Trinkaus Engineering, LLC
114 Hunters Ridge Road
Southbury, Connecticut 06488
203-264-4558 (ph)
E-mail: strinkaus@earthlink.net
Website: http://www.trinkausengineering.com

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Mr. Chris Stone, PE
CT DEEP
79 Elm Street
Hartford, Connecticut 06106-5127

Re: Proposed Stormwater Requirements for Ground Mounted Solar Arrays:

Dear Chris,

I have reviewed the proposed modifications to the document entitled "Appendix I Stormwater Management at Solar Array Construction Projects" as prepared by your department. Before I provide my comments, I want to provide a commentary on the stormwater and erosion issues which I have seen on several small and large ground mounted solar arrays.

A. Many ground mounted solar arrays are located on farmland or forest areas. When located on densely vegetated farm fields, such as for hay or undisturbed forest land, many environmental benefits are lost as follows:
    a. Deciduous, evergreen trees as well as all other herbaceous and woody vegetation provide interception of rainfall via branches and leaves, thus reducing the amount of rainfall which directly hits the ground surface. Some of the intercepted rainfall is absorbed by the leaves for use in photosynthesis. Other intercepted rainfall runs the branches and trunk to the ground surface where is will infiltrate into the forest litter layer found on the ground surface. This environmental benefit will be fully LOST when densely vegetation areas are used for ground mounted solar arrays.
    b. By the interception of rainfall by the branches and leaves, the velocity of the falling raindrops is greatly reduced and thus when the raindrops reach the ground, they do not cause erosion of the forest litter layer. This environmental benefit will also be fully LOST by ground mounted solar arrays.
    c. All growing vegetation (trees, shrubs and herbaceous groundcover species) found in the forest and other vegetated areas absorb carbon dioxide from the air and release oxygen. Carbon from the carbon dioxide is stored in all woody vegetation and sequestered from being released.
B. Many of the sites which I have reviewed proposed some degree of grading of the area of the ground mounted array. Even when the extent of grading is minor (2'

cut or fill from existing grade), the natural properties of the soil are adversely affected. In other cases, the grading has been substantial (greater than 2' cut or fill from existing grade). In both cases, all stumps and woody debris is removed from the ground surface. The natural topsoil layer is removed, and underlying soils are disturbed. The movement of construction equipment over the soil surface compacts it, thus reducing the natural porosity (infiltrative capacity) of the soil. The result in all cases is a significant reduction of infiltration and a significant increase in the amount of runoff from rainfall events,

C. Compacted soils make the establishment of new vegetation very difficult as the roots simply are unable to penetrate the ground surface. When vegetation can grow, it is not a contiguous fashion, but has many bare soil areas.
D. In the plans which I have reviewed and the site I inspected in the field, runoff from the soil panels is not falling on the ground surface and running perpendicular to the panel rows. Runoff is falling off the panels and then running parallel to the panel rows. As this runoff moves down the slope, it becomes more concentrated. Concentrated flow has a higher velocity and thus a higher ability to erode the ground surface, which occurred at the array in East Lyme.
E. Many of the sites have some type of stormwater practice located at the bottom of the array rows and it is assumed that the runoff from the array always occurs as overland flow and not concentrated flow. This simplistic assumption has resulted in the failure of stormwater basins and erosion control systems on East Lyme and Pomfret solar arrays.
F. Whether grading is proposed or not, in the plans which I have reviewed, the solar panels have not been considered impervious. The assumption by the designer results in both the peak rate and runoff volume being under-estimated by roughly 40% or more depending upon the site.
G. Designers make a further error in judgement by using the same soil classification for post-development conditions as for pre-development conditions which assumes that there are no changes to the ability of the soil to infiltrate runoff. As stated above, post-development soil conditions will generate more runoff as less infiltration occurs. This assumption contributes to under-estimating post-development peak rates and runoff volumes.
H. The designers make another incorrect assumption in using post-development vegetative cover as being in Good Condition, the best condition used in TR-20 or TR-55 Hydrologic Models. It takes years for any vegetative cover to become fully established, so this assumption again contributes to the under-estimation of runoff for post-development conditions.
I. Contractors are disturbing more than five acres at one time and the erosion control measures in the field are inadequate to control stormwater from the disturbed soils.
J. Erosion control plans rely on a single row of siltation fence barrier or other type of erosion control barrier at the bottom of the slope. A singular row of a barrier is easily overwhelmed by the concentrated flow which has occurred in the field.
K. No provisions are made to restore the infiltrative capacity of compacted soils prior to vegetation.
L. Designers are under-estimating the affect of long slopes and steep grades of disturbed areas and how long flow paths are responsible for the high velocity, concentrated runoff during the active construction period.

