1/9/2019

Spotsylvania Solar Energy Center - Analysis of 100ft Setback

Summary:

A 100 ft setback panel setback from residential parcels with properties will ensure the mitigation of potential impacts of the solar energy facility regarding Urban Heat Island, Screening, Property Value and Noise.

Analysis:

1) Urban Heat Island

Both sPower and Staff Consultant Dewberry agree that there are no Heat Island Effects anticipated with the solar field due to the facts that the panels cool completely over-night, and there are no sustained and significant latent heat effects of the Heat Islands. Additionally, sPower and Dewberry also agree dense vegetation will help mitigate any latent heat concerns.

See Appendix A for a synopsis of the effects of vegetative buffers and berms on Heat Island Effects.

2) Screening

Proposed screening, including berms, landscaping and regrowth will provide virtually full screening of the solar facility from adjacent houses. The current screening scenario would include 7,000 linear feet (1.3 miles) of berms with landscaping and separately 10,000 linear ft (1.8 miles) of landscaping. In addition, there will be substantial regrowth behind the landscaping and berming to provide additional screening.

sPower believes that following the guidelines in the Design Standards Manual Article 6 – Landscaping and Screening which allow berming to reduce landscaping requirement by half will provide more than adequate screening to negate any potential visual, temperature, noise and property value impacts.

See Appendix B that includes visual simulations of berm/landscaping from adjacent residential properties at Chancellors Meadows Lane and Fawn Lake, examples of regrowth currently on site and DSM based landscaping standards.

3) Property Value

Local property appraiser Chris Kaila, MAI, SRA, who provided a report regarding the potential impacts to the values of surrounding properties, has determined pursuant to his research, that a minimum 100 foot screened buffer appears sufficient to address any impacts to adjoining property owners' property values. He also noted:

"There is no evidence that there is any negative impact on neighboring property values, despite unsupported claims to the contrary. The studies that have been done on this issue, that I find to be credible, also conclude and agree that there is no negative impact on property value resulting from proximity to solar farms."

4) Noise

As noted throughout the staff report, once installed, solar facility are very quiet and the only significant noise associated with them is during installation. The installation noise will be temporary and with the loudest noise from pile driving taking place over days, not weeks or months. Additionally, staff has added conditions that would significantly decrease the temporary impacts of noise from construction.

Appendix A

Effects of Berms and Vegetative Buffers on Heat Island Effects

Effects of Berms and Vegetative Buffers on Heat Island Effects
Spotsylvania Solar Energy Center

Executive Summary

Concerns specific to Heat Island Effects were initially raised during the CPCN process. After further analysis and investigation, both sPower and Staff Consultant Dewberry agree that there are no Heat Island Effects anticipated with the solar field due to the facts that the panels cool completely over-night, and there are no sustained and significant temperatures increases characteristic of the Heat Islands.

Heat Islands are well established and recognized phenomena, characterized by sustain duration and intensity and attempting to reclassify the issue as "temporary temperature increase" of a few degrees is problematic for several reasons:

- Small, short-lived fluctuations in temperature may be cause by a variety of factors and it would be almost impossible to contribute such small changes solely to the solar farm
- For these same reasons, modeling for "temporary temperature changes" would be equally as impossible
- It deviates from the original concerns voiced during the CPCN process

Changes in temperature *within* the facility are to be expected as with any development that results in a change in ground cover, such as a large asphalt parking lot or industrial park. Any latent heat generated within the solar field dissipates quickly and there is disputing evidence as to how much distance is required for it to dissipate completely. However, there is clear consensus the required distance will be greatly reduced with the presence of additional vegetation, including the grass within and around the panels, existing vegetation located in the conservation areas, as well as the proposed regrowth and vegetative buffers. Vegetation helps this effort in 2 main ways:

- Shading
- Evapotranspiration

It is also clear that berms will have an effect on reducing the required distance through turbulence increasing vertical mixing.

