**Comprehensive Agricultural Integration with Grazing Sheep**

**East Windsor Solar One Project, East Windsor, CT**

**Prepared for Verogy by Agrivoltaic Solutions LLC**

Verogy has enlisted the services of Agrivoltaic Solutions LLC (AVS) in preparing the East Windsor Solar One project to host grazing sheep throughout the life of the project.

1. Overview
2. Civil Design Recommendations
3. Risk Management
4. Emergency Protocols
5. Manure Management
6. Sheep Procurement and Seasonal Management Schedule

## Overview

Project Objectives: To effectively manage vegetation each year throughout the growing season at the East Windsor Solar One site in East Windsor, CT. This will be accomplished through managed sheep grazing to optimize environmental benefits and maintain agricultural production on the farmland the site is built on.

The project will be managed to:

- Prevent panel shading and equipment damage from overgrowth
- Prevent Erosion
- Manage invasive and undesirable species pressure
- Promote long term soil health
- Maintain the grazing animals in good health
- Maintain a mutually beneficial relationship with the contracted farmer

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## Civil Design Recommendations

1. Perimeter fencing: whether chain link or "ag type" woven wire should be installed to the ground, buried slightly below grade, or with a *maximum* gap of 1-2". Gaps cause by uneven ground should be cleaned up with a dozer if possible. If chain link fencing is used, it should be installed with a bottom tensioning wire.
2. Perimeter Gates: should be installed to meet evenly and have an even spacing to the ground. As above, a *maximum* gap of 1-2". Care should be taken to add some gravel or grade the roadbed to avoid large gaps around the road shoulders in the gateways.
3. Planting & Seeding: As always, best scenario is building on existing sod or hay-ground and focusing on minimizing construction damage. Little extra seeding will be needed other than meeting permitting requirements. For additional seedings, clover or legume mixes are a good option for vigor and grazing friendliness. For grass species, fescue species should be avoided unless they are *endophyte-free* varieties. Note that species such as Reed Canary grass and some Orchardgrass varieties can produce tall growth and fibrous seed heads that may remain un-grazed after the sheep pass through (for example). Note that the blends such as Fuzz and Buzz Standard and Fuzz and Buzz Premium can be good to model off of if you are trying to blend grazing with solar and some pollinator friendly species. Our ASGA partner Ernst Conservation Seeds and the Cornell Sheep Program, in conjunction with the manager of the American Solar Grazing Association developed these mixes. We expect the seed mix selected for Bristol will be customized for the site.
4. Water: A water source would be ideal for multiyear grazing at these sites. AVS has recommended that the spigot be activated for filling and water distribution at the site. This choice on the part of Verogy will drive down costs in the long term for the partner grazer.
5. Aux Boxes: Providing 110V power outlets at the transformers is recommended to ease long term site management.

**Risk Management –**

1. What risks to the project site are posted by grazing? How do we minimize the risks?
    i. Sheep grazing poses a lower risk from a site damage perspective than conventional mowing. Sheep are generally too small to be able to damage any major site components and their behavior does not generally include interaction with equipment beyond some rubbing/scratching. The focus of risk management should be good wire control and ensuring any small wires, in particular module-module connectors and anything that droops from cabling systems or electrical boxes are tied up securely.
    ii. A grazing plan, a contract with an experienced sheep producer familiar with the area and with managed grazing, good fencing and a water supply, and attention to detail around the installed seed mix will address most issues of concern for Verogy.
2. Could sheep damage fencing?
    i. If the perimeter fencing is installed well with good tension and very low ground clearance, the chances of the fence being damaged by the sheep are next to zero.
3. Could sheep pull on exposed cabling?
    i. Sheep do not, by their nature, pull on cabling. Sheep do not seek out wiring, BUT are likely to be in danger of becoming accidentally tangled if wiring is left loose. We have witnessed loose, low wiring become a hazard for mowers, sheep, and humans alike over the operations phase of other solar projects. However, if good wire control is in place and wires are tightly secured, there is almost no chance of sheep pulling on them or damaging them.
4. Could a sheep damage the panels, trackers or inverters?
    i. At East Windsor, we recommend the Inverter pads have basic exclusion fencing. This is to keep the inverter and transformer area free of sheep and sheep manure at all times. This exclusion fencing will allow any electrical service workers freedom of movement, and easy access. Typical agricultural tube fencing will serve as an off-the-shelf exclusion.
    ii. The panels at East Windsor have a 36” leading edge height and are safely above sheep height.

