Nagog Pond Watershed and Solar Feasibility Study

Acton/Littleton, MA

Submitted to:

Town of Concord
Concord Public Works Water/Sewer Division

Submitted by:

Environmental Partners Group, Inc.

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In Association with:
Mackie Shea O'Brien, PC.

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Nagog Pond Water Supply Master Plan – Phase 1

Task 3

NAGOG POND WATERSHED AND SOLAR FEASIBILITY STUDY

ACTON/LITTLETON, MA

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TASK 3 – NAGOG POND WATERSHED AND SOLAR FEASIBILITY STUDY

The principal goals of Task 3 include the review and updating of the Town of Concord *Watershed Resources Protection Plan* inventory for the purpose of assessing the potential for utilization of watershed lands for the financial advancement of an advanced water treatment facility at Nagog Pond. As defined more specifically, this includes an assessment of the compatibility of said watershed lands for the development of solar photovoltaic energy systems, and the potential for the generation of revenue through the development of alternative energy resources, the practice of silviculture, and/or the sale of lands for residential purposes.

The Project Team met with Town of Concord Water Department staff on April 30, 2013 to review existing information sources, present certain preliminary findings, and to identify and review additional specific areas of interest. The later included the potential for developing a photovoltaic array on or over the waters of Nagog Pond, an assessment of the potential for generating wind-driven energy on Town-owned watershed lands, and the review of the hydrologic connection between Nagog Pond and "Little Nagog Pond" immediately north of Route 2A/119.

The following sections review the results of the 2011 *Water Resources Protection Plan* inventory review, the legal opportunities and constraints associated with alternate uses of the Nagog watershed lands currently owned by the Town of Concord, and the viability and potential revenue generation associated with the development of the alternative uses.

1.0 NAGOG POND WATERSHED RESOURCE PROTECTION PLAN INVENTORY REVIEW

A review of the most recent Nagog Pond *Watershed Resources Protection Plan*[1] inventory has been conducted utilizing current Massachusetts Geographic Information System (GIS) data, and Town of Acton and Town of Littleton GIS and public databases. In addition, field inspections were conducted, with particular attention focused on recent development and existing natural resources. In that the focus of this investigation is the alternative use of watershed lands owned by the Town of Concord, this update focused primarily on those areas. Information on the acquisition history of the Town-owned watershed parcels was supplied in large part by the Concord Department of Public Works Water and Sewer Division and supplemented when available by information from the above-referenced databases.

1.1 Town of Concord Land Holdings - Nagog Pond Watershed

Since the 1940's the Town of Concord has purchased over 95 acres of land within the Nagog Pond watershed, primarily with the stated purpose of protecting the quality of this public water supply. Over the years these purchases have included both large and small parcels and the method of acquisition has varied, as has the source of acquisition funds.

The individual parcels comprising the Town-owned watershed parcels are shown in Figure 1, *Concord-Owned Watershed Parcels Map* (Attachment A). Information concerning these individual parcels, including size, acquisition date, and current zoning are detailed in Table 1, *Town of Concord, Nagog Pond Watershed Land Holdings*. To the degree it could be determined, the method of purchase and/or the legislative source of funding for the individual parcels is identified as "Notes" in Table 1.

1.2 Nagog Pond Watershed - Existing Conditions

The 2011 update of the *Water Resource Protection Plan* for Nagog Pond, including associated maps, was conducted in the summer of 2011 and, as described therein, served "as an update to the July 1998 Watershed Protection Plan (last amended August 30, 1991)." The 2011 plan contained "updated maps of the Nagog Pond Watershed to identify current and potential contamination sources along with a Watershed Characteristics and Land Use Map." As part of the effort presented herein, the 2011 Plan inventory and the associated land use maps have been reviewed both for changes in the existing land use since the previous inventory, as well as for the potential for alternative land uses, as described above.

Figure 2, *Nagog Pond Watershed – Aerial Locus Map*, is a vertical aerial photograph showing the existing conditions of the Nagog Pond Watershed. The figure illustrates the

[1] Town of Concord, *Watershed Resource Protection Plan*, Nagog Pond, August 2011(revised)

Table 1-1 Town of Concord Nagog Pond Watershed Land Holdings

Parcel #	Area (acres)	Acquired	Zoning	Notes
LITTLETON				
RO1 - 9	1.70	11/13/1961	R (40,000sf)	
RO1 - 10	0.34	1/6/1986	R (40,000sf)	Quitclaim
RO1 - 11	0.08	9/16/1964	R (40,000sf)	Ch. 79; Ch. 201 (1884); "to protect the sanitary conditions of the waters of Nagog Pond."
RO1 - 12	0.18	1979/1980	R (40,000sf)	Quitclaim.
RO1 - 13	0.13	1972	R (40,000sf)	Ch. 79; Ch. 201 (1884)
RO1 - 14	0.22	1964	R (40,000sf)	Ch. 40; Ch. 79; Ch. 201 (1884); by eminent domain "for sanitary purposes"
RO1 -16 - 1	4.67	8/5/1993	R (40,000sf)	"...for the public purposes set forth in Article 97 ... including the protection and conservation of forests, water and other natural resources...".
RO1 - 16 - 0	10.04	8/5/1993	R (40,000sf)	Same as above
RO1 - 17 - 2	1.24	1995	R (40,000sf)	Ch. 40 Sec 41; for sanitary purposes
RO2 - 6 - 1	2.26	1993 8/9/1990	R (40,000sf)	
RO2 - 11 - 0	0.51	1945/1964	R (40,000sf)	
RO2 - 13 - 0	17.64	12/31/1945	R (40,000sf)	"Bonds Point"
RO2 - 12 - 0	1.52	1945/1964	R (40,000sf)	"Bonds Island"
ACTON				
C3 - 3	2	6/12/1944	R8 (80,000sf)	
C4 - 14 - 1	0.27	4/28/1905	R8 (80,000sf)	
C4 – 14, incl: First Parcel Second Parcel Third Parcel Fourth Parcel Fifth Parcel Sixth Parcel Seventh Parcel	55.85 8.9 7.5 3.5 5.3 2.36 3.0 10.9	1909 – 1914	R8 (80,000sf)	Compilation of parcels purchased or taken by eminent domain between 1909 and 1914, including "First Parcel" through "Seventh Parcel" taken for "the purpose of preserving and protecting the purity of the water and for uses incidental to the construction ... of said water system...".
C4 - 32	3.75	7/19/2003	R10/8 (100,000sf)	Land swap with Acton for the purpose of constructing a water treatment facility.