The amount of time, effort, and data required to adequately and accurately model the effects of vegetation and berming in order to produce a quantitative value exceeds the available timeframe. In lieu of said modeling effort, quotes, references, and affidavits from Dewberry, academics and the EPA were included to demonstrate the overwhelming consensus that the grass within and around the panels, existing conservation areas, and the proposed regrowth and vegetative buffers will have a positive effect on greatly reducing latent heat concerns.

Vegetative Screening Effects on Heat Island

I. Background

Traditionally the Heat Island Effect has been in the context of cities, which is why the more common term for the phenomenon has been the "Urban Heat Island Effect". Urban Heat islands form as vegetation is replaced by asphalt and concrete for roads, buildings, and other structures. These surfaces absorb—rather than reflect—the sun's heat, causing surface temperatures and overall ambient temperatures to rise. Waste heat generated from appliances, air conditioning units, and personal vehicles also contribute to Urban Heat island Effect. Displacing trees and vegetation also minimizes the natural cooling effects of shading and evapotranspiration (evaporation of water from soil and leaves).

As with the Urban Heat Island effect, large PV solar fields induce a landscape change that reduces albedo so that the modified landscape is darker and, therefore, less reflective. However, several differences between the Urban Heat Island effect and potential PV Solar Field effects confound a simple comparison; such as (*i*) PV installations shade a portion of the ground and therefore could reduce heat absorption in surface soils, (*ii*) PV panels are thin and have little heat capacity per unit area but PV modules emit thermal radiation both up and down (panels do not retain heat as long as other materials such as concrete or asphalt), and (*iii*) if vegetation is removed, there is a reduction in the amount of cooling due to transpiration

II. Timeline

Potential Heat Island Effect concerns from the solar farm were first voiced by Mr. Russ Mueller during the CPCN hearings. Mr. Muller provided a scientific study by Dr. Vasilis Fthenakis (Study). During the CPCN hearings Mr. Aschenbach of Virginia DGIF confirmed that not enough was known regarding HIE and suggested a literature review.

sPower performed the requested literature review as part of the TRC comment process, which included the Study provided by Mr. Mueller, among others, and provided its findings to the County in the "Heat Island Executive Summary" Document1. sPower also contacted Dr. Fthenakis, who authored the Study provided by Mr. Mueller for further clarification and information.

Spotsylvania County's third-party consultant, Dewberry, also conducted a similar literature review which had mixed results: in a field experiment, Dewberry found no change in temperature at the perimeter of a solar farm. However, their review of the Dr. Fthenakis' paper suggested setbacks may be needed. Although, Dr. Fthenakis, identified several mistakes in Dewberry's initial assessment of his study, Dewberry nevertheless stood by their analysis during a subsequent discussion with County on 12/17/18. It was during this same response document Dewberry gerrymandered and replaced the terminology from "Heat Island Effect" to "temporary temperature increase;" a substitution which <u>does not</u> describe the same phenomenon as Heat Island Effect.

III. Discussion

The revision to "temporary temperature increase" from Heat Island Effects is problematic and concerning for several reasons:

a. Unlike Heat Island Effect, which is a widely documented and clearly defined phenomenon, "temporary temperature increase" is extremely vague in both terms of intensity and duration. Heat Island Effects refer to a consistent and significant increase in temperature, which lasts both day and night.

b. Reverting from a genuine concern of consistent, significantly elevated temperatures to temporary, imperceptible differences of 1-2° is problematic because:

    1. At this small scale, temporary changes in temperatures could be the result of any one of multiple factors (a slight breeze for instance, or walking from the north side to the south side of one's home). When observed at the property line, "temporary temperature increases" at such a fine, inconsistent scale could also result from any of the aforementioned Heat Island contributors from the neighboring property (such as concrete structures, asphalt, air conditioning units, and personal vehicles). It would be difficult to attribute such small, temporary temperature change directly to the Solar Farm.
    2. Because of the multiple potential causes, modeling a "Temporary Temperature Increase", let alone being able to attribute it solely to the solar farm, would be almost impossible.

In order to ensure the original concern is being addressed, the focus should continue to be on potential Heat Island Effects as raised by Mr. Mueller. Heat Island Effect is a well-defined and quantifiable phenomenon and can easily be attributed to a source such as the solar farm, should it exist.

