MS&B McMANIMON • SCOTLAND • BAUMANN 75 Livingston Avenue, Roseland, NJ 07068 (973) 622-1800

April 1, 2025

VIA OVERNIGHT AND ELECTRONIC DELIVERY
Honorable Sherri Golden (board.secretary@bpu.nj.gov)
Secretary of the Board
New Jersey Board of Public Utilities
44 South Clinton Avenue
3rd Floor, Suite 314
Trenton, NJ 08625

RE: IN THE MATTER OF THE **RENEWED** PETITION OF THE NORTH JERSEY DISTRICT WATER SUPPLY COMMISSION, IN CONJUNCTION WITH NEXAMP SOLAR, LLC., FOR A FLOATING SOLAR PROJECT ELIGIBILITY WAIVER UNDER THE COMPETITIVE SOLAR INCENTIVE PROGRAM, (P.L. 2021, c. 169)
BPU Docket No. __________

Dear Secretary Golden:

As I believe Staff is aware, this office serves as general counsel to the North Jersey District Water Supply Commission ("Commission"). In that regard, enclosed please find the following items on the Commission's behalf for filing and service:

1. An original and nine (9) copies of the Commission's **Renewed** Verified Petition (with exhibits and its attached service list), as above captioned, for both (a) the Board's internal use; and (b) service, by the Board Secretary, upon those identified in the service list appended to the Petition; and,
2. Our firm's check in the amount of $25.00, made payable to the Treasurer, State of New Jersey, to cover the filing fees.

Kindly stamp one copy as "filed" and return it to the undersigned in the enclosed self-addressed stamped envelope provided. Kindly effectuate service upon those identified in the service list pursuant to *N.J.A.C.* 14:1-4.5.

Thank you for your attention to this matter. Should you have any questions, please do not hesitate to call.

Respectfully submitted,

Ted Del Guercio, III
Ted Del Guercio, III

TJD/
Encls.
cc: Service List (w/ Encls. – courtesy copies - FedEx)
Frances C. McManimon, Esq.

STATE OF NEW JERSEY
Board of Public Utilities
44 South Clinton Avenue
Trenton, New Jersey 08625-0530

IN THE MATTER OF THE PETITION OF THE NORTH JERSEY DISTRICT WATER SUPPLY COMMISSION, IN CONJUNCTION WITH NEXAMP SOLAR, LLC., FOR A **RENEWED** FLOATING SOLAR PROJECT ELIGIBILITY WAIVER UNDER THE COMPETITIVE SOLAR INCENTIVE PROGRAM, (P.L. 2021, c. 169).	STATE OF NEW JERSEY BOARD OF PUBLIC UTILITIES BPU Docket No.: ____________ CSI Project I.D. 23CSIHDB3WU **VERIFIED PETITION FOR WAIVER**

1. This Verified Petition is being filed pursuant to N.J.A.C. 14:1-1 et seq., the Board of Public Utilities' (the "**Board**" or "**BPU**") Rules of Practice, and pursuant to N.J.S.A. 48:3-119(f) pertaining to the Competitive Solar Incentive Program, by both the North Jersey District Water Supply Commission (either the "**Petitioner**" or the "**Commission**") and in conjunction with, Nexamp Solar, LLC. ("**Nexamp**") (collectively, the "**Parties**"). The Commission is a public body corporate of the State of New Jersey. Nexamp is a company organized and operating under the laws of the State of Delaware, and authorized to do business within the State of New Jersey.

2. The Commission again seeks an Order from the Board, pursuant to both (i) the Board's Order Launching the CSI Program ("**CSI Program**"), Docket QO21101186, and dated December 7, 2022 (the "**CSI Order**") and (ii) N.J.S.A. 48:3-119(f), declaring that, with respect to the proposed 10MWdc floating photovoltaic solar system at the Commission's Wanaque Reservoir (the "**FPV System**" or "**Project**")[1], that a CSI Program waiver be granted by the full Board pursuant to N.J.S.A. 48:3-119(f), by virtue of the presence of the Project within the Highlands Preservation Area, that a waiver be granted pursuant to this Petition and the Board's prior January 10, 2024 Order (the "**January Order**"), which was entered under BPU Docket No. QO23060349), so that the Project would be eligible with respect to participation within the CSI Program.

[1] The Commission in conjunction with Nexamp also contemplates a 5MWdc community solar component of the overall project. However even combined, the surface area of the Reservoir impacted by the overall project is less than 1.5 percent of surface area.

Pertinent Background to this Current Petition

3. The Commission is a public body corporate duly organized and existing under and by virtue of the laws of the State of New Jersey (the "**State**"), exercising public and essential governmental functions and providing for the public health and welfare, and is engaged in developing raw water sources, storing water and distributing a reliable supply of potable water to its participating municipalities. That includes, among other things, the maintenance of various reservoirs.

4. The Commission has a responsibility by statute to ensure the safe, secure, and uninterrupted delivery of potable water to more than three million people, which includes the safety and protection of the public and public property pursuant to the Commission's enabling legislation, N.J.S.A. 58:5-1 et seq.

5. The Commission has determined that it is necessary to retain professional services for the provision of work associated with the finance, design, construction, installation, operation, and maintenance of the FPV System for the Commission (the "**Floating Solar Services**"). In that regard, Nexamp is the current sole source provider thereof.

6. Under the Board's SuSI Program, all large net metered non-residential floating solar projects above 5MW, including the FPV System, do not qualify for the pre-determined SREC-IIs values set by the Administratively Determined Incentive ("**ADI**") portion of the SuSI Program, which jeopardizes the economic feasibility of the Project. As a result, the CSI Program became a viable and attractive option for the Commission and Nexamp to pursue in connection with the Project.

7. The Commission and Nexamp had sought prequalification in prior CSI tranches, but had been denied, since the proposed Project is within the Highlands Preservation Area.

8. That denial had precipitated the filing of a prior Petition with the Board with respect to this Project, which was brought under BPU Docket No. QO23060349 on or about June 9, 2023 ("**Prior Petition**").

9. The Prior Petition is on file with the Board and BPU Staff, and is incorporated herein by reference as if set forth at length.

10. At the Board's January 10, 2024 regular Board meeting, the Board considered the Prior Petition, and denied without prejudice the sought CSI waiver relief.

11. That denial was predicated largely on the fact that the Board did not have the benefit of certain feedback, recommendations and conclusions, and attendant input, from both the Highlands Council, and the New Jersey Department of Environmental Protection ("**NJDEP**").

12. A true copy of the January Order so indicating, is appended hereto as **Exhibit A**.

13. In pertinent Part, the Board found and directed within the January Order:

> The Board also **FINDS** that the conditions set by the [Highlands] Council and the information required by the NJDEP must be addressed *before* the Board can make a make a positive finding with regard to this petition. The Board **FINDS** that the Petitioners have not documented sufficient facts or circumstances establishing the public's specific interest in siting the CSI-eligible facility on or within the Highlands Preservation Area.
>
> The Board **FINDS** that granting the waiver of the Board's CSI Siting Rules pursuant to N.J.A.C. 14:8-12.3(a)(2) is not warranted and is not in the public interest pursuant to N.J.A.C. 14:8-12.6(a) and **DENIES** the waiver. The Board **FINDS** that the Petitioners are not eligible to participate in the CSI Program's second solicitation. Thus, the Board **DIRECTS** the CSI Program Administrator not to process a prequalification package from Nexamp and/or NJDWSC for the second solicitation, if received. The Board **FINDS** that the *Petitioners may be eligible to participate in a future solicitation under the CSI Program if additional information is provided and the specific requirements discussed herein are met.* If Petitioners choose to continue pursuing participation in the CSI Program, then the Board encourages Petitioners to *submit the following information to the Board Secretary in a timely manner on a schedule or deadline set by Staff: an updated permit readiness checklist so that NJDEP's OPPN can schedule a follow-up meeting, and documentation that the meeting with NJDEP's OPPN was held, including recommendations and/or conclusions about the Project.* **Exhibit A** (Emphasis added)

14. Subsequent to the Board's issuance of the January Order, the Commission and Nexamp continued to engage with the NJDEP and the Highlands Council, and did indeed supply, among other things, an updated permit readiness checklist to the same for consideration in advance of a meeting to discuss the same.

15. A true copy of the updated permit readiness checklist, with exhibits, actually submitted to the NJDEP and the Highlands Council on or about February 24, 2025, is appended hereto as **Exhibit B**.

16. Following that submission, the respective teams of the Commission, Nexamp, the Highlands Council, NJDEP and BPU Staff, met on February 27, 2025, to discuss the permit readiness checklist, a presentation provided by Nexamp, and to discuss recommendations and conclusions with respect to the Project.

17. A true copy of the presentation made at the February 27, 2025 by Nexamp is appended hereto as **Exhibit C**.

18. Following the February 27, 2025 meeting, NJDEP staff prepared and furnished a high level summary of the recommendations and conclusions discussed.

19. A true copy of the summary of the Project recommendations and conclusions discussed is appended hereto as **Exhibit D**.

20. The Commission has reviewed that summary with Nexamp, and is fully prepared to address, engage and meet further with NJDEP with respect to compliance with all of the recommendations set forth therein if a waiver is granted, and a CSI award is made with respect to this Project. And Nexamp, with the cooperation of the Commission, will, of course, obtain all necessary NJDEP permits for the Project prior to construction.

21. By way of example and not limitation, the Commission and Nexamp will meet further with and engage with NJDEP with respect to the following raised in the recommendations: (a) concerns raised by Dam Safety, including flood hazard limitations, recommended docks on the floating solar arrays, blue heron habitat and nesting considerations, and other pertinent issues; (b) any requirements necessary to obtain a flood hazard permit; (c) any requirements raised by Freshwater Wetlands, including those pertaining to any concern over fill posed by the proposed Project; and, (d) considerations respecting historic preservation and character.

22. Nexamp has identified the necessary external resources required to address dam safety, habitat, historic preservation, and other noted concerns. Such experts are readily available and will be engaged, along with other technical experts typically expected for solar projects, if the Project is successful in securing a CSI award.

23. As noted in our first Petition, the Highlands Council, on April 23, 2021, already issued a Highlands Applicability Determination (a "**HAD**"), granting a Highlands Preservation Area Exemption Determination based upon the applicability of Exemption #11 (pertaining to public utility systems within the Highlands Preservation Area) for this Project.

24. A true copy of the HAD is appended hereto as **Exhibit E**.

25. Notably the HAD is valid for three years after permits issue for the Project. As no permits have issued at this time, the HAD remains a viable determination of the Highlands Council with respect to this Project.

26. Between the HAD and the NJDEP recommendations, all requirements of the Board set forth in the January 2024 Order have been addressed.

27. On the strength of the forgoing, the directives set forth within the January 2024 Order, and the directives, recommendations and conclusions of Staff at the February 27, 2024 meeting referenced above and summarized in Exhibit D, which our team is fully prepared to address and engage, the Commission and Nexamp now renew this Petition seeking a CSI Program Waiver, all as aforesaid.

Legal Standards and Analysis

28. Pursuant to N.J.S.A. 48:3-119(f):

> A developer may petition the board for a waiver to site a solar power electric generation facility in an area proscribed by subsection c. of this section [which including, among others, those in the Highlands Preservation Area]. The petition shall set out the **unique factors that make the project consistent with the character of the specific parcel, including whether the property is a contaminated site or landfill, otherwise**

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> **marginal land, or whether the project utilizes existing development or existing areas of impervious coverage.** The board shall, in consultation with the Department of Environmental Protection or Secretary of Agriculture, as appropriate, **consider the petition and may grant a waiver to a project deemed to be in the public interest.** However, in no case shall the projects approved by the board pursuant to this section occupy more than five percent of the unpreserved land containing prime agricultural soils and soils of Statewide importance, as identified by the United States Department of Agriculture's Natural Resources Conservation Service, located within any county's designated Agricultural Development Area, as determined by the State Agriculture Development Committee. (Emphasis added)

29. For the reasons expressed both within this petition and the Prior Petition, the Project is consistent with the character and nature of the Wanaque Reservoir within the intendment of the CSI Program. It will be situated upon the "surface" of "an existing, serviceable structure" (e.g., the Wanaque Reservoir), which was built for water supply purposes more than a century ago (e.g., a purpose "other than solely to facilitate solar development"). As a result, it will have no detrimental impact upon the Highlands Preservation Area, is inherently beneficial within the intendment of the CSI Program, and will serve the public interest.

a. No detrimental impact to Highlands Preservation Area: the Project will not occupy agricultural resources, land use is limited to areas already used by the Commission, small percentage use of the Reservoir minimizes the impact to avian or aquatic resources, no impact to public recreational activities, historic preservation criteria to be included in the design as well as all other concerns to be discussed and approved within the permitting process.

b. Inherently beneficial: This Project is precisely the type of development intended under the CSI program. Large solar renewable energy, with minimal environmental impact and maximum economic benefit at lowest possible cost to the State. The competitive power purchase agreement delivers the best possible economic value to the Commission, and the CSI solicitation process ensures the State's SREC 2 incentives will be at the lowest possible value through the public bidding process. The anticipated robust permitting process will ensure the Project is designed, constructed and operated within State guidelines.

c. Serving the Public Interest: This Project not only lowers the operating costs for the Commission, but also significantly delivers on-site energy production thereby increasing in-state, renewable energy production. This coincides with long standing State energy goals but also coincides with a dire need for increased PJM-connected generation resources. The PJM Interconnection, the largest regional transmission organization in the U.S., is currently grappling with significant generation capacity issues, with projections indicating potential shortages as early as the 2026/2027 delivery year. This situation is exacerbated by climate-impact to existing generation fleet, the accelerating retirement of thermal generation and the slow pace of new capacity additions. On-site renewable solar energy presents a viable solution to these challenges by providing a decentralized and resilient source of power. Solar energy systems can be rapidly deployed and scaled to meet local demand, reducing the strain on the centralized grid. Additionally, on-site solar generation can help mitigate the financial risks associated with volatile capacity market prices and enhance grid stability by diversifying the energy mix. Embracing on-site solar energy not only addresses immediate capacity concerns but also aligns with long-term sustainability goals, ensuring a reliable and clean energy future for the PJM region.

30. The FPV System is projected to be the largest floating solar project in the State - and , as of this Petition date, in the entire country. It is also expected to provide 90% of the energy needs at the Commission's Wanaque, New Jersey location - making it the first State entity to be substantially powered by renewable energy. As a result, the FPV System will serve as a national model for resiliency and distributed energy resources in the utilities sector - a sector which has been particularly challenging to make more sustainable and resilient.

31. As the Board noted in the SuSI Program Order, of which the CSI Program is a component, floating solar projects specifically can "alleviate development pressure on open space" and can "offer an additional way to alleviate pressure from solar development on open space." See, the SuSI Program Order at pp. 108, 113. Of note, the Wanaque reservoir is critical infrastructure with restricted access. The reservoir is not available for public use or access and is not an open space available for recreational use. Prudent and thoughtful use of the Reservoir's surface area is important to achieving the Commission's energy goals consistent with the State renewable energy goals.

32. Public solar projects such as the FPV System are important for achieving climate change resiliency and furthering the distributed energy network. The Commission - which provides drinking water to 14 communities with approximately 3 million customers - desires to become a more resilient facility and further serve as an example of the type of leadership the State is capable of. When public projects are prioritized, the entire community reaps the benefit of a greener economy - in addition to taxpayer/ratepayer savings, opportunities are created for public and stakeholder participation and education, public works/jobs are utilized during construction, and ongoing jobs are created for operation and maintenance. Additionally, the FPV System represents a unique job creation opportunity since limited opportunities for project of this scale exist in the region.

33. Public solar projects such as the FPV System will contribute significantly towards the State's and the Board's desired renewable energy goals and objectives.

34. For all of these reasons, a Board grant of waiver pursuant to both the CSI Order and N.J.S.A. 48:3-119(f) is appropriate here, as the Project is wholly consistent with the character of the Wanaque Reservoir and in the public interest, thereby warranting such relief for CSI Program participation.

Conclusion

35. The CSI Order deems installations such as that contemplated here, to be "presumptively in the public interest, **despite being sited on an otherwise prohibited land use**, provided that the structure **or surface** has existed for at least three (3) years prior to the date that the waiver application is filed." CSI Program Order, page 40 (Emphasis added) The Wanaque Reservoir upon which the Project is proposed has existed for nearly a century. There will be no impact upon open space, farmland or any other raw

and open land area. The CSI Order's presumption that the Project will benefit the public interest under the totality of the circumstances should stand in this case.

36. The Wanaque Reservoir has existed for nearly a century upon a rock foundation and base as described in the Prior Petition, which may certainly be considered an impervious surface within the intendment of State regulations. There will be no impact upon open space, farmland or any other raw and open land in the Highlands Preservation Area, as the Project is proposed as a floating solar system upon a very small (1%) area of the Wanaque Reservoir's surface (20 acres out of a 2,310 acre surface area).

WHEREFORE, for the reasons previously set forth herein and, as applicable, with this Prior Petition, the Commission, together with Nexamp, submits that pursuant to both the CSI Order and N.J.S.A. 48:3-119(f), Board relief, consistent with this Petition, is warranted and appropriate in these circumstances, along with such other relief as the Board may deem appropriate. A CSI Program Waiver should be granted.

I certify that a copy of the within Petition has been simultaneously sent to all parties on the attached Service List via Federal Express.

Respectfully submitted,

/Ted Del Guercio, III/

Ted Del Guercio, III, Esq.
McMANIMON, SCOTLAND & BAUMANN, LLC
75 Livingston Avenue
Roseland, New Jersey 07068
(973) 622-1800
Attorney for Petitioner,
North Jersey District Water Supply Commission (and on behalf of Nexamp)

DATED: April 1, 2025

VERIFICATION

STATE OF NEW JERSEY)
) ss.
COUNTY OF PASSAIC)

I, Timothy Eustace, of full age, being duly sworn, according to law, depose and say:

1. I am the Executive Director of the North Jersey District Water Supply Commission, and am authorized to make this Verification on behalf of the Commission.

2. I have reviewed the within Petition and its exhibits, and the information contained therein is true according to the best of my knowledge, information and belief.

____

TIMOTHY EUSTACE

Sworn to and subscribed this

____ day of ________________ 2025

____

VERIFICATION

STATE OF NEW JERSEY)
) ss.
COUNTY OF PASSAIC)

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TIMOTHY EUSTACE

Sworn to and subscribed this
1 day of April 2025

MICHAEL J. BRONCATELLO
ID #2435844
NOTARY PUBLIC
STATE OF NEW JERSEY
My Commission Expires July 2, 2028

SERVICE LIST

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EXHIBIT A

Agenda Date: 1/10/24
Agenda Item: 8C

STATE OF NEW JERSEY

Board of Public Utilities
44 South Clinton Avenue, 1st Floor
Post Office Box 350
Trenton, New Jersey 08625-0350
www.nj.gov/bpu/

CLEAN ENERGY

IN THE MATTER OF THE PETITION OF THE NORTH JERSEY DISTRICT WATER SUPPLY COMMISSION, IN CONJUNCTION WITH NEXAMP SOLAR, LLC., FOR A FLOATING SOLAR PROJECT ELIGIBILITY WAIVER UNDER THE COMPETITIVE SOLAR INCENTIVE PROGRAM, (P.L. 2021, C. 169)	)	ORDER DOCKET NO. QO23060349

Parties of Record:

Brian O. Lipman, Esq., Director, New Jersey Division of Rate Counsel
Ted Del Guercio, III, Esq., McManimon, Scotland & Baumann, LLC, on behalf of North Jersey District Water Supply Commission and Nexamp Solar, LLC

BY THE BOARD:[1]

This Order concerns a request for a waiver of the New Jersey Board of Public Utilities' ("Board's") siting prohibitions for Competitive Solar Incentive-Eligible Facilities ("CSI-eligible facilities") at N.J.A.C. 14:8-12.3(a)(1). On June 9, 2023, pursuant to N.J.A.C. 14:8-12.6, the North Jersey District Water Supply Commission ("NJDWSC"), in conjunction with Nexamp Solar, LLC ("Nexamp") (collectively, "Petitioners") filed a petition with the Board seeking to waive the prohibition ("Petition"). Petitioners seek to locate a floating solar project on the Wanaque Reservoir at Block 106, Lot 1, 1 F.A. Orechio Drive, Wanaque, Passaic County, New Jersey 07465 ("Project") on land within the Highlands preservation area, as designated in subsection b. of section 7 at L. 2004, c. 120 (N.J.S.A. 13:20-7b).

BACKGROUND

On July 9, 2021, Governor Murphy signed the Solar Act of 2021 (L. 2021, c.169) into law, effective immediately. Among other requirements, the Solar Act of 2021 ("Act") directed the Board to establish a comprehensive program to provide incentives for the development of at least 3,750 megawatts ("MW") of new solar generation by 2026.[2] This target was informed by New Jersey's

[1] Commissioner Michael Bange abstained from voting on this matter.

[2] MW measured in direct current ("dc").

2019 Energy Master Plan ("EMP") and Governor Murphy's goal of achieving 100% clean energy by 2050.[3] Specifically, the Act directed the Board to create two (2) solar incentive programs: a small facilities incentive program for community solar facilities and net metered facilities up to five (5) MW in size, and a competitive solicitation process for grid supply solar facilities and net metered facilities greater than five (5) MW.

The Act also directed the Board, in consultation with the New Jersey Department of Environmental Protection ("NJDEP") and the Secretary of the New Jersey Department of Agriculture ("Secretary of Agriculture"), to establish solar siting rules that will apply to all grid supply solar facilities and net metered solar facilities greater than five (5) MW in size.[4]

The Act specifically requires that the solar siting criteria must:

1. facilitate the State's commitment to affordable, clean, and renewable energy, and the carbon dioxide emissions reduction goals established in the Global Warming Response Act (C.26:2C-45);
2. minimize, as much as is practicable, potential adverse environmental impacts; and
3. where appropriate, consider:
    a. existing and prior land uses of the property;
    b. whether the property contains a contaminated site or landfill;
    c. any conservation or agricultural designations associated with the property;
    d. the amount of soil disturbance, impervious surface, and tree cover on the property;
    e. other site-specific criteria.[5]

The Act lists a series of land uses that are not authorized for solar project siting unless the applicant, in accordance with the waiver provisions specified in the Act,[6] files a waiver petition with, and receives approval from, the Board to proceed.[7] Among the areas specified is Highlands preservation area. Id. at -119(c)(5).

The Act allows developers to "petition the board for a waiver to site a solar power electric generation facility in an area proscribed by subsection c. of this section" and requires that the "petition shall set out the unique factors that make the project consistent with the character of the specific parcel, including whether the property is a contaminated site or landfill, otherwise marginal land, or whether the project utilizes existing development or existing areas of impervious coverage."[8] In such cases, the Board is required to consult with the NJDEP or Secretary of Agriculture, as appropriate, and "may [...] grant a waiver if it determines that a project is in the public interest.[9]

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[3] 2019 New Jersey Energy Master Plan: Pathway to 2050, https://nj.gov, https://nj.gov/emp/docs/pdf/2020_NJBPU_EMP.pdf.

[4] N.J.S.A. 48:3-119(b).

[5] Ibid.

[6] N.J.S.A. 48:3-119(f).

[7] N.J.S.A. 48:3-119(c).

[8] N.J.S.A. 48:3-119(f).

[9] Ibid.

On July 28, 2021, the Board issued an Order establishing the Solar Successor Incentive ("SuSI") Program and providing notice of the opening of the Administratively Determined Incentive ("ADI") Program and of the concurrent closing of the Transition Incentive ("TI") Program on August 28, 2021.[10] The ADI Program provided incentives for residential projects and non-residential net metered projects of five (5) MW or less. In addition, the ADI Program included an interim incentive for projects participating in the Board's Subsection (t) program, which covers solar projects on brownfields, areas of historic fill, and properly closed sanitary landfills, in order to provide a bridge for these projects until the CSI Program launch.

By Board Order dated December 7, 2022, the Board approved the establishment of the CSI Program.[11] The CSI Program is open to qualifying grid supply solar projects (i.e., those selling into the wholesale markets) and net metered non-residential projects greater than five (5) MW in size. The CSI Program provides for solar projects to qualify in one of five tranches:

- Tranche 1: Basic Grid Supply
- Tranche 2: Grid Supply on the Built Environment
- Tranche 3: Grid Supply on Contaminated Sites and Landfills
- Tranche 4: Net Metered Non-residential Projects above 5 MW
- Tranche 5: Storage Paired with Grid Supply Solar[12]

All CSI-eligible solar generation facilities, regardless of whether a project chooses to pursue an incentive or not, are also subject to solar siting restrictions that aim to protect New Jersey's vulnerable farmland and open spaces from unintended impacts of solar development. On the same date, the Board approved for publication in the New Jersey Register a rule proposal that amended the SuSI Rules to establish the CSI Program and a proposal for siting rules for grid supply and large net metered solar facilities. On September 18, 2023, the proposed CSI Siting Rules were adopted and published, with non-substantial changes, in the New Jersey Register at 55 N.J.R. 2015(a). The new rules include a mechanism to allow siting of CSI-eligible facilities on otherwise restricted land uses if the developer seeks and receives a waiver of the siting prohibition. The rules also provide for an administrative waiver in appropriate circumstances. Projects that would be constructed on prohibited land but for which the facility would be located exclusively on the built environment, are deemed to be presumptively in the public interest. The Board has designated the approval of such applications to Board Staff ("Staff") or the program administrator. This expedited process was devised to allow developers a quicker route to participation based on project type but applies only to the specific subset of projects located entirely on the built environment.

In compliance with the Act, the Board's rules at N.J.A.C. 14:8-12.6(a) require any petitioner to include documentation of "sufficient facts and circumstances" to demonstrate why siting a CSI-eligible project on a prohibited land use is in the public interest. In such cases, the Board requires consultation with other State agencies, as appropriate, to determine if a project is in the public interest. As indicated in the Summary of the CSI Siting Rule Proposal, the Board and its sister agencies may, at their discretion, consider mitigation measures project proponents suggest in

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[10] In re a Solar Successor Incentive Program Pursuant to P.L. 2018, c.17, BPU Docket No. QO19010068, Order dated July 28, 2021 ("SuSI Program Order").

[11] In re Competitive Solar Incentive ("CSI") Program Pursuant to P.L. 2021, c.169, Order Launching the CSI Program, BPU Docket No. QO21101186, Order dated December 7, 2022. ("CSI Program Order").

[12] CSI Program Order at 15, 44.

determining whether a particular solar project is in the public interest, such as proposals that include the preservation of other lands (for example, donating substantial desirable land into permanent conservation), or the like. 55 N.J.R. 136.

While the Act only requires that solicitations for the CSI Program be held at least once every 18 months, the Board intends to hold annual solicitations to promote industry growth and competition. The prequalification window for the first solicitation opened February 1, 2023, and the bid submission closed on March 31, 2023, at 11:59:59 PM. On July 12, 2023, the Board announced that no awards were issued for the first solicitation because the responsive bids were in excess of the pre-determined price caps put in the place by the Board to protect ratepayers from excessive costs.[13] The Board also directed the next solicitation in the CSI Program to open on an expedited timeline, opening to prequalification on October 1, 2023, and closing to bids on December 31, 2023 at 11:59:59 PM. Id. at 14. Subsequently, to accommodate further refinements to the CSI Rules, the Board delayed the opening of second solicitation of the CSI Program until November 27, 2023 with the solicitation window to be closed February 29, 2024.[14]

Petitioner's Actions in the First Solicitation

On March 7, 2023, Petitioners submitted a prequalification application for the Project, to which they refer to as the "Initial Application," to participate in Tranche 4 (net-metered, non-residential). Petition at 11 and Exhibit A.

On March 9, 2023, Staff provided a written response to the Initial Application in which Staff communicated the requirement for obtaining a land use waiver since the project was in an area for which the Solar Act of 2021 required such a waiver. Petition at 13 and Exhibit B.

On March 27, 2023, Petitioners submitted what they referred to as an "expedited application" to obtain an administrative waiver from Staff as described in the CSI Program Order. Petition at 15 and Ex. C. Stressing the benefits the Project would deliver to the NJWDSC, Petitioners pointed to an April 23, 2021 letter from the Highlands Council ("Council") supporting the grant of a Highlands Applicability Determination ("HAD") ("April 23 Letter"). Petition at 12. The April 23 Letter supported a Highlands Preservation Area Exemption Determination based on the applicability of exemption #11 for the Project.[15] Petitioners argued that the Project should be considered to be located on the built environment because it would be built on the surface of the Wanaque Reservoir, which was constructed in the 1920s, rather than on "land" within the Highlands Preservation Area.

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[13] In re Competitive Solar Incentive ("CSI") Program Pursuant to P.L. 2021, c.169, Order on the Outcome of the CSI Program Solicitation, BPU Docket No. QO21101186, Order dated July 12, 2023.

[14] In re Competitive Solar Incentive ("CSI") Program Pursuant to P.L. 2021, c.169, Order Addressing the Timing of the Second CSI Program Solicitation, BPU Docket No. QO21101186, Order dated September 27, 2023.

[15] Exemption number 11 relates to "the routine maintenance and operations, rehabilitation, preservation, reconstruction, repair, or upgrade of public utility lines, rights of way, or systems, by a public utility, provided that the activity is consistent with the goals and purposes of this act[.]" N.J.S.A. 13:20-28

On March 28, 2023, the Division of Law advised Counsel for NJWSDC that since the Project was located in one of the areas for which a waiver was statutorily required, the Initial Application could not be processed until a land use waiver had been granted by the Board. Petitioners noted that no written basis for this position was provided at that time, but the basis was provided in writing one week later, as described below. Petition at 24.

On March 30, 2023, Petitioners submitted a subsequent application, which they refer to as the "Second Application." Petition at 26 and Exhibit E. Petitioners continued to request an administrative waiver, or conditional administrative waiver, given the impending closing of the first solicitation on March 31, 2023. Petition at 27. Petitioners claimed that the Council's letter dated April 23, 2021 negated the need for a land use waiver, or, alternatively, supported the basis of an administrative waiver. Since a Board meeting previously scheduled for March 22, 2023 had been canceled, Petitioners argued that there was no time for the Board to issue a waiver for the Project. Petition at 32.

On April 3, 2023, Staff responded to the Second Application, reiterating its position that a Board waiver was needed pursuant to the Solar Act of 2021 and that an administrative waiver could not be issued by Staff. Petition at 42, 43, and Exhibit F.[16]

Petition

By letter dated June 9, 2023, NJDWSC and Nexamp filed the Petition seeking a waiver of the statutory prohibition on siting a large scale solar project within the Highlands Preservation Area, as designated in subsection b. of section 7 at L. 2004, c. 120 (N.J.S.A. 13:20-7b). Petitioners sought the waiver for a proposed floating solar project on the Wanaque Reservoir at Block 106, Lot 1, 1 F.A. Orechio Drive, Wanaque, Passaic County, New Jersey 07465. The Project is planned to be 10MWdc consisting of two (2) islands, each approximately 10 acres in size, with on-land interconnection components.

Petitioners' arguments largely reiterate the claims made in their filings during the first solicitation. Petitioners continue to claim that the 2021 HAD issued by the Council obviated the need for a Board waiver and that if a waiver is needed, Staff could and should have granted an administrative waiver. Petitioners add that, if the Board determines that a waiver may only be granted by the Board, the Board should grant the waiver.[17]

According to Petitioners, as a floating solar project that will not occupy any open space within the Highlands Reservation Area, the Project is unique and warrants an administrative waiver from Staff. Petition at 16-17. Further, Petitioners contend that the Wanaque Reservoir constitutes a "Built Environment" within the meaning of the CSI Program Order because it is manmade and is over three years old, being built in the 1920s. In support of this point, Petitioners noted that the CSI Program Order favors solar development "situated on previously existing impervious surfaces" and argued that the Wanaque Reservoir provides such a surface because its floor is

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[16] See Letter from Michael Beck, Esq. to Timothy Eustace, NJWDSC Executive Director, April 3, 2023 ("April 3 Letter").

[17] The petition also asked that any waiver granted be made retroactive to March 31 to allow the Project to participate in the first solicitation. However, on August 31, 2023, Petitioners withdrew this request for relief because no awards were issued by the Board for the first solicitation but affirmed their request to be eligible for the second solicitation.

composed of bedrock resistant to filtration. Petition at 19-20. According to Petitioners, such a waiver would be "consistent with the spirit" of the CSI Program. Petition at Par. 23.

STAFF RECOMMENDATIONS

A petitioner for a land use waiver must provide sufficient evidence that a project serves the public interest, and the unique factors that make the project consistent with the character of the specific site, as outlined in the Background above. A petitioner may include evidence of community support; approval(s) from an overseeing agency at the State or Federal level; considerations of alternative siting, compensatory mechanisms for any detrimental effects, and/or resiliency benefits to critical infrastructure, services or communities; a valid letter of interpretation or other determination of resource value classification; and/or considerations for and avoidance of the net loss of environmental resources. For a contaminated site or landfill sited on prohibited land uses, a petitioner may also include maps and/or details on the status of applicable compliance and/or remediation requirements.

Pursuant to the Act and the Board's waiver provisions for siting on prohibited land uses at N.J.A.C. 14:8-12.6, Staff consulted with other State agencies, namely the Highlands Council ("Council") and NJDEP. The Council provided a letter to the Board containing information on its review and approval process on November 20, 2023 ("November 20 Letter"). The Council advised that it had received no new information since issuing the April 23 Letter, meaning that Petitioners had not yet provided the documentation specified in that letter: a replanting and monitoring plan for proposed removal of the forested area; a restoration plan for the temporary disturbance to the northern assembly and launch area; and restoration and/or landscaping plans for the proposed disturbed area for the onshore equipment.

Staff transmitted a copy of the petition to NJDEP for review and advice on August 17, 2023. NJDEP's Office of Permitting and Project Navigation ("OPPN") provided a memo to the Board on November 28, 2023, containing its feedback ("November 28 Memo"). The NJDEP advised that OPPN had met with Petitioners for the Project on November 5, 2020. During/As a result of that meeting, the NJDEP determined that the Project violated the Flood Hazard Area Control Act Rules, necessitating a hardship waiver and also impacted both threatened and endangered species and the Raymond Dam. The NJDEP requested more information at that time to determine a permitting path forward, but such information was not provided. In the November 28 Memo, the NJDEP concluded that additional information for the Project is needed in order to make a determination for granting a waiver to participate in the CSI Program.

On September 13, 2023, following coordination with the NJDEP, Staff requested further supporting information from Petitioners. Staff specifically advised Petitioners first, to submit an updated permit readiness checklist so that OPPN could schedule a follow-up meeting and second, to provide documentation that the meeting with OPPN was held, including recommendations and/or conclusions about the Project. Not receiving this requested information, Staff contacted Petitioners again on October 25, 2023, requesting the information by November 1, 2023 to allow the Board to make a timely decision for the CSI Program's second solicitation. Notwithstanding these repeated requests, Petitioners failed to provide any additional information by that date. On January 8, 2024, Petitioners submitted additional information as requested by Staff. In addition to an updated permit readiness checklist and a letter to the NJDEP requesting to meet with OPPN, both dated January 8, 2024, Petitioners provided a letter of support from the Land Conservancy of New Jersey dated January 2, 2024. However, the environmental concerns enumerated in this Order remain unaddressed in their entirety.

Since Petitioners have not been actively engaging with either NJDEP or the Council, and did not receive positive support from the NJDEP, Staff does not believe that the record supports a positive finding that would justify a waiver for the Project. As described, there are environmental issues that remain outstanding, which require additional information from the Petitioners before a waiver can be granted. Petitioners have had the opportunity to provide that information to the NJDEP since at least November 5, 2020 and to the Highlands Council since April 2021, and received a specific request from Staff to provide it for purposes of this waiver request over three months ago, but have failed to respond.

Petitioners contend, however, that the CSI Program Order expressly authorized Staff to grant an administrative waiver with respect to the Project. Petitioners look to the language in that Order providing that "solar facilities located on the built environment but otherwise within an area of prohibited land use, are in the public interest" and . . . "grant[ing] Staff authority to administratively grant a waiver for such projects." CSI Program Order at 44.[18] In support of this contention, Petitioners point first to the April 23 Letter. Petition at 2(a), 18, and 30. That document itself, however, undermines this claim. In the April 23 Letter, the Council quotes the applicable statute to identify the restrictions from which a HAD exempts a project:

> The Highlands Act, at N.J.S.A. 13:20-28, specifies that a project deemed to be exempt is exempt from the Highlands Act as well as from the "the regional master plan, any rules or regulations adopted by the Department of Environmental Protection pursuant to this act, or any amendments to a master plan, development regulations, or other regulations adopted by a local government unit to specifically conform them with the regional master plan.

None of these exemptions can be construed to include an exemption from the siting prohibitions established by the Solar Act of 2021. Thus, an approval from the Council does not satisfy the statutory requirement that "[u]nless authorized pursuant to [a waiver from the Board]" . . . a net metered facility greater than 5 MW shall not be sited" in the Highlands preservation area." N.J.S.A. 48:3-119(c)(5). By the same token, Petitioners' statements regarding the minimal environmental impacts of the Project, Petition at 12, 17, even if completely accurate, do not negate the statutory directive to get a waiver from the Board.

Petitioners claim that the statute prohibits only solar projects located on "lands located within the Highlands preservation area" and thus does not apply to the Project as a floating solar installation. Petition at 17, quoting N.J.S.A. 48:3-119(c)(5) (emphasis added). They state that no farmland or open space will be impacted by the proposed Project. Petition at 21.

Petitioners err. First, the Project does entail construction on land adjacent to the Reservoir, including the removal of a small amount of forest. April 23 Letter. For that reason, the Council required replanting and restoration plans, as well as noting impacts to critical wildlife habitat. Ibid. In addition, nothing in the relevant statutory language indicates that "land" is to be narrowly construed to exclude waterways. Moreover, as Petitioners themselves note, the NJDWSC manages the Wanaque Reservoir because it is charged by statute with "developing raw water sources, storing water and distributing a reliable supply of potable water to its participating municipalities . . . . [including] among other things, the maintenance of various reservoirs." Petition

[18] The CSI Rules took effect on December 18, 2023 during the pendency of this petition. 55 N.J.R. 2555(a) (Dec. 18, 2023). The rules also delegate Staff the authority to waive the statutory prohibition for installations exclusively on the built environment. N.J.A.C. 14:8-12.6(b)(1).

at 3. The Wanaque Reservoir's character as a body of water is thus integral to the importance of protecting it from over-development, the underlying goal of the siting restrictions in the Solar Act of 2021.

Next, Petitioners argued that the CSI Program Order authorizes Staff to grant an administrative waiver because the Wanaque Reservoir constitutes a "built environment" as defined in the CSI Order. Petition at 19. In Petitioners' opinion, since the CSI Program Order deems solar installations on the built environment to be "presumptively in the public interest" even when sited on an otherwise prohibited land use, the Project's location on the manmade Wanaque Reservoir means that it should be deemed to be in the public interest. Petition at 22, citing CSI Program Order at 40. As the NJWDSC was advised by the Board's General Counsel in April 2023, this argument misconstrues the CSI Program Order. See April 3 Letter. That Order defines "built environment" as "the surface of one (1) or more existing, serviceable structures or a serviceable, improved and impervious roadway(s) built for a purpose other than solely to facilitate solar development" and provides as examples "rooftops, canopies over parking lots or parking decks, and other similar installations on the existing built environment." CSI Program Order at 15-16. A reservoir does not constitute a "similar installation" to a rooftop or a canopy over a parking deck. The fact that the floor of the Wanaque Reservoir is "impervious," Petition at 20, does not suffice to make it similar to a parking lot.

Nor is it apparent that floating solar should be considered "inherently beneficial," as Petitioners contend. Staff notes that NJDEP issued an update to its Solar Siting Analysis ("SSA") with respect to floating solar projects in 2017.[19] Assigning floating solar to the "Indeterminate" permit categorization, NJDEP noted that by its nature, each floating solar installation is unique; each is likely to raise different compliance questions, require different NJDEP permits, and have different environmental impacts. NJDEP stated that placing such large manmade structures on bodies of water, even artificial bodies of water, may raise issues regarding possible negative impacts on wetlands, erosion, water temperature, and endangered species. In addition, the possibility exists of conflicts in usage, flood hazards, navigable waters, and perhaps other unintended consequences.

Moreover, the CSI Program Order specifically considered and rejected the proposal that floating solar qualify for any specialized tranche. CSI Program Order at 20, 44, 52-53. The Order notes that Staff consulted NJDEP on this question and that NJDEP advised that the environmental impacts of floating solar are still being studied and that it is not necessarily beneficial to the environment. CSI Program Order at 20, 52-53. Floating solar is thus ineligible to be considered as constructed on the "built environment" under the CSI Program Order because projects on the built environment are presumed to be in the public interest. CSI Program Order at 20, 40, 44, 52-53. Thus, Petitioners' contention that nothing in the CSI Program Order prohibits Staff" from granting an administrative waiver, Petition at 1(c), must fail, as must their claim that the Project was "precisely the type of application envisioned by the waiver provisions." Petition at 30.

Petitioners also asserted that since "built environment" is defined in the context of Tranche 2 ("Grid Supply on the Built Environment"), that definition should not apply to the Project because Petitioners seek to qualify it in Tranche 4 ("Net Metered Non-residential Projects above 5 MW"). In other words, Petitioners claimed that Staff should have ignored the CSI Program Order's definition of "built environment" in considering the Project and accepted the rationale put forward

[19] New Jersey Department of Environmental Protection, Solar Siting Analysis Update 2017, https://www.nj.gov/dep/aqes/SSAFINAL.pdf.

by Petitioners for deeming the Wanaque Reservoir the "built environment." Petition at 48-50. This argument refutes itself. The CSI Program Order granted Staff limited authority to grant an expedited waiver only to a project located on the built environment.[20] No such authority was delegated to Staff for net metered projects over five (5) MW and thus, Staff had no ability to grant a waiver on that basis.

Petitioners also contended that Staff could have granted them relief by granting a waiver conditioned on a timely application by the Commission to the Board pursuant to *N.J.S.A.* 48:3-119(f), thus allowing NJDWSC to make a CSI Program application by the March 31, 2023 deadline. Petition at 36-37. In support of this argument, Petitioners pointed out that since NJDWSC first made a prequalification application on March 7, 2023 and the CSI Program deadline was March 31, 2023, there was no way for it to receive a determination from the Board in time to meet the CSI Program March 31, 2023 deadline. Petition at 11, 31-32. However, neither the statute nor the CSI Program Order authorize Staff to grant a waiver conditioned on a future petition to the Board. Nor does the timing of NJDWSC's pre-qualification application bestow such authority. Rather, the Board's Order provides that a project needing a waiver must obtain it from the Board prior to entering a solicitation round.[21]

In the alternative, Petitioners argued that the Board should grant the waiver in response to this petition. According to Petitioners, the Project is consistent with the character and nature of the Wanaque Reservoir; will be situated upon "an existing, serviceable structure," the Wanaque Reservoir; will have no detrimental impact upon the Highlands Preservation Area; is inherently beneficial within the meaning of the CSI Program Order; and will serve the public interest. Petition at 55. Nothing adduced by Petitioners here changes the analysis already set out. Staff does not dispute the Council's determination that the Project is consistent with the goals and purposes of the Highlands Act, N.J.S.A. 13:20-28(a)(11), nor that the Wanaque Reservoir is an existing item serving a purpose other than solar.

However, as previously discussed, a floating solar project cannot be deemed "inherently beneficial" as that term is defined in the CSI Program Order. The Board deferred to NJDEP's advice that such installations are not necessarily beneficial to the environment and that study of their impacts is ongoing. CSI Program Order at 20, 52-53. Thus, Staff does not recommend that the Board find that the petitioner has documented sufficient facts and circumstances to establish that waiving the siting restriction would be in the public interest. <u>See</u> CSI Program Order at 39.

Petitioners pointed to various benefits they assert would be provided by the Project, stating that the Project would provide 90 percent of the Wanaque facility's energy and provide resilient energy to critical infrastructure, reducing its energy footprint and costs to ratepayers. Petition at 56, 58. Petitioners also cited benefits to the communities served by the Wanaque Reservoir such as job creation, job sustainability, and educational and participatory opportunities. Petition at 58. In addition, Petitioners asserted that the Project's location on the Wanaque Reservoir would preserve open space and provide shading for the reservoir that would translate into a decrease in algal blooms, water evaporation, and chemicals needed. Petition at 57, 60.

Staff acknowledges that the resiliency benefits to critical infrastructure and the economic benefits to the communities impacted by the Project are supported by the State's and the Board's clean energy goals. Similarly, the environmental benefits cited by Petitioners have some scientific

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[20] CSI Program Order at 44.

[21] CSI Program Order at 23.

support. [22] However, Staff notes that over the last two to three years, Petitioners have failed to provide the missing site-specific information requested by the Council and NJDEP regarding the Project. This failure to address the specific concerns of the relevant administrative agencies outweighs general statements about environmental or community benefits. As noted above, NJDEP has advised that floating solar is an emerging technology that necessitates a case-by-case analysis. Given the lack of specific information in the record, Staff does not recommend waiving the protection the Legislature has afforded to the Highlands Preservation Area from solar development. Staff recognizes the importance of innovative technologies such as floating solar to advance the State's clean energy goals but notes that – just as the NJDEP needs more study of this technology's environmental impacts - more research is needed on its role in sustainable energy in New Jersey. As of October 31, 2023, the State had only two (2) operational floating solar facilities with an installed capacity of 12.22 MW.[23]

Based on the information contained in the Petition, the conditions set by the Council, and the recommendation of the NJDEP, Staff does not believe that the Board should make a positive finding that the Project as proposed is in the public interest. Staff recommends the Board deny Petitioners' request for a land use waiver and prohibit Petitioners from moving forward in the CSI Program's second solicitation prequalification process. Staff recommends that this denial be without prejudice to Petitioners' ability to provide the additional information and evidence requested by Staff, the Council, and NJDEP to enable further evaluation and potential grant of a waiver to participate in a future solicitation.

DISCUSSION AND FINDINGS

The Board has long supported solar development in New Jersey, designing policies and programs that support the continued growth of the solar industry while carefully balancing the costs and benefits to ratepayers. The CSI Program forms the first incentive structure designed to facilitate large-scale grid supply solar development in the State, a type of solar development which has been shown in other states to provide clean energy at competitive prices. The CSI Program will provide incentives for 300 MW of new solar annually in New Jersey and thus forms a critical element in pursuing the interrelated goals of 5.2 GW of solar by 2025, 12.2 GW by 2030, and 17.2 GW by 2035, all of which form part of New Jersey's least-cost path to 100% clean energy by 2050. As highlighted in the CSI Program Order, the CSI Program uses competitive principles to ensure that the cost of the Solar Renewable Energy Certificate-II awards represent the lowest incentive contribution from New Jersey ratepayers.

The Board also recognizes the significant benefits associated with the expansion of local, distributed, renewable, non-polluting sources of energy. In addition to the reduction of emissions that contribute to global warming, there is the reduction of air pollutants and the associated health benefits; increased resilience in the form of distributed generation; a lessened need to site solar on open space in a State that seeks to preserve open space; and the economic growth fueled by local job creation. Furthermore, as designed by the Board, the CSI Program implements the directive of the Solar Act of 2021 to direct grid supply solar "toward marginal land and the built environment and away from open space, flood zones, and other areas especially vulnerable to

[22] Spencer, Robert S., Macknick, Jordan, Aznar, Alexandra, Warren, Adam, & Reese, Matthew O. Floating Photovoltaic Systems: Assessing the Technical Potential of Photovoltaic Systems on Man-Made Water Bodies in the Continental United States. United States. https://doi.org/10.1021/acs.est.8b04735.

[23] New Jersey's Clean Energy Program. 2023. October 31, 2023 Solar Activity Reports, https://www.njcleanenergy.com/renewable-energy/project-activity-reports/project-activity-reports.

climate change" and to create a land use policy for grid supply siting "to affordably expand New Jersey's commitment to renewable energy while not compromising the State's commitment to preserving and protecting open space and farmland."[24]

The Board believes that floating solar represents a potentially positive development in renewable energy technology. The EMP supports and encourages innovative energy programs and technological solutions for meeting the State's clean energy targets and advancing New Jersey's clean energy economy, and the Board has included it as a permissible site in the permanent Community Solar program.[25] Furthermore, the Board's policy decisions pertaining to the incentives available for floating solar projects within the ADI Program demonstrate evidence of the Board's support for advancing New Jersey's solar potential in this market segment.[26,27] The Board commends Petitioners for proposing a large, grid-supply floating solar facility in order to help support and achieve the State's goals; however, as it is a novel technology in New Jersey, the Board must follow the regulatory and procedural requirements for thoroughly evaluating and making such decisions on vulnerable lands.

In providing incentives pursuant to the Solar Act of 2021 and implementing that Act's directive to prohibit siting CSI-eligible facilities on prohibited land types, the Board furthers the State policy of meeting its clean energy goals at the least cost to ratepayers.[28] The CSI siting criteria were developed in cooperation with the NJDEP, the Department of Agriculture, and the State Agriculture Development Committee. To fully effectuate the legislative intent to protect vulnerable lands, the Board made these siting criteria applicable to all CSI-eligible solar generation facilities, regardless of whether a project chooses to pursue an incentive or not. The universal applicability ensures that the State's interest in preserving open space and agricultural lands will be applied to all solar projects on an equal basis.

Pursuant to the Solar Act of 2021, the Board's siting criteria provide the opportunity to submit a petition to obtain a waiver for construction of a CSI-eligible facility on certain prohibited lands. The Board will only grant such waiver after consultation with the Department of Agriculture or NJDEP, as appropriate, and upon a determination that the public interest in the specific project being allowed outweighs the presumptive greater public interest in preserving the land. The Board considers projects that would be constructed on prohibited land but which would be located exclusively on the built environment to be presumptively in the public interest. For such projects, the Board has delegated the waiver determination to Staff or the program administrator. This expedited process was devised to allow developers a quicker route to participation based on project type but applies only to a specific subset of projects.

The Board **FINDS** that the Project is proposed to be located on approximately 20 acres of the Wanaque Reservoir within the Highlands Preservation Area, Block 106, Lot 1, at 1 F.A. Orechio

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[24] N.J.S.A. 38:3-114(c).

[25] In re the Community Solar Energy Program – Order Launching the Community Solar Energy Program, BPU Docket No.QO22030153, Order dated August 16, 2023.

[26] In re a Solar Successor Incentive Program Pursuant to P.L. 2018, c.17, BPU Docket No. QO19010068, Order dated July 28, 2021 ("SuSI Program Order").

[27] In re a Solar Successor Incentive Program Pursuant to P.L.2021, c.169, BPU Docket Nos. QO20020184 and QO23040206, Order dated May 10, 2023, redistributed on July 10, 2023, with a typographical correction.

[28] N.J.S.A. 38:3-114.

Drive, Wanaque, Passaic County, New Jersey 07465. The Board **FINDS** that, as required by the Solar Act of 2021, Staff consulted with the NJDEP on the Project. The Board **FINDS** that, as required by the Board's CSI Siting Rules for "consulting with other State agencies, as appropriate," Staff consulted with the Council on the Project. Though the Council did not object to the NJDEP issuing an Exemption No. 11 for the Project, as proposed in 2021, the Board **FINDS** that Petitioners have not provided the documentation identified by the Council in the April 23, 2021 Letter: a replanting and monitoring plan for proposed removal of the forest, a restoration plan for the temporary disturbance to the northern assembly and launch area, and restoration and/or landscaping plans for the proposed disturbed area for the onshore equipment. The Board **FURTHER FINDS** that the NJDEP determined that it had not received the information necessary to make permitting decisions regarding a hardship waiver of the Flood Hazard Area Control Act Rules, threatened and endangered species, or the Raymond Dam. Based on NJDEP's conclusion that it needs additional information on these matters, the Board **FINDS** the Project does not have positive support from the NJDEP to move forward. In addition, the Board **FINDS** that Staff twice requested supporting information from Petitioners to be supplied by November 1, 2023, to enable a timely decision on this waiver request and that Petitioners provided a partial response on January 8, 2024.

The Board also **FINDS** that the conditions set by the Council and the information required by the NJDEP must be addressed before the Board can make a make a positive finding with regard to this petition. The Board **FINDS** that the Petitioners have not documented sufficient facts or circumstances establishing the public's specific interest in siting the CSI-eligible facility on or within the Highlands Preservation Area.

The Board **FINDS** that granting the waiver of the Board's CSI Siting Rules pursuant to N.J.A.C. 14:8-12.3(a)(2) is not warranted and is not in the public interest pursuant to N.J.A.C. 14:8-12.6(a) and **DENIES** the waiver. The Board **FINDS** that the Petitioners are not eligible to participate in the CSI Program's second solicitation. Thus, the Board **DIRECTS** the CSI Program Administrator not to process a prequalification package from Nexamp and/or NJDWSC for the second solicitation, if received. The Board **FINDS** that the Petitioners may be eligible to participate in a future solicitation under the CSI Program if additional information is provided and the specific requirements discussed herein are met. If Petitioners choose to continue pursuing participation in the CSI Program, then the Board encourages Petitioners to submit the following information to the Board Secretary in a timely manner on a schedule or deadline set by Staff: an updated permit readiness checklist so that NJDEP's OPPN can schedule a follow-up meeting, and documentation that the meeting with NJDEP's OPPN was held, including recommendations and/or conclusions about the Project.

This Order is issued in reliance on the information provided by the Petitioners, Council, and NJDEP and does not grant any rights in connection with the registration or construction of the proposed project.

Agenda Date: 1/10/24
Agenda Item: 8C

This Order shall be effective on January 17, 2024.

DATED: January 10, 2024

BOARD OF PUBLIC UTILITIES
BY:

CHRISTINE GUHL-SADOVY
PRESIDENT

DR. ZENON CHRISTODOULOU
COMMISSIONER

MARIAN ABDOU
COMMISSIONER

ATTEST:

SHERRI L. GOLDEN
SECRETARY

I HEREBY CERTIFY that the within document is a true copy of the original in the files of the Board of Public Utilities.

IN THE MATTER OF THE PETITION OF THE NORTH JERSEY DISTRICT WATER SUPPLY COMMISSION, IN CONJUNCTION WITH NEXAMP SOLAR, LLC., FOR A FLOATING SOLAR PROJECT ELIGIBILITY WAIVER UNDER THE COMPETITIVE SOLAR INCENTIVE PROGRAM, (P.L. 2021, C. 169)

DOCKET NO. QO23060349

SERVICE LIST

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EXHIBIT B

PERMIT READINESS CHECKLIST

New Jersey Department of Environmental Protection
Office of Permitting & Project Navigation

Completion of this form will help the New Jersey Department of Environmental Protection (NJDEP) staff review the proposed project, determine possible permitting requirements, and ensure that all applicable programs attend or provide comments for a pre-application meeting. Please respond to the questions as completely as possible, noting any areas you are not sure of, and including any information about the project and/or site that might aid the NJDEP's review.[1]

Once you have completed the form, please submit electronically to David Pepe (David.Pepe@dep.nj.gov) and Katherine Nolan (Katherine.Nolan@dep.nj.gov). If desired, one hard copy may also be submitted via mail[2]. Once this submitted form and attachments are deemed administratively complete by the Office of Permitting and Project Navigation (OPPN) staff, a pre-application meeting will be scheduled with the applicable permitting programs within NJDEP.

Please prepare to give a brief presentation of your proposal at the beginning of the pre-application meeting. If you have any questions, please contact OPPN at (609) 292-3600.

Please include the following attachments if available:

1. A 1–2 page narrative description of the proposed project, its function, and its benefits;
2. Any overarching regulatory or policy call(s), or guidance known prior to the receipt of the application to determine the project's feasibility, regulatory, or review process;
3. United States Geological Survey (USGS) map(s) with site boundaries of the proposed project clearly delineated, including the title of the USGS quadrangle sheet from which it was taken;[3]
4. Aerial photos and/or Geographic Information Systems (GIS) information and/or shape files regarding the site;
5. A site map including any known environmental features (e.g., wetlands, streams, buffers, etc.);[4]
6. Site plans to the extent available;
7. Street map indicating the location of the proposed project;
8. List of any local or regional governments or entities and their historical involvement with this project or site;
9. Identification of conflicts with DEP rules, with contact names and information whose attendance/input would be helpful in facilitating this project (e.g., Soil Conservation Districts, health departments, local zoning officials, etc.);
10. Any other information that you think may be helpful to the NJDEP in reviewing this project.

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[1] Please be advised that this form is NOT an application for a permit from the NJDEP. To receive authorization, approval, or a permit to conduct regulated activities, a formal application must be filed, and a formal permit or authorization must be issued by the appropriate Bureau within the NJDEP prior to commencement of the regulated activity. This form is used solely for the NJDEP's preliminary review and discussion of this project to determine what permits or authorizations may be needed to conduct the proposed activity. Any guidance offered to the applicant during this process is non-binding on the NJDEP or the applicant and a final response can only be rendered through the actual issuance of permits, approvals, and/or authorizations.

[2] Hard copies may be submitted to:

New Jersey Department of Environmental Protection
Office of Permitting and Project Navigation
P.O. Box 420, Mail Code 07J
Trenton, New Jersey 08625

[3] USGS maps may be purchased from NJDEP, Maps and Publications, P.O. Box 420, Trenton 08625-0420; (609) 777-1038

[4] NJGIS information

A. GENERAL INFORMATION

1. Name of Proposed Project: **NJDWSC Floating Solar**

2. Consultant/Contact Information (if any): **Felix Aguayo - NEXAMP Phone 201-401-4438**

3. Name of Prospective Applicant: **North Jersey District Water Supply Commission**
   Address/tel./fax: **1 F.A. Orechio Drive, Wanaque, NJ 07465**
   Company name: **North Jersey District Water Supply Commission**
   Company address/tel./fax: **1 F.A. Orechio Drive Wanaque NJ 07465, Phone 973-616-2906**

   Does the applicant own the property? **Yes**

   If the applicant is not the property owner, please provide contact information for the property owner and evidence of having property owner permission to use the property for the proposed project. **NA**

4. Does the project have any existing NJDEP ID#s assigned (e.g., Case number, Program Interest (PI)#, Program ID#)? **YES, FOR BPU CSI PROGRAM** If yes, please provide: 23CSIHDB3WU

B. PROPOSED PROJECT LOCATION

1. Street address: **1 FA Orechio Drive** Municipality: **Wanaque**
   County: **Passaic** Zip Code: **07465**
   Impacted Parcels (Block #, Lot #), (Block #, Lot #)… **Block 500 Lot 1**
   X Coordinate in State Plane (project centroid): **41°02'53.96"N**
   Y Coordinate in State Plane (project centroid): **74°17'46.56"W**

C. PROPOSED ACTIVITY AND SCHEDULE

1. Project Type:
   New Construction: **X** Redevelopment: _____ Restoration: _____
   Alternative Energy: **X** Other (Please describe): _____

(a) Estimated Schedule: Date permits needed or desired by, beginning construction date; construction completion, and operation of facility date: Schedule largely determined by permitting process: for planning purposes we are assuming 12 months for NJ DEP approvals, 3 months for building and electrical permits, 3 months for mobilization (staging area preparation and barge siting), and 12 months of construction. Assuming NJ solar incentive is awarded July 2025, we expect all permits in hand by September 2026, construction start January 2027 and permission to operate by December 2027.

(b) Funding Source: Is any Federal Funding being used for this project? **NO**
State Funding over one million dollars? **NO** Is funding secured at this time? **NO**
Is funding conditional? YES If yes, on what? Securing State solar incentives_____

(c) Is the project contingent on receiving the identified funding? Yes
If yes, please explain: Project economic viability depends on state solar incentives.

(d) What DEP permits do you think you will need for this project (The Department will confirm this through the checklist review process)? Flood Hazard Area Individual Permit with hardship exception, Freshwater Wetlands Individual Permit, and address concerns from T&E Unit, Historic Preservation Office and Bureau of Dam Safety.

2. For additional guidance on Department permits, please refer to the New Jersey Department of Environmental Protection's website at https://www.nj.gov/dep/.

(a) Which, if any, Department(s), Bureau(s), and/or Department staff have you already contacted regarding the proposed project? Office Permitting and Project Navigation meeting on 11/5/2020 with DLRP, T&E Unit, NJ Fish & Wildlife & ENSP, Highlands Council, Bureau of Dam Safety, SHPO, Site Remediation, Clean Energy & Climate Change and BPU.

(b) Are there any Department permits that will need to be modified because of this project? NO
If yes, please explain and identify the project reviewer of the permit to be modified. We don't believe a modification to NJDWSC Water Allocation permit is required if a ballasted system is used since the impact on the water reservoirs' capacity is de minimis but we need guidance from DEP to determine applicability.

(c) Please indicate which of the following pre-permit actions or modifications you have applied for or obtained from the Department or other state agencies for this project: N/A

i. Water Quality Management Plan (WQMP) consistency: _____
ii. Highlands Consistency: **X**
iii. Wetland Delineation/Letter of Interpretation (LOI): _____
iv. Tidelands Conveyance: _____
v. Flood Hazard Jurisdiction or determinations: _____
vi. Water Allocation: _____
vii. Remedial Action Workplan (RAW), Remedial Action Permit (RAP) Soil and/or Groundwater, No Further Action (NFA), Response Action Outcome (RAO): _____
viii. Landfill Disruption Approval: _____
ix. Landfill Closure Plan: _____
x. New Jersey Pollutant Discharge Elimination System (NJPDES) Discharge to Ground Water (DGW), NJPDES Discharge to Surface Water (DSW) _____
xi. Other: _____

D. NJDEP PROGRAM QUESTIONS

The remainder of the Permit Readiness Checklist contains questions which are designed to help the Department determine possible permitting requirements for the proposed project. If a question does not apply to your project, please write "N/A" in the response field. Please include any additional information that you think may be helpful to the Department's review.

OFFICE OF TRANSACTIONS AND PUBLIC LAND ADMINISTRATION – (609) 940-4400

https://dep.nj.gov/otpla/

Is any portion of the project site on land owned or administered by the State of New Jersey?No

If the answer to the above question is yes, the applicant must submit a request to use State property. Please visit https://dep.nj.gov/otpla/requests-for-use-of-njdep-property-form/ for information on initiating a request to use State property. **The submission of a request to use State property is a prerequisite to the scheduling of a pre-application meeting.**

Has the applicant submitted a request to use State property? No

COMMUNITY INVESTMENT & ECONOMIC REVITALIZATION – (609) 633-0700

Green Acres – (609) 984-0500

https://www.nj.gov/dep/greenacres/

Is any part of the project site on land that is subject to a Green Acres restriction? **NO**
If yes, please describe: _____

Does the project require the use of property funded with federal Land and Water Conservation Funding? **NO** If yes, please describe: _____

Does the project include activities that are under the jurisdiction of the Watershed Property Review Board? NO If yes, please describe: _____

Has the Watershed Property Review Board made a jurisdictional determination for the project site? NO

Historic Preservation Office – (609) 984-0176
https://www.nj.gov/dep/hpo/

Is the site a historic site, or in a district that is on or eligible for the State and/or National registry? **YES**

Will there be impacts to buildings over 50 years old? **NO**

Are there known or mapped archeological resources on the site? **NO**

STATE PARKS, FORESTS, & HISTORIC SITES – (609) 984-0370
https://www.nj.gov/dep/parksandforests/index.html

Will temporary use of DEP lands administered by the Divisions of Parks & Forestry and/or Fish & Wildlife be required for pre-construction, construction and/or post construction activities? **NO**
If yes, please describe: _____

New Jersey Forestry Service – (609) 292-2520
https://www.nj.gov/dep/parksandforests/forest/

Forest clearing activities/No Net Loss Reforestation Act
Will implementation of the project result in the clearing of 0.5 acres or more of forested lands owned or maintained by a State entity? **NO** If yes, how many acres? _____

NEW JERSEY FISH AND WILDLIFE – (609) 292-2965
https://dep.nj.gov/njfw/

The NJDEP Fish and Wildlife Office of Environmental Review is responsible for evaluating proposals, plans, policies and projects to ensure potential impacts to fish and wildlife and the habitat on which they depend, are avoided or minimized. To facilitate the review the below information must be provided. In lieu of the below information, the Natural Heritage Database data request response for endangered and threatened species of flora fauna from the NJDEP Office of Natural Lands Management is acceptable. The NJ-GeoWeb is available for free and can be accessed at https://nj.gov/dep/gis/geowebsplash.htm. Questions regarding this section of the checklist should be sent to the Office of Environmental Review at FWOER@dep.nj.gov.

