LOCAL ENVIRONMENTAL BENEFITS OF SOLAR FARMING IN WISCONSIN

APPENDIX B2: ANALYSIS OF PHOSPHORUS RUNOFF REDUCTION FROM A SOLAR FARM SITED ON FORMER CROPLAND AT THE PROPOSED KOSHKONONG SOLAR FARM

CLEAN WISCONSIN

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1. Introduction and Methodology

This analysis was originally submitted Paul Mathewson, PhD, on behalf of Clean Wisconsin to Wisconsin Public Service Commission docket 9811-CE-100, Application for a Certificate of Public Convenience and Necessity of Koshkonong Solar Energy Center LLC to Construct a Solar Electric Generation Facility.

To obtain an estimate of how much phosphorus surface runoff to local waterways could be saved by replacing existing row crops with the planned solar fields at the proposed Koshkonong solar farm, I used SnapPlus 20.0 software. SnapPlus is Wisconsin's nutrient management planning software, developed by researchers at the University of Wisconsin with a well-established history of use and vetting (Panuska et al. 2007, Good et al. 2012, Vadas et al. 2015). Of interest for this analysis, the software calculates phosphorus runoff, based on a field's soil test phosphorus concentration, predominant soil type, slope, proximity to waters, and cropping, tillage, and nutrient management practices.

Koshkonong Solar Farm project boundaries were intersected with field boundaries from the Agricultural Conservation Planning Framework (ACPF) database. The application states that the majority of the crops grown in the project area are corn and soybean. Ex.-Koshkonong Solar-Application-Section 5.3. This is consistent with the ACPF database which reports that 85% of the fields grew either corn or beans for at least 5 of the previous 6 years. Thus, to simplify this analysis, we assumed that only corn and soy are grown on these fields. One important limitation of ACPF's crop history dataset for the purposes of this analysis is that it does not distinguish between corn grown for grain and corn grown for silage. SnapPlus distinguishes between corn for grain and corn for silage, with fields growing corn for silage having more soil and phosphorus loss as a result of corn for silage harvesting leaving much less residue on the ground. To bound this uncertainty as to exactly what crops are grown, I performed calculations assuming four different crop rotations: continuous corn for grain, continuous corn for silage, a corn (grain)-soybean rotation (corn-soy-corn-soy-corn), and a corn (silage)-soybean rotation (corn-soy-corn-soy-corn).

I imported shapefiles of the primary fields within the Koshkonong project area to SnapMaps within the SnapPlus software to obtain the predominant soil types, slopes and distances from waters. For soil phosphorus levels, I averaged the median value from the Department of Agriculture Trade and Consumer Protection's summary of all soil tests from 2010-2014 (the most recent summary available) in Dane, Jefferson and Rock counties (Table 1). I applied this soil phosphorus level to every field in the project area. Average values from the counties were substantially higher than the median values (Table 1), indicating that a smaller number of fields with significantly higher phosphorus levels are influencing the average values, which supports the use of the median value instead.

Table 1. Average and median soil P tests in Dane, Jefferson and Rock counties submitted between 2010-2014.

	Dane	Jefferson	Rock	3-County Average
Average Soil P Test	52	57	45	51
Median Soil P Test	38	39	32	36

Tillage choice also is an important factor in SnapPlus's soil loss calculations. To bound uncertainty regarding tillage practices on the different fields, for each of the four crop rotations I performed calculations assuming fall tilling (chisel, disk). This resulted in a total of eight different crop rotation/tillage combinations that I performed calculations for.

For the purposes of this analysis, we assumed that the soil phosphorus levels remained at the same average value for the entirety of the simulated periods, and did not model any fertilizer or manure application since the assumed soil phosphorus level is high enough to not need any additional phosphorus under University of Wisconsin's recommendations for these crops. Thus, in effect, I modeled a scenario in which any phosphorus addition from manure or fertilizer was fully incorporated into the soil and exactly matched crop uptake in order to maintain a constant soil phosphorus level.

To simulate the effect of replacing crops on these fields with solar panels over a perennial grassed surface, I set all fields to be "Grassland, permanent, not harvested" with no fertilizer application for 35- 50 years, the expected lifespan range of the proposed solar farm.