M. In some cases, topsoil has been removed from the site in the beginning of the construction period and then not returned to the site. In addition to soil compaction issues, the lack of an organic topsoil adversely affects the establishment of vegetation on the soils.

It is my professional opinion that the requirements found under (1)(a) to (e) of the draft standards will not address the stormwater issues associated with the Ground Mounted Solar Arrays. I would propose that the following requirements take the place of this section.

Proposed Stormwater Standards for Ground Mounted Solar Arrays:

1. Paved access driveways, Gravel access driveways, concrete or bituminous concrete pads for electrical equipment, and solar panels shall be considered 100% impervious for the purposes of calculating the required Water Quality Volume (WQV) per Section 7.4.1 of the CT DEP 2004 Storm Water Quality Manual "2004 Manual"; the Groundwater Recharge Volume (GRV) per Section 7.5 of the 2004 Manual as well as all stormwater management computations.
    a. Soil types shall be obtained from the Natural Resource Conservation Service Websoil Survey (https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx) and verified by the excavation of a sufficient number of test holes within the area of the soil array and any stormwater practice in the field.
    b. The soil class for determining the Runoff Coefficient Number (RCN) shall be increased by one soil class if there is any disturbance of the ground surface ***(Rationale: the movement of construction equipment will compact the soil surface)*** or regrading within the solar array which is 2' higher or lower from the original ground surface ***(Rationale: regrading of native soils reduce the porosity of the native soils, thus reducing the infiltrative capacity of the soil)***. A Class B soil for pre-development conditions would become a Class C soil for post-development conditions.
    c. The soil class for determining the RCN shall be increased by two soil classes if the regrading within the solar array is greater than 2' higher or lower from the original ground surface. These requirements are fully applicable whether the regrading is a cut or a fill. A Class B soil for pre-development conditions would become a Class D soil for post-development conditions.
    d. All disturbed areas within the area of the solar array and the areas cleared or disturbed to provide full solar exposure shall be vegetated with an appropriate seed mixture containing native plants.
    e. Vegetated surface under and between the rows of solar panels shall be modeled either as Meadow in Fair Condition or Lawn in Fair Condition (50% to 75% coverage) on the modified soil class for post-development conditions. ***(Rationale: It takes a minimum of two to three years for vegetated surfaces to be fully established, so using Fair Condition is a more accurate representation of the ground surface in determining the post-development runoff conditions. Meadow in particular requires***

years to fully develop with roots systems extending 12" or more down into the soil, which provides pathways for rainfall to infiltrate).

f. All Stormwater management basins shall be designed in full compliance with the standards defined in the 2004 Manual for a practice.

g. Stormwater practices shall be proposed as specified in the 2004 Manual as off-line or on-line with appropriate pre-treatment of runoff as well as bypass provisions. ***(Rationale: I have seen Infiltration basins proposed for solar arrays which will receive runoff from all rainfall events. This approach has failed in practice. Practices to address water quality are required to off-line to treat Water Quality Volume or Water Quality Flow only with an appropriate by-pass system for events larger than the water quality storm (1" of rain/24 hours).***

h. The Stream Channel Protection requirement per Section 7.6.1 of the 2004 Manual shall be met for all stormwater basins at all discharge points for the solar array. The Stream Channel Protection requires that the post-development peak rate for the 2-year/24-hour rainfall event (using NOAA 14 data) shall be reduced to 50% of the pre-development peak rate for the 2-year/24-hour rainfall event.

i. Peak Rate attenuation shall be provided for the WQ storm (1" of rainfall per 24 hours), the 1-year, 2-year as noted above, and 10-year, 24-hour rainfall events using NOAA 14 data.

j. Overflow provisions for passing the 25 year/24-hour rainfall event, 50-year/24-hour rainfall event and the 100-year/24-hour rainfall event using NOAA 14 data shall be incorporated into the design of all stormwater basins.

