STORMWATER MANAGEMENT ON SOLAR FARMS IN VIRGINIA

To date, utility-scale solar development has spurred substantial job growth and economic investment in Virginia. A memo recently published by the Virginia Department of Environmental Quality (DEQ) proposed changes to stormwater management regulations on solar facilities, which could hamper the continued growth of the industry in the state. Stormwater management opportunities at solar farms are unique, but require thoughtful, research-based regulation to be realized, as explored by this memo.

Utility-scale solar development has catalyzed sizable investment in Virginia in recent years. With deployment skyrocketing from only 1,371 MWh in 2020 to 3,365 MWh in 2021, solar development has supported both job and revenue growth.[1] The Solar Energy Industries Association estimates the solar industry has thus far invested $4.2 billion in the Commonwealth, and AEE estimates advanced electricity generation created 11,800 jobs in the state by the end of 2020.[2] Further growth is expected as both utilities and private institutions strive for carbon neutrality. For example, Amazon is supporting the construction of 1,430 MW of new utility-scale solar facilities that will come online before 2023.[3] These projects alone represent $2.1 billion in investment, support 6,050 full-time jobs, and will provide up to $2 million in tax contributions annually to participating counties.

A memo addressing post-development stormwater management at solar projects issued on March 29, 2022 by the Virginia Department of Environmental Quality (DEQ) caught the solar industry off-guard by changing stormwater management regulations on solar facilities. The memo specifically classifies panels as impervious and unconnected impervious surfaces, changing the existing practice of solely counting the posts and beams as impervious. The regulatory change immediately placed gigawatts of planned projects at risk, does not align with regulation in neighboring states, and from a technical perspective, may overstate water quality and quantity impacts from solar facilities.

Advanced Energy Economy (AEE) and American Clean Power Association (ACP) have prepared the following memo delineating the impacts of changes made by the DEQ memo, investigating DEQ's justification for the change, and illustrating why stormwater management opportunities at solar farms are unique.

[1] https://www.eia.gov/electricity/data/browser/#/a 1https://www.eia.gov/electricity/data/browser/#/topic/0?agg=2,0,1&fuel=0000k&geo=g0000001&sec=g&freq=A&start=2001&end=2021&ctype=linechart&ltype=pin&rtype=s&pin=&rse=0&maptype=0 2 https://www.seia.org/state-solar-policy/virginia-solar, https://info.aee.net/hubfs/2021%20State%20Jobs%20Fact%20Sheets/VA-Fact-Sheet-2021.pdf 3 https://aws.amazon.com/blogs/publicsector/aws-in-virginia-the-economic-impact-of-solar/ [2] https://www.seia.org/state-solar-policy/virginia-solar, https://info.aee.net/hubfs/2021%20State%20Jobs%20Fact%20Sheets/VA-Fact-Sheet-2021.pdf [3] https://aws.amazon.com/blogs/publicsector/aws-in-virginia-the-economic-impact-of-solar/

UNDERSTANDING NEW CLASSIFICATIONS

In a memo issued on March 29th, the DEQ announced it would classify solar facilities as both impervious and unconnected impervious surfaces. This alters the calculations used by solar developers to estimate water quality and quantity impacts of ground-mounted solar projects.

The new water quality guidance dictates that panels must be calculated as impervious areas when using the Virginia Runoff Reduction Method (VRRM).[4] The VRRM uses a calculator to quantify the stormwater impacts of development. Before constructing a project, solar developers plug in the number of acres they plan to develop broken down by soil category, as classified by the United States Department of Agriculture, and land cover type.[5] The calculator then quantifies impact and offers options for mitigation based on a credit system.

The DEQ memo changes which land cover type solar panels are categorized as in these calculations. Presently, there are three possible categories that solar panels can be categorized under in the VRRM:

- **Forest/Open Space is defined in the VRRM calculator as "undisturbed, protected forest/open space."**
- **Managed Turf is defined in the VRRM calculator as "disturbed, graded for yards or other turf to be mowed/managed."**
- **Impervious Cover is defined in Section 9VAC25-830-40 of the Virginia Code as "a surface composed of any material that significantly impedes or prevents natural infiltration of water into the soil. Impervious surfaces include roofs, buildings, streets, parking areas, and any concrete, asphalt or compacted gravel surface."[6]**

Inherent to the logic of the VRRM is the understanding that vegetation naturally mitigates impacts on stormwater quality. Therefore, areas with greater vegetated cover require less mitigation while areas with less vegetated cover require more.

Historically, solar panels were treated as Managed Turf and the concrete bases as impervious cover. This categorization reflected that the soil under the panels is often covered in vegetation and can serve as productive cropland. However, this new guidance issued by the DEQ, changes the categorization of panels to Impervious Cover.