borders of the watershed and the 400-foot Zone A Water Supply Protection Area around the Pond and the 200-foot Zone A around its tributaries. In addition, the figure highlights the positions of existing structures. The location of the existing Town of Concord Nagog Pond Ozone Facility and associated entranceway off of Hazelnut Street is also highlighted.

Land Use within the Nagog Pond Watershed as mapped by MassGIS is shown on Figure 3, "*Nagog Pond Watershed - Land Use Map*." As noted in prior inventories, the bulk of the watershed lands (and virtually all of the Town-owned watershed lands) are forested. There

are several large (one acre and larger) residential lots located throughout the watershed, particularly in the western portion of the watershed in the Town of Littleton. There is a more densely developed mixed-housing complex in the eastern portion of the watershed opposite Route 2A/119 in the Town of Acton. Commercial/retail development within the watershed is limited to the Nagog Pond strip mall and office park, also located in the eastern portion of the watershed opposite Route 2A/119.

Finally, Figure 4, "*Nagog Pond Watershed – Bathymetry, Terrain and Wetlands Map*," illustrates the physical character of the watershed, including the generalized depth of Nagog Pond. As shown, the Pond is bound by relatively steeply sloping lands to the south and west, and more gradual to almost level lands to the north and east. Meanwhile, the pond is relatively shallow, having a maximum depth on the order of 30 to 45 feet at its center, but generally less than 18 feet within 300 feet of its shoreline. Depths in the eastern cove proximate to the Nagog Pond Dam and gatehouse for the ozone facility are generally less than 8 to 18 feet.

1.3 Nagog Pond Watershed Land Use Changes and Updates

There have been no significant land use changes within the Nagog Pond watershed since the 2011 inventory. Field inspections have, however, revealed a number of wetland resource areas not previously identified or mapped by MassDEP. In addition, a number of developments located within or proximate to the watershed are currently in the proposal or design phase. These changes and or potential projects are identified as "Changes in Land Use" and "Observed Wetlands" on Figure 3.

1.3.1 Changes in Land Use

As noted above, there appear to have been no significant changes in land use within the Nagog Pond watershed since the 2011 update. A small, four-house subdivision which was likely initiated prior to 2011 has been completed off of Route 2A/119 at the edge of the watershed, and five new homes have been constructed on "approval not required" (ANR) lots on Henley Road, most of which straddle or are located beyond the watershed boundary (see "A" on Figure 3). Similarly, several homes in a new subdivision east of the watershed may straddle the watershed boundary, although a field inspection suggests they are topographically beyond the watershed divide ("B" on Figure 3). The Nagog Hill Orchard outlet store and storage barn at the corner of Nashoba Road and Nagog Hill Road was not previously identified as a commercial use, but is shown as such on Figure 3 ("C"). Meanwhile, a review of Town of Littleton and Town of Acton databases, as well as discussions with Littleton and Acton Planning Department, Building Department and Highway Department personnel have resulted in the identification of several significant projects being proposed within the watershed, including large-scale residential developments in Littleton and Acton, and a significant roadway improvement project in Littleton. The locations of these developments are shown on Figure 3 and summarized below.

Acton – *The Residences at Quail Ridge* (Figure 3 – "D"). The Residences at Quail Ridge Project was identified in the 2011 Water Resources Protection Plan inventory as the "*Quail Ridge Country Club.*" The project entails the re-development of a portion of the Quail Ridge Country Club golf course as senior residential units. As shown in Figure 3, the project is located 300 or more feet from the downstream border of the Nagog Pond watershed. As such, issues of watershed proximity such as stormwater runoff should not be of significant concern. However, residential proximity does raise concern as to the possibility of increased pedestrian activities within the watershed, and associated potential impacts from pet walking and trail erosion runoff. The Residences at Quail Ridge project has established a public trail easement on its northern border that skirts the watershed Zone A boundary and will connect to other trails on Town of Acton conservation lands that lay within the Zone A boundary.

It is our understanding that the local and state permitting and approvals for this project have been issued and that the project is proceeding toward construction. Given the proximity of this Project to Nagog Pond, continued monitoring of this development by the Town of Concord during construction and operation is warranted. Although trails are not prohibited within Zone A of a surface water supply, expanded signage prohibiting entry into Town-owned watershed lands is warranted.

