Understanding hydrology, soils, and vegetation on solar farms in complex terrain in central PA

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Guiding Questions

- *How do ground-mounted solar panels alter 'natural' hydrologic processes?*
- *Under what conditions is there runoff generation or erosion?*
- *When is structural stormwater management needed?*
- *How can we manage runoff in ways that generate other co-benefits? …particularly on more challenging or 'marginal' lands*

Our Approach

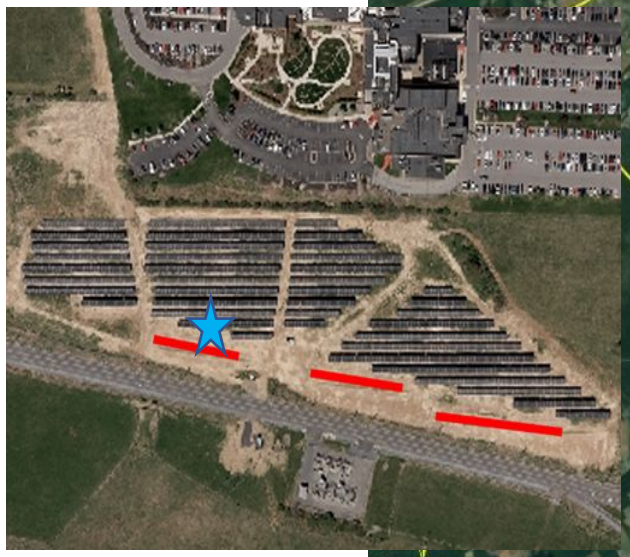
- *Field evaluation at two focal sites near State College with complex terrain*

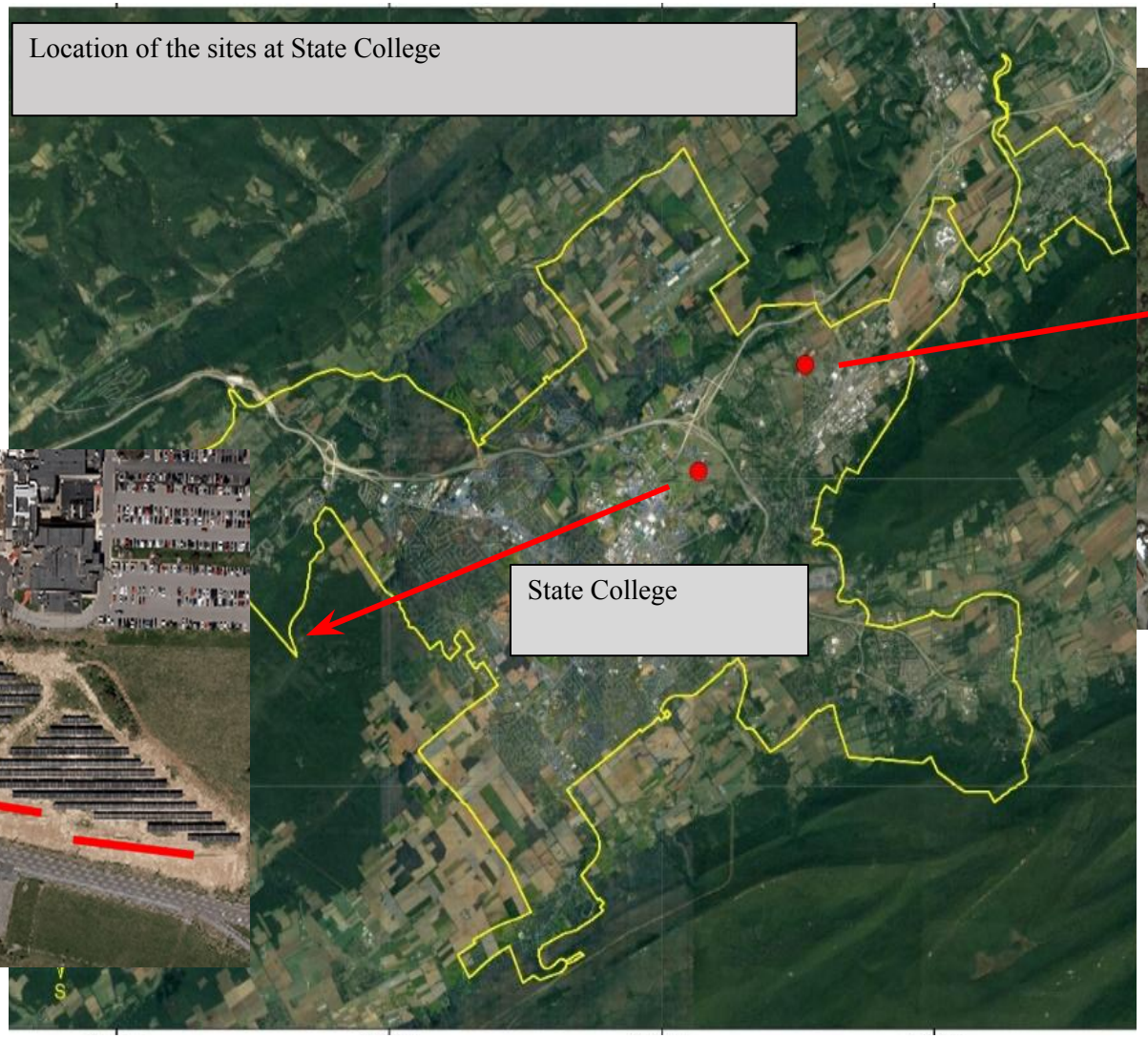
- *Modeling efforts to better understand our sites + potential scenarios for alternate management*

