ENVIRO – STEWARDS

engineering change

CENTRE PIVOT IRRIGATION SELF-ASSESSMENT TOOL FOR:

Holland Marsh Growers' Association

January 28, 2022

HMGA-02-P01

519.578.5100
enviro-stewards.com

Centre Pivot Irrigation System Self-Assessment Tool

Why Assess Your Centre Pivot Irrigation System's Performance?

- Helps you visualize how uniformly water is applied & make adjustments to improve crop coverage;
- Allows you to determine the depth of water applied;
- The crop and your pocket book will benefit by a properly functioning irrigation system. Quality product + maximum yield = maximum profit.

How Often Should You Assess Your Irrigation System?

- At least once a growing season.

How Do You Assess Your Irrigation System's Performance?

Observation: look for problems such as runoff, wet or dry patches in target and non-target areas.

Distribution Uniformity (Low Quarter) Test: evaluates how evenly irrigation water is applied over a collection area. The **target is 90%** for a centre pivot system; however, 70% is considered fair but requires regular annual system maintenance to ensure performance does not drop below 70%.

Tools

- Identical collection buckets:
  - The number must be divisible by 4;
  - The height of the buckets should be at least 120 mm (5”);
  - The entrance diameter of the bucket should be one-half to one times its height, but not less than 60 mm (2.5”);
  - The collector should be light in colour to minimise evaporation.
- Measuring tape;
- Large bucket (at least 17.5 litres) with volume scale &/or a graduated cylinder to measure water in collection buckets;
- Tablet or clipboard to record data;
- Boots;
- Towels: to wipe down equipment.

Equipment used in these tests is presented in Figure 1.

Figure 1: Test Equipment

Distribution Uniformity (Low Quarter) Test

Setting up the buckets:

You will be setting up a lot of buckets, which takes time. Give yourself enough time for bucket set up before irrigation of the test area begins.

- The buckets should be spaced uniformly in a straight line perpendicular to the direction of travel of the pivot arm (Figure 2);
- Starting from the centre (pivot), Place the first bucket at a distance that is 10% to 20% (ideal) the length of the entire pivot arm:
  - You may need to adjust the first bucket's placement to avoid a wheel track and to ensure the total number of buckets is divisible by 4.
- Space the buckets not more than:
  - 3 m (10 ft) apart for spray devices;
  - 5 m (16 ft) apart for impact sprinklers;
  - If possible, the bucket spacing should **not** be an even multiple or fraction of the sprinkler or spray device spacing;
  - If you don't have enough buckets, use a wider bucket spacing.
- The nozzle's discharge should be at least 1 m (3.3 ft) above the top of the bucket;
- The buckets should be no more than 0.3 m (1 ft) above the ground or crop canopy;
- Adjust the bucket location to avoid wheel tracks;
- If there is an end gun, place buckets to cover the full reach of the gun:
  - If possible, the number of buckets should be divisible by 4 in order to determine low quarter for the end gun zone;
  - You may want to set up a few extra buckets beyond the end gun's radius to verify how much water the gun is delivering beyond the target area. These buckets are a visual check only and are not included in the distribution uniformity calculation;
  - Site constraints such as road, buildings, end of property may restrict the number of buckets that can be placed.
- Ensure the buckets are level;
- Ensure the tops of the buckets are above the plants;
- Ensure the tops of all buckets are the same height:
  - Move a bucket if it is on top of a plant, hill or wheel track so that it sits level & as close to the measured location as possible.

Things to avoid:

- Bucket placement in a wheel track;
- Windy conditions;
- Rain;
- Leaving the buckets out on sunny, hot days after the system has passed by to avoid evaporative losses of collected water;
- A location where there is a risk of vandalism or loss of the buckets if the site is left unsupervised;
- Obstructions that will interfere with the movement of the water.