Littleton – *Village Green Apartments at 15 Great Road* (Figure 3 – "E"). This project was not identified, *per se*, in the 2011 Water Resources Protection Plan inventory, but the address, 15 Great Road, Littleton, was identified as the "*only … parcel zoned for residential use within the watershed that is privately owned and undeveloped*." As noted therein, the parcel "*covers a total of 54 acres with 13 acres in the Nagog Pond watershed.*"

On February 11, 2013 the Littleton Board of Selectman voted to execute a host community agreement for the "Village Green Apartments at 15 Great Road," a residential development composed of 190 rental housing units and a 22 lot subdivision, including a private onsite wastewater treatment and disposal facility. It is our understanding that the local and state permitting and approvals for this project are not yet complete.

As shown on Figure 3, a portion of the proposed rental housing lies within the Nagog Pond watershed, as does the proposed wastewater treatment facility and a portion of the associated treated wastewater disposal field. While located between 400 and 1,000 feet from the shore of Nagog Pond, this development adds to the already densely developed nature of the northeastern portion of the watershed.

Presumably the 15 Great Road project stormwater runoff and sanitary wastewater systems will be developed in accordance with local, state and federal regulations designed to protect surface water and groundwater. However, given the proximity of the development to Nagog Pond and, in particular, the proposed construction of a private wastewater treatment facility and disposal field all and/or partially within the Nagog Pond watershed, continued monitoring of this development by the Town of Concord DPW during all phases

of design and approval, construction, and post-construction operations is highly recommended. Although not a direct abutter to the project, the Town of Concord DPW should request copies of all permit filings for the project, as well as notification of all public meetings, and should review and comment on all such filings as deemed necessary.

Littleton – *Nashoba Road Improvements* (Figure 3 – "F"). The Town of Littleton is currently in the design and permitting phase for the reconstruction of Nashoba Road from the Town of Acton border at or near Route 2A/119, west to the intersection of Nagog Hill Road. It is our understanding that the construction contract has not yet being let out to bid.

As shown on Figures 2 and 3, almost all of this section of roadway lies within the Nagog Pond watershed and, more significantly, within Zone A of Nagog Pond. The project includes the complete reconstruction of the roadway for the purpose of improving roadway width, drainage and safety. Currently, roadway drainage consists of a combination of sheet flow, and limited storm drains with standard catch basin design. As with the developments identified above, it is presumed that the project stormwater runoff systems will be developed in accordance with local, state and federal regulations designed to protect surface water and groundwater. However, given the proximity of the proposed work to Nagog Pond, continued monitoring and input from the Town of Concord DPW regarding this project during all phases of design and approval, construction, and post-construction operations is highly recommended. Particular attention should be directed at the northern section of this project where the road lies immediately adjacent to the Pond and well within the Zone A of Nagog Pond. Alternative stormwater runoff treatment may be warranted in this section, including the use of stormceptor technologies.

1.3.2 Observed Wetlands

The 2011 Water Resources Protection Plan inventory maps included wetlands mapped by the MassDEP and shown on MassGIS. The MassDEP wetland maps have been developed for planning purposes, but do not represent formal wetland mappings and are not for use in permitting efforts. While it is beyond the scope of this investigation to formally map wetlands within the watershed, field inspections revealed additional wetlands not mapped by MassDEP. These additional wetland areas are shown on Figure 3 and include two fairly significant bordering vegetated wetlands along Nashoba Road ("W-1" and "W-2"), a bordering vegetated wetland and a stream segment immediately west of the existing Town of Concord water treatment facility ("W-3" and "W-4"), and a stream segment running from a wetland west of Nagog Hill Road to Nagog Pond ("W-5"). Other un-mapped regulated wetland areas may exist, particularly along the edge of Pond.

1.3.3 Little Nagog Pond

As requested at the April 30th Project Workshop meeting, an inspection of Little Nagog Pond was conducted for the purpose of determining a hydrological link between it and

Nagog Pond. In addition, Town of Acton roadway drainage maps were reviewed for evidence of culvert connections between Little Nagog Pond and Nagog Pond

Little Nagog Pond is located well within the northern, topographic boundary of the Nagog Pond watershed and is separated from Nagog Pond by Route 2A/119. The pond receives stormwater flow from a number of storm drains and culverts. Town of Acton drainage maps indicate an 18-inch diameter storm drain carrying flow from Nonset Path at the southern end of the pond, an unlabeled storm drain carrying flow to the pond from a single catchbasin at the entrance to Nonset Path, a similarly unlabeled storm drain carrying flows from multiple catchbasins in Route 2A/119 and the entranceway to Nagog Park, a 12-inch diameter storm drain carrying flow from the Nagog Park roadway and the parking lot opposite the northern end of the pond, and single 24-inch and 12-inch diameter storm drains carrying flow from the parking lot of Nagog Park (see Figure 5*, Little Nagog Pond Surface Water Runoff Collection System*). All of these drains appear to be reinforced concrete and, with the exception of the 18-inch drain, all were observed to be at or partially within the water level of the pond. In addition to the above, a 24-inch diameter reinforced concrete storm drain forms a culvert beneath Nonset Path that connects a narrow wetland located along Route 2A/119 to the southern end of Little Nagog Pond.