Current focal sites

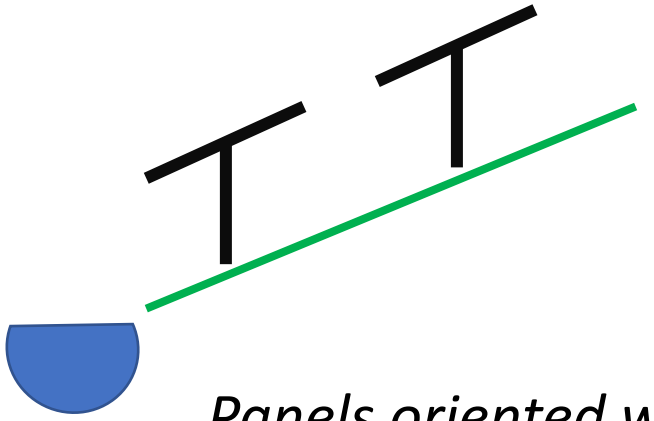
2 solar farms in central PA

Site 1





Site 2



Panels oriented with land slope, and infiltration basin at base

Site 1

Characteristics:

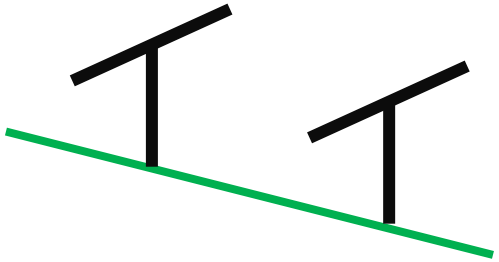
- 20-25 % slope
- Silt loam soils
- Upslope parking lot runoff
- Meadow vegetation
- Infiltration basins at base of slope

Site 2

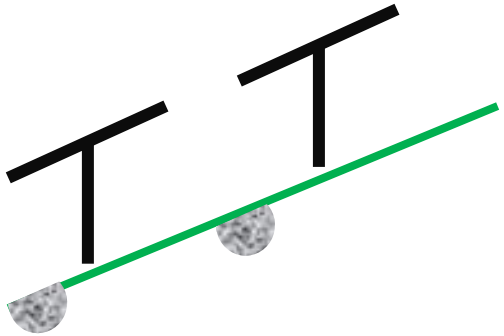
Site Characteristics:

- Variable slope <10%
- Rocky outcrops; silt loam soil
- Meadow vegetation
- 2 phase solar array
- Contoured infiltration trenches in phase 2
- Sheep grazing (started summer 2022)