Using the NJ-GeoWeb Landscape layer, please indicate if the subject property or the land immediately adjacent contains any of the following species/habitats:

- Rank 3, 4, or 5 polygons: **YES**
- Vernal habitat: **NO**
- Freshwater mussel habitat: **NO**

Using the NJ-GeoWeb Surface Water Quality Classification layer, determine if the subject property contains any streams, brooks, or rivers that are classified as trout production or trout maintenance. Are any of the waters on the subject property classified as trout production or trout maintenance? NO

Using the Trout Stocked Streams layer on NJ-GeoWeb, determine if the subject property contains any streams, brooks, or rivers that are classified as trout stocked or are within one mile upstream of a trout stocked waterway. NO

Please be advised Landscape Project Mapping (v3.3) is a "planning resource." A determination of no rank 3, 4, or 5 does not guarantee the applicant has no responsibilities with regards to impacts to endangered or threatened wildlife. It is recommended the applicant have a wildlife biologist review the Landscape Project findings for adjacent rank 3, 4, or 5 habitats along with the presence of potential habitat on site, or have the applicant apply for a Natural Heritage Database Request.

WATERSHED AND LAND MANAGEMENT – (609) 777-0454
https://nj.gov/dep/wlm/

Division of Land Resource Protection – (609) 777-0454
Division of Watershed Protection and Restoration – (609)-292-1932
https://www.nj.gov/dep/landuse/

Please indicate which of the following regulated areas will be impacted by or are in proximity to developments and/or activities involved with the proposed project. Please describe the type and extent of developments, activities, and/or impacts, including the distance to regulated features:

- Water courses (streams): **NO**
- State Open Waters: **YES**
- Freshwater Wetlands and/or freshwater wetland transition areas: **NO**
- Flood Hazard areas and/or riparian buffers: **YES**
- Waterfront development areas: **NO**
- Tidally Flowed Areas: **NO**
- Bureau of Tidelands Management (https://www.nj.gov/dep/landuse/tl_main.html): **NO**
- Coastal Area Facility Review Act (CAFRA) Planning Area (viewable on NJ-GeoWeb, https://www.nj.gov/dep/gis/geowebsplash.htm): **NO**

NJPDES Stormwater Permitting – (609) 633-7021
https://nj.gov/dep/stormwater/
https://www.nj.gov/dep/dwq/bnpc_home.htm

Will the proposed project site activity disturb more than one acre? **NO**

Will industrial activity be conducted at the site where material is exposed to rain or other elements? **NO**

Does the facility have an existing NJPDES permit for discharge of stormwater, surface, and/or groundwater? **YES** If yes, please describe: NJPDES Discharge to Surface Water Permit

Is the facility assigned one of the Standard Industrial Classification (SIC) Codes (to determine the SIC Code, see the box "Industry Code" on your New Jersey Department of Labor Quarterly Contribution Report)? **49, 494**

Water Quality Management Planning Program – (609) 633-7021
https://www.nj.gov/dep/wqmp/

Does the project involve a new, expanded, or relocated wastewater treatment facility not identified in the applicable Water Quality Management Plan (WQMP)? **NO**

For projects conveying wastewater to an onsite or offsite wastewater treatment facility or treatment works, is any portion of the project site located outside the sewer service area? **NA**

For projects located within an assigned sewer service area, will any wastewater flow generated from the project site be conveyed to a facility other than the assigned facility? **NA**

If the answer to any of the above questions is yes, the project is inconsistent with the applicable WQMP and a **WQMP amendment may be required before any NJDEP permits can be issued.**

Division of Resilience Engineering & Construction – (609) 322-9566
https://www.nj.gov/dep/cfr/

Bureau of Dam Safety – (609) 984-0859
https://www.nj.gov/dep/damsafety/

Will the project involve construction, repair, or removal of a dam? **NO** If yes, please describe: _____

Bureau of Climate Resilience Design and Engineering
https://www.nj.gov/dep/bcrp/

Has climate resilience been considered in the design of the proposed project? **YES**

Office of Coastal Engineering – (609) 292-9236
https://www.nj.gov/dep/shoreprotection

Is the proposed project located at or adjacent to a beach nourishment or shore protection project? **NO**

WATER RESOURCES MANAGEMENT – (609) 292-4543
https://nj.gov/dep/wrm/

Division of Water Supply & Geoscience – (609) 292-7219
https://nj.gov/dep/watersupply/

New Jersey Geological and Water Survey Element – (609) 292-1185
https://www.nj.gov/dep/njgs/

Please indicate which of the following, if any, will be involved with the proposed project:

- Development of a new water supply source: **NO**
- Require aquifer testing: **NO**
- An existing or abandoned mine: **NO**
- Geothermal or offshore energy: **NO**
- Subsurface sequestration in geological formations: **NO**
- Acid soils at the project site: **NO**
- Geologic hazards of concern at the project site: **NO**
- Activity within a karst area: **NO**
- Adverse effects to groundwater recharge: **NO**
- Crossing of any steep slopes: **Yes, cables coming to shore will cross steep slopes**

Bureau of Water Allocation and Well Permitting – **(609) 984-6831**
https://www.nj.gov/dep/watersupply/

Is the project seeking a new ground water allocation permit or modification? NO If yes, does the project have all necessary well construction and safe drinking water permits? NA

Is the project located within an area of critical water supply concern? NO

Will the project have the capability to divert 100,000 gallons-per-day (70 gallons-per-minute) or more, or 50,000 gpd (35 gpm) or more in the Highlands Preservation Area, from a single source or a combination of surface and/or groundwater sources? NO

Will the project draw 100,000 gpd or more of ground/surface water for construction or operation? NA

Other than wells utilized for environmental evaluation or remediation, does the project entail the drilling of any wells, including but not limited to those utilized for potable/non-potable water supply or geothermal use? NO

Is there known or suspected groundwater contamination present at the project location? NO

Are there any abandoned wells located on the project site which need to be decommissioned? NO

Bureau of Water System Engineering – (609) 292-2957
https://www.nj.gov/dep/watersupply/

Is the project located within an existing water purveyor service area? **YES** If yes, which one? **NJDWSC**
Does the purveyor have adequate firm capacity and allocation to support project demand (see https://www.state.nj.us/dep/watersupply/pws.html for details on water system capacity)? **N/A**

Do water pipes currently extend to the project location? **N/A** If not, is the proposed project located within a franchise area? **N/A**

Does the project have an approved Safe Drinking Water main extension permit? N/A If yes, what is the permit number? _____

Does the water purveyor hold a Safe Drinking Water Main Master Permit? N/A

Will the project affect any land or water controlled by a Water Supply Authority or water purveyor in New Jersey? **YES** If yes, please identify and explain. FLOATING **SOLAR PANELS TO BE PLACED ON WANAQUE RESERVOIR AND INVERTERS, TRANSFORMERS AND SWITCHGEAR ON ADJACENT LAND USED BY THE COMMISSION.**

Division of Water Quality – (609) 292-4396
https://www.nj.gov/dep/dwq/

Bureau of Surface Water and Pretreatment Permitting – (609) 292-4860
https://www.nj.gov/dep/dwq/swp.htm

Is the proposed project a wastewater facility that will discharge to surface water? **NO**

- If yes, state the name of the stream that will receive the proposed wastewater. **NA**
  Describe the proposed discharge of wastewater to surface water. **NA**
- If no, how is the wastewater proposed to be discharged (e.g., to be conveyed to another sewage treatment plant (STP), publicly owned treatment works (POTW), etc.)? **NA**

Will the proposed project involve discharge of industrial or commercial wastewater to a publicly owned treatment works (POTW)? **NO** If yes, name of POTW: **NA** Volume of wastewater (gpd): **NA**

Bureau of Groundwater, Residuals, and Permit Administration – (609) 984-4428
https://www.nj.gov/dep/dwq/bpr.htm

Will the proposed project/facility have a sanitary wastewater design flow which will discharge more than 2,000 gpd to groundwater? **NO**

Will the proposed project/facility discharge industrial wastewater to groundwater in any quantity? **NO**

Please indicate which of the following activities or structures are included with the project/facility, or that wastewater will be discharged to groundwater through:

- Upland Combined Disposal Facility (CDF): **NA**
- Dredged Material: **NA**
- Spray Irrigation: **NA**
- Overland Flow Subsurface Disposal System, Underground Injection Control (UIC): **NA**
- Landfill Infiltration/Percolation Lagoon: **NA**
- Surface Impoundment: **NA**

Please specify the source of wastewater for every structure identified above (e.g., sanitary wastewater to a subsurface disposal system, non-contact cooling water to a dry well, etc.): **NA**

Please specify lining materials for each proposed lined structure, and give its permeability in cm/sec (e.g., 8-inch thick concrete-lined evaporation pond at 10-7 cm/sec): **NA**

Does the proposed project include an individual subsurface sewage disposal system design for a facility with a design flow of less than 2,000 gpd which does not strictly conform to the State's standards? **NA**

Does the proposed project involve 50 or more realty improvements? **NA**

Will this project involve the generation, processing, storage, transfer and/or distribution of industrial or domestic residuals generated because of wastewater treatment (including sewage sludge, potable water treatment residuals and food processing by-products)? **NA** If yes, please explain. **NA**

CONTAMINATED SITE REMEDIATION AND REDEVELOPMENT – (609) 292-1250
https://www.nj.gov/dep/srp/

Division of Remediation Management – (609) 292-1251
https://www.state.nj.us/dep/srp/about/remediation_division.html

Is the project located on a known or suspected contaminated site (please reference https://www.state.nj.us/dep/srp/kcsnj/)? **NO**

Is the project located adjacent to a known or suspected contaminated site (please reference https://www.state.nj.us/dep/srp/kcsnj/)? **NO**

Is the project within a designated Brownfield Development Area (BDA) (please reference https://www.nj.gov/dep/srp/brownfields/bda/index.html)? **NO**

Has a No Further Action (NFA) Letter or Response Action Outcome (RAO) been issued for the entire project area? **NO**

Were any engineering or institutional controls implemented as part of a remedial action for discharges at the site? **NO**

What is the status of compliance with the biennial certification requirements and a remedial action permit? **NA**

What is the status of the remediation for other areas of concern for which an NFA Letter or an RAO has not been issued (Please include remedial phase, media affected, contaminant(s) of concern, and whether the contamination is onsite or offsite)? **NA**

Name of current SRP Case Manager or Licensed Site Remediation Professional (LSRP) and Preferred Identification (PI) Number: **NA**

Is the applicant a responsible party for discharges at the site? **NA**

Upon taking title to the site, will the applicant become either a responsible party for contamination at the site or a person responsible for conducting the remediation? **NA**

Has the remedial status of this site triggered Direct Oversight pursuant to N.J.S.A. 58:10C-27 and N.J.A.C. 7:26C-14? **NA**
If yes, has the applicant complied or how does the applicant intend to comply? **NA**

AIR, ENERGY, & MATERIALS SUSTAINABILITY – (609) 292-0149
https://www.nj.gov/dep/aqes/

Division of Sustainable Waste Management – (609) 633-1418
https://www.nj.gov/dep/dshw/

Will the project receive, utilize, or transport solid or hazardous wastes? **NO**

Will the project involve disposal of hazardous substances pursuant to 40 CFR part 261 and N.J.A.C. 7:26? **NO**

Will the project include operation of a solid waste facility pursuant to N.J.A.C. 7:26-1-et seq? **NO**

Is the project a solid waste facility or recycling center? **NO**

Is the project included in the appropriate county's Solid Waste Management Plan? **NO**
Please explain: _____

Is the project located on a landfill that will be redeveloped for human occupancy? **NO**
If yes, is there an approved Landfill Closure Plan? **NA**

Division of Air Quality – (609) 633-2829
https://dep.nj.gov/airquality/

Will activity at the site release substances into the air? **NO**

Will the project require air preconstruction permits per N.J.A.C. 7.27-8.2(c)? **NO**

Will the project require air operating permits per N.J.A.C. 7:27--22.1? **NO**

Will implementation of the project result in a significant increase in emissions of any air contaminant for which the area is in nonattainment with according to the National Ambient Air Quality Standards (NAAQS) (all of NJ for VOC and NOx emissions; 13 counties for fine particulates emissions), thereby triggering the Emission Offset Rule at N.J.A.C. 7:27-18? **NO**

Will the proposed project emit hazardous air pollutants and/or toxic substances above the reporting thresholds listed in N.J.A.C. 7:27-17? **NO**

Will the proposed project result in stationary diesel engines (generators, pumps, etc.), or mobile diesel engines (bulldozers, forklifts, etc.) operating on the site? **NO** If yes, please identify which: **NA**

Will the proposed project have potential for offsite odors and/or dust impacts? **NO**

Bureau of Air Quality Evaluation and Planning – (609) 292-6722
https://dep.nj.gov/airplanning/

All counties in New Jersey are in nonattainment for the United States Environmental Protection Agency's (USEPA's) 2008 and 2015 ozone National Ambient Air Quality Standards (NAAQS). Thirteen counties (Bergen, Essex, Hudson, Mercer, Middlesex, Monmouth, Morris, Passaic, Somerset, and Union) in New Jersey are in maintenance for the USEPA's 2006 fine particulate matter (PM 2.5) NAAQS. The USEPA promulgated the federal General Conformity regulation (40 CFR 93, Subpart B), which was established under the Clean Air Act (Section 176 (c)(4)), to ensure that actions taken by federal agencies do not interfere with a state's plans to attainment/maintain the NAAQS.

If the answer to any of the following questions is yes, the proposed project (or a portion of the proposed project) may require a General Conformity Applicability Analysis and possibly a General Conformity Determination. For more information, please see the USEPA's General Conformity website at https://www.epa.gov/general-conformity.

Is there a "lead" federal agency for this project? **NO** If yes, which agency? **NA**

Will this project receive federal support or financial assistance? **NO**

Will this project require a federal approval, license, or permit? **NO**

Climate, Clean Energy & Radiation Protection – (609) 633-7964
https://www.nj.gov/dep/dess/

Climate Change, Clean Energy & Sustainability – (609) 777-4213
https://www.state.nj.us/dep/aqes/bes.html

Does the proposed project involve renewable energy technology? **YES**

Is the proposed project a solar PV project? **YES**
If yes, please indicate the type:

- Behind the meter/Net metered: **YES**
- Grid supplied: **NO**
- Grid supplied- Subsection t (On a landfill, brownfield, or area of historic fill): **NO**
- Community Solar: **YES**

Is the proposed project a wind energy project? **NO**
If yes, what type? Onshore **NA** Offshore **NA**

Is an environmental and energy innovative technology included in this project? YES
If yes, please provide a brief description Floating solar technology is relatively new in the United States and in New Jersey. This project will use the latest innovations in floating solar technology.

Please indicate which, if any, green building rating systems the proposed project will be certified by:

- US Green Building Council, Leadership in Energy and Environmental Design (LEED): NO
- ASHRAE Standard 189.1: NO
- National Green Building Standard ICC 700-2008: NO
- USEPA's ENERGY STAR: NO
- International Living Future Institute-Zero Energy Certification: NO
- International Green Construction Code (IgCC): NO

Have you incorporated green design features into this project (e.g., renewable energy, water conservation, use of low impact design for stormwater)? Yes, this is a photovoltaic facility.

Bureau of Environmental Radiation – (609) 984-5400
https://www.state.nj.us/dep/rpp/ber/

Will the proposed project receive, store, or dispose of radioactive materials? **NO**

Will the proposed project employ any type of x-ray equipment? **NO**

OFFICE OF ENFORCEMENT POLICY – (609) 913-6700
https://www.nj.gov/dep/enforcement/

Does the applicant have outstanding DEP enforcement violations? **NO**
If yes, please identify the case, case manager, program and phone number, and status: **NA**

Does the proposed project facilitate compliance where there is a current violation or ACO? **NA**

OFFICE OF ENVIRONMENTAL JUSTICE – (609) 292-2908
https://nj.gov/dep/ej/

Is the proposed project or facility located in an overburdened community (OBC) according to the Environmental Justice Mapping, Assessment and Protection Tool (EJMAP) (https://experience.arcgis.com/experience/548632a2351b41b8a0443cfc3a9f4ef6)? **NO**

Please indicate which, if any, of the following facility types the proposed project or facility is/will be:

- Major source of air pollution (e.g., gas fired power plant, cogeneration facility): **NO**
- Resource recovery facility or incinerator, sludge processing facility: **NO**
- Sewage treatment plant with a capacity of more than 50 million gpd: **NO**
- Transfer station or solid waste facility: **NO**
- Recycling facility that will receive at least 100 tons of recyclable material per day: **NO**

- Scrap metal facility: **NO**
- Landfill: **NO**
- Medical waste incinerator, except those attendant to hospitals and universities: **NO**

What community groups and stakeholders have you identified that may be interested in or impacted by this project? No community groups have been identified as potentially interested or impacted by the project. Wanaque Reservoir is a non-recreational body of water and public access is not allowed. We do have support letters from Passaic County, Land Conservancy of NJ and IBEW Local 102 and expect to receive further support from community organizations for the community solar phase of this project.

Will you engage with community and stakeholders in this project? Yes If yes, how? NJDWSC will develop an appropriate community outreach and awareness program at the appropriate time. Inclusion of a community solar component to the project will benefit subscribers to the project (about 1,000 residences).

What are the potential impacts of this project on the community? None that are known at this time.

What are the community concerns or potential concerns about this project? None that are known at this time.
How do you intend to address these concerns? not applicable.

As part of this project, do you plan to perform any environmental improvements in this community? **NO** If yes, please describe: **NA**

Please provide the NJDEP with an additional narrative description of the proposed project's function and its local/regional environmental, social, and economic benefits and impacts, the sensitive receptors that are currently present and how might they be affected by this project.

The NJDEP is committed to the principles of meaningful and early community engagement in the project's approval process. The NJDEP has representatives available to discuss community engagement issues with you and we encourage this communication to take place as early as possible.

ADDITIONAL AGENCY REVIEW

Is the proposed project subject to any of the following?

- Highlands Regional Master Plan – Planning or Preservation Area: **YES**
  https://www.nj.gov/njhighlands/about/

- Pinelands Comprehensive Management Plan: **NO**
  https://www.nj.gov/pinelands/home/maps/index.shtml

- Delaware and Raritan Canal Commission Standards: **NO**
  https://www.nj.gov/dep/drcc/regulatory-program/maps/

- Delaware River Basin Commission: **NO**
  https://www.state.nj.us/drbc/
  https://drbc.maps.arcgis.com/apps/OnePane/basicviewer/index.html?appid=d87c64691108457fb333df5315dfef03

- New Jersey Sports and Exposition Authority: **NO**
  https://www.njsea.com/who-we-are/

- U.S. Army Corps of Engineers review: **NO**
  https://www.usace.army.mil/

- Other State or Federal Agencies? If yes, please specify: **USFWS**

Permit Readiness Checklist Submitted By:

Timothy J. Eustace
Signature

February , 2025
Date

Tim Eustace, Executive Director
Print Name

Attachments

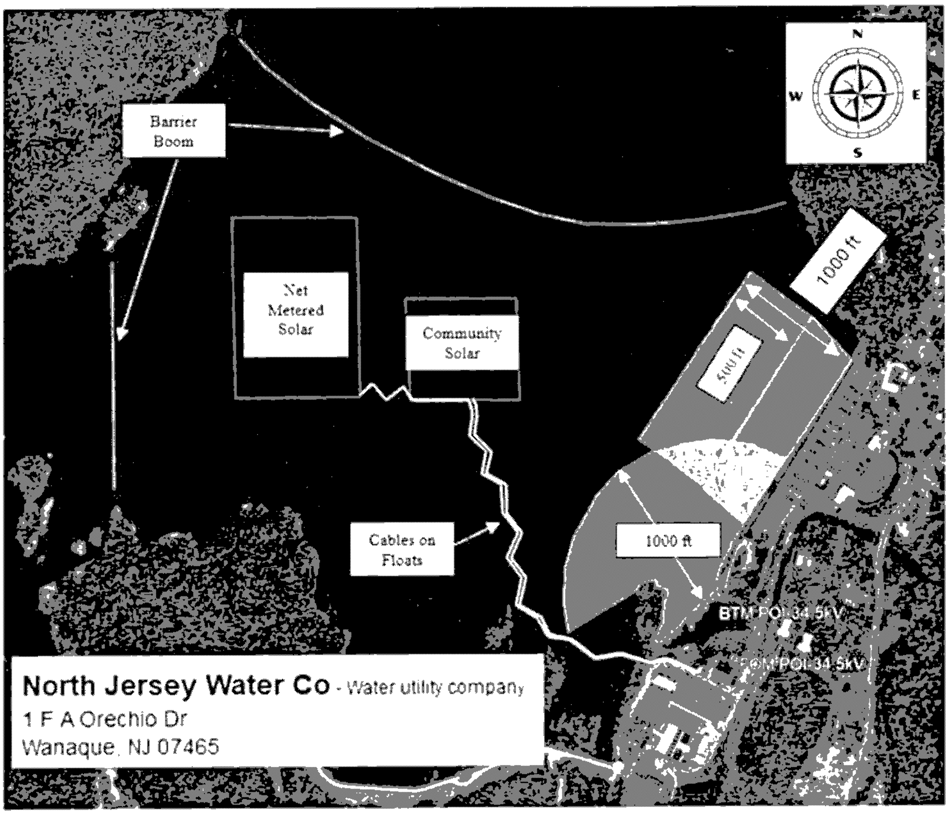
Attachment 1 - WANAQUE FLOATING SOLAR PROJECT

Executive Summary

On March 22, 2023 the North Jersey District Water Supply Commission (NJDWSC) authorized Nexamp Solar LLC to provide necessary support to submit an application to the NJ Clean Energy Program's Competitive Solar Incentive Program (CSI) for a solar project to supply, build, finance and operate an approximately 10 MWdc / 8MWac floating photovoltaic (FPV) system to be located on the Wanaque Reservoir and interconnect with the grid for net-metered operations. Subsequently NJDWSC approved expanding the proposed solar system to also include a 5MWdc/4MWac floating community solar system to interconnect with the JCP&L distribution system. The addition of the community solar component is integral to achieving the project economic objectives and delivering tangible benefits to the local community.

The net metered FPV system will supply over 13,450 MWh per year of solar electricity, increasing the Commission's resiliency through self-supply and offsetting approximately 90% of supplied energy on an annual basis, significantly reducing electricity costs and supporting NJ's energy mandate for increased renewables. The community solar system will provide access to the solar energy to local residences, with particular focus on low-and-moderate income households. The addition of community solar adds negligible environmental impact to the proposed net metered system, will allow up to 1,000 residences to subscribe for guaranteed energy discounts, must include 51% low-and-moderate income subscribers, and delivers a local community solar solution in Northern New Jersey where development restrictions have limited these types of opportunities.

Project General Arrangement

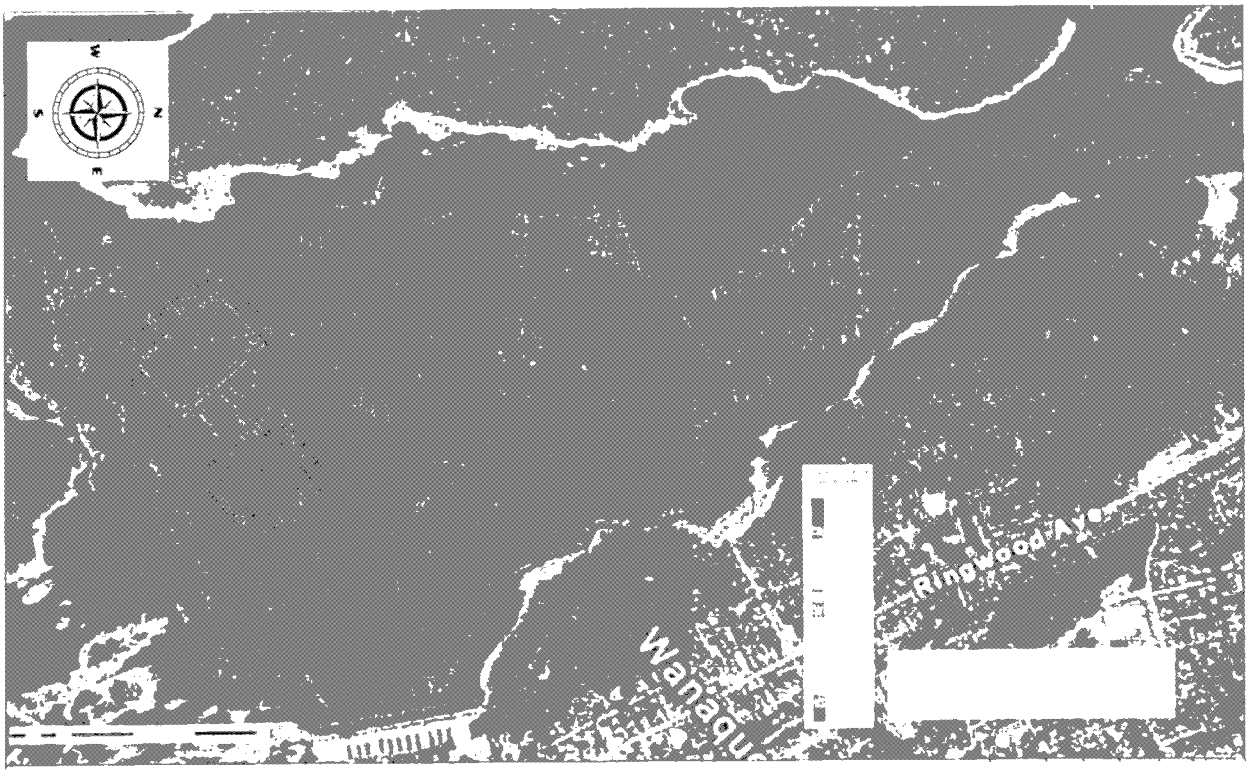


Design Overview

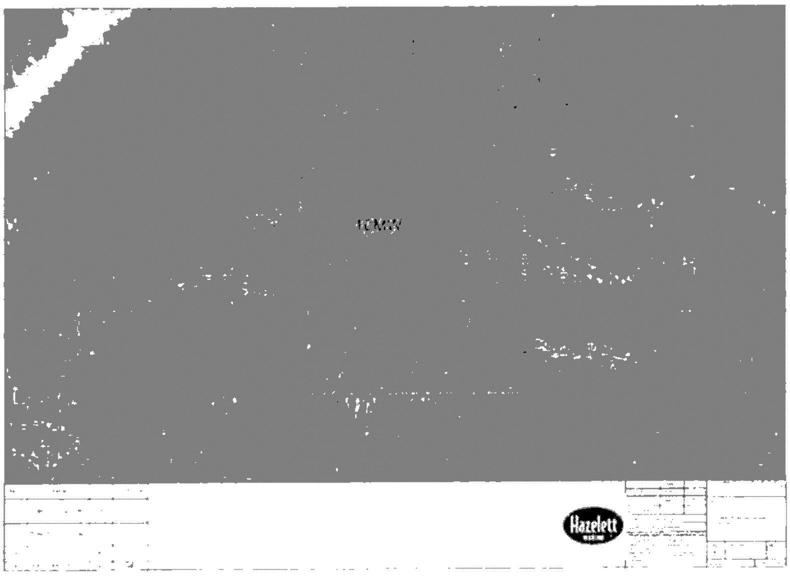
Net metered solar island and community solar islands will be located away from any dam infrastructure and secured by mooring lines anchored to reservoir bottom. Anchoring will be consistent with best industry practices and consistent with safety factors to ensure islands are stable under ASCE weather conditions. DC power will come to shore on marine grade cables on floats and run on enclosed cable tray (see ground equipment section) to electrical equipment for conversion to AC power and step up transformers. AC power is then routed to point interconnection on poles. Note that all equipment is located over 1000 feet from overflow weir and above-water dam infrastructure and will be located greater than 500 feet from any submerged dam infrastructure.

Solar Islands

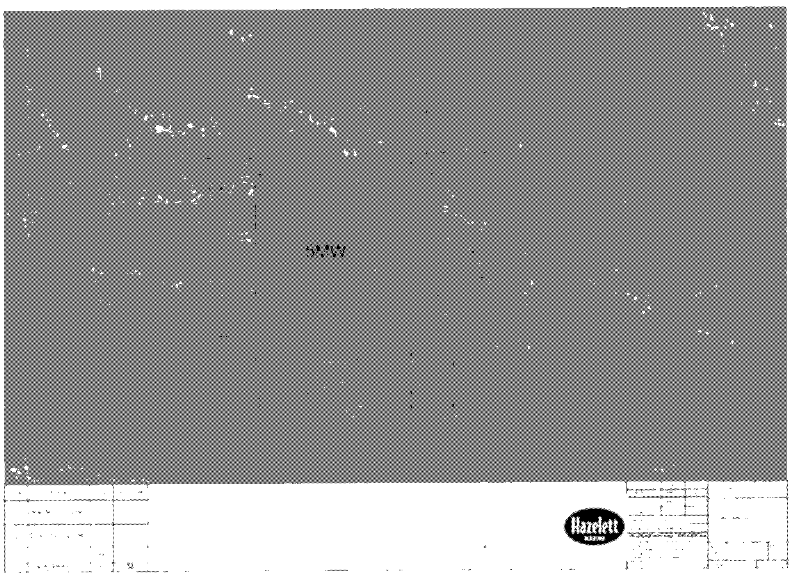
The conceptual layout is a 10MW net-metered system single-island design, and an adjacent 5MW community solar system. Based on bathymetry of the Wanaque reservoir, wind exposure, existing infrastructure and proposed interconnection plan, the proposed solar islands are expected to be located at the south end of the reservoir. Final location of the islands will depend on geotechnical studies and the anchoring plan specific to those findings, however, their position will not encroach within the 1000-foot buffer of any known Bald Eagle nest and will be located away from any dam infrastructure.



The net-metered system includes a floating island covering approximately 576,450 sf (13.23 acres) of surface water (or 0.57% of the reservoirs 2,310 acres of surface water). The mooring and anchor system will angle away from the floats and span approximately 20.3 acres of the reservoir bottom. On the floats, 17,075 photovoltaic modules will be supported above the water line (each module measures 3'8"'x 8') on HDPE floats. Anchors (pre-geotech investigation) specified as 80 1-ton ballast blocks.



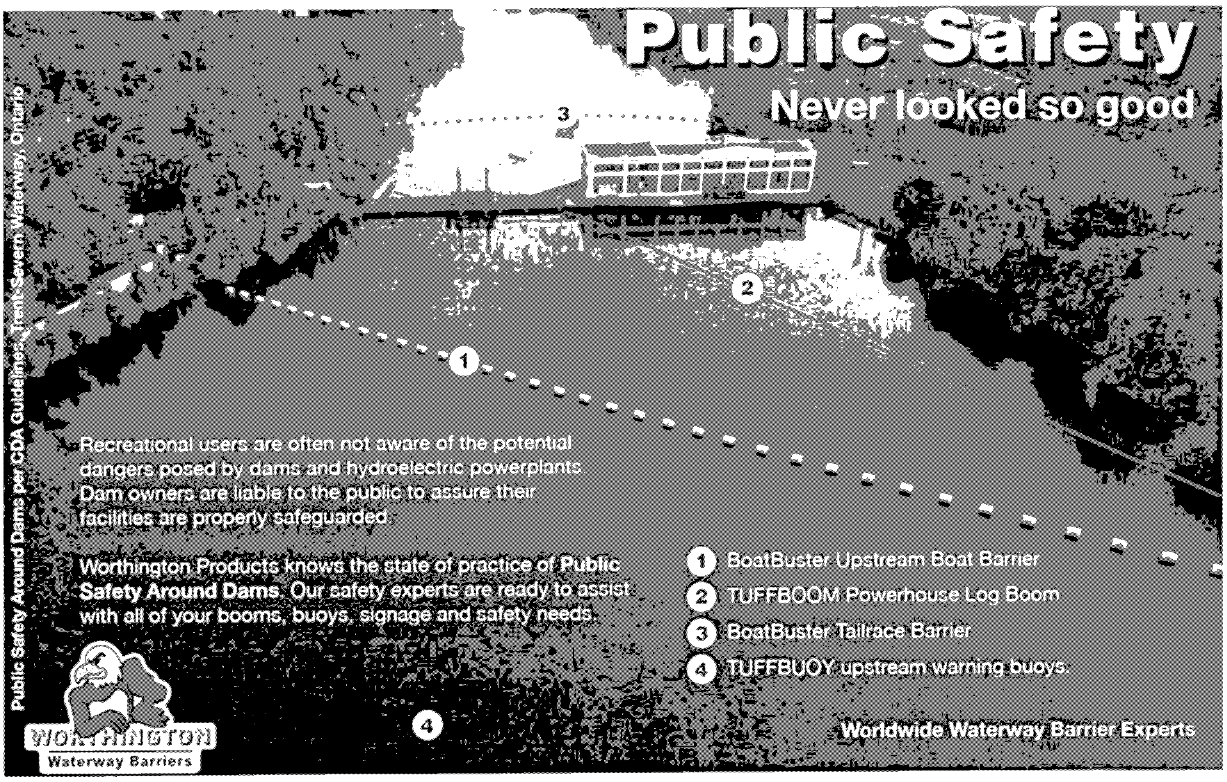
The community solar system includes a floating island covering approximately 289,280 sf (6.64 acres) of surface water (or 0.29% of the reservoirs 2,310 acres of surface water). The mooring and anchor system will angle away from the floats and span approximately 18.36 acres of the reservoir bottom. On the floats, 8,537 photovoltaic modules will be supported above the water line (each module measures 3'8"'x 8') on HDPE floats. Anchors (pre-geotech investigation) specified as 46 1-ton ballast blocks.



Solar Island Protection

To protect the solar islands from objects driven by the prevailing northern and western winds, debris barriers will be installed. These barriers are specifically designed to prevent large objects, such as floating trees, from impacting the islands. The design, including the length, location, and specifications of the barriers, is based on the prevailing wind patterns and the safety requirements of the solar array.

The barriers are intended to act as deflection barriers, not to catch debris. Any material that is incidentally trapped will be cleared during semi-annual maintenance. Importantly, these barriers will not be installed on the dam or the overflow weir, ensuring that these critical structures remain unobstructed.



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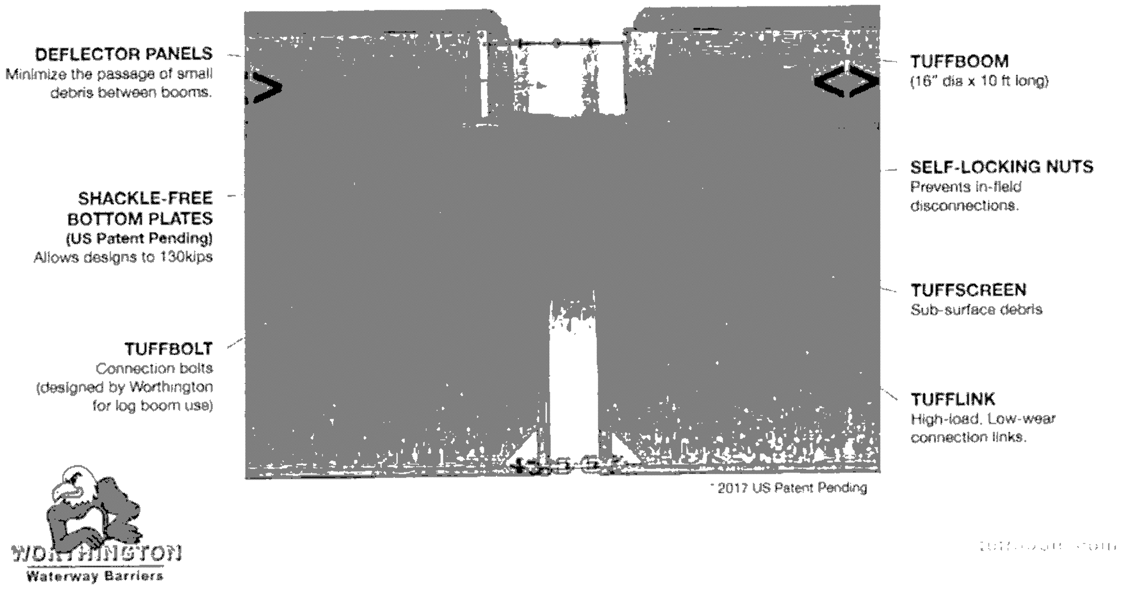
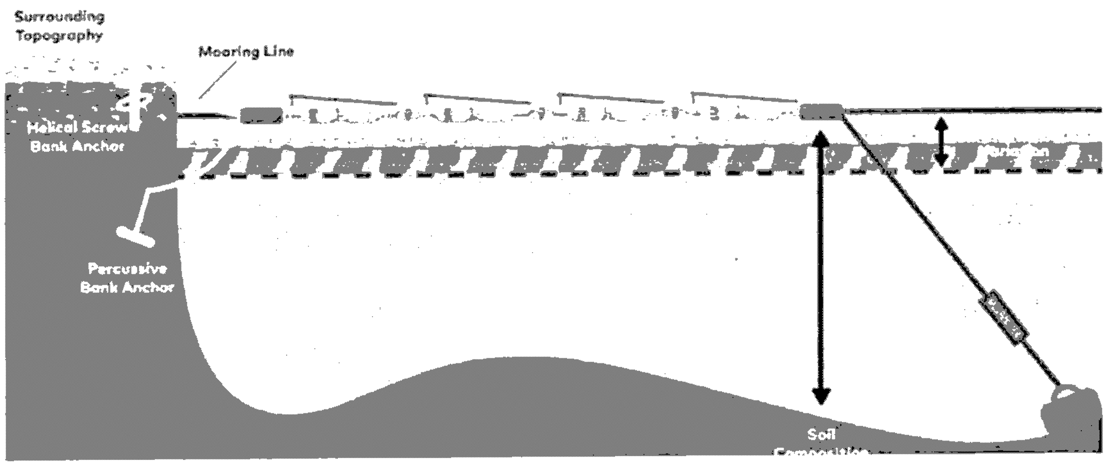


Mooring and Anchoring

The islands are secured in place with a mooring/anchor system attached to the reservoir bottom using an elastomeric system that allows for changes in water level of the reservoir. The flexible mooring system also provides greater safety as failure of one line leads to a redistribution of forces to the other lines without a single point of failure.

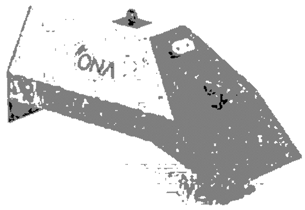


We anticipate anchors may include helical anchors or embedment ballast anchors to provide flexibility for bottom conditions and added safety. The final specification of anchors will depend on geotechnical investigation yet to be completed. However, ballast blocks and helical anchors provide different benefits and therefore a mix is expected.

The proposed anchors for the project include both ballasted and screw anchors. Ballast blocks will be surface-mounted, while screw anchors will be embedded in sandy soils. Currently, percussion anchors are not under consideration, although this may change depending on the safety factors required by the DEP and NJDWSC.

Given the known fault line in the area, any anchors that need to be placed in bedrock will require a comprehensive geotechnical analysis. This analysis will include an impact assessment to ensure the fault line is not adversely affected.

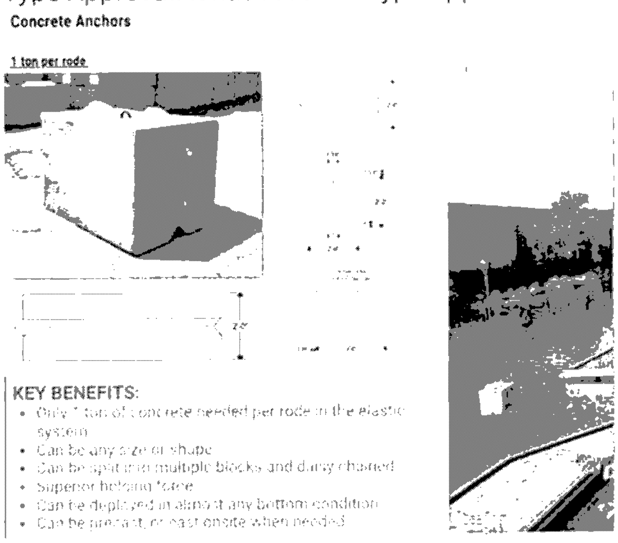
EMBEDMENT BALLAST ANCHORS



Embedment ballast anchors are fascinating engineering marvels that find their purpose in various contexts due to their exceptional drag embedment characteristics. They have been deployed in some of the most remote and challenging marine territories on Earth.

Key features:

- Holding Power: unparalleled holding power, even in strong soils.
- Economic Possibility: By overcoming soil limitations, it enables operators to explore new energy resources across a larger global area.
- Hard Soil Expertise: With 25 years of operational experience, including stiff clays, dense sands, cemented soils, and rocks, embedment anchors excel where conventional anchors may struggle.
- Geometry Enhancements: The anchor's geometry combines improvements in penetration, handling, and efficiency.
- Type Approval: It has received type approval from main Class Authorities.



HELICAL PILE

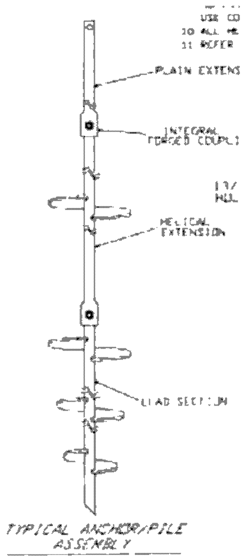
A helical pile, also known as a helical pier, helical anchor, screw pile, or screw anchor, consists of a shaft – either a solid square bar or a hollow tubular – with helical plates welded to it. These are normally segmented shafts ranging in length from 5" to 10"[2]. In most applications, only the lead or first section has helical plates while plain extensions are added to reach competent load-bearing soil strata. The industry refers to helical installations in tension (tiebacks, tiedowns, soil screws, etc.) as anchors and they are almost always solid square shafts. Note that proposed helical piles are intended for use in sandy/loamy soils and are not intended for anchoring to rock. At this time we do not anticipate drilling or percussion anchoring to bedrock. If such anchoring is required for project safety, adequate geotechnical investigation would be required to ensure no impact to the fault line known to exist within the reservoir.

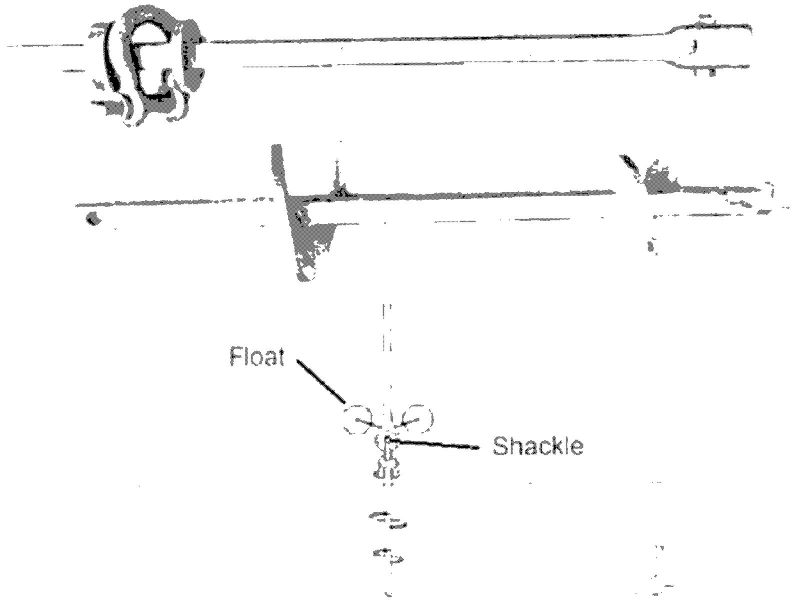
ADVANTAGES:

- Fast installation, cut schedules substantially
- Lower cost than driven or drilled piles – do not go as deep to reach the same capacity
- Install in any weather & site conditions
- Quick, safe, and efficient installation
- Load immediately after installation
- Minimum access and clearances needed for installation
- Eliminate or minimize concrete use and related issues
- No excavation or soil disturbance
- Minimal equipment and crew needed for construction
- No installation vibration or noise concerns
- Used in both compression and tension applications
- No spoils to remove or transport, beneficial on contaminated soil sites
- Minimum quality control concerns, pre-engineered & manufactured
- Easily removed and reused as needed for site changes or temporary installations
- Ecologically sensitive sites
- Install in tight space
- Little or no disturbance to the site
- Wide range of allowable loads up to 500 tons.
- Adaptability to a variety of installation angles
- Minimal support equipment
- Suitability for low-headroom and other limited-access areas
- Easy pile cutoffs
- Low mobilization and demobilization costs
- Minimum construction mobilization & activity coordination

Helical Anchors

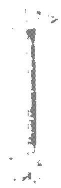
SS5 Helical Anchors





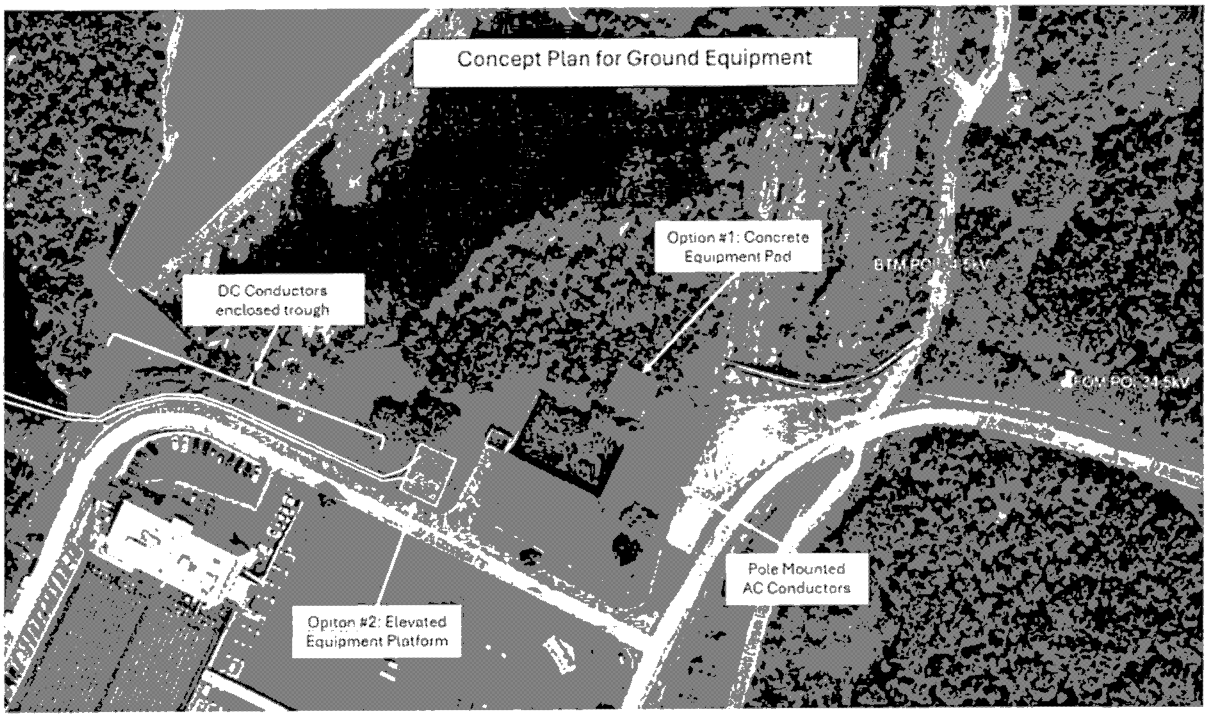
KEY BENEFITS:

- Versatile, high-load capability to serve any permanent anchoring need
- Holding power which cannot be equaled by traditional mushroom anchors or deadweight blocks
- Maintains its holding power even with the shorter scoping necessary in congested harbors
- Removable if required for inspection or dredging



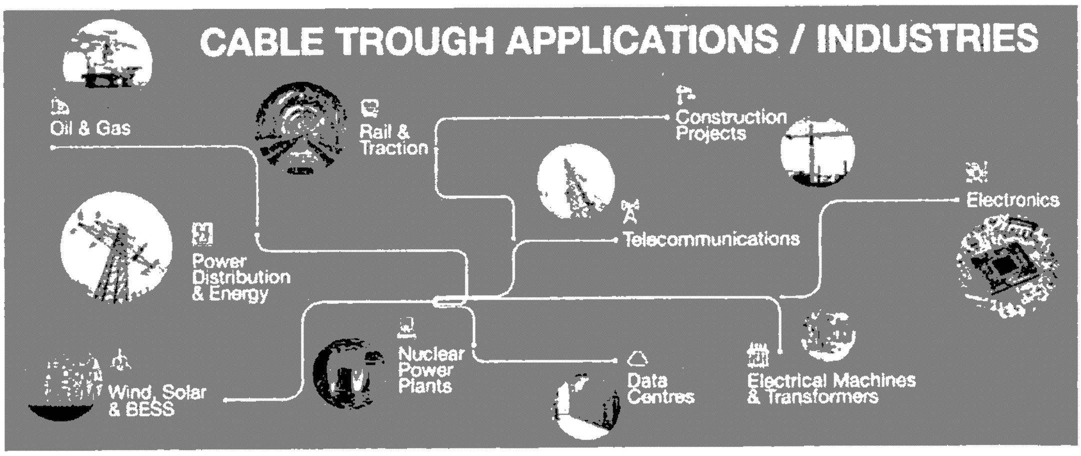
Land-Based Power Equipment and Cables

Marine grade power cables will deliver DC electricity from floating solar arrays to electrical equipment platform or pads with inverters, switchgear and transformers. The direct current (DC) generated by the solar panels will be routed through surface DC conductors on anchored floats (in the water) and routed where possible in above grade enclosed cable trough (on land) to one of two equipment pad locations currently under consideration. Cable trough will be installed adjacent to the existing driveway. The equipment pads will include inverters, switchgear and step-up transformers. AC power at 34.5kV will then be routed on pole-mounted overhead conductors, ultimately reaching the point of interconnection with the grid. The net-metered solar array will connect behind-the-meter (BTM) and the community solar array will connect front-of-the-meter (FOM).



Cable Trough

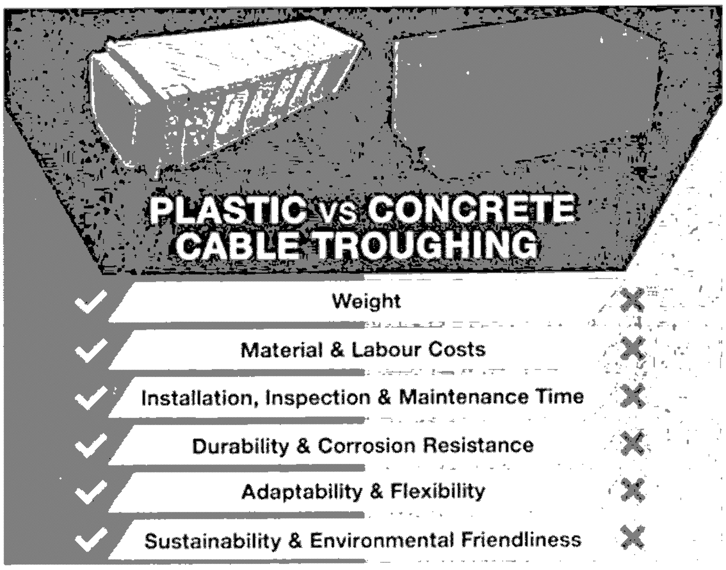
Cable trough often called Cable Raceway, Cable Routing System, Cable Management Trough, Electrical or Industrial Cable Routing, is a specialized system designed to protect, organize and route electrical cables within a defined pathway. Essentially, it provides a secure and accessible channel for cables, wires and ducts, preventing damage and ensuring efficient cable route management. Cable troughs are made from durable materials including Glass Reinforced Plastic (GRP), concrete, PVC or plastic. GRP troughs are lightweight, strong and corrosion-resistant, and easy to handle and install. They are ideal for harsh environments due to their chemical and UV resistance, and they are also fire and non-conductive for safety. With low maintenance needs, a long lifespan and recyclability, cable troughs are cost-effective and environmentally friendly cable routing solutions.



Because cables are contained within the trough, this makes them readily visible and accessible for inspection, maintenance or modifications. In turn, this reduces downtime because technicians can quickly locate and address any issues without disrupting other components.

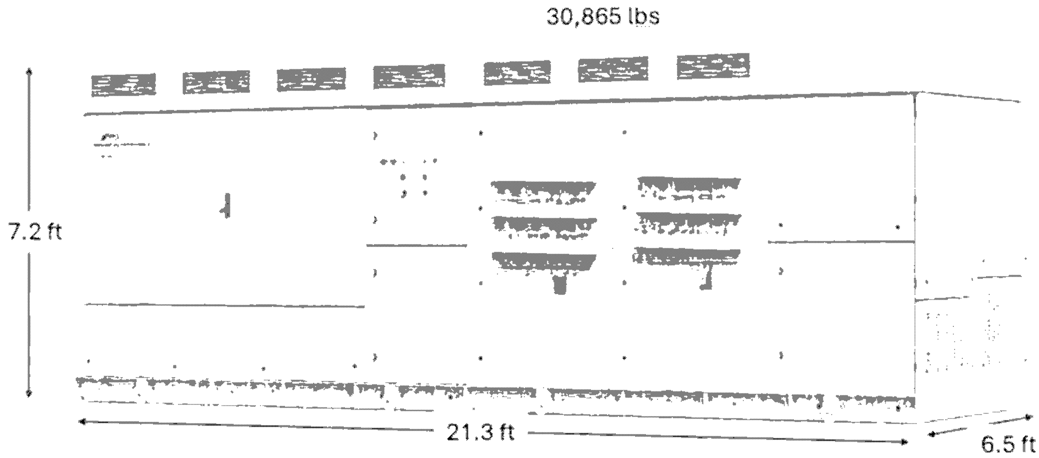
In addition to enhancing aesthetics, cable troughs serve as a protective barrier, shielding cables from damage due to impacts, crushing, abrasion or adverse environmental conditions. This protection is especially crucial in environments with heavy machinery, or potential for contact with exposed live wires, reducing the risk of electric shocks for both workers and the public. Additionally, by containing cables in a non-combustible cable trough, the risk of fire spreading is minimized. In the event of a short circuit or overheating, the trough can help to prevent the fire from reaching other combustible materials.

Lastly, cable routing systems are modular and customizable, enabling quick and easy installation to meet bespoke project requirements. This design reduces labor costs and project timelines while providing flexibility during both the design and installation processes.



Power Equipment

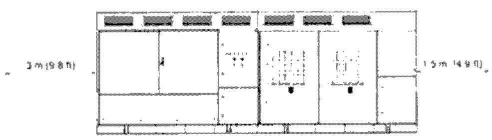
Electrical equipment will be selected to minimize space requirement. Preference will be given for integrated modules that include string inverters, switchgear and step up transformer in a containerized unit. Since the transformer needs to step up the AC voltage to 34.5kV, the transformer must be mineral oil filled with adequate containment provisions for spill prevention. One possible option is to use the Power Electronics HEMI units with a power rating of 4MWac / 5MWdc per block. At that capacity, 2 HEMI units would be used with the net-metered solar 10MWdc array, and 1 HEMI unit would be used with the community solar 5MWdc array.

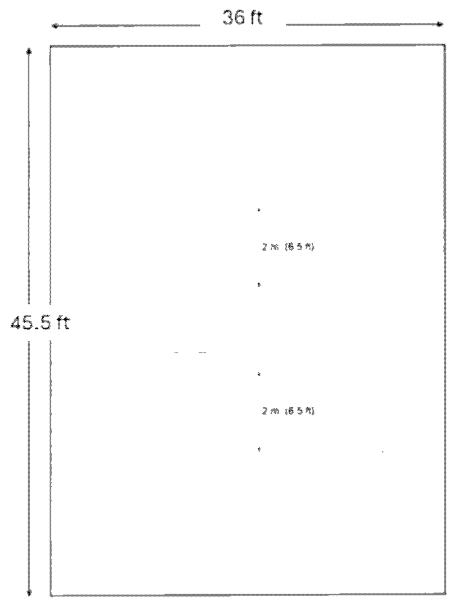


The integrated units would be arranged on a suitable structure (elevated or pad mounted depending on the selected equipment location).

Equipment Pad

- 3 Integrated units required for the proposed solar array
  - Each unit will support 5MWdc/4MWac capacity
  - Total capacity: 15MWdc/12MWac
  - Total weight (minus support structure) = 92,595 lbs
- Support Structure:
  - Steel structure on piers
  - Dimensions (ft): 45.5ft x 36ft





Final equipment pad location is yet to be finalized and requires geotechnical investigation and further discussion with NJDWSC, however, conceptually, the equipment will be sited on property already developed and in use. Two equipment pad locations are under consideration: one location requires an elevated platform for the electrical equipment but no tree removal, the other location allows for pad-mounting of equipment but require tree removal of 50'x50' area next to the existing waste wash-water basin.

EQUIPMENT PAD LOCATION

NORTH JERSEY DISTRICT WATER SUPPLY COMMISSION	NORTH JERSEY DISTRICT Water	FLOATING SOLAR EQUIPMENT PAD LOCATION ALTERNATIVES

ADDITIONAL PROJECT RELATED INFORMATION

ECONOMIC BENEFIT

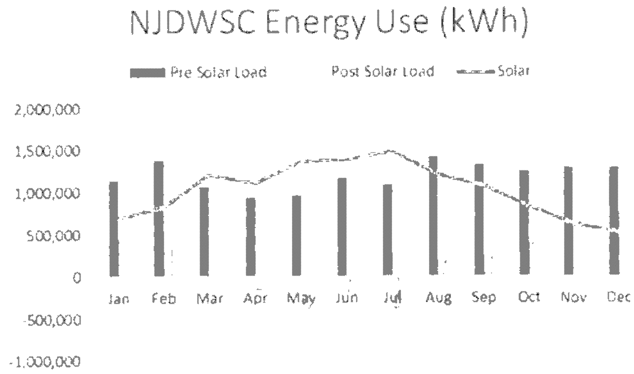
The North Jersey District Water Supply Commission (NJDWSC) provides water services to over 3 million people in northern New Jersey. This extensive service area means NJDWSC's ability to deliver high-quality, low-cost potable water is mission critical. The proposed 10MW net metered floating solar project is part of NJDWSC's strategic vision to re-imagine the nexus of energy and water management and revolutionize the energy consumed by NJDWSC, while also providing substantial economic and environmental benefits. The floating solar project will supply approximately 86% of the energy load for NJDWSC's main electric account, which itself constitutes 98% of the energy supplied by JCP&L at a current cost of $1.38 million per year. By delivering clean, renewable energy at a discounted rate compared to the current utility rate, the project will significantly reduce operational costs. Additionally, the power purchase agreement (PPA) for the solar project spans an initial 15-20 year period, ensuring a stable and predictable energy cost, thereby mitigating the risk of fluctuating grid-supplied power rates (which are expected to increase in the near and medium term) and providing financial certainty for NJDWSC.

North Jersey District Water Supply Commission

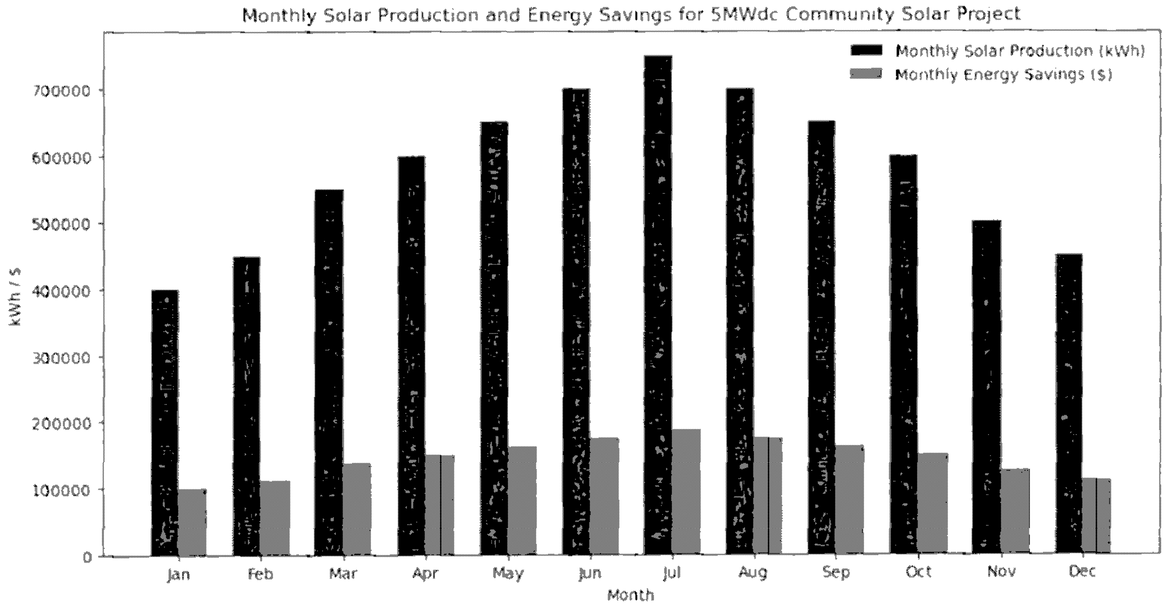
JCP&L Accounts		kWh/yr
744 Ringwood Ave, Wanaque, NJ 07465	98.04%	14,389,236
57 Furnace Ave, Wanaque, NJ 07465	0.01%	1,063
0 Westbrook Road, Wanaque, NJ 07442	0.01%	1,158
Lines Avenue, Wanaque, NJ 07442	0.38%	56,080
0 Ringwood Ave, Wanaque, NJ 07442	0.17%	24,305
16 Lines Ave, Wanaque, NJ 07442	0.00%	
680 Ringwood Ave, Wanaque, NJ 07442	0.07%	10,198
Orechio Drive and Ringwood Ave, Wanaqu	0.04%	5,376
801 Hamburg Tpke, Pompton Lakes, NJ 07	0.76%	110,913
Blk 402 Lt 2.01, Dupont Ave, Wanaque, NJ	0.00%	399
1 Hemlock Road, Pompton Lakes, NJ 0744	0.35%	51,260
Greenwood St, Haskell, NJ 07420	0.18%	26,000
278 Garden Road, Pompton Lakes, NJ 074	0.00%	221
Gaging Station Rt 46, Pine Brook, NJ 0705	0.01%	1,134
Total		14,677,343

NJDWSC Main Account Energy (kWh)

	Pre Solar Load	Solar	Post Solar Load
Jan	1,140,457	694,600	445,857
Feb	1,383,309	834,159	549,150
Mar	1,075,042	1,218,138	-143,096
Apr	941,643	1,107,227	-165,584
May	970,171	1,377,714	-407,543
Jun	1,174,721	1,393,662	-218,941
Jul	1,085,847	1,483,766	-397,919
Aug	1,421,891	1,220,297	201,594
Sep	1,335,613	1,077,081	258,532
Oct	1,255,394	830,640	424,754
Nov	1,302,766	631,752	671,014
Dec	1,302,382	527,877	774,505
Total	14,389,236	12,396,913	1,992,323
		86%	14%



The unique construction challenges of installing floating solar on the Wanaque reservoir requires scaling the project to mitigate unavoidable fixed costs and still deliver the desired economic value to NJDWSC. Fortunately, the project can achieve cost-effectiveness by adding community solar and simultaneously enhancing its value to the local community, particularly for low-and-moderate income households, and the state. Residential subscribers will enjoy 20-30% discounts on their energy bills, fostering economic relief and community engagement, and together with the net metered system, will expand the availability of clean, renewable energy in New Jersey, reducing reliance on fossil fuels and contributing to the state's de-carbonization goals. NJDWSC's limited useable land holdings make the vast water surface under management an ideal location for deploying renewable energy (with virtually no environmental impact – less than 2% of the surface area will be used by both floating solar projects and the reservoir has no public recreational access) and leveraging existing resources productively and responsibly.



Monthly Solar Production (kWh): The blue bars represent the amount of energy produced each month.
Monthly Energy Savings ($): The green bars show the savings on electricity bills, calculated at 20-30% of average residential rate of $0.15/kWh.