No pipe or culvert connections between Little Nagog Pond and Nagog Pond are shown on the above drainage maps, and none were observed. However, a pair of flared 24-inch diameter storm drains located at the northern end of the pond is shown as carrying flow from Little Nagog Pond northward to a discharge point out of the Nagog Pond drainage basin. These drains are shown as merging as a 36-inch diameter pipe opposite the Nagog Park service road, and then stepping up to a 48-inch diameter pipe. This pipe was observed to discharge into a wetland stream approximately 2,000 feet north of Little Nagog Pond (see Figure 2). The mouths of the two 24-inch diameter outlet drain pipes appear to be partially within the water level of the pond and, during normal conditions, are flooded with an inch or so of water with no apparent out flow or in flow. Immediately following the approximately 2-inch rainfall event of June 7th and 8th, water of a depth of approximately six inches was observed flowing out of Little Nagog Pond through these outlet pipes.

As can be seen in the drainage map of Figure 5, the catch basins and storm drains of Nagog Park, the Nagog Park driveways, and portions of Nonset Path are directed to Little Nagog Pond and/or directly to the twin 24-inch outlet pipes associated with Little Nagog Pond. As such, virtually all of the surface water from the Nagog Park complex is diverted out of the Nagog Pond drainage basin. The portion of the Nagog Park drainage basin being diverted is approximated on Figure 2 and is on the order of 60 acres in area.

Interestingly, the surface water level elevation of Nagog Pond is shown as 226 feet on the Acton drainage map reproduced as Figure 5, while the surface water level elevation of Little Nagog Pond is shown as 225.3 feet. This would suggest a hydrologic gradient from Nagog Pond to Little Nagog Pond. Meanwhile, despite the number of drainage pipes emptying to Little Nagog Pond, no evidence of past flooding in the pond, such as a high water wrack

line or debris in branches, was observed. Hence, it would appear that the outlet pipes are sized so as to accommodate flood events and prevent flooding of Little Nagog Pond. Although concern has been raised as to the potential for Little Nagog Pond waters seeping into Nagog Pond beneath Route 2A/119, it would appear that the two ponds are at best hydraulically neutral, and that it may be more likely that Nagog Pond seeps into Little Nagog Pond.

Finally, during the various inspections of Little Nagog Pond a pump system was observed on the north shore of Little Nagog Pond, and a 2-inch diameter PVC pipe was observed extending into the pond. A sign posted in the adjacent lawn reads "Well Water in Use," suggesting that Little Nagog Pond is being utilized for landscape irrigation purposes.

1.4 Summary – Nagog Pond Water Resources Protection Plan Inventory Review

There has been no significant change in land use within the Nagog Pond watershed since the 2011 Water Resources Protection Plan inventory and, based on the review conducted, no specific changes are warranted to the text of the Land Use Assessment section of the 2011 Plan. The identification of additional wetlands within the watershed does not change the existing character of the basin. However, these and existing wetlands do pose a potential limitation to the alternative use of watershed lands.

Several small residential developments have been advanced within or proximate to the watershed since the issuance of the 2011 Plan, but none appear to pose a direct threat to the water quality of Nagog Pond. Meanwhile, several larger developments are being advanced within or proximate to the watershed and should be closely monitored by the Concord DPW, although, again, they do not appear to pose a direct threat to Nagog Pond water quality. The proposed Residences at Quail Ridge project in Acton is actually located down-gradient of the Pond, while the Village Green Apartments project in Littleton is located beyond the Zone A of the Pond and proposes advanced treatment for project wastewater, with a large portion of the actual discharge occurring outside of the watershed. The Town of Concord is an abutter to the Residences at Quail Ridge project and should receive and review all filing associated with that project. While not a direct abutter to the Village Green Apartments project, the Town should request notice of and should review all associated filings.

The proposed roadway improvements on Nashoba Road may well result in improved stormwater runoff quality through the adoption of stormwater runoff improvements compliant with current local, state and federal stormwater runoff control measures. Nonetheless, the Concord DPW should take this opportunity to review the proposed plans and to provide feedback where appropriate.

Finally, the diversion of surface water runoff by way of Little Nagog Pond should be assessed as to the potential quantity impacts versus the (likely) quality benefits.

2.0 NAGOG POND WATERSHED – ALTERNATIVE LAND USE REGULATORY CONSIDERATIONS

The use of watershed lands may be dictated by physical constraints such as ground slope, vegetative cover and/or associated shadow, and wetlands. Use may also be limited by legal constraints such as federal and state regulation, by restrictions associated with the method or conditions of the purchase, or by local regulation and zoning.

The following sections review those constraints that have the potential to act as limiting factors to alternative use of watershed parcels or, in the extreme that may result in actual prohibition of the proposed use. As such, this is not intended as a review of all applicable laws and regulations associated with watershed land use, but rather an assessment of those factors that would have the greatest effect or limitation on the potential generation of revenue from watershed lands through the development of alternative energy resources, the practice of silviculture, and/or the sale of lands for residential purposes.

2.1 Federal, State and Local Environmental Regulation

The alternative use of Nagog Pond watershed lands owned by the Town of Concord would likely be subject to a number of federal, state and local environmental legislation and regulations. Work within or proximate to these lands, including within or over Nagog Pond, may be subject to Sections 401 and 404 of the US Clean Water Act, the Massachusetts Wetlands Protection Act, and the Wetland Protection Bylaws of the towns of Littleton and Acton. Nagog Pond and the wetlands bordering it are deemed Class A Outstanding Resource Waters under the Massachusetts Surface Water Quality Standards (314 CMR 4.00), and the Concord-owned watershed lands lie almost entirely within Zone A as defined by the Massachusetts Water Supply regulations (310 CMR 22.00). Additionally, Nagog Pond is listed by the Massachusetts Department of Environmental Protection (MassDEP) as a Massachusetts Great Pond and work within the Pond is therefore subject to Chapter 91 licensing requirements (310 CMR 9.00). Work would also likely be subject to review under MassDEP stormwater standards that were incorporated into some of the aforementioned regulations.