Bucket spacing: Example 1,055’ pivot arm with 98.3’ radius end gun

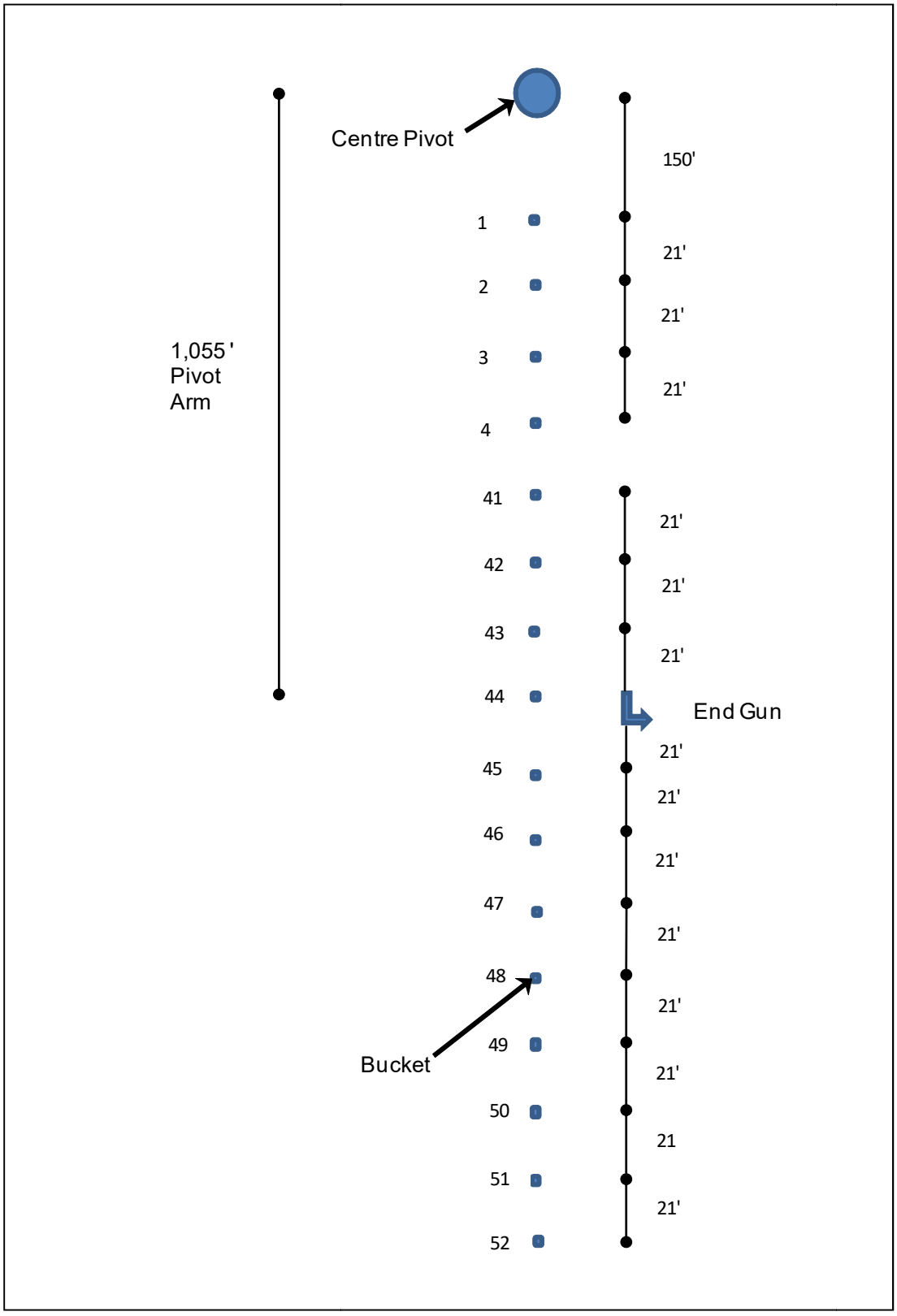
An example bucket layout for a 1,055’ long pivot arm with 98.3’ radius end gun is presented in Figure 2. The number of buckets must be divisible by 4. In the following bucket layout example, the first bucket is placed 150’ from the centre pivot.

