pipe or siphon tube systems. Please refer ahead if you are evaluating a side-roll system.

The Spreadsheets Within

There are five sheets within the spreadsheet: *Field*, *Snapshot*, *Bucket, Seasonal*, *Report, and Conversions*. Ignore *Conversions* it is simply a reference sheet for some basic unit adjustments. Having this sheet means updating the spreadsheet in the future will be quicker and easier.

Field: This sheet asks for the input of field level parameters such as size, furrow width, length, etc. Collecting this information means that as (furrow) readings are recorded they can be instantaneously converted to useful irrigation information that is field scale. Some of this produced field information includes:

- field efficiency: water likely absorbed by root zone / total water applied
- irrigation efficiency: (inflow – outflow) / inflow[1],
- distribution uniformity,
- inches applied, and
- inches available to the crop.

Snapshot: This sheet relates to the furrow assessment portion of the evaluation. Prompts ask for furrow flow information and calculate the Distribution Uniformity (DU) of flows along measured furrows. DU is a comparison of averages: average of (lowest quarter of flows), divided by: average of (overall flows); the higher this fraction the better the uniformity.

Due to the complications with measuring DU in a furrow operation the spreadsheet provides a number of options. The “Furrow Snapshot Protocol” section gives more detail on the choices that are available and what might best suit the field you are working with.

Bucket: If furrow flows are being measured by timing volumes out of gates into a vessel then this sheet will convert stopwatch fill times into gpm flows for the *Snapshot* sheet. Make sure you select the correct “Top Measure” at the top left of *Furrow Snapshot* when using this sheet.

[1] Moist fields, especially those growing pasture (grass hay, alfalfa) or with tail-water drainage problems are not conducive to a traditional “in versus out” water balance measurement. In these cases furrow flow measurements at the bottom of the field or volumes collected out of pipe gates used to calculate distribution uniformity and field efficiency will suffice.

Note: these bucket times will work as a surrogate for Distribution Uniformity but when calculating irrigation efficiencies the correct flow values will be needed.

Seasonal: This sheet relates to the field or seasonal assessment portion of the evaluation. Prompts collect management information relevant to assessing seasonal irrigation efficiency and efficacy that was not recorded in the furrow flow assessment.

The "Seasonal" sheet also has additional subsections which allow for a more detailed description of furrow irrigation terminology and recommendations based on anecdotal information about how irrigation is practiced within the evaluation area throughout the growing season.

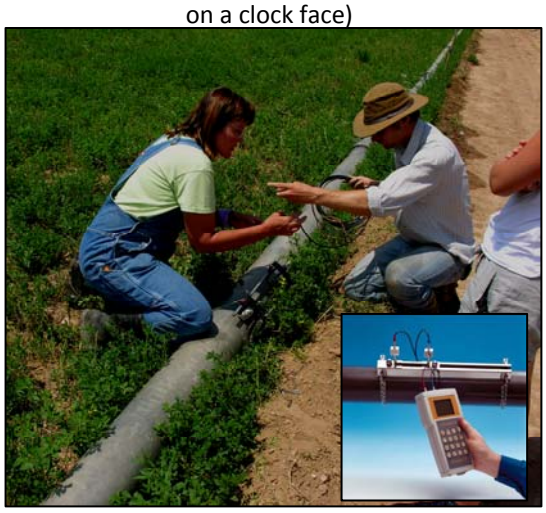
Furrow Snapshot Protocol

The furrow assessment can be performed a variety of ways. The most important variables the evaluator is seeking for a furrow assessment are flow onto the field and how this is distributed between the furrows. If the evaluator can determine how much water is leaving the field this is also useful, but not essential for a meaningful evaluation.

For determining flow onto the field there are a number of options available to the evaluator:

1. Flume at the headgate: for most ditch companies there is a flow measuring device such as a Parshall flume at the property or lateral headgate (if lateral users share water). If there are no major leaks or significant stretches of earthen ditch between the device and the irrigated field this measure makes a perfectly satisfactory inflow measurement.
2. Portable magnetic flowmeter[1] (mag-flow): for gated pipe systems there is usually a stretch of pipe upstream of irrigation that a portable magnetic flowmeter can comfortably fit around. Check the mag-flow manual that you have enough unimpeded pipe up and downstream of measurement to give an accurate measurement. Also be sure you attach the sensor so air bubbles or sediment layers do not interfere (see Figure 1).