Nexamp, a national leader in distributed solar energy and community solar development, will spearhead the development, construction and operation of both projects. This collaboration aligns with NJDWSC's goals of cost containment, responsible operations, de-carbonization, and local community engagement. The proposed floating solar projects are not just an energy solution; they are strategic investments in the future of NJDWSC and the communities it serves. By harnessing renewable energy, NJDWSC will achieve significant cost savings, enhance financial stability, and contribute to a sustainable and resilient energy future for New Jersey.

HIGHLANDS APPLICABILITY DETERMINATION

The Highlands Council, on April 23, 2021, issued a Highlands Applicability Determination ("HAD"), granting a Highlands Preservation Area Exemption Determination based on the applicability of Exemption #11 (pertaining to public utility systems within the Highlands Preservation Area) for the net-metered Project. HAD documentation included in the permit readiness checklist Attachment 7.

The proposed community solar phase of this project has not yet obtained a Highlands Preservation Area Exemption Determination for two practical reasons:

1) Filing a HAD for community solar only makes sense if the Net Metered project is successful in the CSI bid. Standalone, the community solar economics does not work given the significant expected permitting and construction costs.
2) If the Net Metered solar project is successful in the CSI bid, the development team will seek to obtain permits for both the Net-metered solar project and the Community Solar project. Concurrent with the permit processing, we would seek HAD for Community Solar or a waiver based on the reasons outlined below. In either case, we will have 36 months to achieve PTO for the net metered system and during that time will work on the HAD (or waiver thereof) to apply into the community solar solicitation available when we have NJDEP permits and can manage the PTO timing requirements consistent with the community solar program.

Community solar projects are designed to provide clean, renewable energy to multiple customers, including individuals, businesses, and nonprofits, often benefiting those who cannot install solar panels on their own properties. Given the environmental and social benefits of community solar, it is crucial to consider the unique nature of these projects when evaluating regulatory requirements.

1. Environmental Benefits: Community solar projects contribute significantly to reducing greenhouse gas emissions and promoting sustainable energy use. By generating clean energy, these projects help mitigate climate change and reduce reliance on fossil fuels. The Highlands Preservation Area aims to protect environmental quality, and community solar aligns with this goal by enhancing air quality and reducing carbon footprints. Furthermore, the siting of the floating solar array is on a man-made reservoir and will not impact existing forests, storm water runoff, flood plains, and other ecologically sensitive areas.

2. Minimal Environmental Impact: Community solar projects typically have a minimal environmental footprint compared to other types of development. They often utilize existing impervious surfaces, such as rooftops, brownfields, landfills and reservoirs, which are already disturbed and do not require further land disruption. This approach ensures that the natural landscape and critical habitats within the Highlands Preservation Area remain undisturbed.

3. Alignment with Preservation Goals: The Highlands Preservation Area is intended to protect water resources, forests, and other natural habitats. Community solar projects can be strategically sited in areas that do not compromise these goals. For instance, the proposed project would be located on a non-recreational, impervious body of water, with no public access (ie no fishing), thus ensuring it will not encroach on pristine natural areas.

4. Economic and Social Benefits: Community solar projects provide economic benefits by creating local jobs and reducing energy costs for residents and businesses. They also promote energy equity by making renewable energy accessible to low-income households and those who cannot install solar panels on their properties. These social benefits align with the broader objectives of sustainable development and community well-being.

5. Precedent and Regulatory Flexibility: The New Jersey Department of Environmental Protection (DEP) has provisions for granting waivers and exemptions for projects that meet specific criteria. Given the minimal environmental impact and significant benefits of community solar projects, they should be considered for such exemptions. This approach is consistent with the DEP's practice of evaluating projects on a case-by-case basis to ensure they meet statutory standards to the maximum extent possible.

Requiring a Highlands Preservation Area Exemption Determination for the community solar project may impose unnecessary regulatory burdens that could hinder the development of clean energy solutions. Given their environmental, economic, and social benefits, and their alignment with the preservation goals of the Highlands Act, the community solar project should be exempt from this requirement. This exemption would facilitate the growth of renewable energy while ensuring the protection of the Highlands Preservation Area.

DAM IMPACT

The project design area eliminates any impact to Raymond Dam. No equipment for the floating solar system will be adjacent to or in contact with Raymond dam or the spillway. The floating solar systems will be 1,000 feet or more from Raymond dam with the islands positioned approximately 1,800 feet from the spillway. DC cables will be routed above the water surface on floats and positioned 500 feet or more from overflow currents at maximum reservoir level.

GEOTECHNICAL STUDIES

The geotechnical studies for the floating solar project are essential to ensure the stability and safety of the installation. These studies will be conducted in several phases, each focusing on different aspects of the reservoir's subsurface conditions.

Initially, a preliminary investigation will be carried out to gather existing data and assess the general geological conditions of the site. This phase will involve reviewing historical records, geological maps, and any previous studies conducted in the area.

Following the preliminary investigation, detailed site investigations will be conducted using non-invasive geophysical methods. These methods, such as seismic surveys, resistivity surveys, and electromagnetic surveys, will provide a comprehensive understanding of the subsurface conditions without the need for drilling. The data collected will help identify the composition and characteristics of the sediments and any potential hazards.

In areas where anchors need to be placed in bedrock, a more in-depth geotechnical analysis will be required. This analysis will include an impact assessment to ensure that the installation does not adversely affect the known fault line in the area. The assessment will evaluate the potential impact of the anchors on the fault line and recommend any necessary mitigation measures.

The results of the geotechnical studies will be compiled into a detailed report, which will include recommendations for the design and installation of the anchors and other structural components of the floating solar project. This report will serve as a critical reference for ensuring the long-term stability and safety of the installation.

The geotechnical survey, including preliminary investigations, geophysical surveys, and data analysis, is expected to take several months to complete. The cost for these studies is expected to range from $80,000 to $120,000, depending on month of survey, depth of reservoir at time of survey, area of exploration limited to proposed location, and the specific methods used.

BALD EAGLE IMPACT

EcolSciences, Inc. conducted an initial habitat assessment of the Wanaque Reservoir for the state-endangered bald eagle to address concerns from the New Jersey Department of Environmental Protection (NJDEP) regarding the impact of a proposed floating solar array. The assessment included reviewing annual NJDEP Bald Eagle Project reports, NJDEP Landscape Project mapping, and a site inspection.

Key Findings:

1. **Annual Reports:** Two eagle nests (Wanaque A and Wanaque B) were documented near the proposed solar array. Data on incubation, hatching, and fledging were provided for these nests.
2. **On-site Assessment:** Three active eagle nests were found at the reservoir, with one nest (Wanaque B) being closest to the proposed array. No eggs were observed during the visit, but incubation was expected to begin soon.
3. **Landscape Project:** The NJDEP's Landscape Project maps the reservoir and adjacent land as critical habitats for nesting, foraging, and wintering eagles.
4. **Eagle Impacts:** The proposed solar array is expected to have negligible impact on the local eagle population, as it would not approach any nest sites or forested shorelines. Construction should ideally occur during the non-breeding season (August 1 to December 31) to minimize disturbance.

The letter concludes that the project would have minimal impact on the bald eagle population if conducted with appropriate timing and precautions. The full report is provided in the checklist readiness report.

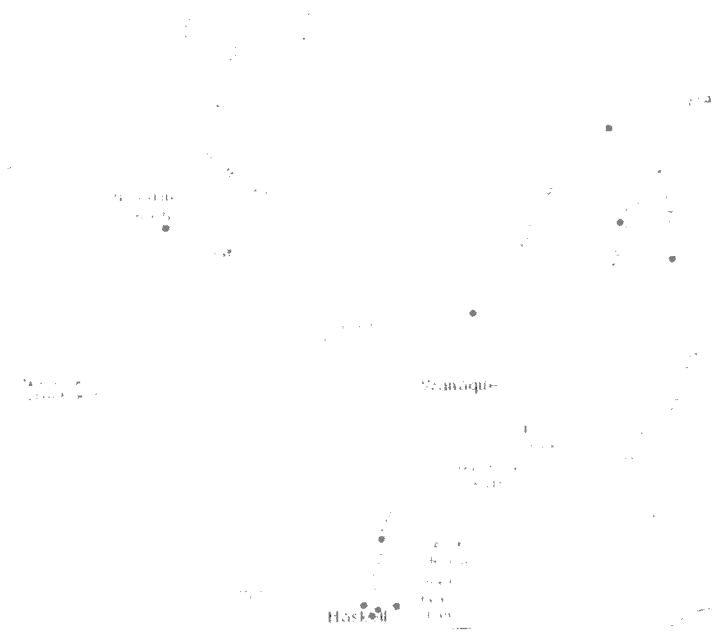
IMPACT TO AQUATIC LIFE

NJDWSC manages fish stock within the Wanaque reservoir. The size and location of the floating solar array are expected to have negligible impact on fish. Furthermore, no public access to the reservoir is allowed therefore recreational fishing is not an impact. Floating solar installations covering less than 1% (20 acres out of 2,310acres) of a water body's surface are generally expected to have minimal impact on aquatic life. The shading effect from the panels can reduce water temperature and limit sunlight penetration, which may affect photosynthesis in aquatic plants and algae. This can lead to changes in the local ecosystem, potentially reducing the growth of certain plant species and altering the habitat for fish and other aquatic organisms. However, the small coverage area means these effects are likely to be localized and not significantly disruptive to the overall aquatic environment. Additionally, floating solar panels can help reduce water evaporation and mitigate harmful algal blooms by blocking sunlight. Overall, while some ecological changes may occur, the limited coverage area suggests that the broader impact on aquatic life would be relatively minor.

NOT A CONTAMINATED SITE

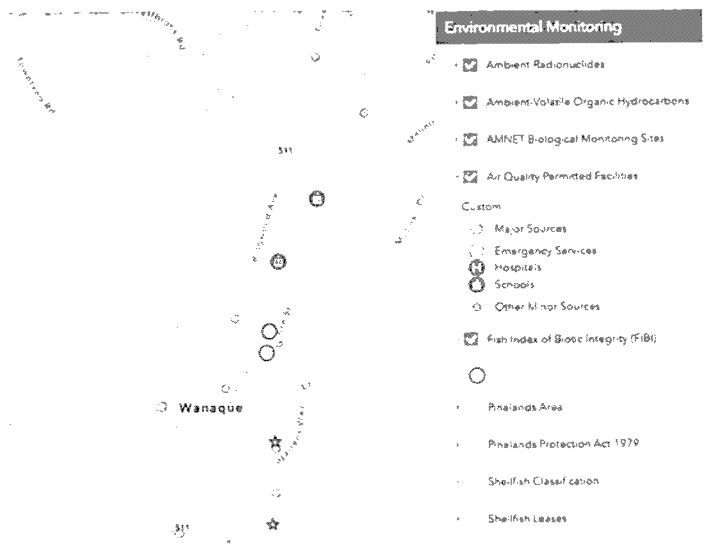
The proposed floating solar system on the Wanaque Reservoir is not located on a contaminated site, ensuring the safety and integrity of the project. According to the New Jersey Department of Environmental Protection (NJDEP) Known Contaminated Sites List (KCSL), the Wanaque Reservoir itself is not listed as a contaminated site[1].

njdep::known-contaminated-site-list-for-new-jersey



Additionally, the NJDEP's GeoWeb interactive mapping tool, which provides detailed information on contaminated sites, confirms that the Wanaque Reservoir is not within the boundaries of any known contaminated areas[2]. While there are concerns about contamination from the nearby Ringwood Mines/Landfill Superfund site, it is important to note that this site is located approximately one mile away from the reservoir[3]. The contamination from Ringwood has not been detected in the Wanaque Reservoir, and ongoing monitoring ensures that any potential threats are managed effectively[4].

https://njdep.maps.arcgis.com/



This clean status supports the feasibility and environmental safety of installing a floating solar array on the Wanaque Reservoir, aligning with New Jersey's clean energy objectives without compromising the local ecosystem.

References

[1] Known Contaminated Site List for New Jersey - ArcGIS
[2] Contaminated Site Remediation & Redevelopment Program
[3] NJDEP CSRR - GIS - (Interactive Mapping) - The Official Web Site for ...
[4] Settlement Addresses Groundwater Cleanup at Ringwood Mines/Landfill ...

FEASIBILITY OF SOLAR AT THE WANAQUE RESERVOIR

Technical Feasibility:

1. **Site Suitability:** The Wanaque Reservoir, with its large surface area, is well-suited for floating *solar installations. The reservoir's depth and stable water levels provide a conducive* environment for the installation and maintenance of floating solar panels[1].
2. **Installation and Maintenance:** Floating solar systems are relatively easy to install and maintain. They require anchoring systems to keep the panels in place and can be designed to withstand local weather conditions[2].
3. **Energy Production:** Floating solar panels benefit from the cooling effect of water, which can enhance their efficiency compared to land-based systems. This can lead to higher energy yields[1].

Environmental Impact:

1. **Minimal Land Use:** Floating solar installations do not compete for land, preserving valuable land resources for other uses[3]. No forested areas will be impacted.
2. **Water Conservation:** By shading the water surface, floating solar panels can reduce water evaporation, conserving water resources[3].
3. **Aquatic Life:** Covering less than 2% of the reservoir's surface, the impact on aquatic life is expected to be minimal. The shading effect may alter local ecosystems slightly, but the overall impact is likely to be minor[4].

Economic Feasibility:

1. ***Cost Considerations:*** *While the initial investment for floating solar is slightly higher than* ground-mounted systems, the long-term benefits, including higher efficiency and water conservation, can offset these costs[1].
2. **Funding and Incentives:** New Jersey offers various incentives and funding opportunities for renewable energy projects, which can help reduce the financial burden of the initial investment[3].

Benefits Supporting NJ Clean Energy Objectives:

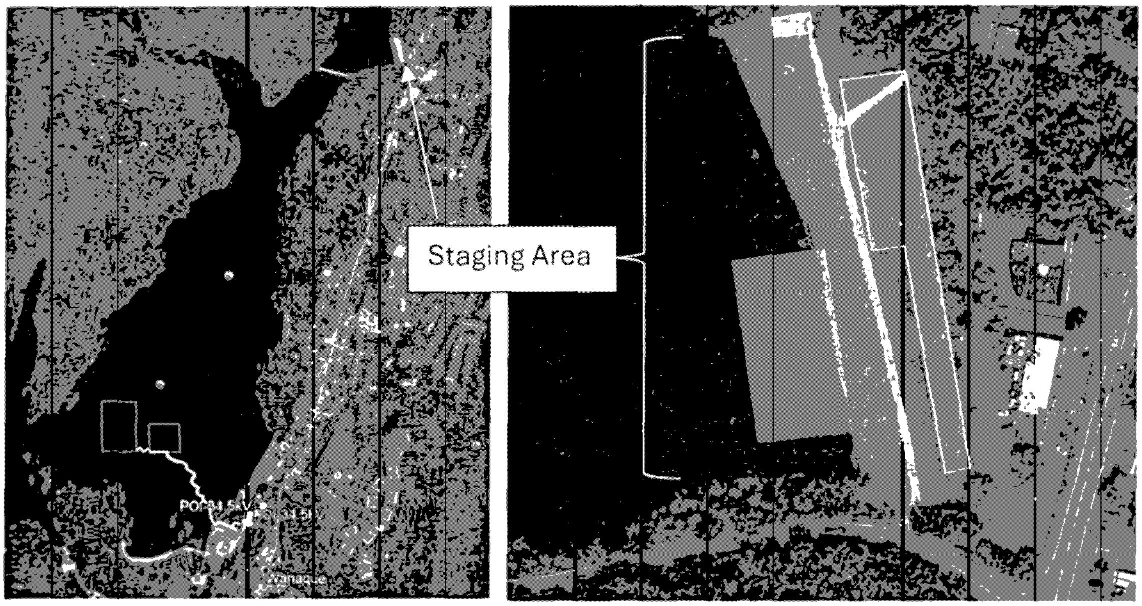
1. **Renewable Energy Goals:** Installing floating solar on the Wanaque Reservoir aligns with New Jersey's goal of achieving 100% clean energy by 2050. It contributes to the state's renewable energy capacity without using additional land[3].
2. **Carbon Emission Reduction:** Floating solar installations can significantly reduce carbon emissions by providing a clean energy source, helping New Jersey meet its greenhouse gas reduction targets[4].
3. **Energy Security:** Increasing the state's renewable energy capacity enhances energy security and reduces dependence on fossil fuels[5].

Installing floating solar on the Wanaque Reservoir is technically and economically feasible, with significant environmental and clean energy benefits. This project would support New Jersey's clean energy objectives by contributing to renewable energy capacity, reducing carbon emissions, and conserving water resources.

References
[1] Crunching the numbers on floating solar - PV Tech
[2] DESIGN AND IMPLEMENTATION OF FLOATING SOLAR POWER PLANT - OAIJSE
[3] News Release: Floating Solar Panels Could Support US Energy Goals
[4] Current Study: Floating-PV could support energy goals in the U.S.
[5] Floating solar panels could support US energy goals

PROJECT CONSTRUCTION OVERVIEW

Staging and Assembly Area: Due to limited access to the reservoir from other locations, Furnace dam is the designated staging area where the floating arrays will be assembled prior to floating to their final installation location. The staging area will include material delivery and storage areas (orange area), construction and personnel trailers (green area) and temporary float assembly dock (blue area). The assembly dock is expected to be 250 ft x 125 ft sloping into the reservoir so that as the island blocks are assembled, they can slide into the water. Additional civil and site investigation is needed to determine slope of assembly area and required fill material, however, we expect to bring additional rip rap to shape the angle of the assembly dock consistent with personnel safety and ease of sliding the sub-assemblies into the water.



Anchoring and Mooring: While the staging area is being prepared, cranes and barges are used to position anchors per the system design. Temporary mooring lines will be attached to the anchors to indicate their location and to facilitate the construction of the islands with subassemblies towed into position.

Construction of the Floating Solar Project: With the staging area ready and anchoring in place, the construction phase commences. The process begins with the delivery of materials, including high-density polyethylene (HDPE) floats, solar panels, and anchoring equipment. These materials are carefully organized in the staging area to ensure efficient assembly. The area will be behind fencing for security reasons.

Assembly and Construction Management: Construction management teams will oversee the assembly stations, where workers attach solar panels to the HDPE floats and assemble string-level float subassemblies to be towed to the final installation location with boats. Each subassembly is sized for efficient labor rates, sizing consistent with clearances under Westbrook Road bridge and temporary anchoring at the final location as the full island is under construction. Boats are used to transport the subassemblies from the platforms to the anchor locations. Each subassembly is then interconnected to form a cohesive floating solar array and secured to the final anchor and mooring arrangement.

Electrical Integration: Electrical integration follows with the solar panels electrically connected to combiner and recombiner boxes on the island. Power DC cables are then towed to position and connect the island electrical system to the equipment on land. The system undergoes rigorous testing to ensure efficient and safe energy production.

Demobilizing: After the solar system is fully tested and deemed ready for commercial operations, the assembly area is restored to its original state. Any material brought in for proper staging of the assembly dock is removed and all construction related equipment is removed from site. Furnace dam is restored to its pre-construction state.

Decommissioning and Site Restoration: After years of successful operation, decommissioning process is as carefully planned as the construction. The floating platforms are disconnected from the power grid and carefully transported back to a newly prepared staging area. Specialized equipment is again used to ensure safe and efficient removal from the water. In the staging area, the platforms are dismantled. Solar panels, floats, and other components are separated and prepared for recycling. The project team ensures that all materials are disposed of in an environmentally responsible manner, with many components sent back to manufacturers for recycling. Finally, the staging area and the reservoir are restored to their original condition. Temporary facilities are removed, and the site is cleaned. The Wanaque Reservoir returns to its natural state, with the floating solar project leaving behind a legacy of renewable energy and environmental stewardship.

NEW JERSEY LEADERSHIP IN FPV PROJECTS

The proposed floating solar project at Wanaque Reservoir stands to benefit greatly from the successful precedents set by similar projects in New Jersey. Notably, the Canoe Brook, Sayreville, and Clayton Sands floating solar installations have demonstrated the viability and advantages of this innovative technology. Furthermore, NJ leads the US in total installed MWs of floating solar capacity.

Canoe Brook: The Canoe Brook floating solar project, completed in 2022, is the largest floating solar array in the United States, covering 17 acres and generating 8.9 megawatts (MW) of clean energy[1]. This project has been instrumental in providing approximately 95% of the power needs for the New Jersey American Water's Canoe Brook Water Treatment Plant[2]. The success of this project highlights the potential for floating solar to efficiently meet substantial energy demands while utilizing underutilized water surfaces.

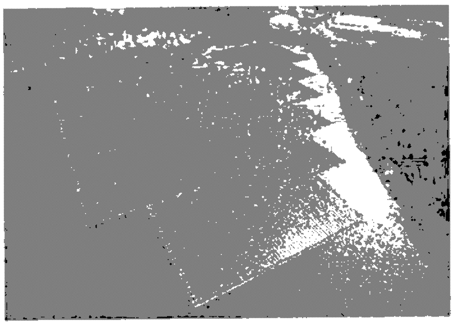
Sayreville: The Sayreville floating solar project, completed in 2020, was the first of its kind in New Jersey and the largest in the country at the time, with a capacity of 4.4 MW[3]. This installation powers 100% of Sayreville's water treatment plant, showcasing the effectiveness of floating solar in supporting critical infrastructure[4]. The project also demonstrated the feasibility of large-scale floating solar installations in the state, paving the way for future developments.

Clayton Sands: The Clayton Sands floating solar project, announced in 2020, involves a 3.2 MW array at a sand mining facility[5]. This project is notable for its integration with the facility's operations, providing all its power needs through New Jersey's Net Metering program[6]. The success of this project underscores the adaptability of floating solar technology to various industrial applications, further supporting New Jersey's clean energy goals.

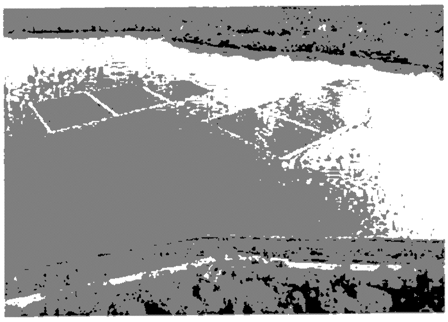
These successful projects illustrate the potential for floating solar to contribute significantly to New Jersey's renewable energy objectives. By leveraging the state's water bodies for solar energy production, these projects help reduce carbon emissions, conserve land resources, and enhance energy security. The Wanaque Reservoir floating solar project can build on these successes, contributing to a sustainable and clean energy future for New Jersey.

References

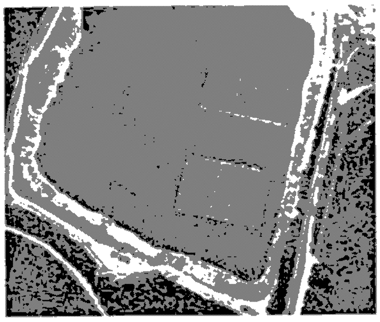
[1] Floating Solar-Millburn - New Jersey Resources
[2] NJR CLEAN ENERGY VENTURES AND NEW JERSEY ... - New Jersey Resources
[3] The country's largest floating solar system keeps water clean
[4] America's largest floating solar project completed
[5] Large floating solar array set for US sand miner Clayton
[6] Large floating solar array set for US sand miner Clayton - List.Solar



4.4MWdc Sayreville FPV



8.9MWdc Canoe Brook FPV



3.2Wdc Clayton Sands FPV

Attachment 1a – Overarching Regulatory , Policy or Guidance

November 6, 2020 comments from Office of Permitting & Project Navigation

Felix Aguayo

From:	Nolan, Katherine <Katherine.Nolan@dep.nj.gov>
Sent:	Friday, November 6, 2020 1:21 PM
To:	Jendrasiak, Ryan; Michael J. Gross Esq.; sgouin@ghclaw.com; Scott Hesser; Rod Viens; Thomas Leyden; Felix Aguayo; Lloyd Naideck; James Stachura; Tim Eustace
Cc:	Ryan, Patrick; Contois, Dennis; Dow, Diane; Keller, Colleen; Albizati, Christina; Torok, Larry; Khan, Faraz; Clark, Kathy; Bowers, Jeanette; Davis, Kelly; Green, Keri; Hunter, Benjamin; Maresca, Vincent; Carper, Elizabeth; Myers, Stephen; Oman, Clint; Ray, Russell; Qureshi, Sana; Brunatti, Megan; Pepe, David; Rosenblatt, Jane
Subject:	Wanaque Reservoir Floating Solar-11/5/20 Meeting Follow-up
Attachments:	Wanaque Reservoir Floating Solar- LRP Comments.docx

EXTERNAL EMAIL: This email originated from outside the organization. Do not click links or open attachments unless you recognize the sender and are confident the content is safe.

Good Afternoon,

It was a pleasure to meet with you yesterday on the proposed Wanaque Reservoir Floating Solar Project.

If you wish to have additional follow-up meetings, please let our office know and we will coordinate and schedule the meeting accordingly. If you would like to work with the programs directly, we just ask that you keep us copied on any correspondence so we may update our records.

To close out this email, below is a courtesy conceptual summary of possible permits and action items this project may require (but not limited to): *** this is neither a comprehensive nor a technical summary ***

Land Resources Protection: Dennis Contois (Dennis.Contois@dep.nj.gov), Patrick Ryan (Patrick.Ryan@dep.nj.gov), Diane Dow (Diane.Dow@dep.nj.gov), Colleen Keller (Colleen.Keller@dep.nj.gov), Christina Albizati (Christina.Albizati@dep.nj.gov), Larry Torok (Larry.Torok@dep.nj.gov), Faraz Khan (Faraz.Khan@dep.nj.gov).

- Individual Permit likely required for fill in an open water.
    - More information needed on anchoring system and design specs for a more detailed permitting discussion.
- Since the panels will be located within a floodway, a Flood Hazard IP is required with a hardship waiver.
    - *N.J.A.C 7:13-11.3.*
- Please see additional written comments provided by DLRP's Threatened and Endangered Species Unit regarding the Bald Eagle foraging habitat concerns.
- Follow-up meeting with Land Resources Protection recommended when more information is available.

New Jersey Fish and Wildlife & ENSP: Kathy Clark (Kathy.Clark@dep.nj.gov), Jeanette Bowers (Jeanette.Bowers@dep.nj.gov), Kelly Davis (Kelly.Davis@dep.nj.gov).

- 2 Bald Eagles nests have been mapped at the site. The 1st nest has recently moved further away from the proposed site, and the second nest is approximately 3.5 miles north of the project area.
- Coverage of the surface area by the solar panels is a concern for both Bald Eagle foraging habitat as well as aquatic life.
- Any data that the applicant could provide on the aquatic life would be helpful to review.
- If there are any studies available regarding the impacts of the floating panels on aquatic life, please share with DEP.

Highlands Council: Keri Green (Keri.Green@Highlands.nj.gov)

Please accept the following as the Highlands Council's comments on the referenced permit readiness checklist. The property lies in the Preservation Area of the Highlands Region, and as such is subject to the Highlands Water Protection and Planning Act, (NJSA 13:20), the NJDEP Highlands Water Protection and Planning Act Rules (NJAC 7:38) and the Highlands Regional Master Plan (RMP). Please note that NJAC 7:38-3.6(b) states no Major Highlands Development is to be sited in Highlands Open Waters or their associated 300 foot buffer. The Highlands Regional Master Plan supports this at Objective 1D4b.

The NJDWSC Wanaque Reservoir facility, as a public utility, should consult with the NJDEP Division of Land Resource Protection regarding whether or not a Highlands Act Exemption #11 would be applicable to this project. This exemption allows for the "routine maintenance and operations, rehabilitation, preservation, reconstruction, repair or upgrade of public utility lines, rights of way, or systems, by a public utility, provided that the activity is consistent with the goals and purposes of the Highlands Act". NJDEP issues those exemptions in the Preservation Area, and the Highlands Council consults with the Division as to whether the project is consistent with the goals and purposes of the Highlands Act.

If more information is needed or you have questions regarding these comments, please do not hesitate to contact me. We would like to be included any eventual meeting with the applicant.

Dam Safety: Clint Oman (Clint.Oman@dep.nj.gov) and Russell Ray (Russell.Ray@dep.nj.gov)

The Wanaque Reservoir is formed by a series of High Hazard dam structures which are regulated by the Bureau of Dam Safety. Based on the proposed location of the solar array in relation to the Raymond Dam and the Overflow Spillway, the Bureau of Dam Safety would need to review and approve the project relative to any dam safety issues. The following comments will need to be addressed by the applicant:

- The proposed plan includes "MV" underground and below ground circuits running along the crest of Raymond Dam. Additional details will need to be provided to ensure the circuits do not impact the safety of the dam or proper operation/maintenance/inspection of the structure.
- Details on the proposed anchoring to the reservoir bottom would need to be provided to ensure the anchoring does not adversely impact any of the dams or spillway.
- The proposed location of the array (Rev. C) is in close proximity of the Overflow spillway. Unimpeded operation of the spillway is critical to the safe performance of the dams, so it must be confirmed that the proposal will not impact the operation of the spillway. In addition, it must be ensured that the array is sufficiently anchored to ensure that the array can not become dislodged during required design storm events and block the spillway or reduce spillway flow.

SHPO: Vincent Maresca (Vincent.Maresca@dep.nj.gov)

- **Historic Architecture:** Upon review, the proposed project is located within the Wanaque Reservoir Historic District which is eligible for listing on the New Jersey and National Registers of Historic Places (SHPO Opinion: 3/2/2006). Specifically, the proposed project includes installing circuits along Raymond Dam which is a contributing resource to the historic district. *If subject to formal regulatory review, the HPO would recommend an assessment of effects of project impacts on the New Jersey and National Register eligible-Raymond Dam*
- **Archaeology:** Upon review, there are no archaeological sites identified within the proposed project area. In addition, based on the geographic location of the project area and limited proposed ground disturbance, there is a low potential to encounter Pre-Contact period and historic period archaeological resources. *If subject to formal regulatory review, the HPO would not recommend any further archaeological survey.*
- Thank you for providing this opportunity for review and comment on the potential for this project to affect historic and archaeological resources. Please reference the HPO project number 21-0023 in any future calls, emails, or written correspondence to help expedite your review and response.

Site Remediation: Sana Qureshi (Sana.Qureshi@dep.nj.gov)

The applicant should check Geoweb (including determining whether fill material is located at the property) and the NJ's Known Contaminated Sites list to determine whether the project is located on a known contaminated site. In accordance with the Solar Act, the applicant should ensure the solar development does not interfere with any remediation.

Clean Energy & Climate Change: Elizabeth Carper (Elizabeth.Carper@dep.nj.gov)

- The proposed floating solar array is located on a reservoir which is identified as "indeterminate" per the Solar Siting Analysis, meaning more information is needed to determine if solar is feasible at this location.
- Visit the BCCCE Solar Siting webpage https://www.state.nj.us/dep/aqes/solar-siting.htm
- BES would be interested in any studies/research you can provide on floating solar projects.

NJBPU: Scott Hunter (Benjamin.Hunter@dep.nj.gov)

- The applicant will have 1 year to construct after a TREC submission. Important to keep in mind with permitting timeframes.
- The successor program is anticipated to start early 2021.
- There is a pending petition to the Board for reconsideration of the TREC factor.

Next Steps:

- Provide additional information
- Additional meetings/consultation as necessary.

Should circumstances or conditions be or become other than as set forth in the information that was recently provided to the NJDEP, the comments and regulatory requirements provided above are subject to change and may no longer hold true. Statements made within this email are not indicative that the NJDEP has made any decisions on whether the proposed project will be permitted. OPPN looks forward to working with you on the proposed project.

If you have any questions or concerns, please let me know.

Katie Nolan
New Jersey Department of Environmental Protection
Office of Permitting & Project Navigation (formerly Permit Coordination)
401 East State Street
Trenton, NJ 08625-0420
Mailcode: 401-07J

Office #: (609) 272-3600
Direct #: (609) 984-6506
Fax #: (609) 633-1196
Email: Katherine.Nolan@dep.nj.gov

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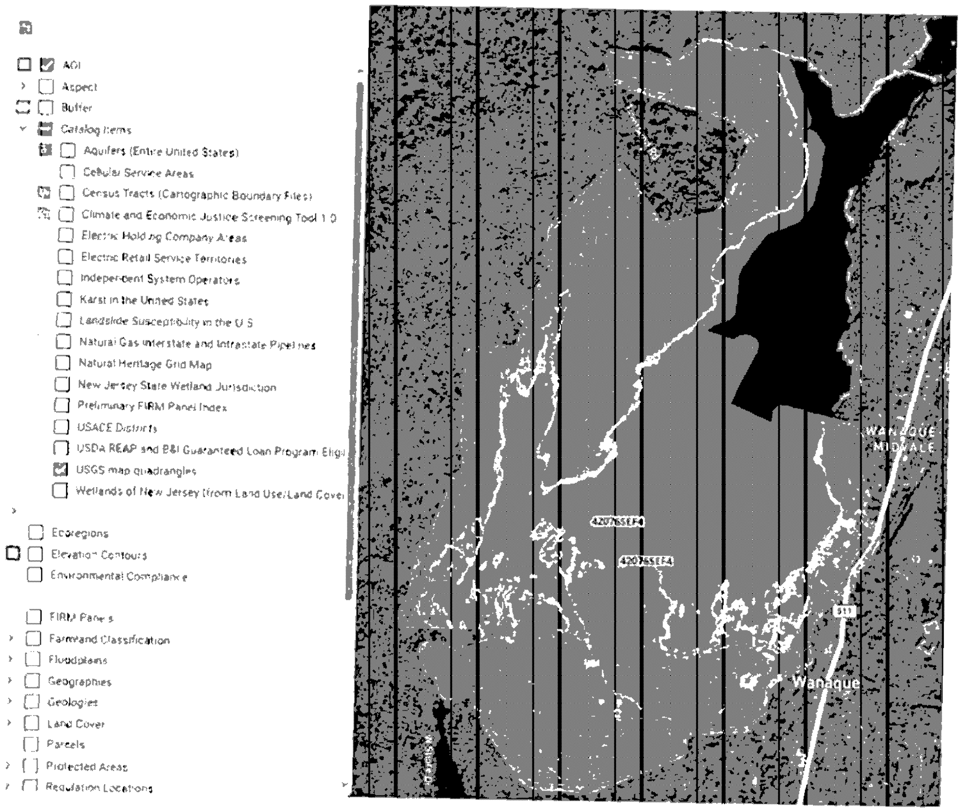
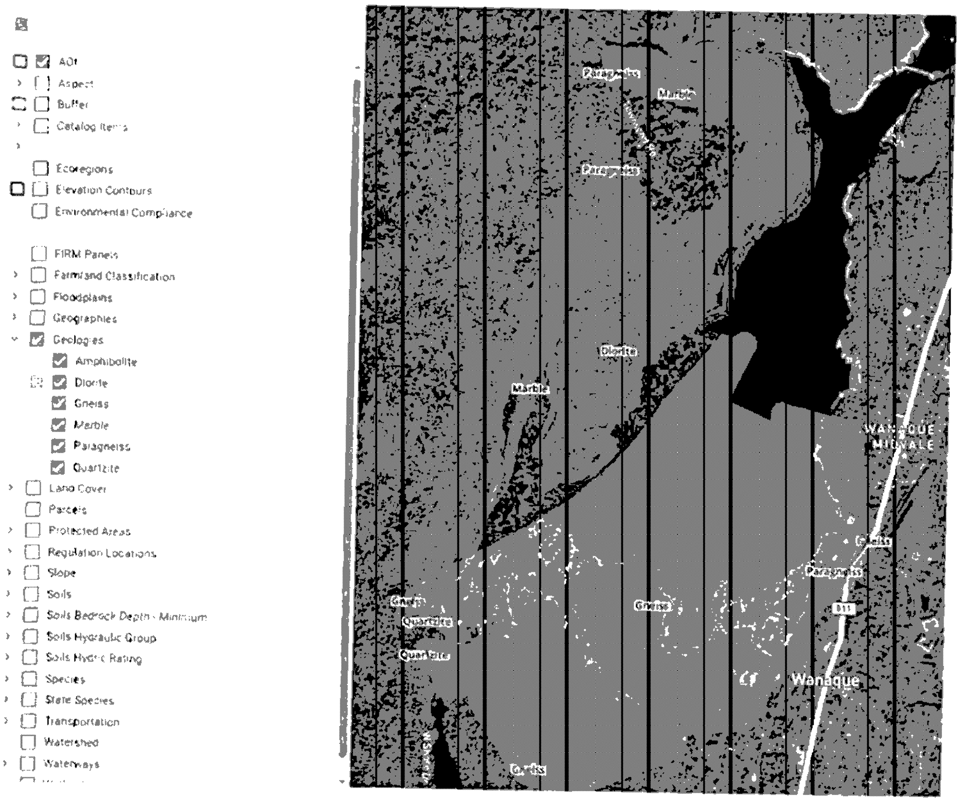
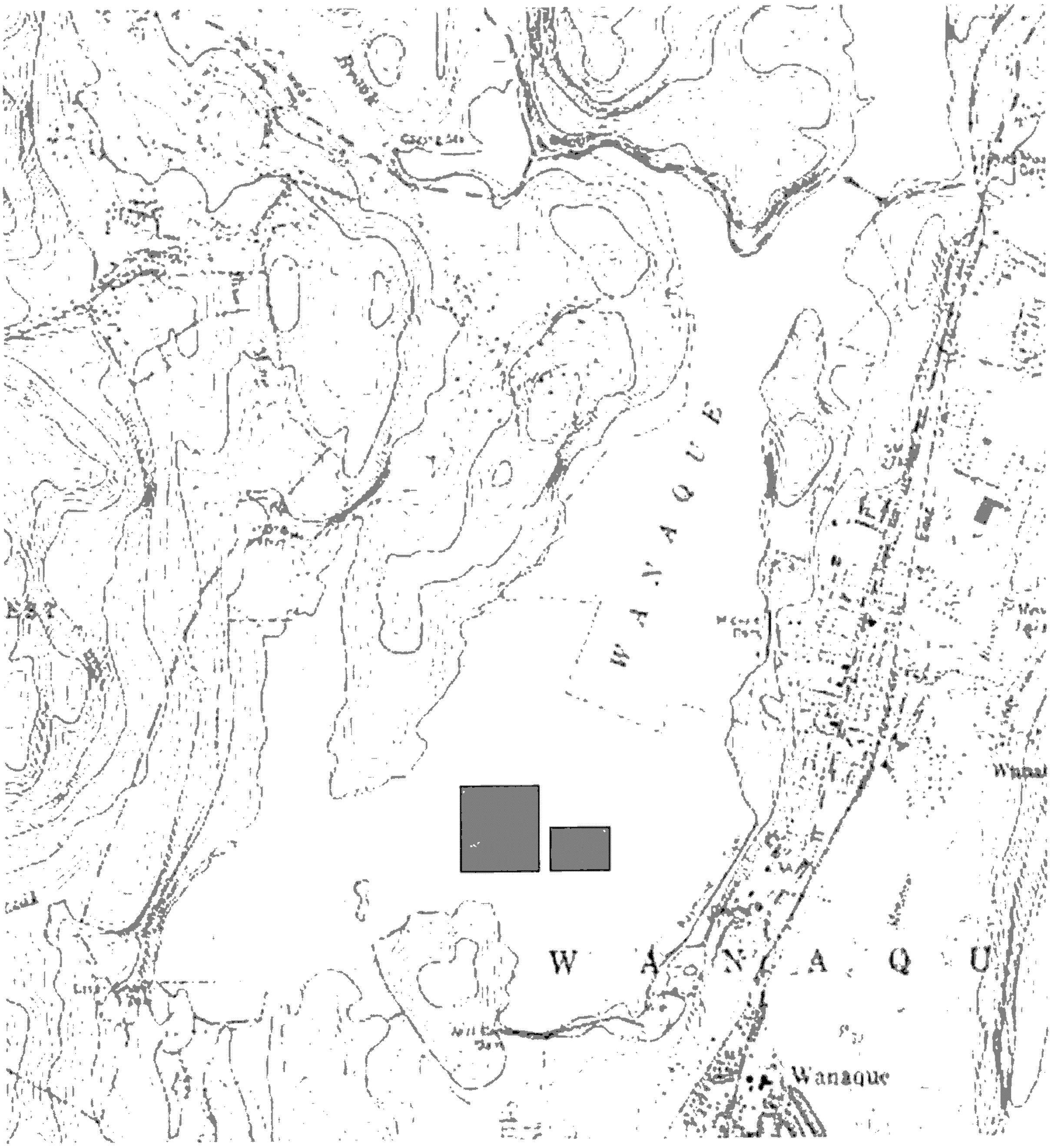
STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Attachment 2 – US Geological Survey with Site Boundaries and Proposed Project



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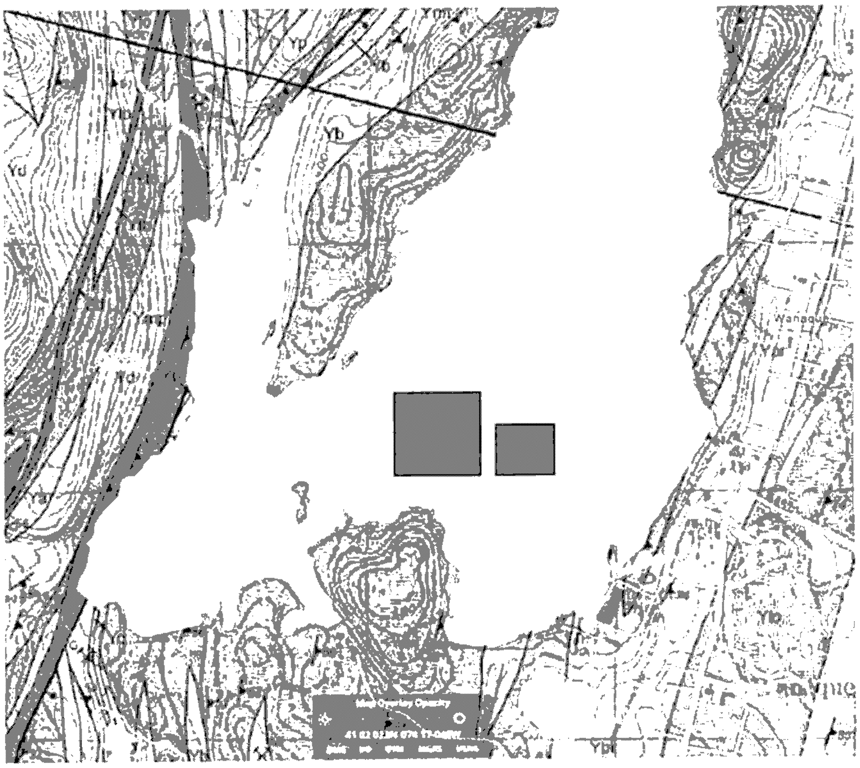
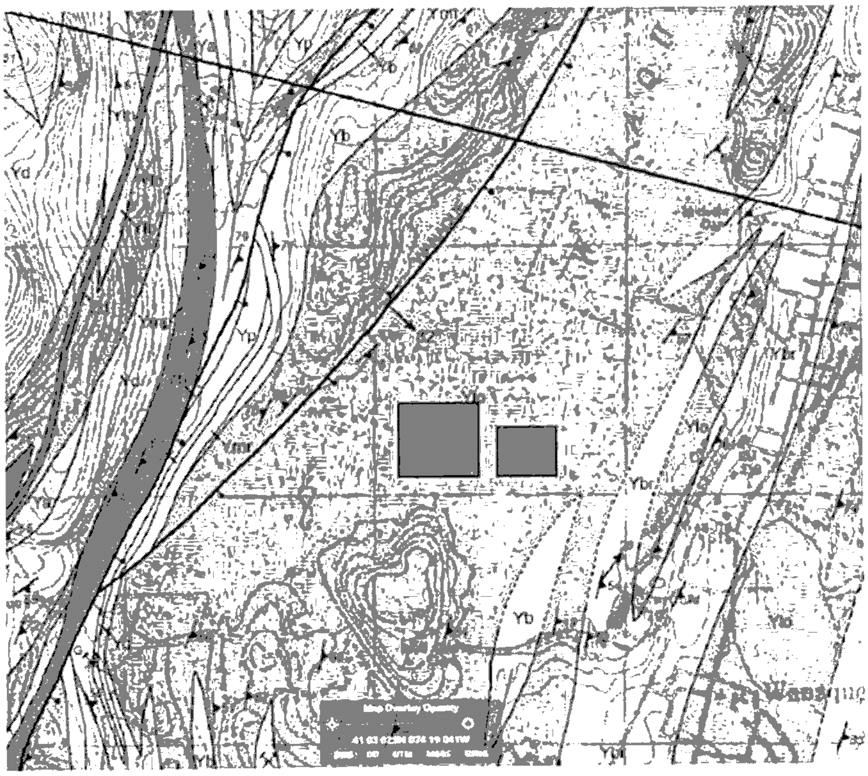




NEW JERSEY HIGHLANDS

Ygm

Mount Eve Granite (Mesoproterozoic) - Granite, light-gray to pinkish-gray, medium- to coarse-grained, massive

Ybu

Byram Intrusive Suite, undivided (Mesoproterozoic) - Granite, alaskite, quartz monzonite, and monzonite. Pinkish-white or light pinkish-gray, medium- to coarse-grained, massive

Ylhu

Lake Hopatcong Intrusive Suite, undivided (Mesoproterozoic) - Granite, alaskite, quartz monzonite, and monzonite. Greenish-gray, medium- to coarse-grained, massive

Yf

Marble (Mesoproterozoic) - Marble, white or grayish-white, fine- to coarsely crystalline, calcitic to locally dolomitic. Host rock of Franklin and Sterling Hill zinc-iron-manganese deposits

Ymu

Metasedimentary and metavolcanic rocks, undifferentiated (Mesoproterozoic) - Gneiss, locally rusty, pinkish-white, light-gray, or greenish-gray, medium-grained, moderately foliated to well layered

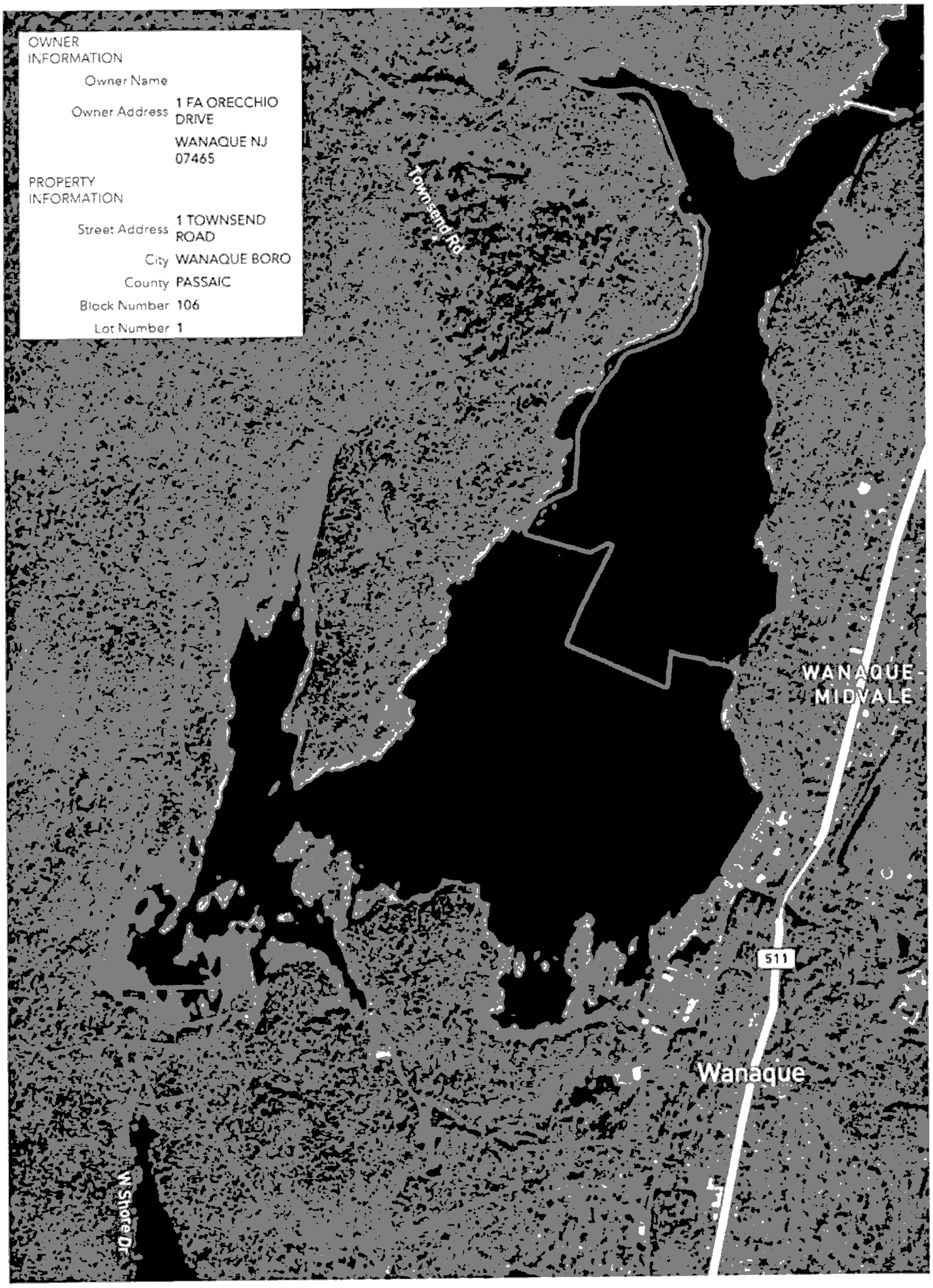
Ylu

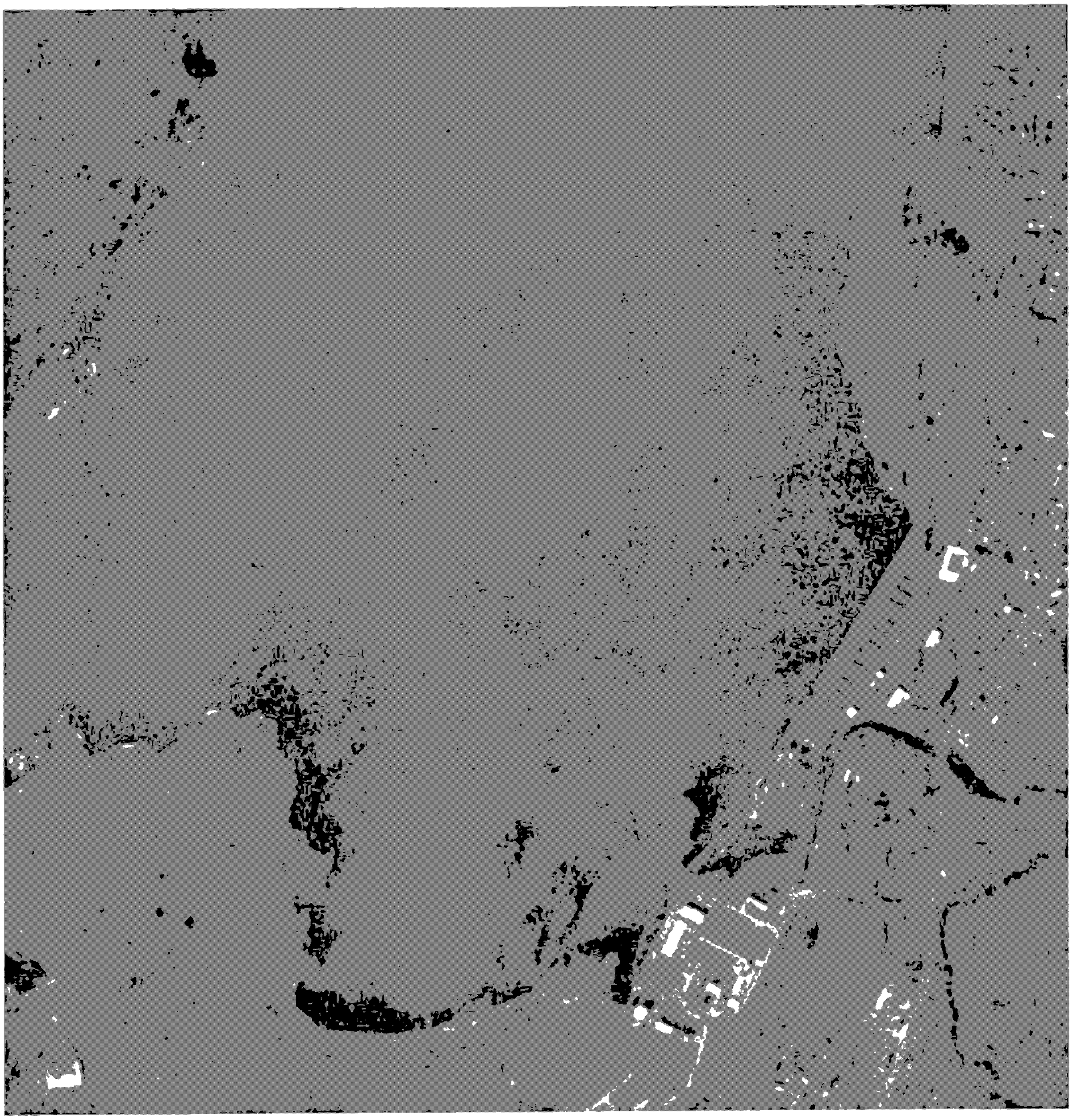
Losee Metamorphic Suite, undivided (Mesoproterozoic) - Gneiss, granite and metadiorite, light-greenish-gray or greenish-gray, medium- to coarse-grained, massive to layered

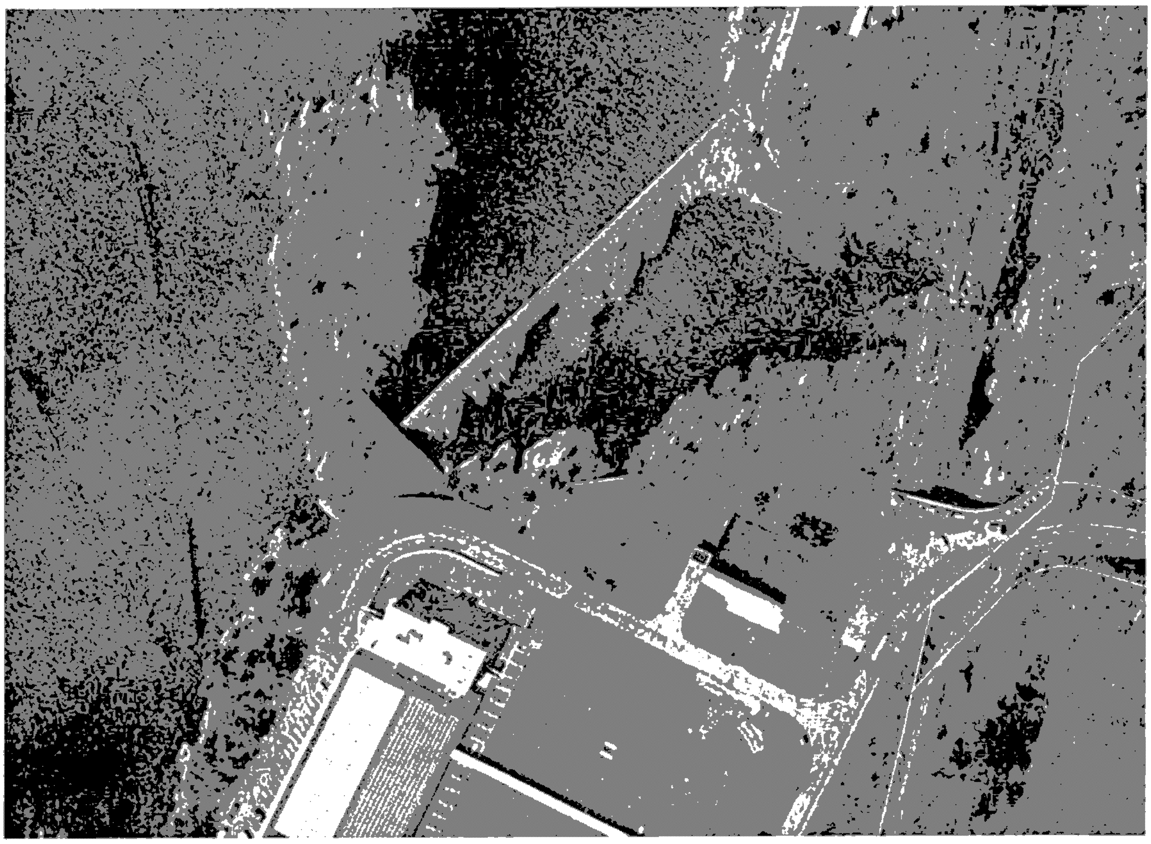
Yu

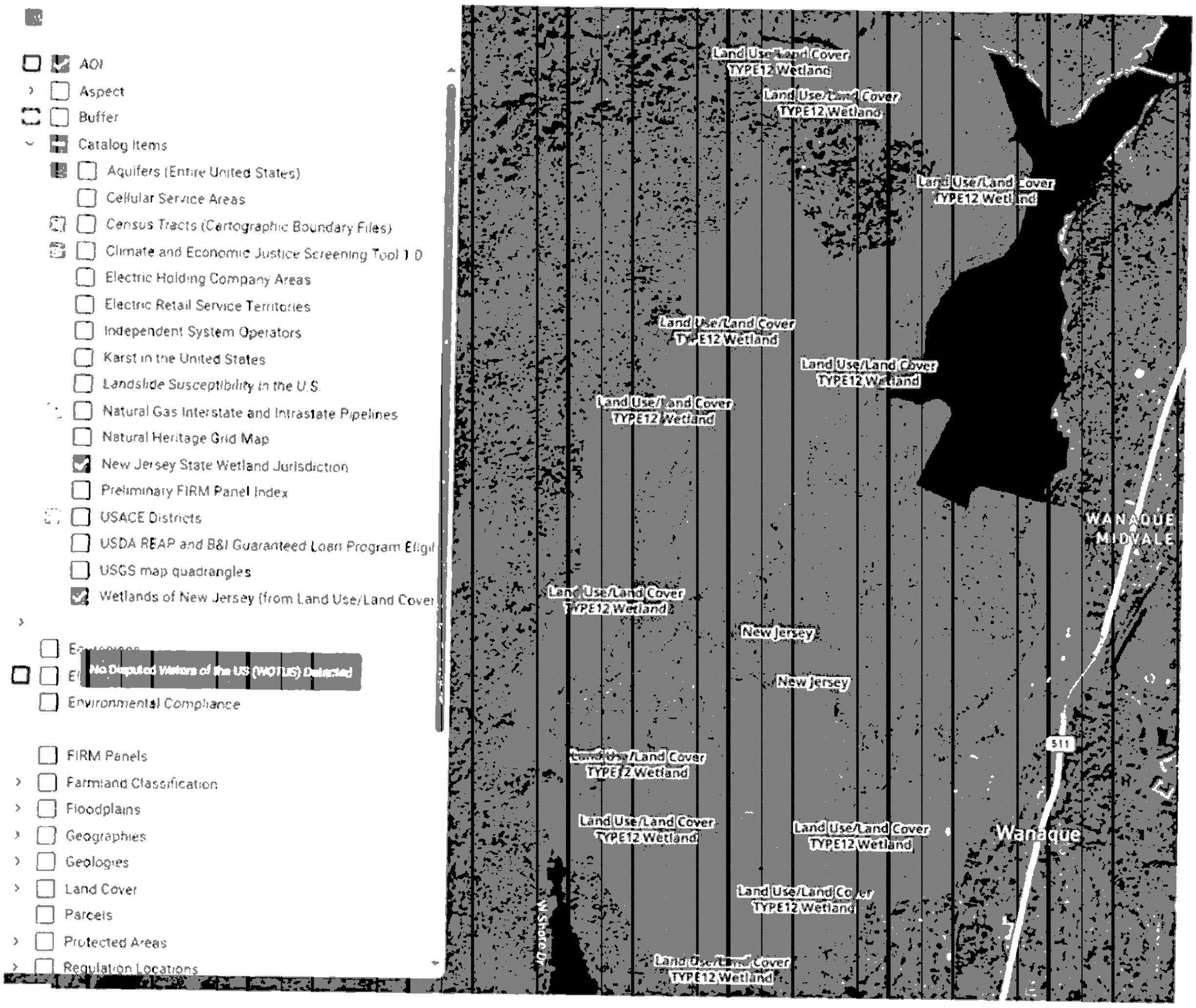
Amphibolite, mafic gneiss and microantiperthite alaskite, undifferentiated (Mesoproterozoic) - Amphibolite and mafic gneiss - Grayish-black, fine- to medium-grained, foliated. Microantiperthite alaskite - Light greenish-gray, medium- to coarse-grained, massive

Attachment 3 – Aerial Photos and GIS Information of the Site





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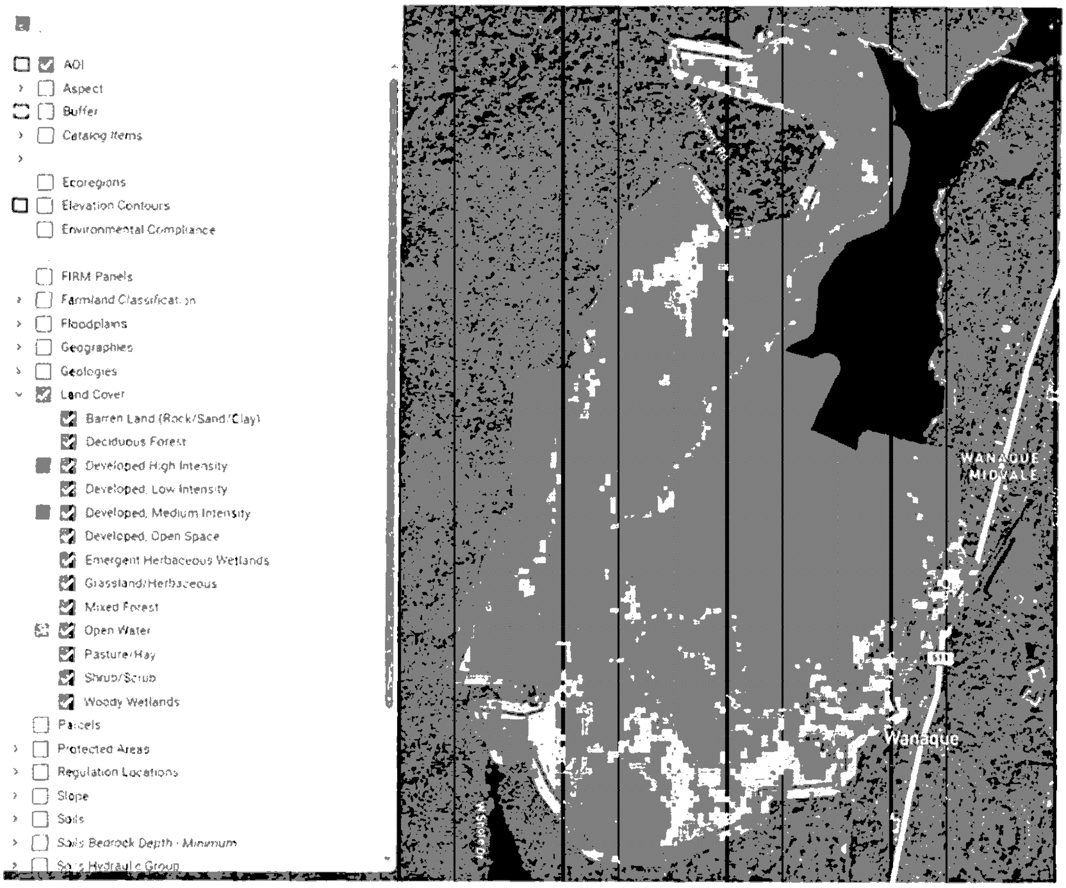
Catalog Items
Aquifers (Entire United States)
Cellular Service Areas
Census Tracts (Cartographic Boundary Files)
Climate and Economic Justice Screening Tool 1.0
Electric Holding Company Areas
Electric Retail Service Territories
Independent System Operators
Karst in the United States
Landslide Susceptibility in the U.S.
Natural Gas Interstate and Intrastate Pipelines
Natural Heritage Grid Map
New Jersey State Wetland Jurisdiction
Preliminary FIRM Panel Index
USACE Districts
USDA REAP and B&I Guaranteed Loan Program Eligi
USGS map quadrangles
Wetlands of New Jersey (from Land Use/Land Cover
No Disputed Waters of the US (WOTUS) Detected
Environmental Compliance
FIRM Panels
Farmland Classification
Floodplains
Geographies
Geologies
Land Cover
Parcels
Protected Areas
Regulation Locations
Land Use/Land Cover
TYPE12 Wetland
New Jersey
WANAQUE
MIDVALE
511
Wanaque
W Shore Dr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Ecoregions
Elevation Contours
Environmental Compliance
FIRM Panels
Farmland Classification
Floodplains
Geographies
Geologies
Land Cover
Barren Land (Rock/Sand/Clay)
Deciduous Forest
Developed High Intensity
Developed, Low Intensity
Developed, Medium Intensity
Developed, Open Space
Emergent Herbaceous Wetlands
Grassland/Herbaceous
Mixed Forest
Open Water
Pasture/Hay
Shrub/Scrub
Woody Wetlands
Parcels
Protected Areas
Regulation Locations
Slope
Soils
Soils Bedrock Depth - Minimum
WANAQUE
MIDVALE
511
Wanaque