The following sections review the key environmental regulations for the protection of wetlands, water quality and waterways as they relate to the alternative land uses contemplated for the Nagog Pond watershed lands as described herein. Note that this is not a list of all the permits necessary for advancing alternative energy development, residential development, or forestry practices on these lands, but rather a review of those key environmental regulations that would likely pose the greatest constraint on any such development. Note also that none of these regulations specifically prohibits the uses contemplated, provided the work complies with regulatory performance standards, but may limit the areal extent of any such proposed activity.

2.1.1 Wetlands Protection

While the federal, state and local definitions of what constitutes a wetland or wetland resource area vary, for the purpose of this discussion wetlands include water bodies, streams, and lands containing high groundwater levels, hydric soils and dominated by vegetation dependent on wet conditions ("bordering vegetated wetlands," or "BVW"). In general, federal, state and local wetland regulations prohibit the filing or disturbance of wetlands with limited and varying exceptions.

Section 404 of the US Clean Water Act (CWA). Section 404 of the Clean Water Act (CWA) establishes programs to regulate the discharge of dredged or fill material into waters of the United States, including wetlands. Section 404 is administered by the U.S. Army Corps of Engineers (ACOE) and U.S. Environmental Protection Agency (EPA). States also have a role in Section 404 decisions through State program general permits, water quality certification, or program assumption (see 401 discussion below). Activities in waters of the United States regulated under the Section 404 program include, but are not limited to, fill for development. Section 404 requires a permit from the ACOE before dredged or fill material may be discharged into waters of the United States, unless the activity is exempt from Section 404 regulation (e.g. certain farming and forestry activities).

The basic premise of the Section 404 program is that no discharge of dredged or fill material may be permitted if: (1) a practicable alternative exists that is less damaging to the aquatic environment, or (2) the nation's waters would be significantly degraded. In other words, when applying for a permit, it must be demonstrated that the project has, to the extent practicable:

- Taken steps to avoid wetland impacts;
- Minimized potential impacts on wetlands; and
- Provided compensation for any remaining unavoidable impacts.

Generally speaking, activities proposed in a water of the United States are allowed only upon demonstration that such activities are essential to the project purpose and could not be practicably avoided. As such, the placement of an alternative energy system or the construction of a residential unit within a wetland would not ordinarily be allowed except under very limited circumstances. The crossing of a wetland for the purpose of access to an upland site, or for the placement of a transmission line, may be allowed upon demonstration that no alternative access to upland areas is available and that the work has been designed so as to minimize the wetland impact area. In addition, augured piles may not have the effect of fill as defined under the CWA; hence, a pile supported array of solar panels, for example, would potentially not be deemed to constitute a fill activity that is subject to review by the ACOE.

A permit under Section 404 is generally not required if the discharge of dredged or fill material is associated with forestry activities related to the harvesting of forest products. This exemption only pertains to normal harvesting activities that are part of an established, ongoing forestry operation. Activities which convert a wetland which has not been used for forestry into such uses are not generally considered part of an established operation, and are not exempt. In addition, forestry may be allowed within a wetland proper without a permit from the ACOE, provided that the forestry activity does not result in a change in the topography or drainage characteristics of the area, and that no "filling" occurs. Under Section 404, ACOE has historically defined a discharge of fill as including the felling and dragging of trees and the use of swamp mats to support forestry equipment. Hence, forestry may be practiced within wetlands, but must be conducted in a manner such that no trees or branches fall within the wetland and that the forestry equipment does not rut or otherwise degrade the area. This latter condition could be met by limiting work to periods of frozen ground conditions.

Pre-filing consultation meetings with the ACOE are recommended to determine if a specific activity is subject to Section 404 review on a case-by-case basis.

Section 401 of the U.S. Clean Water Act. The 401 program is a Federal statute administered through state regulations (310 CMR 9.00) by MassDEP to insure that a project complies with state water quality standards (314 CMR 4.00). A 401 Water Quality Certificate (WQC) is required under the CWA for activities resulting in a discharge of dredged or fill material into wetlands and waterways.

Generally speaking, a Section 401 WQC would be required by MassDEP in the event the ACOE requires an Individual Permit under Section 404; if more than 5,000 square feet of bordering or isolated vegetated wetlands and land under water bodies and waterways cumulatively are altered by fill material; or if the project results in a discharge of fill into an Outstanding Resource Water (e.g., vernal pools and public drinking water supplies and the tributaries thereto). The clearing of vegetation in wetlands, as an example, is generally not subject to MassDEP jurisdiction under Section 401 because it does not typically result in a discharge of fill material (unless swamp mats are used to support construction equipment).

Certification under Section 401 generally requires the completion of an alternatives analysis and may require pre- and post-water quality and/or sediment quality sampling and analysis. An assessment of fisheries impacts is commonly required for rivers and coastal waters, but may be waived for a non-fisheries based water supply reservoir.