Example site typologies

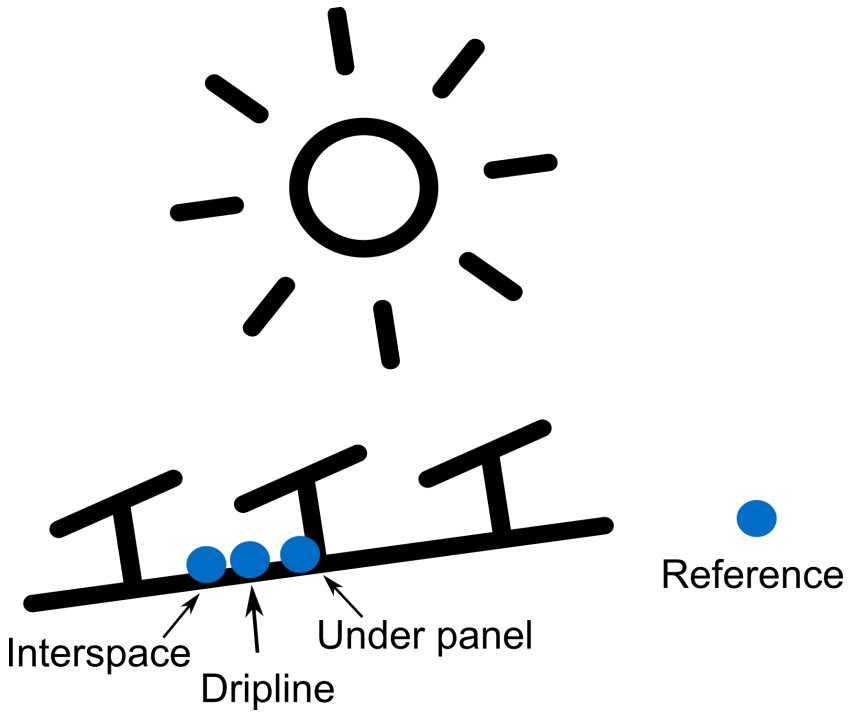


Phase 1 panels at reverse orientation to slope



Phase 2 panels oriented with slope, with infiltration trenches

Key Types of Data Collection



Vegetation surveys

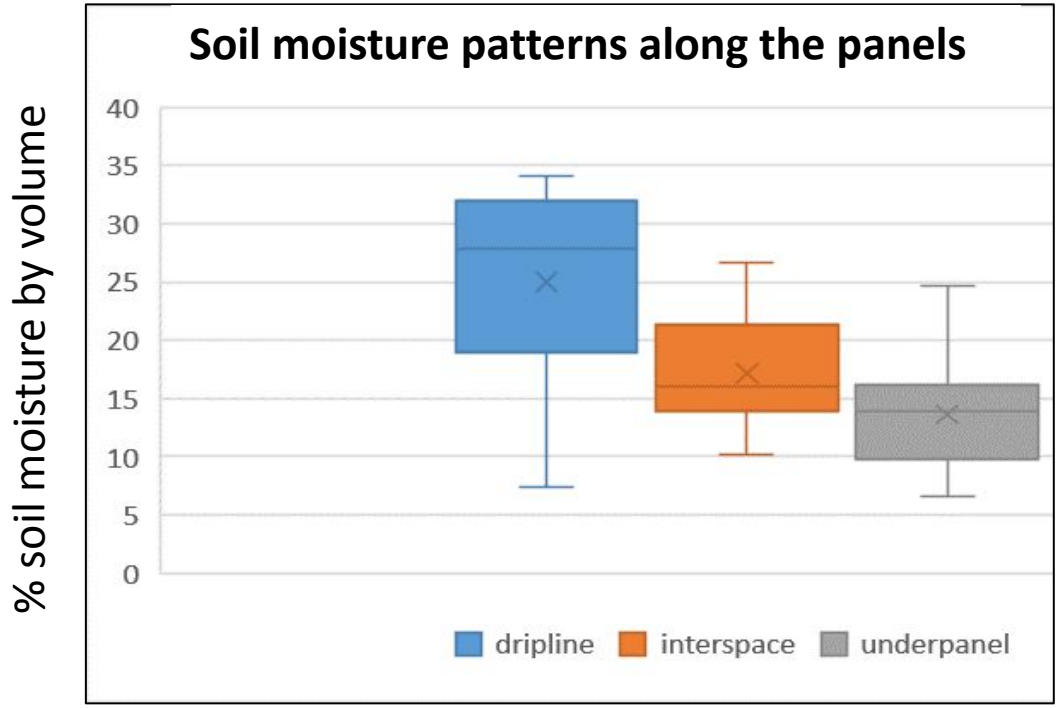
Soil properties

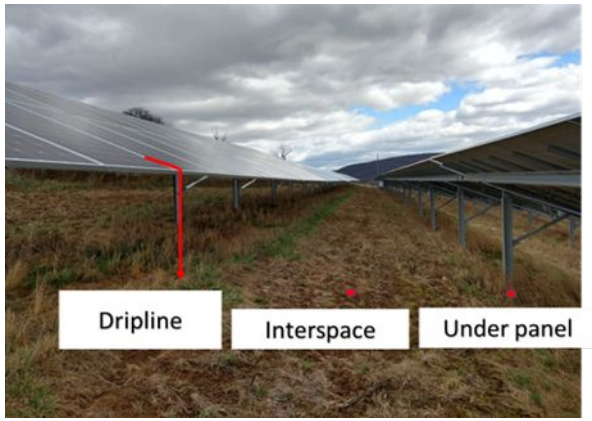
Solar radiation (for ET calculation)

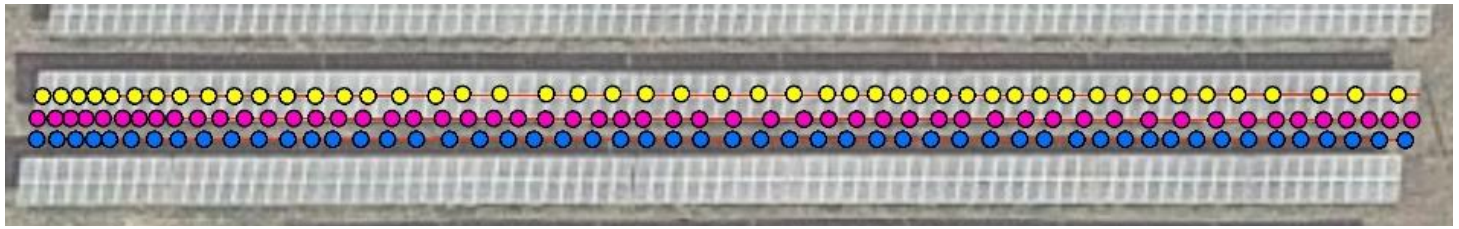
Soil moisture sensor clusters+ manual measurements