AOI
Aspect
Buffer
Catalog Items
Ecoregions
Elevation Contours
Environmental Compliance
FIRM Panels
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Barren Land (Rock/Sand/Clay)
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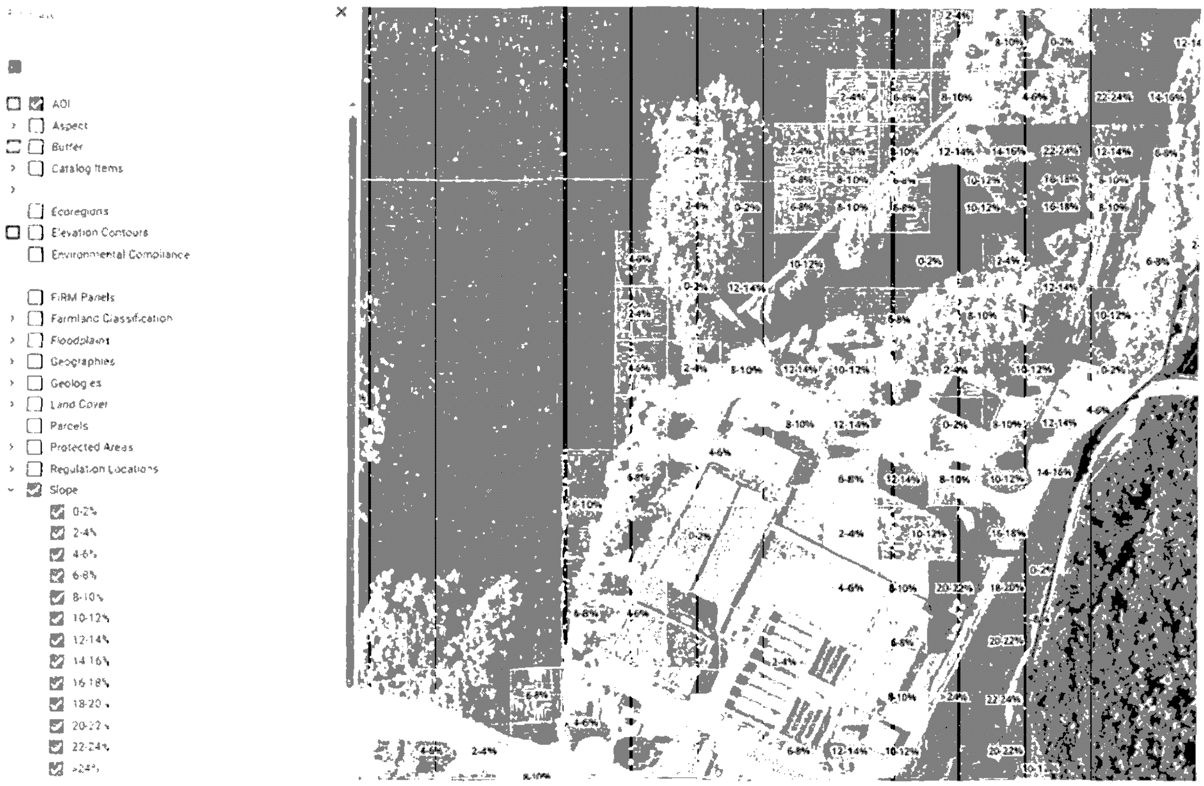
Shrub/Scrub
Woody Wetlands
Parcels
Protected Areas
Regulation Locations
Slope
Soils
Soils Bedrock Depth - Minimum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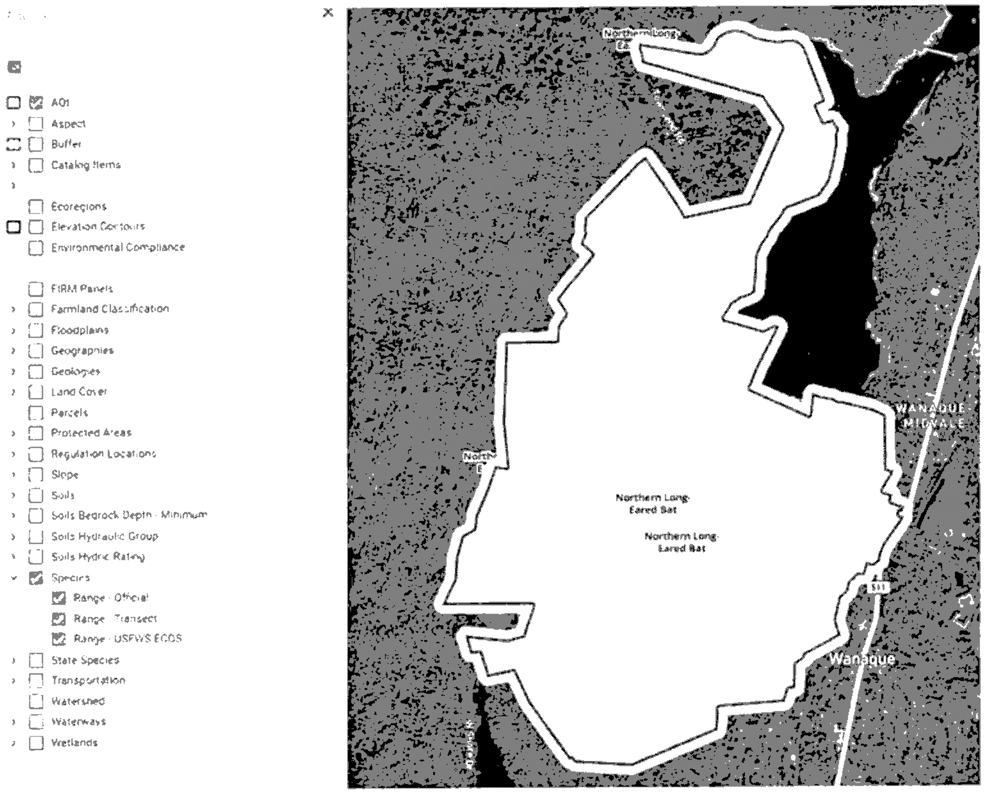
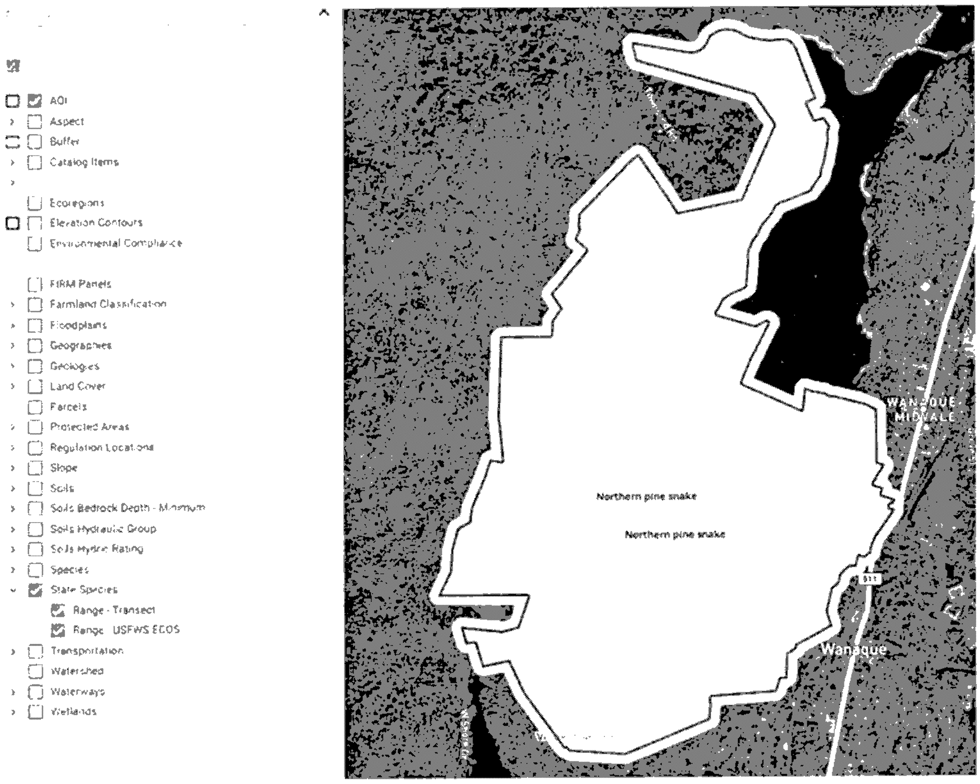
Farmland Classification
Floodplains
Geographies
Geologies
Land Cover
Parcels
Protected Areas
Regulation Locations
Slope
0-2%
2-4%
4-6%
6-8%
8-10%
10-12%
12-14%
14-16%
16-18%
18-20%
20-22%
22-24%
>24%

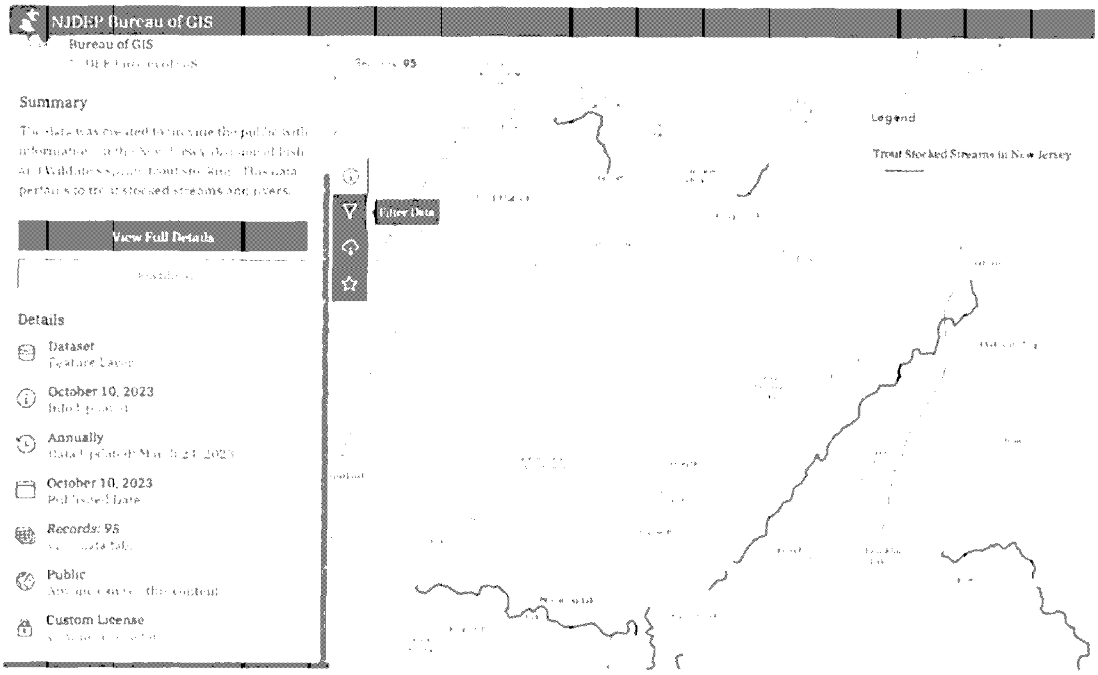

NJ-GeoWeb
New Jersey Department of Environmental Protection BGIS
Legend
Historic Fill
Historic Fill
Quadrangles Not Mapped
No Fill
Municipalities
Camp
Westbrook Rd
Audubon Society
Gallo
Townsend Rd
Wanaque Reservoir
Wanaque
Ringwood Ave
511
Wanaque Borough

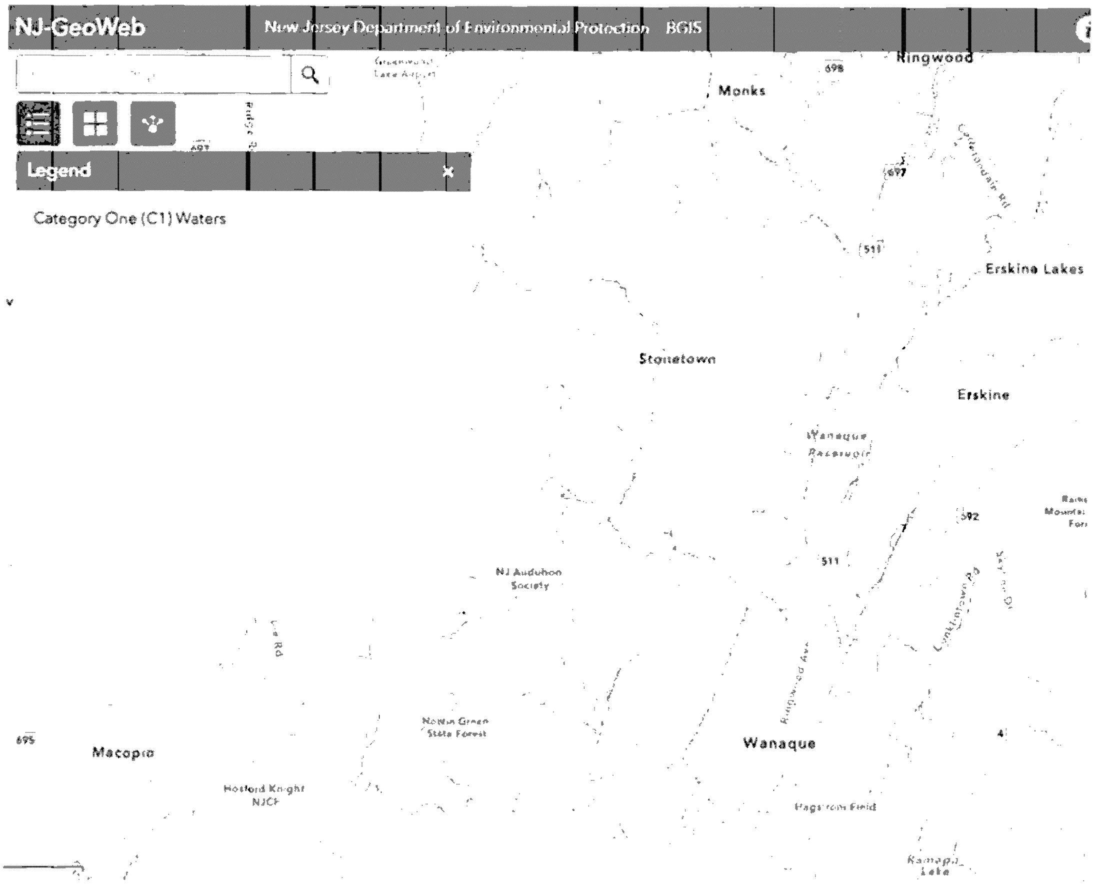

NJ-GeoWeb
New Jersey Department of Environmental Protection BGIS
Legend
Known Contaminated Site List
Municipalities
NJPDES Regulated Facility Locations
Site Remediation Program Preferred ID Sites
Active
Active - UHOT
RAP\Post Remedial
Closed
Pending
Camp
Audubon Society
Gallo
Wanaque
Wanaque Borough
Hagstrom Field
511

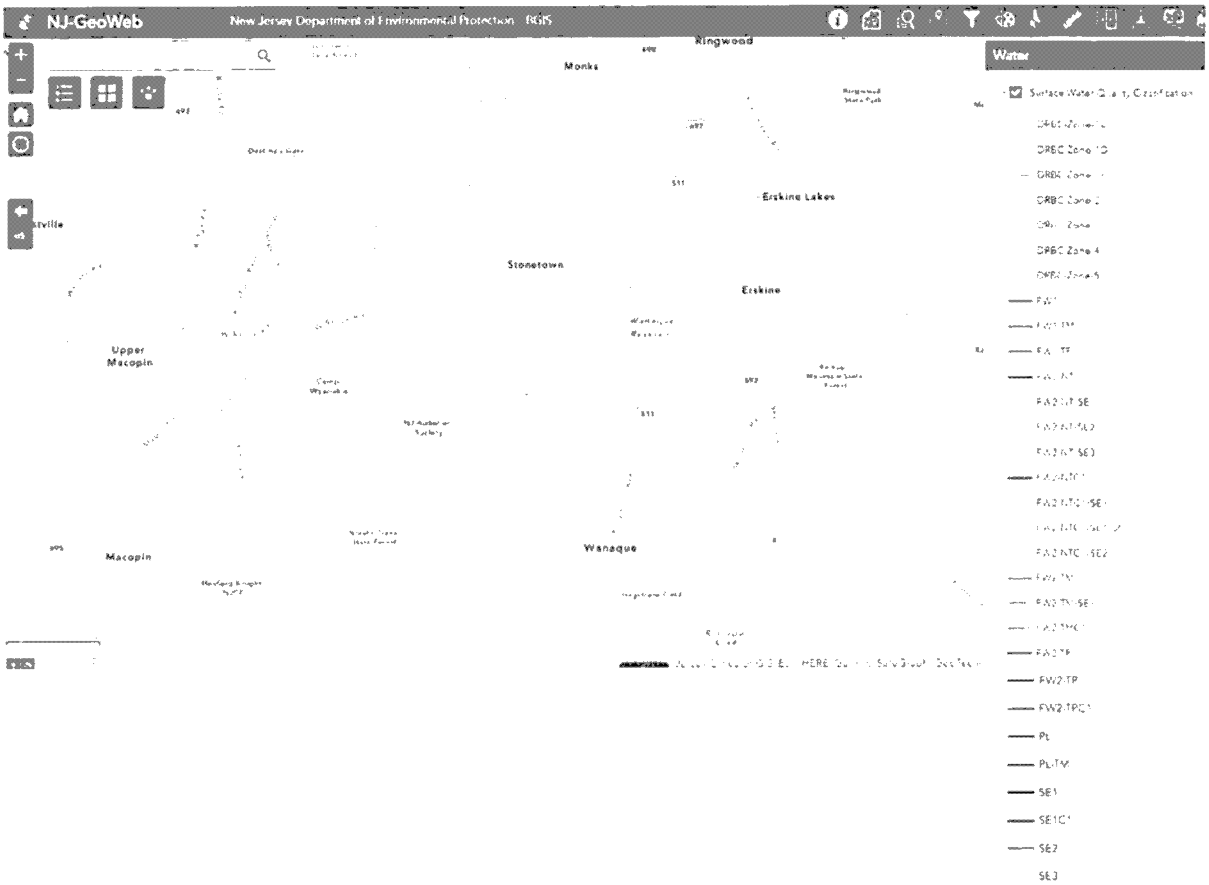
Attachment 4 – Site Map including known Environmental Features





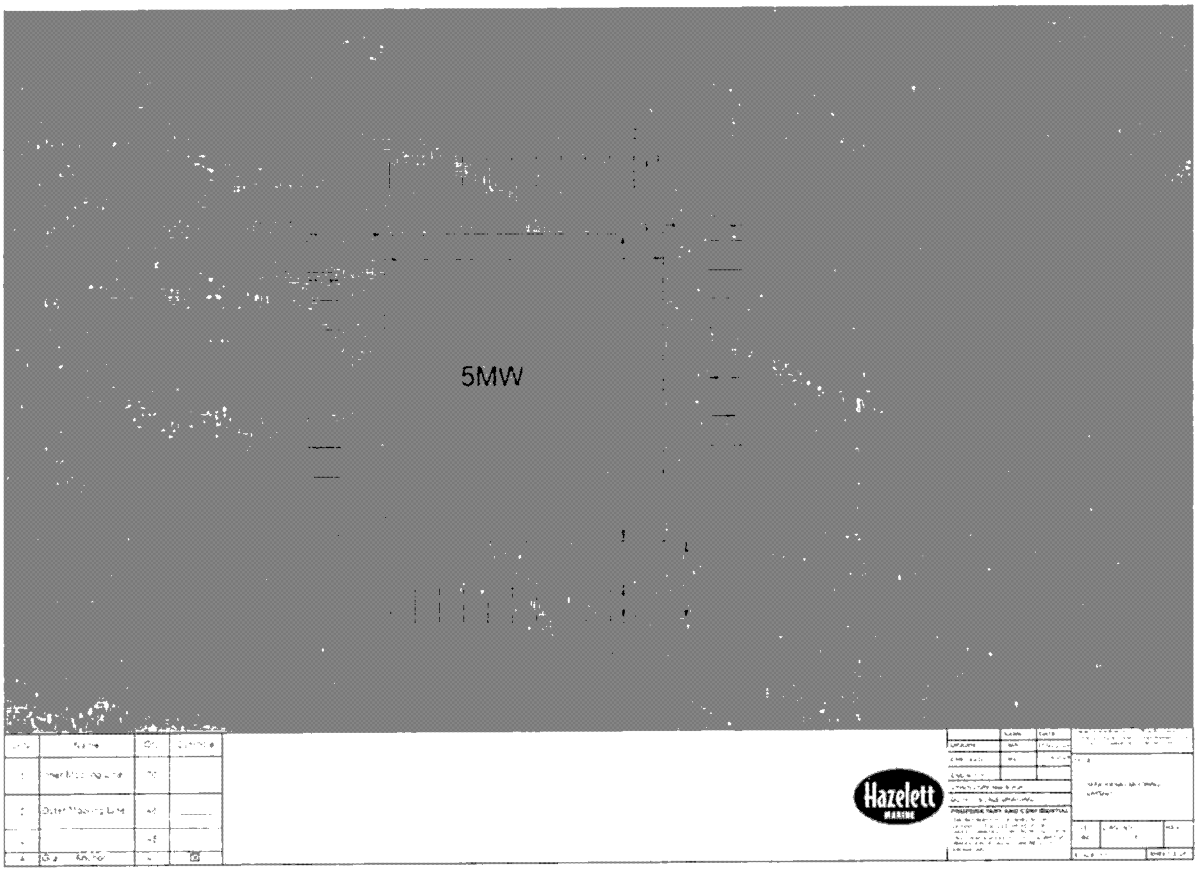

NJDEP Bureau of GIS
Bureau of GIS
Summary
View Full Details
Details
Dataset
October 10, 2023
Annually
October 10, 2023
Records: 95
Public
Custom License
Filter Data
Legend
Trout Stocked Streams in New Jersey


NJ-GeoWeb
New Jersey Department of Environmental Protection BGIS
Legend
Category One (C1) Waters
Ringwood
Monks
Erskine Lakes
Stonetown
Erskine
Wanaque Reservoir
NJ Audubon Society
Wanaque
Macopin
Hosford Knight NJCF
Norvin Green State Forest
Ramapo Lake

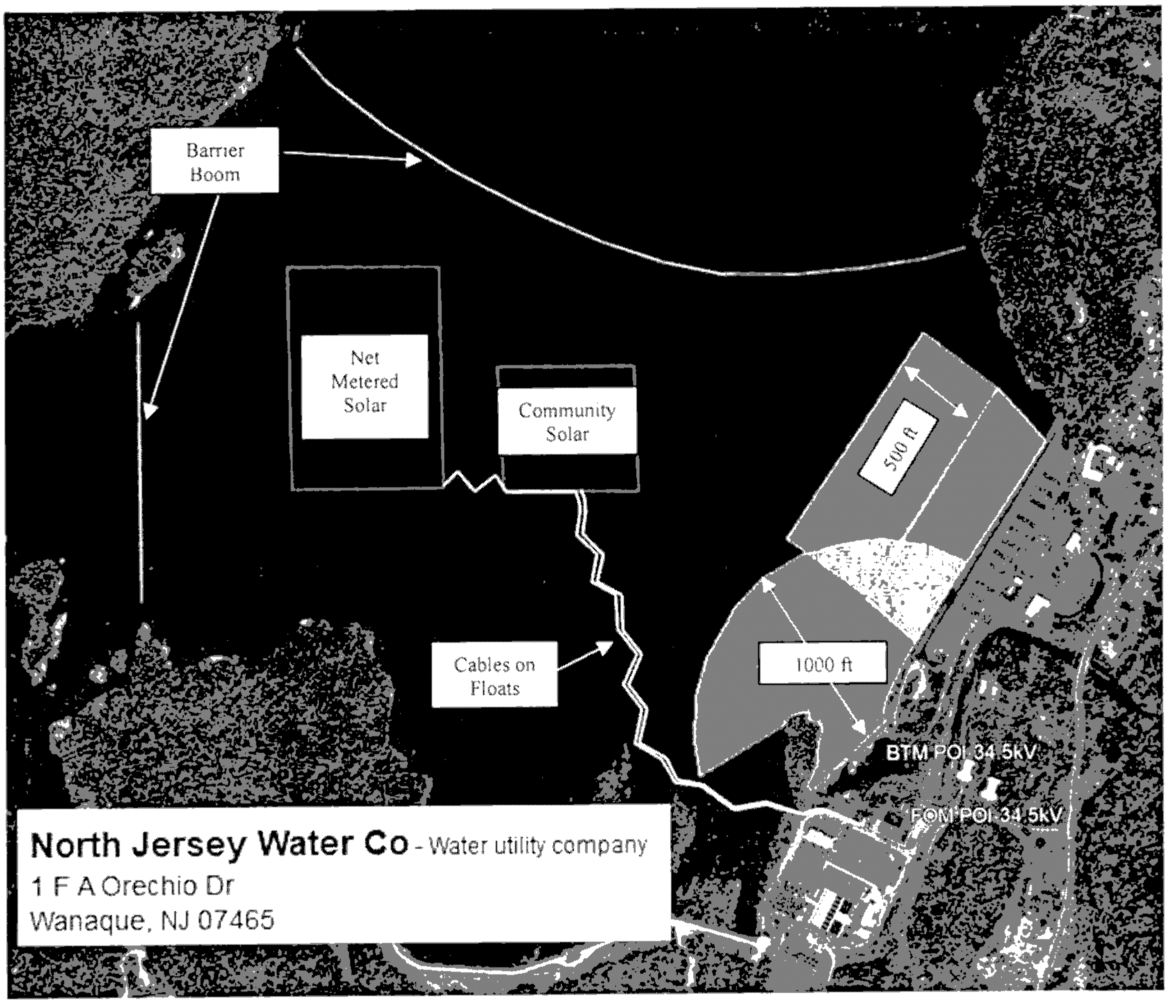

NJ-GeoWeb
New Jersey Department of Environmental Protection BGIS
Ringwood
Monks
Erskine Lakes
Stonetown
Erskine
Upper
Macopin
Wanaque
Macopin
Water
Surface Water Quality Classification
FW2-TP
FW2-TPC1
PL
PL-TM
SE1
SE1C1
SE2
SE3

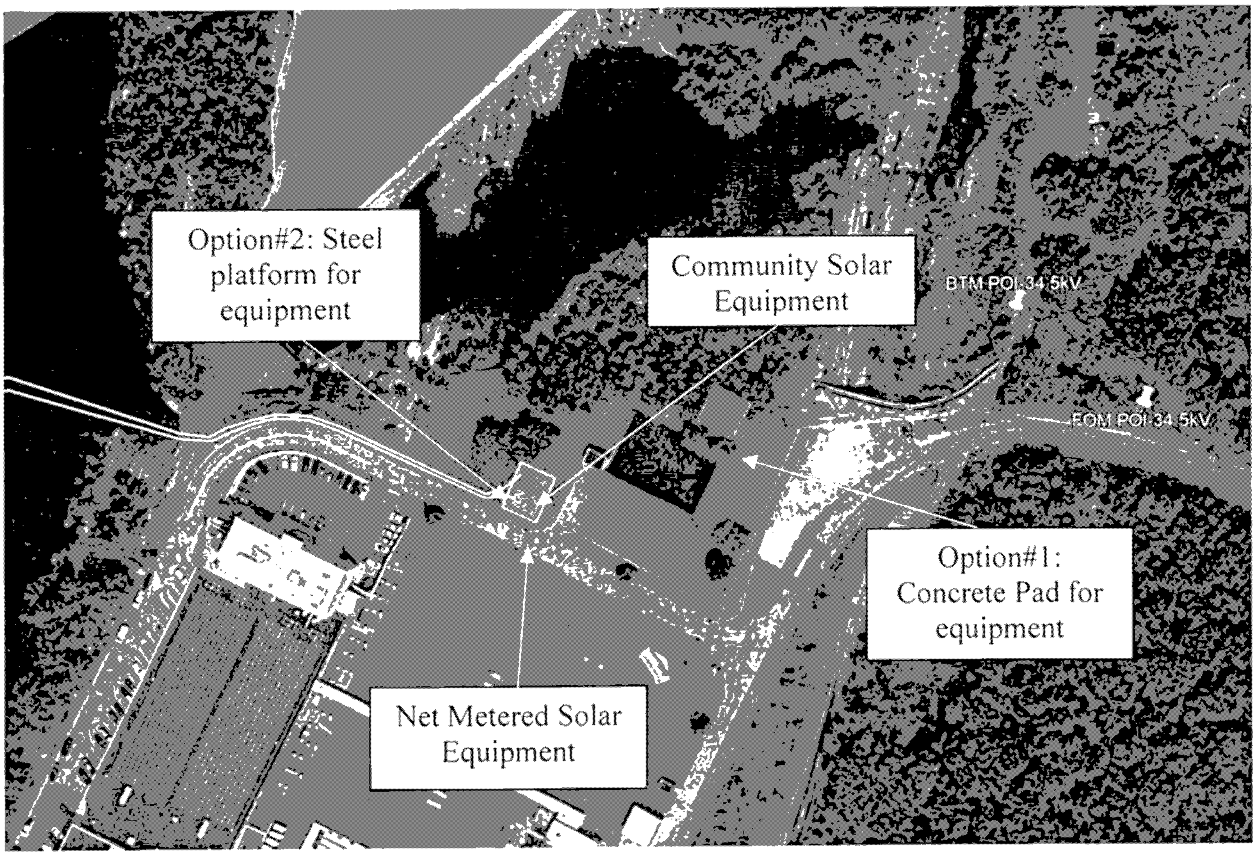
Attachment 5 –Site Plans (conceptual plans subject to revision)


10MW


5MW
Hazelett

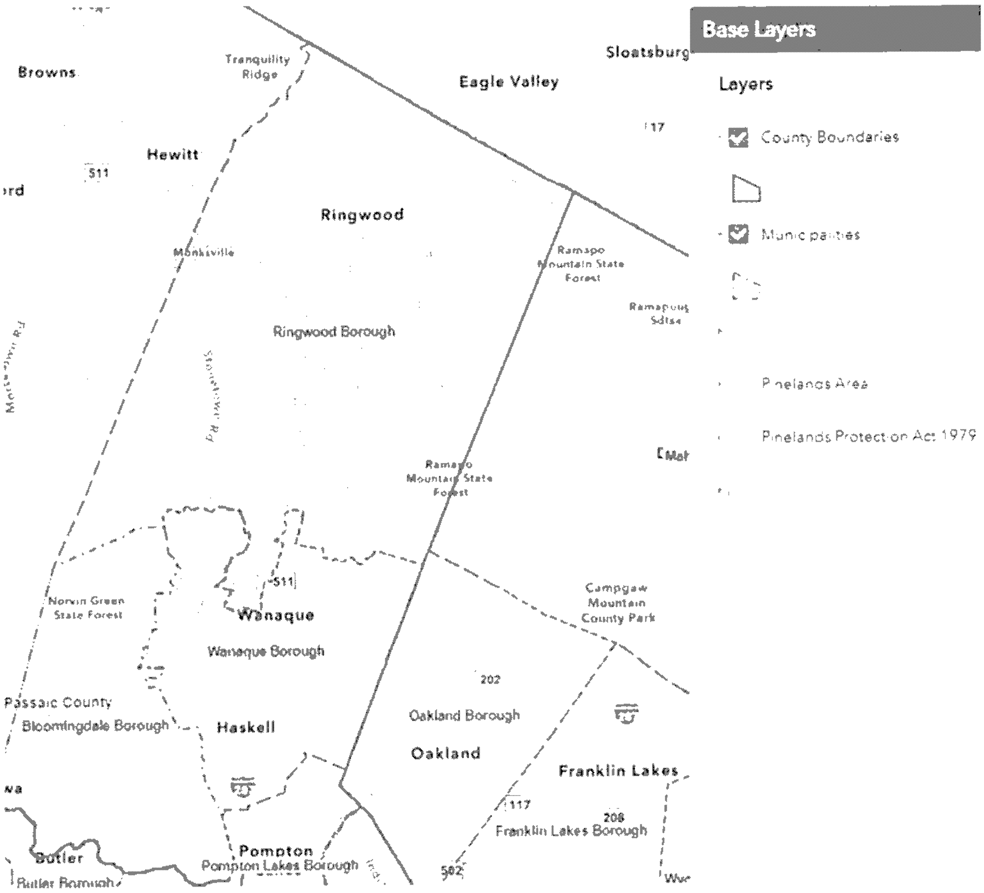
Attachment 6 Street Map indicating the location of the Proposed Project (Conceptual and subject to Change)

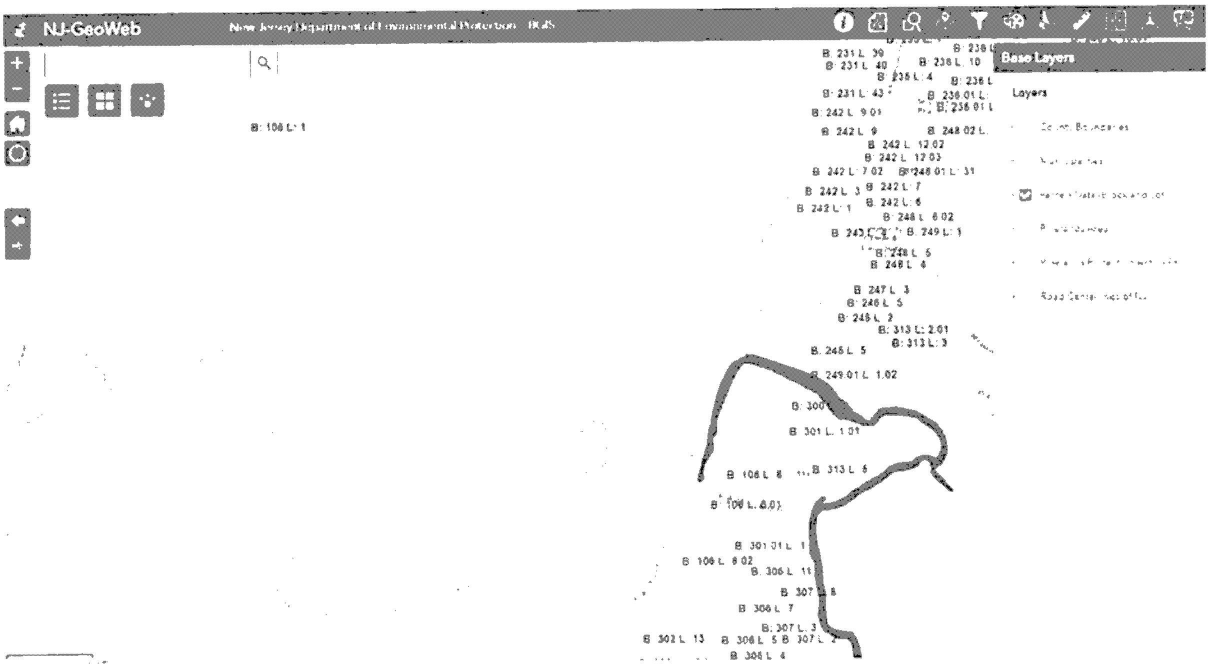



Option#2: Steel platform for equipment
Community Solar Equipment
BTM POI 34.5kV
FOM POI 34.5kV
Option#1: Concrete Pad for equipment
Net Metered Solar Equipment

EQUIPMENT PAD LOCATION

NORTH JERSEY DISTRICT WATER SUPPLY COMMISSION		FLOATING SOLAR EQUIPMENT PAD LOCATION ALTERNATIVES


Base Layers
Layers
County Boundaries
Municipalities
Pinelands Area
Pinelands Protection Act 1979
Browns
Tranquility Ridge
Sloatsburg
Eagle Valley
Hewitt
Ringwood
Ringwood Borough
Ramapo Mountain State Forest
Norvin Green State Forest
Wanaque
Wanaque Borough
Campgaw Mountain County Park
Passaic County
Bloomingdale Borough
Haskell
Oakland Borough
Oakland
Franklin Lakes
Franklin Lakes Borough
Pompton
Pompton Lakes Borough
Butler


NJ-GeoWeb
Base Layers
Layers

Attachment 7 – List of any local or regional governments or entities and their historical involvement with this project or Site.

SEE ATTACHED:

- **Highlands Applicability Determination**
- **The Land Conservancy – letter of Support**
- **Passaic County – Letter of Support**
- **IBEW Local Union 102 – Letter of Support**

From:	Castanhas, Karen (HIGHLANDS) on behalf of Plevin, Lisa (HIGHLANDS)
To:	Jennifer.Moriarty@dep.nj.gov
Cc:	Tropiano, Michael (DEP); Ryan, Patrick (DEP); Green, Keri (HIGHLANDS)
Subject:	Highlands Preservation Area Exemption Determination, Exemption #11, Floating Solar Installation – Wanaque Reservoir
Date:	Friday, April 23, 2021 10:06:00 AM
Attachments:	042321_EMAIL_HAD 11-NJDWSC_Floating Solar.pdf

Dear Ms. Moriarty,

On behalf of the Highlands staff, attached please find our response for the Highlands Preservation Area Exemption Determination, Exemption #11, Application for Highlands Applicability Determination (HAD), North Jersey District Water Supply Commission Floating Solar Installation, Wanaque Reservoir, Borough of Wanaque, Passaic County.

Note: Due to Highlands staff working remotely during the COVID-19 pandemic, please consider this email communication our formal response.

Thank you,
Lisa

Lisa Plevin
Executive Director

New Jersey Highlands Council
100 North Road (Route 513)
Chester, NJ 07930-2322
(908) 879-6737 ext. 101
(908) 879-4205 Fax

lisa.plevin@highlands.nj.gov
www.nj.gov/njhighlands

State of New Jersey
Highlands Water Protection and Planning Council
100 North Road (Route 513)
Chester, New Jersey 07930-2322
(908) 879-6737
(908) 879-4205 (fax)
www.nj.gov/njhighlands

Highlands Council
New Jersey

PHILIP D. MURPHY
Governor

SHEILA Y. OLIVER
Lt. Governor

CARL J. RICHKO
Chairperson

LISA J. PLEVIN
Executive Director

April 23, 2021

VIA EMAIL ONLY:
Jennifer Moriarty, Director
Bureau of Inland Regulation, Division of Land Resource Protection
New Jersey Department of Environmental Protection
Mail Code 501-02A
PO Box 420
Trenton, NJ 08625-0420

Re: **Highlands Preservation Area Exemption Determination, Exemption #11**
Application for Highlands Applicability Determination (HAD)
North Jersey District Water Supply Commission
Floating Solar Installation – Wanaque Reservoir
Borough of Wanaque, Passaic County

Determination: Consistent with Goals and Purposes of Highlands Act, with Specified Conditions

Dear Ms. Moriarty:

This letter is regarding the above-referenced application, which is currently before the New Jersey Department of Environmental Protection (NJDEP). The applicant seeks a Highlands Applicability Determination (HAD) on an exemption for a project proposed within the Highlands Preservation Area. The Highlands Act, at N.J.S.A. 13:20-28, specifies that a project deemed to be exempt is exempt from the Highlands Act as well as from the "the regional master plan, any rules or regulations adopted by the Department of Environmental Protection pursuant to this act, or any amendments to a master plan, development regulations, or other regulations adopted by a local government unit to specifically conform them with the regional master plan."

As you know, NJDEP determinations regarding Exemptions 9 and 11 in the Preservation Area are made in consultation with the New Jersey Highlands Council (Highlands Council), in accordance with the Highlands Act and NJDEP's Highlands Rules (N.J.A.C. 7:38-1.1 et seq.). Therefore, the Highlands Council has reviewed the subject project to determine the applicability of the Highlands Act and specifically whether this application meets the standard of eligibility for Exemption #11 of the Highlands Act ("the routine maintenance and operations, rehabilitation, preservation, . . ."), which mandates that a Highlands Act exemption is only to be granted "provided that the activity is consistent with the goals and purposes of the Highlands Act."

The North Jersey District Water Supply Commission (NJDWSC) oversees the operation of the largest regional water supply in the State of New Jersey, including more than 95-square-miles of watershed area, two major reservoirs, two river-diversion pumping stations, and a 210-million gallon/day (MGD) water filtration plant located at the Commission's headquarters in the Borough of Wanaque. At peak capacity, the Commission's facilities can serve the water needs of more than three million people in Northern New Jersey.

According to the information submitted with the application, the NJDWSC proposes the installation and operation of a floating solar facility, to be situated on the Wanaque Reservoir. The proposed design includes multiple floating solar arrays, or islands, anchored to the bottom of the reservoir and located approximately 300 feet from the shoreline in an area north of the Raymond Dam. Marine grade cables will deliver DC electricity from the solar arrays to electrical equipment, including inverters and oil-less transformers, installed on land. The marine grade cables will come ashore in a previously disturbed area. The onshore portion of the project is proposed for an area approximately 5,000 square feet in size. Electrical wiring from the transformers will be routed to an overhead, pole-mounted interconnection point located behind the NJDWSC's electrical meter. A new right of way (ROW) will be constructed through a wooded portion of the property. The entirety of the project will be on property owned by the NJDWSC. The solar array will cover approximately 20 acres of the surface of the reservoir. A separate area of disturbance is proposed north of West Brook Road, for an assembly and launch area. The area has been described as 2,500 square feet in size and the disturbance as temporary.

Highlands staff has reviewed the submitted materials and has assessed whether the project is consistent with the goals and purposes of the Highlands Act. To do this, staff first assessed what Highlands resources have the potential be affected by the project. These resources are: Highlands Open Waters and associated 300-foot Highlands Open Waters Protection Area, Total Forest Area and Critical Wildlife Habitat.

Highlands Open Waters: The floating solar arrays are proposed to occupy approximately 20 acres of the water surface of the reservoir. The total acreage of the reservoir is approximately 2,310 acres. The reservoir is mapped by the Highlands Regional Master Plan (RMP) as a Highlands Open Water, in which development is not permitted. However, as the size of the array is less than 1% of the total area of the reservoir, this is characterized as a de minimis impact. The panels will not affect the flow of stormwater, and in accordance with the Highlands Act, the panels themselves are not counted as impervious cover.

Highlands Open Waters Protection Area: The 300-foot buffer that surrounds all Highlands Open Waters is mapped for the areas proposed for the onshore electrical equipment, the new ROW and the northern assembly and launch area. These areas are described as disturbed, and contain roadways, developed parking, and ancillary facilities. However, these areas also drain to the reservoir and the associated reservoir outfall.

Total Forest Area: The vicinity of the proposed new ROW for overhead powerlines is mapped as Total Forest Area. The application materials calculate the forested area to be disturbed as 0.37 acres

Critical Wildlife Habitat: The application materials identified 24 endangered, threatened, and special-concern species as having suitable habitat present in the vicinity of the project, including 3 mammals, 17 birds, and 4 reptiles. Among these species, only bald eagle (*Haliaeetus leucocephalus*), cliff swallow (*Petrochelidon pyrrhonota*), and northern long-eared bat (*Myotis septentrionalis*) habitats have potential to be affected by project development. Potential impacts to bald eagle and cliff swallow habitat may arise from the siting of the floating solar array on or over foraging habitat. Potential impacts to northern long eared bat habitat may arise from the removal of the forested area for the new ROW.

Based on review of the application and associated documentation, the Highlands Council finds this project **Consistent with the Goals and Purposes of the Highlands Act with the following specified Conditions.** These conditions are separate from any condition which may be imposed by the New Jersey Department of Environmental Protection through subsequent permitting actions.

1) For the removal of the 0.37 acres of total forest, replanting to the standards of the No Net Loss Compensatory Reforestation Act (N.J.S.A. 13:1L-14.1 et. seq.) shall be accomplished on the NJDWSC property. By using the tree replacement factor of 204 balled and burlapped trees per acre of removal this amounts to replanting of 76 trees. The trees shall be of native species, common to the area, 2 inches diameter breast height, shall be appropriately irrigated and protected from deer browse. The plantings shall be monitored for 5 years and an 85% survival rate shall be assured. If mortality greater than 85% is noted, replanting shall occur. The applicant shall provide the Highlands Council with a replanting and monitoring plan for review and approval.

2) For disturbances to mapped critical wildlife habitat, the Highlands Council will defer to the NJDEP-Endangered and Nongame Program (ENSP) for conditions for avoiding, minimizing, and mitigating impacts to mapped habitat. The applicant shall provide copies of any plans developed to address concerns of the NJDEP-ENSP regarding critical wildlife habitats.

3) For the temporary disturbance to the northern assembly and launch area, provide the Highlands Council with a restoration plan for review and approval that includes appropriate soil conservation methodologies, replanting plan to include native species and monitoring of plantings.

4) Provide the Highlands Council with restoration and/or landscaping plans for the proposed 5,000 square foot disturbed area for the onshore equipment, in proximity to the solar arrays. These areas shall be restored upon completion of construction with native species, in compliance with other permit conditions.

5) Provide copies of all permit applications, and final permits to the Highlands Council.

The Highlands Council does not object to the NJDEP's issuance of an Exemption (No. 11) for this project. This determination is based upon the proposed project as described in the application (received March 12, 2021) for a HAD under Exemption #11 prepared by Colliers Engineering and Design, submitted on behalf of the NJDWSC. Should circumstances change, we reserve the right to modify this recommendation. This determination does not eliminate the need for any permits, approvals, or certifications required by the NJDEP or any federal, State, county, or municipal review agency with jurisdiction over this project/activity.

If you have any questions or require further assistance, please contact me at (908) 879-6737, extension 101 or by email at Lisa.Plevin@highlands.nj.gov.

Sincerely,

Lisa J. Plevin
Executive Director

c: Patrick Ryan, NJDEP-DLR
Michael Tropiano, NJDEP-DLR

THE LAND CONSERVANCY
OF NEW JERSEY

19 Boonton Avenue
Boonton, NJ 07005
Tel (973) 541-1010
Web tlc-nj.org

January 2, 2024

Mr. Tim Eustace
Executive Director
North Jersey District Water Supply Commission
744 Ridgeewood Avenue
Wanaque, NJ 07465

Dear Mr. Eustace,

The Land Conservancy of New Jersey supports the North Jersey District Water Supply Commission's application to construct a 10 15 MW floating solar photovoltaic system on the Wanaque Reservoir. Switching from current electric fuel sources to solar is an urgent priority to head off the dramatic negative effects of climate change This project will result in no damage to natural features in the Highlands Preservation Area and will likely have positive effects on the Wanaque Reservoir by providing shade to cool the water and provide additional fish habitat This project can also serve as a wonderful example for other government agencies to follow in doing their part to complete the much needed energy transition

The Land Conservancy of New Jersey urges fast permit approval for this critical project.

Sincerely yours,

David Epstein
President

ACCREDITED

COUNTY OF PASSAIC
Board of County Commissioners

September 26, 2024

New Jersey Board of Public Utilities
Clean Energy Program
44 Clinton Avenue
Trenton, New Jersey 08625

RE: Community Solar Development
Wanaque Community Solar FPV
1 F.A. Orechio Drive, Wanaque, New Jersey 07465

Dear New Jersey Board of Public Utilities Representatives

I am writing to express the County of Passaic's support for the Community Solar application proposed by Nexamp Solar, LLC for the development of a community solar project at 1 F A. Orechio Drive in Wanaque, New Jersey. This project will be located on the Wanaque reservoir using floating solar technology on open space not available for recreational use and with negligible impact to the environment. The County of Passaic is eager to have this new community solar project constructed, as it will help up to 1,000 residents benefit from renewable energy in the form of discounted electricity

The proposed solar project advances the County's goals and advances collaboration opportunities with companies like Nexamp and North Jersey District Water Supply Commission that make smart use of the "built environment" to provide additional benefits for communities throughout New Jersey

This project conforms to the State of New Jersey's guidelines and aligns perfectly with the needs of Passaic County residents. This solar project will provide a clean, renewable source of sustainable energy that will meet the needs of the present and future generations without compromising the environment. This project is a win-win for our residents, our commercial companies, and the environment. The County enthusiastically supports this project to expand the available community solar and deliver discounted electrical energy to our residents, enable the use of the built environment, and help New Jersey achieves its equity and climate goals.

In consideration of the above, it is with great pleasure that we extend our support and endorsement of the community solar project proposed by Nexamp.

Sincerely,

Matthew P. Jordan, Esq
County Administrator

INTERNATIONAL BROTHERHOOD OF ELECTRICAL WORKERS

LOCAL UNION NO. 102
57 Parsippany Road
Parsippany NJ 07054
973-887-1718 Tel
973-887-1976 Fax

January 12, 2024

VIA EMAIL SUBMISSION ONLY
Honorable Sherri Golden
Secretary of the Board
New Jersey Board of Public Utilities
44 South Clinton Avenue
3rd Floor, Suite 314
Trenton, NJ 08625

RE: IN THE MATTER OF THE PETITION OF THE NORTH JERSEY DISTRICT WATER SUPPLY COMMISSION, IN CONJUNCTION WITH NEXAMP SOLAR, LLC, FOR A FLOATING SOLAR PROJECT ELIGIBILITY WAIVER UNDER THE COMPETITIVE SOLAR INCENTIVE PROGRAM, (P.L. 2021, c. 169)
BPU Docket No. QO23060349
Letter of Support on Behalf of International Brotherhood of Electrical Workers, Local 102

Dear Secretary Golden:

With respect to the forgoing waiver application of the North Jersey District Water Supply Commission ("Commission") as it pertains to the construction and undertaking of a floating solar project upon the Wanaque Reservoir ("Project") utilizing the BPU's Competitive Solar Incentive Program ("CSI Program"), please accept this letter of support of and for both that Project, and the Commission's pending waiver application, on behalf of the International Brotherhood of Electrical Workers, Local 102 ("Local 102").

The construction and undertaking of the Project, presently anticipated to be approximately 10MW in size, will generate not only tangible benefits to the Commission for on-site electrical consumption and self-sufficiency, but also, benefits to the wider community at large, both within and without Passaic County. Further, the Project, as one being undertaken upon publicly owned property, would be subject to prevailing wage requirements, which would in turn be beneficial to the membership of Local 102. A Project of this significance and size would provide tremendous benefit to both electrical and other workers upon the Project, including our own membership, and the prevailing wage paid for Project work. We believe the benefits of this Project are tangible, and will benefit all involved.

For these reasons, Local 102 supports both the Commission's undertaking of the Project, as well as its waiver application, within the intendment of the CSI Program so that this beneficial Project may proceed in due course to benefit all residents, including Local 102 rank and file.

Thank you for your time and your kind consideration of this matter.

Very truly yours,

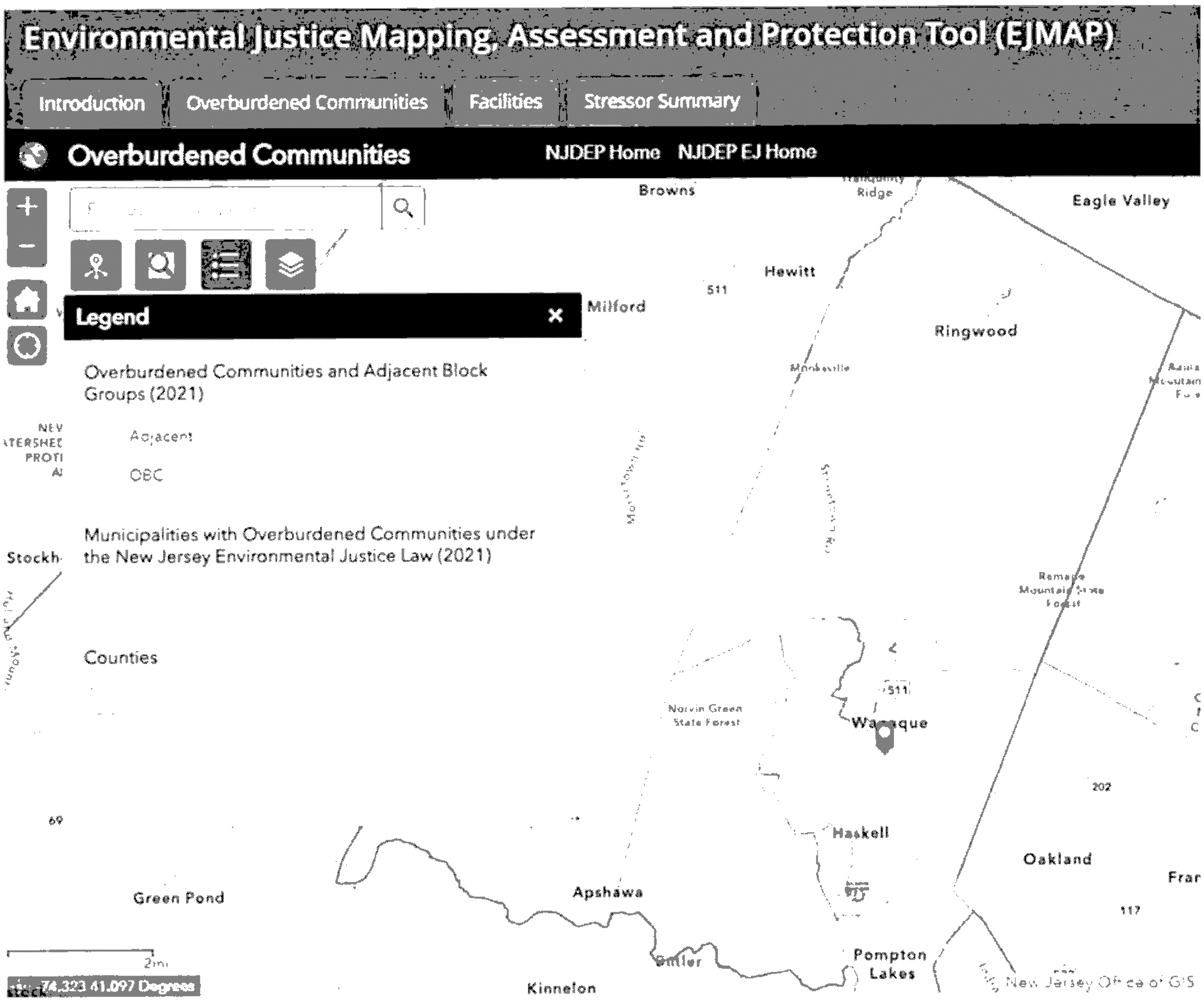
Patrick R. Della Cava,
Business Manager,
IBEW, Local 102

Attachment 8 – Identification of conflicts with DEP Rules

None that are known.

Attachment 9 – Other Helpful Information for DEP Review

1) Environmental Justice Mapp of the Wanaque Area
2) Water Quality Assessment by Baywa
3) Assessment of Water Quality of three Different FPV Systems
4) Assessment of FPV Potential and Water Conservation
5) NREL Assessment of Floating PV on Federally Controlled Reservoirs
6) Assessment of Bald Eagle Activity in the Wanaque Reservoir Area


Environmental Justice Mapping, Assessment and Protection Tool (EJMAP)
Introduction
Overburdened Communities
Facilities
Stressor Summary
Overburdened Communities
NJDEP Home
NJDEP EJ Home
Legend
Overburdened Communities and Adjacent Block Groups (2021)
Adjacent
OBC
Municipalities with Overburdened Communities under the New Jersey Environmental Justice Law (2021)
Counties
Browns
Eagle Valley
Hewitt
Milford
Ringwood
Norvin Green State Forest
Haskell
Oakland
Green Pond
Apshawa
Pompton Lakes
Kinnelon
New Jersey Office of GIS
-74.323 41.097 Degrees

Water Quality Studies

Increasing adoption of floating solar has resulted in increased research. Cornell University has a dedicated team of scientists studying the impact of FPV on the environment. While we don't have research papers for inclusion, we did find the following article timely and specific enough to provide some useful information.

Floating solar positively affects aquatic environments, says BayWa re

German renewable energy developer BayWa re has collected scientific data on aquatic fauna, water quality, and avifauna from several environmental impact monitoring studies on eight of its operational floating PV facilities in Europe. It has found the artificial habitats under the panels offer protection to some animal species and improvements to water quality.

DECEMBER 19, 2023 GWÉNAËLLE DEBOUTTE

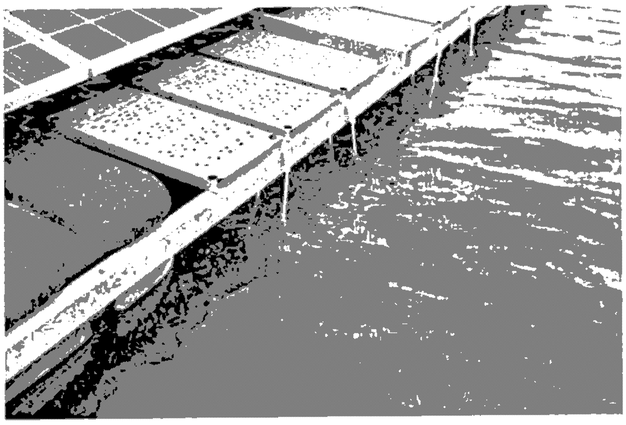


Image: BayWa re

BayWa re has published the first results of several environmental impact studies conducted on avifauna, wildlife fish farming and water quality of two of its floating solar farms in the Netherlands. The results show that artificial habitats under the panels, or "biohuts," are very beneficial for aquatic ecosystems.

The first surveys carried out by Ecocean on the 20 biohuts of the 18-hectare Bomhofsplas floating solar park, three years after installation, showed a considerable increase in the presence of aquatic fauna, for both invertebrates and fish.

Biohuts have a nursery function, protecting small fish from predators. They also serve as spawning grounds for fish and habitats for microorganisms and invertebrates.

At the same Bomhofsplas floating solar park, the water quality did not change after the installation of the solar panels. the University of Groningen measured water quality for more than 10 months. These measurements were carried out using sensors placed at different depths in open water and under the panels.

The company's experts also found that dissolved oxygen levels also remain at normal levels. The temperature differences under the panels have even been reduced compared to the open water area. The temperatures of the upper water layer, during warm periods, were lower under the panels and the cooling of the water, during cold periods, also occurred more slowly under the panels.

BayWa re also conducted a study on avifauna at the Weperpolder floating solar farm. Commissioned in 2018, the 1.5-hectare array is located near a natural area. The census campaigns aimed to measure the number of birds and geese before and after the construction of the floating solar park.

Observations indicate a high presence – and comparable to the initial situation – of birds and geese on the lake. Some of them – ducks and seagulls – even use floating photovoltaic installations as a resting place.

"This research effort allows us to improve our knowledge and the design of our parks. A large number of articles are published, but only a few are based on measurements, monitoring or solid scientific bases," said Constantin Magne, a spokesperson for BayWa re in France.

BayWa re currently has 19 floating solar parks under construction or in operation, or more than 300 MW.

Contents lists available at ScienceDirect

Energy Reports

journal homepage: www.elsevier.com/locate/egyr

Research paper

Floating photovoltaic pilot project at the Oostvoornse lake: Assessment of the water quality effects of three different system designs

Vincent Bax *, Wietse I. van de Lageweg, Rik Hoosemans, Bas van den Berg

Department of Technology, Water & Environment, Building with Nature Research Group, HZ University of Applied Sciences, Het Groene Woud 1, 4331 NB Middelburg, The Netherlands

A R T I C L E I N F O

Article history:
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Received in revised form 17 October 2022
Accepted 23 December 2022
Available online xxxx

Keywords:
Floating solar
Renewable energy
Energy and water nexus
Environmental impact
Water quality monitoring

A B S T R A C T

Floating photovoltaics (FPV) is emerging as a promising renewable energy technology which enables the production of electricity on surface waters. While this technology could potentially make an important contribution to the energy transition, the current uncertainty about the water quality effects of FPV deployment poses a major barrier to FPV project development and implementation. In this study, we investigated the water quality effects of three distinctive FPV system designs, implemented as part of a 1-year pilot project at the Oostvoornse lake, the Netherlands. A water quality monitoring campaign was set up to monitor on a continuous basis a set of key water quality parameters, including light intensity, water temperature and dissolved oxygen concentration. The measurements were conducted below each of the three FPV systems and contrasted with reference measurements at open water adjacent to the systems. Our monitoring results show that of the water quality parameters considered, the impact of the FPV systems on light intensity was found to be most pronounced, with a light reduction between 73% and 100% relative to the reference measurements. We found limited evidence to corroborate that the FPV systems induced changes to the water temperature and dissolved oxygen concentration. However, it must be noted that this study took place under highly specific conditions due the limited size of the FPV pilot systems and the brackish water of the Oostvoornse lake. This means that the water quality effects reported here may not be representative for a larger scale application of the FPV designs, and may not be one-on-one transferable to other non-brackish project locations elsewhere.

1. Introduction

In the coming decades, a major expansion in the production capacity of renewable energy will be needed to reduce global carbon emissions and achieve energy security objectives (Ho et al., 2006; Owusu and Asumadu-Sarkodie, 2016). Long-term energy projections indicate that solar energy technologies, and in particular solar photovoltaics, will play a predominant role in future energy supplies (Oliveira-Pinto and Stokkermans, 2020). Photovoltaic systems are traditionally being deployed on rooftops and land surfaces using rigid mounting structures. A relatively recent innovation in the solar energy sector is the installation of floating photovoltaic (FPV) infrastructure on inland water bodies. The use of water bodies to produce solar energy alleviates the pressure on land resources, reduces conflict with other land-uses (Gadzanku et al., 2021) and has the potential to increase the electric efficiency of the PV modules due to the cooling effect of the water surface (Dörenkämper et al., 2021). Since the establishment of the first commercial FPV facility in 2007, several major advancements in the design and application of FPV have been made to increase its economic and technical performance (Gorjian et al., 2021). However, FPV technology is still maturing and several aspects of FPV remain poorly investigated. In particular, it is currently not fully understood what effects FPV systems could have on the host aquatic ecosystem (de Lima et al., 2021a; Exley et al., 2021b; Haas et al., 2020).

The uncertainty about possible water quality effects poses a major barrier to the widespread roll-out of FPV technologies (Gadzanku et al., 2021). Waterboards and other government institutions currently lack the knowledge and data required to facilitate licensing and permitting processes (de Lima et al., 2021b), which could lead to the delay or complete abortion of FPV project development. More knowledge on water quality effects is at the same time required to optimize FPV system design solutions and

* Corresponding author.
E-mail address: [illegible] (V. Bax).

[illegible]

define adequate environmental mitigation measures (Cagle et al., 2020). Uncertainty about possible impacts of FPV on the aquatic ecosystem has furthermore been identified as a factor that could trigger public opposition to the deployment of FPV facilities (Bax et al., 2022). Therefore, to accommodate concerns that may exist within the community, it is vital to gain a thorough understanding of the environmental effects of FPV and disseminate scientific knowledge among the public. The water quality effects of FPV could be expected to vary according to system design, location and other project-specific conditions, which calls for studying these effects on a case-by-case basis.

In this study, we examine potential water quality impacts of FPV. We hereby focus on the FPV pilot project at the Oostvoornse Lake, as a specific case study. The pilot project was established in the summer of 2020 with the aim to investigate the mechanical stability, electrical performance and environmental impacts of three distinctive FPV system designs for a period of approximately one year. Here, we describe the results of the water quality study and address the following main research question:

"What is the impact of the three FPV systems on the water quality at the Oostvoornse lake?".