Figure 1 : Installing the Ultrasonic Flowmeter
(notice sensor is at 45° to pipe center or "1:30" on a clock face)



3. Flow grabs at gates or "bucket test[2]" using a flat tub of known volume. The time to fill from each gate can be used to calculate flow into each furrow. This

[1] Contact NRCS or CSU Extension for gaining access to short term use of ultrasonic flowmeters

[2] A "bucket test" is where a vessel of a known volume i.e. the flat tub mentioned, is timed to fill directly from water flow out of a gate. This is then converted to a flowrate.

method doesn't work so well for tubes since raising the tubes to fit in the tub or "bucket" will lower the flow out of the tube.

4. Furrow flumes[1]: are by far the most cumbersome method for measuring flow and not necessarily that accurate. This method is most suited for measuring flows in row crops like corn. When using flumes make sure all water in the furrow passes through unimpeded and that they are level i.e. at 0% grade.

Schedule your primary evaluation visit so that you are onsite for the second half of an irrigation set. This is to measure furrow flow behavior after water has advanced to the end of the field. If it takes longer than three-quarters of the total set time to advance water across the field, it is potentially a symptom of sub-optimum IWM. Examine soils, field grade and furrow maintenance closely.

Figure 2: Checking root depth using a soil probe

Start with the *Field* sheet and enter basic information for the evaluation area: acreage, furrow length, center spacing, etc. Other information like root depth can be measured with a soil sampling probe (see Figure 2): this will work for pasture and hay crops – for row crops it is best to dig up a representative plant sample and physically measure the root zone. For soil type consult USDA-NRCS's soil survey[2]. If more precise soil information is available this can be entered manually in the middle column marked "Manual".

Figure 3 : **A bucket test** being timed for estimating furrow flow.

To measure inflow some head-gates will have a flow-meter or flume for others you will need to use an ultrasonic flow-meter. In some cases neither will be possible and "bucket" tests on pipe gates will be all that is possible; the spreadsheet will account for this and make a best estimate of efficiency and DU.

For pipe gate **bucket testing:** select a container of known volume that will catch the majority of water leaving pipe gates e.g. a large tupperware cake container (see Figure 3). Randomly select between 12 and 20 gates and time flows into the container. Enter volume of container into *Bucket Test* sheet along with times to fill and the spreadsheet will automatically convert times to flows in gallons per minute and enter them into the *Furrow Snapshot* sheet under the "1. Raw Furrow Flows" table (check "Top Measure" is selected as "bucket" not "flume").

[1] furrow flumes are available through your local NRCS office http://www.co.nrcs.usda.gov/contact/index.html

[2] Online at: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

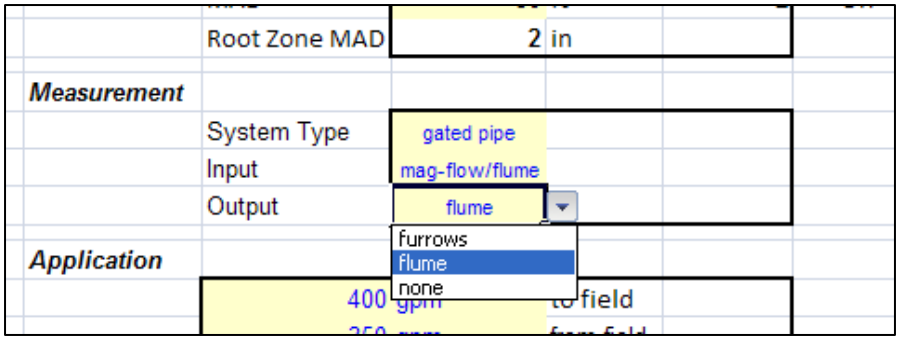
For the **furrow flume assessment**: place available flume pairs at the top and bottom of furrows that are representative of furrow flows within the evaluation area. Check that each furrow with a flume at the top also has a flume at the bottom. Use a spirit level to ensure that furrows are level both "north, south" along the furrow and "east, west" across the furrow. Pack soil around inlet to the flume so *all* surface flow from the measured furrow passes unimpeded through the flume. The longer throated section should have a scale up the side of the throat – this end of the flume should point "upstream" toward the gated pipe / cement ditch (see Figure 4). Make sure you have the means to translate the scale into flow units (gallons per minute, gpm)[1].

Figure 4: Placing Furrow Flume (notice a spirit level is used to ensure lengthways and crossways that the flume is flat).

