Erosion and Storm Water Runoff

sPower Solar Farm Project: Watershed Environmental Analysis

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Abstract

The University of Richmond has announced their partnership with sPower's Spotsylvania Solar Energy Center that is to be developed in the next two years to contribute to their 2050 carbon neutrality goals. The university is supposed to have 20 MWs of the 500 MW solar development, which should produce enough energy to account for 100% of the electricity usage on campus. This will make the University of Richmond the first institution of higher education in the southeast to match 100% of its electricity needs with solar energy and will decrease the university's greenhouse gas emissions by 60% (University of Richmond 2019). While this is a huge step for the university, the solar development has been receiving a lot of opposition from the community of Spotsylvania in concern for the potential environmental impacts that will come from the solar project. This solar project is extremely large scale and has unavoidable environmental impacts, but sPower has designed extensive mitigation strategies to combat them. This report discusses where those environmental concerns are coming from, focusing specifically on erosion and storm water runoff from the installation of the solar panels, as well as the mitigation strategies designed by sPower. The goal of this report is to look further into the information released to the public by sPower, to expand on the information in a simpler but educational way, so that any stakeholder of the solar project can understand the information presented.

Background

Introduction

As the presence and impacts of climate change become more of a prevalent issue to members of society, many individuals, organizations, as well as businesses are beginning to make changes to reduce their carbon footprints, favoring clean and renewable energy instead of fossil fuels. Clean, renewable energy is on the rise, and with that comes investments in the development of alternative energy sources such as wind and solar farms. Following this rise of alternative energy, there has been an ongoing debate on a proposed, and recently approved, solar farm project that is to be built in Northern Virginia, specifically in western Spotsylvania County,

by Sustainable Power Group (sPower), an industry leading owner and operator of over 160 renewable energy projects with new offices located in Spotsylvania County and in Richmond. This is to be one of the largest solar farms in the United States, as well as the largest solar farm east of the Rocky Mountains, consisting of three projects sites that encompass approximately 6,350 acres, where 3,500 of these acres will be developed into the solar project, and at least 2,000 acres will be preserved as undeveloped, conserved land (Sustainable Power Group 2019). The development is to be named the Spotsylvania Solar Energy Center, holding 500 Megawatts (MWs) of energy, where large stakeholders, including Microsoft as well as the University of Richmond, have announced their partnership with the solar project (Sustainable Power Group 2019). Microsoft is planning on purchasing 315 MWs of energy and the University of Richmond is planning on purchasing 20 MWs (University of Richmond 2019).

There has been heavy protest against the development of the solar project by the community of Spotsylvania County, and although the project has been recently approved, the community is continuing to make an effort to receive information from sPower as the development advances, to counter these decisions. These protests are driven by community concerns regarding the environmental impacts of their county, where many of the residents hold property in close relation to the project sites. Although environmental impacts are unavoidable regardless of any type of development, there are ways that sPower can mitigate the potential environmental risks of building the solar center. The purpose of this report is to dig deeper into the potential environmental impacts that the community members are concerned about, specifically looking at the land cover of the project sites, to analyze potential erosion and storm water runoff that can come from developing the solar farms. This report will also be discussing storm water management strategies that can prevent potential erosion as well as runoff.

Community Concerns

Listed below are a couple of the main concerns coming from the community regarding soil damage as well as potential runoff in the area within sPower's project sites, along with sPower's responses to those concerns.

Community Concern: Most of the 6,350 forested acres have been logged and will be cleared. Significant soil regrading is anticipated to provide vast flat fields for the solar panels.	**sPower Response:** sPower has made significant and costly modifications to our grading plan, reducing the amount of grading and earthwork than what was previously proposed. Also, the project will be phased with only 400 acres open and active at any one time in any one watershed.
Community Concern: Specific plans are needed to prevent severe muddy runoff problems, such as recently encountered in Essex County due to construction of a 200-acre solar farm -- after only 1/2" of rain	**sPower Response:** sPower has committed to several Stormwater and Erosion control measure that go above and beyond what is required by county and state regulations, including but not limited to: sediment basins that are over-sized for their respective drainage areas, an accelerated sediment removal regime (cleaning the basins twice as frequently as required), diversion ditches on top of proposed slope to further divert and slow runoff, and stormwater conveyance channels and ditches at full design (a level of design effort reserved for the site development plan stage). Spotsylvania County has reviewed and approved these designs.
Community Concern: sPower has indicated that they will not use biosolids to condition soil. (Biosolids, if used, could pollute the groundwater and drinking water drawn from the rivers downstream.)	**sPower Response:** This is correct.