Massachusetts Wetlands Protection Act (WPA). The Massachusetts Wetlands Protection Act (MGL c.131 § 40) (WPA) and implementing regulations (310 CMR 10.00) is a state statute administered locally by Town or City Conservation Commissions. In addition to administering the WPA, certain communities such as Acton and Littleton administer more stringent Wetland Bylaws (see discussion below). The WPA/Bylaws require the preparation of a Notice of Intent (NOI) for work within a wetland resource area and/or work within 100

feet of certain wetland resource areas (i.e., the "100-foot Buffer Zone"). The general performance standards for work or activities occurring within each wetland resource area are identified in the WPA and Bylaw regulations. For example, work within Bordering Vegetated Wetlands (BVWs) is limited to 5,000 square feet of alteration (310 CMR 10.55) with only a few exceptions pertaining to Limited Project activities. The Conservation Commission may approve such work upon a demonstration that project impacts to BVW have been avoided, minimized and mitigated accordingly and that work complies with the performance standards. Meanwhile, the allowable areal extent of impact in a buffer zone is not specified, but work in the buffer zone must be demonstrated to have no impact on the actual resource area. This is generally achieved by maintaining a reasonable limit of work setback from the wetland edge, installing and maintaining sedimentation and erosion control devices, and other similar Best Management Practices.

Generally speaking, the construction of any alternative energy system or a residential unit would not be allowed within a wetland resource area because said work could not be designed or conditioned by the Commission to comply with the regulatory performance standards (e.g., 5,000 square-foot threshold for BVW, alternatives analysis, etc.). Like the CWA, however, the WPA regulations do allow for the crossing of a wetland for the purpose of access to an upland site, or for the placement of a transmission line, provided that demonstration is made that no alternative access or route is available and that the work has been designed so as to minimize the impact area. Furthermore, the impact area for such access can exceed the 5,000 square foot limitation under the "*limited project*" provisions of the regulations. These regulations establish provisions for Commissions to allow certain activities even though they may not meet the performance standards otherwise required for work in certain wetland resource areas, such as the 5,000 square-foot limitation on alteration of BVW. Almost all limited projects are approved or disapproved, after a review of alternatives and impacts, at the discretion of the Conservation Commission.

While the construction of energy facilities and residential housing within wetland resource areas is generally prohibited, the WPA does provide an exemption for the "*normal maintenance and improvement of land in agricultural use*" (§10.04). The definition of agricultural use in the WPA regulations includes forestry, but only under highly specific conditions. It is also important to note that the forestry exemption is for the work, not the land. For the forestry activity to qualify for the exemption it must take place on lands "*in agricultural use*" and involve "*normal maintenance*" or "*normal improvement*." The land must be presently and primarily used to grow forest products, and be demonstrated to be devoted to such use over an extended period of time, either previously, or going forward. Such a demonstration would generally include activities such as enrollment in a federal or state program to improve forest resources, and must include a cutting plan approved by the Massachusetts Department of Conservation and Recreation.

While forestry activities may be exempted from regulation under the WPA, certain associated activities, such as the construction of forestry access roads, are not. Such

activities would be subject to review under the WPA regulations, although, like the access roadways described above, would be regulated under the limited project provisions. The limited project provisions allow for certain activities associated with forestry, such as the construction of lumber roads, provided there is no change in the existing topography and drainage, the work is conducted when the ground is frozen or sufficiently dry enough to support any associated equipment, and that the operation generally not occur within 25 feet of the bank of a water body.

Town of Littleton and Town of Acton Wetland Protection Bylaws. Both the Town of Littleton and the Town of Acton have adopted wetland protection bylaws. The Littleton Bylaw outlines the application and review process, but generally adopts the definitions and provisions of the WPA, including the exemptions provided therein. The Town of Acton Bylaw similarly adopts the provisions of the WPA, but establishes a number of more restrictive guidelines for work within or proximate to wetland resource areas.

Of particular note as regards the alternative uses of watershed lands as identified herein relate to the wetland set-backs established by the Town of Acton Wetland Bylaw. These include provision of a 50-foot zone of no disturbance around all wetland resource areas and a 75-foot setback from all wetlands for all "*driveways, roadways, and structures*." As regards the potential for alternative energy systems and residential development, the Bylaw recognizes and adopts the limited project provisions of the WPA, but otherwise establishes a 75-foot minimum set-back requirement for the associated structures. Similarly, the Acton Bylaw adopts the agricultural exemption for forestry activities, and the limited project provisions for activities associated with forestry practices.

2.1.2 Water Quality Protection

The Massachusetts drinking water regulations at 310 CMR 22.00 establish certain quantitative guidelines for the protection of surface water supplies. Key among these is the classification of water protection "*Zones*" around surface water supplies and their tributaries, and the establishment of land use and protective guidelines for these zones. The regulations establish three zones defined as below:

- Zone A: the land area within 400 feet of the bank of a surface water supply and 200 feet of the bank of a tributary to that supply;
- Zone B: the land area within the watershed and one-half mile of the bank of a surface water supply (including the Zone A lands); and,
- Zone C: the land area within the watershed of a surface water supply not within Zone A or Zone B.

As shown on Figures 1, 2 and 3 virtually all of the Town-owned lands within the watershed of Nagog Pond are located within Zone A. The remainder lies within Zone B of the Pond.

Note also, that the Zone A extends beyond the watershed boundary at the northern corner of the Pond, and in the eastern cove at the outfall of the Pond.