k. Conveyance systems such as Dry Swales, Wet Swales or Riprap Swales shall be used to convey runoff from the perimeter of the solar array to an appropriately designed stormwater basin. All swales shall be designed in full compliance with the specifications found in the 2004 Manual. Flow velocities within the swales shall be non-erosive for the surface material (grass, stone, etc.). Field stone check dams shall be used to maintain non-erosive flow velocities.

l. Flow velocities for all stormwater discharges from stormwater basins shall be reduced by appropriate outlet protection sized in accord with the CT DEP Guidelines for Soil Erosion and Sediment Control "2002 Guidelines" and shall be reduced to non-erosive velocities for the 25-year rainfall event using NOAA 14 data.

m. Discharges from all stormwater basins shall be to either a) a well-defined stable wetland boundary or watercourse (intermittent or perennial) or b) an upland area where it must be shown that the discharge will remain as overland flow and not become concentrated flow. Measures defined in the 2004 Manual shall be used to convert concentrated flow to overland flow. If flows are not directed to a defined wetland or watercourse, non-erosive velocities must be provided when the runoff leaves the site under control of the applicant.

Comments on other sections of ***Design and construction requirements:***

(2): The vertical clearances of the panels to the ground surface are based upon the angle of the panels and the specifications of the manufacturers. This standard is too prescriptive (one size fits all) to work in the real world.
(3): A third party review of the erosion control/phasing plan and stormwater management plan shall be done by a licensed professional engineer with proven significant expertise in these fields. In my experience, the Conservation Districts do not have the expertise to evaluate the design of the stormwater management systems for these projects.
(4): The Licensed Professional Engineer shall perform the required inspections of the site during the active construction period as required by the CT DEP 2002 Guidelines for Soil Erosion and Sediment Control "Guidelines".
(5): This requirement is acceptable.
(6): A minimum of five (5) day notice shall be provided by the Licensed Professional Engineer for the project to the CT DEEP prior to commencement of any construction activity on the site, including the cutting of trees.
(7): This requirement is acceptable.
(8): A bond is a good idea. However, the $15,000/acre is excessive. The purpose of a bond of this type is to ensure that the approved design is constructed per the design in the field. The issue which has been observed in the field on several sites is that the design of the erosion control plan and stormwater management designs have not been adequate for the site. If the plan is inadequate, then no amount of bond will be enough to fix the problems. A bond of $ 2,000/acre is more than adequate for the correction of any erosion issue during the construction period when an appropriate erosion control plan has been designed and approved.

Design requirements for post-construction stormwater management measures:

The listed requirements in (1), (2), (3) (a to e inclusive) can be eliminated as they are addressed above. The following provisions shall take their place.

1. Solar arrays shall not be permitted on slopes greater than 15% as measured along the alignment of the row of solar panels.
2. A Storm Water Pollution Prevention Plan (SWPPP) shall be prepared by the applicant which fully complies with the 2002 Guidelines.
3. The SWPPP shall be reviewed by a Qualified Licensed Professional Engineer (per the General Permit) and a written statement of acceptance shall be provided by the Qualified Licensed Professional Engineer.
4. Appropriate and adequate erosion control measures shall be implemented on the site to reduce the slope length of disturbed areas to prevent the concentrated flow down a long earth slope.
5. The area to be disturbed (stump removal and/or grading) for the solar array shall be limited to five (5) acres at one time. The area must be stabilized with vegetation (75% vegetative cover over the area) prior to moving to the next phase.
6. If the area to be disturbed at one time is more than five (5) acres, the requirements of Part 1: Large Construction Site Sequences found on pages 4-2 to 4-5 of the CT

DEP Guidelines for Soil Erosion and Sediment Control shall be fully complied with.

7. Permanent stormwater basins shall be constructed in the early phases of the project, vegetated with appropriate seed mixture or plugs so that they are ready to accept stormwater when the array is constructed.
8. Permanent stormwater basins shall NOT be used as temporary sediment basins or traps during the active construction period as they cannot be stabilized appropriately to accept post-development runoff.
9. Short term and long-term Maintenance specifications and plans shall be provided for all components of the stormwater management system for the solar array.

Please feel free to contact me if you have any questions concerning this information. I believe a public hearing is necessary so that all opinions on the proposed regulations can be presented for discussion.

Respectfully Submitted,
Trinkaus Engineering, LLC

Steven D. Trinkaus, PE