After setting up, check the row of buckets & adjust them to make sure they are in a line, not in a wheel track, above the plants, at the same height, & sitting level.

Irrigation system operation

- Record the time it takes to water the test area, including the extension gun zone;
- To reduce evaporative losses, start measuring the water in the buckets where irrigation is complete, rather than waiting until the system has passed over all the buckets.

Figure 2: Example of 1,055' Pivot Arm with 98.3' Radius End Gun



Record Observations

Record any issues observed during system operation & while walking the irrigated area (Table 1):

- While the system is operating look for:
  - Malfunctioning gun;
  - Gun: improper angle of throw;
  - Malfunctioning sprinklers: not rotating, dribbling, improper angle of throw;
  - Leaks: centre pivot riser, pivot arm spans, sprinkler heads, regulators (for systems on rolling or hilly terrain), gun;
  - Malfunctioning gear box;
  - Water flowing out of the drainage system.
- After the system stops look for:
  - Leaks in pipe work;
  - Dry patches;
  - Ponded water or wet patches;
  - Runoff or erosion;
  - Non-target land is wet; e.g., non-cropped or adjacent irrigated areas;
  - Water flowing out of the drainage system.
- At least once per month, evaluate pump and motor performance to identify when maintenance is needed on the pump or power supply:
  - Record system outlet pressure;
  - Record flow rate (for systems with a flow meter);
  - Record energy use if displayed or diesel use.

Table 1: Record Observations During & After System Operation

Date	Location	Record Value	Initials
	Record outlet pressure		
	Record flow rate		
	Record energy use		
Date	**Location**	**Issue**	**Initials**

Measure Water in Buckets

Number the buckets as indicated in Figure 2. Record the volumes in Table 2.

Table 2: Record the Volume in Each Bucket

Bucket #	Volume (ml or inches)	Bucket #	Volume (ml or inches)
1		27	
2		28	
3		29	
4		30	
5		31	
6		32	
7		33	
8		34	
9		35	
10		36	
11		37	
12		38	
13		39	
14		40	
15		41	
16		42	
17		43	
18		44	
19		Gun 45	
20		Gun 46	
21		Gun 47	
22		Gun 48	
23		Gun 49	
24		Gun 50	
25		Gun 51	
26		Gun 52	

What do These Measured Water Volumes Reveal?

Observations:

- Looking at the amount of water in the buckets gives a good indication how evenly the water was distributed over the area;
- Watching the system operate & walking the irrigated area after the system is finished, allow you to identify and correct issues quickly.

Measured volumes:

- Tell you how much water was applied over the area and how evenly it was distributed;
- NOTE: Discard measurements for tipped or leaking buckets or other explainable variances not due to the irrigation system's performance:
  - Deleted measurements should not exceed 3% of the total measured volumes.

Calculate Distribution Uniformity (Low Quarter)

Pivot arm plus gun:

- Arrange the volumes from lowest to highest;
- Calculate the average volume for the low quarter of all the volumes (for 52 buckets, calculate the average for the 13 lowest volumes) = Average Low Quarter (ml or inches);
- Calculate the average volume for all the buckets = Total Average (ml or inches);
- Distribution Uniformity (Low Quarter) = $\frac{Average\ Low\ Quarter\ (ml\ or\ inches)}{Total\ Average\ Volume\ (ml\ or\ inches)}$
- The **target is 0.9 (90%) or greater,** anything less indicates a problem; however, research conducted by Michigan State University indicates that 70% is considered fair & that regular annual maintenance is required to ensure the performance of this section does not slip below 70%.

Pivot arm only:

- Arrange the volumes from lowest to highest for the pivot arm buckets only;
- Calculate the average volume for the low quarter of all the volumes (for 44 buckets, calculate the average for the 11 lowest volumes) = Average Low Quarter (ml or inches);

- Calculate the average volume for all the buckets = Total Average (ml or inches);
- Distribution Uniformity (Low Quarter) = $\frac{Average\ Low\ Quarter\ (ml\ or\ inches)}{Total\ Average\ Volume\ (ml\ or\ inches)}$
- The **target is 0.9 (90%) or greater**, anything less indicates a problem; however, research conducted by Michigan State University indicates that 70% is considered fair & that regular annual maintenance is required to ensure the performance of this section does not slip below 70%.

