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Yellowstone Earth Science
Attn: Eric Miller
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RE: Irrigation System Application Efficiencies

Eric:

This letter is written to discuss irrigation equipment application efficiencies and the potential water savings impact of removing pivot end gun sprinklers from center pivot irrigation systems.

Irrigation System Application Efficiency

Irrigation application efficiency is typically defined as the percentage of water that is delivered to a field that is stored in the crop root zone and available for crop use. For irrigation sprinkler equipment it is specifically the percentage of water that is delivered through the irrigation equipment that is stored in the crop root zone and available for crop use. Water losses that contribute to inefficiency for irrigation system equipment include evaporation, wind drift, deep percolation, and surface runoff.

Attainable Irrigation System Application Efficiencies for different system types as presented by the National Center for Appropriate Technology, "The Idaho Irrigators Pocket Guide", September 2006, in Table 4 are included below.

Table 1. Attainable Irrigation System Application Efficiencies

Sprinkler System Type	Efficiency %
Linear move	75-90
Center pivot (low pressure)	75-90
Fixed solid set	70-85
Center pivot (high pressure)	65-80
Hand move or side roll laterals	60-75
Traveling gun	60-70
Stationary gun	50-60

A similar table can also be found on the U.S. Bureau of Reclamation, Agrimet web page at: https://www.usbr.gov/pn/agrimet/irrigation.html#Efficiency. Irrigation application efficiencies as presented in Table 1 are based on averages for well-managed and maintained systems.

Center Pivot End Gun Evaluation

Average application efficiency for a center pivot end gun can be represented by the efficiency listed for a traveling gun in Table 1 with a range of 60-70%. A value of 65% is typically utilized for an end gun in the design of a new center pivot system. On a standard ¼ mile long center pivot an end gun will typically irrigate about 9.5 acres assuming that it is turned on for all four corners that are typically missed by the main center pivot (end gun operates 50% of the pivot revolution). Three options for water savings with the removal of a pivot end gun are discussed as a part of this document: end gun removal without transferring the water to other acreage, end gun removal and transfer of water to other acreage irrigated by hand line or wheel line sprinklers (hand move or side roll laterals in Table 1), and end gun removal with transfer of water to other acreage irrigated by a center pivot system.

End Gun Removal without transferring the water to other acreage.

Maximum water savings with end gun removal can be achieved by removing end gun sprinklers from a center pivot without transferring the water to other acreage. Water savings, with this option, can be estimated by multiplying the end gun flow rate by the amount of time that the end gun typically operates during the irrigation season.

End Gun Removal and transfer of water to other acreage irrigated by hand line or wheel line.

Average application efficiency for hand line or wheel line sprinklers from Table 1 shows a range of 60-75%. A value of 65% is typically used in the design of a hand line or wheel line irrigation system. This is the same value as for a pivot end gun. There would likely be no water savings, or minimal savings, if a pivot end gun was removed and the water was transferred to equivalent acreage that would be irrigated by hand line or wheel line sprinklers since the water application efficiencies are similar.

End Gun Removal and transfer of water to other acreage irrigated by a center pivot system.

Average application efficiency for low pressure center pivot from Table 1 shows a range of 75-90%. A value of 85% is typically used in the design of a center pivot irrigation system. There could be some water savings if a pivot end gun was removed and the water was transferred to equivalent acreage that would be irrigated by a center pivot without an end gun. Water savings, with this option, can be estimated by multiplying the end gun flow rate by the amount of time that the end gun typically operates during the irrigation season and multiplying that value by 20%. The value of 20% is based on a 20% improvement in water application efficiency by going from an end gun sprinkler to a center pivot without an end gun, which would irrigate an equivalent acreage.

Conclusion

If center pivot end guns are removed from a center pivot sprinkler system without transferring the water to other acreage then water savings can obviously be achieved by decreasing irrigated acreage and system flow rates. If center pivot end guns are removed

and water is transferred to equivalent acreage irrigated by hand lines or wheel lines there would likely be no water savings since application efficiencies of the two systems are similar. If center pivot end guns are removed and water is transferred to acreage irrigated by a center pivot with no end gun then a water savings of about 20% of the end gun usage could possibly be achieved based on an improvement in water application efficiency. The evaluation of potential water savings is based on the assumption that the irrigation systems are well-managed and maintained.

References

National Center for Appropriate Technology, 2006, The Idaho Irrigators Pocket Guide.

U.S. Bureau of Reclamation, AgriMet Irrigation Guide, Irrigation System Attainable Application Efficiencies, https://www.usbr.gov/pn/agrimet/irrigation.html#Efficiency.

Keller, J. and Bliesner, R., 1990, Sprinkle and Trickle Irrigation, New York: Chapman & Hall.

Sincerely,

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