[4] https://swbmp.vwrrc.vt.edu/vrrm/ [5] https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba
[6] https://law.lis.virginia.gov/admincode/title9/agency25/chapter830/section40/

This classification requires the same amount of mitigation a developer would employ when covering the same acreage in asphalt or a similar impervious surface. This classification departs from stormwater management practices in other states, including neighboring states, such as Pennsylvania, Maryland, and North Carolina.

Similarly, the new water quantity guidance dictates panels must be calculated as unconnected impervious areas when using the hydrologic methods specified in the Virginia Stormwater Management Program Regulations.[7] This alters calculations by changing a solar property's land type category, which corresponds with a runoff curve number (CN). Higher runoff curve numbers generally mean projects require more mitigation, while lower runoff curve numbers generally mean they require less. Depending on the project, developers have historically used categories made for fields with varying degrees of grass cover. The change promulgated by the DEQ's memo instead requires developers to calculate a unique runoff curve number based on the ratio of panel size to land between panels, still disregarding the area under the panels. Because of greater variance in the water quantity calculation, DEQ's new water quantity guidance will impact some projects more than others. All projects, however, will bear a greater burden for mitigation.

Further, both referenced water quality and water quantity calculations use one-dimensional modeling, which does not consider the attributes of the land under impervious surfaces. Historically, there has not been a need to model these attributes, as the soil beneath a sidewalk or roadway, for example, does impact water quality or quantity because concrete or asphalt blocks all stormwater from being absorbed into the ground. On the other hand, water can freely flow under and on top of solar panels. The new classification of solar panels does not account for this unique attribute of solar facilities and the soil underneath panels. Furthermore, the classification may disregard substantial opportunities various vegetation management strategies can provide for mitigation.

[7] https://law.lis.virginia.gov/admincode/title9/agency25/chapter870/s

SOLAR IN THE CHESAPEAKE BAY PROGRAM MODEL

The March 29 DEQ memo stated that the regulatory change sought to align stormwater management policy more closely with the Environmental Protection Agency's Chesapeake Bay Program (CBP). Specifically, the memo noted, "[T]he Environmental Protection Agency's (EPA) Chesapeake Bay Program considers solar panels to be impervious areas for the purposes of performing water quality monitoring/calculations for the Chesapeake Bay Total Maximum Daily Load." The memo subsequently called for the implementation of a new state policy in part to "ensure consistency with EPA's Chesapeake Bay Program." The following section will (a) delineate the Chesapeake Bay Program and its Land Use Working Group (LUWG) from official EPA regulation, (b) discuss the LUWG decision to no longer classify solar projects as entirely impervious surfaces in its modeling, and (c) comment on how the CBP may change its modeling inputs based on forthcoming research.

By way of background, the Chesapeake Bay Program is a unique regional partnership, managed by EPA through its Chesapeake Bay Program Office. It is staffed by employees from several federal and state agencies, non-profit organizations and academic institutions, and thus does not promulgate regulation or rulemakings on behalf of the EPA. Its LUWG, which consists of representatives from state and local governments, federal agencies, and nonprofit organizations, is one of the technical workgroups responsible for overseeing the development of land use data and monitoring land use change in support of CBP Partner decisions. It also informs the suite of modeling tools associated with the EPA Chesapeake Bay Total Maximum Daily Load (TMDL). Modeling decisions by the LUWG do not represent EPA policy. Nonetheless, it is vital to share context on the CBP LUWG, and its relatively recent decision to no longer classify solar projects as entirely impervious.

For nutrient load modeling purposes, solar panels had been modeled previously as impervious surfaces due to their resemblance to asphalt surfaces via satellite imagery.[8] However, noting increased solar deployment in the Chesapeake Bay watershed, the LUWG group opted to begin addressing this issue in 2020 on the basis that the solar facilities should have a more nuanced classification than impervious, determining **"solar fields do not exhibit the same hydrologic functions as other types of impervious cover."** [9] One participant observed the complexity of this exercise, noting "

[8] USGS. Personal Communication. 4/28/22. [9] Chesapeake Bay Program. CBP Land Use Classification Scheme 2013 - 2021 12.02.2020. Available: https://www.chesapeakebay.net/channel_files/41525/lc_classification_proposedfinal_120220.pdf

There is evidence...that the panels do not function hydrologically like a parking lot and that the pervious portions do not function like cropland."[10] Following presentations and robust discussion on this issue the Land Use Work Group agreed to create unique classes for solar facilities.[11] The panels would continue to be classified as impervious, but three new classification would apply to the vegetation planted between and around the arrays: barren, herbaceous, and scrub-shrub.[12]

Based on communication with members of the LUWG, despite the inclusion of these new solar land use classes in the latest 1-meter resolution land use/cover data, the current data informing the Chesapeake Assessment and Scenario Tool (CAST) do not have any solar land use classes and will not have them until the suite of Bay models are updated in 2025 and 2026.