5. Could an animal get electrocuted? Do we have to do anything to protect the grounding system?
    i. Nothing needs to happen to protect the grounding system
    ii. Sheep rarely chew on wires, much less thick solar collection lines. However, in the extremely unlikely event that if a sheep were to chew on or touch a line that was damaged in other ways then yes, it is conceivably possible a sheep could be electrocuted. In this instance the farmer would remove the sheep from the premises for off-site burial, as is the protocol with any other animal mortality.
6. What risks to the project site are posted by grazing? How do we minimize the risks?
    i. Sheep grazing poses a lower risk from a site damage perspective than conventional mowing. Sheep are generally too small to be able to damage any major site components and their behavior does not generally include interaction with equipment beyond some rubbing/scratching. The focus of risk management should be good wire control and ensuring any small wires, in particular module-module connectors and anything that droops from the inverters or collection boxes is tied up securely.
    ii. A grazing plan, a contract with an experienced sheep producer familiar with the area and with managed grazing, good fencing and a water supply, and attention to detail around the installed seed mix will address most issues of concern for Verogy.

**Emergency Protocols**

In the event of a site emergency, the following protocol is to be on hand to ensure safe site access for emergency personnel:

1 – Clear signage will be displayed at the main gate with emergency contact information of the sheep manager. The manager should be contacted immediately in the event emergency personnel have to enter the site in order to ascertain if there are animals present, and to provide notification to the sheep manager that the animals may need to be removed.

2 – If portable electric fence is installed crossing site roadways, the fence charger will be placed clearly by the side of the roadway. In the event of emergency, the charger will only need to be switched off and the fence pulled up by hand to allow passage.

3 – If possible, animals should remain inside the site during an emergency, until the sheep manager can safely remove them. They will likely move as a flock away from any commotion and pose little risk of being in the way. If they do escape during the site emergency, they should be monitored and pushed towards fields and away from roads if possible.

## Manure Management

Manure management is a subset of the flock management and sheep management planned for the solar site. The primary purpose of the placement of sheep on the solar site is to achieve vegetation management goals.

The planned movement of the sheep around the solar site has the underlying benefit of moving and distributing sheep manure at the same time. Sheep manure is typically small and pelletized. For the layperson, sheep manure may resemble the manure of rabbits or deer. Similarly, the manure is typically invisible within a short period of time and begins nutrient cycling in the soils.

The correct sheep stocking rate and density (sheep per acre per unit of time) will be calculated before the grazing season based on site size, and quantity and type of vegetation present. This metric also ensures that no over-grazing occurs, and that the amount of manure deposition does not outpace the rate of manure decomposition throughout the grazing rotation.

The flock will not overwinter within the fenced area of the solar array. This will be specified in the solar grazing contract.

Fences are used at other solar arrays and as a principle of water quality management to exclude sheep from accessing ponds and streams. A review of the East Windsor Solar site, with attention to the placement and location of future interior fences is under way by Agrivoltaic Solutions LLC. Attention will be paid to respecting riparian corridors, wetlands, and ponds with exclusion fencing.

## Water Quality & Solar Grazing

With the exclusions, noted above, and the planned rotation of the flock during the grazing season, there should be improved soil health at the East Windsor One Solar Facility. The soil health improvements that we anticipate seeing, and could be monitored by a soil scientist, include additional water holding capacity by the soil on site. Well-managed grazing should lead to improved water filtration and reduced runoff potential.

East Windsor Solar will be planted with a seed mix that includes deeper rooted grasses and other forages. Once established, these plants will aid in the grazing management and fresh water quality improvements, described above.

During normal site grazing activities, the rotation of the sheep flock and effect it has on manure dispersal means that there will be likely no noticeable amount of manure on site that will not be effectively broken down by decomposition and biological activity within the first 2-3 weeks after the sheep pass by. There will also not likely be any amount of manure that is noticeable from outside of the site.