End gun only:

- Arrange the volumes from lowest to highest for the end gun buckets only;
- Calculate the average volume for the low quarter of all the volumes (for 8 buckets, calculate the average for the 2 lowest volumes) = Average Low Quarter (ml or inches);
- Calculate the average volume for all the buckets = Total Average (ml or inches);
- Distribution Uniformity (Low Quarter) = $\frac{Average\ Low\ Quarter\ (ml\ or\ inches)}{Total\ Average\ Volume\ (ml\ or\ inches)}$
- The **target is 0.9 (90%) or greater**, anything less indicates a problem; however, research conducted by Michigan State University indicates that 70% is considered fair & that regular annual maintenance is required to ensure the performance of this section does not slip below 70%.

Calculate Average Amount of Water Applied

- Calculate the average amount of water collected in all the buckets:

$$\frac{Total\ Volume\ Collected\ in\ all\ Buckets\ (ml\ or\ inches)}{\#\ of\ Buckets}$$

- Convert average total water volume to inches:
  - Measure the opening area of your bucket; for example, a 23.3 cm x 23.3 cm opening = 542.89 cm^2

$$cm = \frac{Average\ Total\ Water\ Volume\ (ml)}{Bucket\ Opening\ Area\ (\mathrm{cm2})}$$

$$\text{Inches} = \frac{cm}{2.54\ cm/inch}$$

Potential System Improvements

- Repair leaks;
- Grade uneven ground in wheel tracks;
- Sprinklers (general rule, replace sprinkler nozzle package at least every 10,000 to 12,000 hours of operation):
  - Ensure sprinkler/nozzle flow rate & pressure matches design specifications for section of pivot arm;
  - Standardize sprinklers/nozzles make & model;
  - Replace if plugged or worn;
  - Repair or replace if not rotating;
  - Replace if leaking.
- End gun:
  - Adjust angle of throw;
  - Adjust rotation;
  - Repair or replace if leaking;
  - Repair or replace if plugged or worn.
- Record system pressure at least once a month to identify pump, motor & other problems:
  - Adjust system pressure.
- Record energy use at least once a month to identify pump, motor & other problems:
  - Repair or replace motors.
- Contact an irrigation system professional to discuss other potential solutions.

The estimated costs to implement some of the suggested improvements are presented in Table 3.

.

Table 3: Estimated Costs to Implement Potential Recommendations

Recommendation	Details	Estimated Installed Cost ($)
Adjust orientation, rotation of gun	Visual inspection. Reorient or adjust rotation as required. 1 hr @ $20/hr (utilizing staff) Or consult with irrigation equipment supplier.	$20/gun (staff) $TBD (vendor)
Leak repair	Ongoing maintenance (labour only). 30 min/nozzle leak @ $20/hr 1 hr/leak @ $20/hr for gun, pivot arm, regulator, centre pivot riser leaks.	$10/nozzle leak $20/other leaks
Adjust system travel rate to improve target application; e.g., 1”	1 hr @ $20/hr (utilizing staff) Or consult with irrigation equipment supplier.	$20 (staff) $TBD (vendor)
Irrigation pump upgrades such as pressure delivered at the centre pivot	Consult with the irrigation equipment supplier to determine the required changes.	$TBD (vendor)
Install a Flow Meter or Vibration Sensor	Non-data logging flow meter on a 6” pipe with1 00 micron strainer * 4 hrs * $100/hr Or Vibration data logger & software package	$3,000 (Flow Meter Package) $310 (Vibration Package)