The novelty of the work presented here is twofold. First, this is to the best of our knowledge the first study in which the water quality effects of distinctive FPV system designs are investigated and compared. Second, our study provides insight into the impact of FPV on the availability of light in the water column directly below the systems through the measurement of light intensity – a crucial water quality parameter which thus far has been omitted in FPV-related water quality monitoring studies.

The rest of the paper is structured as follows. The following Section 1.1 provides an overview of the theoretical background and key insights from previous research on water quality effects associated with the deployment of FPV. In Section 2 we present our research methodology, including a description of the study area, the three FPV system designs and our approach to data collection and analysis. The results of the water quality monitoring are provided in Section 3, after which a discussion of these results is provided in Section 4. Finally, in Section 5 we outline the conclusions and reflect on some of the limitations of this study.

1.1. Theoretical background

Recent reviews of the scientific literature and gray documents provide evidence that so far only a handful of studies have evaluated the water quality effects of FPV systems and other artificial floating structures (Dionisio Pires and Loos, 2020a; Exley et al., 2021b). In light of the limited available knowledge on the subject and the lack of a clear water quality monitoring framework, Dionisio Pires and Loos (2020b) developed monitoring guidelines that define which parameters need to be accounted for in the context of FPV-related water quality monitoring activities. These guidelines point to three water quality parameters that are considered to be most important: (1) light availability, (2) water temperature, and (3) dissolved oxygen concentration.

Sunlight is the primary source of energy in aquatic ecosystems and controls for much of all biological and chemical processes, including primary production, photosynthetic oxygen dynamics and the regulation of water temperature. Several studies associate the physical presence of FPV and other artificial floating structures with reduced light availability below the floating infrastructure (de Lima et al., 2022; Sahu et al., 2016) and point to the consequences this could have for a water body at large (Pimentel Da Silva and Branco, 2018; Wang et al., 2021). In general terms, the extent to which FPV causes light suppression will be largely dependent upon FPV system design characteristics – in particular system size and its degree of openness (Exley et al., 2021a). It is reasonable to assume that larger systems, that consist of continuous surfaces of opaque materials and structures, will have the greatest potential to reduce light availability and, as such, to adversely affect the host aquatic ecosystem. However, empirical research aimed at quantifying the availability of light below FPV systems and relating this to FPV design characteristics, such as system size and surface coverage density, is currently not available (Dionisio Pires and Loos, 2020a; Exley et al., 2021b). To the best of our knowledge, only a recent study by Yang et al. (2022) measured the impact of an FPV facility on the amount of solar radiation beneath the panels, but their measurement data reflect ambient air conditions and were not employed to quantify the impact on the availability of light in the water column directly below the facility. The lack of in-situ underwater monitoring data makes it difficult to predict how light suppression impacts will vary according to FPV system design and how this will translate into impacts on ecosystem health and functioning more broadly.

Even though field data on light intensity impacts seem to be largely unavailable, a few previous studies have explored FPV-induced changes to light climate through the use of models. For instance, Delft3D model calculations by Loos and Wortelboer (2018) show that FPV deployment may reduce light availability by 68%–100% (Dionisio Pires and Loos, 2020a). Beyond research oriented to FPV specifically, a few studies have shown how other artificial structures at the water surface reduce solar radiation inputs. For instance, Maestre-Valero et al. (2011) pointed out that a suspended shade cloth, implemented as a measure to counter evaporative losses of irrigation water in Spain, reduces light transmission by almost 100%. In similar manner, Able et al. (2013) found that light abundance below an urban pier located at Hudson River Park in New York was significantly lower compared to a reference location at open water adjacent to the pier.

In addition to reducing light availability, the installation of FPV has been found to shelter the host water body from the influence of wind, leading to a decrease in wind speed and wind-driven water movement (Exley et al., 2021a). Both light suppression and reduced wind speed affect the thermal conditions of a water body, albeit in opposite directions. More specifically, a decrease in wind speed will tend to increase the water temperature at the surface, while a decrease in sunlight penetration will tend to lower the temperature at the surface (Kalf, 2022). Exley et al. (2021a) show through model simulations that temperature effects of reduced wind speed and solar radiation input are highly variable and largely dependent on FPV system design and surface coverage density. Their model results suggest that the percentual decrease in solar radiation input has a larger effect on water temperature than the percentual decrease in wind speed. In other words, when light penetration and wind speed decrease in the same order of magnitude, then it is to be expected that the water temperature at the surface also decreases. In this regard, several studies have associated the installation of FPV with a decrease of the water temperature (e.g., de Lima et al. (2021a), Wang et al. (2021)). The simulations of Exley et al. (2021a) show on the other hand that an increase (up to 2 °C) of the surface water temperature may be possible under the assumption that no more than about 25% of the potential solar radiation input is blocked by the installation of FPV. Yet, current FPV configurations tend to have a limited degree of openness through which sunlight could penetrate the underlying water column, making it improbable that FPV installations could concur with a noticeable increase of the surface water temperature.

However, beyond the effects of wind speed and solar radiation, the study of Yang et al. (2022) shows that the heat energy produced by FPV panels may have a considerable effect on the surface water layer below the panels. More specifically, Yang et al. (2022) show based on in-situ measurements coupled with numerical modeling that the conductive heating of FPV panels warms-up the air layer between the panels and the water surface with about 4 °C on average in the daytime, causing the temperature of the top water layer directly below the panels to increase with about 0.3 °C to 0.5 °C. This suggests that the potential of FPV to reduce water temperature due to the suppression of light may be (partly) offset by the heat transmitted from the FPV panels into the underlying water column — an effect which may be particularly prominent in the case of systems consisting of closed constructions with few openings between the floater modules and PV panels.

Several studies have furthermore associated the suppression of sunlight and wind with changes in the availability of dissolved oxygen in the aquatic system (de Lima et al., 2021; Wang et al., 2021). Wind tends to oxygenate a water body directly, through wind-driven turbulence at the water surface (Hull et al., 2016), while sunlight alters dissolved oxygen levels indirectly through respiration and photosynthetic production by phytoplankton and macrophytes (Staehr et al., 2010). Hence, a reduction in wind and sunlight induced by FPV is likely to change a water body's oxygen dynamics, but how and to what degree remains still a subject of discussion. For instance, Chateau et al. (2019) showed through field experiments coupled with model simulations that a 40% solar panel coverage of a fish pond results in a significant reduction in dissolved oxygen levels and water temperature. This could, in turn, translate into negative impacts on fish populations and other animal species and disrupt food chains; a concern which was furthermore expressed by Pimentel Da Silva and Branco (2018).

In contrast to these negative impacts, some studies anticipate that the deployment of FPV may have an overall positive influence on the dissolved oxygen regime of the host aquatic ecosystem. For instance, Haas et al. (2020) argue that FPV-related shading effects could control for excessive algae growth, reduce eutrophication and prevent the depletion of oxygen as a consequence of bacterial decomposition of organic residues. Furthermore, Loos and Wortelboer (2018) point out that the installation of large-scale FPV could increase dissolved oxygen levels, primarily because lessened water movement is considered to improve the conditions for oxygen production by phytoplankton.

As outlined above, a broad range of changes to biochemical and physical processes may be set in motion through the introduction of FPV and it remains highly complex to predict how these changes will play out and what this means in terms of water quality locally as well as for the entire water body. This calls for an expansion of the current body of knowledge, through comprehensive field monitoring of the water quality effects associated with the deployment of FPV systems.

2. Methodology

2.1. Study area

The Oostvoornse lake is a brackish lake located in the province of South-Holland, the Netherlands (Fig. 1). The industrial area and Port of Rotterdam border the lake on the north, while the town of Oostvoorne is located approximately 3 km to the south. The lake has a surface area of about 270 ha, an average water depth of about 20 m and a maximum water depth of about 40 m. The lake was created through the construction of a dam (*the Brielse Gatdam*), after which it came into use as a major sand excavation area for the construction of the Maasvlakte extension of the Port of Rotterdam in the 1960s (Dembska, 2013).

Through the years, the lake's water salinity level has been dropping steadily due to the influx of fresh water from the adjacent dune areas. This has resulted in increasing algae and cyanobacteria growth and, in turn, a reduction of the water transparency and the overall water quality. In an attempt to preserve the lake's unique biodiversity and recreational value, it was decided in 2008 to start supplementing salt water to the lake through the installation of an underground pipeline between the Mississippihaven (one of the Maasvlakte's main channels) and the lake's north bank. Yet, despite this saltwater inlet, excessive algae growth remains a major problem and continues to negatively impact the water quality.

In the months of September and October 2020, three distinctive FPV energy systems were installed at the Oostvoornse lake as part of a 1-year pilot project to evaluate the electrical performance, mechanical stability and ecological impact of the FPV systems. The pilot project also allowed for research into the social acceptability of FPV technology more broadly. The FPV systems were established in the northwest corner of the lake, at about 100 m from the lake banks, see Fig. 1. The research facility further consisted of a floating walkway between the shore and the FPV systems, as well as electrical infrastructure on land.

2.2. FPV system designs

The three FPV systems considered in this study were established by different private developers and varied in size and technical design features, see Fig. 2 and Table 1. The systems will be referred to as "System A", "System B" and "System C". The information below is based on de Jong (2020) and summarizes some of the features of the FPV systems that may be relevant to explain and interpret their water quality effects.

System A has a size of about 350 m² and an estimated water surface coverage of 75%. The system is based on a set of High-Density Polyethylene (HDPE) tubes which act as the floating construction upon which the system is build. The tubes are connected by aluminum frames (so called saddles) which are placed on top of the tubes and keep the PV modules in place. The HDPE tubes in the main part of the system are attached to so-called bridle pipes located on the North and South sides of the system. The bridle pipes are in turn moored to the bottom of the lake with 4 anchors.

System B is roughly rectangular, with a size of about 400 m² and an estimated water surface coverage of 100%. The system consists of polypropylene floaters upon which the PV panels are mounted at an angle of 5 degrees. The system is moored with multiple anchor lines from all four sides, connected to 8 anchors.

System C is a roughly circular system, with a size of about 600 m² and an estimated water surface coverage of 75%. The system consists of PV solar modules mounted to metal frames, which are in turn mounted to polypropylene floaters. The floaters are interconnected and attached to a circular floating HDPE tube, the so-called inner wave breaker. Around the inner wave breaker is the outer wave breaker — an octagonal HDPE floating tube which is moored to the bottom of the lake with 8 anchors.

2.3. Data collection

A monitoring campaign was set up to assess how and to what extent the FPV systems implemented at the Oostvoornse lake affect the water system. This included the continuous measurement of light intensity, as well as a set of physicochemical parameters, including water temperature, dissolved oxygen concentration, pH, turbidity, electrical conductivity and oxygen reduction potential. These parameters could be considered to be straightforwardly measurable, as the measurements require relatively little time and resources and can largely take place in-situ. The monitoring of these parameters aligns closely with previous

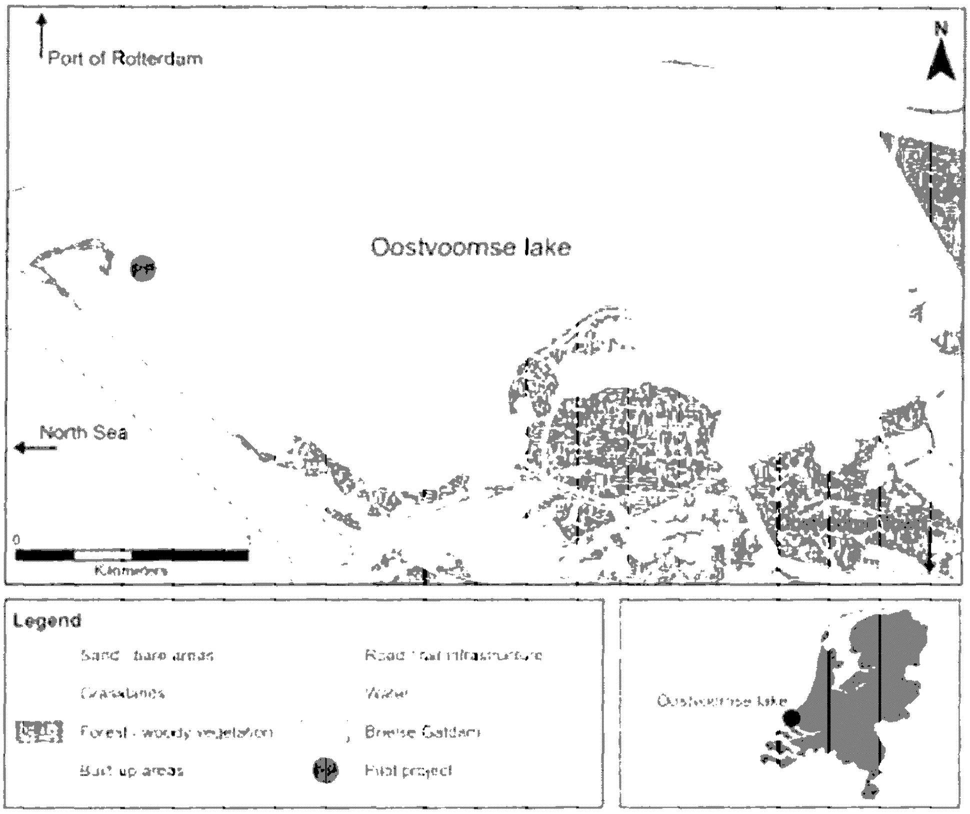

Fig. 1. Study area. The Oostvoornse lake is a brackish lake located in the province of South Holland, the Netherlands. In the period between September and October 2020, a FPV pilot project was implemented in the northwest corner of the lake (about 100 m from the lake bank). The pilot project allowed for research into technological aspects as well as ecological and societal impacts associated with the project.

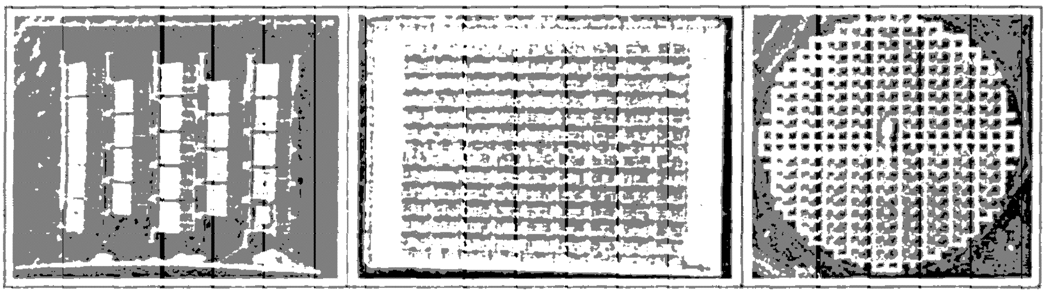

Fig. 2. Top view photos of the three FPV system designs considered in this study, including System A (left), System B (middle), and System C (right). Photos are adapted from [illegible].

Table 1
Overview of the FPV system designs installed at the Oostvoornse lake as part of a one-year pilot project.

	System A	System B	System C
System size	250 m²	400 m²	600 m²
System shape	Roughly rectangular	Rectangular	Roughly circular
Water surface coverage	[illegible]	100%	75%
Installed capacity	41.93 kWp	39.42 kWp	50.[illegible] kWp
Number of PV modules	136	108	130
PV module angle	15 degrees	5 degrees	25 degrees
Module orientation	East-West	South	Tracking
Floating system	HDPE tubes	Polypropylene floats	Polypropylene floats

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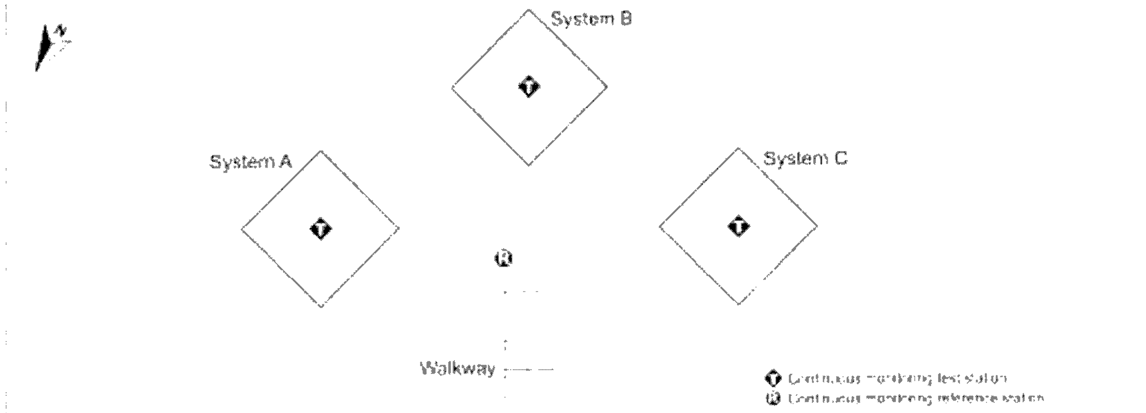

Fig. 3. Schematic overview of the locations of the FPV systems and the reference station, and the locations where the monitoring equipment was installed to collect continuous data on light intensity, water temperature and dissolved oxygen concentration.

research on water quality effects related to the deployment of FPV de Lima et al. (2021a), Wang et al. (2021).

In this paper, we focus our attention on three water quality parameters specifically: 1) light intensity, 2) water temperature and 3) dissolved oxygen concentration. In particular, because the monitoring of these parameters has been recognized to be most important to gain insight into the water quality effects of FPV deployment ([illegible] 2020b). The data on the other water quality parameters are available as supplementary materials to this article.

Continuous measurements of light intensity were conducted using HOBO UA-002-64 Pendant Temperature/Light Intensity Loggers, based on measurement intervals of 5 min. Measurements of the water temperature and dissolved oxygen concentration were conducted using Hanna HI9829 portable Multiparameter devices, based on measurement intervals of 30 min. This type of equipment has been regularly used for similar purposes in other water quality studies, see for instance [illegible] (2021), [illegible] et al. (2012) and [illegible] et al. (2015).

The monitoring equipment was placed at the center below each of the three FPV systems, with the sensors submerged at a two-meter water depth. Specifically, we introduced the equipment into the water column through an opening in between the floats and attached the cable to the edge of the floater construction, which positioned the sensors exactly at a depth of two meters below the edge of the floats at the water surface. A reference monitoring station was positioned at open water adjacent to the FPV systems. The specific water depth of two meters was considered to be sufficiently deep to minimize the influence of atmospheric reaeration on the dissolved oxygen measurement, while close enough to the FPV systems to remain in their sphere of influence and measure potential water quality impact. Furthermore, based on preliminary trial-and-error light intensity measurements at a range of water depths, it was found that measurements at a two meter water depth are not under the direct influence of sunlight penetrating through the openings in between the PV panels, but accurately reflect the global shading effect of the FPV systems at large, see also the supplementary materials to this article. Fig. 3 provides a schematic overview of the location of the three FPV systems and corresponding monitoring locations.

Monitoring of light intensity took place in the period between July and November 2021 – a period which stretches from the summer into the end of the fall, covering a broad range of solar radiation intensity. Monitoring of the water temperature and dissolved oxygen concentration took place in the period between March and October 2021 – a period which covers the summer season when primary production is highest, and the fall when die-off and decomposition of organic matter takes place. The length of our monitoring period is similar to the duration of previously reported monitoring activities (de Lima et al., 2021a; Wang et al., 2021). Over the course of the monitoring period, regular field visits (once every two to three weeks) were carried out to read out the collected water quality data and conduct instrument maintenance activities, including cleaning, re-calibration and overall verification of proper functioning of the equipment.

The field monitoring was subject to a number of events and incidents. This hampered to some extent the collection of continuous water quality data and led to missing data in the final database. For instance, strong winds and excessive precipitation events interrupted some of our monitoring activities in the months of March and April 2021. Further, over the course of the study period, some technical issues with the Hanna multiparameter monitoring equipment arose. This required repairment or replacement of the equipment, leading to multiple gaps in the collected data.

2.4. Data analysis

As a first approach to data analysis, the longitudinal measurement data were plotted in charts using graphical software to visualize trends and fluctuations, and to draw comparisons between the different monitoring locations. Outliers in the collected datasets were identified using histograms and subsequently removed before proceeding with further analyses.

Based on previous research (de Lima et al., 2021a; Wang et al., 2021), it may be expected that the water quality effects caused by the FPV systems take place in a largely consistent manner. In other words, a particular FPV system is likely to cause either an increase or decrease in the measurement value of any given water quality parameter over time. In contrast, the observation of incidental increases or decreases in the measured values may be more likely attributable to external factors related to for example abrupt changes in weather conditions or equipment failure. Accordingly, to evaluate the water quality effects of the FPV systems, the measurement data obtained at the location of each of the FPV systems were contrasted with the data obtained at the reference station at open water to identify possible differences in measurement values between these locations and examine to what extent these differences were measured consistently over

Table 2
Average light intensity during daytime (6 a.m.–6 p.m.) in lux. The percentages between brackets reflect the average reduction in light intensity below the FPV systems compared to the reference station.

	System A	System B	System C	Reference
July/August	1022 (−77%)	36 (−99.2%)	1196 (−73%)	4403
September/October	613 (−75%)	11 (−99.6%)	488 (−80%)	2454
November	154 (−85%)	3 (−99.7%)	139 (−87%)	1038

time. For each water quality parameter, average values were calculated and compared to further examine to what extent the data collected at the FPV systems deviate consistently from the reference data.

As pointed out previously, the final database contained multiple gaps with missing data as a result of issues with the monitoring equipment as well as project-related incidents. As a consequence, in order to contrast the different monitoring locations, it was necessary to conduct the analyses based on segments of the monitoring period for which continuous data collected at multiple monitoring locations was available. Meanwhile, to provide insight in seasonal variation, the analyses were as much as possible conducted on a month-by-month basis.

3. Results

This section provides an overview and analysis of the water quality data collected at the location of the three FPV systems and the reference station. Each of the colored datasets in the figures below correspond to a specific monitoring location, with System A displayed in red, System B in blue, System C in green and the reference station in gray. High-resolution figures are available as supplementary materials to this article.

3.1. Light intensity

The light intensity data are presented in three separate graphs, corresponding to the period July/August (Fig. 4a), September/October (Fig. 4b) and November (Fig. 4c). The marked differences in the measured light intensity across the monitoring period, as can be noted in the figures, reflect the large seasonal variation in solar radiation intensity. The data show that over the course of the monitoring period, the measured light intensity at the reference station is considerably higher than below the three FPV systems. In line with expectations based on the estimated surface water coverage (Table 1), we found that System B had the highest impact on light intensity. Yet, also System A and System C appear to cause a substantial reduction in light availability.

Table 2 displays the average light intensity during daytime, measured in the periods July/August, September/October and November 2021. The percentages between brackets reflect the average reduction in light intensity below the FPV systems compared to the reference station. The data show that between July and November, an average light reduction of nearly 100% was observed below System B, whereas the reduction in light intensity below System A and System C ranged on average between 73% and 87%. Light reduction below System A and System C was found to be higher in November (−85% and −87%, respectively) compared to the July/August period (−77% and −73%, respectively).

3.2. Water temperature

Fig. 5 provides an overview of the water temperature at the location of the FPV systems and the reference station in the period between March and October 2021. Over this period, the water temperature ranged from about 5 to 22 °C. The data in Fig. 5 point to a very low variation in water temperature between the FPV systems and the reference station. The dataset of System A overlies much of the data collected at the other three locations, which reduces the visibility of these datasets in the figure.

The water temperature data collected at the location of the FPV systems and the reference station are displayed as monthly averages in Table 3. It can be noted that the average temperature measured below System A is consistently higher than the reference measurements at open water, albeit the differences are small, ranging from 0.12% to 0.47%. In contrast, the average temperature below System B was found to be consistently lower in the months for which temperature data is available, but again with only modest differences of no more than −0.58%. In the case of System C, the water temperature was mostly lower than the reference station, with the only exception being the average water temperature measured in June.

3.3. Dissolved oxygen

The variation in the dissolved oxygen concentration at the FPV systems and the reference station is displayed in Fig. 6. Throughout the monitoring period, the measured concentrations range roughly between 5 and 10 mg l^{-1}. Broadly speaking, the data in Fig. 6 show a slightly downward trend, with relatively high concentrations measured in March (between about 8 to 10 mg l^{-1}) and lower concentrations towards the end of the monitoring period (between about 5 to 8 mg l^{-1}).

Table 4 includes the dissolved oxygen concentration at the location of the FPV systems and the reference station, presented as monthly averages at daytime (between 12:00 and 24:00) and nighttime (between 00:00–12:00). Generally, higher dissolved oxygen concentrations were measured at daytime than nighttime, albeit the differences between day and night were found to be quite modest. In line with Fig. 6, the average dissolved oxygen concentrations seem to be slightly higher at the beginning of the monitoring period than at the end.

The data in Table 4 show that the average dissolved oxygen concentration measured below System B was consistently lower than the reference measurement. The largest differences with the reference station were measured in the period between July–August/September (on average between −4% and -6%).

Less consistent differences were found between the reference station and the systems A and C. In the case of System C, the average dissolved oxygen concentration was incidentally higher (up to 5% in May) and incidentally lower (around -6% in June) than the average dissolved oxygen values measured at the reference station. In the case of System A, the average dissolved oxygen concentration was found to be considerably higher in the months of June and Augustus/September (about 11% to 13%). Differences were less marked in the other months, ranging from 4% higher values to 5% lower values compared to the reference station.

4. Discussion

The FPV pilot project at the Oostvoornse lake has offered the opportunity to investigate technological aspects along with environmental and social impacts associated with the deployment of three distinctive FPV system designs. In this study, we investigated the potential water quality effects of these systems, by monitoring a set of standard water quality parameters on a continuous basis for a prolonged period of time. The data presented in this study demonstrate how key water quality conditions have changed over time and provide insight into the extent to which these changes may be linked to the deployment of the three FPV systems.

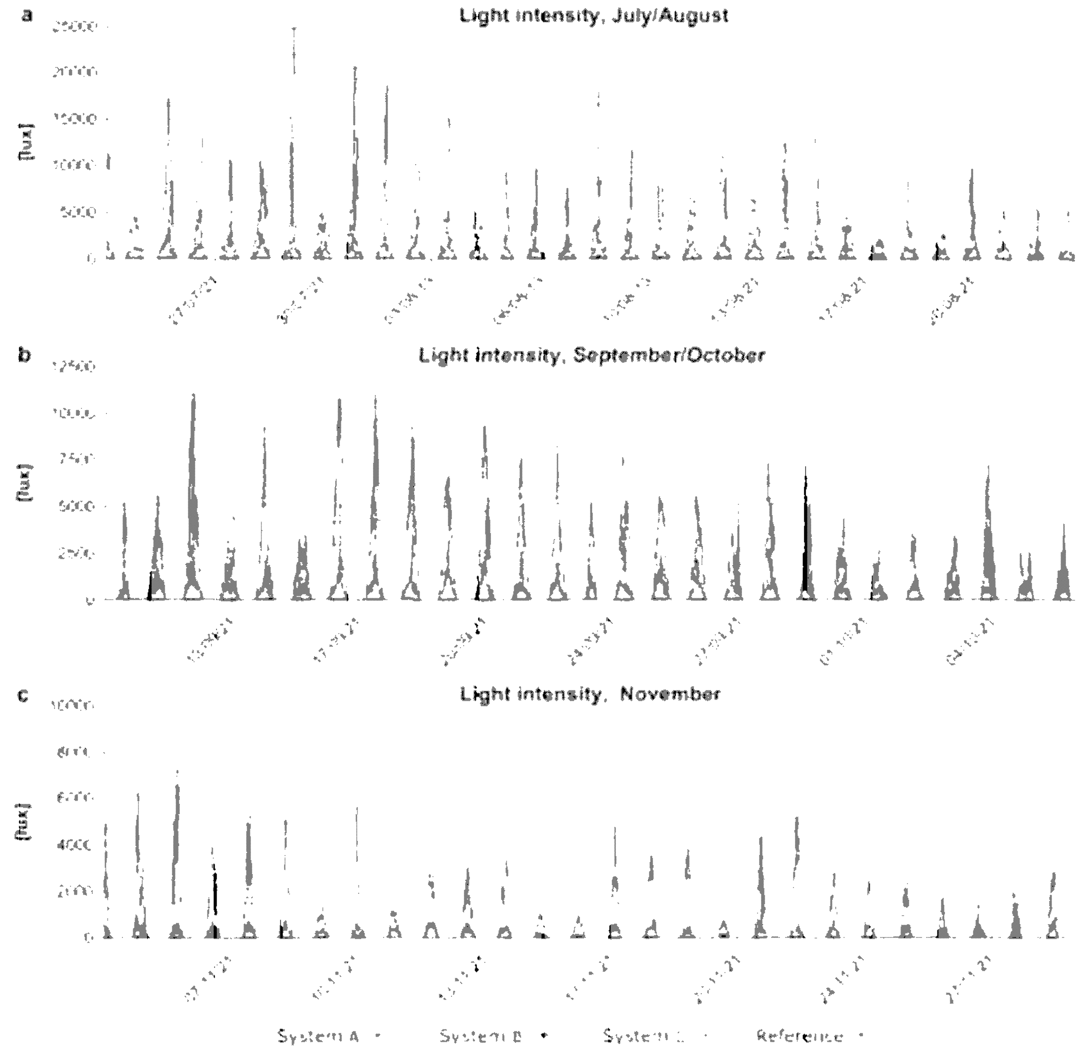

Fig. 4. Overview of the light intensity data collected in July/August 2021 (a), September/October 2021 (b) and November 2021 (c).

Table 3
Monthly average water temperature in degrees Celsius (°C). The percentages between brackets reflect the average difference in water temperature below the FPV systems compared to the reference station.

	System A	System B	System C	Reference
March	6.30 (0.47%)		6.12 (2.47%)	6.28
April/May	10.36 (0.12%)	10.29 (0.38%)	10.21 (1.18%)	10.27
June	20.15 (0.18%)		20.12 (0.10%)	20.10
July	18.93 (0.36%)	18.86 (0.01%)	18.82 (0.24%)	18.86
August	18.32 (0.15%)	18.21 (0.13%)	18.21 (0.23%)	18.25
September/October	17.75 (0.15%)	17.68 (0.04%)	17.66 (0.14%)	17.69

In line with expectations and previously reported modeling results ([illegible]), we found that the FPV systems cause a significant reduction of the available light in the water column directly below the systems. The most notable impact on light was found to be associated with System B, reaching a light reduction of nearly 100%. This extensive shading effect can be explained by the closed design of the system, consisting of a continuous surface without openings in between the PV panels and the polypropylene floater construction through which light can penetrate the underlying water column. Both System A and System C have a considerably higher degree of openness, but their impact on light availability was nonetheless substantial, with an average light reduction ranging from 73% to 87%. The light suppression impacts of System A and System C were found to be slightly higher in the autumn/winter period than in the summer period. This suggests that their impact on light availability is generally higher under cloudy weather conditions than under clear skies when sunlight is more likely to penetrate directly into the water column. In a similar manner, this may also indicate

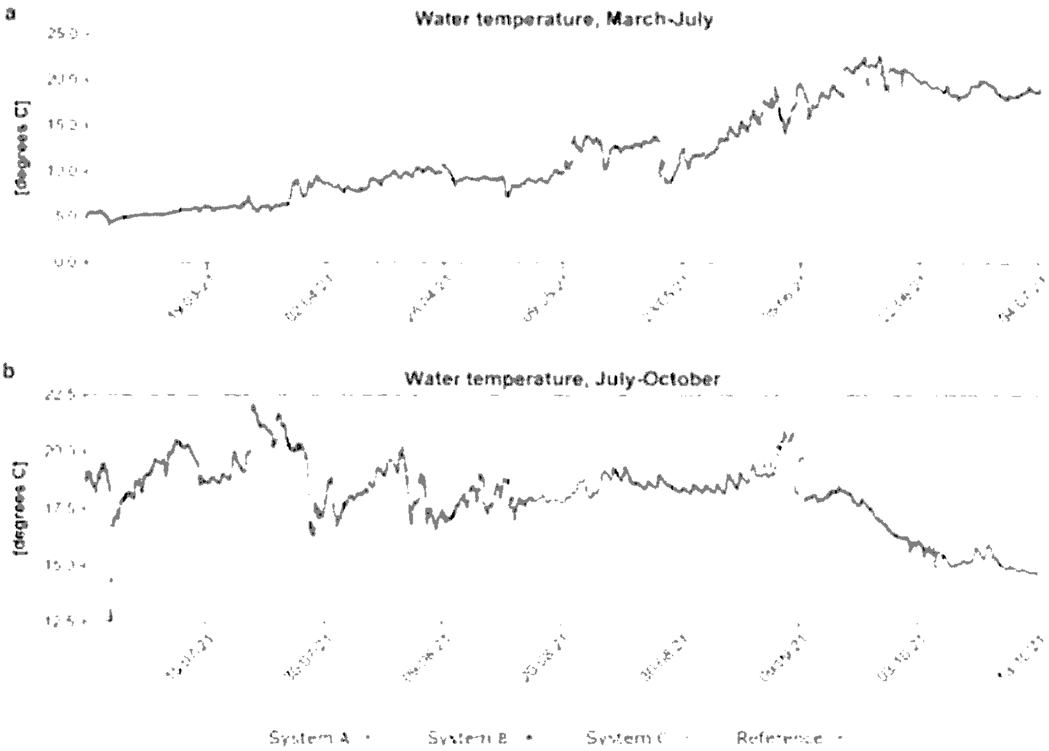

Fig. 5. Overview of the water temperature data collected in the period March-July 2021 (a) and July-October 2021 (b).

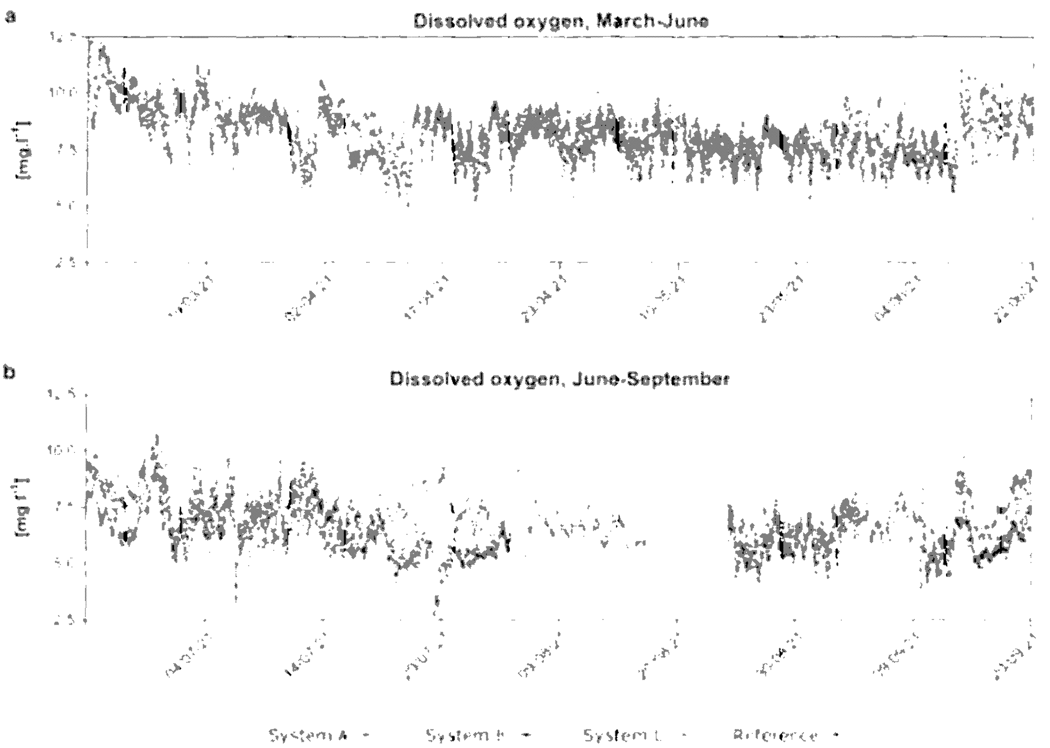

Fig. 6. Overview of the dissolved oxygen data collected in the period March-June 2021 (a) and June-September 2021 (b).

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Table 4
Dissolved oxygen concentration in mg l⁻¹, as monthly averages at nighttime (between 00:00–12:00) and daytime (between 12:00 and 24:00). The percentages between brackets reflect the average difference between the dissolved oxygen concentration below the FPV systems and the reference station.

		System A	System B	System C	Reference
March	00:00–12:00	9.04 (0.8%)		8.87 (−1.1%)	8.97
	12:00–24:00	9.40 (2.3%)		8.96 (−2.5%)	9.19
April	00:00–12:00	7.78 (−1.1%)	7.70 (−2.2%)	8.14 (3.3%)	7.87
	12:00–24:00	8.29 (−2.9%)	8.21 (−3.9%)	8.71 (2.0%)	8.54
May	00:00–12:00	7.97 (4.2%)	7.54 (−1.3%)	7.96 (4.1%)	7.64
	12:00–24:00	7.80 (2.9%)	7.61 (−1.0%)	8.08 (5.2%)	7.69
June	00:00–12:00	8.91 (12.6%)		7.49 (−5.6%)	7.93
	12:00–24:00	9.08 (11.6%)		7.95 (−2.5%)	8.13
July	00:00–12:00	6.93 (−3.9%)	6.85 (−5.0%)		7.21
	12:00–24:00	7.14 (−4.7%)	7.18 (−4.2%)		7.49
August/September	00:00–12:00	6.79 (10.6%)	5.80 (−5.5%)		6.14
	12:00–24:00	7.24 (13.0%)	6.05 (−5.6%)		6.40

that the FPV systems cause a higher blockage of light when the position of the sun is relatively low.

A decrease in the availability of sunlight could in theory lead to reduced photosynthetic oxygen production and adversely affect aquatic organisms, including fish and invertebrate animals (Chislock et al., 2013; Kraemer et al., 2017). These effects are particularly expected when oxygen levels drop below a critical threshold value of about 5 mg l⁻¹ (Rose et al., 2007). Our monitoring results indicate that the dissolved oxygen concentration almost never reached this critical value. On the other hand, we found that the dissolved oxygen concentration gradually decreased over the course of the monitoring period, from about 8–10 mg l⁻¹ in the spring period to about 5–8 mg l⁻¹ in the summer and fall periods. It appears to be unlikely that this falling trend in dissolved oxygen has been caused by the deployment of the FPV systems specifically, because a similar downward trend also applies to the oxygen conditions measured at the reference station. Instead, the observed decrease in oxygen concentration is more likely to be associated with natural seasonal variation, as oxygen levels in large water bodies are usually higher in the winter season and tend to fall in the summer and autumn periods (Araoye, 2009; Rentmeester and Stolerio, 2014). In addition, the falling trend might also be partly explained by a gradually decreasing capacity of the monitoring equipment to measure the dissolved oxygen level properly. In particular, we noticed over the course of the monitoring period that it became increasingly difficult to calibrate the dissolved oxygen sensors and gain accurate measurement values.

More generally speaking, our monitoring results provide limited evidence to corroborate that the FPV systems caused changes to the oxygen conditions directly below the systems. In the case of System A and System C, we found both higher and lower dissolved oxygen values compared to the reference location, suggesting that the effect these systems may have on the dissolved oxygen concentration is not strictly positive or negative. In the case of System B, we found slightly lower dissolved oxygen values compared to the reference station, which in turn, might be associated with the extensive shading effects caused by the system. Meanwhile, the differences between System B and the reference measurements were quite modest, on average roughly between 1% and 5%, and may have also been caused by other factors. For instance, the Hanna multiparameter monitoring instruments used in our study are associated with a certain level of measurement accuracy. According to the equipment manual, a measurement error of ± 0.10 mg l⁻¹ could considered to be acceptable, but in practice we found these measurement errors to be much higher – at least ± 0.30 mg l⁻¹ and occasionally even higher.

Our monitoring results furthermore show that the water temperature conditions at the FPV monitoring locations and the reference station were not notably different. This contrasts with temperature effects of FPV reported in previous studies. For example, de Lima et al. (2021a) recorded lower temperature values in the top water layer below a large-scale FPV facility, compared to an adjacent reference location in open water. Their results furthermore showed that FPV-induced shading effects cause the heating of water to take place more slowly (i.e. a delay in water heating) and more uniformly (i.e. a reduction in water temperature peak values). Beyond water temperature dynamics, de Lima et al. (2021a) also found that other water quality conditions varied markedly between the FPV and reference monitoring locations. For instance, the dissolved oxygen concentration below the FPV facility was recorded to be about 1.1 to 1.7 mg l⁻¹ lower compared to the nearby reference station.

It is important to note that the work of de Lima et al. (2021a) describes temperature and oxygen effects associated with the implementation of a utility-scale FPV facility of about 18.25 ha, consisting of about 72,000 PV panels. Our study focused on three small-scale FPV systems of about 500 m², whose effects on the water quality tend to be much smaller. In particular, the deployment of a large-scale FPV facility suppresses the exchange of water underneath the FPV system and its immediate surroundings (see e.g. Loos and Wortelboer (2018)) – an effect which could be expected to be less pronounced in the case of smaller FPV facilities. Hence, as the degree of mixing of water below and adjacent to small-scale systems is relatively high, it is reasonable to assume that the water quality conditions measured below these systems also partly reflect the conditions adjacent to the systems. This means in practice that the observed water temperature and oxygen effects of the FPV pilot systems may only partly reflect the effect that a particular FPV design could potentially cause when implemented at a larger scale.

As discussed above, the water quality effects of the three small-scale FPV systems considered in this study seem to be less pronounced than the effects of larger FPV facilities as reported in previous studies. This sheds light on the possibilities of implementing FPV without compromising water quality management objectives. More specifically, an opportune implementation solution of FPV that comes to mind is the adoption of small-scale systems. It is increasingly recognized that the development of small-scale renewable energy initiatives will make an important contribution to the energy transition (Ramos et al., 2020). Previous research has furthermore shown that the deployment of small-scale FPV facilities is generally supported by the nearby community (Bax et al., 2022), which could facilitate FPV development and implementation processes. In the specific case of the pilot project considered in this study, the installed capacity of the three FPV systems together adds up to around 130 kWp. By comparison, this roughly corresponds to about 10 to 130 residential rooftop PV installations (Wierling et al., 2021). An expansion of the current scale and installed capacity could be expected to increase the water quality impact of the three FPV systems, but how and to what extent remains subject to further investigation.

In the context of upscaling FPV technologies, it will be important to understand how water quality effects taking place locally (i.e. directly below the FPV systems) translate into impacts on the aquatic ecosystem at large. In this regard, not just the absolute dimensions of the FPV systems play a role, but in particular the lake surface coverage (or the ratio between the area covered by the systems and area of the basin) will shape the degree to which FPV deployment could induce changes to water quality conditions. In the specific case of our study, the combined areal extent of the FPV systems (about 1500 m^2) in proportion to the surface area of the Oostvoornse lake (about 270 ha) translates into a lake surface coverage of less than 0.1%, which is clearly much too low to cause any lake-wide impacts. Model outcomes produced by Loos and Wortelboer (2018) indicate that impacts on the aquatic ecosystem are most likely to take place with lake surface coverages of about 50% or more, depending on the water body in question and FPV-specific design characteristics such as the degree of openness. Our water quality data could be used in conjunction with modeling tools such as the Delft3D application developed by Loos and Wortelboer (2018) to explore how water quality conditions throughout the Oostvoornse lake could respond to an increase in the surface coverage of the three FPV system designs considered in our study.

In retrospect, it has become apparent that the Oostvoornse lake may not have been the most suitable location to establish the pilot project in relation to examining the water quality effects of the FPV systems. On the one hand, the corrosive properties of the brackish lake water seem to have caused the monitoring equipment to become increasingly less reliable over time. This might have led to inaccurate measurement results. For instance, the dissolved oxygen concentration showed a gradually decreasing trend, which might have been caused by a reduced performance of the monitoring instruments over the course of the monitoring period. On the other hand, the aim of the pilot project was to gain insight into the technical and ecological performance of three different FPV system designs and test whether these designs are adequate for a larger-scale application elsewhere. However, the water quality analysis took place under highly specific conditions due to the brackish water of the Oostvoornse lake, and the observed water quality effects reported in this study may therefore not be well-transferable to other non-brackish study locations. Finally, scale matters: the relatively modest scale of the employed FPV systems raises uncertainty about the transferability of the water quality outcomes to utility-scale application.

5. Conclusion

In this study, the water quality effects of three different FPV system designs were examined through the in-situ monitoring of a set of key water quality parameters, including light intensity, dissolved oxygen concentration and water temperature. Data on these parameters were collected below each of the three FPV systems and contrasted with reference data collected at open water adjacent to the systems. Based on the results obtained in this analysis, it can be concluded that the three systems had only a minor impact on the water quality.

Of the water quality parameters considered, the impact of the systems on light availability was found to be most pronounced. More specifically, our light intensity data show a decrease in the availability of light directly below the FPV systems, ranging from about 73% to nearly 100% relative to the reference measurements. A reduction of sunlight may cause shifts in fundamental biological processes such as primary production and change the functioning of the aquatic ecosystem at large. However, the effects of shading caused by the FPV systems could be assumed to be low given the small-scale of the pilot systems and their proportion in relation to size of the Oostvoornse lake.

Beyond the impact on light intensity, we found no specific evidence to suggest that the FPV systems adversely impact the water quality in any other notable way. Generally speaking, our data show that over the course of the monitoring period, water quality conditions such as water temperature, and dissolved oxygen concentration were similar across the FPV and reference monitoring locations. Even though we also recorded differences, they tended to be inconsistent, meaning that the measured value of a given water quality parameter at the location of the FPV systems was not consistently higher or lower than the reference measurement. As previous research has shown that water quality effects caused by the deployment of FPV take place in a largely consistent manner, we may assume that inconsistent variation between the different monitoring locations is associated with other factors, such as abrupt changes in weather conditions or measurement errors.

Although our research shows that the water quality impact of the FPV systems was limited, it must be noted that the results reported here are highly case and context-specific and may not similarly apply to project locations elsewhere. The brackish water of the Oostvoornse lake provide for highly specific water quality conditions, and it is likely that the effects of the FPV systems are different when implemented on freshwater ecosystems. On the other hand, the Oostvoornse lake has a considerable size and water depth, which allows for relatively high water flow velocities, currents and extensive water mixing. This mixing capacity of the Oostvoornse lake may give rise to the situation in which the water quality measurements directly below the FPV systems partly reflect the water quality conditions in the surrounding areas. Hence, to gain further insight into the water quality effects associated with different FPV system designs, it would be required to expand the current scale of the systems or evaluate how they change the water quality conditions of calmer surface waters (e.g. shallow ponds and reservoirs of limited size).

CRediT authorship contribution statement

Vincent Bax: Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Supervision, Project administration. **Wietse I. van de Lageweg:** Conceptualization, Methodology, Resources, Writing – original draft, Writing – review & editing, Supervision, Project administration, Funding acquisition. **Rik Hoosemans:** Methodology, Formal analysis, Investigation, Writing – original draft. **Bas van den Berg:** Methodology, Investigation, Writing – original draft.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Vincent Bax reports financial support was provided by the project Pilot Oostvoornse Meer, a collaboration between TNO, SABIC, Equinor and the municipality of Westvoorne.

Data availability

Data have been included as supplementary materials to the article

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Appendix A. Supplementary data

Supplementary material related to this article can be found online at

References

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Energy for Sustainable Development

Assessment of floating solar PV (FSPV) potential and water conservation: Case study on Rajghat Dam in Uttar Pradesh, India

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ABSTRACT

Widely acceptable Photovoltaic (PV) technology faces the challenge of substantial land requirement. However, emerging PV technology over water bodies through floating solar panels can resolve this challenge and additionally leads to operation of the panels at low temperature, improving the energy generation efficiency and it also shades the water bodies to account for reduction in evaporation loss. In this work, simulation tasks are performed to assess the technical potential of floating photovoltaic power generation and discusses the sustainable system of floating solar PV technology in terms of prospective PV potential, conservation of water and potential to conserve agriculture land bank. The study estimates power potential of 651.3 MW_p for 25% coverage of total submergence area at Rajghat dam situated in the Southern part of Uttar Pradesh, India and annual power generation of 10,62,553 MWh. The study also reports annual evaporation loss reduction of 1,395 cubic meter per MWp (or 0.91 per kWh) as an additional benefit. In terms of economic assessment, the levelized cost of energy (LCoE) is reported as $0.036/kWh (INR 2.51/kWh) with 8.5% internal rate of return (IRR), a very encouraging parameter for large scale deployment of FSPV plants. Based on the findings, the study recommends FSPV installation in water reservoirs, satisfied by considerable savings in water evaporation losses and avoiding use of cultivable land for solar PV installation purpose.

Introduction

As government of India has taken a massive target of solar power of the order of 175 GW by 2022, the states have been asked to fulfil this target through their individual renewable power obligations (RPO). However, due to COVID pandemic, the target has been revised to 100 GW. The state of Uttar Pradesh has taken the RPO obligation to the tune of 10,700 MW by 2022. In order to achieve this target, it is proposed to develop 4300 MW on roof top and balance 6400 MW on ground. Typical land area requirement to meet this target of 6400 MW is about 12,800 ha with a consideration of 2 ha/MW land requirement for solar power generation (Solar policy, 2017). Deployment of solar power plant on agriculture land deprives the land from agriculture produce for at least 25 years, which is a great loss for the human being. If land is not so fertile, then also it could be utilized for forest development, residential development or industrial development. Traditionally, solar developers in India have explored utility scale solar project development as a land-based project development, considering the fact that land is abundant and developers can make reasonable return on their investment. However, the land prices have a steep increase in proximity of urban areas, hence, large scale solar project development are pushed away far from cities due to low cost availability of land in remote areas. In addition to this, it leads to the additional cost of transmission line to a long distance to carry power and increased transmission losses due to long distance between solar parks and load centers. Large scale deployment of solar PV in India has a major constraint, as the land availability is not close to the load centers. With all these unfavorable facts, another major aspect that is overlooked in solar project development in the state of Uttar Pradesh, India is the massive surface area on dams, which is available in close vicinity to the urban area (shown in Fig. 1).

In recent years, there has been significant development in the solar PV technology, and using this PV technology as floating solar technology option to generate renewable electricity. A partial cover on the water bodies through floating solar panels leads to operation of these solar panels at low temperature thereby improving the generation efficiency of PV panels. Insulating water bodies through

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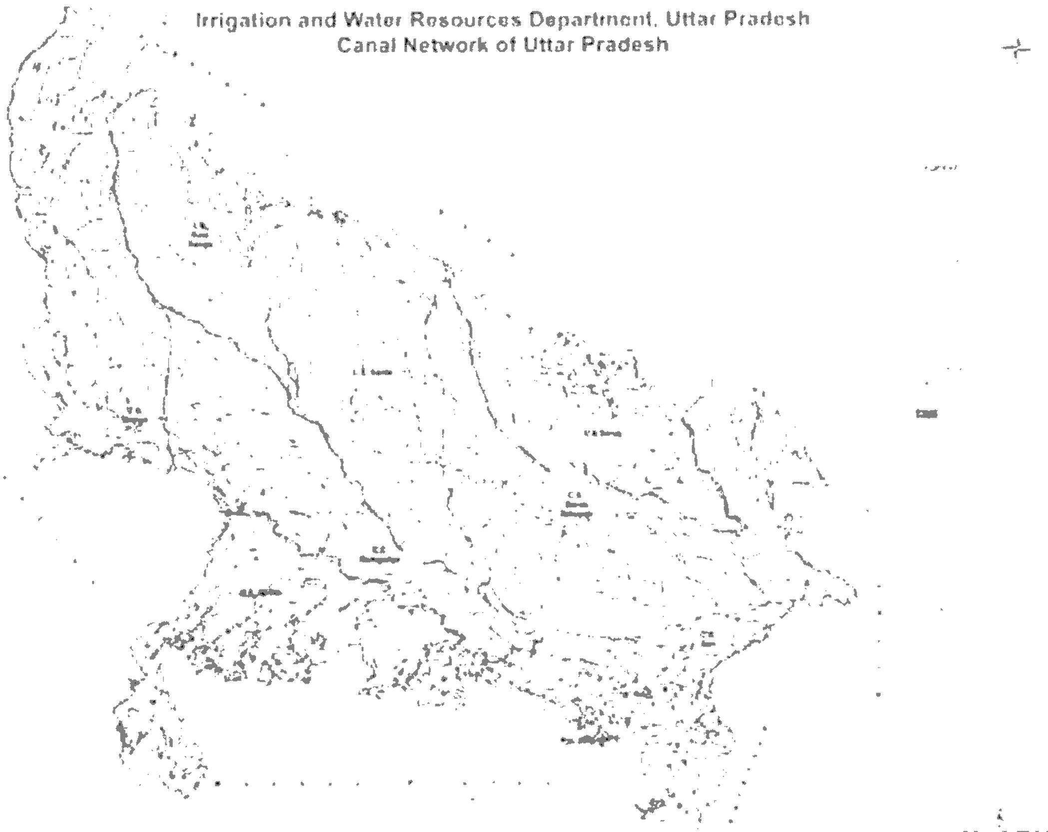

Fig. 1. Water infrastructure of Uttar Pradesh (Source: State Water Resources Agency (SWaRA) Uttar Pradesh)

floating solar panels leads to reduction in the water evaporation losses as well as improvement in overall water quality. Use of water bodies for solar power also helps in conservation of precious land bank to remain productive for agriculture purpose as well as for other industrial/urban development. Hence rather than focusing the solar PV development on the land areas, it is advisable to explore the water bodies which will be able to provide an alternative to the land bank used for solar power generation.

While government of India is in the process of adopting solar power as its mainstream power source, this study will add into the knowledge domain of floating solar PV technology to policy makers, renewable energy professional and government bodies for increased understanding in terms of assessment of potential (potential to conserve water resources) and potential to conserve agriculture land bank. Though floating solar is slightly costly option as compared to land based PV installations, the study will provide a platform to quantify additional benefits of floating solar PV compared to land based PV installation. Uttar Pradesh has several reservoirs which act as primary source of water for the people in terms of potable water as well as irrigation needs. Bundelkhand region of Uttar Pradesh considered as the study area, is a water scarce and drought affected region located in tropical conditions having high potential for floating photovoltaic installation. Several dams have been constructed in this area to fulfil drinking as well as irrigation water requirement. This study will estimate the PV potential, economic feasibility and evaporation losses reduction due to floating solar PV installation at [illegible] dam in Bundelkhand region of Uttar Pradesh, India.

Research background

Carolina Perpiña Castillo et al. [illegible] (2016) assessed the potential of European regions for solar power generation using GIS to combine solar radiation information with geographical factors like slope, land use, urban extent and population distribution as well as proximity to the power grid to generate a suitability map and its comparison with recent European Union (EU) incentives for the development of this renewable energy source. Kougias et al. (2016) have evaluated potential of water infrastructure to accommodate solar PV systems in Mediterranean islands. Their study evaluates that about [illegible] m^3 of water savings per MW of solar PV installation can be achieved on water bodies.

The study conducted by [illegible] (2017) had compared the levelized cost of energy (LCOE) of typical ground mounted solar PV grid connected systems with the LCOE of floating solar PV Systems. The LCOE of grid connected system is lower than the floating solar PV system. However, other benefits such as water evaporation loss reduction and land use reduction compensate for the higher cost. [illegible] established [illegible] Grid connected FPV plant at [illegible] in Taiwan covers [illegible] m^2 to install [illegible] kWp. Thus [illegible] ha area is required to establish 1 MWp FPV with capex cost inclusive of [illegible] is [illegible] USD/kWp while excluding [illegible] system cost per kWp is [illegible] USD.

[illegible] (2018) had studied the performance of an existing FPV installation in Tengeh reservoir Singapore. The study results highlighted that FPV system was generally 5% to 10% cooler than similar modules mounted on rooftops. The cooling effect of FPV system yields about 10% higher Performance Ratio (PR). [illegible] et al. (2018) had also studied the effect of temperature on existing FPV solar plant at Hambantota, Sri Lanka. The study result showed that low operating cell temperature led to increased efficiency of solar panels. Dash and Gupta (2015) had studied effects of air and water cooling system on decreasing the module operating temperature. The result displayed a linear trend of temperature and effect relationship curve. Louise (2017) had studied floating solar PV system through a case study of Shrimp solar farm in Thailand. As per their study results, floating solar PV system proved to give higher reliability as compared to ground mount PV systems. The report also highlighted that floating PV system proved to increase energy efficiency compared to ground mount PV and at the same time reduce water evaporation.

Surface water evaporation is a complex phenomenon and various factors affects the water evaporation from open water surface, some of these factors include water surface area, temperature, vapour pressure difference, wind effect, atmospheric pressure and quality of water. An assessment of water evaporation losses was reported by Central Water Commission, New Delhi (CWC, 2006). As per this report, average annual evaporation losses are of the order of 225 cm. The total surface area of large and medium storage water bodies in India is of the order of 12,000 Sq.km which is likely to increase to about 25,000 Sq km in the ultimate stage of development. Considering 225 cm as annual evaporation loss rate, evaporation works out to be about 56,000 MCM every year. Hartzell (2016) conducted study in Arizona, estimated water evaporation losses to the tune of 4.4% per annum on dams & canals of Central Arizona Project. The study also estimated technical potential and electricity generation potential in Arizona water reservoirs. Yao et al. (2010) studied suspended & floating covers for evaporation reduction at water bodies. The report estimated that if Waterfhoe dams was fully covered, the annual efficiency of evaporation reduction reached to 76% for suspended covers and 68% for floating covers. The report also estimated cost per unit water saved of the order of 1.14$ to 1.75$ per kilo liter (Yao et al., 2010). Gaikwad and Deshpande (2017) had also studied the evaporation control using floating PV system and canal top system. However, the paper did not quantify the water evaporation loss factor. Melvin and Xiang (2015) had studied effect of solar panel on reducing water evaporation in Singapore reservoirs. The study showed that floating solar panels above water bodies had a reduction effect of approximately 30% on evaporation rates. As per the experimental setup results, average daily evaporation rate was about 7 mm/day which was reduced to about 5 mm/day by covering water body surface using solar panels.

Solar PV generation is variable resource by nature. Hence, stable power supply can be provided through integration of solar with an existing thermal station, gas station and/or hydro station. Tavakkoli, Adabi, Zabihi, Godina, and Pouresmaeil (2018) had studied frequency stability in hybrid power stations. Creating a micro grid with solar PV and hydro power can provide stable power supply in a region. Farfan and Breyer (2018) had also studied the impact of combining floating solar PV system with hydro power systems. The study estimated 6.3% additional water available through prevention of water evaporation and resulted in increased hydro power electricity generation by 6.3%. Sharma, Kothari, Sharma, and Kothari (2016) had studied the uses of floating solar power in tandem with Pump hydroelectric system. The study had assessed reservoir surface area and existing hydroelectric installations in India. The results highlighted that uninterrupted green power of 13 GWp could be exported to the grid by using a combination of floating solar PV and pumped hydroelectric system in selected dams of India.

Da Silva, Drago, and Branco (2018) had assessed environmental impact of floating vs conventional photovoltaic system in terms of water quality depletion, bird collision, water management and employment. As per the report floating solar does not utilize chemicals and herbicide, hence less pollution. Floating solar also avoids use of precious agriculture land, hence cause less deforestation. Environmental impact assessment for floating solar system on wine farms, in the Western Cape Wine region, report assessed environmental impact on flora and fauna due to covering of water bodies. Dizier (2018) studied the impact of implementing active cooling strategies on floating power plant's overall performance in Taiwan and found net power generation gain of 6.6% compared to FPV plant alone. Sudhakar (2019) had reviewed the benefits of FPV plants in the form of SWOT analysis. Their study highlighted the advantages of FPV system as compared to ground mounted system.

Floating PV plant: overview of modules

The floating solar power plant have modules, inverters similar to ground-mounted solar power plant. Main difference between the two, is that of module mounting structure and appurtenant structures. Components other than module and inverters, of floating solar PV plants are the following:

1. *Floating platform structure (Pontoon)*: This is the main component of the FSPV which supports the PV panels and keep them floating over the water. The most common material used for this purpose globally is HDPE. However, other materials are also being used at certain places. Various designs have been developed by companies and being used as per their requirements.

2. *PV module support structure*:

Floats: The float is a buoyant body that rests above the water and also acts as a solar panel installation base. It also includes components for the fixing of mooring cables.

Upright Stands: When mounted to the float, this acts as a base component that produces an angle of inclination for the solar panels.

Bridges: The bridge is a component that connects floats to one another and serves as a foothold during construction and maintenance.

Binding Bands: The binding band fixes floats together. Two varieties are available to match the wind pressure load.

Anchor Bolts: These bolts anchor the solar panel brackets to the floats.

Solar Panel Brackets: The fixing brackets are fixed with float bolts and act as a support fitting to fix the solar panels in place.

3. *Anchoring and Mooring system*: The FSPV plants installed on water are subjected to seasonal water level variation as well as wind pressures during their lifetime. To keep the FPV plant stable and anchored at its intended location, Anchoring and Mooring system is designed. This system design requires Bathymetry survey, water level fluctuation, soil conditions and the location. Various types of Mooring systems have been used worldwide such as Quays, Wharf, Jetties, Piers, Anchor buoys and Mooring buoys.

4. *Balance of System*: Components other than mentioned above, such as Cabling, Combiner box, Switch board, Transformer, SCADA etc. are termed as balance of system are same as ground mounted system. However, cables used in the FSPV plants are different from the ground-mounted solar PV plant because the cables are in constant contact with water. The length requirement of the cable is also higher in the case of FPVI and also needs to be UV resistant.

Approach and methodology

As the major objective of this study is to assess the prospective potential of solar PV installation on the Rajghat dam water body in Uttar Pradesh. The potential of floating solar PV technology is assessed through a pilot case study on Rajghat dam. The total area at dead storage level of water body (Rajghat dam) is taken and considered for assessing technical potential of solar PV installation on Rajghat dam. The technical potential is evaluated in terms of installed capacity as MWp and annual energy generation as MWh. The installed capacity in the pilot case study is assessed using physical installation of floating solar PV modules on the usable area (surface area at Dead Storage Level of Dam). Further, usable surface area is estimated based on the driest month of the year where water is available in sufficient depth. The assessment of potential has also been done keeping overall area equal to 10% of the submerged area at full reservoir level.

The system is modelled on PVsyst to assess annual energy production considering different orientation. A comprehensive review of secondary data has been done to assess water evaporation losses and effectiveness of floating solar in reduction of evaporation losses. Based on preliminary results of experimental results, quantification of reduction in evaporation losses has been done. A financial model in terms of LCOE (Levelized cost of Energy) has been developed and levelized cost with fixed tilt of 15° orientation is estimated. The capital cost of floating solar PV generation is taken based on recent estimates provided by TERI (The Energy and Resources Institute) ([illegible] et al., 2019), World Bank Group, ESMAP (Energy Sector Management Assistance Program), Solar Energy Research Institute of Singapore (2019), MNRE and queries from companies working in this field (Ciel & Terre, Sungrow). The analysis performed through the pilot case study establishes the fact why floating solar PV installation would be beneficial on water bodies, especially for the study region, Uttar Pradesh, India.

Case study of floating solar PV plant at Rajghat dam, site selection

The Rajghat dam in Uttar Pradesh, India is the location selected for case study to assess the FSPV potential especially due to its large open area. The maximum height of dam is 50 m and depth of water at full reservoir level (FRL) is 55 m. The water spread at FRL is approximately 242 km^2 which shows the scope to accommodate large number of solar PV panels. This reservoir serves multipurpose, mainly irrigation and hydro-electric power generation. The peak irradiation at this location is 1885 kWh/m^2 and mean annual ambient air temperature on land is 25.5 °C. The database of the terrain measurements of the solar insolation and ambient air temperatures from the Meteonorm database (PVsyst 7.0) is used for the calculation of the solar energy capacity of the dam. Table 1 presents the values of the average horizontal insolation and land surface temperature for an average day of the month at Rajghat dam and Fig. 2 shows the solar path.

Techno-geographical potential for floating solar on Rajghat Dam

Technical potential for floating solar as defined in this study represents the solar PV capacity installation in MW of a given PV technology. Apart from capacity installations, potential is also assessed in terms of energy generation in MWh. The assessment has been conducted for the pilot case study as mentioned earlier considering topographic limitations and environmental constraints. The primary benefit of assessing technical potential is in establishing benchmark estimate of solar PV capacity to be deployed. The key assumptions in estimating technical

Table 1
Horizontal insolation and surface temperature of Rajghat Dam for an average day of each month.