Water level in infiltration basin

Soil moisture at Site 1 dripline> interspace> underpanel



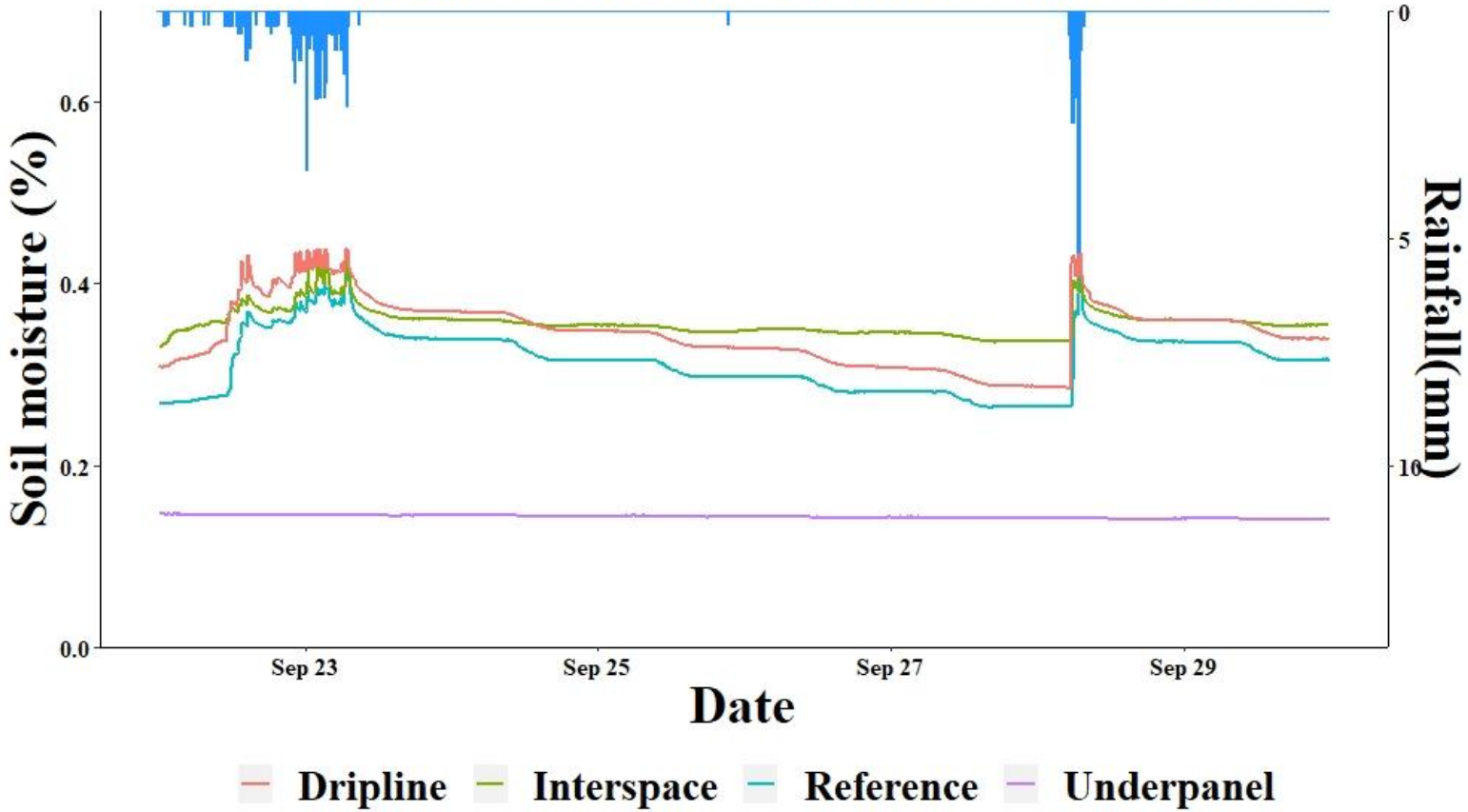




- Significant difference in soil moisture distributions by location
- Dripline highest at dripline and lowest at under panel at solar site 1….though this is not always consistent at Site 2