Nonetheless, the Chesapeake Bay Program partners are revisiting the issue of hydrologic and water quality effects of solar fields later this year or in early 2023 through a workgroup, chaired by a professor of Civil & Environmental Engineering at Penn State University. The LUWG and other technical workgroups may reconsider how to appropriately represent solar panel arrays based on findings from this workshop.

In the meantime, it is important to acknowledge other ongoing research in this field, and conclusions of completed studies.

NREL – PV SMART

There is not a substantial body of research on the hydrologic impacts of utility-scale solar facilities. Thus, the National Renewable Energy Laboratory (NREL) is undertaking a major national study to quantify solar farms' unique attributes and translate them into PV-specific guidance for stormwater management. This multi-year effort, Photovoltaic Stormwater Management Research and Testing (PV-SMaRT), began in 2019 with an initial assessment of state stormwater management policy and literature review, and will conclude with a robust study of hydrological impacts at five solar sites across the U.S. The deliverables will include a series of runoff coefficients based on panel design and vegetation intended to be released by July of 2022.[13]

[10] Chesapeake Bay Program Land Use Workgroup. Conference Call Meeting Minutes October 7th, 2020 Available: https://www.chesapeakebay.net/channel_files/40489/final_draft_luwg_meeting_minutes_10.7.2020_updated.pdf [11] Chesapeake Bay Program Land Use Workgroup Conference Call. Meeting Minutes. October 7th, 2020, Available: https://www.chesapeakebay.net/channel_files/40489/final_draft_luwg_meeting_minutes_10.7.2020_updated.pdf [12] Chesapeake Bay Program Land Use Workgroup. Meeting Minutes February 3rd, 2021 Available: https://www.chesapeakebay.net/channel_files/42093/luwg_meeting_minutes_02.03.21_.pdf [13] Great Plains Institute. Personal Communication. 4/28/22. 14 Cook, Lauren & McCuen, Richard. (2013). Hydrologic Response of Solar Farms. Journal of Hydrologic Engineering. 18. 536-541. 10.1061/(ASCE)HE.1943-5584.0000530.

NREL first determined the lack of research and best practices on this issue create a problem for regulators and solar developers alike. In fact, managing solar farms with non-solar specific stormwater management guidelines and calculations can lead to unnecessary costs and delays for developers, as well as create suboptimal water quantity and quality outcomes.

Researchers determined runoff coefficients were a key deliverable from the effort, noting, "No research, prior to [this report], has established runoff coefficients for ground-mounted PV as a land use, leading to permit officials applying existing curve numbers or runoff coefficients developed for non-solar land uses." Runoff coefficients are used to calculate the amount of water that drains from solar farms and thus are central to pre-construction planning and mitigation. Generally, higher values are used for areas with low infiltration – such as sidewalks- and lower values for permeable areas, such as a forest. In Virginia, and many other states, solar developers are using runoff coefficients that likely do not accurately reflect the unique hydrological impacts of solar farms.

As part of the PV-SMaRT initiative, the Great Plains Institute (GPI) authored a report on the potential barriers and opportunities from stormwater management practices at solar sites. GPI's assessment, which was published in September of 2021, directly challenges the conclusions that solar panels should strictly be considered impervious surfaces:

> **Solar development is unique in the three-dimensional flow of stormwater; stormwater both flows along the impervious panel surface and simultaneously can infiltrate under the panel on pervious ground cover. This unique disconnection changes some of the basic assumptions about accounting for impervious surfaces and designing stormwater and water quality mitigation strategies.**

GPI further noted "[m]ost jurisdictions, including the U.S. Environmental Protection Agency, do not clarify in rules or guidance how to treat solar panels in calculations or impervious surface." Indeed, the "lack of solar-specific standards modeling leads to increased uncertainty in permitting, increased soft costs, and suboptimal water quality outcomes."

OTHER STUDIES

Prior to PV-SMaRT, few studies have examined the water quantity and quality impacts of solar facilities. For example, Cook & McCuen (2011) determined that if designed properly, solar facilities can in fact have a minimal impact on total volume of stormwater runoff and peak discharge rates.[14] Specifically, after panels were installed in models using native grass, runoff volume increased by only 0.35% and peak discharge increased only 0.31%.