* Sustainable Power Group. (2019). Concerns and Responses. Retrieved from https://spotsylvania-solar.spower.com/responses/

Solar Panels: Impacts

As solar power becomes more popular as a choice for alternative energy, more solar farms will be built in the near future, and more land will be needed in order to develop these farms. Because solar farms require significant plots of land, it is important to think about the necessary actions to prevent potential impacts that can come from having these developments. But before discussing mitigation strategies, it is necessary to understand what could cause the impacts, from simply the way that solar panels are designed, to the necessary modifications of the land that must be made in order to install the panels.

sPower's project is going to utilize photovoltaic (PV) panel technology where the panels will be approximately 5-7 feet in height. These panels will be pole-mounted, which require less grading and should minimize long-term impacts to the project site. The project will be fenced and monitored 24 hours a day, 7 days a week, and is supposed to have a 50-foot setback from the property line where sPower has drawn up plans for visual screening.

Design

Solar panels are built to be facing the sun, and within solar farms they are usually mounted on metal rods and placed over pervious land (Cook et al. 2013). These panels are impervious to rainwater, so in the event of rain, water flows off the panels and that water either gets redistributed to the unsheltered areas around the panel, or it goes directly under the panels, depending on their set angle, into the ground. This interception of rain causes an “umbrella effect” that delineates the sheltered area. This effect is similar to issues regarding agroforestry, where vegetative cover is of various heights (Elamri et al. 2018). In some cases, the area below these panels are also paved or covered with gravel, which significantly increases the volume of runoff, in comparison to the sheltered land being a pervious surface, such as grass. The angle at which the solar panels are built can also affect the degree of runoff volume. When comparing

panels built at a lower angle of 30°, to the base angle of 45° and a higher angle of 70°, the runoff volume at the lower angle produces an increase in runoff, while the steeper angle produces a decrease in runoff (Cook et al. 2013). Although the difference is only a slight difference, the angle at which the panels are built can still affect the amount of runoff, therefore, it is something that solar farm developers should keep in mind.

Installation Land Modifications

The installation of large-scale solar projects can require extensive land modifications, especially if the land cover is forested. Some modifications include vegetation removal, land grading, soil compaction, and the construction of access roads; activities that increase soil loss by wind and water (Hernandez et al. 2014). If land modifications are necessary, which can be extremely likely, there will be necessary land revegetation as well as land management following the installation of the panels. Something to keep in mind is that with vegetation removal, there can also be resource losses in the process. A decrease in availability of resources resulting from soil erosion can result in biodiversity losses and can also impede the recovery of vegetation (Hernandez et al. 2014).

In the case that the land where the panels are being built is of an arid habitat, there is also the concern of dust emissions that can have an impact on human health, the global biogeochemical cycle, the hydrologic cycle, climate, and desertification (Hernandez et al. 2014). Luckily, the environment in which the Spotsylvania Solar Energy Center is to be developed is within a rural and considerably wet location, so the concern of dust emissions affecting the surrounding area is not a significant concern.

Methods

Geographical Theories

When looking at the issue of erosion and storm water management regarding the construction of sPower's solar project in Spotsylvania, there are two theories that come into mind: source-sink dynamics and ecological resilience theory. Some other geographical theories that are relevant to the project but not extremely specific to the individual focus of this report are: Scale and Innovation-Diffusion theory.

Source-sink dynamics is a theoretical model used by ecologists to describe how variation in habitat quality may affect the population growth or decline of organisms (Source-sink dynamics 2019). Once the solar farm is in place, there are potential risks to the habitat quality that can, in turn, affect the population growth or decline of organisms. In the presentation given by sPower at The Board of Supervisors public hearing held at Spotsylvania County High School in February, they mentioned a couple organisms that could potentially be affected. This theoretical model should be kept in mind so that sPower can ensure the development of the solar project does not cause significant erosion to the land it is being built on, to the point where it is considered extreme variation. The community is concerned about the erosion and storm water runoff that can result from the installation of solar panels, and this theory backs their concern.