**Sheep Procurement and Seasonal Management Schedule –**

Verogy Plans to contract with AVS or a regional sheep producer for overall vegetation management at East Windsor. AVS will work with on-site management to graze the site in accordance with best management practices informed by the managed grazing plan.

Sheep will be delivered to the site each year early in the growing season. This generally will mean early to mid-May. Depending on weather and vegetation growth, the number of sheep may be lower or higher to achieve a slower or faster grazing rotation through the site. After a full grazing rotation of the site, the sheep will either begin the rotation again, or be moved off the site to another solar site. In this scenario, a larger number of sheep would be used, and the rotation completed faster.

The sheep will be managed to evenly graze the vegetation on-site, and maintain it below the leading edge of the panels to prevent shading. Any non-preferential vegetation on the site such as brambles or thistles that may occur, may be managed using traditional mowing. AVS expects this to be limited and likely not be a yearly occurrence.

The sheep manager will visit the flock on-site 2-3 times per week for health and management checks. The manager will maintain clean, fresh water for the animals and will stock the site with other supplemental minerals for the sheep.

The flock will make 2-4 rotations of the site through the growing season, will likely be finished for the year by September-November, at which point they will return to their home farm.

# Sheep Pasture Rotation and Grazing Plan for the Verogy East Windsor Project in East Windsor, CT

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## Introduction

*Ground-mounted solar sites, by nature of their design, have ample fenced areas. The fencing at solar sites is uniquely suited to serve as grazing areas or be subdivided into grazing paddocks in a pasture rotation with sheep. The perimeter fencing also serves as predator deterrent, the solar panels provide shading and shelter for inhabitants, and the solar arrays provide palatable pasture species for ruminant nutrition. In turn, rotationally grazed sheep provide adequate and comparatively cheap vegetation management, optimal ground coverage and thus reduced erosion and run-off, as well as agricultural usage of lands that can add to the viability of farming communities.*

The Verogy East Windsor Project, located in East Windsor, CT, is planned for approximately 20.9 acres. Sheep grazing will be used to control vegetation at the project site to:

- Prevent panel shading from vegetation,
- Control and remove invasive and unpalatable plant species,
- Avoid the growth of brush and woody species under the solar panels,
- Maintain a diverse forage population to support optimal sheep nutrition,
- Encourage flowering forb and plant species to maximize pollinator habitat,
- Optimize sequestered soil carbon through increasing top-soil amount and root matter,
- Control erosion.

To achieve these goals a rotational grazing system will be implemented. Rotational grazing is a technique where animals are moved as one group, from one pastured area ("paddock") to the next (Hodgson, 1979). Only one paddock is grazed at any given time throughout the rotation, while the other paddocks are given a rest period to achieve pasture regrowth. Compared to continuous or extensive grazing, rotational grazing inhibits weed growth, improves the health of pasture, sustains healthy vegetation, and improves sheep health.

## Rotation planning

The Verogy East Windsor Project was assessed for a planned grazing rotation based on the preliminary panel layout, and 21.6 acres fenced area under panels. The grazing plan requires division of the solar array into smaller grazing units, known as *paddocks*. The site layout can be subdivided into 4 separate grazing paddocks with Electronet® fencing (Figure 1). The Electronet® is a portable fence that is a product familiar to farmers in in the grazing community. It is a white, lightweight fence that is energized using a portable

battery, battery/solar, or 110V power supply. This fencing is simple to power on/off and will only be located inside the fenced areas. Its use is to facilitate grazing inside the permanently fenced areas only. The Electronet® will be installed by the grazing manager according to the grazing plan.