Once water is flowing steadily through all flumes go to the *Snapshot* sheet. Enter into the highlighted section on the left under "1. Raw Furrow Flows" flow readings from all the flumes. Be sure to match "Top" flume flows with its corresponding "Bottom" flow. The spreadsheet will calculate a DU for the measured furrows and incorporate them into *Field Info* calculations.

Once you have entered your *Field* and *Snapshot* data in, it's important to adjust the measurement section of the *Field* sheet (see Figure 5) so that the correct inputs are used to calculate irrigation efficiency:

Figure 5: Measurement options on *Field* sheet



- Select the correct system type: siphon tubes or gated pipe.
- Select the correct measurement for calculating flow *into* the field: magnetic flow meter or head gate flume.
- Select the correct measurement for calculating flow *out* of the field: furrow flumes or bucket tests, waste ditch flume or nothing.

The spreadsheet will automatically compensate if you aren't able to measure an Output flow.

[1] USDA-National Resources Conservation Service and CSU Extension has charts for converting flow height to gallons-per-minute (gpm).

The key results from the entering complete data into *Furrow Snapshot* and *Field Info* are the inches of water infiltrated (or absorbed) into the soil around the crop. This combined with the DU and a basic efficiency calculation provides a snapshot of how well the irrigation is performing. Good results are a DU greater than 60 percent, irrigation efficiency of over 35 percent and somewhere between half an inch and an inch of water applied *to the crop* per foot of root depth. Bold red and orange coloring indicates a problematic result and closer examination of entered data. A closer inspection of the irrigation system and its management is strongly encouraged. The Seasonal Assessment and additional inspections or evaluations throughout the irrigation season may shed some light on these problems.

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SIDE-ROLL EVALUATION

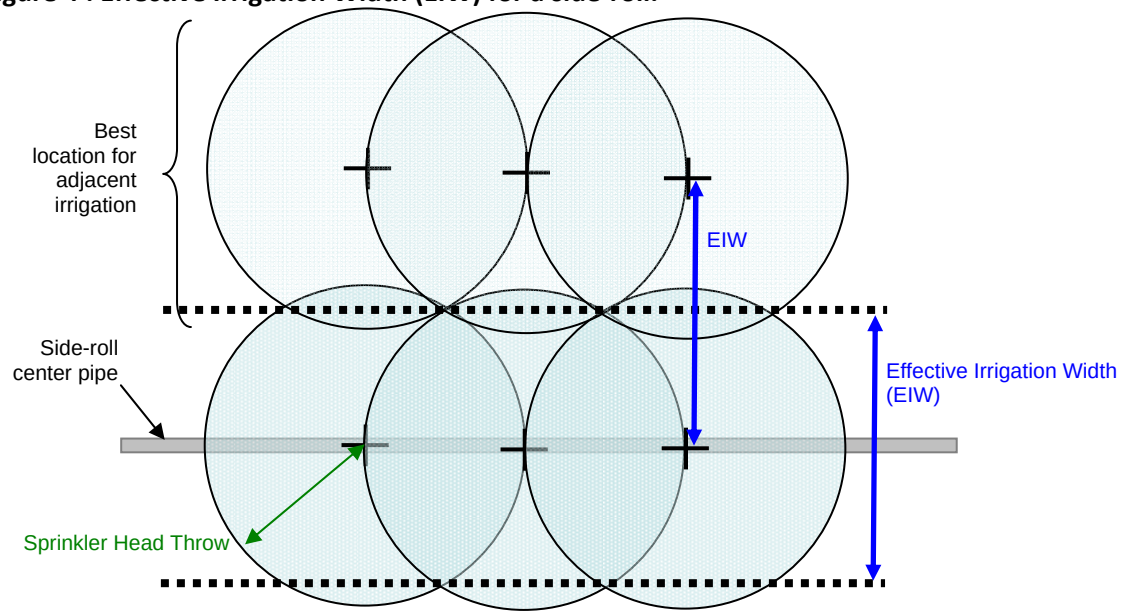
The Sheets Within

Like the furrow assessment, there are four sheets within the side-roll spreadsheet: *Field*, *Snapshot*, *Seasonal*, *Report,* and *Conversions*. As with the furrow evaluation sheet, ignore *Conversions,* it is simply a reference sheet for some basic unit adjustments. Having this sheet means updating the spreadsheet in the future will be quicker and easier.

Field: This sheet asks for the input of field level parameters such as size, crop type, and side-roll dimensions. Refer to the *Furrow Evaluation* for additional information on these parameters.