Ecological resilience theory regards the capacity of an ecosystem to respond to a perturbation or disturbance by resisting damage and recovering quickly. This theory can come into play because it applies to any project that involves any sort of construction of something in an environment that was primarily natural beforehand. The disturbance of the environment would be the construction of the solar farm, and something we must keep in mind would be the aspects of resilience within the theory. There are a couple critical aspects of the theory that I think are important to this project: latitude, resistance, and precariousness. Latitude is the

maximum amount a system can be changed before losing its ability to recover (before crossing a threshold which, if breached, makes recovery difficult or impossible), resistance is the ease or difficulty of changing the system; how "resistant" it is to be changed, and precariousness is how close the current state of the system is to a limit or "threshold (Ecological resilience 2019)."

A large concern that has been brought up by the citizens of Spotsylvania county is that this major land use project places a significant storm water and erosion risk on the included and surrounding properties and wetlands from the inevitable heavy rain and flooding events which develop annually in the area. This is a reasonable concern, but from past studies done on erosion and storm water runoff form solar farms, it has been shown that depending on the land-cover type under the solar panels, the volume of storm water runoff can be considered non-significant. This all depends on the environment of the area in which the solar panels are to be built. When the panels are over grassy land-cover, there was not much of an effect on the volume of runoff, the peak discharge, nor the time to peak. With each analysis, the runoff volume increased slightly but not enough to require storm-water management facilities. However, over gravel or pavement, the volume of the runoff increased significantly, and the peak discharge increased by approximately 100%.

Of course, the solar panel is going to affect the environment, especially at a local scale, but when thinking about the trade-off of the project and the potential good that the project can do for the environment, that is a decision that the stakeholders must make. This is also where innovation-diffusion theory comes in because the theory is meant to explain how over time, an idea or product gains momentum and diffuses (or spreads) through a specific population or social system. The result of this diffusion is that people, as part of a social system, adopt a new idea, behavior, or product (Boston University School of Public Health 2018). Regarding this project,

we just need to spread awareness and information on the solar project to where there are enough members of the community realize that it is an advantageous project and that the small trade-offs (where sPower has also designed preventative strategies) are worth the larger environmental decision.

Methods

To dive deeper into analyzing the community concerns of potential erosion and storm water runoff, I have made a map showing the land within the proposed solar sites to gain perspective on the types of land cover that will be revegetated as well as regraded for the development of the solar project. The map also includes a section of the largest site where I was able to visit and take photos of the land modifications that are already taking place. Before visiting the site, I was aware of the acreage of the development, but I did not have a personal perspective on the actual scale of the project. By driving around the area to try to gain access to the site and walking into the proposed area based coordinates of the location, it gave me a much closer idea about the scale of the project, and how large this development is supposed to be.

I will also be going through sPower's revegetation and management plan to look at their plans regarding land modification that should be in place prior to the installation of the solar panels as well as their plans with managing the land around the solar panels after they are installed. Along with the revegetation and management plan, I will also be looking at sPower's erosion mitigation strategies that they have designed to prevent the issues brought up in the community concerns.

When looking through these documents, it is important that I base all of my critical thinking and reasoning on the geographical theories that I have mentioned above. Because this

large development is indeed something that creates a variation in the habitat, the theory of source-sink dynamics is extremely relevant. Although that is true, the extent at which this variation ends up is important in regard to the ecological resilience of the environment. With any sort of development, especially one of such large scale, comes unavoidable environmental impacts, but what is important to consider because the project is already approved, is the strategies that they are going to put in place to prevent the level of these impacts. With a deeper understanding of the strategies provided by sPower, along with analysis based around these theories, I hope that the community of Spotsylvania county can find peace with the inevitable development of the Spotsylvania Solar Energy Center.