Month	Surface ambient air Temperature (°C)	Solar Horizontal insolation (kWh/m²)	Solar Horizontal insolation (kWh/m² day)
January	[illegible]	124.2	4.0[illegible]
February	20.[illegible]	140.[illegible]	5.[illegible]
March	26.18	184.4	5.[illegible]
April	31.05	184.2	6.[illegible]
May	34.[illegible]	203.4	6.[illegible]
June	31.[illegible]	174.1	5.80
July	28.29	141.1	4.[illegible]
August	27.[illegible]2	142.1	4.5[illegible]
September	2[illegible].4[illegible]	154.4	5.[illegible]
October	26.[illegible]8	153.[illegible]	5.[illegible]
November	21.84	126.[illegible]	4.[illegible]2
December	18.20	122.9	3.9[illegible]
Year	25.5[illegible]	1885.[illegible]8	5.[illegible]

potential are physical constraints as location, topographic constraints, dead storage level in the driest month.

[illegible] et al. (2018) had proposed 24% of the total area and effective area for PV installations had been recommended at 20%. Acharya and Devraj (2019) has suggested 1 to 30% of the total surface area to install FPV plants depending upon the type of water body. However, the suggested range for irrigation reservoirs is 5 to 15% of the total surface area. They have also estimated the FPV power potential of different states of India with reservoirs having water depth more than 2 m and surface area more than 1,500 m^2. The current study proposes water depth more than 2 m and area under submergence (surface area) more than 550 ha. The reason behind this states that the surface area of the water bodies gets depleted significantly during summer. To keep the FPV plant floating and operational during those months and to ensure economic viability of the utility scale, the proposed size is suitable. As per the data obtained from Uttar Pradesh Irrigation and Water Resources Department (UPIWRD), Rajghat dam spans 24,210 ha of water surface area at full storage level (FSL). Since floating solar will be a semi-permanent, moored installation, assessments are made using the lower range of surface area. Lowest surface area available for floating solar PV installation has been estimated from driest month as 6052 ha which is approximately 25% of total submerged area at full reservoir level (FRL).

For estimating the geographical potential, the available surface area has been modelled in Autocad using PV monocrystalline technology 350 Wp modules with 17.7% efficiency. Each module represents about 2 m^2 surface area. In order to model the estimates, Google Earth tool has been used and PV modules strings have been superimposed (shown in Fig. 3). Considerations have also been made for other infrastructure development on water surface such as boat docks and inter-road distance for movement of cleaning equipment. The total PV installed capacity on the available surface area of 6052 ha is estimated as 1515 MWp. The total module area represents roughly 1450 ha and balance unbuildable area represents 4602 ha which shall be used for boat ways and other machinery movement for regular operation & maintenance of the plant. So, practically 24.25% (approximately) of the total submergence area has been utilized for floating solar installations. The remaining 75.75% area accounts for maintenance, row shedding considerations etc. An estimation for 10% coverage area has also been estimated and reported in the study.

[illegible] et al. (2015) had suggested to estimate the value of two densities, namely energy density and power density and to find out a factor FLH ($=$ EL/PH) where EL is the yearly energy production in GWh and PH is the peak power in GW. This factor ranges typically from 800 to 1800 h depending upon the latitude and mean weather condition of the place. The annual energy generation from the Rajghat dam is estimated to be 10,623 GWh and annual power generation estimated to be 6.05 GW. So FLH of this dam is 1756 h and the energy generation is 1.76 GWh per ha per year.

There is an existing hydro power plant of 45 MW capacity adjacent to the Rajghat dam which feeds electricity into the 132 KV GSS. According to the CEA (Central Electricity Authority) India 2018 report, the power generated from this plant is 87.6 MU in 2018. The FLH of hydro power plant is 1946 h which is typically lower than the normally expected from hydro power plants. The power generation per sq. hectare of submerged area is 18 kWh which is exceptionally lower than the power generation of FPV. This may be due to the reason that the reservoir is primarily built for the irrigation purpose. The electricity generated from the floating solar power plant can be fed to the existing GSS. The floating solar power plant can run in tandem with existing hydro power plant which represents an effective alternative to meet the daily and seasonal demand variation. The hydro power plant will operate at its peak during monsoon season when solar power generation is minimal. The solar power generation from floating solar power plant shall be at its peak during summer season when

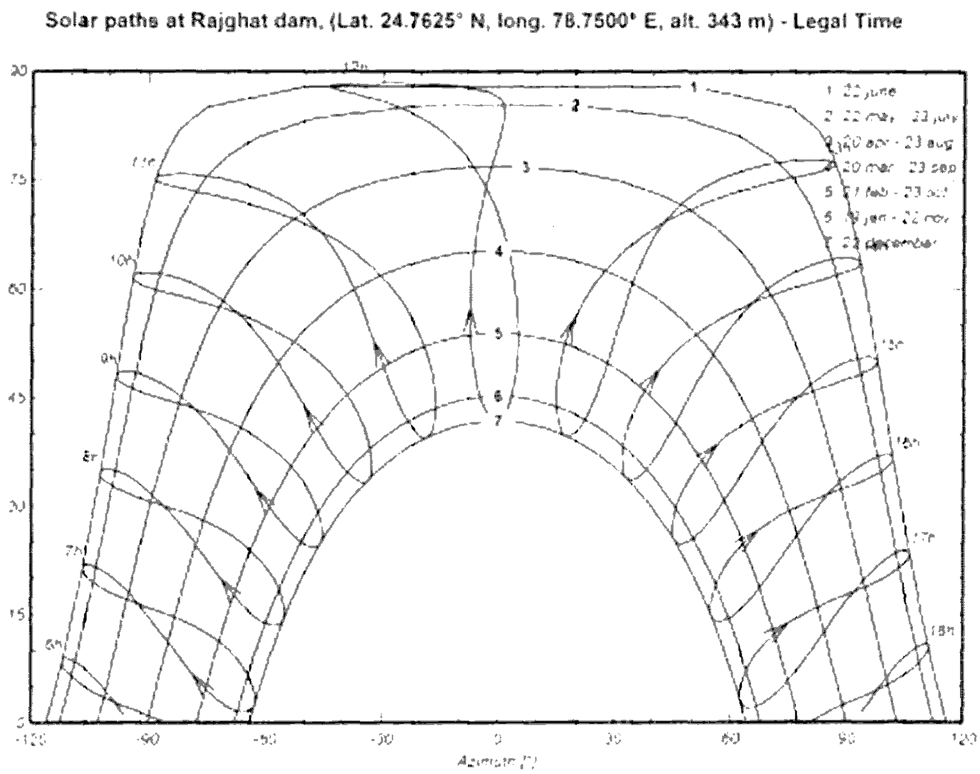

Fig. 2. Solar path at Rajghat dam [illegible]

water availability at Rajghat dam reduces significantly. Further, it can be noted that the floating solar capacity installation is larger than the existing hydro power generation; the surplus power from floating solar can be used through pumped hydro storage system for the successful integration of solar PV with the grid. The combination of existing power evacuation infrastructure, a pump hydro energy hydro system and floating PV solar system represents an excellent site for solar PV hydro hybrid system.

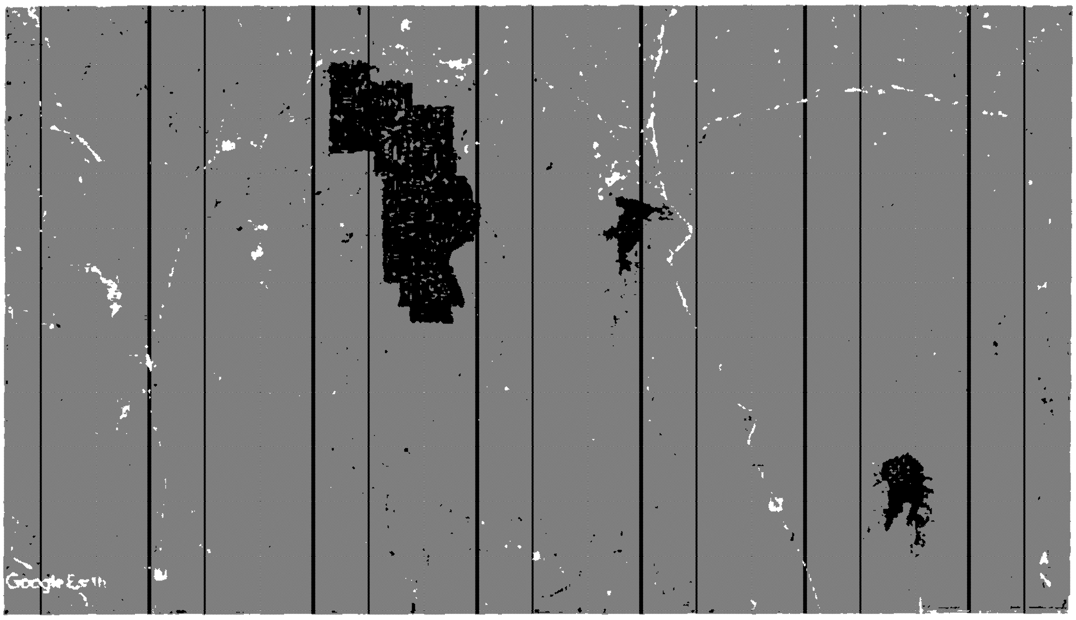

Fig. 3. PV Modules superimposed on water surface (Source: Google Earth and Auto cad for Rajghat)

Reduction in evaporation loss due to FSPV

Water is an essentially scarce resource, even though earth is full of water covering 70% of its area of which only 1% of water is available for drinking. Water stored in reservoir for drinking, irrigation industrial purpose etc. gets reduced in quantity as well as quality due to natural phenomenon of evaporation. Many methods have been tested and developed across the world to reduce evaporation. Youssef and Khodzinskaya (2019), have reviewed various methods of evaporation reduction from water surfaces. Among these techniques the floating covers, as per the study conducted by Urban Water Security research Alliance Technical Report No 28 (Yao et al., 2010), can save 68–76% of water. However, the cost of saving is very high.

Floating PV plants are installed on water bodies such as lakes, reservoirs, hydroelectric dams, mining ponds, industrial and irrigation ponds, water treatment ponds and coastal lagoons. Covering the parts of water bodies by FPV plants, reduces evaporation from these ponds/reservoirs. These plants not only reduce amount of solar radiation reaching the water surface but also acts as wind breakers which are influencing part of the evaporation process. Wind breakers not only reduce evaporation rates from shaded portion of FPV but also from surface not covered by FSPVs. The study for wind breaker effect has not been done yet. However, work on quantifying reduction in evaporation loses due to FSPV has been addressed. Melvin and Xiang (2015) has studied effect of solar panel on reducing water evaporation in Singapore reservoirs. The study shows that floating solar panels above water bodies have a reduction effect of approximately 30% on evaporation rates. Marco Rosa-Clot, Tina, and Nizetic (2017) have studied the effect of covering the lagoons with FSPVs and evaluated the reduction of evaporation in covered as well as open surface. Penman-Monteith equation was used to evaluate the reduction in evaporation. 90% of evaporative reduction was reported with respect to open surface. Perez et al. (2018) studied water conservation due to 100% coverage of water surface over 128 reservoirs of US by FSPVs and reported that 25,000 Mm^3 water was conserved. Studies conducted by Bontempo Scavo, Tina, Cagliano, and Nizetic (2021) have considered different typology of FPV system and quantified the water saved due to reduction of evaporation. In various literatures, evaporative models were compared with design of experiment (DoE) model and linear regression model was developed by them. Experimental data also validated the model developed considering different typology of FSPV as well as different coverage of water body. Evaporation rate for suspended type FSPV varied from 6% for 10% coverage to 60% for 100% coverage. It had been estimated, while considering floats in direct contact with the water and had reported to vary from 18% for 10% coverage to 100% for 100% coverage area. Based on present availability of literature, the evaporation estimation can be best assessed by the Bontempo Scavo et al. (2021) methodology.

In present study evaporation reduction has been assessed for 25% of the coverage area, which is based on preliminary results of the experiment. However, a detail discussion regarding experiment and results will be done somewhere else. Assuming this reduction rate for our case study of Rajghat dam, the evaporation reduction is estimated to be 9.084 million cubic meter (1450/24210*255*0.25) (Area covered by PV panel/Total area of reservoir*Estimated Annual Evaporation from reservoir*evaporation reduction estimated experimentally). It may be noted that installation of 65.13 MW_p FPV at Rajghat dam would save 9.084 million cubic meter of water through water evaporation losses which is about 0.47% of total reservoir capacity and 139.5 l/kW_p.

Economic assessment

As per the information on PV investment costs, retreat from public press releases total CAPEX for FPV system in 2018 ranged between $0.8 and $1.2 per watt-peak, depending on the location, water body depth and variation, and system size (Where Sun Meets Water, Floating Solar Market Report 2018). In March 2018, India based West Bengal Power Development Corporation Limited awarded EPC (Engineering, Procurement and Construction) bid for 5 MWp FPV system to Ciel & Terre International on the basis lowest quote of Rs. 269.12 million (no grant provided), which corresponds to about $4.13 million or $0.83/Wp (average annual exchange rate). The economic assessment of the Solar power plant is based on 2 expenditures namely: Capital Expenditures (CAPEX) and Operation and Maintenance cost (OPEX).

Capital expenditure

A comparison of CAPEX available in literature for floating solar and fixed tilt is given in Table 2.

Some researchers have also estimated cost of fixed tilt FPV. Marco Rosa-Clot et al. (2017) have suggested $1.119/Wp at 2017 price level while Cinco Hermanu, Santoso, and Suyitno (2019) have utilized Rp 31,600/Wp (Rp 13,200 = $1 US) for estimating cost of 1 MWp floating solar PV plant in Indonesia. Various researchers from different countries have estimated the cost of FPV plants ranging from USD 0.5–2.39/Wp during the period of 2015–2018. The EPC cost for India's first large scale FSPV at Kayamkulam, Kerala (India) based on tenders received in 2019 is USD 0.53/Wp. The cost achieved for EPC are site specific and have certain hidden cost, so same cost cannot be utilized for estimation purpose. So, a cost analysis has been done based on market survey and experience.

Cost analysis of floating solar PV plants

The Floating Solar PV (FSPV) plants utilize mono or poly crystalline modules and string or central inverters are being utilized, however central inverters are recommended for large scale plants. A standard PV module price of $ 0.22/Wp and cost of central inverter $ 0.03 has been utilized for estimating Levelized cost of electricity. The cost analysis is given in Table 3 and shown in Fig. 4.)

Module Mounting Structure (MMS) involves civil construction as well as structure, anchoring and mooring system which depends on parameters such as Bathymetry, water level variation, wind and wave characteristics, type of bank and water quality and level of salinity. These parameters are site specific and cost varies from project to project. However, on the basis of queries made with companies working in this field cost of floating structure including anchoring and mooring ranges between $0.12/Wp and $0.22/Wp. An average cost of $ 0.14/Wp has been utilized for Levelised cost of electricity.

Balance of system includes equipment such as combiner box, switch board, transformer, cable and monitoring system SCADA. A cost of $0.13/Wp has been adopted based on experience and queries. Higher cost of cable is due to high insulation to check current leakage, cable routing and slack requirement for constant movement of floating installation would be required. Installation, commissioning and other

Table 2
Comparison of CAPEX for Floating and Ground Mounted Solar System.

CAPEX Component	World bank Floating solar market report[b]	TERI report: Mohit Acharya and Sarvesh Devraj
	FPV 50 MWp ($/Wp) – 2018	FPV 70 MWp ($/Wp) – 2018[a]
Modules	0.25	0.19
Inverters	0.06	0.06
Mounting system	0.15	0.16
BOS	0.13	0.08
Design, Construction, T&C	0.14	0.01
Total CAPEX	0.73	0.50

[a] $1 = ₹ 70 assumed for 2018 by TERI
[b] Where Sun Meets water – Floating solar market report

Table 3
Cost analysis of floating solar PV plants.

Sl No	Parameter	Cost ($/Wp)
1	PV Panel	0.22
2	Inverter	0.03
3	Mounting Structure, Design, civil construction	0.14
4	Electrical Balance of system	0.13
5	Installation cost, land cost and other expenses	0.08
6	Total	0.60

1 $ = Rs 73.5

expenses based on experience and queries has been taken as $0.08/Wp. The cost enumerated above is for fixed mounting structure.

Operation cost (OPEX)

This cost includes operation and maintenance (O&M), insurance, *inverter replacement cost and leasing cost of water body. Leasing cost of* water bodies have wide variation across the globe, so this component has not been considered in the financial calculations. The O&M cost varies depending on the site conditions, which have several factors such as annual variation in water level, wind speed and wind pressure, inspection of mooring cables and anchoring system at regular interval. Replacement of parts or equipment is complicated and time consuming and it also involves safety issues, which potentially adds to maintenance cost.

World Bank Group and Energy Sector Management Assistance Program, Solar Energy Research Institute of Singapore (2019) have recommended $0.011/Wp as the O&M cost for floating solar. Floating PV is in the nascent stage of development and not much data is available, so a value suggested by World Bank floating solar market report (2019) as 0.3% of the system price, paid annually and adjusted to the inflation rate, which is same as for the utility scale ground mounted PV projects. Inverter manufacturer normally offers warranty for 5–12 years, so during operation period proposed for project i.e. 20 years at least once the inverter has to be replaced. World Bank floating solar market report (2019) have suggested a cost of $0.039/Wp for inverter maintenance cost. So OPEX proposed by World Bank floating solar market report (2019) as $0.072/Wp. Ciel et terre, (2020) have utilized 3% of CAPEX as OPEX for estimating LCOE, for which no reasoning is given, while Barbuscia (2018) have suggested €4.26/kWh as OPEX. However, Barbuscia (2018) has proposed breakup for OPEX cost. He suggested four components with their weightage, 69% for management and administration, 12% annual monitoring and maintenance, 17% onsite replacement and works and 3% major replacements and works onshore. He also assumed 6 onsite visual inspection and module cleaning per year, 4 technical periodic maintenances (mainly for structure and inverters) per year and 2 under water visual inspections with Remotely Operated Vehicle, per year. For present study OPEX has been considered as $0.072/Wp based on market survey and experience, which is also suggested by World Bank floating solar market report (2019) based on detail analysis of existing data.

Levelised cost of energy (LCOE)

In order to determine the suitability of technologies discussed above, the cost components such as capital cost, Operation & Maintenance cost, interest rate, Capacity Utilization Factor (CUF) etc. were compared with generated income. An economic assessment has been carried out in terms of Levelized Cost of Energy (LCOE) and Internal rate of return (IRR).

Results and discussions

An assessment of technical potential of floating PV on Rajghat dam for 25% of the total submerged area has been conducted. Considering of infrastructure development on water surface such as boat, decks and inter road distance for movement of cleaning equipment, the total PV installed capacity on the available surface area of 6052 ha is estimated as 6513 MWp. The total module 1,86,14,154 represents roughly 3450 ha and balance unbuildable area, represents 1063 ha which shall be used for boat ways and other machinery movement for regular Operation & Maintenance of the plant. So, practically out of 25% of submergence area, approximately 14.25% of the total submergence area has been utilized for floating solar installations. The remaining 10.75% area accounts for maintenance, row shedding considerations etc. Performance analysis of floating PV has been done using PV_{syst} software and simulation for floating PV plant is done keeping albedo 0.1 for water and soiling at 1%, since water bodies are normally situated away from city, industries etc. away from dust, so less soiling compared to ground mounted. Rest of the parameter were kept as default values and technical data, as provided by the manufacturer data sheet. The power generation has been estimated as 10,623,501 MWh for coverage area of 25% while technical potential for 10% coverage area is 2603 MWp and energy generation is 4,245,105 MWh. Table 4 show the results of performance analysis of floating PV at Rajghat dam.

In present study evaporation reduction has been adopted for 25% coverage area, which is based on preliminary results of the experiment. Assuming this reduction rate for our case study, the installation of 6513 MWp FPV at Rajghat dam would save 9.084 million cubic meters of water from evaporation losses which is about 0.47% of total reservoir capacity and 0.91 l/kWh. Considering the cost, to develop water infrastructure to store water of 9.084 million cubic meter, approximately Rs.137 crores to be invested or Rs 0.12 to 0.14 per kWh will be saved by installing floating solar PV plant over water infrastructure. Additional yield of 482.86 MWh will be generated annually, by the water saved from evaporation.

Considering rate of decaying of module as 1% per year till first 10 years and then @ 0.67% per year for remaining 15 years and avoiding

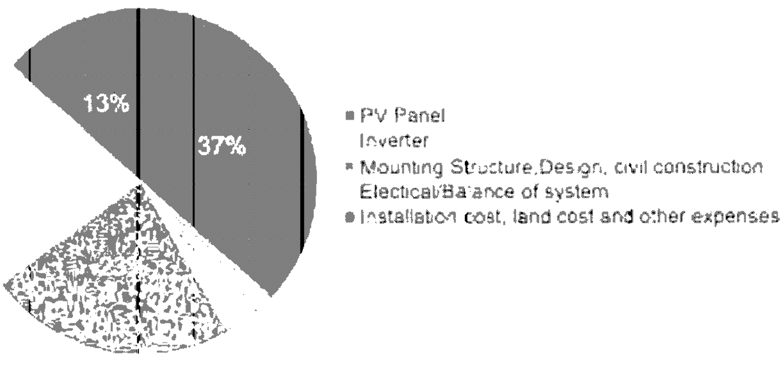

Fig. 4. Cost component of floating solar PV plant.

Table 4
Summary of PV installation capacity and benefits at Rajghat dam.

Latitude	Longitude	Submergence area at FRL (ha)	10% Area exposed			27% area exposed			LCOE	Tariff (Rs/kWh)	IRR (%)	Evaporation Reduction (kWh)
			Area in ha	Power Generation for land mount (MWp)	Specific yield (MWh/year)	Area (ha)	Power Generation by floating (MWp)	Specific yield (MWh/year)				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

cost of transmission line as grid connection is available at dam site the levelized tariff has been estimated as Rs 2 to kWh ($ 0.0[illegible] kWh) and IRR as 8.52. While adding the cost of 5 km transmission line, the levelized cost estimated as Rs 2.5[illegible] kWh ($ 0.0[illegible] kWh) and IRR as 7.14. However, monetary benefits of intangible benefits such as land cost and reduction in evaporation is not accounted for in the estimation. Summary of PV installation and benefits at Rajghat dam are enumerated in Table 4.

Conclusions

The technical potential assessed for floating solar PV installation on Rajghat dam in Uttar Pradesh, India in the study provides a guideline information towards planning floating solar installation on water bodies. These guidelines can be used as a basis to estimate the overall floating solar potential on the water bodies at a regional scale. In this study, the estimation is done for the state of Uttar Pradesh, India. The conclusions from this study can be reported briefly as follows:

- The total capacity of floating solar is estimated to be 5513 MWp with annual energy generation as 10,025,501 MWh.
- This work has also assessed annual evaporation loss reduction of [illegible] m³ per MWp or 0.91 kWh which will reduce the tariff by Rs 0.12 to Rs 0.14 per kWh.
- 9.08 million cubic meter (MCM) water could be saved by installing floating solar on Rajghat Dam, which will fetch additional yield of 482.86 MWh from hydro power generation.
- Economic attractiveness of floating solar are comparable with ground mount PV installation in terms of LCOE and results highlight that if the tangible as well as non tangible benefit associated with floating solar installations are compared, then floating solar PV is equally encouraging option.
- It is noted that floating solar PV System is costlier than land based PV system. The system cost of floating PV is higher mainly because of floating platform upon which PV modules are mounted. These floating platform are typically air filled HDPE floats, a low cost material. While floating PV systems are more expensive, these systems are demonstrated as more efficient as they operate relatively at low temperature as compared to ground mount PV system. Land cost is generally not considered in case of floating solar PV. Hence the overall system cost is marginally higher as compared to ground mount system.
- The added advantage apart from higher energy generation includes improved water quality and decreased evaporation. The arguments are also supported through the scarcity of water for agriculture purpose and incremental agriculture yield through reduction in surface water evaporation losses in water bodies. As the water bodies store potable water, reduction in water evaporation losses would not only reduce water scarcity in agriculture, it will also reduce potable water scarcity.
- It is also important to note that habitat development is in the vicinity of water bodies and injecting this electricity into existing grid infrastructure will reduce government expenditure on additional infrastructure development for power evacuation facilities. Installation of solar PV on water bodies will help in providing sufficient electricity to develop micro irrigation system where in availability of power is a major constraint to take up water from canals to irrigation fields to provide last mile connectivity.
- As the electricity will be injected from floating solar installation to the load centers, this will increase and reduce the Transmission & Distribution losses to a significant extent. Therefore, floating solar PV is recommended for adoption to meet the green power requirement in Uttar Pradesh, India.

Declaration of Competing Interest

Authors declare that there is no conflict of interest.

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News Release: Floating Solar Panels Could Support US Energy Goals

New Study Shows Federally Controlled Reservoirs Could Host Enough Energy To Power Approximately 100 Million US Homes a Year

Jan. 14, 2025 | Contact media relations

For the first time, researchers have used more detailed criteria—like water depth and temperature—to get a more accurate idea of how many floating solar panels some U.S. reservoirs could hold. Even in their most conservative estimates, the country's reservoirs offer huge potential for future development and could host projects with capacities of up to 77,000 megawatts. *Photo from Getty Images*

Federal reservoirs could help meet the country's solar energy needs, according to a new study published in *Solar Energy*.

For the study, Evan Rosenlieb and Marie Rivers, geospatial scientists at the U.S. Department of Energy National Renewable Energy Laboratory (NREL), as well as Aaron Levine, a senior legal and regulatory analyst at NREL, quantified for the first time exactly how much energy could be generated from floating solar panel projects installed on federally owned or regulated reservoirs. (Developers can find specific details for each reservoir on the website AquaPV.)

And the potential is surprisingly large: Reservoirs could host enough floating solar panels to generate up to 1,476 terawatt hours, or enough energy to power approximately 100 million homes a year.

"That's a technical potential," Rosenlieb said, meaning the maximum amount of energy that could be generated if each reservoir held as many floating solar panels as possible. "We know we're not going to be able to develop all of this. But even if you could develop 10% of what we identified, that would go a long way."

Levine and Rosenlieb have yet to consider how human and wildlife activities might impact floating solar energy development on specific reservoirs. But they plan to address this limitation in future work.

This study provides far more accurate data on floating solar power's potential in the United States. And that accuracy could help developers more easily plan projects on U.S. reservoirs and help researchers better assess how these technologies fit into the country's broader energy goals.

Floating solar panels, also known as floating PV, come with many benefits: Not only do these buoyed power plants generate electricity, but they do so without competing for limited land. They also shade and cool bodies of water, which helps prevent evaporation and conserves valuable water supplies.

"But we haven't seen any large-scale installations, like at a large reservoir," Levine said. "In the United States, we don't have a single project over 10 megawatts."

Previous studies have tried to quantify how much energy the country could generate from floating solar panels. But Levine and Rosenlieb are the first to consider which water sources have the right conditions to support these kinds of power plants.

In some reservoirs, for example, shipping traffic causes wakes that could damage the mooring lines or impact the float infrastructure. Others get too cold, are too shallow, or have sloping bottoms that are too steep to secure solar panels in place.

And yet, some hydropower reservoirs could be ideal locations for floating solar power plants. A hybrid energy system that relies on both solar energy and hydropower could provide more reliable and resilient energy to the power grid. If, for example, a drought depletes a hydropower facility's reservoir, solar panels could generate energy while the facility pauses to allow the water to replenish.

And, to build new pumped storage hydropower projects—which pump water from one reservoir to another at a higher elevation to store and generate energy as needed—some developers create entirely new bodies of water. These new reservoirs are disconnected from naturally flowing rivers, and no human or animal depends on them for recreation, habitat, or food (at least not yet).

In the future, the researchers plan to review which locations are close to transmission lines or electricity demand, how much development might cost at specific sites, whether a site should be avoided to protect the local environment, and how developers can navigate state and federal regulations. The team would also like to evaluate even more potential locations, including other, smaller reservoirs, estuaries, and even ocean sites.

The research was funded by the Solar Energy Technologies Office and the Water Power Technologies Office in DOE's Office of Energy Efficiency and Renewable Energy (EERE).

Access the study (see below) to learn more about the immense potential for floating solar plants in the United States, or visit AquaPV to dig into the data on specific reservoirs.

NREL is the U.S. Department of Energy's primary national laboratory for renewable energy and energy efficiency research and development. NREL is operated for DOE by the Alliance for Sustainable Energy LLC.

Floating photovoltaic technical potential: A novel geospatial approach on federally controlled reservoirs in the United States

Author links open overlay panelEvan Rosenlieb, Marie Rivers, Aaron Levine

1. 1. Introduction

The global floating photovoltaics (FPV) industry is a rapidly emerging sector of the renewable energy industry with an average annualized growth of installed capacity of 142 % between 2014 (the year that global installed capacity surpassed 10 megawatts direct current [MWdc]) and 2022 (the most recent year with data, with cumulative capacity topping 13,000 MWdc) [1]. FPV provides a host of attractive benefits relative to ground-mount photovoltaics such as increased panel efficiency because of cooling effects and low shading, co-location with hydropower resources providing co-benefits in hybrid systems, and potential reductions in water evaporation [2]. Some countries, such as South Korea, have explicitly stated FPV development as necessary to meet their long-term solar energy targets [3].

However, as the global FPV market has taken off, efforts to understand its role in future energy systems is still in a nascent stage. The FPV technology faces its own unique technical and engineering constraints, such as problems posed by currents or ice floes. Understanding how much FPV may be reasonably developed when considering these technical limitations—or the "technical potential" of FPV—is a crucial first step to understanding its future pathway to development. To our knowledge, Spencer et al. 2019 was the first published paper that attempted to quantify FPV technical potential (in its case, for dam reservoirs in the United States) [4]. In the 5 years since then, at least nine other papers have been published that have quantified potential FPV development in other regions, countries or globally. However, to our knowledge no analysis has used spatially explicit methods that consider specific waterbody parameters as limitations to FPV development. This type of analysis has been a standard used for ground-mount solar and wind potential estimates for more than a decade [5], [6] but has not yet been developed for this new segment of the renewable energy sector.

2. 1.1. Review of previous methods

As an initial step, we conducted a literature review for previous assessments of technical potential FPV capacity. Although estimates of FPV capacity are frequently created for case studies of a single reservoir or for a subsample of reservoirs [7], we focused on studies that assessed capacity for all reservoirs fitting the study criteria within a defined area (resulting in a sum estimate of FPV potential). Ten previously published papers were identified that met our requirements. Of these 10 papers, only 1 paper—Lee et al. 2020—relied on spatially explicit methods to estimate the amount of developable area within each waterbody [2]. All other attempts to assess FPV potential have included some criteria for which waterbodies should be considered for the assessment but assume a flat percentage of each waterbody is developable for FPV and do not consider any site-specific factors that may influence the amount of water suitable for developing FPV. This method of estimating developable area for each waterbody may produce reasonable results when summed over a large area but cannot help address the question of which waterbodies may be the best targets for FPV development. Although other papers have advanced our knowledge of FPV technical potential by examining other relevant parameters such as evaporation mitigation and system performance, the method of estimating the available area has remained remarkably the same.

Lee et al. 2020 used simple minimum and maximum buffers from shoreline as proxies for other more specific factors [2]. Although this approach does incorporate site-specific aspects of the waterbody, distance from shoreline is not something that would usually render FPV development impossible alone; specific factors that may cause direct incompatibilities for FPV development were not considerd (e.g., parts of reservoirs that are too shallow). As such, we did not find any previous research that attempted to quantify FPV potential using such site-specific factors that would preclude FPV development. A summary of these papers is provided in Appendix A.

3. 1.2. Assessment Goal and Focus

This assessment aims to develop a novel geospatial method for the estimation of technical potential in the U.S. context to update the current understanding of FPV potential in the United States and apply a similar level of precision to estimates as used for ground-mount solar and wind. Because this represents a significant task by itself, this assessment focuses on technical limitations to FPV only and does not consider other regulatory, social, environmental, or economic limitations, such as the locations of recreation areas on reservoirs. In addition, this assessment estimates potential installable capacity and expected annual generation.

This study focused on federally owned and regulated reservoirs in the United States that fall under the jurisdiction of the U.S. Bureau of Reclamation (USBR), U.S. Army Corps of Engineers (USACE), and/or are licensed hydropower projects by the Federal Energy Regulatory Commission (FERC) to better assess U.S. technical potential on large bodies of water as well as to understand the potential for hybrid FPV/hydropower projects.

4. 2. Methodology

The process for estimating the technically feasible waterbody area for FPV development for the study populations of reservoirs, as described in more detail in the respective subsections of the methodology section, follows the following steps.

The requisite data for reservoir geometry and attributes for federally owned and managed reservoirs are collected by cross-referencing the base National Hydrography Dataset (NHD) dataset on reservoirs with USACE, USBR, and FERC datasets to ensure the reservoir belongs to the identified study population. Then, reservoirs with qualities that would conflict with FPV development in any quanitity were excluded via spatial intersection with datasets that indicate such conflicts. This process is detailed in Section 2.1, Reservoir Selection Criteria. Next, the proportion of each identified reservoir that may be developed is estimated. Spatial data representing the areas of each reservoir that are not compatible with FPV development are estimated using available datasets relating to conflicting reservoir attributes using spatial methods as described in Section 2.2, Developable Area Criteria.

5. 2.1. Reservoir selection criteria

The reservoir selection criteria are summarized in Table 1. The step of compiling a single dataset of waterbody geometries for reservoirs that are either owned and managed by USACE and USBR or form a reservoir that is part of a FERC licensed hydropower project is conceptually straightforward. However, because of the differences in data sources available that catalog these reservoirs, there are still spatial processing steps required to do so with certain embedded assumptions. The other two waterbody selection criteria were determined through consultation with experts in the FPV field about what properties of waterbodies may be likely to pose prohibitive obstacles to the development of FPV on the entire reservoir.

Table 1. Summary of criteria used for reservoir selection.

Reservoir Selection Criteria	Rationale
NHD waterbody must be identified as belonging to USACE, USBR, or a FERC licensed hydropower project.	Potential for large-scale and hybrid deployment.
The waterbody must not be part of a USACE maintained navigable waterway.	The large wakes caused by freight shipping vessels can render an area unsuitable for FPV development.
The waterbody must not be located where there is an average monthly low air temperature below −15 °C.	The potential ice floes, heavy freeze/thaw cycles, and snow loading associated with very cold locations are incompatible with FPV development.

6. 2.1.1. Use of NHDPlusv2

To ensure all waterbodies in the analysis are represented by geometries of similar precision and have similar attributes, reservoir locations for each category of reservoir were cross-referenced with a single reservoir dataset, resulting in a study population of reservoir polygon geometries and attributes that are all obtained from a single source. The NHDPlusv2 data product of the NHD program was selected for this purpose because it contains a variety of attributes that are useful for these modeling purposes. It is additionally topologically aligned with a full flowlines network, allowing precise modeling of stream and river inlet and outlet locations. The newer NHD High-Resolution dataset was considered a possibility; however, at the time of analysis, it was not released in its final version and did not contain completed attribute data over the entire domain of analysis.

7. 2.1.2. USACE reservoir matching

The USACE reservoirs dataset obtained from the USACE data portal consisted of 401 reservoirs represented as polygon geometries. This dataset includes variables that identify "dry" reservoirs (which are built for flood control and do not hold water under normal circumstances) and water conservation areas, both of which are considered unsuitable for FPV. In this case, the original data source contains full reservoir geometries, and reservoirs that intersect with navigable waterways were excluded before joining with the NHDPlusv2 waterbody polygons. This ensures no waterbodies that intersect with navigable waterways were falsely included because of differences in waterbody spatial extent definitions between data sources. Once waterbodies that intersect with navigable waterways were excluded, 300 USACE polygons were identified as potential candidates for FPV.

These remaining 300 reservoirs were then spatially joined with the NHDPlusv2 waterbody polygons to find the NHD waterbodies corresponding with each USACE reservoir. NHD reservoirs were considered as spurious pairings and thus discarded from the study area reservoir selection if only a small portion of their polygon area overlapped their intersecting USACE polygons. Because of different spatial precisions and differing standards in how the spatial extents of reservoirs are defined, these 300 USACE reservoirs are ultimately associated with 517 NHD waterbodies.

8. 2.1.3. USBR reservoir matching

Locations for USBR reservoirs obtained from the USBR Reclamation Information Sharing Environment (RISE) catalog came as point coordinates. Nearest neighbor spatial joins were used to match point locations to NHD waterbodies. Initially, a maximum search distance of 25 m was used to prevent points from incorrectly matching with multiple waterbodies. The search distance was then incrementally increased by 50 m, and nearest neighbor joins were applied to the remaining unmatched USBR points and NHD polygons. Waterbody names from the USBR data and NHD data were compared for accuracy, and duplicate NHD waterbodies—caused by multiple associated USBR points—were removed. Through this process, 188 USBR reservoir point locations are associated with 148 NHD waterbody polygons. None of these polygons intersected with USACE navigable waterways. Because the USBR's primary responsibility is water resource management in the arid and mountainous western United States where most waterways are not suitable for navigation, this lack of intersection with USACE navigable waterways is not a surprise.

9. 2.1.4. FERC licensed hydropower reservoir matching

Reservoirs associated with FERC licensed hydropower projects were determined using the Existing Hydropower Assets (EHA) dataset for 2022 and the Hydropower Infrastructure – LAkes, Reservoirs, and RIvers (HILARRI) dataset v1.1, both obtained from the Oak Ridge National Laboratory Hydrosource data portal. The EHA dataset contains point locations (latitude and longitude) and key characteristics including FERC license status for 2,298 currently operational U.S. hydropower and pumped storage hydropower plants. The HILARRI dataset "is a database of links between major datasets of operational hydropower dams and powerplants, and inland waterbodies" and allows for joining EHA assets and NHD waterbodies through ID. The EHA and HILARRI data were joined by a common ID field and then filtered to include only FERC licensed hydropower projects associated with a reservoir. This is accomplished by filtering for assets categorized by HILARRI as "Hydropower dam associated with reservoir and power plant," "Power plant associated with reservoir; no inventoried dam," or "Hydropower dam associated with reservoir; no power plant." This results in 642 FERC licensed reservoir assets and an associated 511 NHD waterbodies. After removing reservoirs that intersect with navigable waterways, 503 FERC associated waterbodies remain.

10. 2.1.5. Combined reservoir study population

The down selecting of reservoirs described in the previous sections resulted in 1,131 unique NHD IDs, which is somewhat less than the sum of the individual categories (1,168) because in certain cases a reservoir was identified as being matched with more than one source. During development of the methods, it was discovered certain adjacent NHD waterbodies are treated as two separate waterbodies by the NHD, where they should be treated as a single waterbody for purposes of this assessment. After merging these polygons, a final number of 1,052 USACE, USBR, and FERC licensed hydropower reservoirs outside navigable waterways were identified.

A small proportion (95) of reservoirs noted in the source datasets were not found in the NHDPlusv2 dataset. Almost all unmatched reservoirs were small reservoirs of approximately 1 ha or smaller. Although there does not appear to be a hard size limit for waterbodies in the NHDPlusv2 dataset, there are very few waterbodies of this size or smaller included—and those small reservoirs probably fall below the spatial precision of the methods used to produce the NHDPlusv2. As the generation capacity of FPV systems that could fit on these reservoirs would necessarily be limited by their surface area, it is not expected their inclusion would have a significant impact on estimated FPV capacity. In addition, it is common for these small unmatched reservoirs to be "pondages" or slightly enlarged sections of rivers behind run-of-the-river dams. Not only are these waterbofies generally small, but they are also likely to have quicker currents and otherwise be unlikely candidates for FPV development.

However, there were also some remaining larger reservoirs that were unable to be matched, such as Lake Nighthorse in Colorado, which was confirmed to be filled after the surveying of the NHDPlusv2. Only two unmatched reservoirs with no apparent records in the NHDV2 were found that were confirmed to both be large enough and old enough to be included: the neighboring Eastman and Hensley USACE reservoirs in California. Potentially, the use of a higher resolution and newer dataset, such as the NHD High Resolution when it is finalized, could solve these issues.

11. 2.1.6. Temperature exclusion

Multiple colder climate factors can pose challenges for FPV development, chief among them ice floes whose momentum can stress float moorings past the limits of reasonable engineering [8]. The presence of ice floes is a complex hydrological process that depends on several interactive waterbody properties such as waterbody volume and depth, water velocity and circulation, salinity, and wind patterns that requires a detailed site analysis and defies a nuanced analysis at the continental scale of assessment. Other colder climate factors that may pose considerable challenges for FPV development include heavy freeze–thaw cycles and snow loading and are similarly difficult to estimate from continental-scale publicly available datasets. Because of these factors, the lowest monthly average low air temperature obtained from the WorldClim suite of data products was used as a proxy screening to exclude reservoirs in locations likely to be influenced by these colder climate factors.

Although this exact proxy value is ultimately uncertain, a cutoff value of −15 °C was chosen via consultations with industry experts as a reasonable value. The minimum temperature variable of the 2.5-minute resolution WorldClim product was associated with reservoirs by taking the lowest value of any intersecting raster cells for each reservoir polygon. The application of the −15 °C cutoff leads to the exclusion of 193 reservoirs, mostly in northern interior states such as Minnesota and North Dakota and parts of northern, interior New England as well as in high-altitude reservoirs in the central and northern Rockies. This resulted in a final study area population of 859 reservoirs with a total surface area of 19,345 square kilometers.

12. 2.2. Developable area criteria

Even though a waterbody may be potentially suitable for FPV, development may not be feasible in all areas of that waterbody. Therefore, we established criteria for developable areas within waterbodies. Because shallow water cannot support FPV, areas with water depths below 1 m were excluded. Based on discussions with FPV developers, FPV floats and moorings are not engineered to withstand currents that exceed 2 m per second (m/s). Therefore, waterbody areas near inlets and outlets were excluded. NHD flowlines were used to identify inlet and outlet locations on study area waterbodies. FPV components can be designed to withstand repeated groundings caused by water level changes if the bottom of the waterbody is flat enough. FPV should be installed only in areas with underlying floors with steep slopes if the waterbody will not go dry. A model of the underlying floor of the waterbody (or bathymetry) was used to estimate freeboard area as a function of fill volume and to calculate floor slope. Finally, a 100-meter buffer from dams was used because of anticipated high currents near outflows and spillways and space that may be needed for dam maintenance. A summary of these criteria is shown in Table 2.

Table 2. Summary of criteria used to determine developable area.

Developable Area	Rationale
Area must have an estimated depth of at least 1 m.	Not deep enough to support FPV development
Area must not be close enough to an inlet or outlet so surface currents may exceed 2 m/s.	2 m/s identified through discussion with developers as the highest current that FPV floats and moorings are engineered to withstand
Area must be in a location that will still hold water at low waterbody volumes or be on a waterbody whose bathymetry is flat enough so floats may be designed to be grounded.	FPV developments can be designed to survive repeated grounding if the underlying waterbody floor is flat enough; if the waterbody floor is steep, FPV must be located where the waterbody will not become dry
Area must be at least 100 m away from a dam.	Areas close to dams are more likely to experience high currents because of either outflows or spillways and also may need space for maintenance

13. 2.2.1. Bathymetry estimation

Bathymetry is a necessary piece of information to determine many of the developable area criteria. It can be used not only to find shallow areas of reservoirs but also to estimate the areas of the reservoir that will still hold water at low volumes and how flat the exposed floor will be when dry.

High-quality bathymetry surveys of freshwater lakes are not commonly available. Although some surveys are available for certain large USBR reservoirs and a small number of other reservoirs surveyed by USGS, there is nothing approaching a comprehensive bathymetry dataset for the reservoirs considered in this assessment. Although commercial bathymetry data are often available for use by boaters and fishermen, even licensed use of these data does not allow for the use of the raw survey data required for the type of analysis needed for this assessment.

The GLOBathy dataset provided an ambitious solution to this dearth of freshwater bathymetry data when it modeled bathymetry for more than 1.4 million waterbodies found in the Global HydroLakes data [9]. In addition, the dataset was validated against available bathymetry surveys with generally good results. Although an excellent resource, its lack of pairing with a topologically aligned rivers dataset (such as the NHD) greatly limited its potential use for this assessment. Reservoir polygon and river line geometries that are not topologically aligned causes not only imprecision in the location of inlets and outlets but also many cases of false inlets and outlets.

Therefore, it was necessary to compute modeled bathymetry for the NHD polygons used for this assessment. The estimation methods used by the GLOBathy dataset are easily replicated given a value for the maximum depth of the waterbody, and code to replicate the modeled bathymetry is provided along with the dataset. In combination with the waterbody depth estimates provided for all on-river reservoirs as part of the NHDPlusv2 dataset, this allows for the imputation of modeled bathymetry using the GLOBathy method to the NHDPlusv2 polygon geometries. For the 140 reservoirs in the study population that are off-river for which the NHDPlusv2 dataset does not provide maximum depth estimates, the maximum depths were estimated using the same methods used for the NHDPlusv2, provided by the lakemorpho R package. Maximum depth estimates were not able to be calculated for 13 reservoirs because the lakemorpho package did not generate valid depth estimates. Manual examination revealed these reservoirs to be either very small or very flat marshy areas, implying they are likely very shallow. In both cases, the reservoirs were determined likely poor candidate locations for FPV development.

For the rest of the 846 reservoirs, modeled bathymetry rasters were created and used to model the other necessary reservoir attributes. These bathymetry rasters were used as templates for all other rasters so the spatial resolution and extent of all rasters produced subsequently are defined to match those of the bathymetry rasters. Slope rasters were created from the bathymetry rasters using the GDAL DEM tool. A Python script was used to estimate the waterbody area at a given percentage of maximum volume. These three outputs (bathymetry, slope, and waterbody area) give the information necessary to answer two of the four developable area criteria.

It is important to note the modeled bathymetry created by the GLOBathy method creates idealized and smoothed bathymetry estimates compared to real-world waterbody floors. Although these data are useful to help understand if the reservoir floors are generally deep or generally shallow—or whether the reservoir floors are generally steep or generally level—the use of the modeled data means the developable criteria related to the bathymetry data are less spatially precise than other criteria used in the study. With this added uncertainty from the modeled data in mind, two values for the reservoir volume assumption and floor slope were used, respectively, to examine the sensitivy of the outputs to the values used. The values chosen for these cutoffs are discussed in 2.2.2 Reservoir volume and area criteria, 2.2.3 Floor slope criterion, and the results are discussed in Section 3.1.

14. 2.2.2. Reservoir volume and area criteria

The minimum water volume that a reservoir may be expected to experience varies widely, depending on the primary use of the reservoir and the climatic conditions of the reservoir and the streams/rivers that serve as its inflow. In extreme examples, a reservoir built for pumped-storage hydro may regularly fluctuate (known as the "normal operating range") between 100 and 15 percent volume or below. Reservoirs used for water resource management in the arid West are commonly well below maximum capacity—for instance, Lake Powell and Lake Mead have recently hit all-time lows of 22 % and 27 % full, respectively [10], [11]. Most reservoirs, particularly in less arid parts of the country, are typically operated at much higher levels with typical minimum water volumes of reservoirs in the Missouri, Columbia, and Tennessee river basins being 40, 70, and 50 %, respectively [12].

Incorporating minimum water levels that are specific for each reservoir, although ideal, is a difficult task with only a subset of reservoirs having comprehensive water level data available. There has been recent progress in modeling water level variation for less data-rich reservoirs, but results are not available in a format easily applicable to the reservoirs considered.[1] Instead, minimum water levels of 25 % and 35 % were examined for all reservoirs in the study area, representing values below or close to the minimum expected volume for most of the reservoirs in the study population. Rasters of the expected reservoir surface area at both volume levels are generated for all study population reservoirs using the modeled bathymetry as an input.

15. 2.2.3. Floor slope criterion

The use of slope as a criterion for whether the ground is level/regular enough to support the grounding of FPV floats is an abstraction of the factors that could preclude an area for FPV development. For example, localized changes in aspect or surface roughness may pose a problem for FPV floats even if the slope is not very steep on an absolute basis. This is similar to the way that slope has been used as an overall proxy of topographic suitability for development for land-based utility-scale PV technical potential assessments, where a cutoff of 5 % has commonly been used, or concentrating solar power (CSP), where a cutoff of 3 % has been used [5].

Much like these cases, only a detailed site analysis with bathymetric surveys can show the exact developable areas supported by the underlying topography of the land. To choose conservative values for the slope criterion, cutoffs of 3 % and 2 % are used as a marker of whether the reservoir floor is generally flat enough to support the grounding of FPV floats. Because the smoothed bathymetry data are not detailed enough to specify which areas of the reservoir floor are above or below these thresholds, the average slope of the entire reservoir floor is used. If the average slope of the reservoir floor is above the threshold, the entire reservoir is considered unsuitable for grounding of floats, and FPV development is assumed to be limited only to areas that are continuously filled with water. If the average slope is below the cutoff, 75 % of the dry area of the reservoir with a water depth of at least 1 m is assumed to be developable—reflecting even in the flattest of reservoirs there will still be localized areas of less floor suitability.

16. 2.2.4. Inlet, Outlet, and dam buffers

Consultation with industry experts yielded a general rule that FPV should not be considered in areas where surface currents may exceed 2 m/s. Although areas closer to inlets and outlets are clearly more likely to experience swift currents than areas far from them, the distance from which FPV should be located is a function of the maximum flow rate and velocity of the inlet or outlet as well as the three-dimensional shape of the reservoir at the location of the inlet and outlet and potentially the relative temperature and salinity of the inflowing water and the reservoir.

To approximate likely areas of current influence from inlets and outlets, monthly average predicted values for flowline velocity and flow volume were used from intersecting NHDPlusv2 flowlines. First, we determined whether the intersecting flowline is likely to exceed 2 m/s. The highest average monthly flowline velocity times a factor of 10 is assumed to be approximately the highest instantaneous velocity produced by the flowline. If this value is not greater than 2 m/s, a small 10-meter buffer from the inlet or outlet is assumed.

In cases where this value does exceed 2 m/s, the distance from which the inlet or outlet may cause currents greater than 2 m/s is assumed to be proportional to the square root of the maximum monthly flow volume. Although this scaling is not mechanistically based, it is informed by the modeled tailrace and forebay currents modeled at a variety of water volume flows on several dams on the Columbia and Snake rivers [13]. The scaling was chosen so the buffer distances are roughly proportional to the hydraulic extents modeled for these dams at similar water volume flows. The report suggests the largest hydraulic extent seen in the sample dams is 11,500 feet in the tailrace of the Bonneville dam in the high-flow 450 cubic feet per second (kfs) rate scenario, whereas approximately a half a mile to a mile is more typical of hydraulic extents for dams modeled with flow rates of 120 kcfs or higher. As such, most inlets and outlets seen in the reservoirs of this study that have flow rates measured in the single-digit kcfs range are expected to have quite low areas of influence in terms of currents.

For a buffer from dams, representing a maintenance and safety area, a flat buffer of 100 m is assumed—although most dams are also outlet locations and may have greater buffers because of the current exclusion. Dam locations are found by snapping the point locations of nearby dams found in the National Inventory of Dams to the closest location on the exterior of the reservoir. Buffers for inlets, outlets, and dams are produced as vectors and converted into rasters for the final developable area analysis.

17. 3. Results

Total developable area for each reservoir (see Fig. 1) was calculated by layering all rasters corresponding to the developable area criteria to find the remaining surface area of each reservoir that is not excluded by any criteria. This analysis was repeated for each of the four combinations of the two minimum reservoir volume thresholds and the two maximum reservoir floor slope thresholds. The final metrics calculated for each waterbody are total FPV developable area in meters squared, the percentage of the maximum reservoir surface area that is estimated to be developable, an estimate for the generation capacity in MWdc that that area could support by applying a power density assumption of 1 MWdc per hectare to the developable area estimates, and corresponding estimated generation in gigawatt-hours per year (GWh/yr). Generation estimates were calculated by associating waterbodies with the closest National Solar Radiation Database coordinate and modeling generation using the Renewable Energy Potential model (reV). Estimates assumed 8,760 operating hours per year, an 11-degree fixed tilt, a 0.7 ground cover ratio, a 1.3 inverter load ratio, and a multiplier of 1.03 to account for the cooling effect of water on FPV units.

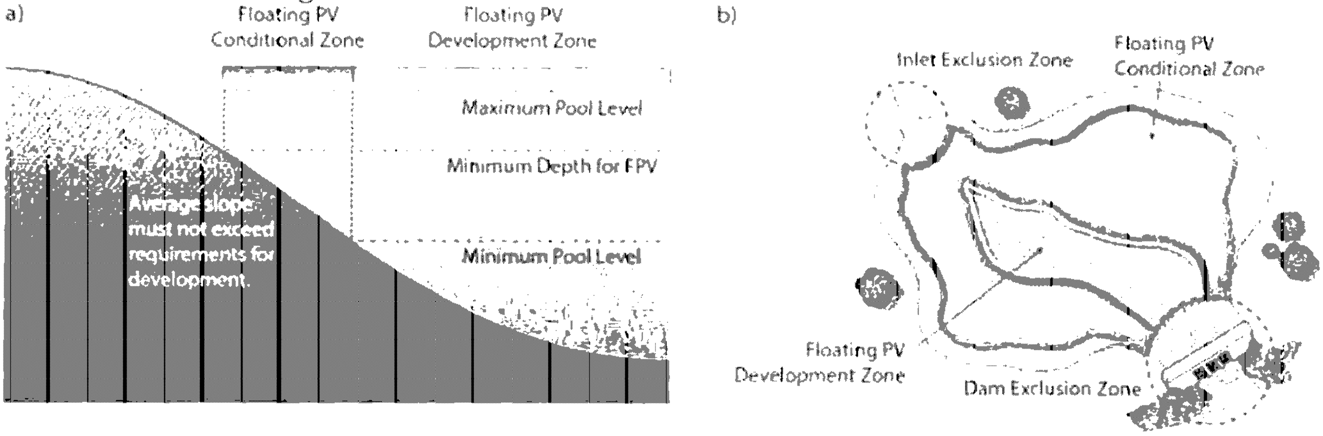

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Fig. 1. Example of application of developable area criteria.

This capacity density assumption is conservative and is meant to include the entire footprint of the development—not just panels and floats but required maintenance and safety buffers, fencing, and any other materials that take up waterbody area. This number was estimated based on an analysis of existing plants in the United States as of 2018 in Spencer et al. (2019); higher estimates have been used in the literature such as 1.2-MWdc in Mahmood et al. (2021), but we use the conservative estimate [4], [14]. These values are high relative to ground-mount solar because of the low tilts and high panel packing densities used for FPV developments relative to ground mount. These configurations minimize wind loading and the number of floats needed at the trade-off of potentially higher cosine losses because of suboptimal tilt and higher interrow shading between panel rows; the magnitude of this trade-off is a function of latitude and irradiance regime.

20. 3.1. Sensitivity analysis

The total estimated potential installed capacity in MWdc for each of the four scenarios is shown in Table 3. The average developable percentage of each reservoir for each of the four scenarios is shown in Table 4. Note this mean is not weighted by size of reservoir.

Table 3. Summary of installed capacity results by scenario.

Empty Cell	25 % Minimum Water Volume	35 % Minimum Water Volume
2 % Slope Cutoff	861 GW direct current (dc) (1,221 terawatt-hours alternating current [TWh ac])	961 GW dc (1,364 TWh ac)
3 % Slope Cutoff	955 GW dc (1,347 TWh ac)	1,042 GW dc (1,476 TWh ac)

Table 4. Summary of percent reservoir developable results by scenario.

Empty Cell	25 % Minimum Water Volume	35 % Minimum Water Volume
2 % Slope Cutoff	28.1 %	33.6 %
3 % Slope Cutoff	32.7 %	37.1 %

The estimated developable capacity ranges from 861 GW in the most restrictive scenario to 1,042 GW in the least restrictive scenario—an increase of 21 % vs. the most restrictive scenario. This is a meaningful difference; however, it does not represent a difference of magnitude large enough to suggest the thresholds used are poorly specified. These numbers are also broadly compatible with the Spencer et al. (2019) analysis finding a potential capacity of 2,116 GW in the United States on a less-restrained study population of reservoirs (including reservoirs not federally owned and managed with a total of 24,419 manufactured waterbodies considered). The analysis in Spencer et al. assumed a flat 27 % developable area that was based on the average waterbody coverage of existing FPV installations in the United States. The average developable percentages seen in our assessment range from 28.1 % in the most restrictive scenario to 37.1 % in the least restrictive scenario, a range higher than the average 27 % found in the Spencer et al. (2018) assessment. This is potentially because our analysis considers only technical barriers to development, whereas the analysis of area used by existing installations reflects other regulatory, social, and economic barriers as well.

We believe our sensitivity analysis does not provide any reason to assume the criteria chosen are unreasonable when applied as single thresholds across such a heterogenous population of study reservoirs. Such single thresholds are certainly overly conservative or liberal on a case-by-case basis but likely represent a reasonable approximation of potential capacity on average using novel, spatially explicit methods tailored to specific factors affecting FPV development. For brevity and to present the potential conservatively, from this point the size and spatial distribution of only the most restrictive scenario will be discussed. Summary charts for other scenarios are included in Appendix C.

21. 3.2. Size distribution

Of the 846 systems considered, 85 or just over 10 % of the reservoirs were found to have a developable capacity of 0 MW, either because of being too shallow or being small and excluded by inlet, outlet, or dam buffer exclusion zones. The potential system size distribution of the remaining 761 reservoirs is shown in Fig. 2. The corresponding potential generation distribution is shown in Fig. 3.

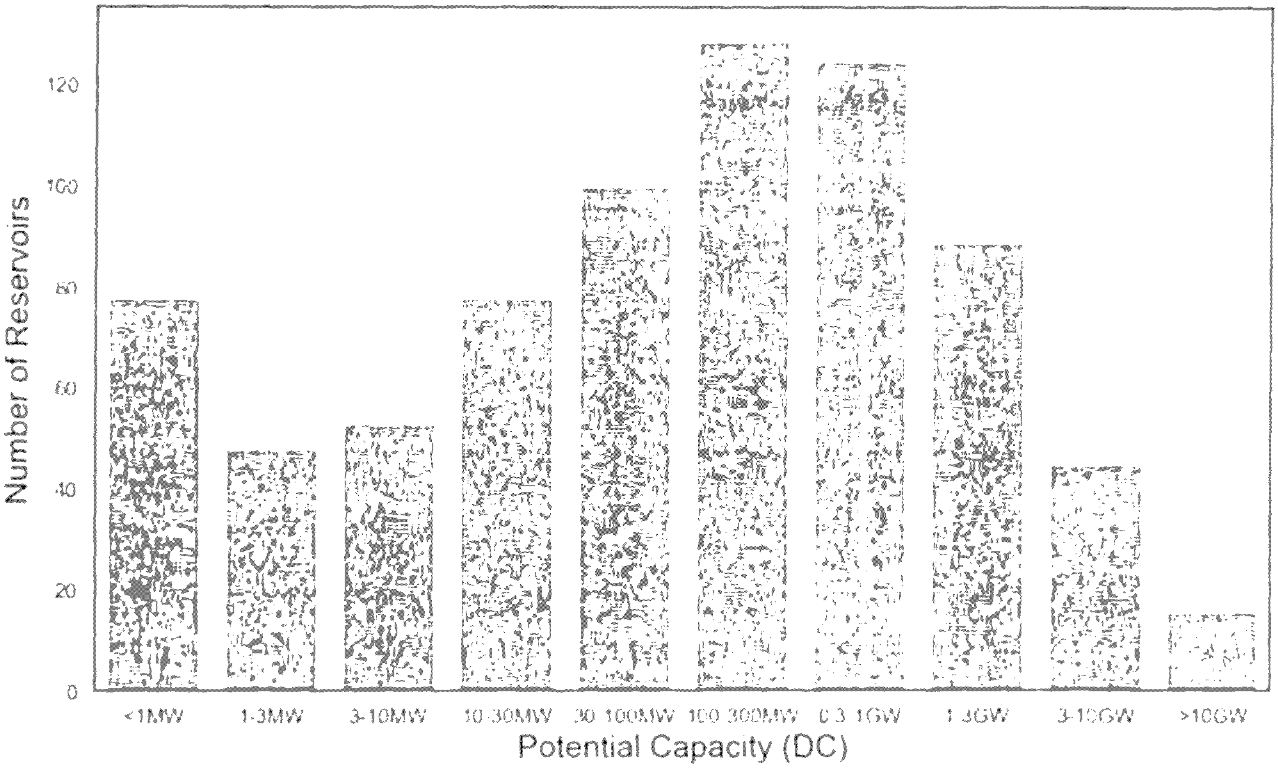

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Fig. 2. Distribution of installed capacity of systems.

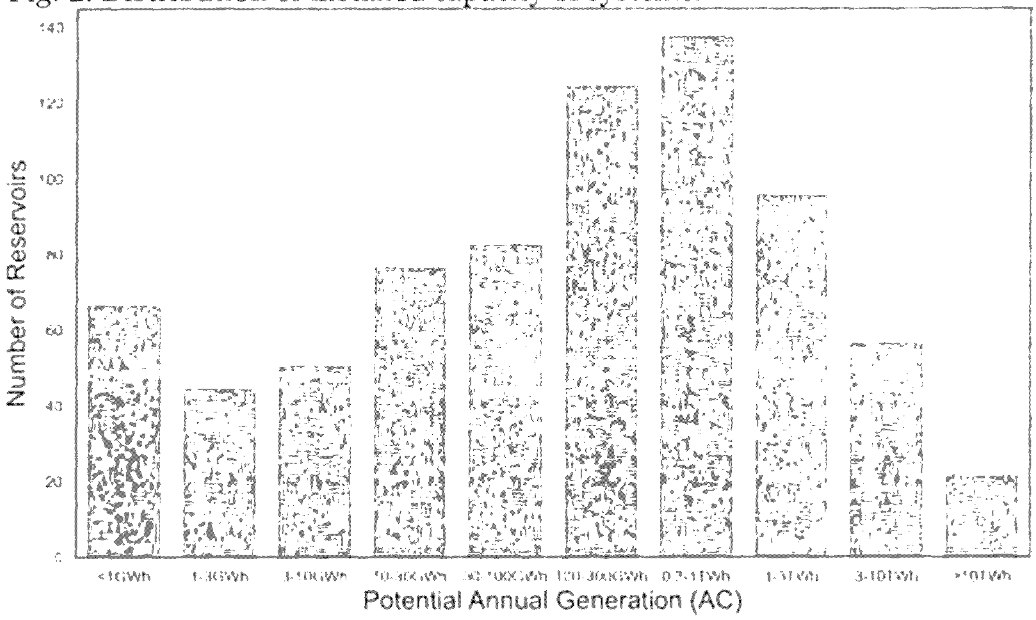

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Fig. 3. Distribtuion of expected generation of systems.

The size of estimated potential systems ranged from 10 kW direct current (kWdc) to 76.6 GW direct current (GWdc). Although 10 kW likely represents an unrealistically small system, only a small proportion of reservoirs are estimated to be in this far left-hand side of the distribution: 2.5 % of reservoirs with nonzero capacity estimates have estimated sizes below 100 kW, and 10 % of reservoirs with nonzero capacity estimates have estimated sizes below 1 MW. Most reservoirs—57 %—are between 10 MW and 1 GW in size with a median of 123 MW. The estimated generation of potential systems ranged from 12 MWh/yr to 130 TWh/yr. Approximately 35 % of waterbodies have an estimated generation between 100 GWh/yr and 1 TWh/yr.

The wide range of system sizes reflects not only differences in estimated developable percentage between reservoirs but also the large variation in the size of reservoirs in the study population. The distribution of developable percentages for reservoirs, controlling for this factor, is shown in Fig. 4.