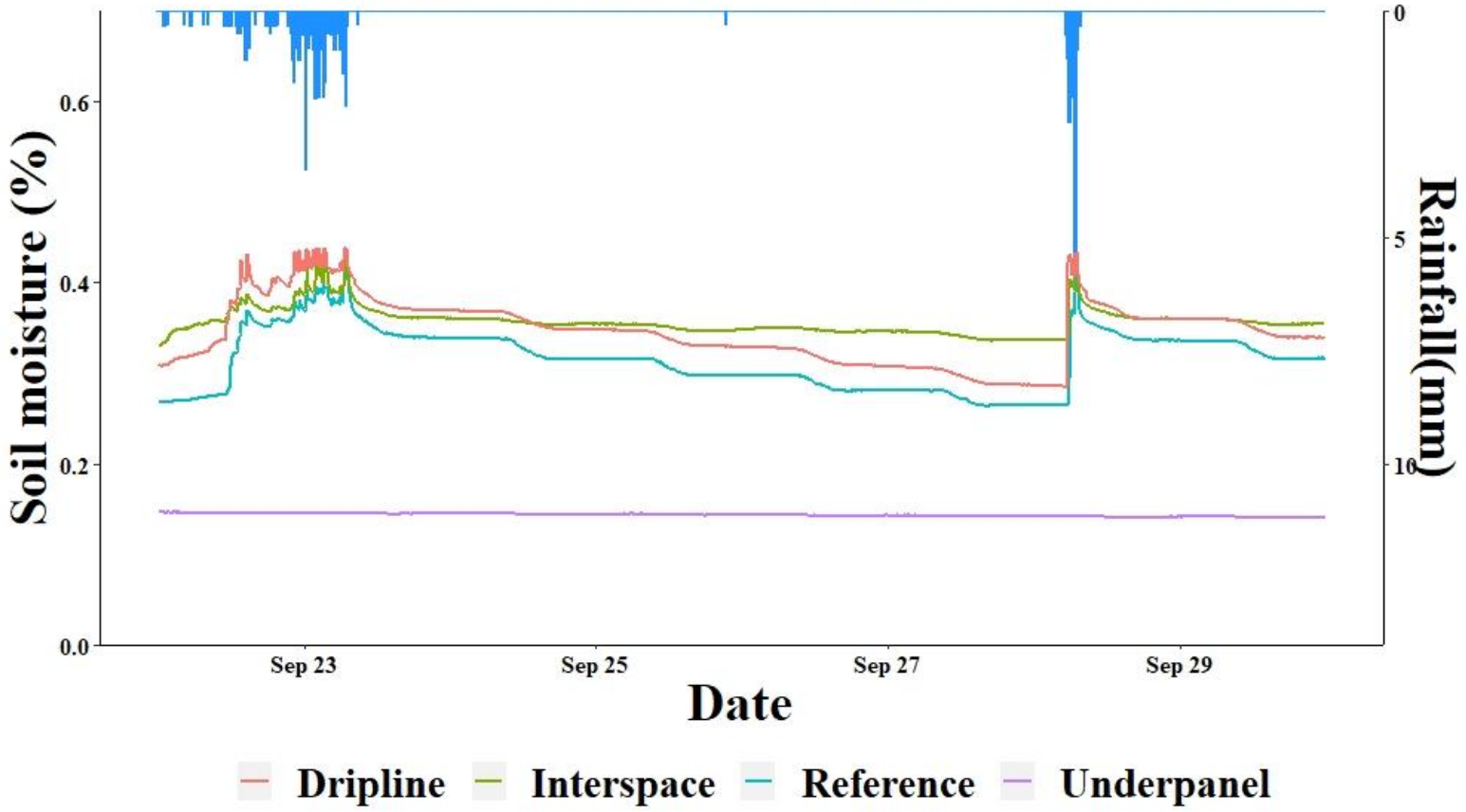
Insights from soil moisture timeseries

Site 1



Soil moisture timeseries reveal brief periods of runoff generation

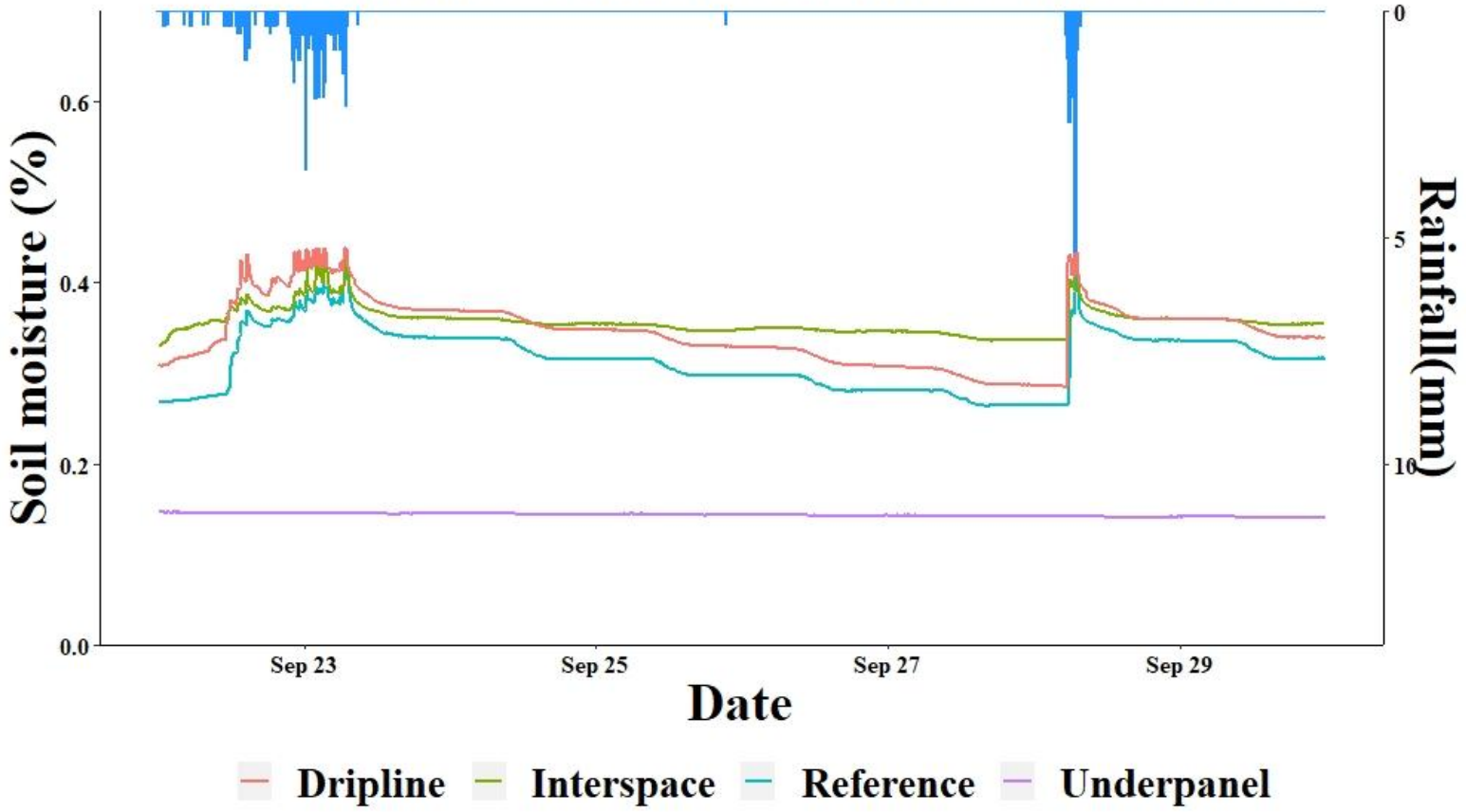
Site 1



- *Evidence of short periods of saturation at dripline during these events*
- *Interspace has a few short spikes to saturation, but generally for less duration than dripline, so there is clearly infiltration occurring in interspace*