The regulations at §22.20B*: Surface Water Protection*, establish prohibitions and/or guidelines for certain uses within each of the above water protection zones. Similarly, the regulations at §22.20C*: Surface Water Supply Protection for New and Expanded Class A Surface Waters,* establish certain prohibitions and/or guidelines to be included in the surface protection zoning and non-zoning controls required of all new surface water supplies. Under §22.20B these include prohibitions on the installation of underground storage tanks and on the above-ground storage of certain liquid hazardous materials within Zone A. The grazing and stabling of livestock within 100 feet of a surface supply or tributary is also prohibited. §22.20C adds the prohibition of facilities that "*generate, treat, store or dispose of hazardous waste … except … very small quantity generators as defined by 310 CMR 30.000.*"

Nothing in the drinking water regulations would appear to prohibit the development of alternative energy systems or the conduct of forestry operations within Zones A, B or C, and therefore within the Town-owned watershed lands surrounding Nagog Pond, provided the work can be designed to comply with MassDEP stormwater management standards (see below). While there is incidental waste associated with wind generators and solar energy systems, the levels are within those that would define very small quantity generators and the storage of any such materials can be placed beyond the limits of the protective zones.

As regards residential development, there is some ambiguity in the drinking water regulations as to the construction of new septic systems within Zone A. The regulations at §22.20B(3)(a) state clearly that "*all on-site subsurface sewage disposal systems, as defined in 310 CMR 15.000 (Title 5), within Zones A, B, and C, shall be in compliance with the requirements of 310 CMR 15.000.*" However, the regulations at §22.20B(3)(b) state "*within the Zone A of all surface water supplies and tributaries as defined in 310 CMR 22.02, all sewer lines* [underlining added for emphasis] *and appurtenances are prohibited, except as required to eliminate existing or potential pollution to the water supply, or where the crossing of tributaries is necessary to construct a public sewer system.*" While §22.20B(3)(b) would appear to be referring to municipal wastewater treatment systems rather than individual residential septic systems, the terms "sewer" and "sewer lines" as used in Title 5 are done so in reference to both municipal sanitary sewer systems and residential septic systems.

Finally, with regard to stormwater management, MassDEP requires the application of the Massachusetts Stormwater Management Standards to projects subject to jurisdiction under the WPA. MassDEP also requires the application of the Stormwater Management regulations when reviewing projects that require a water quality certification pursuant to 314 CMR 9.00 or that require authorization under the NPDES Stormwater Construction General Permit. Any proposed project subject to these aforementioned regulations would need to demonstrate compliance with the stormwater standards. For example, the

definition of Zone A in 310 CMR 22.20 includes the area within 200 feet of a tributary to a public water supply. Discharges are prohibited within 200 feet of a tributary where the stormwater standards are applicable. The definition of Stormwater Discharges includes discharges to both groundwater and surface waters, such as in the discharge of waters into a surface basin and/or an infiltration system.

2.1.3 Waterways – Chapter 91

The protection, care, and supervision of the public's interest in the waterways of the Commonwealth are implemented through the regulatory framework of MGL Chapter 91. The provisions of Chapter 91 provide for the protection of the public's right to navigation and access to the shorelines and waterways of the Commonwealth and are implemented through regulations promulgated and administered by the MassDEP Waterways Program (310 CMR 9.00).

The Chapter 91 regulations identify the geographic areas subject to Chapter 91 jurisdiction as including "*all waterways, including … all submerged lands lying below the high water mark of: (a) Great Ponds.* As noted above, Nagog Pond is listed by MassDEP as a Great Pond and, as such, work within the Pond is subject to the regulatory provisions of Chapter 91.

The Chapter 91 regulations establish different review and requirement standards for waterways projects based upon a number of criteria. Key among these is the project's status as a "*water-dependent*" or "*nonwater-dependent*" project (§9.04). Generally, any marine or maritime uses, or any uses that enhance the public's access to and enjoyment of the water, are deemed water-dependent, while facilities of private tenancy, such as residences and offices, are deemed nonwater-dependent. Certain infrastructure and energy facilities may be deemed "*water-dependent-industrial*" if it can be shown that they "*cannot reasonably be located at an inland site*," or are dependent upon marine service, such as fuel delivery. Otherwise, such facilities are deemed nonwater-dependent (§9.12). Chapter 91 defines "*infrastructure facilities*" as those facilities "*which produces, delivers, or otherwise provides electric …* [or] *water … service to the public*" (§9.04). The alternative energy systems contemplated herein would appear to be defined as nonwater-dependent infrastructure facilities.

The Chapter 91 regulations at §9.32, *Categorical Restrictions on Fill and Structures*, identify those activities allowed on the waterways of the Commonwealth, including Great Ponds. The construction of residential units over the waters of Great Ponds is clearly prohibited, while the construction of "*wind turbine facilities found to be nonwater-dependent*" is specifically provided for at §9.32(1)(a)7. Meanwhile, similar allowance for a solar energy array over the water is left ambiguous. Indeed, while specifically accounting for wind turbines, the regulations at §9.32 do not appear to account for any other alternative energy facility within the waters of a Great Pond. However, the above cite relative to wind turbines includes reference to §9.55, *Standards for Nonwater-dependent Infrastructure*

Facilities which, at §9.55(2), states "*all nonwater-dependent use projects consisting of infrastructure facilities on … Great Ponds shall take reasonable measures to provide open spaces for active or passive recreation at or near the water's edge, wherever appropriate,*" implying that such use may be allowed. §9.55(2) concludes "*Such measures may be provide by any means consistent with the need to avoid undue interference with the infrastructure facilities in question, and to protect public health, safety, or the environment.*"

Assuming a solar energy array or wind turbine could be licensed on or within Nagog Pond, the other key considerations under Chapter 91 are that the facility provide a "*Proper Public Purpose*" [§9.31(2)], that it not interfere with navigation and/or the public's use of and/or access to the water, and that it not interfere with or displace existing water-dependent uses. Proper public purpose is deemed to be met if the facility complies with the conditions of §9.55, including the protection of maritime commerce and public access, the attainment of water quality goals, the protection and enhancement of public views and visual quality, and the protection of historic and archeological resources. In that Nagog Pond is a protected public water supply, the attainment of these goals is compatible with those of water supply protection and any infrastructure project propose for the Nagog Pond watersheet could and would be developed in a manner allowable under Chapter 91.