Results

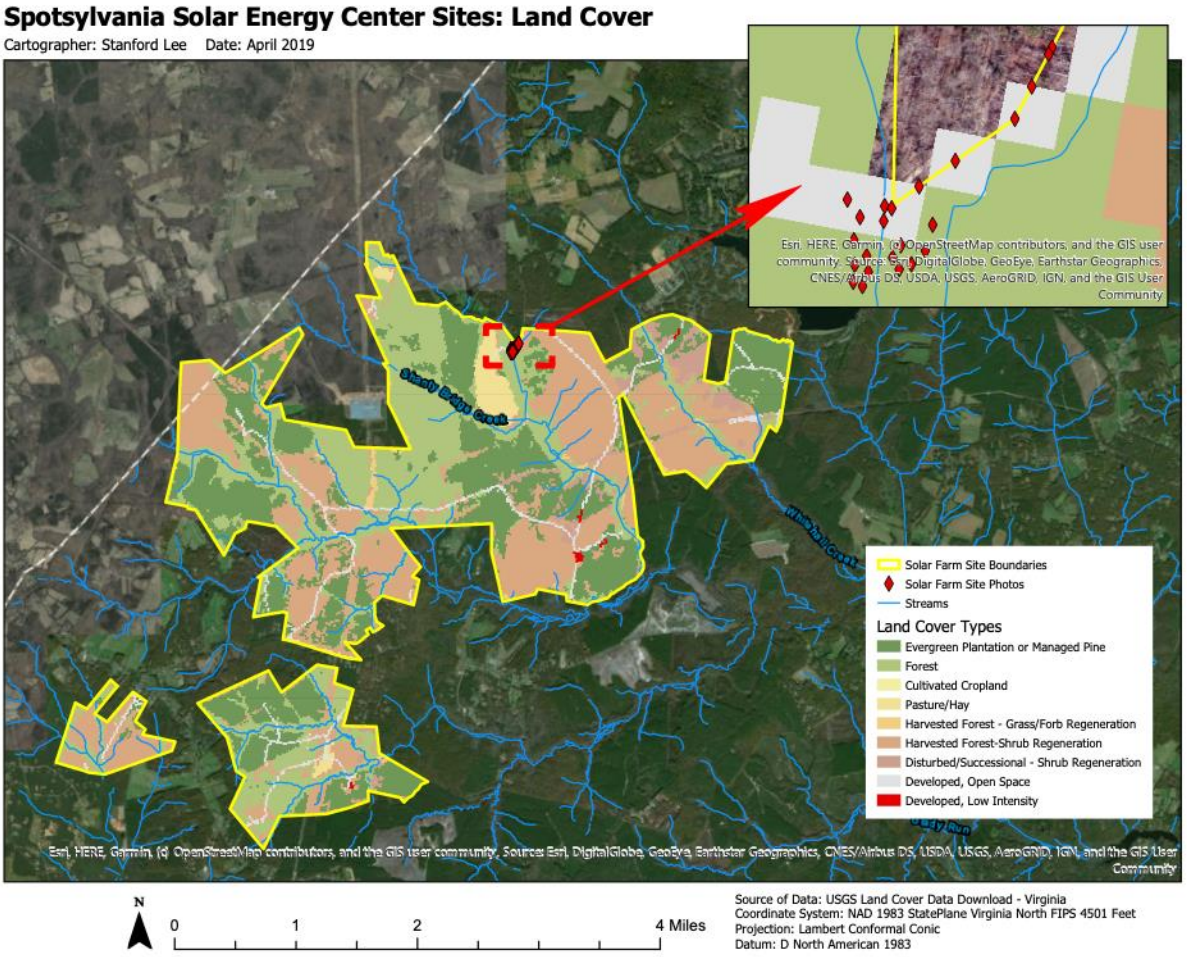
Graphic: Land Cover Map

Below is the map I created using ArcGIS Pro of the three solar farm sites representing the different land cover types within each site boundary. The map includes the boundary line in which Spotsylvania County ends (the diagonal dotted grey line on the upper left side of the map), the streams that run through the area (the blue lines), polygons showing the site boundaries (yellow lines), as well as points (red diamonds) in which I have attached photos I took of the land within the site. For the points, I have included a separate map frame that is zoomed to that specific layer so that it is easier to see the points. To look further into these points and photos, I have uploaded a map file where the photos can be seen through pop-ups by clicking on each point.

The land cover data for the map was downloaded from the United States Geological Survey (USGS) Land Cover Data Download page, specifically the land cover data for the state of

Virginia. I reclassified the land cover types so that all of the forested cover within the sites fall under “Forest” and kept the rest separate. Most of the land cover within the three sites are forest cover, harvested forest where the shrubs are regenerating, or evergreen plantation / managed pine. The coordinate system of my map is NAD 1983 State Plane Virginia North FIPS 4501 Feet, the projection is Lambert Conformal Conic, and the Datum is D North American 1983.