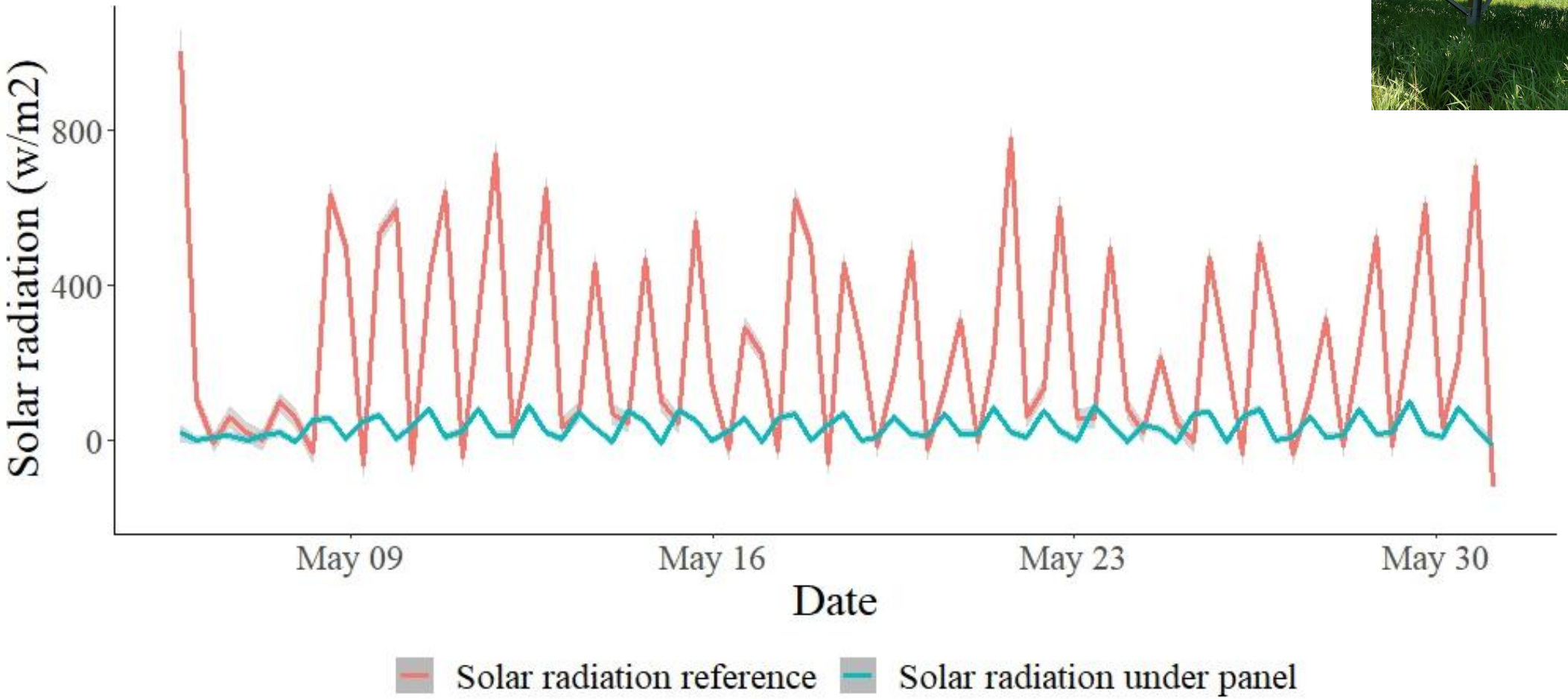
Soil moisture timeseries reveal brief periods of runoff generation

Site 1



Water level loggers in infiltration basin indicate that some limited runoff ultimately makes it to basins in some larger events

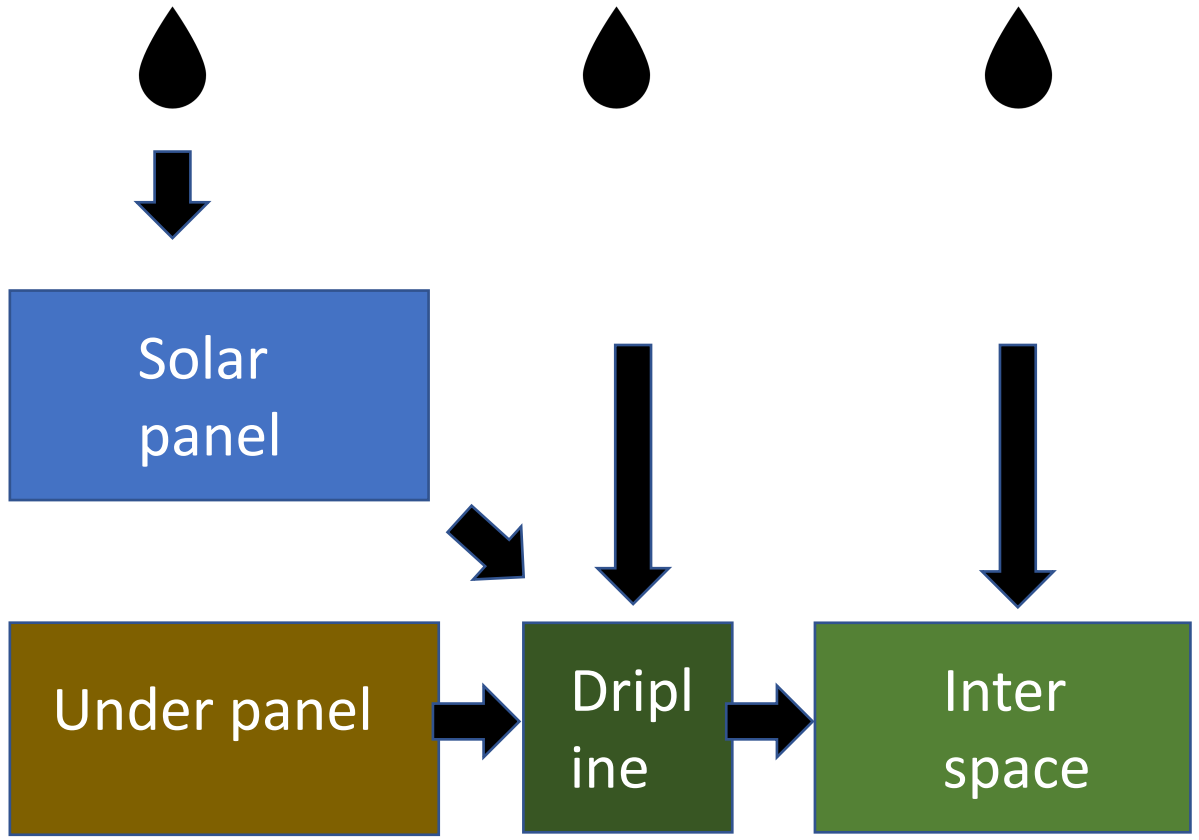
Solar radiation under panels is ~90% less, driving reduced ET