Summaries of annual pounds of phosphorus in surface runoff from the fields entering surface waters were obtained by generating Phosphorus Trade reports in SnapPlus. Total phosphorus runoff for 35 or 50 years of crop rotations was compared to total phosphorus runoff from 35 to 50 years of unharvested grassland following the current cropping regime to quantify the effect of converting these fields from row crops to a solar farm.

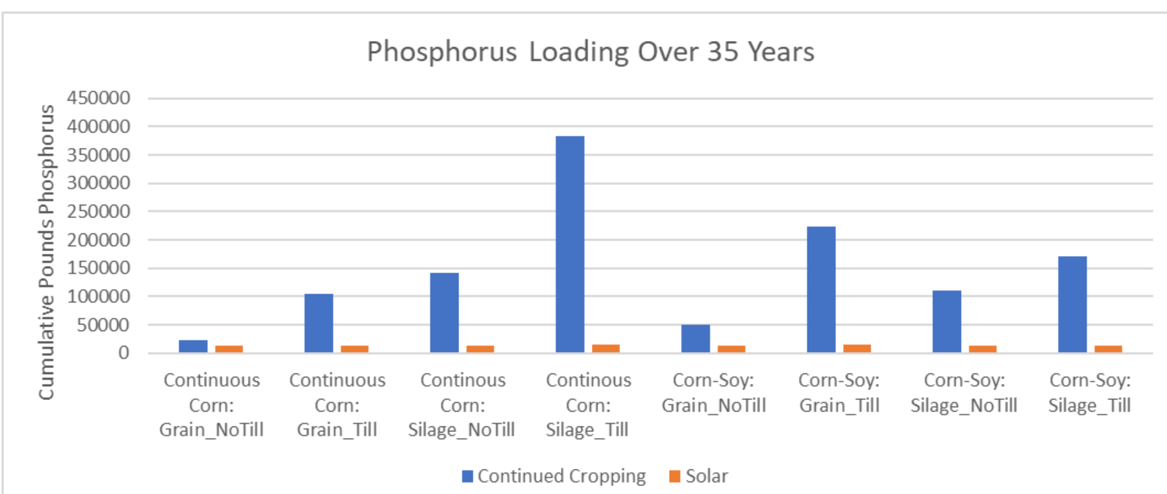
2. *Results*

This analysis indicates that replacing existing crop rotations with solar panels over perennial, unharvested grassed fields would reduce phosphorus runoff by 70-98% for most cropping scenarios (Fig. 1, Table 2). For the no till, continuous corn for grain simulations, phosphorus runoff would be reduced by 40%. This significantly lower reduction is due to the much lower calculated runoff from the cropping scenarios compared to the other scenarios.

Table 2. Reduction in phosphorus runoff from replacing various cropping rotations with a solar farm on the proposed Koshkonong Solar Project's primary fields.

Cropping Scenario	**Percent Reduction in Phosphorus Runoff**
Continuous Corn (Grain): No Till	39%
Continuous Corn (Grain): Fall Till	87%
Continuous Corn (Silage): No Till	90%
Continuous Corn (Silage): Fall Till	96%
Corn (Grain)-Soy: No Till	73%
Corn (Grain)-Soy: Fall Till	94%
Corn (Silage)-Soy: No Till	88%
Corn (Silage)-Soy: Fall Till	92%

(a)



(b)