IV. Potential PV Heat Island Effect

sPower would like to reiterate that there are no sustained PV heat island effects similar to Urban Heat Island Effect due to the fact that the panels cool completely overnight. This was elaborated on in the Heat Island Executive Summary provided by sPower, later confirmed by Dr. Fthenakis in his response to Dewberry's review, and confirmed by Dewberry in their 12/17/18 response to Dr. Fthenakis:

> *"Vasilis ultimately agrees with Dewberry's statements that the panels have a low thermal mass compared to conventional building materials and soil. They lose heat very quickly and do not create a prolonged increase in temperature which suggests a micro-climate as an urban heat island would. Temperatures on a bright sunny day will be several degrees hotter above and around the panels, but will return rapidly to ambient by night time."* (underline added for emphasis)

It is known that temperature increases do occur in, and around the panels within the solar field during the day, but this latent heat dissipates quickly with distance away from the solar field.

Dewberry presented evidence for heat dissipation from their own study: “Washington Solar Project Local Heating”. Dewberry previously conducted a study on the impact of a solar farm on local heating on a previous project in Washington, NJ. The following was observed:

- Temperatures were several degrees higher directly above the panels within the solar farm
- Temperatures decreased to ambient at the perimeter of the solar farm.

However, despite these findings at the Washington project, Dewberry suggested 350 ft project setbacks in their review of the Dr. Fthenakis’ paper brought forth by Mr. Mueller, and confirmed in their position in their 12/17/18 response letter.

“A 350-foot buffer between the solar arrays and residential property line is consistent with the study’s findings when considering the maximum distance observed during testing in which the temperature increase dissipated to ambient temperature (328-feet). We consider this to be a conservative approach since no further evidence or documentation was provided to quantify the potential for the landscape buffering/berms to mitigate the propagation of additional temperature differential.”

According to Dr. Fthenakis in his review:

“I wrote ‘Analysis of the Potential for a Heat Island Effect in Solar Farms’ but I did not mention anything about necessary setbacks. Perhaps Dewberry misinterpreted the field data I listed indicating that the heat build-up from the plant would have been effectively dissipated within a distance of 100 m (328 ft) from the perimeter of a large solar farm, as temperature at such distance has approached the ambient within 0.45 C (1 ^{O}F). However, these data corresponded to maximum mean temperature differences that may occur for only a few hours.”

It should be clarified by Dewberry whether the 350ft setback was prescribed to address Heat Island Effects or “temporary temperature increases” (which, again should not be considered for the reasons described above).

Regardless, Dr. Fthenakis has since obtained follow-up study results from colleagues who found:

“At 131 feet (40 meters) from the edge of the array no difference was found between temperatures recorded by probes and the surrounding ecosystem (Barron-Gafford 2018).”

Study/Source	Distance to Ambient	Source
Washington, NJ study	At project perimeter	Provided by Dewberry
Fthenakis and Yu, 2013	328 feet (disputed)	Conservative recommendation by Dewberry, disputed by Fthenakis
Barron-Gafford, 2018	131 ft	Barron-Gafford

It is worth noting that the *Fthenakis and Yu* and the *Barron-Gafford* papers did not exhibit the extensive grass cover the Spotsylvania project will have. This is incredibly important to keep in mind when discussing the increased evapotranspiration effects on heat (discussed below).

V. Effects of Vegetative buffers

Trees and vegetation lower surface and air temperatures by providing shade and through evapotranspiration. Shaded surfaces, for example, may be 20–45°F (11–25°C) cooler than the peak temperatures of unshaded materials.1 Evapotranspiration, alone or in combination with shading, can help reduce peak summer temperatures by 2–9°F (1–5°C) (EPA.gov).

According to the subject expert (Dr. Fthenakis), accurately modeling the quantitative effects a berm and vegetative screening would have on setback distances would take several months and would require enough effort to qualify as a Master's Thesis. According to him, the effort would require adding inputs to existing models including a description of berms (turbulence increasing vertical mixing) and evapotranspiration for the heat that the trees and bushes remove from the environment. Although the effect on distance cannot be exactly quantified without the extensive modeling effort, there is qualitative evidence the vertical mixing and evapotranspiration from vegetation will decrease the required distance.