One of the important parameters calculated on this page for the Side-roll evaluation is the *effective irrigation width* (EIW). The EIW marks a width along the length of the entire side-roll where sprinkler heads overlapping is maximized (see Figure 4). If this distance is used for moving the sprinkler between irrigations it will help improve field distribution uniformity. It will be worth measuring wheel circumference to assist the producer with estimating move distance.

Figure 4 : Effective Irrigation Width (EIW) for a side-roll.



Snapshot: There are a number of methods for calculating distribution uniformity or DU for a side-roll. The catch-can test for this program is focused on maximizing information return from time invested.

This spreadsheet asks for up to 30 catch can volumes for two separate catch can tests to calculate a side-roll DU and application rate. The two tests are from diagonally opposing sections of the irrigated area surrounding the side-roll. The results calculated from these two tests provide a reasonable estimate of irrigation performance for the full length of the side-roll. These results are then incorporated into the Field and Seasonal assessments.

Side Roll Snapshot Protocol

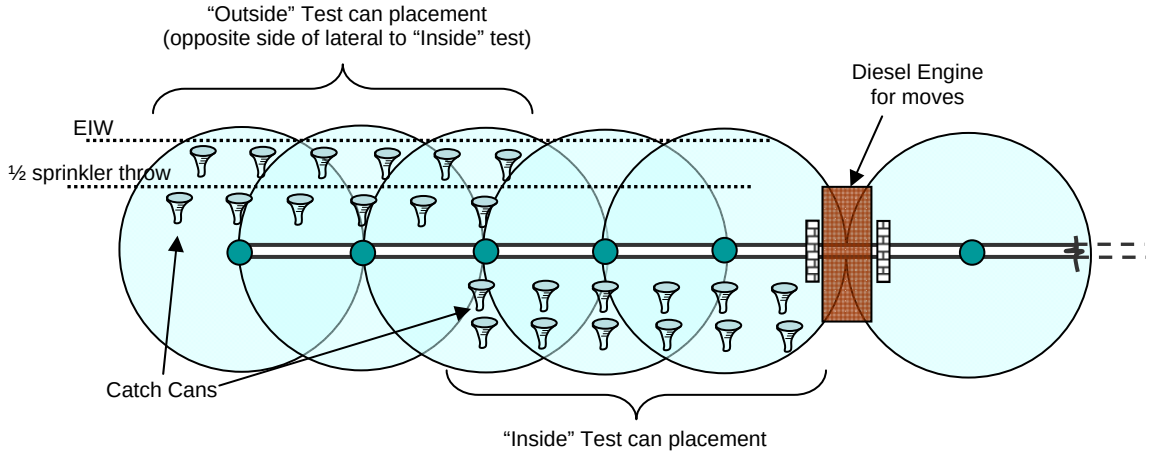
If you have control over the inlet water to the side-roll we recommend turning it off to place catch-cans. If this isn't possible then (be prepared to get wet!) start timing the test with the placement of the first can. Leave time between placing each can equivalent to what it would take to measure cans; about 6-10 seconds. Follow the placement guide in Figure 5: Set cans in two rows parallel to the side-roll. Have the inner most row just under half a sprinkler throw away (if sprinklers throw 40 feet then about 15 feet is a good placement). Have the outermost row between half a sprinkler throw and the Effective Irrigation Width away from the side-roll (about 7/8's of sprinkler throw), so for the 40 feet throw example, about 30 feet is a good distance).

You will need at least 15 minutes of continuous irrigation to adequately fill catch cans (25mL). The calculations in the spreadsheet use a standard 15.9 square-inch throated can but it is worth considering using wide-mouth cylinders and measuring each with a graduated cylinder; make sure you adjust the throat diameter accordingly. Note: this is potentially more accurate, giving you more measurement coverage but will tend to take a little more time.

The process requires two timed catch can tests, one on sprinkler heads adjacent to the central water inlet point (where the diesel move motor is) and one on the outermost sprinklers. Make sure these are on opposing sides of the side-roll. The pairing of these two tests gives a snapshot of the full length of the side-roll system.

The *Snapshot* spreadsheet will produce a number of DU numbers, for the side roll as a whole and separately for the innermost and outermost sprinklers. This will allow you to determine if a sub-optimum DU is perhaps being caused by a lack of water making it to the outermost heads.