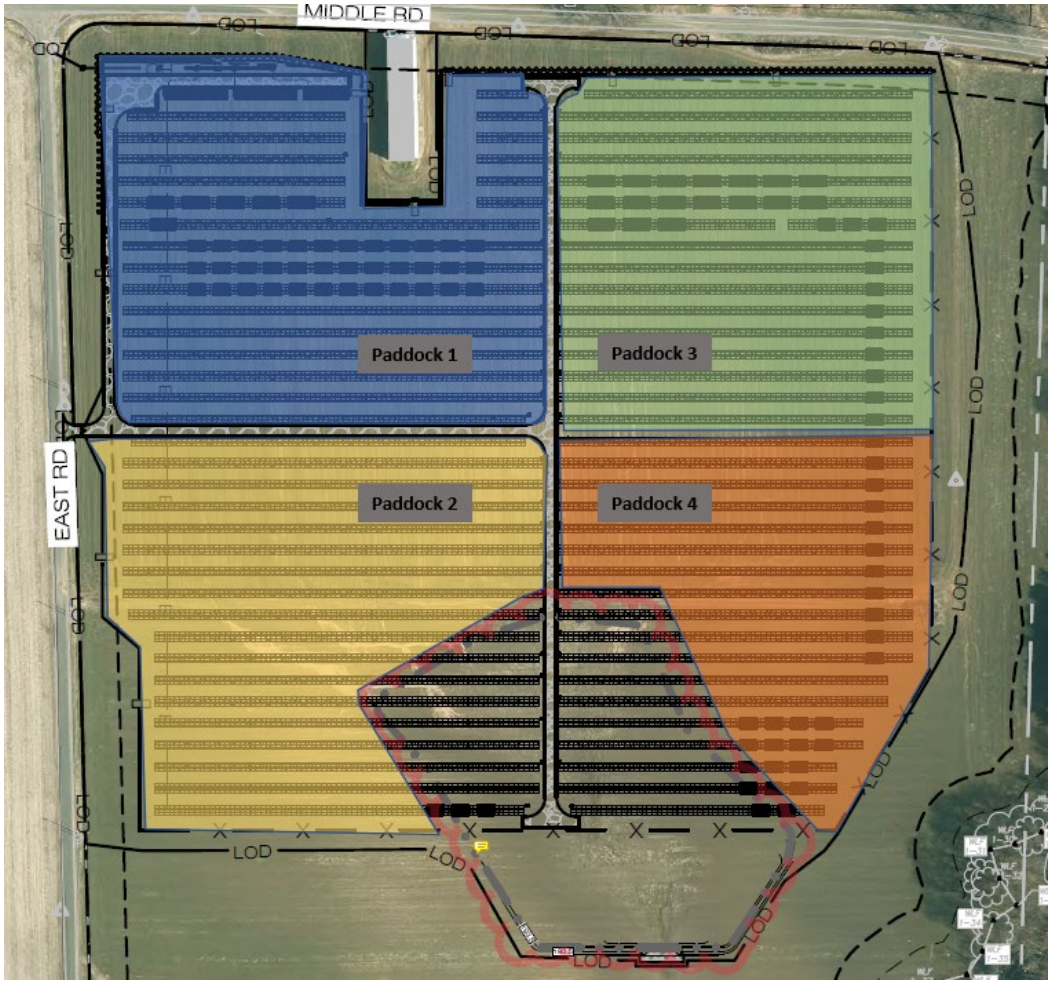


Figure 1. Verogy East Windsor Project Site Layout with distinctly colored sections. Please note that this is an approximation and subject to change. The excluded section on the South side of the site is a stormwater basin that is designated to be fenced apart from the grazing program.

- Paddock 1 (6.0 acres)
- Paddock 2 (4.8 acres)
- Paddock 3 (6.0 acres)
- Paddock 4 (4.8 acres)

The number of grazing paddocks in each array is dependent on a unique set of factors. The number depends on size and layout of the permanently fenced array, panel orientation, and space used for access roads, inverter pads, and other non-forage producing areas.

Acreage

The sheep flock is sized to cover the three grazing paddocks in a full rotation, i.e. the amount of sheep needed to graze Paddock 1, 2, and 3, 4 with 6.0, 4.8, 6.0, and 4.8 acres, respectively, in a +/- 45-day rotation. The precise number of days per paddock may be adjusted over the season by the flock manager, depending on weather and forage growth conditions. The number of sheep determined by the grazing plan can be found in Table 1. Grazing Plan Verogy East Windsor Project:

Table 1. Grazing Plan Verogy East Windsor Project

| | | Paddock | | | | |
|---|---|---|---|---|---|---|
| | ***Item*** | *1* | *2* | *3* | *4* | *Total* |
| **Acreage** | Array size, ac | | | | | 21.6 |
| | Number of paddocks | | | | | 4.0 |
| | Paddock size, ac | 6.0 | 4.8 | 6.0 | 4.8 | 5 |
| | Rest period, days | | | | | 35.0 |
| | Days in paddock | | | | | 8.8 |
| **Sampling and analysis** | Vegetation cover: %, ac | 80% 4.8 | 80% 3.8 | 80% 4.8 | 80% 3.8 | 80% 17.3 |
| | Biomass / yard², lbs | 1.0 | 1.0 | 1.2 | 1.2 | 1.1 |
| | DM % / yard², lbs | 18% 0.2 | 22% 0.2 | 28% 0.3 | 24% 0.3 | 23% 0.3 |
| | DM / ac, lbs | 871 | 1,065 | 1,626 | 1,394 | 1,225 |
| | DM / paddock, lbs | 4,182 | 4,089 | 7,806 | 5,353 | 21,160 |
| | Refusals: %, lbs | 30% 1,255 | 30% 1,227 | 30% 2,342 | 30% 1,606 | 30% 6,348 |
| | Total paddock DM, lbs | 2,927 | 2,862 | 5,464 | 3,747 | 14,812 |
| **Feed intake** | Average sheep weight, lbs | | | | | 160.0 |
| | DM Intake: % BW, lbs | | | | | 3.5% 5.6 |
| | Sheep in paddock | | | | | 2,645.0 |
| **Totals** | **Total acreage** | | | | | **21.6** |
| | **Total sheep** | | | | | **76** |
| | **Stocking rate** | | | | | **3.5** |

The rest time for a given grazed area is largely guided by management for the sheep flock's health. The rest time can be considered the window during which the sheep are not present in a given area and the space is given a rest. The pasture rest period (time between grazing periods) in the US Northeast should not be less than 40-days to minimize internal parasite pressure for sheep. Internal parasites are a health risk to the sheep but not to humans. Internal parasites of sheep are not zoonotic, but a threat only to the health of sheep. This health risk to sheep is minimized by following the following prescriptive grazing plan.

A common internal parasite specific to ruminates is the stomach nematode *H. contortus* or barber pole worm. It has a life cycle of 40 days; thus, a clean pasture can only be achieved with rest periods of 40+ days to avoid reinfection through ingestion of larvae. However, in effective grazing regimens with parasite-resistant sheep flocks, exceptions can be made by the flock manager if the vegetation pressure is too high to adhere to a 40-day rest period before re-grazing.

Sampling and analysis

In newly commissioned solar sites, full vegetation coverage cannot be expected in the first 1-2 years. Additionally, access roads, inverter pads and other site infrastructure will reduce the overall vegetation cover. Our estimate for NY State solar sites lies between 65 and 85% vegetation coverage for new sites. This number should be estimated and considered separately for each individual paddock. This number will be adjusted over subsequent years and grazing seasons.

As previous management regimes for solar sites might consist of hay fields, crop fields, marginal pastures or brush areas, the vegetation coverage is expected to be heterogeneous. Therefore, vegetation sampling must be performed to determine sheep stocking rate and density, which is a requirement prior to establishing a grazing rotation. Tabular dry matter and nutrient values as they are published for uniform stands of established crops, hay field or other, are not adequate for evaluating solar array site vegetation for grazing. A detailed organic matter (OM) vegetation sampling protocol is published on the American Solar Grazing Association (ASGA) website. The grazing rotation will largely depend on the amount of forage dry matter (DM) growing within the individual areas. Manager may perform vegetation sampling at intervals to analyze the nutritional value of the forage.

Forage analysis laboratories such as Dairy One provide detailed analyses that can be used to calculate the available DM per grazing paddock from submitted OM samples. Dry matter is a percent of total percent plant weight minus water content. These DM values are necessary to establish the amount of available feed for sheep, and eventually the sheep stocking rate and density. Typically, pasture DM values in the Northeastern US for well-maintained pastures are between 18-25%, depending on the season.

Typically, well managed Northeast pastures can achieve yields above 2,500 lbs DM per acre. The yield in the grazing plan draft above is substantially lower; it is expected that the solar array pastures will take time after establishment to reach their potential. It is necessary to plan a grazing rotation prior to the grazing season, which would be used to guide a flock manager's rotation plan. The flock manager would then use his/her own experience and observation to decide daily if the rotation plan is reasonable and responsible, and to make necessary adjustments in rotation days and stocking rates.