There is an almost unanimous consensus that vegetation will reduce any potential heat effects. These effects occur through increased shading, as well as evapotranspiration. This has been acknowledged already both by Dr. Fthenakis and Dewberry, and even recommended as mitigation measures:

"In the case of Spotsylvania, the spacing of the panels from each other (rather than a solid mass of panels) encourages conductive heat flux in open areas which in turn will lower overall sensible heat. Also, trees provide significant shading of the ground currently. Thus, there will be little if no change in the conductive heat flux in the overall area."

-Dewberry Third Party Review 11/26/2018

"Latent heat flux describes heat used by plants and trees for evapotranspiration. Dense vegetation that absorb soil moisture and increase the amount of latent heat flux by the means of evapotranspiration. The heat island effect in Spotsylvania will benefit greatly from grasses growing underneath panels that provide latent cooling. Encouraging latent heat flux in the area as much as possible proves very useful as a mitigation strategy."

-Dewberry Third Party Review 11/26/2018

"Typical mitigation strategies against the effect of a PVHI involve minimizing change to the energy balance. This is encouraged by providing dense vegetation of the area around and underneath the panels to maximize latent heat flux contribution to the area to lower sensible heat."

-Dewberry Third Party Review 11/26/2018

"Temperature increases have been observed within solar farms, but increased temperatures dissipate as distance from the panel's increases. Heat will dissipate in a manner similar to that of light or sound. In an idealized situation where there is no interference with surroundings, the strength of a power source will decreases exponentially as distance increases. Exact quantification can be complex due to wind, spatial orientation, and surroundings. However, this describes the way heat will dissipate into the air. Buffers should be placed at the point where the rate of temperature decrease minimizes."

-Dewberry Third Party Review 11/26/2018

"The vegetative buffers and berms must be installed with shade trees as well as shrubs and to create a dense screen and maximize absorption of any radiative heat."

-Dewberry Third Party Review 11/26/2018

"Vegetative coverage in the area must be maximized. Dense grasses that grow well in shade should be used throughout the site. This will help mitigate evapotranspiration and heat absorbed by soils. -Dewberry Third Party Review 11/26/2018

"Within natural ecosystems, vegetation reduces heat gain and storage in soils by creating surface shading, though the degree of shading varies among plant types. "

-Barron-Gafford et al. 2016

"In rural areas, vegetation and open land typically dominate the landscape. Trees and vegetation provide shade, which helps lower surface temperatures. They also help reduce air temperatures through a process called evapotranspiration, in which plants release water to the surrounding air, dissipating ambient heat. "

-EPA, *Reducing Urban Heat Islands: Compendium of Strategies, Urban Heat Island Basics*

VI. Conclusion

No Heat Island Effects are anticipated with the solar field due to the facts that the panels cool completely over-night, and there are no sustained and significant temperatures increases characteristic of the Heat Island Effect concerns as originally expressed by Mr. Mueller.

There is mixed data on the required distance for any latent heat generated from the facility to dissipate to ambient levels.

Berms will have a reducing effect on this distance by increased turbulence increasing vertical mixing.

Increased vegetation will have a reducing effect on this distance through shading as well as cooling via evapotranspiration. This is effected through grass cover as well as tree and shrub cover.

The sPower facility is already designed to have significantly more grass cover in-and-around the solar panels than any of the studies discussed so far. The site plan also has over 2,000 acres of preserved vegetative communities which will help dissipate any latent heat.

In addition to this, in order to get relief on the conservative 350 ft setback proposed by Dewberry to address "temporary temperature increases" (which again, shouldn't be a concern) sPower is proposing to increase the vegetative buffers from 50ft to 100ft to further enhance shading and evapotranspiration effects.