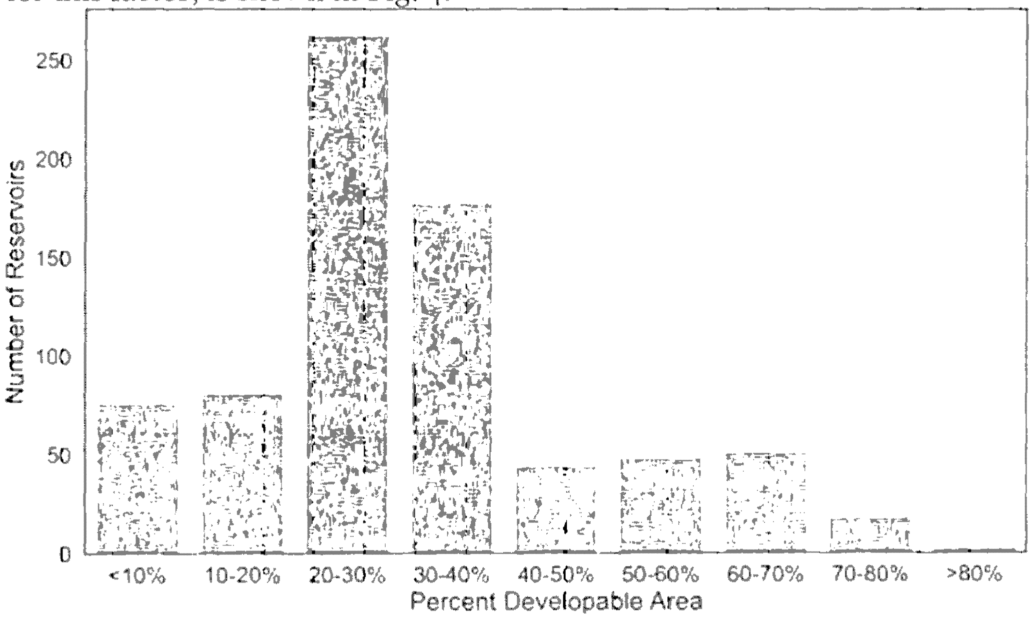

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Fig. 4. Distribution of reservoir percent developable area.

The estimated developable area percentages for reservoirs with nonzero capacity range from 2 % to 81 %. Although estimated percentages anywhere along this range are not rare, there is a marked clustering of estimates around the median estimate of 28 %, with 58 % of reservoirs having estimates between 20 % and 40 %. Despite this clustering of reservoirs at the central tendency, the range of developable area estimates produced shows how important the spatially explicit criteria considered in this assessment are; flat percent developable assumptions can be either significantly low or high depending on site-specific factors.

22. 3.3. Spatial distribution

A map of the spatial distribution of results is shown in Fig. 5.

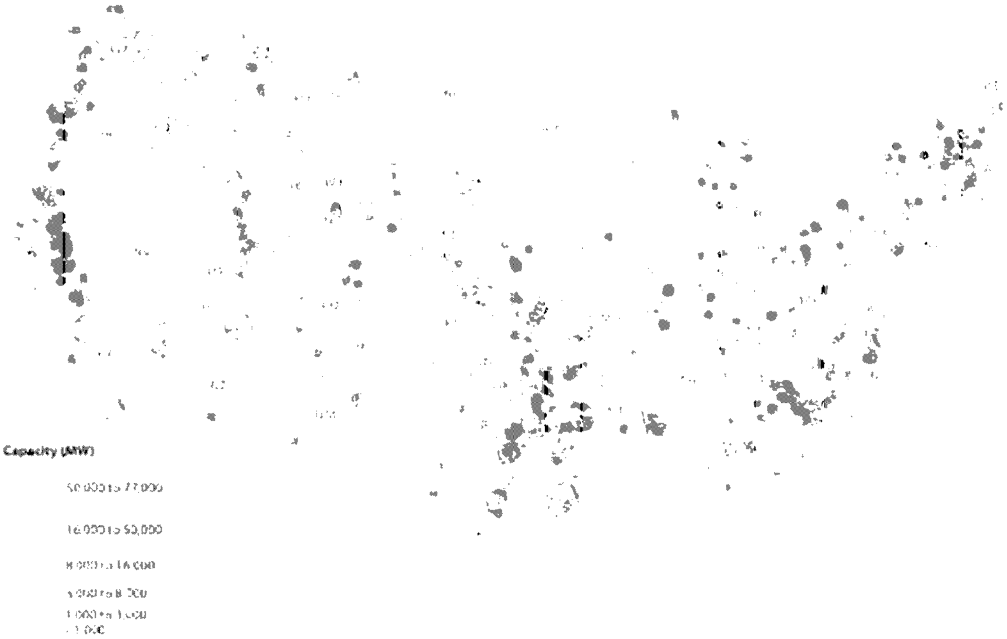

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Fig. 5. Map of spatial distribution and size of potential FPV systems.

FPV potential is well-distributed throughout the country outside of the areas where the cold temperature cutoff removed potential reservoirs from consideration. The reservoirs with the largest capacities are generally found in the southeast and southern plains states where dense river networks support large numbers of reservoirs built for flood control, hydropower, and other mixed uses. Associating potential capacity by state by assigning capacity in reservoirs that cross state boundaries via area weighting shows three states are outliers in sum capacity relative to other states: Texas, California, and Oklahoma with 137, 102, and 84 GW of potential capacity, respectively. The state with the next largest capacity is Montana with 44 GW; the median state has a potential capacity of 9.6 GW. Under this conservative scenario, Texas contains approximately 16 % of the nation's total FPV capacity.

23. 4. Discussion and limitations

The results of this assessment show two primary takeaways:

- 1.
  Accounting for specific technical limitations relevant to FPV development, there is still likely a very high technical potential for FPV on reservoirs in the United States. Even in the most conservative scenario considered for this subset of federally owned and regulated reservoirs, the estimated potential for FPV is more than half the PV capacity estimated to be required for a decarbonized U.S. electricity grid in 2050 (861 GW vs. 1600 GW) [15].
- 2.
  The spatially explicit criteria used in this study show the developable area of a reservoir expressed as a percent of the total area can vary widely, depending on site-specific factors for each reservoir. This highlights the shortcomings of

methods that assume a flat percentage of reservoir area as developable and the need for continued work to refine these efforts.

As the first attempt to apply such methods for an assessment of FPV potential, there are several limitations and potential extensions to this work in future.

As discussed previously, the purpose of this assessment is to assess the potential for FPV development purely from a standpoint of technical feasibility; the assessment does not consider limits to development posed by other regulatory, social, environmental, or economic factors—which are likely to be substantial. If these estimates are properly understood for what they are, they represent an important starting point from which more limitations can be added. For example, the results of this analysis could be used as a reference for an upper bound of the potential an environmental analysis could use to further constrain as a result of environmental factors. As a greater understanding of these potential limitations is achieved, adding them onto the current work in a spatially explicit manner serves as a natural extension of this work. Including development exclusions for recreation areas in reservoirs represents a straightforward and important example of such an extension.

Similarly, another extension of this work would be to apply similar methods to a less-constrained population of reservoirs, including other reservoirs, natural waterbodies, and potentially estuaries and marine offshore. It should be noted, however, the less similar the waterbody types are to the reservoirs considered in this paper, the more likely it is for different datasets to be required and different exclusion criteria to be developed and applied.

Of the criteria considered in this assessment, many depend on the modeled bathymetry data. Although this represented the best available option for complete coverage for the reservoirs considered, there are many potential shortcomings compared to actual bathymetric survey data. In addition to the modeled bathymetry being too smooth relative to real bathymetry, the form of most reservoirs considered in this assessment caused by dams placed along major rivers causes a bias in average depth along the direction of the river (upstream sections are more shallow; downstream sections are less shallow). This bias is not accounted for using GLOBathy's modeling algorithm. The impacts of the modeled data can be compared to real bathymetry where available and new algorithms developed to better represent dammed river reservoirs.

Although the spatially explicit exclusions of this assessment allow for considerably more tailored results to each waterbody than methods previously used for FPV assessment, many criteria used can be further specified to each waterbody instead of following study-wide thresholds. Specifically, cold climate exclusions could be further refined from a temperature cutoff to better represent actual ice floe and snow loading impacts. Reservoir minimum volume assumptions could be adjusted based on each reservoir's use and climate. The influence of changing climatic conditions could be examined on minimum reservoir volume and inlet/outlet buffers, which is not considered in this assessment.

24. 5. Conclusion

This assessment outlines a novel geospatial method to assess FPV technical potential accounting for factors specific to FPV technology on federally owned and regulated reservoirs in the United States. The results of the analysis show ample technical potential for FPV development on these reservoirs, ranging from 861 to 1,042 GWdc depending on assumptions, which is consistent with previous studies that have attempted to quantify FPV potential. However, unlike these studies, this assessment shows high variability of reservoir suitability for FPV development based on site-specific factors. This serves as an important improvement that will help better inform not only how much FPV capacity may be available but also where this capacity may be more likely to be built.

25. CRediT authorship contribution statement

Evan Rosenlieb: Writing – original draft, Methodology, Investigation, Conceptualization. **Marie Rivers:** Writing – original draft, Visualization, Methodology, Data curation. **Aaron Levine:** Writing – review & editing, Project administration, Conceptualization.

26. Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

27. Funding Acknowledgment

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28. Appendix A. . Table of previously published assessments

Title	Extent	Waterbody Input Dataset	Study Area Criteria	Developable Area Criteria
Floating photovoltaics systems on water irrigation ponds: Technical potential and multi-benefits analysis [16]	The province of Jaén in Spain	Waterbody Information maintained by the System of Multiterritorial Information of Andalusia	Artificial irrigation ponds	Flat percentage assumptions of 25, 50, and 100 % of waterbody surface area
Energy production and water savings from floating solar photovoltaics on global reservoirs [17]	Global	Global Reservoir and Dam Database (GRanD), Georeferenced Global Dam and Reservoir (GeoDAR), and OpenStreetMap (OSM)	All reservoirs	Flat percentage assumption of 30 % with a maximum size cap

Title	Extent	Waterbody Input Dataset	Study Area Criteria	Developable Area Criteria
Floating Solar PV and Hydropower in Australia: Feasibility, Future Investigations and Challenges [14]	Australia	Not clear	Hydropower reservoirs	Flat percentage assumptions of 1, 5, 10, and 15 % of waterbody surface area
Floating Photovoltaic Systems: Assessing the Technical Potential of Photovoltaic Systems on Man-Made Water Bodies in the Continental United States [4]	Continental U.S.	National Inventory of Dams (NID) from U.S. Army Corps of Engineers and National Hydrography Dataset (NHD) from USGS	Manufactured waterbodies filtered to exclude reservoirs below a minimum depth, below a minimum size, outside of a maximum transmission buffer, or with an incompatible primary use	A flat percentage assumption of 27 % of waterbody surface area
Techno-economic potential and perspectives of floating photovoltaics in Europe [18]	Europe	Global Reservoir and Dam Database (GRanD)	Manufactured waterbodies filtered to exclude reservoirs below a minimum depth, below a minimum size, or with an incompatible primary use	A flat percentage assumption of 1 % of waterbody surface area
Technical potential of floating photovoltaic systems on artificial water bodies in Brazil [19]	Brazil	Waterbody data maintained by the Brazilian Water Agency	Artificial/manufactured waterbodes outside of protected areas	A flat percentage assumption of 1 % of waterbody surface area
Hybrid floating solar photovoltaics-hydropower systems: Benefits and global assessment of technical potential [2]	Global	Global Reservoir and Dam Database (GRandD)	Freshwater reservoirs with filters to exclude reservoirs outside of a maximum distance from transmission lines outside of minimum and maximum latitude	Nine scenarios with varying shoreline buffers (minimum buffers of 0, 50, and 100 m and maximum buffers of 500, 1,000, and 2,000 m)
A sound potential against energy dependency and climate change challenges: Floating photovoltaics on water reservoirs of Turkey [20]	Turkey	Waterbody data maintained by the General Directorate of State Hydraulic Works	"Constructed water reservoirs," all purposes considered; filters to exclude reservoirs below a minimum water area and located within protected wetlands or special environmental reserve areas	A flat percentage assumption of 10 % water surface coverage
Assessment of floating solar photovoltaics potential in existing hydropower reservoirs in Africa [21]	Africa	Reservoir data from satellite data previously developed by authors	A total of the 146 largest hydropower reservoirs in Africa in 2016 with an installed capacity > 5 MW	Flat percentage assumptions of 25, 50, and 100 % of waterbody surface area

29. Appendix B. . Datasets used

Data Source	Dataset	Purpose
United States Army Corps of Engineers (USACE) Geospatial Data Portal	USACE Reservoirs	Identification of USACE reservoirs
USACE Geospatial Data Portal	National Inventory of Dams	Identification of location of dams on reservoirs; reservoir attribute cross-referencing
Bureau of Transportation Statistics (BTS) Open Data Portal	Navigable Waterways Network Lines	Identification of freight shipping routes
U.S. Bureau of Reclamation (USBR) RISE Data Catalog	RISE Point Location	Identification of USBR reservoirs
ORNL Hydrosource	EHA 2022	Identification of Federal Energy Regulatory Commission (FERC) hydropower project reservoirs
ORNL Hydrosource	HILARRI	Identification of FERC hydropower project reservoirs
USDA EPA	National Hydrography Dataset plus v2 Flowlines	Identifications of locations of inflows and outflows of reservoirs
USDA EPA	National Hydrography Dataset plus v2 Waterbodies	Waterbody polygons used to define waterbody extents; lake morphology data used to model bathymetry
USDA EPA	National Hydrography Dataset plus v2 Hydrology Rasters	Used to estimate waterbody depth for subset of reservoirs that did not already have value estimated
WorldClim	Average Minimum Temperature	Identification of areas prone to heavy freezing

30. Appendix C. . Summary charts of Additional scenarios

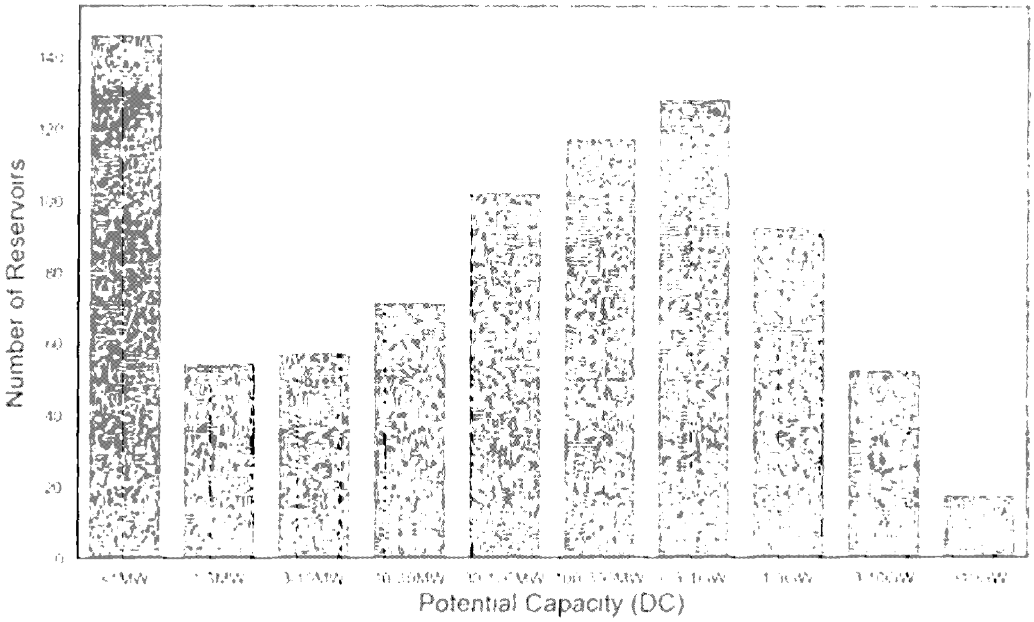

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Fig. 6. Capacity distribution of reservoirs with 25% minimum fill assumption and 3% maximum slope assumption.

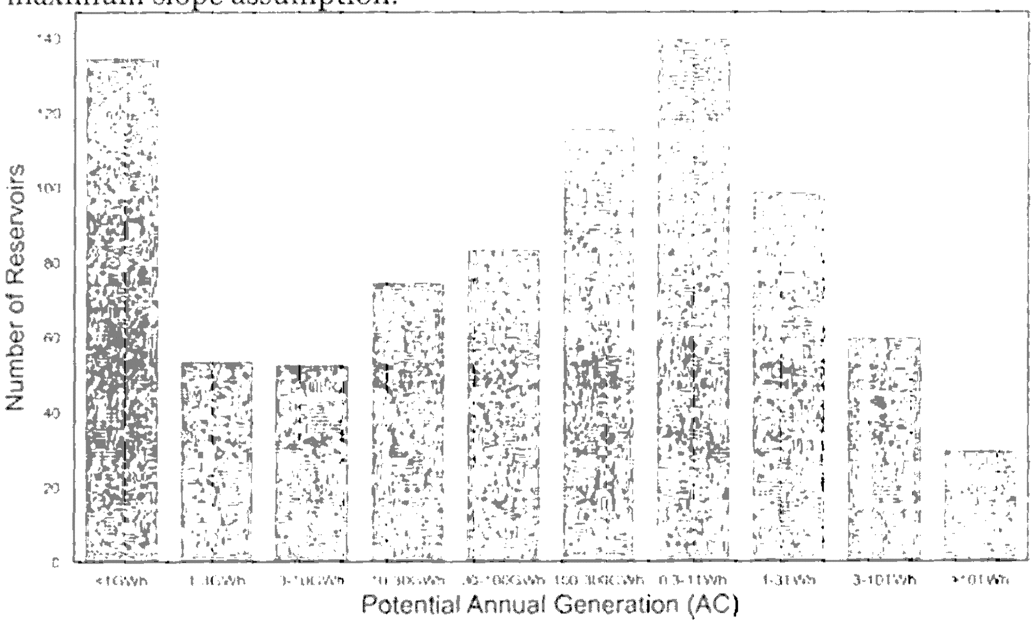

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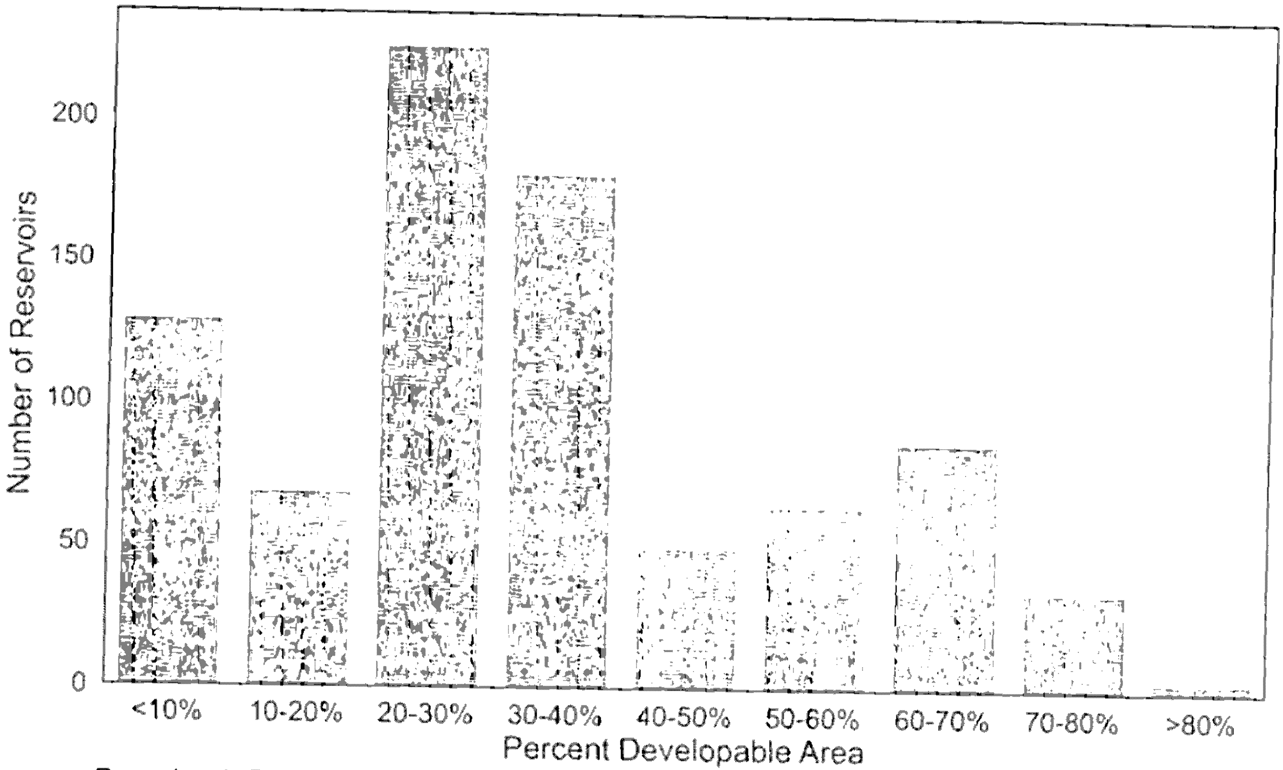
Fig. 7. Estimated annual generation of reservoirs with 25% minimum fill assumption and 3% maximum slope assumption.



1. Download: Download high-res image (169KB)
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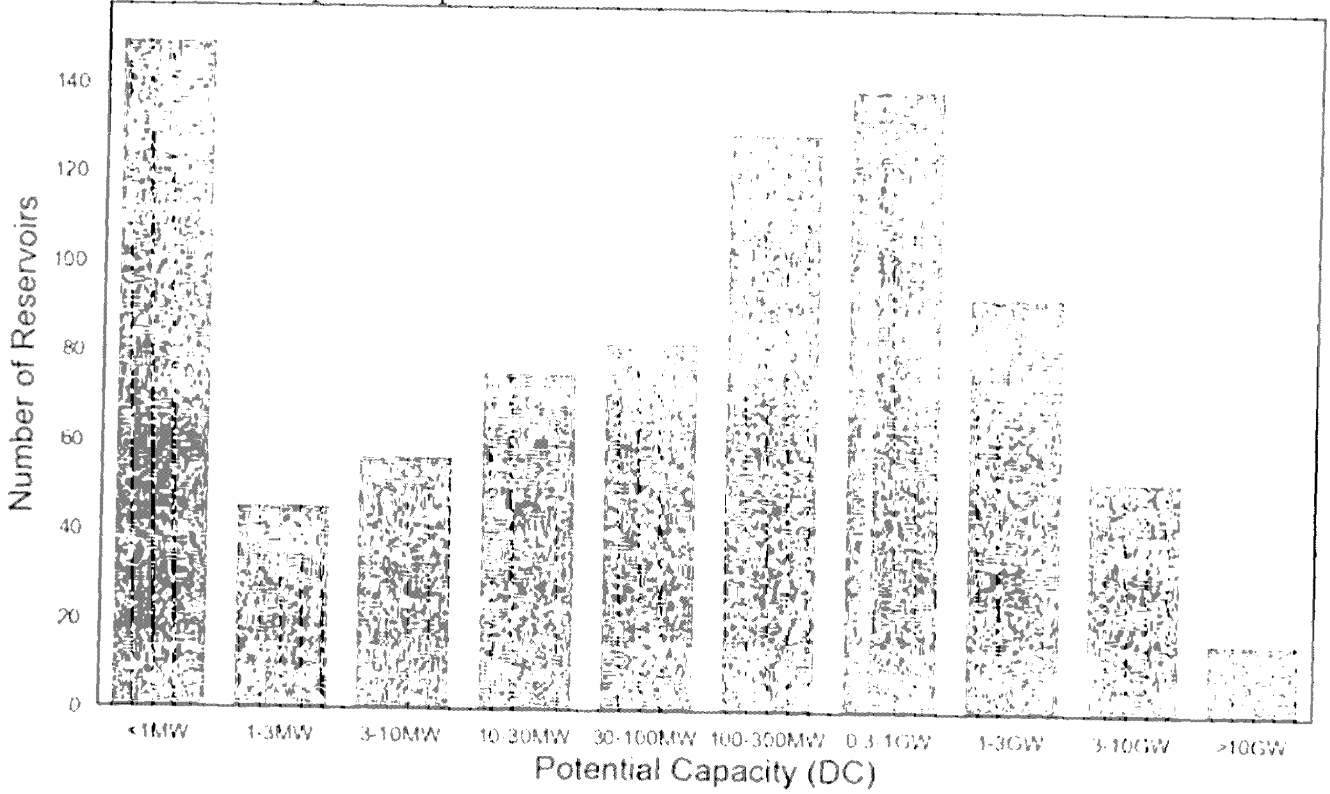
Fig. 8. Percent developable distribution of reservoirs with 25% minimum fill assumption and 3% maximum slope assumption.



Jan 2025

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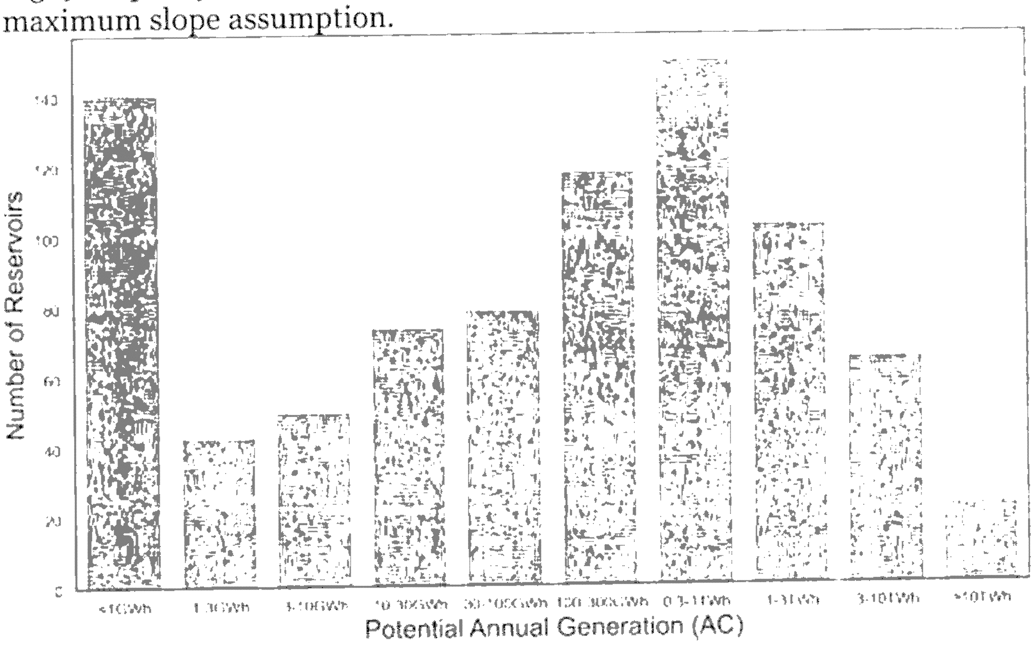
Fig. 9. Capacity distribution of reservoirs with 35% minimum fill assumption and 2% maximum slope assumption.



1. Download: Download high-res image (123KB)
2. Download: Download full-size image

Fig. 10. Estimated annual generation of reservoirs with 35% minimum fill assumption and 2% maximum slope assumption.

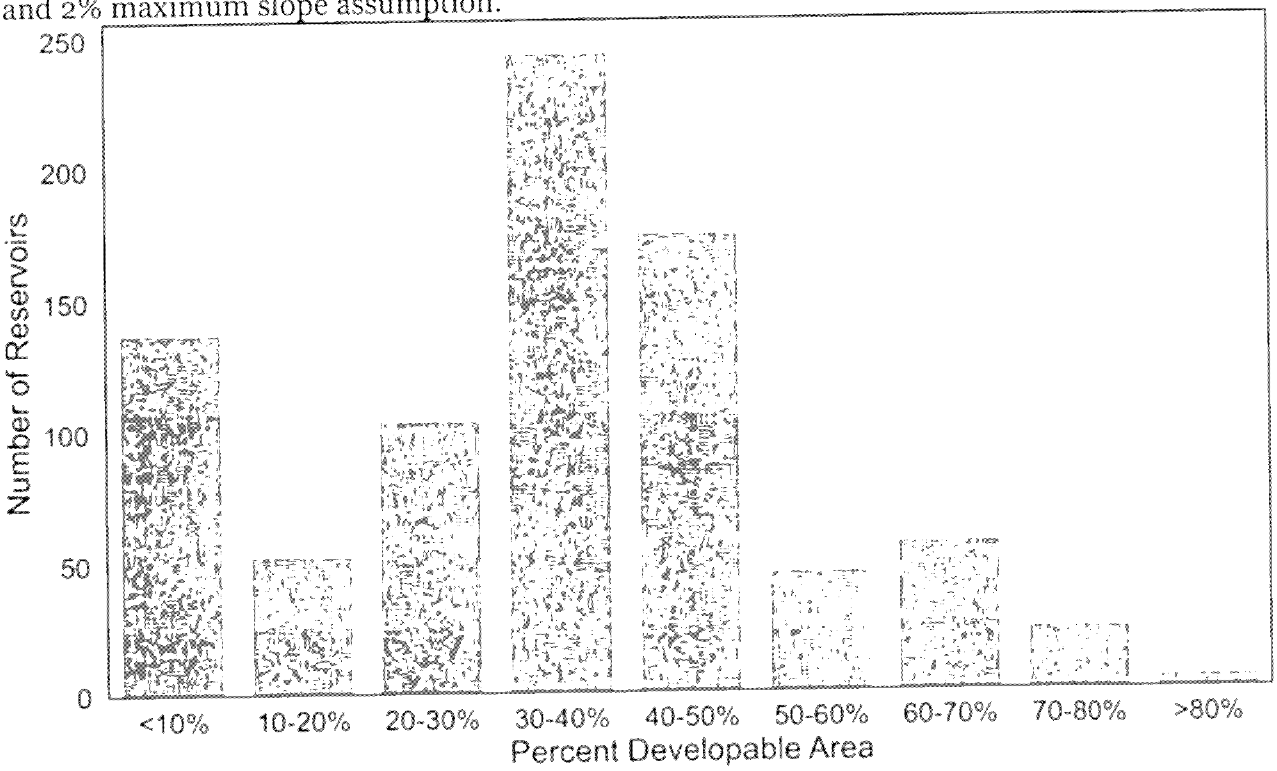


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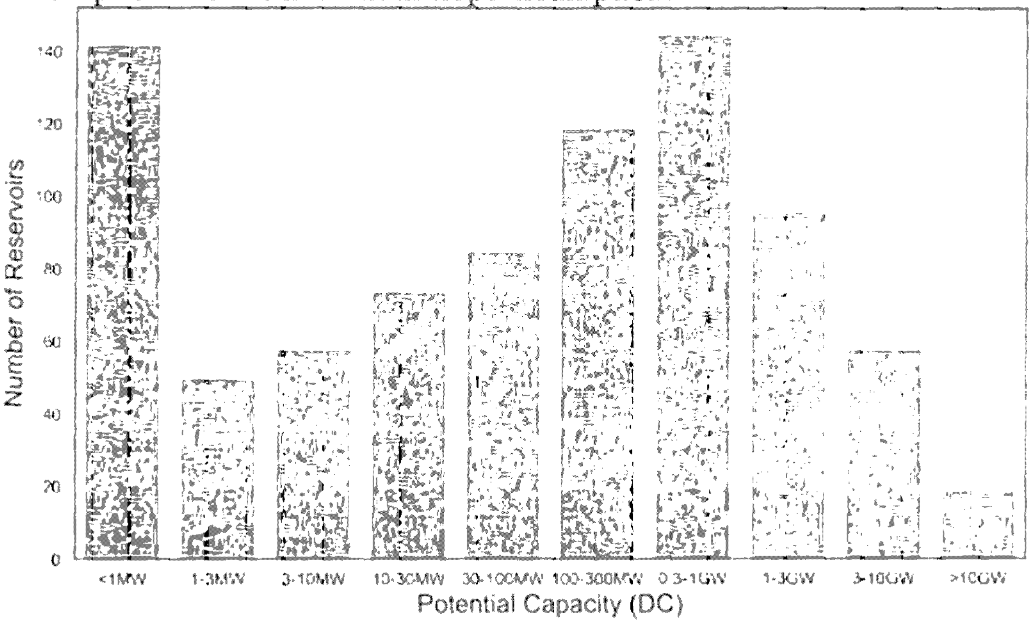
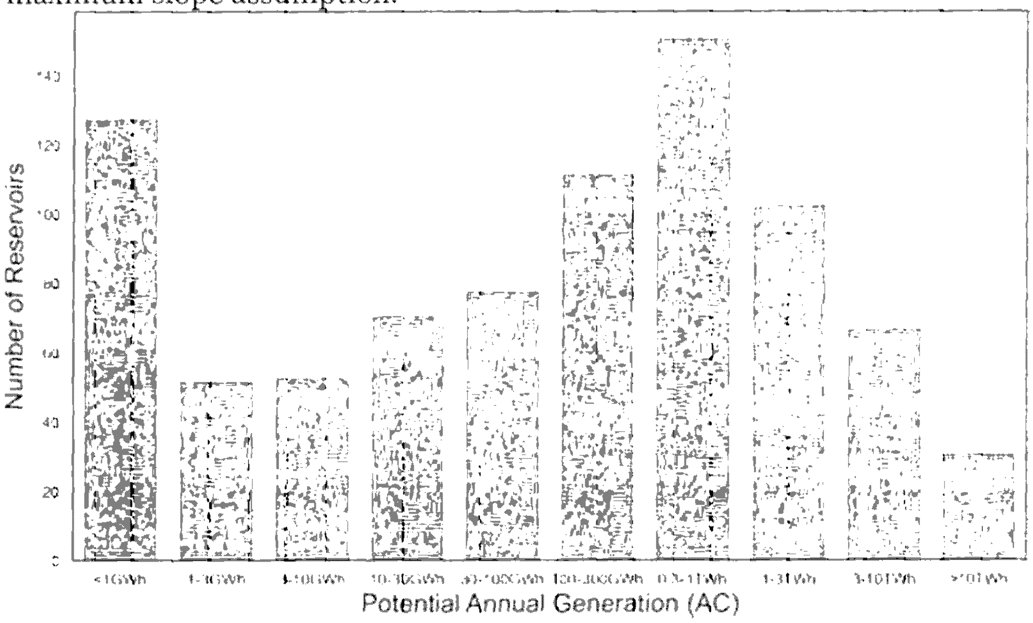
Fig. 11. Percent developable distribution of reservoirs with 35% minimum fill assumption and 2% maximum slope assumption.



1. Download: Download high-res image (126KB)
2. Download: Download full-size image

Fig. 12. Capacity distribution of reservoirs with 35% minimum fill assumption and 3% maximum slope assumption.



1. Download: Download high-res image (123KB)
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Fig. 13. Percent developable distribution of reservoirs with 35% minimum fill assumption and 3% maximum slope assumption.

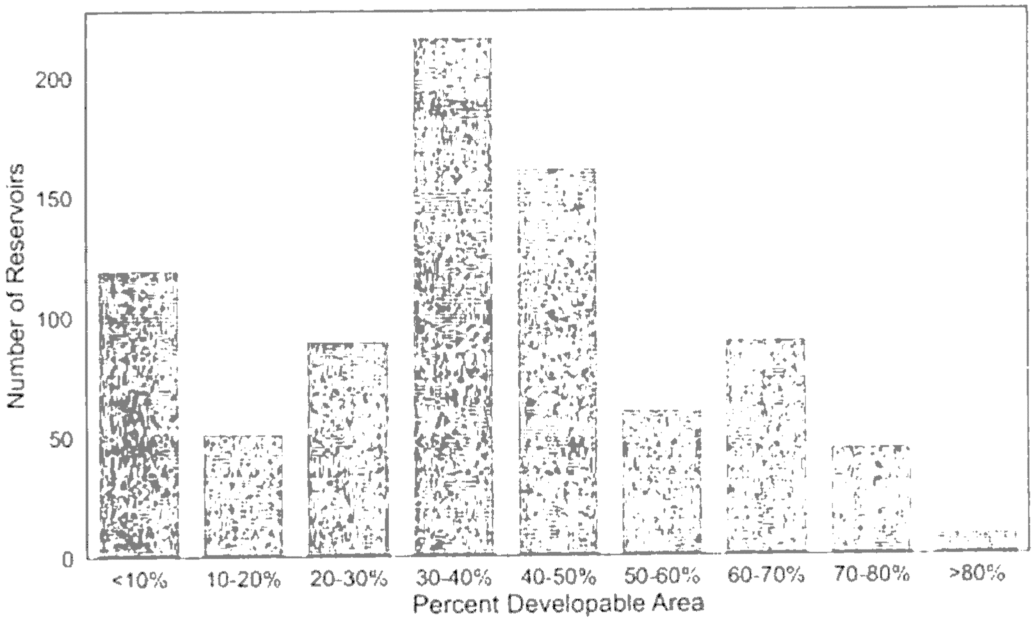

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Fig. 14. Estimated annual generation of reservoirs with 35% minimum fill assumption and 3% maximum slope assumption.

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1

For instance, one such recent model of supply and demand of water to U.S. reservoirs, the ISTARF-CONUS model, used a different base dataset (GRaND) and did not have complete coverage over the smaller reservoirs used in this study.

Bald Eagle Assessment in the Wanaque Reservoir Area

February 23, 2024

Mr. Felix Aguayo
Vice President, Business Development
Nexamp Solar, LLC
101 Summer Street, 2nd Floor
Boston, Massachusetts 02110

Re: Bald Eagle Assessment
Wanaque Reservoir Floating Solar Array
"128021 Wanaque BTM Floating PV"

Dear Felix:

EcolSciences. Inc. has completed an initial habitat assessment of Wanaque Reservoir for the State-endangered bald eagle (*Haliaeetus leucocephalus*) to address concerns raised by the New Jersey Department of Environmental Protection (NJDEP) Endangered and Nongame Species Program (ENSP) that a proposed floating solar array may impact eagle nesting, foraging, and wintering habitats and the fisheries resources they depend on.

As presented below, the habitat assessment involved reviewing the annual *New Jersey Bald Eagle Project* reports prepared by the NJDEP Endangered and Nongame Species Program (ENSP), reviewing NJDEP Landscape Project mapping, and a site inspection to locate eagle nests and observe eagle activity at Wanaque Reservoir.

Annual ENSP Bald Eagle Reports

The annual *New Jersey Bald Eagle Project* reports provide an update on the state's nesting population, noting the success or failure at each known nest site. As of 2023, ENSP and their volunteers were monitoring 286 nest sites. Two nests had been documented at Wanaque Reservoir and are referenced as Wanaque A and Wanaque B[5]. According to the 2023 report, the mapped

[5] **New Jersey Department of Environmental Protection, Division of Fish and Wildlife, Endangered and Nongame Species Program. 2024.** New Jersey Bald Eagle Project, 2023. Available at: Bald Eagle Report - 2023 (nj.gov)

locations of these nests are approximately 3.5 miles north and 1 mile west of the proposed solar array, respectively.

The ENSP reports provide dates for incubation, hatching, fledging, and other notes for each documented nest. Data for Wanaque A and Wanaque B has been collated into Tables 1 and 2 on the following page.

Table 1: Wanaque A Nest Data

Year	Incubation	Hatching	Banding	Fledging	Number Fledged	Failed Date	Notes
2023	2/24	4/20		7/6	1		
2022	2/24				0	Unk	
2021	T						New nest location
2020	*No data*						
2019	*No data*						
2018	*No data*						
2017					1		
2016	Unk				1		
2015	3/30			8/1	1		
2014	3/12	4/16			1		
2013	2/24			6/22	2		
2012	2/18	3/25		6/17	1		
2011	2/27	4/3		7/10	2		
2010	2/17	4/11		6/4	1		New nest tree
2009	2/27					5/10-unk	
2008	2/8	3/29		6/22	3		
2007	2/23	3/30	5/11	6/26	3		
2006	3/5	4/2		~6/24	2		
2005	4/2	4/24		July	2		New nest discovered 3/20

Source: NJDEP, DFW, ENSP. New Jersey Bald Eagle Project. Available at: NJDEP| Fish & Wildlife | Raptors in NJ.

Table 2: Wanaque B Nest Data

Year	Incubation	Hatching	Banding	Fledging	Number Fledged	Failed Date	Notes
2023	2/24	4/13			U		
2022	<4/2	4/9		7/2	3		
2021					3		
2020	Unk	Unk		Unk	3		
2019	*No data*						
2018	*No data*						
2017					2		
2016	Unk				2		
2015	3/30			8/2	2		

2014	3/12	4/16			2		New pair

Source: NJDEP, DFW, ENSP. New Jersey Bald Eagle Project. Available at: NJDEP| Fish & Wildlife | Raptors in NJ.

In addition to nesting data, the *New Jersey Bald Eagle Project* reports formerly provided results of eagle counts conducted each winter. Prior to 2014, New Jersey participated in the National Mid-Winter Eagle survey every January. Results were provided in the annual reports from 2000 through 2013. The survey included a transect grouping Wanaque and nearby Monksville Reservoirs together with data readily available from 2000 through 2011. Table 3 lists the number of eagles counted at these waterbodies during the NJ Midwinter Eagle Survey.

Table 3: Wanaque & Monksville Reservoirs NJ Midwinter Eagle Survey Data			
Year	**Total Bald Eagles**	**Adult**	**Immature**
2011	4	4	0
2010	4	2	2
2009	7	1	6
2008	8	3	5
2007	5	3	2
2006	8	3	5
2005	7	2	5
2004	8	4	4
2003	8	2	6
2002	8	2	6
2001	2	0	2
2000	9	3	6

Source: NJDEP, DFW, ENSP. New Jersey Bald Eagle Project. Available at: NJDEP| Fish & Wildlife | Raptors in NJ.

On-site Assessment

Daniel Brill of EcolSciences conducted a field visit at the reservoir on February 16, 2024. Richie Thompson of the Wanaque Reservoir North Jersey District Water Supply Commission provided escort and was very helpful providing current information regarding local eagle activity. As shown in the attached Figure 1, there are three active eagle nests at the reservoir, not two as indicated in the 2023 *New Jersey Bald Eagle Project* report. Two nests occur in the northern portion of the reservoir (north of Westbrook Road) and one in the southern portion of the reservoir. None were observed to have eggs, though incubation was expected to soon begin at each nest.

The Wanaque B nest is closest to the proposed solar array at approximately 1 mile west northwest. It is perhaps the only eagle nest with a viewshed that would include the finished array. The nest was viewed from both afar on the east side of the reservoir and in close at 100 yards with no activity observed. A second nest attributable to this pair used from 2014 to 2017 no longer exists though the tree it occurred in remains. Richie Thompson had indicated adult eagles are often seen around the southeastern corner of the reservoir, perched in trees on islands over 1,400 feet south of the proposed array. I did see at least one adult eagle overfly the Raymond Dam and Wolf Den Dam here and later saw one perched in a tree over the Wanaque River just below the Wolf Den Dam, ostensibly to catch fish.

The Wanaque A eagle pair were observed bringing sticks to a new nest amid a large cormorant colony on an island at the north end of the reservoir 3.6 miles northeast of the proposed solar array. Richie Thompson indicated the pair had nested the previous few years in a large white pine just over 100 yards from this new location. Prior to this, the Wanaque A pair used a nest, which no longer exists, on the mainland west of the new nest.

There is a third, undocumented eagle pair at the reservoir I will reference as Wanaque C based around 0.6 miles north of the Westbrook Road bridge. This is apparently its second season here. There are two large nests in close proximity, but the pair were only focused on one. The other was snow-covered. The viewshed of this nest includes the area off Westbrook Road you had indicated would be used to assemble the solar array and put it into the water.

Only one additional eagle was seen at the reservoir that is not among the nesting population. One immature bird was observed foraging and flying over the Westbrook Road area.

Landscape Project

NJDEP's concerns regarding bald eagle stem in part from their Landscape Project critical habitat mapping, which maps Wanaque Reservoir and adjacent land as nesting, foraging, and wintering habitat.

The Landscape Project was developed by the NJDEP, Division of Fish & Wildlife, Endangered & Nongame Species Program (ENSP) as a habitat-mapping utility used to identify potential habitats for endangered, threatened, and special concern wildlife. This method takes documented sightings of listed wildlife and, based on a species-specific model or "occurrence area", maps areas of suitable land cover either contiguous to or near the sighting as habitat. Landscape Project 3.3 is the current version, released in May 2017. This version, now seven years old, often does not reflect current conditions and species data.

Landscape Project 3.3 employs 2012 land use/land cover for its critical habitat base. There are 84 distinct land use/land cover categories, and each wildlife species values a unique subset of land use/land cover as critical habitat. All applicable land use/land cover polygons within a "species occurrence area," an area of species-dependent radius centered on a documented record, will be valued as critical habitat. Major roads (County Route 600 and above) are used to divide otherwise contiguous areas of land use/land cover.

Figure 2 illustrates local bald eagle nesting and foraging habitats according to Landscape Project 3.3 with current and former eagle nest locations. Eagle nest habitat values essentially all non-urban land use/land covers within one kilometer of a documented nest. The foraging model values water greater than 8 hectares (19.8 acres) in area, expanding outward from a nest until a cumulative area of 660 hectares (1,631 acres) is reached. The foraging model also includes a 90-meter buffer off selected waters to value perching habitat (NJDFW 2017). In certain circumstances, the buffer can exceed 90 meters where there are intersecting emergent wetlands and additional smaller waterbodies[6]. Figure 1 accounts for the old Wanaque A and Wanaque B nests as of 2014. The entirety of Wanaque Reservoir and other nearby large waterbodies are valued as foraging habitat.

[6] **New Jersey Division of Fish and Wildlife**. 2017. New Jersey Landscape Project, Version 3.3. New Jersey Department of Environmental Protection, Division of Fish and Wildlife, Endangered and Nongame Species Program.

Figure 3 shows local eagle wintering habitat. According to Landscape Project 3.3 documentation, eagle wintering habitats "were identified using eagle sightings recorded during the annual Eagle Midwinter Survey, as well as recorded sightings of eagles during the winter period of November 1- January 31 and not associated with a known nest." Wintering habitat values water and emergent wetlands and adjacent forested habitats within 250 feet of a documented sighting. Wanaque Reservoir has five wintering records associated with the mapped habitat, most recently recorded in 2007. Most of Wanaque Reservoir and adjacent forests are valued as eagle wintering habitat.

Eagle Impacts
The project as proposed consists of two arrays with a total surface area of 20 acres (8.1 hectares) with cable connection to the mainland south of the Wolf Den Dam. The nearest land would be greater than 1,500 feet from the arrays. A review of historic topographic maps prior to the construction of Wanaque Reservoir indicates that the local water depth where the arrays would be placed is approximately 40 feet.

The completed project would appear to have negligible impact on the local eagle population, as the solar arrays would not approach any of the three nest sites, nor would the arrays closely approach the forested shoreline which may be used by perched or foraging eagles. At 907.6 hectares in surface area, Wanaque Reservoir alone more than meets the bald eagle foraging requirements of 660 hectares of water referenced in the Landscape Project documentation. The solar arrays would occupy less than one percent of the reservoir surface area.

Construction of the arrays would also appear to have low or no impact but may require some circumspection. The NJDEP often places a prohibition on activities within 1,000 feet of a nest, and the proposed construction would not encroach upon this buffer. However, the local nesting population is essentially non-migratory. In addition, the Bald Eagle Management Guidelines prepared by the United States Fish and Wildlife Service (FWS) cite specific time periods during the breeding season where eagles are most sensitive to disturbance, particularly during courtship and nest building, egg-laying, incubation and early brooding period, and the weeks approaching fledging[7]. Based on recent ENSP data, the Wanaque A and Wanaque B nests will likely be on eggs before the end of February with hatching at the end of March and fledging in mid-June. Any fledged young may be still reliant on the adults into July or later. The NJDEP would look more favorably on the proposed project if it could be completed during the non-breeding season August 1 through December 31.

I trust this letter suits your needs. Please contact David Moskowitz or me if you have any questions or need anything else.

Very truly yours,

EcolSciences, Inc.

[7] **USFWS. 2007.** Bald Eagle Management Guidelines. Available at: Microsoft Word - Guidelines - June11. 2007.v2.doc (fws.gov).

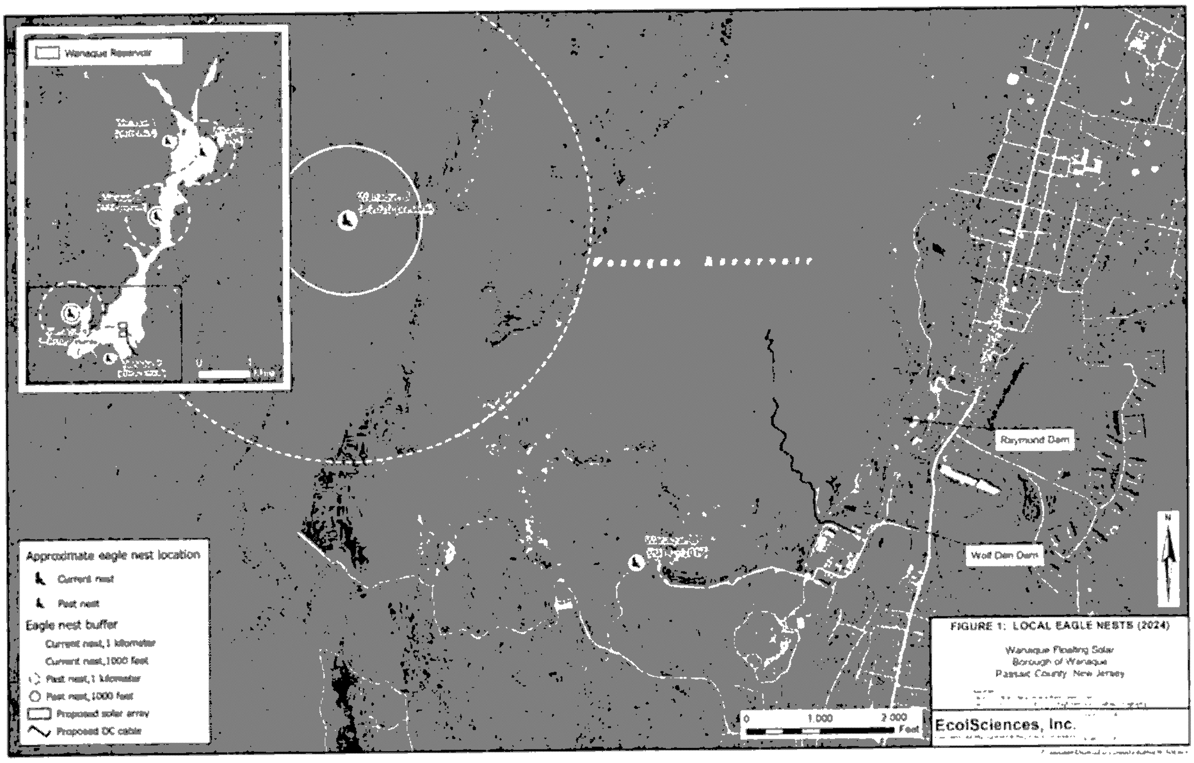
Daniel Brill

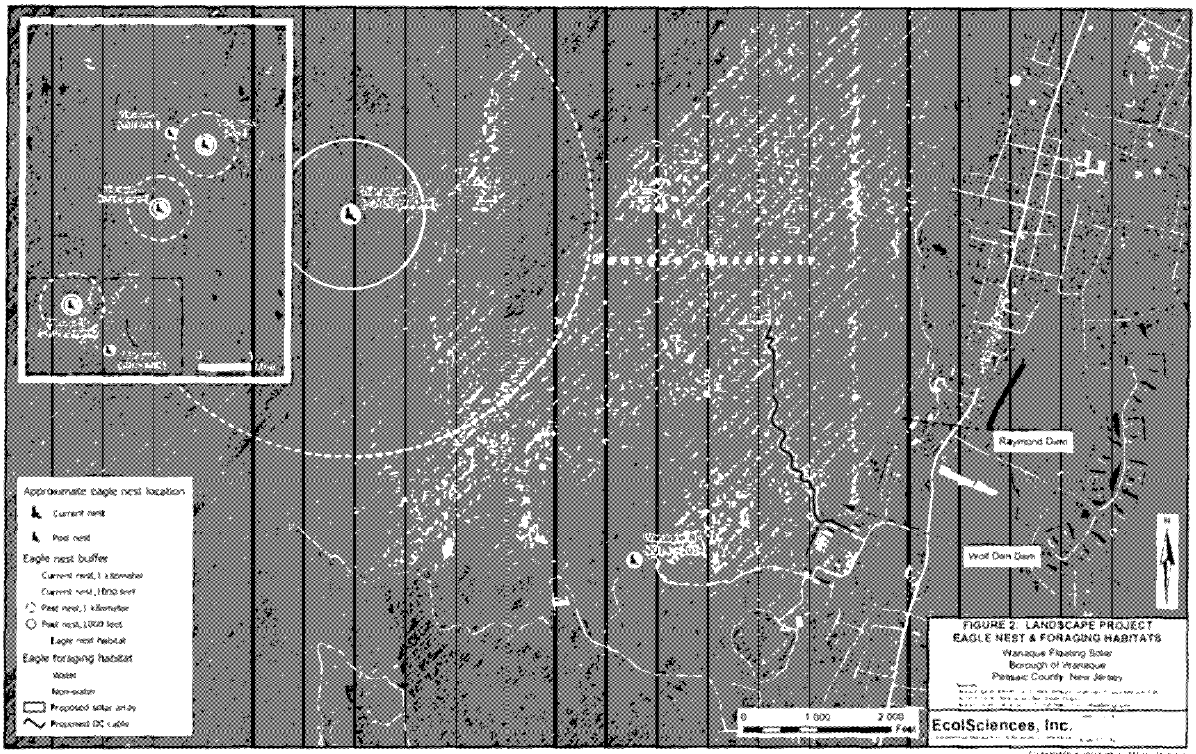
Daniel Brill
Senior Environmental Scientist/Senior Ornithologist

DB/bms

Attachments

Cc: David Moskowitz, Ph.D., SPWS




Raymond Dam
Wolf Den Dam
N
Approximate eagle nest location
Current nest
Past nest
Eagle nest buffer
Current nest, 1 kilometer
Current nest, 1000 feet
Past nest, 1 kilometer
Past nest, 1000 feet
Eagle nest habitat
Eagle foraging habitat
Water
Non-water
Proposed solar array
Proposed DC cable
0
1 000
2 000
Feet
FIGURE 2: LANDSCAPE PROJECT
EAGLE NEST & FORAGING HABITATS
Wanaque Floating Solar
Borough of Wanaque
Passaic County, New Jersey
EcolSciences, Inc.

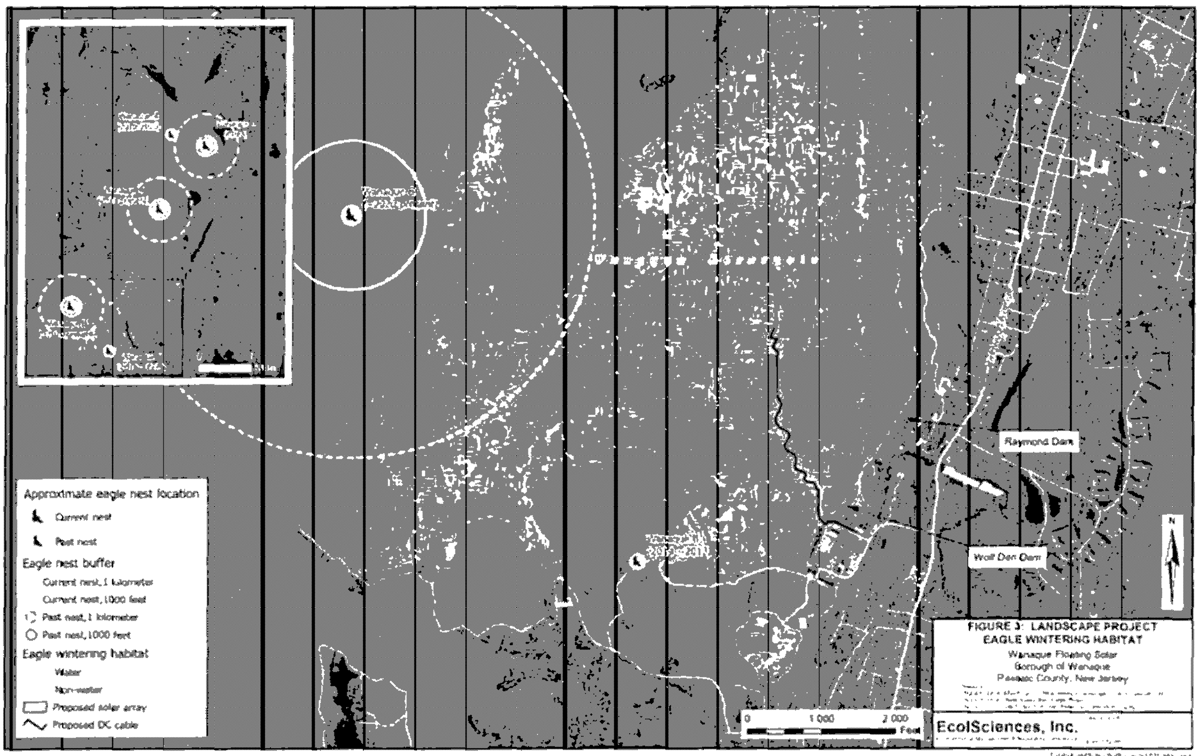

Raymond Dam
Wolf Den Dam
N
Approximate eagle nest location
Current nest
Past nest
Eagle nest buffer
Current nest, 1 kilometer
Current nest, 1000 feet
Past nest, 1 kilometer
Past nest, 1000 feet
Eagle wintering habitat
Water
Non-water
Proposed solar array
Proposed DC cable
0
1 000
2 000
Feet
FIGURE 3: LANDSCAPE PROJECT
EAGLE WINTERING HABITAT
Wanaque Floating Solar
Borough of Wanaque
Passaic County, New Jersey
EcolSciences, Inc.