We know that this will also affect vegetation….but yet we still see abundant coverage of plants underpanel

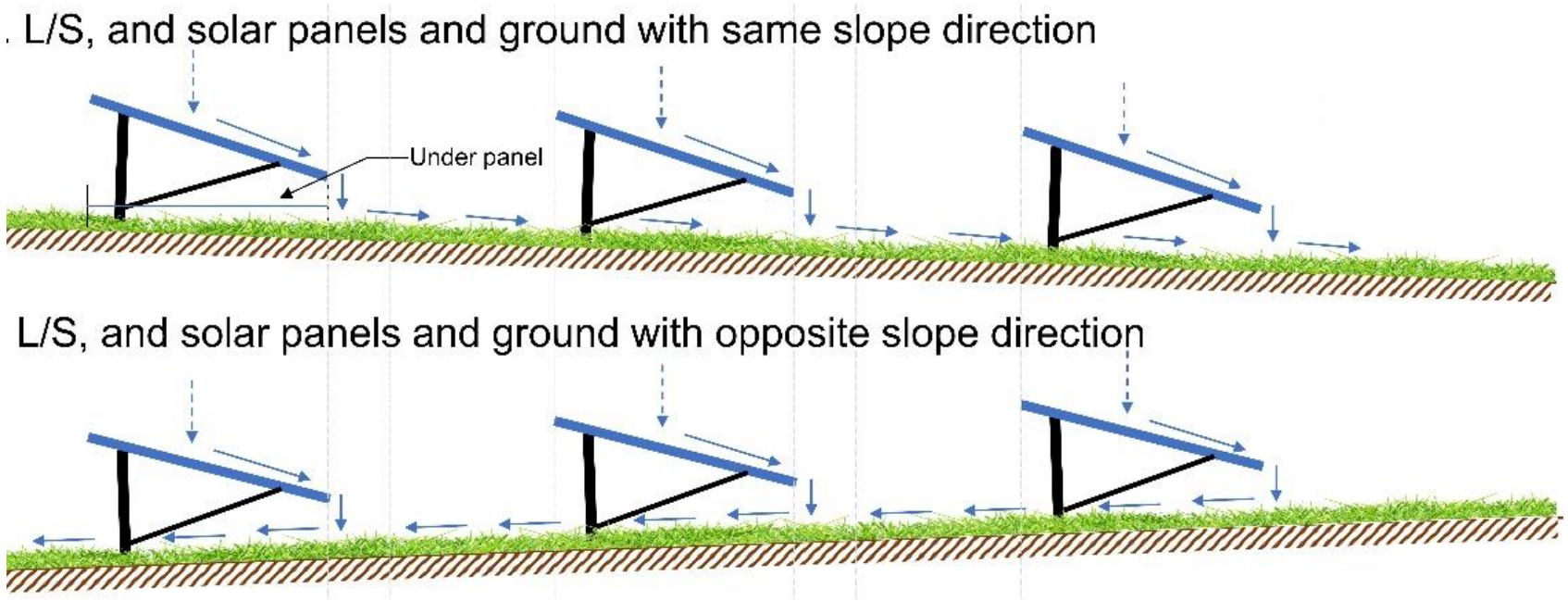
Modeling efforts

Currently refining models in EPA SWMM + OpenHydroQual



Modeling efforts

Initially focused on Site 1 w/ additional scenarios for altered slope, panel configuration, BMPs