References

Barron-Gafford, Greg, 2018. Phone call between Jessica O'Dell (ESA) and Greg Barron-Gafford (University of Arizona). March 16, 2018. https://www.co.fresno.ca.us/home/showdocument?id=30154

Barron-Gafford, G. A., Minor, R.L., Allen, N.A., Cronin, A.D., Brooks, A.E., Pavao-Zuckerman, M.A. 2016. "The Photovoltaic Heat Island Effect: Larger solar power plants increase local temperatures" Nature. October 13, 2016. Accessed March 9, 2018

https://www.epa.gov/heat-islands/using-trees-and-vegetation-reduce-heat-islands

Appendix B

Visual simulations of berm/landscaping from Chancellors Meadows Lane, Fawn Lake, examples of regrowth currently on site and DSM based landscaping standards

DSM Based Landscaping Standard

The current staff report has the following conditions regarding landscaping:

7. Buffer plantings shall be planted in accordance with the GDP's Landscaping Plan except that:

a) Residential structures adjacent to the Property, which are not separated from the Property by a minimum of forty (40) feet of the Applicant's preserved woodlands, and which are located 300 feet or
less from the Property's boundary shall be screened with a bermed buffer consisting of a minimum eight (8) foot high earthen berm planted with a minimum of one (1) evergreen tree with a minimum height of six (6) feet every ten (10) feet, one (1) large deciduous tree with a minimum trunk caliper of two (2) inches measured six (6) inches from the ground every fifteen (15) feet, one (1) understory deciduous tree with a minimum trunk caliper of two (2) inches measured six (6) inches from the ground every fifteen (15) feet, one (1) evergreen shrub with a minimum height of four (4) feet every ten (10) feet.

b) Residential structures located 300 feet or less from the Property boundary which are separated from the Property by a minimum of forty (40) feet of the Applicant's preserved woodlands, or residential structures located 600 feet or less from the Property's boundary, or adjacent to VDOT right-of-way, shall be screened with a buffer consisting a minimum of one (1) evergreen tree with a minimum height of six (6) feet every fifteen (15) feet and one (1) large deciduous tree with a minimum trunk caliper of two (2) inches measured six (6) inches from the ground every ten (10) feet.

A review of the landscape buffer proposed by County staff by sPower consultant Kimley Horn found the following:

Overall, the buffer planting height and plant spacing appear to be generally acceptable according to industry standards, with the exception of the large deciduous tree paced every fifteen (15') feet. This spacing for this type of tree is recommended to be at least twenty (20') feet in order to allow for full maturity growth. Additionally, the amount of planting material proposed would be very dense within a fifty (50') buffer and the competition between plants for soil, light, and nutrients would be high. This would result in a higher percentage of tress not making it to their ultimate mature growth. This density would also increase the risk of trees dying or being out-competed by adjacent trees. The installation of the proposed density of trees on a berm is also not recommended. The installation process and stabilization is more difficult along the top and slope of the berm, further increasing the chances of the trees dying due to non-ideal installation locations. Kimley-Horn would expect the berm and plantings to be constructed separately, which would require a substantially larger setback than the currently proposed fifty (50’) feet. Finally, installing the proposed density of trees in front of an eight (8’) foot berm would make the berm nearly impossible to see after a few years of plant growth. Hence, this removes the benefit of the berm due to the visibility being substantially blocked by the plantings.

Therefore, sPower believes that the project should qualify for reduced plantings, per the guidelines in DSM Article 6 – Landscaping and Screening. Installation of berms that completely screen the facility should allow for halving of landscaping requirements as indicated or intended in the following sections of the DSM:

D. The transitional screening yard width and planting requirements may be reduced as much as two-thirds (2/3) where the developer chooses to construct a seven (7) foot brick or architectural block wall. This wall may be reduced to a height of six (6) feet where the Planning Director deems such a height will satisfy the purpose and intent of this Division (See Plate 6-21).