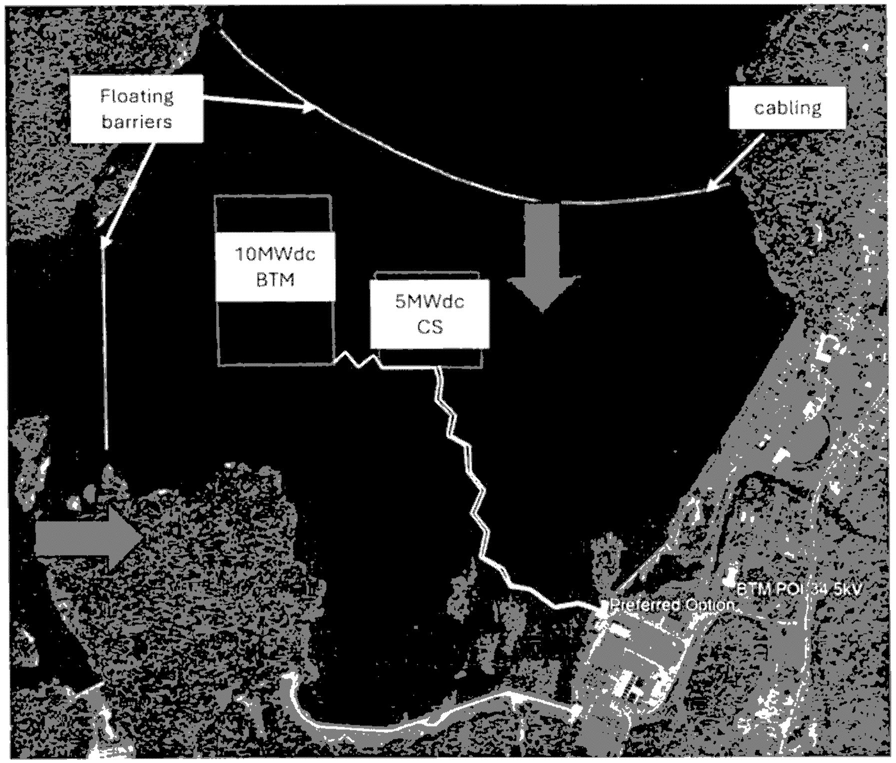
EXHIBIT C

Wanaque Solar Overview

2/27/25

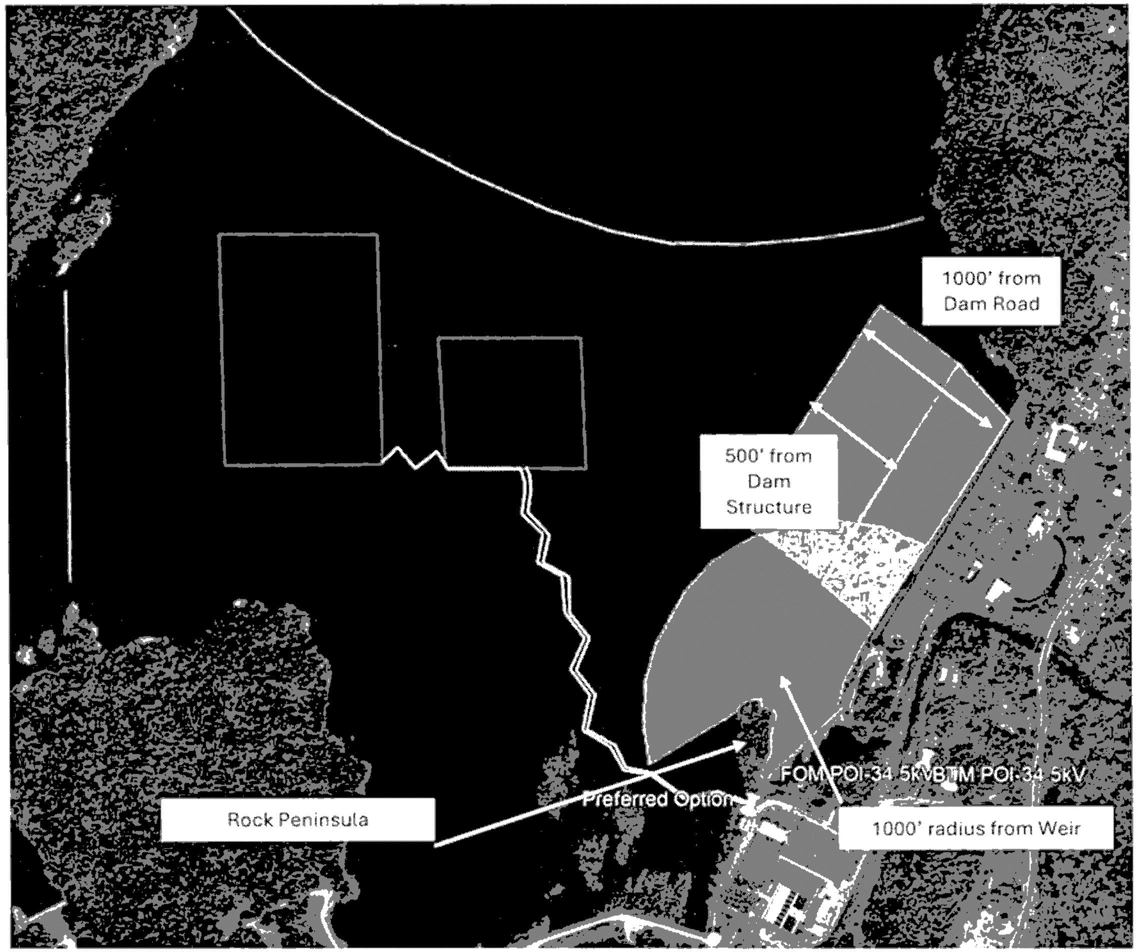
General Layout

- **Objective**: Build, finance, and operate floating photovoltaic (FPV) systems for NJDWSC operations and community
  - **Net-metered system**: 10 MWdc / 8 Mwac
    - Annual Output: Over 13,450 MWh
    - Benefits:
      - Offsets approx. 90% of on-site load
      - Reduces electricity costs
      - Supports NJ's renewable energy mandate
  - **Community solar system**: 5 MWdc / 4 Mwac
    - Annual Output: 6,725 MWh
    - Benefits:
      - Supports up to 1,000 residential subscribers
      - Minimum of 51% low-and-moderate income households
      - Guarantee energy discount for subscribers, local community solar resource

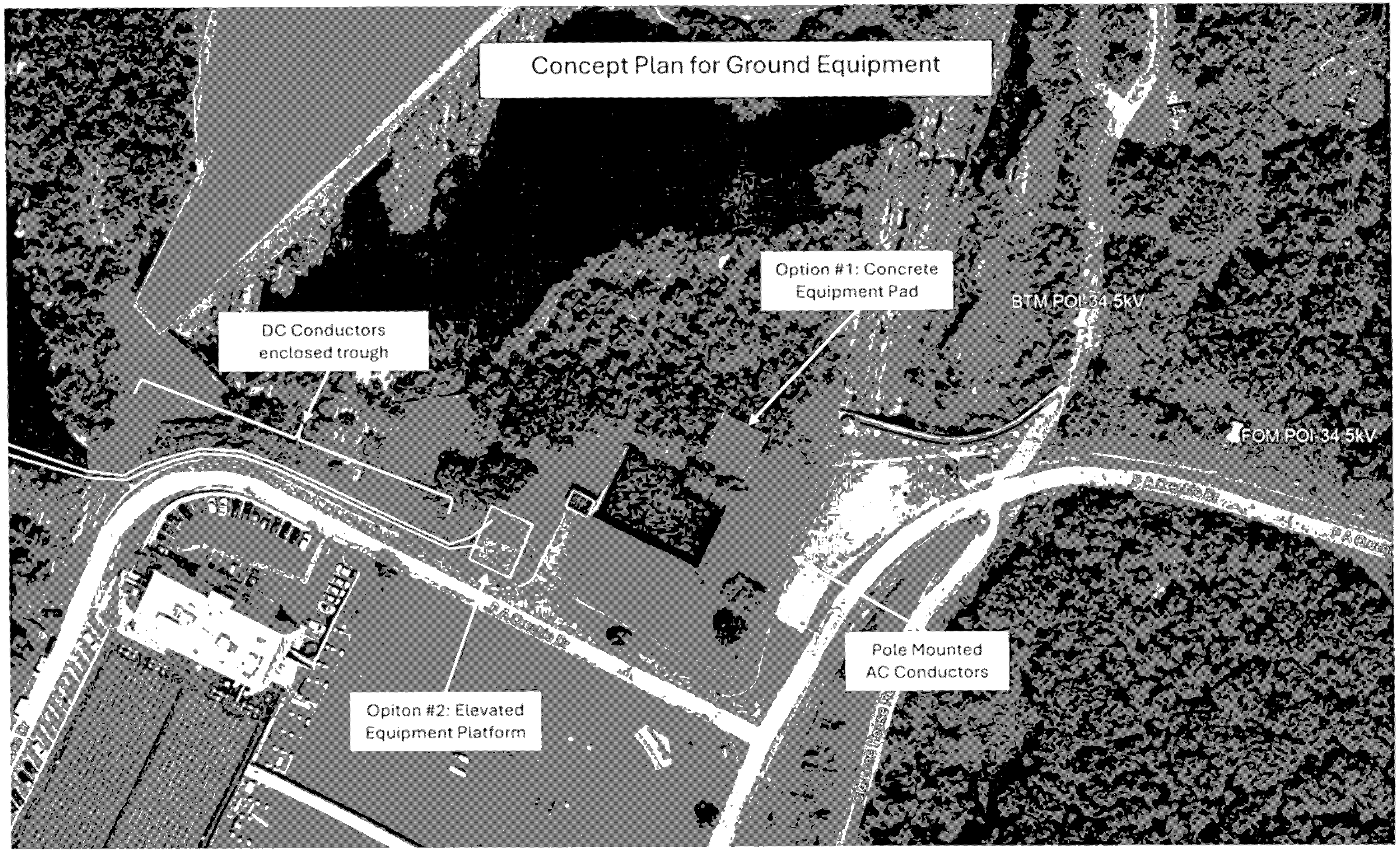


- **Project Name**: Wanaque Floating Solar Project
- **Commission**: North Jersey District Water Supply Commission (NJDWSC)
- **Developer**: Nexamp Solar LLC
- **Location**: Wanaque Reservoir, New Jersey

Setbacks from Dam and Weir

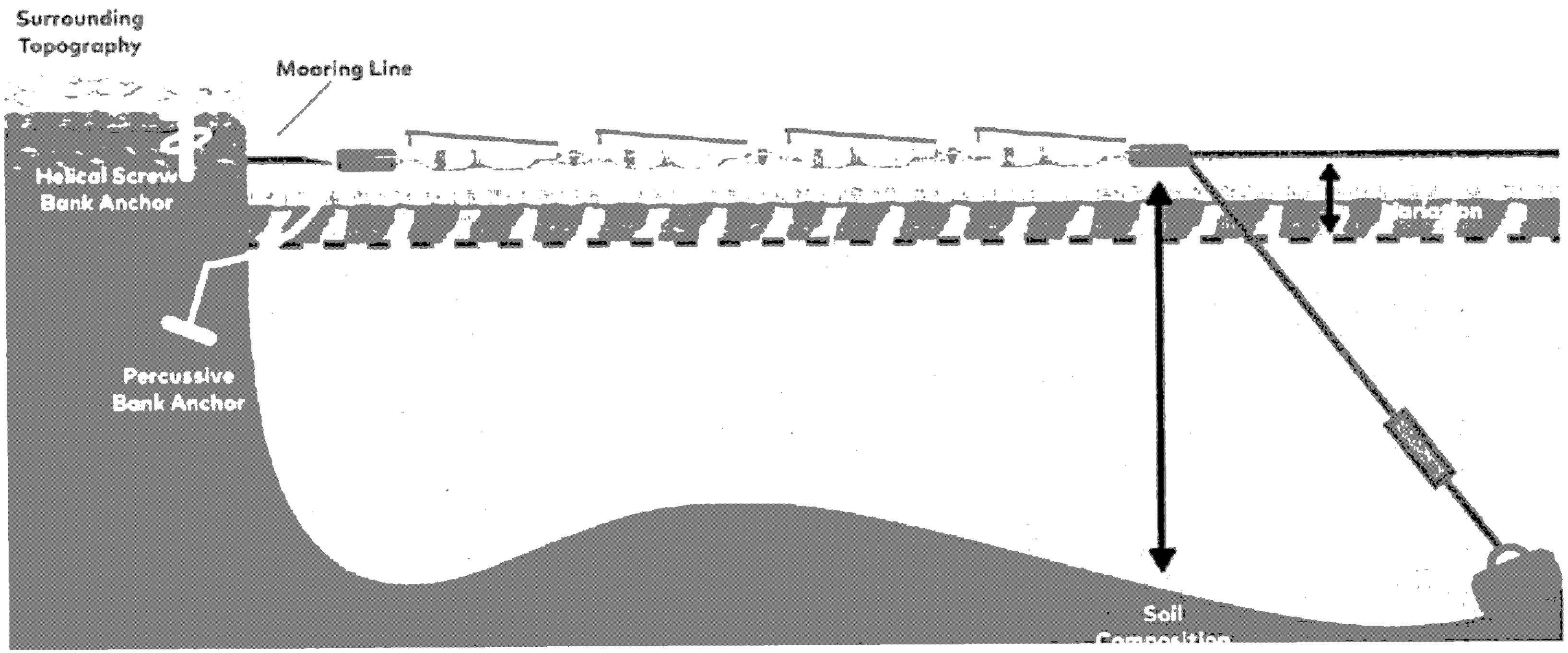


Equipment Location



FPV Key Components

- Floats
- Mooring
- Anchors

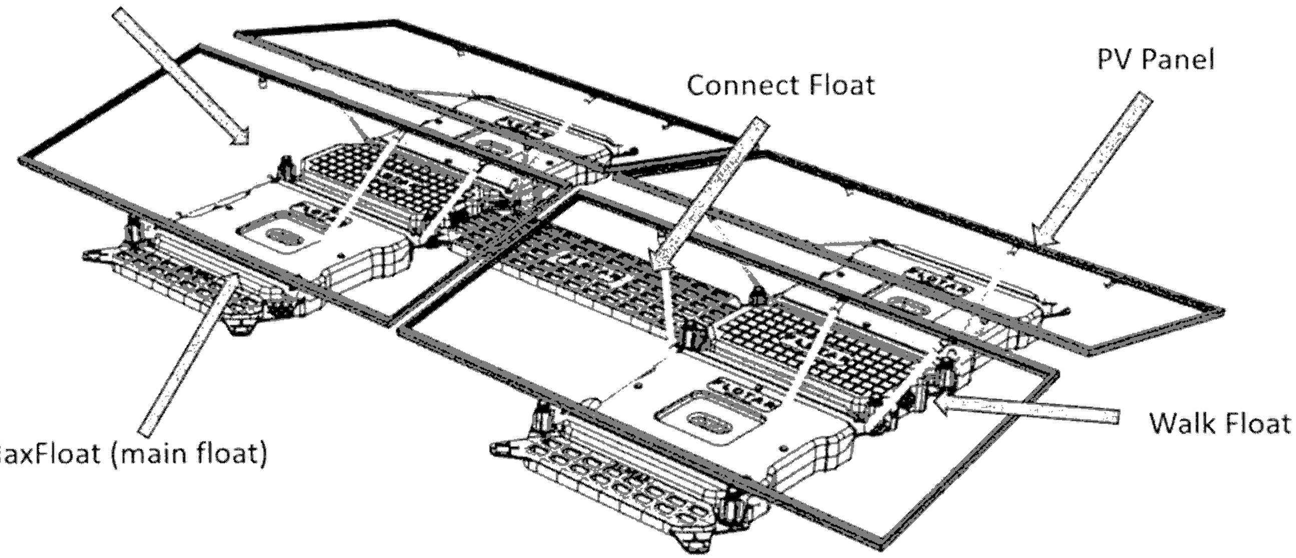


Floats

PROFLOATING

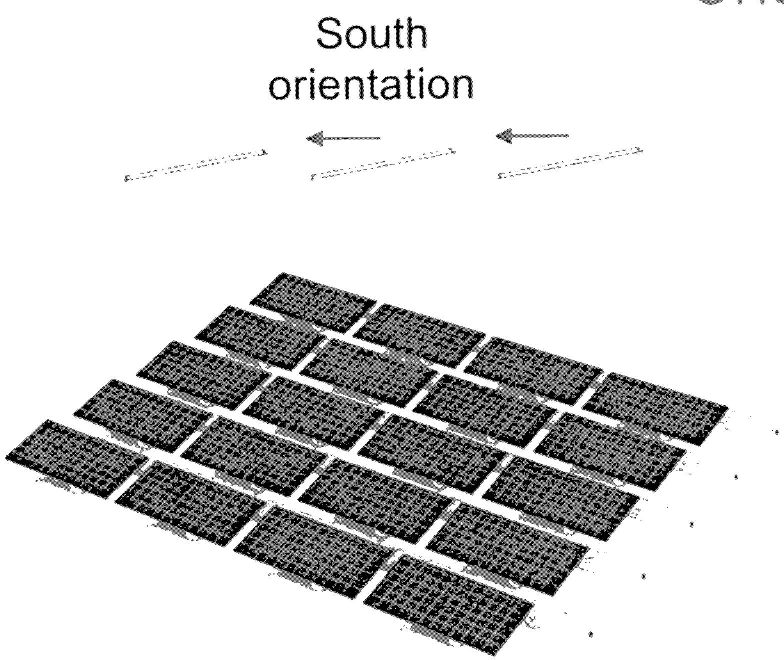
FLOTAR® System Overview

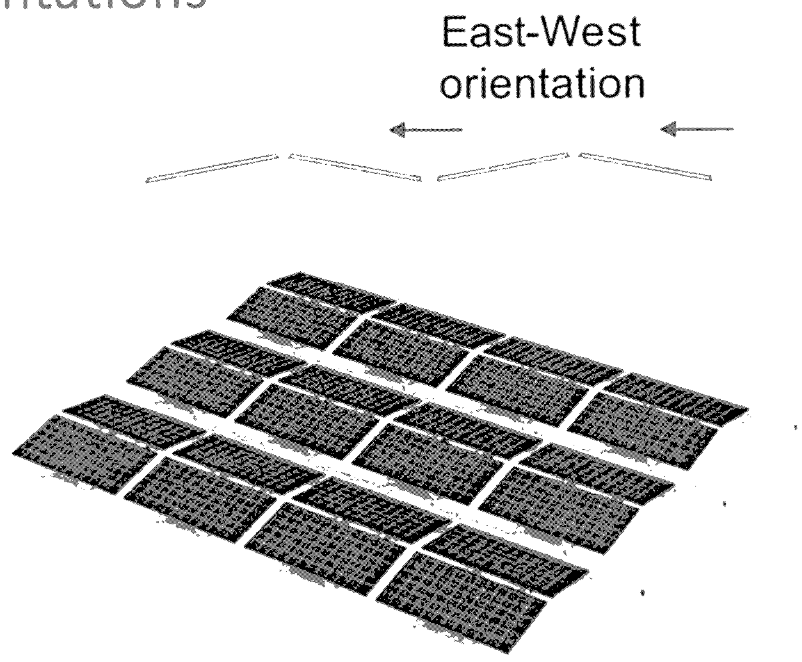
Shown with East - West Orientation



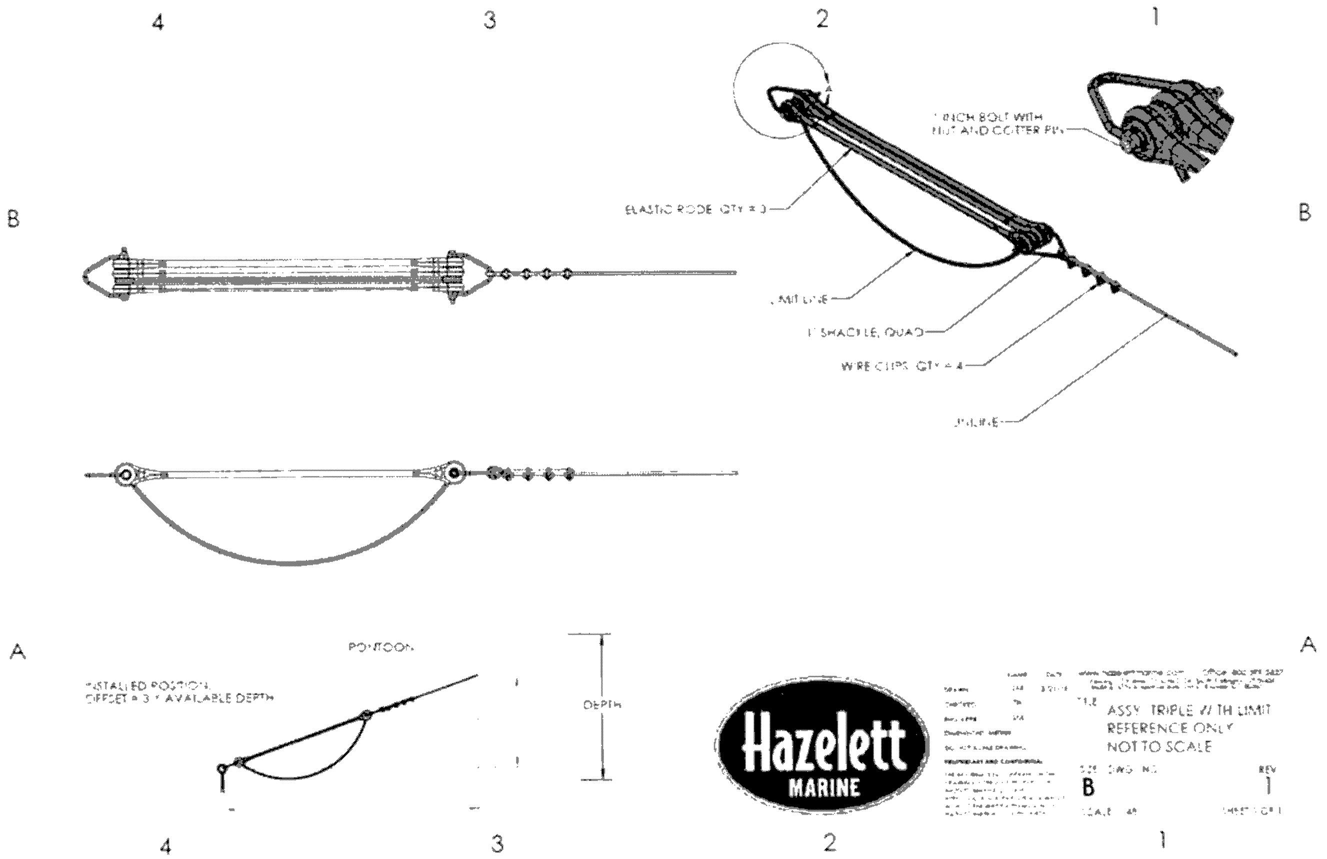
Flexible orientation/anchoring

Orientations

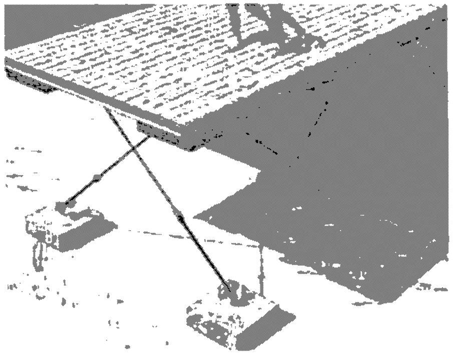




Elastic Mooring System

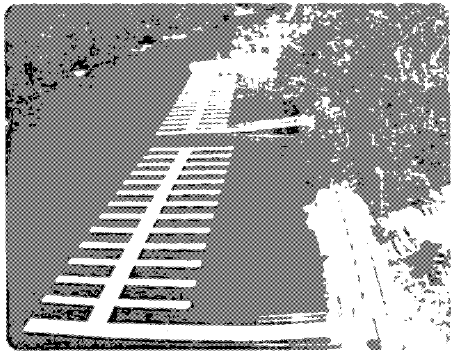


BENEFITS OF AN ELASTIC MOORING SYSTEM



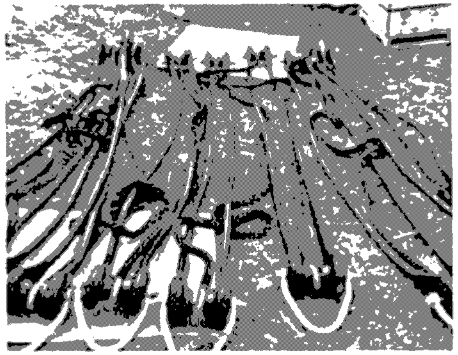
Superior Dampening of Forces

Elastic moorings dampen the damaging horizontal forces that your docks encounter. This makes the docks safer to navigate during these events by absorbing the forces of the wind, waves and current.



Increases Float Life

Holding in position creates the largest stress on a structure. Our elastic systems protect your structures by greatly reducing point loads. This in turn extends the life of your investment.



Very Low Maintenance

Our elastic rodes are extremely smooth, which inhibits marine growth. Our units are UV protected, do not corrode, and are chemical resistant. You should not have any expected costs or maintenance for at least 20 years.

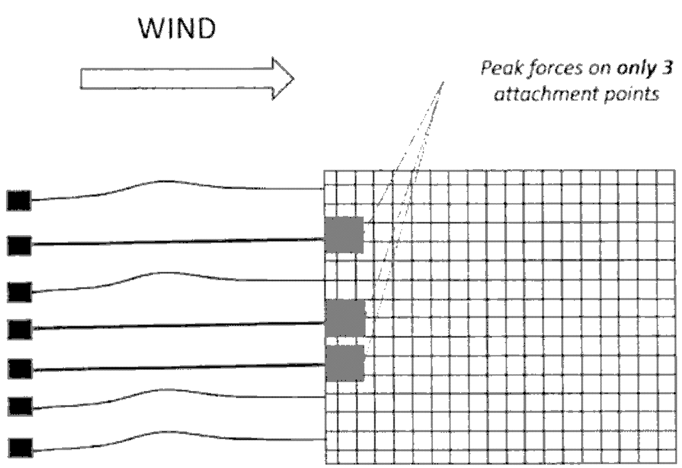
Easy Installation

Our elastic systems are easy to install and maintain. All parts are easily replaceable and readily available. We offer full installation services as well as training programs for companies looking to become certified Hazelett Marine installers.

Static vs Elastic Mooring: Safety

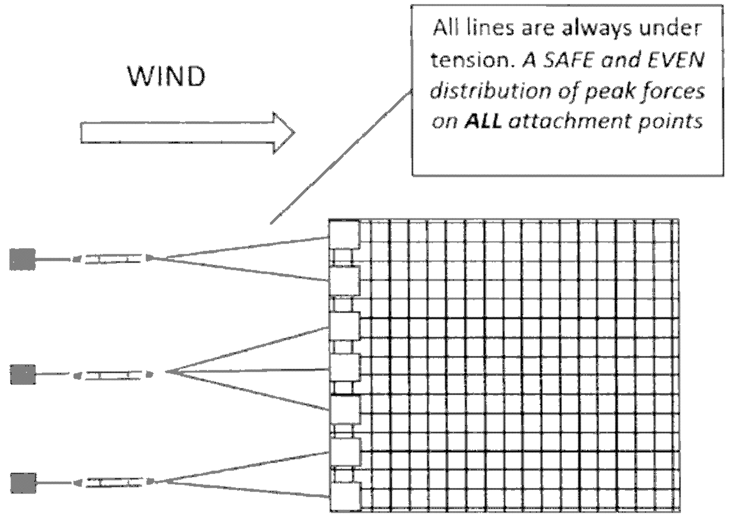
Uneven Distribution

Static material of cable, chain, rope used as a mooring line



Even Distribution

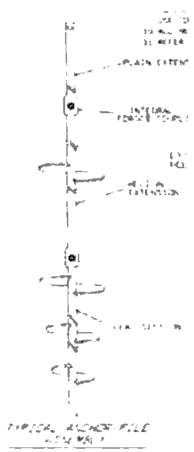
Elastic material

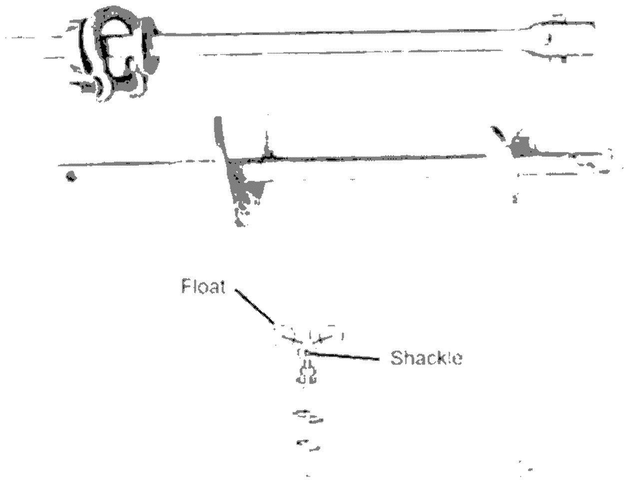


Anchors

Helical Anchors
(sediment/clay anchoring)

SS5 Helical Anchors



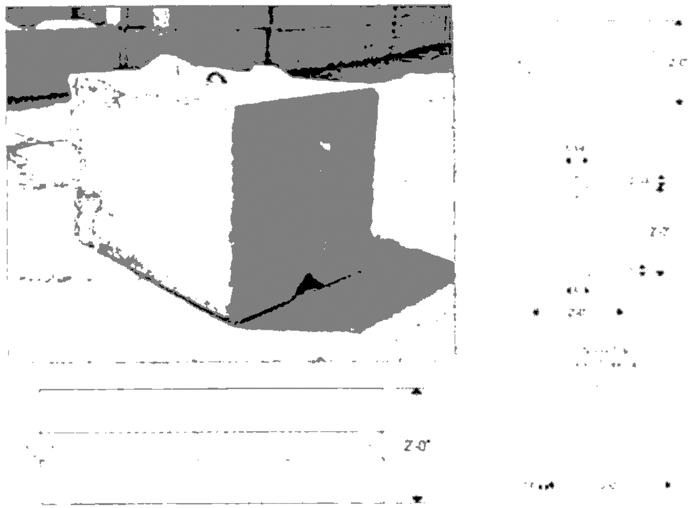


KEY BENEFITS:

- Versatile, high-load capability to serve any permanent anchoring need
- Holding power which cannot be equaled by traditional mushroom anchors or deadweight blocks
- Maintains its holding power even with the shorter scoping necessary in congested harbors
- Removable if required for inspection or dredging

Ballast Anchors

1 ton per rode



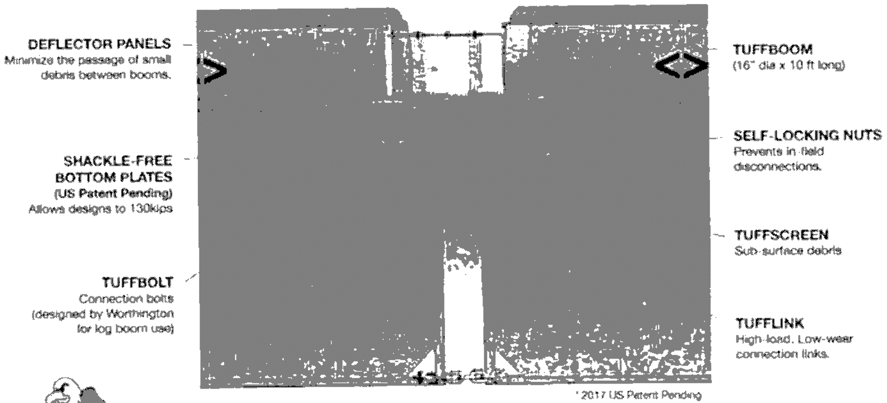
KEY BENEFITS:

- Only 1 ton of concrete needed per rode in the elastic system
- Can be any size or shape.
- Can be split into multiple blocks and daisy chained
- Superior holding force
- Can be deployed in almost any bottom condition
- Can be precast, or cast onsite when needed

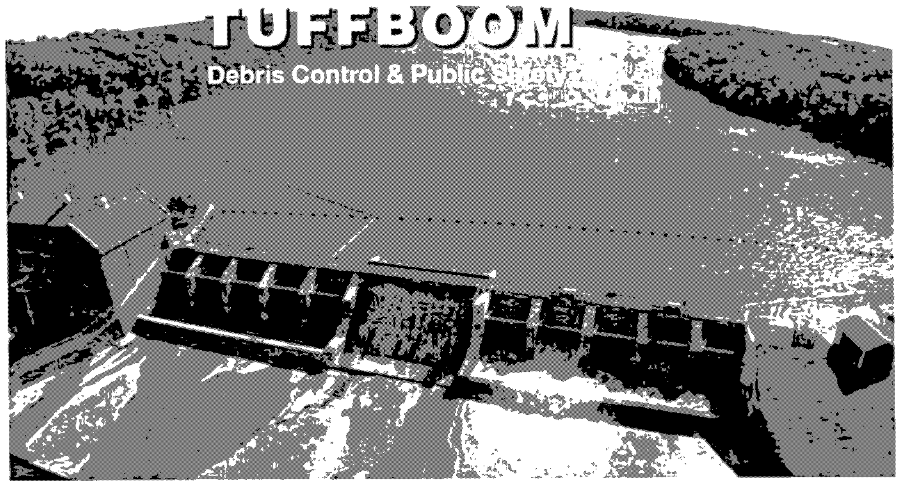
Barrier Technology

TUFFBOOM

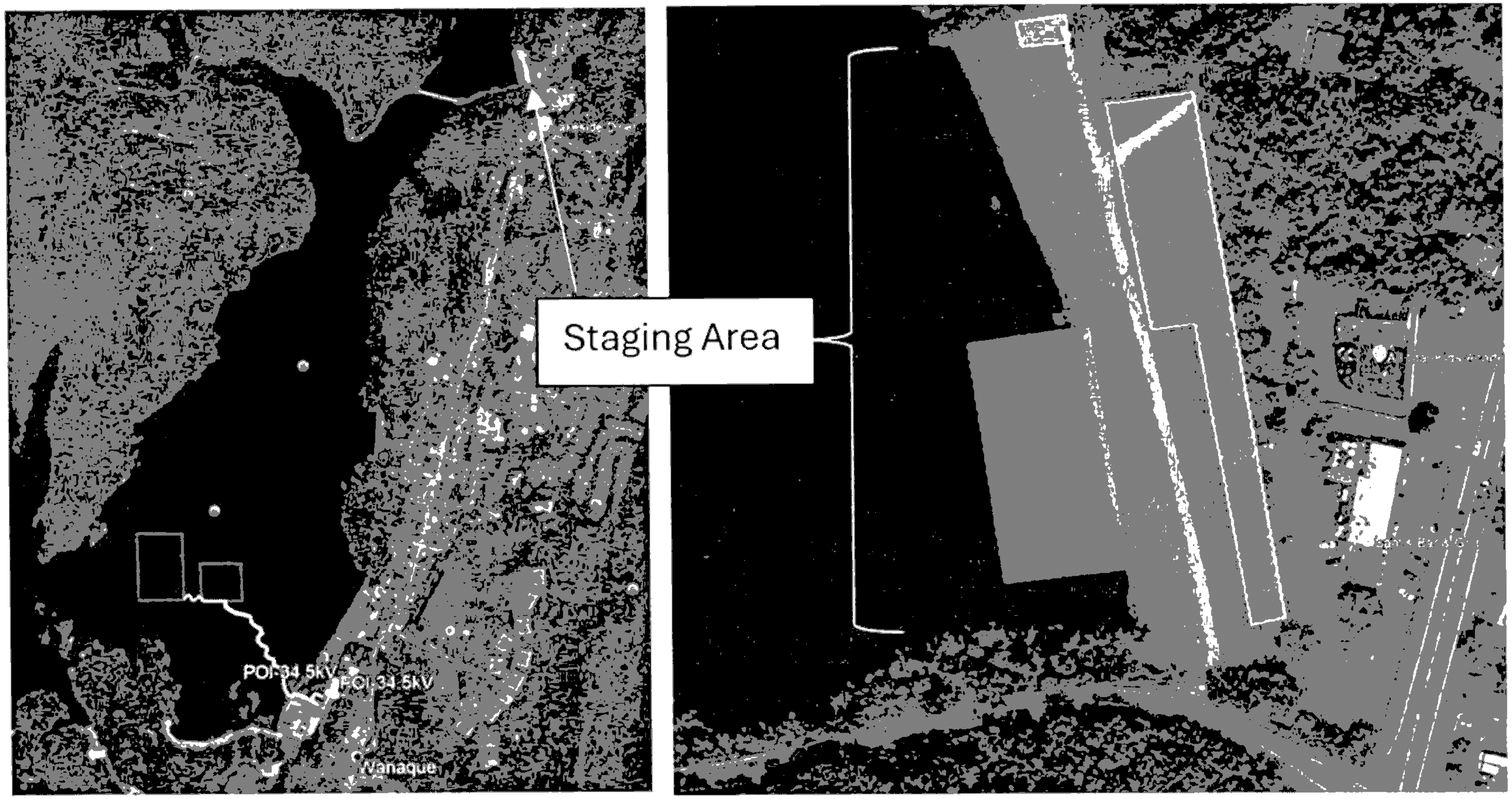
Now with the strongest, most reliable **SHACKLE-FREE** connections available.



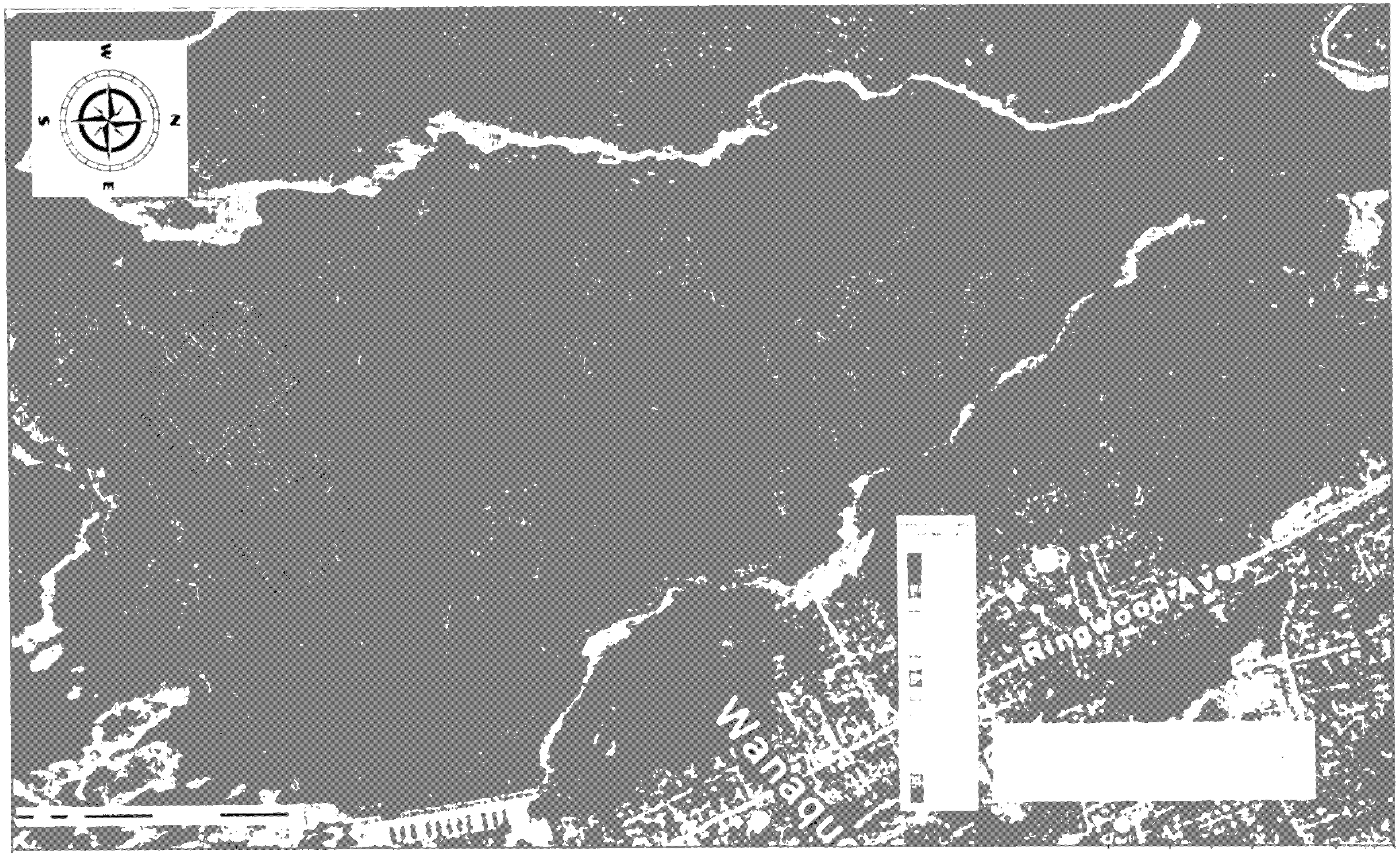
WORTHINGTON
Waterway Barriers



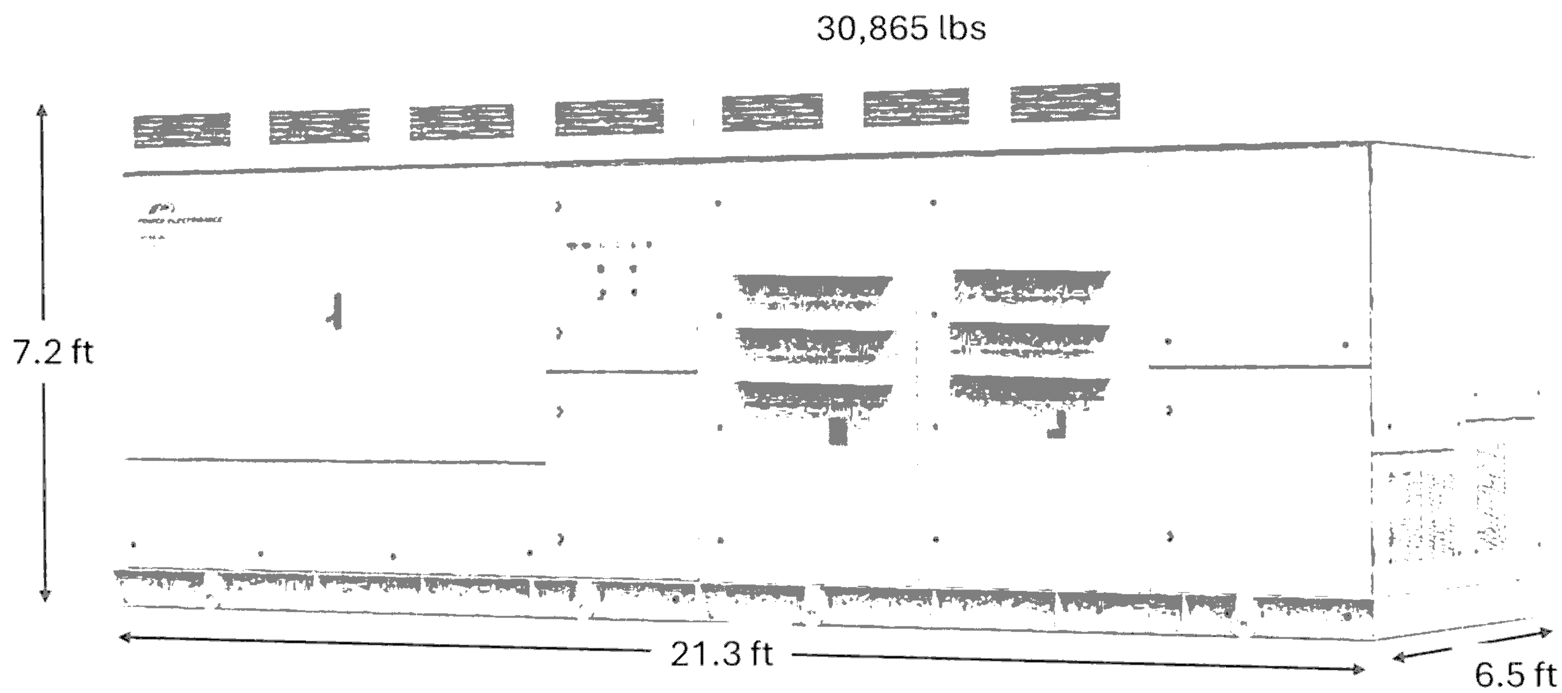
Project Areas



Solar Islands



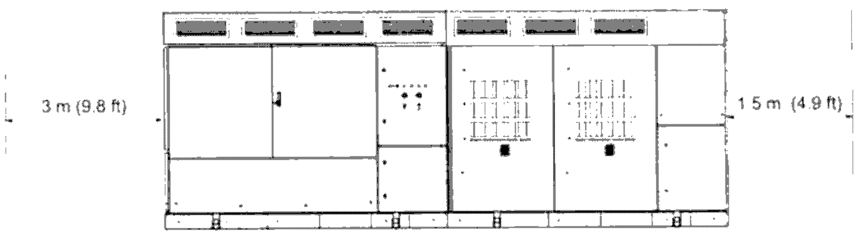
Integrated Inverter/Switchgear/Transformer

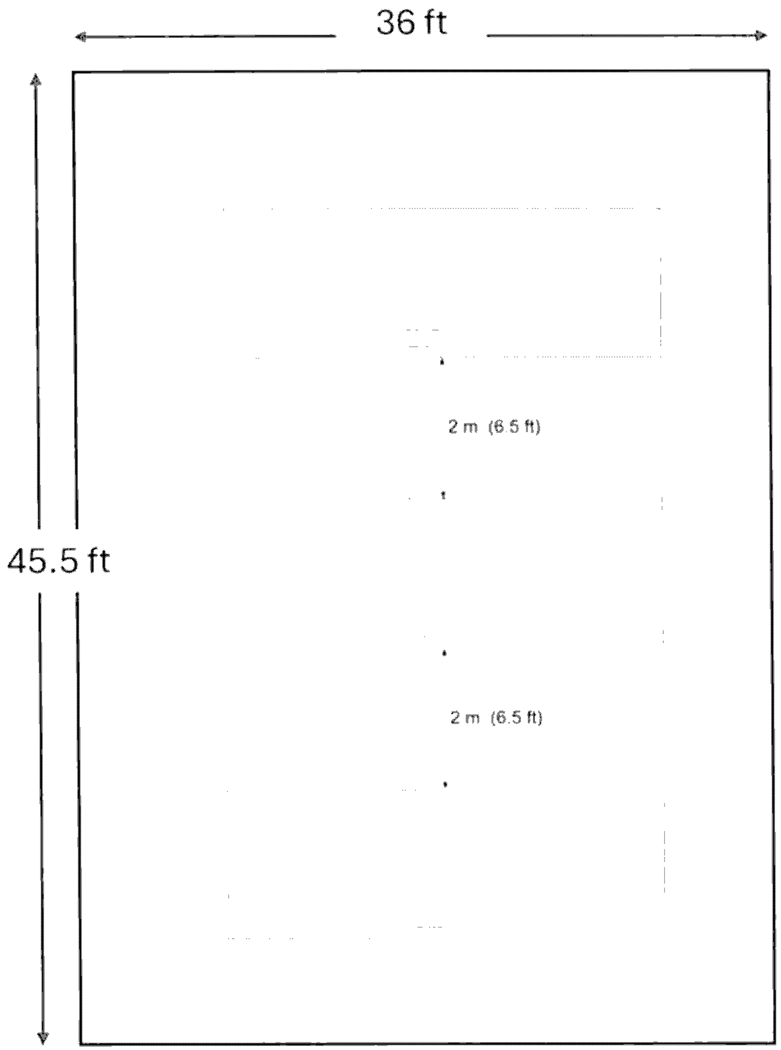


4MVA per block can support 5MWdc Solar

Equipment Pad

- 3 Integrated units required for the proposed solar array
  - Each unit will support 5MWdc/4MWac capacity
  - Total capacity: 15MWdc/12MWac
  - Total weight (minus support structure) = 92,595 lbs
- Support Structure:
  - Steel structure on piers
  - Dimensions (ft): 45.5ft x 36ft





Environmental Considerations

- All equipment certified drinking water safe
- Less than 2% of the Wanaque reservoir covered by solar islands
- De-minimis impact to reservoir capacity with ballast blocks (0.000039% of reservoirs' capacity)
- Outside 1000 ft radius of known Bald Eagle nests
- No anticipated impact to fish
- Will require bird management features to avoid panel soiling
- Ground equipment only in areas actively used by NJDWSC
- No impact to dam or weir

Bald Eagle Overview

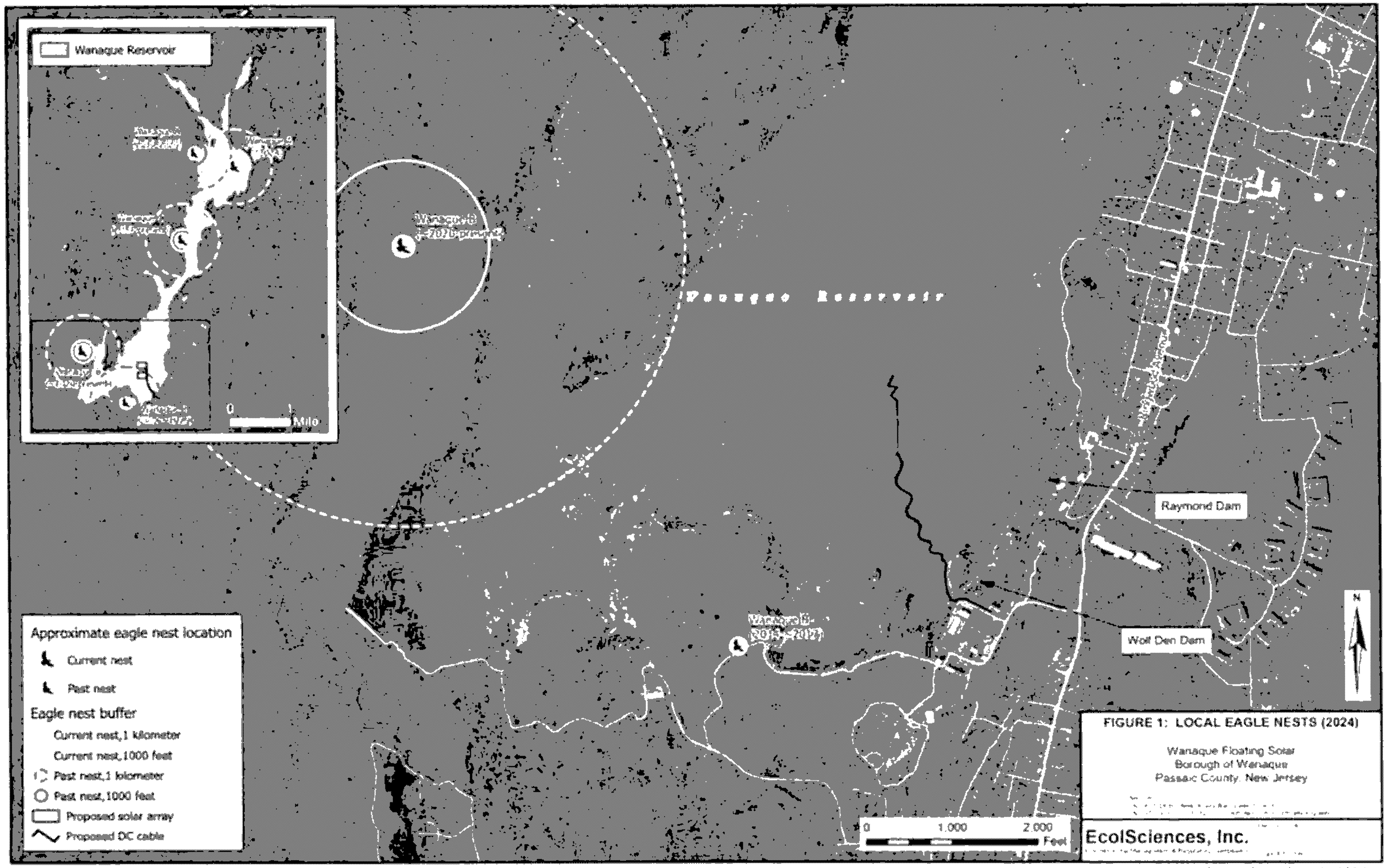


EXHIBIT D

Ted J. Del Guercio, III

From: Groskorth-Flynn, Taylor [DEP] <Taylor.Groskorth-Flynn@dep.nj.gov>
Sent: Friday, February 28, 2025 11:09 AM
To: Frances C. McManimon; Felix Aguayo; Ted J. Del Guercio, III; Tim Eustace; Maria Alliegro; James Stachura; Tom Leyden; Ryan.Jendrasiak@WestonSolutions.com; Steven P. Gouin
Cc: Pepe, David [DEP]; Lange, Elizabeth [DEP]; Maresca, Vincent [DEP]; Davis, Kelly [DEP]; Dalton, Richard [DEP]; Komar, Ken [DEP]; Ray, Russell [DEP]; Leynes, Jennifer [DEP]; Hudgins, Robert [DEP]; Contois, Dennis [DEP]; Humphries, James [HIGHLANDS]; Dench, Stephen [DEP]; Watson, Diane [BPU]; Scatena,Laura [BPU]; Bittner, Allison [HIGHLANDS]; Rizvi, Syed-Imteaz [DEP]; Bracey, Devin [DEP]; Kobesky, Dwayne [DEP]; Morgan, Sawyer [BPU]
Subject: Wanaque Reservoir Floating Solar - Meeting Summary 2/27/25

Good Morning,

It was a pleasure meeting with you on 2/27/25.

If you wish to have additional follow-up meetings with multiple programs, please let our office know and we will coordinate and schedule the meeting accordingly. If you would like to work with any of the individual programs directly, we just ask that you keep us copied on any correspondence so we may update our records.

To close out this email, below is a courtesy conceptual summary of possible permits and action items this project may require (but are not limited to): ***this is neither a comprehensive nor a technical summary***

Watershed and Land Management

Bureau of Dam Safety – Russell Ray (Russell.Ray@dep.nj.gov)

The Wanaque Reservoir is formed by a series of High Hazard dam structures which are regulated by the Bureau of Dam Safety. Based upon the proposed location of the solar array in relation to the Raymond Dam and the Overflow Spillway, the Bureau of Dam Safety would need to review and approve the project relative to any dam safety issues. The following comments will need to be addressed by the applicant:

- Details on the proposed anchoring to the reservoir bottom will need to be provided to ensure the anchoring does not adversely impact any of the dams or spillways.
- The proposed location of the arrays is in close proximity to the Overflow Spillway. The Bureau is concerned about the consequences if the arrays were to dislodge and block the spillway or reduce spillway flows. Unimpeded operation of the spillway is critical to the safe performance of the dams creating the Reservoir. It must be ensured the arrays are sufficiently anchored during all reservoir operating conditions and design storm events. **Therefore, strong engagement with the Bureau of Dam Safety is encouraged during the permitting process, and a separate meeting with Dam Safety is recommended.**

Bureau of Flood Hazard & Stormwater Engineering – Dennis Contois (Dennis.Contois@dep.nj.gov)

- The Wanaque Reservoir is considered a floodway in the state flood study, so the solar array would meet the fill within floodway threshold.
  - A Flood Hazard Permit with a Hardship Exemption will be required.

Bureau of Freshwater Wetlands – Stephen Dench (Stephen.Dench@dep.nj.gov)

- If the solar array is considered fill, a Freshwater Wetlands Individual Permit is required, and the applicant will have to demonstrate that the array will not have any adverse impacts.
- If the solar array is not considered fill, a General Permit #2 will be needed for the electrical line.

NJ Fish & Wildlife – Kelly Davis (Kelly.Davis@dep.nj.gov)

- As long as the solar array covers less than 10% of the lake there is not much concern from fisheries.
- It is recommended that a visual aid, such as dotting, be added to the panels to help bald eagles distinguish the panels from the water surface.
- There are concerns about the solar panels dislodging from their anchoring systems and disturbing nesting bald eagles; this should be consulted with the Bureau of Dam Safety to ensure the security of the panel's anchoring system.
- If platform option #1 is utilized, there will be a timing restriction for any tree clearing to avoid disturbing bat habitat and nesting:
  - April 1st to November 15th, or April 1st to September 30th (depending on consultation with the Threatened & Endangered Species Unit)
- There are reports of two Great Blue Heron nests directly west of the bridge, and south of the bridge on the point, Fish & Wildlife requests that the applicants be conscious of disturbing them if the birds are still present and stay to the eastern side while passing.

State Historic Preservation Office – Vincent Maresca (Vincent.Maresca@dep.nj.gov), Jennifer Leynes (Jennifer.Leynes@dep.nj.gov)

The proposed project is located within the Wanaque Reservoir Historic District, which is eligible for listing on the New Jersey and National Registers of Historic Places (SHPO Opinion 3/2/2006). The proposed floating solar arrays will be located approximately within the reservoir, which is a contributing resource to the historic district, and 1,500 feet west of the contributing Raymond Dam and Wolf Den Dam. The proposed marine cable landing location, equipment pad, and overhead pole connection wires are also located within the boundaries of the Wanaque Reservoir Historic District.

If subject to formal regulatory review, the HPO would recommend the following:

1. The project as proposed has a low potential to affect any archaeological resources as work is confined to areas of existing ground disturbance for construction of reservoir infrastructure.
2. The project as proposed has the potential to adversely affect the Wanaque Reservoir Historic District, as it will introduce new solar arrays and associated infrastructure within the historic district's boundaries. As a result, an assessment of the project's effects on the Wanaque Reservoir Historic District, to be performed by an Architectural Historian who meets the Secretary of the Interior's Professional Qualifications Standards [48 FR 44738-9] in Architectural History, is needed. If the effect of the project is determined to be adverse, then the applicant must provide proposed mitigation measures.

Please reference the HPO project number 25-0520 in any future calls, emails, or written correspondence in order to expedite our review and response.

Water Resource Management

Bureau of Water System Engineering – Syed-Imteaz Rizvi (Syed-Imteaz.Rizvi@dep.nj.gov), Devin Bracey (Devin.Bracey@dep.nj.gov)

- No permitting is required from the Bureau of Water System Engineering, as long as there are no changes to the intake of the structure, and the array does not affect water quality.

Bureau of Water Allocation & Well Permitting – Robert Hudgins (Robert.Hudgins@dep.nj.gov), Ken Komar (Ken.Komar@dep.nj.gov)

- The Bureau requests confirmation that the water fluctuations will not cause the anchoring system to fail.
- If the project needs any construction-related dewatering:
  - A Short-Term Water Use Permit-By-Rule will be needed for dewatering lasting less than 30 days.
  - A Temporary Dewatering Permit will be needed for dewatering lasting over 30 days.

NJ Geological & Water Survey – Richard Dalton (Richard.Dalton@dep.nj.gov)

NJ Geological & Water Survey could not attend the meeting, but provided the following comments:

- There are no geologic issues related to this project. The geologic bedrock map the applicant shows is the most current bedrock map of the area and was published by R. A. Volkert in 2011. The surficial mapping of the area by S. D Stanford was published in 1993 and is the most current surficial geology of the site. Both of these maps are available on the New Jersey Geological and Water Survey website.
- The applicant indicates they are going to use geophysics to determine the local geology as opposed to drilling. If they are using the geophysics to get the depth to bedrock that may work, but it is unlikely that they will be able to determine the individual bedrock units as shown on the published map, since the bedrock in this region consists of massive granites and gneisses, as shown on Volkert's map.

NJPDES Surface Water – Dwayne Kobesky (Dwayne.Kobesky@dep.nj.gov)

- No surface water discharge is anticipated from this proposed project. However, if a surface water discharge becomes necessary from construction related dewatering, a NJPDES Discharge to Surface Water General Permit will be needed.
- If the discharge will be uncontaminated groundwater generated during construction activities, the appropriate NJPDES Discharge to Surface Water General Permit is the B7 - Short Term De Minimis General Permit (http://www.nj.gov/dep/dwq/gp-b7.htm). As per the B7 application checklist, analytical lab data of all the parameters specified in Attachment 1 must be submitted, and the results must demonstrate that they are below the effluent standards.
- If the discharge will be treated groundwater from remediations and dewatering, the appropriate NJPDES Discharge to Surface Water General Permit is the BGR – General Groundwater Remediation Clean-up Permit (http://www.nj.gov/dep/dwq/gp_bgr.htm). As per the BGR permit application, a summary of the contaminants of concern must be submitted where the data was collected no more than 12 months prior to the submittal of the application. In addition, a Treatment Works Approval (TWA) from the Bureau of Environmental, Engineering and Permitting may be needed for the construction of the treatment system.
- If more than one acre will be disturbed, a general permit for Construction Activities, (5G3) may be required. The permit application process is available online at http://www.state.nj.us/dep/DWQ/5G3.htm.

NJ Highlands Council – James Humphries (James.Humphries@dep.nj.gov), Allison Bittner (Allison.Bittner@dep.nj.gov)

- The property lies in the Preservation Area of the Highlands Region, and as such is subject to the Highlands Water Protection and Planning Act, (NJSA 13:20), the NJDEP Highlands Water Protection and Planning Act Rules (NJAC 7:38) and the Highlands Regional Master Plan (RMP).
- The Highlands Council has no comments unless construction of onshore equipment which would lead to new disturbance or added impervious cover is required. If new land disturbance and/or new impervious surface is proposed, the NJDWSC Wanaque Reservoir facility, as a public utility, should consult with the NJDEP Division of Land Resource Protection regarding whether a Highlands Act exemption #11 would be required. NJDEP issues those exemptions in the Preservation Area, and the Highlands Council consults with the Division as to whether the project is consistent with the goals and purposes of the Highlands Act.
- The Highlands Council does not anticipate any changes from the previous Highlands determination.

Board of Public Utilities – Diane Watson (Diane.Watson@bpu.nj.gov), Laura Scatena (Laura.Scatena@bpu.nj.gov), Sawyer Morgan (Sawyer.Morgan@bpu.nj.gov)

- This project will need to submit a new petition for a Waiver for citing, because of its location in the Highlands.
    - The new information that was provided in the updated Permit Readiness Checklist should be included in the petition application.
    - The new petition should be submitted as soon as possible to address any concerns before the next CSI Solicitation.
- The BPU unit will regroup with Sawyer Morgan, the community solar contact, and reach back out about the project's community solar, upon his return.

Should circumstances or conditions be or become other than as set forth in the information that was recently provided to the NJDEP, the comments and regulatory requirements provided above are subject to change and may no longer hold true. Statements made within this email are not indicative that the NJDEP has made any decisions on whether the proposed project will be permitted.

Thank you for your participation and cooperation during this process. If you have any questions or concerns, please let me know as soon as possible.

Taylor Groskorth-Flynn she/her
Administrative Analyst 1 | Office of Permitting and Project Navigation
New Jersey Department of Environmental Protection
401 East State Street, Trenton, NJ 08625
Office: (609) 940-5620
OPPN website

EXHIBIT E

State of New Jersey
Highlands Water Protection and Planning Council
100 North Road (Route 513)
Chester, New Jersey 07930-2322
(908) 879-6737
(908) 879-4205 (fax)
www.nj.gov/njhighlands

Highlands Council
New Jersey

PHILIP D. MURPHY
Governor

SHEILA Y. OLIVER
Lt. Governor

CARL J. RICHKO
Chairperson

LISA J. PLEVIN
Executive Director

April 23, 2021

VIA EMAIL ONLY:
Jennifer Moriarty, Director
Bureau of Inland Regulation, Division of Land Resource Protection
New Jersey Department of Environmental Protection
Mail Code 501-02A
PO Box 420
Trenton, NJ 08625-0420

Re: **Highlands Preservation Area Exemption Determination, Exemption #11**
Application for Highlands Applicability Determination (HAD)
North Jersey District Water Supply Commission
Floating Solar Installation – Wanaque Reservoir
Borough of Wanaque, Passaic County

Determination: **Consistent with Goals and Purposes of Highlands Act, with Specified Conditions**

Dear Ms. Moriarty:

This letter is regarding the above-referenced application, which is currently before the New Jersey Department of Environmental Protection (NJDEP). The applicant seeks a Highlands Applicability Determination (HAD) on an exemption for a project proposed within the Highlands Preservation Area. The Highlands Act, at N.J.S.A. 13:20-28, specifies that a project deemed to be exempt is exempt from the Highlands Act as well as from the "the regional master plan, any rules or regulations adopted by the Department of Environmental Protection pursuant to this act, or any amendments to a master plan, development regulations, or other regulations adopted by a local government unit to specifically conform them with the regional master plan."

As you know, NJDEP determinations regarding Exemptions 9 and 11 in the Preservation Area are made in consultation with the New Jersey Highlands Council (Highlands Council), in accordance with the Highlands Act and NJDEP's Highlands Rules (N.J.A.C. 7:38-1.1 et seq.). Therefore, the Highlands Council has reviewed the subject project to determine the applicability of the Highlands Act and specifically whether this application meets the standard of eligibility for Exemption #11 of the Highlands Act ("the routine maintenance and operations, rehabilitation, preservation, . . ."), which mandates that a Highlands Act exemption is only to be granted "provided that the activity is consistent with the goals and purposes of the Highlands Act."

The North Jersey District Water Supply Commission (NJDWSC) oversees the operation of the largest regional water supply in the State of New Jersey, including more than 95-square-miles of watershed area, two major reservoirs, two river-diversion pumping stations, and a 210-million gallon/day (MGD) water filtration plant located at the Commission's headquarters in the Borough of Wanaque. At peak capacity, the Commission's facilities can serve the water needs of more than three million people in Northern New Jersey.

According to the information submitted with the application, the NJDWSC proposes the installation and operation of a floating solar facility, to be situated on the Wanaque Reservoir. The proposed design includes multiple floating solar arrays, or islands, anchored to the bottom of the reservoir and located approximately 300 feet from the shoreline in an area north of the Raymond Dam. Marine grade cables will deliver DC electricity from the solar arrays to electrical equipment, including inverters and oil-less transformers, installed on land. The marine grade cables will come ashore in a previously disturbed area. The onshore portion of the project is proposed for an area approximately 5,000 square feet in size. Electrical wiring from the transformers will be routed to an overhead, pole-mounted interconnection point located behind the NJDWSC's electrical meter. A new right of way (ROW) will be constructed through a wooded portion of the property. The entirety of the project will be on property owned by the NJDWSC. The solar array will cover approximately 20 acres of the surface of the reservoir. A separate area of disturbance is proposed north of West Brook Road, for an assembly and launch area. The area has been described as 2,500 square feet in size and the disturbance as temporary.

Highlands staff has reviewed the submitted materials and has assessed whether the project is consistent with the goals and purposes of the Highlands Act. To do this, staff first assessed what Highlands resources have the potential be affected by the project. These resources are: Highlands Open Waters and associated 300-foot Highlands Open Waters Protection Area, Total Forest Area and Critical Wildlife Habitat.

Highlands Open Waters: The floating solar arrays are proposed to occupy approximately 20 acres of the water surface of the reservoir. The total acreage of the reservoir is approximately 2,310 acres. The reservoir is mapped by the Highlands Regional Master Plan (RMP) as a Highlands Open Water, in which development is not permitted. However, as the size of the array is less than 1% of the total area of the reservoir, this is characterized as a de minimis impact. The panels will not affect the flow of stormwater, and in accordance with the Highlands Act, the panels themselves are not counted as impervious cover.

Highlands Open Waters Protection Area: The 300-foot buffer that surrounds all Highlands Open Waters is mapped for the areas proposed for the onshore electrical equipment, the new ROW and the northern assembly and launch area. These areas are described as disturbed, and contain roadways, developed parking, and ancillary facilities. However, these areas also drain to the reservoir and the associated reservoir outfall.

Total Forest Area: The vicinity of the proposed new ROW for overhead powerlines is mapped as Total Forest Area. The application materials calculate the forested area to be disturbed as 0.37 acres.

Critical Wildlife Habitat: The application materials identified 24 endangered, threatened, and special-concern species as having suitable habitat present in the vicinity of the project, including 3 mammals, 17 birds, and 4 reptiles. Among these species, only bald eagle (*Haliaeetus leucocephalus*), cliff swallow (*Petrochelidon pyrrhonota*), and northern long-eared bat (*Myotis septentrionalis*) habitats have potential to be affected by project development. Potential impacts to bald eagle and cliff swallow habitat may arise from the siting of the floating solar array on or over foraging habitat. Potential impacts to northern long eared bat habitat may arise from the removal of the forested area for the new ROW.

Based on review of the application and associated documentation, the Highlands Council finds this project **Consistent with the Goals and Purposes of the Highlands Act with the following specified Conditions.** These conditions are separate from any condition which may be imposed by the New Jersey Department of Environmental Protection through subsequent permitting actions.

1) For the removal of the 0.37 acres of total forest, replanting to the standards of the No Net Loss Compensatory Reforestation Act (N.J.S.A. 13:1L-14.1 et. seq.) shall be accomplished on the NJDWSC property. By using the tree replacement factor of 204 balled and burlapped trees per acre of removal this amounts to replanting of 76 trees. The trees shall be of native species, common to the area, 2 inches diameter breast height, shall be appropriately irrigated and protected from deer browse. The plantings shall be monitored for 5 years and an 85% survival rate shall be assured. If mortality greater than 85% is noted, replanting shall occur. The applicant shall provide the Highlands Council with a replanting and monitoring plan for review and approval.

2) For disturbances to mapped critical wildlife habitat, the Highlands Council will defer to the NJDEP-Endangered and Nongame Program (ENSP) for conditions for avoiding, minimizing, and mitigating impacts to mapped habitat. The applicant shall provide copies of any plans developed to address concerns of the NJDEP-ENSP regarding critical wildlife habitats.

3) For the temporary disturbance to the northern assembly and launch area, provide the Highlands Council with a restoration plan for review and approval that includes appropriate soil conservation methodologies, replanting plan to include native species and monitoring of plantings.

4) Provide the Highlands Council with restoration and/or landscaping plans for the proposed 5,000 square foot disturbed area for the onshore equipment, in proximity to the solar arrays. These areas shall be restored upon completion of construction with native species, in compliance with other permit conditions.

5) Provide copies of all permit applications, and final permits to the Highlands Council.

The Highlands Council does not object to the NJDEP's issuance of an Exemption (No. 11) for this project. This determination is based upon the proposed project as described in the application (received March 12, 2021) for a HAD under Exemption #11 prepared by Colliers Engineering and Design, submitted on behalf of the NJDWSC. Should circumstances change, we reserve the right to modify this recommendation. This determination does not eliminate the need for any permits, approvals, or certifications required by the NJDEP or any federal, State, county, or municipal review agency with jurisdiction over this project/activity.

If you have any questions or require further assistance, please contact me at (908) 879-6737, extension 101 or by email at Lisa.Plevin@highlands.nj.gov.

Sincerely,

Lisa J. Plevin
Executive Director

c: Patrick Ryan, NJDEP-DLR
Michael Tropiano, NJDEP-DLR