Good Irrigation Practices

- Have the system designed by a professional irrigation system designer;
- Staff training: issues to look for (observations), record pressure, flow, energy use, report observations, make repairs;
- Appoint a person dedicated to recording pressure, flow & energy use, checking the irrigation system while it is operating & to walk the irrigated area after system operation, looking for:
  - Ponded water or spongy, suck your boots off, patches;
  - Runoff or erosion;
  - Dry patches;
  - Non-target land that has been irrigated; e.g., non-cropped areas or adjacent irrigated areas;
  - Malfunctioning sprinklers: not rotating, dribbling, plugged;
  - Improper equipment installation, such as sprinklers not meeting design pressure & flow rate;
  - Malfunctioning gun: not rotating, dribbling, improper angle of throw;
  - Leaks: centre pivot, pivot arm span, sprinklers/nozzles, regulators (systems on uneven ground), end gun;
  - Gun orifice clogging or wear;
  - Tire inflation;
  - Water running out of drainage system during or after irrigation system operation;
  - Water application interference by crop (particularly if long drops are used).
- Conduct a pre-season inspection that includes:
  - Checking for proper tire inflation;
  - Checking the condition of the water-carrying conduit, the boots, clamps, & gaskets;
  - Checking for & replacing broken or worn sprinklers. As a general rule, sprinkler packages should be replaced at least every 10,000 to 12,000 hours of operation;
  - Inspecting the pivot pad & anchor bolts;
  - Greasing all moving parts, including the pivot point bearing, towable hubs, & corner rollers;
  - Checking hydraulic fluid levels & looking for leaks on hydraulically driven units;
  - Repairing or replacing motors;
  - Repairing malfunctioning gear boxes;
  - Repairing or replacing frayed or damaged electrical wires;
  - Checking system alignment;
  - Adjusting tower box microswitch settings to realign pivot. Improper settings can cause pivot misalignment, resulting in shutdowns. Note: microswitches used on many electrical systems for both the alignment & safety circuits have a recommended 10-year service life;
  - Removing the sand trap & thoroughly flushing the system with water;

  - If available, examining yield maps to help identify possible irrigation issues such as a plugged sprinkler, this can significantly reduce yield;
  - Starting up the unit and bringing it up to pressure to check the system for leaks & sprinkler operation;
  - Checking regulators on systems on rolling or hilly terrain to ensure uniform application. Water squirting from the side of a regulator indicates the rubber bladder has failed.
- Irrigate cropped surfaces only;
- If possible, irrigate when it is still, wind speed less than 5 km/hr;
- Based on the results of the irrigation assessment, make upgrades, repairs, changes;
- Install a flow meter if one is not present on the system to manage application rate & identify problems:
  - After upgrades, repairs or changes have been made to the irrigation system, record the value on the flow meter (Start Value);
  - Record the time to run the irrigation system for one set;
  - Record the value on the flow meter (End Value);
  - Total Water Use = End value - Start value;
  - Total Water Use/Hour = $\frac{End\ Value - Start\ Value}{Hours\ of\ Operation}$
  - Every time the system runs, calculate the hourly water use;
  - If this value begins to shift, look for potential issues, including pump operation.
- System winterization:
  - Check for wear on the gun nozzle;
  - Buried pipe work: blow out with compressed air or suck water out;
  - Replace worn or broken nozzles;
  - Check for obstructions or plugging of the intake screen on systems using surface water to irrigate.
- Other considerations:
  - Utilize a soil moisture meter & irrigate based on soil moisture level;
  - Invest in a yield mapping system, such as satellite imaging, to identify irrigation issues;
  - A drone may be an effective tool for some operations to help identify non-uniform application of irrigation water.

Resources

Rebecca Shortt
Engineer, Water Quantity, OMAFRA
519-420-7645
rebecca.shortt@ontario.ca

Water Efficiency and Conservation Practices for Irrigation

http://www.omafra.gov.on.ca/english/engineer/facts/12-013.htm

Best Management Practices: Irrigation Management

https://bmpbooks.com/publications/irrigation-management/

Uniform Water Application Essential for Irrigated Plots and Research, Michigan State University

https://www.canr.msu.edu/news/uniform_water_application_essential_for_irrigated_plots_and_research

Successful Farming, Pre-Season Pivot Checkup, Tharran Gaines, April 26, 2021

https://www.agriculture.com/preseason-pivot-checkup