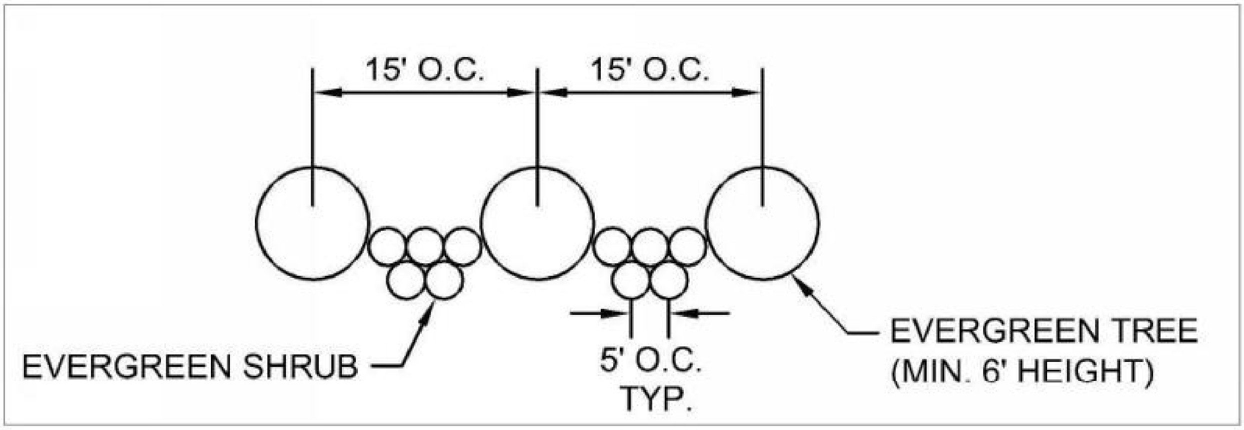
D. The landscape requirements for the buffer may be reduced by 40 percent when an earthen berm or brick or architectural block wall is provided. The berm or wall shall be a minimum of 3 feet in height measured from the road surface and be designed to lessen the impact of vehicle movement upon the residential development.

(3) The street buffer width and planting requirements may be reduced by as much as ½ where the developer chooses to construct a berm or wall. This berm or wall must be no more that three feet in height.

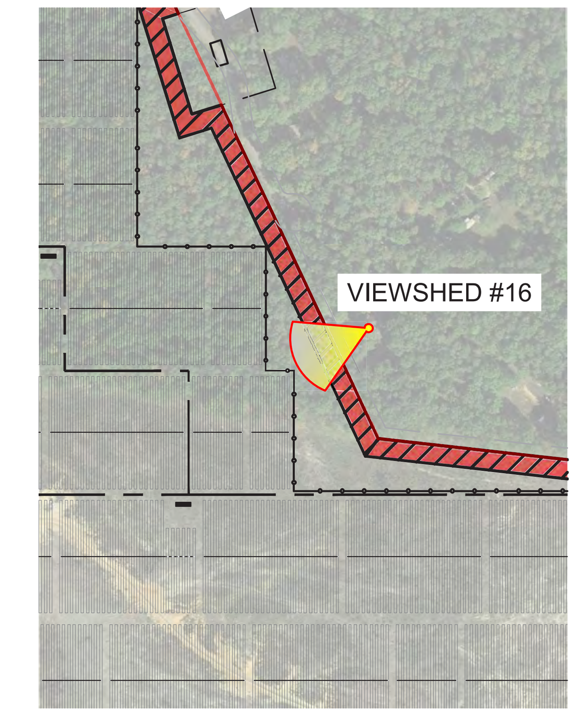
By halving the screening requirement, sPower is proposing to be in general compliance and with the intent of Transitional Screening 3 requirements as shown below:

C. Transitional Screening 3 shall consist of an unbroken strip of open space a minimum of 50 feet wide and planted with (See Plate 6-20): …..
(2) With approval of the Planning Director, one large evergreen tree with an ultimate height of fifty (50) feet or greater for every fifteen (15) linear feet, plus one medium evergreen tree with an ultimate height of twenty (20) to forty (40) feet for every five (5) linear feet plus one small deciduous tree with an ultimate height of twenty (20) feet or less for each twelve (12) linear feet, plus seven (7) medium evergreen shrubs with an ultimate height of twelve (12) feet or less for each ten (10) linear feet.

sPower proposes the following plantings at bermed locations as shown below and illustrated in the attached visual simulations at Fawn Lake and Chancellor Meadows Lane.