RUNOFF VOLUME USING NATIVE GRASS UNDER THE PANELS:

Peak discharge increased only 0.31%
Runoff volume increased by only 0.35%

RUNOFF VOLUME USING GRAVEL OR CEMENT UNDER THE PANELS:

Peak discharge increased by 73%
Runoff volume increased by 7%

Central to the effectiveness of this model is the use of native vegetation around the panels. Using gravel or cement under the panels – which is not common industry practice – increased stormwater volume by 7% and peak discharge by 73%. **In short, the stormwater impacts of solar farms with native grass cover are both minimal and vastly different than stormwater impacts of impervious surfaces like cement.**

Walston et al (2021) illustrated how standard vegetation management strategies result in preferable environmental outcomes at solar facilities, compared with conventional agriculture.[15] The study determined sediment export, a technical term for erosion, under the solar-native grassland combination was 95% lower than that of agricultural land. Water retention on solar farms with native grass was also 9.5% higher than on agricultural lands.

[14] Cook, Lauren & McCuen, Richard. (2013). Hydrologic Response of Solar Farms. Journal of Hydrologic Engineering. 18. 536-541. 10.1061/(ASCE)HE.1943-5584.0000530.
[15] Walston L J, Li Y, Hartmann H M, Macknick J, Hanson A, Nootenboom C, Lonsdorf E and Hellmann J 2021 Modeling the ecosystem services of native vegetation management practices at solar energy facilities in the Midwestern United States Ecosyst. Serv. 47 101227

Turf grass did not yield as favorable outcomes as native vegetation, yet still resulted in less sediment export and greater water retention level than conventional agriculture. This research not only highlights the substantive difference in vegetation management strategies, but demonstrates converting agricultural land into solar farms can result in more favorable environmental outcomes. Under a flexible and nuanced regulatory framework, solar farms can even provide significant ecosystem benefits beyond the air and water benefits that come from using clean energy rather than fossil-fired generation.

STORMWATER MANAGEMENT REGULATION & THE SOLAR DEVELOPMENT PROCESS

ACP and AEE affirm that the proposed stormwater management regulations set a course to significantly change stormwater management at solar facilities without sufficient justification, and severely disrupt solar deployment, which is a long-term, intricate process requiring significant upfront investment.

In order to begin applying for county and state permits, a Virginia solar facility must undergo a series of three studies with the regional transmission operator, PJM. PJM manages the electric grid spanning 13 states and the District of Columbia and provides potential projects with relevant information on the costs associated with interconnecting the facility to the grid.

TIMELINE FOR COMPLETION OF THREE REQUIRED PJM STUDIES

6 Months
Feasibility study

6 Months
Impact study

2+ Years
Facility study

The initial two studies take PJM staff approximately six months each to complete, whereas the final study requires over two years for PJM to perform and send back to the developer. Given the rapid growth of wind, solar, and gas in the PJM region, the operator is substantially backlogged in performing these analyses and issuing the studies back to developers. In fact, the average length of time to complete the PJM interconnection process in 2000-2009 was just 1.5 years, from 2011-2019, this increased to 3.5 years on average. The backlog is so severe PJM proposed a two year pause on new service requests this year.[16]

Given the transmission interconnection process requires at least 3.5 years, solar projects require long-term certainty on regulations governing both construction and operations. ACP and AEE members have reported the proposed stormwater regulations would reduce a typical solar project by 20%, given the need to increase the size of basins, vegetated area between panels, or buffers. Materially modifying project sizes can require a new study to be performed by PJM, and a project to move back in the PJM interconnection queue. The proposed stormwater management regulations setback projects that were initially entered the PJM interconnection queue as early as 2018.

As evidenced above, these solar projects are far enough along in the process to have invested greatly in these sites by securing property interests and incurring other design and study costs, and even to have negotiated contracts with offtakers and other partners. Thus, the projects and their companies are put at severe financial risk if the proposed stormwater regulations apply to projects already in the process of moving through the PJM queue. The later in the PJM process the stormwater management regulations apply, the greater these risks become, and, in turn, the greater the risk that Virginia will not achieve its renewable energy goals according to timelines set by law.

AEE and ACP encourage stakeholders consider existing research on this matter, and how to appropriately balance stormwater management strategies while maintaining low energy costs and minimizing land-use conversion.

[16] https://pv-magazine-usa.com/2022/02/03/pjm-flooded-with-interconnection-requests-proposes-two-year-review-pause/

LEARN MORE ABOUT STORMWATER MANAGEMENT ON VIRGINIA'S SOLAR FARMS

Virginia Advanced Energy Economy and American Clean Power continue to engage members and stakeholders across Virginia, building awareness around research-based stormwater management regulation. If you would like to learn more, please contact **David Murray at dmurray@cleanpower.org** and **Nikki Chiappa nchiappa@aee.net**.

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