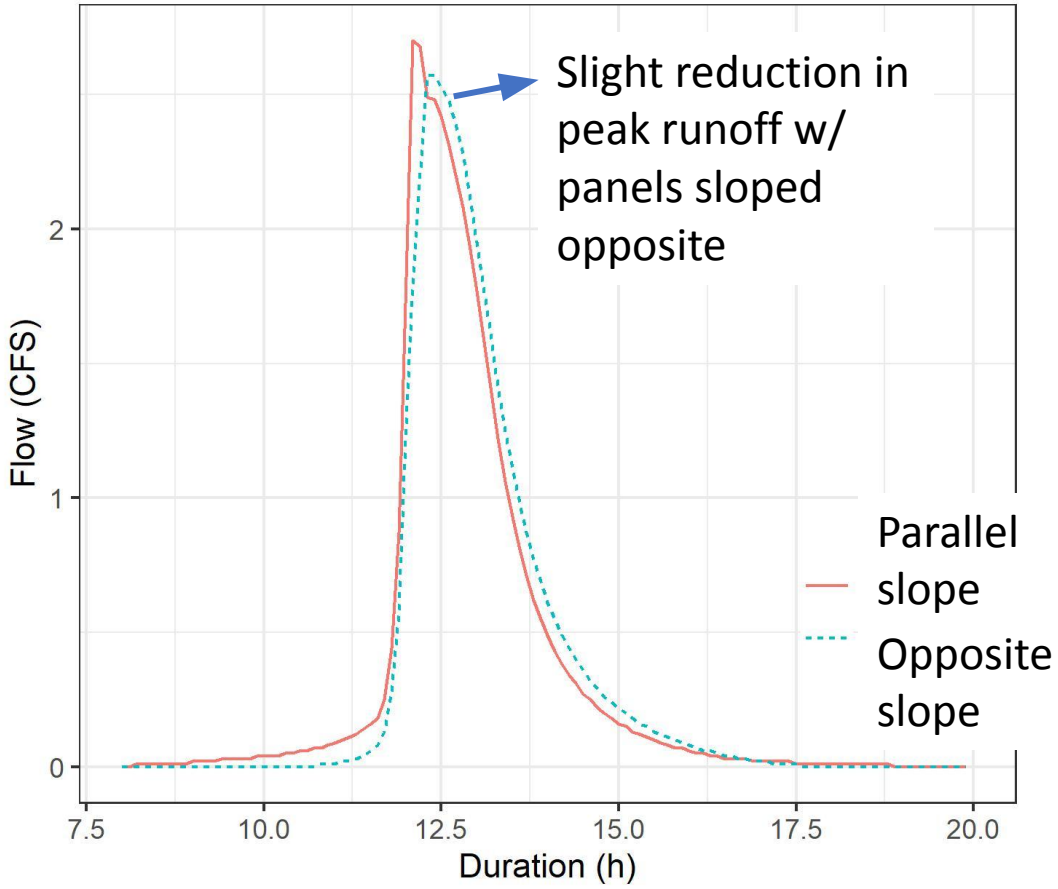


A few insights from SWMM modeling

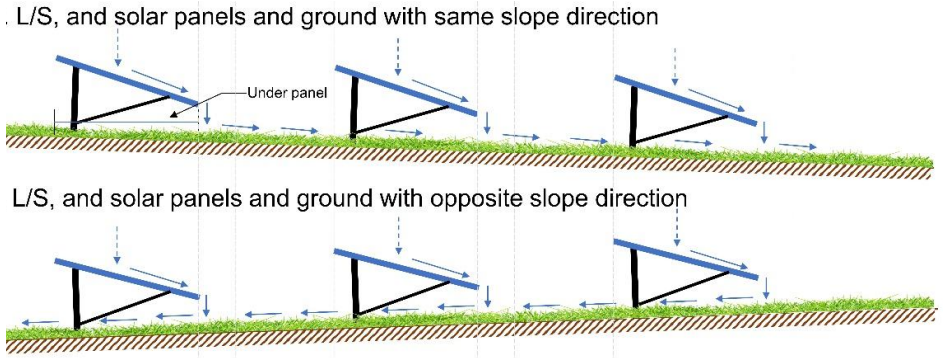
‘Low impact development’ with adequate interspace + healthy vegetation + soils may be enough to prevent post-development changes in runoff volumes, though peak flow rates were always increased

Design Storm	Maximum flow (CFS)		Outfall volume (10^6 gal)	
	Post	Pre	Post	Pre
2 y	0.87	0.57	0.025	0.025
10 y	1.45	1.12	0.054	0.048
25 y	1.86	1.54	0.070	0.063
50 y	2.25	1.93	0.079	0.070
100 y	2.70	2.37	0.087	0.076

A few insights from SWMM modeling



For sites where panel slope can be opposite to landscape, this configuration can reduce peak flow rates…. though may increase overall runoff volume



From our analysis thus far….

Ground-mounted solar panels re-route water in the landscape, concentrating it at driplines.

There is runoff generation, particularly at the dripline, though much can infiltrate in interspace with healthy, well-established vegetation.

On sites more prone to runoff generation, adequately sized + placed structural stormwater management can provide mitigation.

Even in the shaded underpanel zone, vegetation can thrive and provide adequate ground coverage.

And more insights will be coming as our analysis progresses further!

Questions?

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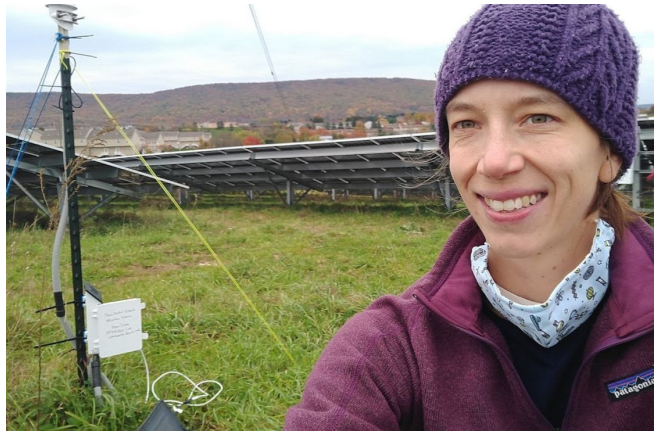

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