In addition, as shown in the Regrowth Illustrations, regrowth behind berms and landscaping will provide additional dense screening that sPower believes will completely screen the facilities from nearby residences.



VIEWSHED #16 LOCATION
SCALE: 1" = 400'

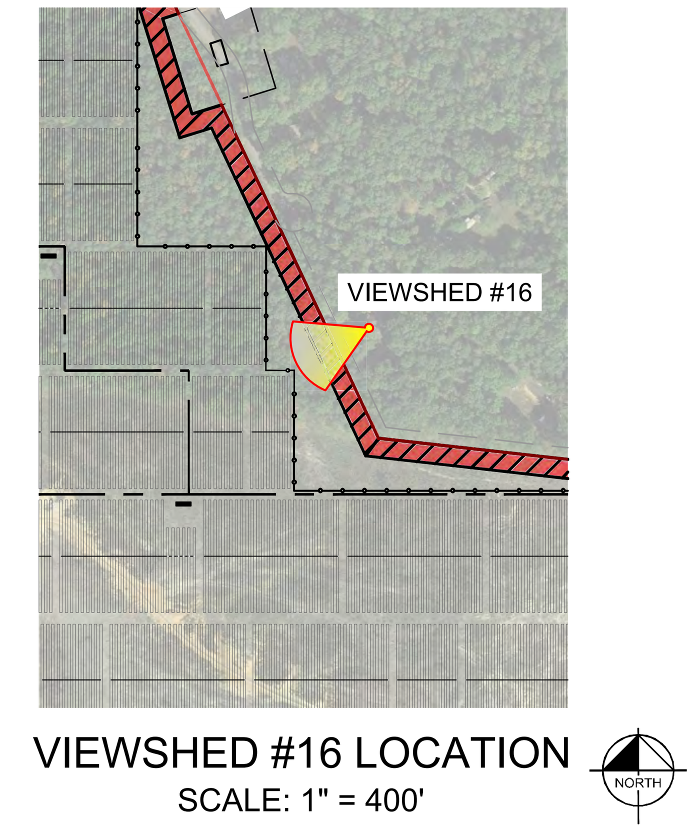
SPOTSYLVANIA SOLAR ENERGY CENTER
Spotsylvania County, Virginia

S·POWER
SUSTAINABLE POWER GROUP

VIEW 16 - Original
JANUARY 2, 2019

Kimley»Horn

Landscaping shown at install height



VIEWSHED #16 LOCATION
SCALE: 1" = 400'

SPOTSYLVANIA SOLAR ENERGY CENTER
Spotsylvania County, Virginia

S·POWER
SUSTAINABLE POWER GROUP

VIEW 16 - Perspective
JANUARY 2, 2019

Kimley»Horn

Landscaping shown at mature height

SPOTSYLVANIA SOLAR ENERGY CENTER

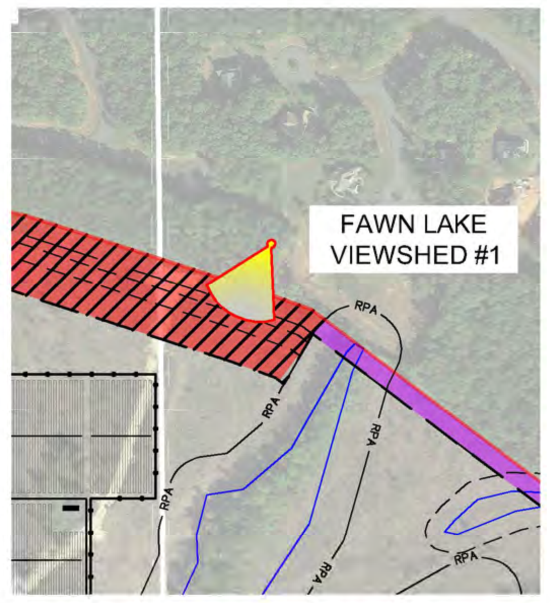
Spotsylvania County, Virginia

S·POWER
SUSTAINABLE POWER GROUP

VIEW 16 - Perspective

JANUARY 2, 2019

Kimley»Horn



FAWN LAKE VIEWSHED #1
LOCATION
SCALE: 1" = 400'