Figure 5 : Can placement. Cans can either be offset (outside) or in-line (inside). The diagram is to demonstrate both options - be consistent and use same layout for both tests.



Additionally application rates are calculated, both for the length of the side-roll and for the tested sections. This data combined with crop and field characteristics will allow for optimum scheduling of irrigations. DU of less than 50% is considered poor for a side-roll and below 60% is problematic. The *Seasonal* sheet outlines some considerations that may contribute to poor DU.

Figure 6: Catch-cans set in two rows next to the side roll. This side roll has a sprinkler throw of 40 ft. The innermost row is placed less than half of the throw (20ft) away from the side-roll and the second row is placed between half the throw distance and the outside of the Effective Irrigation Width or EIW (~35 feet away).

SEASONAL ASSESSMENT

This section relates to the *Seasonal* sheets for both the furrow and side-roll irrigation spreadsheets. Responses on this sheet combine to provide a rough seasonal assessment of irrigation.

The Seasonal Assessment is a guide for interviewing the irrigator for site specific information about the evaluated area and its irrigation management that may not be otherwise available to the evaluator via the snapshot furrow and catch-can tests. As crops grow and water temperature and quality changes irrigation management must also adapt to be consistent in its delivery of water to meet crop needs. The objective of this section is to imprecisely determine how successful the irrigation manager has been at applying water to the crop throughout the season.

The *Seasonal* sheet is broken into four major sections:

- Soils
- Field
- Water
- Season Efficiency (Eff_{seas})

Some of the information from other sheets, such as DU and soil type, are transferred from the *Field Info* and *Furrow Snapshot* sheets to make calculations more consistent.

Each section contains a *Definitions* column and an *Analysis and Recommendations* column. These two latter columns help the land manager first understand why he/she was asked certain questions (*Definitions)* and likely fixes to problems (*Analysis and Recommendations):*

Soils: The objective of this section is to determine if measured infiltration rate is consistent with the potential infiltration rate of the soil. An inconsistency between the two could point to a leak, ponding (surface sealing) or water loss through rapid percolation (sandy soils).

Field: The objective of this section is determine if the crop matches the available root zone and if the field has been suitably prepared for furrow irrigation. A poorly graded or marked field with a shallow hardpan layer would severely limit agronomic options and irrigation effectiveness.

Water: The purpose of this section is to gauge how well water flow is managed throughout an irrigation set. Does the irrigator get water across the field in good time, reduce flows post-advance and manage wheel and non-wheel rows separately (for furrows), or checked for head corrosion of blocked nozzles (side-roll). A lack of or inconsistency with these practices can contribute to poor DU or sub-optimum irrigation efficiency.

Seasonal Efficiency (Eff_{seas}): This section is to determine the land manager's appreciation for the seasonal component of irrigation scheduling. The major indicator of poor seasonal scheduling is a very low seasonal efficiency. Such a result would be an opportunity to educate the irrigator about the use of soil moisture probes, soil moisture sensors and soil moisture by feel[1], and timing of sets and interval.

Seasonal efficiency is best thought of as a comparison of the known average seasonal consumptive use of the crop for the area to an estimate of annual water applied the field.

For example: A fully irrigated field of alfalfa in the Grand Valley annually consumes about 32 inches of irrigation water on average. If the irrigator applies about 8 inches per irrigation[2] and does so about 15 times per year. Then seasonal efficiency:

$$Eff_{seas} = \frac{32 inches}{(15 * 8) inches} = 27\%$$

Finally when you are satisfied all information has been correctly entered and results recorded, the *Report* sheet is available as a formatted-for-printing one-page summary. This printout works well as a hard-copy record for files and to leave with the irrigator.

Conclusion

The combination of the furrow snapshot and the analysis of general, seasonal IWM information allows the evaluator provide a meaningful and constructive assessment of furrow irrigation on a small acreage. This evaluation alone is unlikely to be all an interested small acreage manager could use to improve his/her IWM. It is recommended that the evaluator or partners follow up with additional calls and visits to see where help with recommendations could be provided. Returning both for the day after irrigation to measure soil moisture with a 5/8" ball probe or by feel and then for the next irrigation are excellent starting points for follow-up. Be sensitive to strengths and weaknesses.

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[1] Online at: http://attra.ncat.org/attra-pub/soil_moisture.html and ftp://ftp-fc.sc.egov.usda.gov/MT/www/technical/soilmoist.pdf

[2] This "per irrigation" amount applied is taken from the *Field Info* water applied calculation of the audited irrigation.