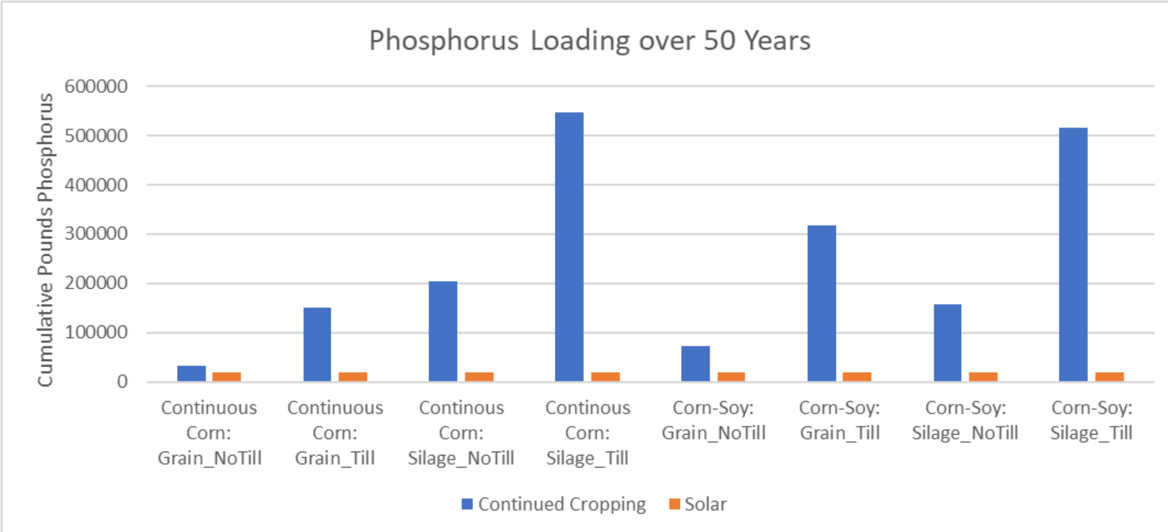


Figure 1. Comparisons of total phosphorus runoff from primary leased fields assuming continued cropping (various scenarios) and the solar facility for a 35 year (a) or 50 year (b) lifespan.

3. *Limitations*

There are several limitations of this analysis that are important to be recognized:

- This analysis assumes that solar panels do not substantially alter the volume of stormwater runoff from the field or velocity of stormwater hitting the field surface (and thus alter the stormwater-induced erosion from different soils assumed by SnapPlus). The only study examining this that I am aware of suggests that this is a reasonable assumption (Cook & McCuen 2013, but see MPCA 2019 indicating that solar panels may increase stormwater volume). If stormwater-induced erosion is increased by the presence of solar panels, these calculations would underestimate the phosphorus runoff from the simulated solar farm fields and thus overestimate the phosphorus reduction benefits of the project.
- Similarly, this analysis assumes that grassland vegetation planted under and around solar panels develops and holds soil in place in an equivalent manner to grassland vegetation on a field without solar panels. Shading from the panels could reduce plant density compared to a field without solar panels, which might increase erosion and phosphorus runoff. A scenario with solar panels over native plants has not been modeled or included in SnapPlus yet, so we used the unharvested grassland option in the program as a proxy.
- This analysis does not consider any increased runoff during the construction phase. It assumes the field immediately goes from a cropland to a permanently grassed surface. However, required construction stormwater best management practices likely capture most of this increased runoff. Furthermore, over the course of the 35-50 year analysis, a small increase in the first year or two would not alter the overall conclusions.
- As described above, I relied on county-level data on soil phosphorus levels rather than using soil phosphorus data from the specific fields being leased. If true soil P values on these fields are significantly different than the estimated value, the runoff calculations could either be overestimates or underestimates, depending on how true soil P values differ from the estimated soil P values.
- SnapPlus does not account for the effect of concentrated flow channels or tile drainage. If any such features are present on these fields, the calculated phosphorus

runoff will underestimate phosphorus losses, particularly under a cropping regime. Thus, presence of these features would suggest that this analysis underestimates the phosphorus runoff reduction benefit of a solar farm.

4. References

Cook LM, McCuen RH. 2013. Hydrologic response of solar farms. Journal of Hydrologic Engineering 18: 536-541.

Good LW, Vadas P, Panuska JC, Bonilla CA, Jokela WE. 2012. Testing the Wisconsin phosphorus index with year-round field-scale runoff monitoring. Journal of Environmental Quality 41: 1730-1740.

Minnesota Pollution Control Agency. 2019. Stormwater management for solar projects and determining compliance with the NPDES construction stormwater permit. Available at: https://stormwater.pca.state.mn.us/index.php?title=Stormwater_management_for_solar_projects_and_determining_compliance_with_the_NPDES_construction_stormwater_permit. Last accessed December 9, 2020.

Panuska J, Good LW, Wolkowski R. 2007. Converting CRP land to corn: minimizing phosphorus loss. University of Wisconsin Extension Publication A3831.

Vadas PA, Powell JM, Brink GE, Busch DL, Good LW. 2015. Whole-farm phosphorus loss from grazing-based dairy farms. Agricultural Systems 140: 40-47.