The information presented by the map is meant for any audience looking for more information on the land cover that is already present in the solar sites. The purpose of showing the land cover types within the sites is to get a perspective on what land is going to be modified when sPower starts the development of the sites. They have plans to regrade and revegetate the land, and a large part of their plans also allows for regeneration of the natural land that is already there to minimize how much of the habitat they need to change. I have designed this map in this way so that it can be a simple visual representation of how much of the three main land cover types are within the solar project sites. The symbolized colors were also chosen to represent colors that would be close to that of each land cover type.



sPower Revegetation and Management Plan

sPower has released their in-depth revegetation and management plan for the public to access, describing their plans to regrade and revegetate the land within their solar farm sites. The purpose of this document is for sPower to establish general guidelines for their approach on landscaping, revegetating, as well as maintaining the land within their solar project sites. The goals that they are trying to reach with these plans are to enhance aesthetics, attract native pollinators, provide erosion and sediment control, as well as screen visibility of the project from adjacent properties during the operational lifetime of the project (Landscape Reveg and Mgmt Plan 2019).

Within their Erosion Control plans, it states that permanent vegetation is to be established on site and will not be considered established until a ground cover is achieved that is mature enough to survive and mitigate erosion (Erosion and Sediment Control Docs 2019). This will happen through a mixture of sPower's planting process as well as allowing the natural occurring vegetation to replenish itself with time. They also want to install plants and trees as early as possible following the establishment of their erosion and storm water management controls, as long as they don't inhibit the construction of the facility.

They are planning on using specific seed mixtures that allow for low maintenance and are low growing during construction, to minimize or eliminate mowing as well as fertilizer and herbicide usage. In their Landscaping, Revegetation and Management plans, it states that the grasses near the solar panels will be kept maintained at no higher than 24 inches, which tells me that they are planning on having the land underneath the solar panels be grass (Landscape Reveg and Mgmt Plan 2019). Their Emergency Response Plan for Construction also states that because the solar panels are utilizing driven posts, there will not be a requirement for the use of concrete (Emergency Response Plan – Construction 2019).

Although there are a lot of concerns about erosion and storm water runoff from the development, sPower has made extensive preparations in designing prevention strategies that go above and beyond county and state regulations. By following these design plans, they can mitigate a lot of the resource and habitat destruction that can come with heavy land modification. Within their project site boundaries, they are also preserving a lot of the areas that were not already logged as natural visual screening.

Storm Water Runoff Mitigation Strategies

sPower has designed erosion and storm water management strategies that are currently under review by Spotsylvania County. The designs include plans to build storm water conveyance channels (SCCs) and diversion ditches for permanent storm water control that will utilize check damns or weirs to control sediment transport. Rock check damns are also supposed to be installed in the SCCs immediately following construction and establishment of final land grading (Erosion and Sediment Control Docs 2019). Along with the SCCs, they are also going to install sediment basins, equipped with measuring devices to accurately determine the sediment capacity of the basins. Sediment is to be removed from basins when accumulation reaches 25% of the required wet storage volume for each individual basin and remediation crews should be of sufficient size to remove sediment within 24 hours (Erosion and Sediment Control Docs 2019).

sPower has included in their concept plan from the start that they are implementing storm-water management strategies such as resource protection areas, perimeter controls, silt fencing, sediment traps, ponds and basins, etc. (sPower Erosion and Sediment Control Docs 2019). Recently it has also been confirmed that these erosion and storm-water management designs are under review by Spotsylvania County. Anthony Bell, sPower's Permitting & Environmental Compliance Analyst, has confirmed this along with stating that their designs go above and beyond the regulations: "Our Erosion and Stormwater control designs are under review with Spotsylvania County, but much of what we've designed goes above and beyond county and state regulations; i.e. emptying catch basins twice as frequently, installing additional windrows and conveyance channels, and drill-seeding for stabilization. Full designs can be shared once they are finalized during the site plan stage with the County (A. Bell, personal communication, April 2, 2019)."