Pasture utilization should be between 70 and 85% to ensure optimal regrowth and animal nutrition. Thus, pasture refusals (uneaten vegetation remaining after grazing) should be part of the calculation and should be between 15% and 35%.

Two examples of common adjustments to rotation plans include: First, in late spring after rain events and with the warming weather, stocking rates may have to be increased to be able to clear the vegetation growth. Secondly, in the summer, sheep may have to be moved from paddock to paddock faster than they were in spring or fall due to the slowed growth of dormant cool-season vegetation.

Feed Intake

It is recommended to graze uniform animal groups that are either dry (non-lactating) ewes, open (non-pregnant) ewes, ewes in their early stages of pregnancy, yearling ewes or growing lambs of at least 60 lb. (or alternatively, 50% of their mature body weight in case of small breeds). In the case of groups of growing lambs, the lambs should be of the same sex or the males should be castrated.

| Table 2. Body weight and feed intake | | | | |
|---|---|---|---|---|
| ***Breed*** | ***Stage of production*** | ***Body weight, lbs*** | ***Feed intake, DM %BW*** | ***Feed intake, lbs DM*** |
| Katahdin hair sheep | Growing lamb, 50% mature BW | 65 | 2.5 | 1.6 |
| | Yearling | 110 | 3.0 | 3.3 |
| | Open, dry ewe | 130 | 3.5 | 4.6 |
| Polypay composite | Growing lamb, 50% mature BW | 80 | 2.5 | 2.0 |
| | Yearling | 130 | 3.0 | 3.9 |
| | Open, dry ewe | 160 | 3.5 | 5.6 |
| Texel | Growing lamb, 50% mature BW | 90 | 2.5 | 2.3 |
| | Yearling | 150 | 3.0 | 4.5 |
| | Open, dry ewe | 180 | 3.5 | 6.3 |

Depending on the breed and uniformity of the group of sheep, an average weight for the individual animals in the flock can be determined. Table 2. Body weight and feed intake, gives an overview of BW (body weight) and feed intake across popular Northeastern sheep breeds. According to NRC nutritional requirements for small ruminants (NRC, 2007), daily DM consumption per animal can be estimated as a percentage of bodyweight.

Totals

These calculations can be used to determine the optimal number of sheep per paddock according to body weight and stage of production. By using this with the chosen grazing rotation days (or rest period), the stocking rate (the necessary sheep number for the calculated grazing time within each paddock) can be calculated, and the optimal grazing flock size calculated.

**On the 20.9 acre Verogy East Windsor project, the grazing plan allows for 75 mature ewes managed in six grazing paddocks, a stocking rate of 3.6 sheep per acre, and 12 grazing days per paddock with a 35-day rest period.**

## Animal welfare recommendations

Regardless of season, ad libitum clean and fresh water access is crucial for animal welfare (NRC, 2007). Site-specific amenities like well water or connection to municipal water lines are ideal, but transported water is typical of solar grazing operations. For sheep of the recommended production stages (non-lactating and > 60 lbs growing lambs), water requirements are very low in spring and fall. Typically, dry, non-gestating ewes will consume between 5 and 10 % of their BW water daily.

Granulated mineral feed must be available ad libitum and contain adequate concentrations. Mineral feed should be offered in troughs that can be moved with the flock according to the rotation and rotation days. Mineral feed is specially blended and commercially available for sheep producers (Cargill, 2019).

Sheep will be visually inspected on every rotation day by the flock manager. A closer inspection of each member of the flock is recommended at regular intervals (every 6 weeks on site), including parasite monitoring or treatment with a FAMACHA (FAffa MAlan CHArt) protocol (Wyk and Bath, 2002), and 5-point checks (Bath and van Wyk, 2009).

Each spring, before the flocks begin the grazing season, certain protocols are recommended to ensure they are in optimal health before their work at the solar site begins:

- Feet must be checked and trimmed,
- Ear tags replaced or added, in compliance with USDA regulations,
- Wool sheep must be shorn,
- Wool sheep should be tail-banded,
- Body-condition scores should be recorded to monitor nutritional and health status across the grazing season,
- ***Sheep should be kept in a dry lot on hay 24 hours prior to moving on site in Spring and de-wormed with a commercially available de-wormer to prevent parasite infections on site.***

## Literature

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