SPOTSYLVANIA SOLAR ENERGY CENTER

Spotsylvania County, Virginia

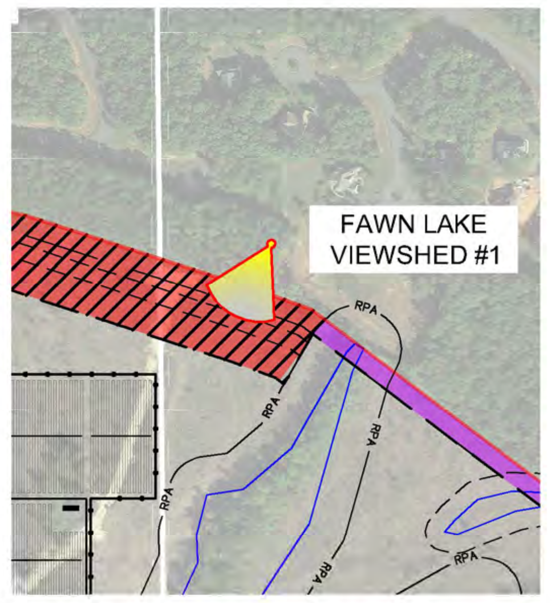
S·POWER
SUSTAINABLE POWER GROUP

Fawn Lake View 1-
Original

JANUARY 2, 2019

Kimley»Horn

Landscaping shown at install height



FAWN LAKE VIEWSHED #1 LOCATION
SCALE: 1" = 400'

SPOTSYLVANIA SOLAR ENERGY CENTER

Spotsylvania County, Virginia

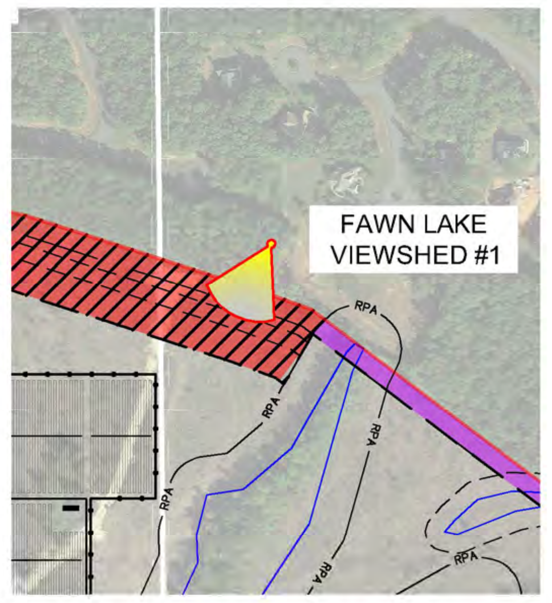
S·POWER SUSTAINABLE POWER GROUP

Fawn Lake View 1- Perspective

JANUARY 2, 2019

Kimley»Horn

Landscaping shown at mature height



FAWN LAKE VIEWSHED #1 LOCATION
SCALE: 1" = 400'

SPOTSYLVANIA SOLAR ENERGY CENTER

Spotsylvania County, Virginia

S·POWER
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Fawn Lake View 1- Perspective

JANUARY 2, 2019

Kimley»Horn

Regrowth will provide 100% Screening within 2-3 Years

2 Growing Seasons of Regrowth – View from Buckland Road into Project Site
100% screening

2 Growing Seasons of Regrowth – Shows Scale and Screening of Regrowth

Regrowth Site A – Off West Catharpin East of Access #3

View Towards House

View from Property Line towards Project

Site A – Off West Catharpin East of Access #3

1 Growing Season of Regrowth

Regrowth - Site A –West Catharpin, West of Access #3

View Towards House

View from Property Line towards Project

Site A – Off West Catharpin West of Access #3

1.5 Growing Season of Regrowth