These designs include specific monitoring and reporting strategies as well. The project is to have one Responsible Land Disturber (RLD) and at least one certified Erosion Control Inspector (ECI) per open zone of construction. The RLD and ECI will be required to be knowledgeable of environmental permit compliance requirements, be experienced in Erosion and Sediment Control, Storm Water Management, as well as Best Management Practices so that they follow installation, operation and maintenance requirements. They are also expected to keep a daily log of activity documenting the project activities. Post-rainfall event inspections will also be required for any runoff producing event (generally more than 0.5 inches of rain) and will be maintained on site and logged in an e-report uploaded to a central FTP server (sPower Erosion and Sediment Control Docs 2019).

Land Cover Strategies Regarding Solar Farms

Although it is reasonable to be concerned about the potential erosion of the area in which the solar farm is going to be built, there are ways that sPower can easily prevent these impacts from happening. As stated before, due to the design of solar farm solar panels, there is usually an increase in potential erosion as well as volumes of storm-water runoff within solar farms. This concern can be eliminated as long as the land cover under the panels is managed well.

In a 2013 study done by Lauren Cook of the American Society of Civil Engineers specifically for the purpose guiding future designs of solar farms, she analyzed conditions that would prevent potential erosion as well as increased volumes of storm-water runoff from developing solar farms (Cook et al. 2013). This study concludes with design suggestions that state, with well-maintained grass underneath the panels, the solar panels themselves do not have much effect on total volumes of the runoff or peak discharge rates. A model was created to

simulate the effect of adding solar panels over a grassy area, and with each analysis, the runoff volume increased slightly, but not enough to need storm-water management facilities.

While looking at the land cover within the project sites in Spotsylvania county, the majority of the landcover is evergreen plantation / managed pine, forest cover, and shrub regeneration of harvested forest. Assuming that a large portion of the forested land within the solar farm sites are going to be cleared out (not including the areas they decide to preserve for conservation of the natural habitat or for visual screening), as long as the land is not paved over or filled with gravel, and instead maintained with grass, the problem of erosion from increased storm-water runoff can be significantly mitigated. In the case that using gravel, or paved land is unavoidable (which has been confirmed to be unnecessary), then the storm-water management strategies discussed earlier will be there to prevent the level of increased runoff volume.

Discussion

Conclusion

As we know, the final permits for the sPower Spotsylvania Solar Energy Center have now been approved, so the development is now able to proceed. sPower expects to have the facility operating within two years. The purpose of this report was to look further into the information released to the public and present it in a way that is simpler to understand, while also analyzing the potential erosion and storm water runoff of the project. While there are going to be unavoidable environmental impacts resulting from this large-scale solar development, sPower has done extensive work to design strategies to mitigate these impacts. They have also released a lot of information about their plans for the public to access, so I would assume they are going to do the same as the development process proceeds. A large part of the community of Spotsylvania

county has been opposed to the solar project from the start, and now that the permits are approved, many of these opponents now feel betrayed by the supervisors who approved the solar project. The only thing that the community can do now is work with sPower and follow the development process so that they can make sure that sPower follows their plans to keep the environmental impacts low.

Regardless of the type of development, there are always going to be environmental impacts. When discussing whether or not this solar project is worth the trade-off of potential environmental impacts of the area, the advantages that will come from the energy created from the project as well as the jobs created should outweigh the risks. The community should understand that although there are going to be environmental impacts, the ones that come from this solar development are the same if not less than environmental impacts coming from housing developments. Increases in housing density and associated development on rural forest lands can be linked to numerous changes to private forest services across watersheds, including decreases in native wildlife; changes in forest health; and reduced water quality, forest carbon storage, timber production, and recreational benefits (Stein 2005). A large majority of the opponents are members of the newly built Fawn Lake neighborhood, and it does not seem reasonable that they are content with the environmental impacts that come with living in a giant housing development that is located around a lake, but not with a solar development that will create a source of renewable energy.

As more members of the community become more informed about the strategies that sPower has designed regarding revegetation, regrading, erosion control, as well as storm water management control, I can only hope that they will be more supportive of the decisions made to approve the development of the Spotsylvania Solar Energy Center. This project should bring

many advantages to the surrounding county, the large investors in play including Microsoft, Apple, as well as the University of Richmond, as well as our environment as a whole. This development is a step for the United States towards using renewable energy and a step towards a more sustainable country.

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