2.2 Article 97 Land Protection

In November 1972 the citizens of Massachusetts approved at the ballot Article 97, which became the 97th Amendment to the State Constitution. Article 97 states that "*the people shall have the right to clean air and water,*" and that "*the conservation, development and utilization of the agricultural, mineral, forest, water, air and other natural resources is hereby declared to be a public purpose.*" Article 97 also establishes that "*lands and easements taken or acquired for such purposes shall not be used for other purposes or otherwise disposed of except by laws enacted by a two thirds vote, taken by yeas and nays, of each branch of the general court.*"

The Town of Concord has purchased over 95 acres of land within the Nagog Pond Watershed, mostly along the shore of Nagog Pond. It owns 19% of the watershed land and 40% of the land within the Zone A. Although not specifically referenced or identified in all purchases (see Table 1), it can reasonably be presumed that these purchases were conducted so as to aid in the protection of water quality. Indeed, several of the property deeds specifically reference Article 97, the "preserving and protecting the purity of the water," and the protection of "the sanitary conditions of the waters." According to the 2011 *Nagog Pond Watershed Management Plan*, Concord has worked and continues to work closely with landowners and developers in the watershed on appropriate protective land management controls and, although the watershed has effectively reached build-out, Concord continues to communicate its interest in the purchase of property or of a conservation restriction to limit the future use and development in order to protect water quality. Toward this end, Concord has posted its property and controls public access to the watershed land, and conducts inspections and surveillance of watershed lands. Concord

also works closely with Acton, Littleton and Mass DOT to manage roads and stormwater in accordance with Best Management Practices to protect the Pond.

Concord owns the Nagog Pond Dam located at the eastern end of the Pond and proximate to the Town of Concord Ozone Facility (see Figure 1). The dam was constructed in 1909 as part of the development of Nagog Pond as a water supply and underwent significant rehabilitation in 2012. In relation to maintaining the Pond as a viable water supply, Concord has conducted Dam Safety Phase I and II inspections, has an Emergency Action Plan to cope with failure of the dam, and is evaluating improvements to rehabilitate the dam, piping, spillway and gate controls.

2.2.1 Change in Use and/or Sale of Article 97 Lands

Notwithstanding the commitment to purchase and manage watershed land to protect water quality, Concord is contemplating the sale and/or lease of some parcels for single-family residences, and/or solar photovoltaic (PV) or wind electricity generation for a source of revenue to fund rehabilitation of the Nagog Pond intake and treatment facilities, watershed land acquisition, and water supply operations. Additionally, Concord is considering a smaller scale PV system to power the Nagog Pond pumping and treatment facility.

Concord's watershed holdings are public lands presumably acquired for protection of the Nagog Pond water resource (see Table 1 and Section 2.2, above). As such, the transfer, sale, grant or lease, or alteration of the use of these lands will require adherence to the procedural protections afforded by Article 97 of the Amendments to the Massachusetts Constitution. Article 97 applies to all lands, easements and interests whenever taken or acquired for public natural resource (e.g., ponds, forests), conservation purposes, even prior to the November 7, 1972 effective date.

The Executive Office of Energy and Environmental Affairs (EEA) is charged with protecting all open space lands covered by Article 97. Potential disposition of the lands requires analysis and compliance with the February 19, 1998 EEA Article 97 Land Disposition Policy (Attachment B). EEA will not support land disposition unless "exceptional circumstances exist" and the following conditions are met:

- no feasible and substantially equivalent option;
- the disposition does not destroy or threaten a unique or significant resource;
- minimum acreage necessary for the proposed use and the resources are still protected to the maximum extent possible;
- the disposition serves a public purpose; and,
- the disposition is not contrary to the "express wishes" of the party who sold the land.

Municipalities seeking to dispose of public lands subject to Article 97 must satisfy the following:

- a two-thirds vote of town meeting to submit a "home rule" petition to the Legislature;
- a two-thirds vote of the state legislature; and,
- compliance with applicable funding sources and disposition policy.

Every year dozens of bills to divert conservation land to other uses are filed with the Legislature and many are routinely approved. In that, by definition, any such proposed conversion of land has already met with local approval and presumably been vetted by local counsel, such approval by the Legislature is not necessarily surprising. However, local opposition, particularly by neighboring towns which share legislative representation, can obviously have great effect upon any such vote.

2.2.2 Use of Article 97 Lands for Solar and Wind Energy Projects

With respect to compliance with other disposition policies, Concord would need to request MassDEP approval for solar or wind energy projects on lands owned by or controlled by public water systems for drinking water purposes. The March 26, 2012 Guideline from the MassDEP Bureau of Resource Protection Drinking Water Program for proposed wind and solar energy projects on water supply lands (Attachment C) explains that while MassDEP supports solar energy projects, it "*recognizes that lands under the control of public water systems have been identified as the most critical to protect drinking water reservoirs and wells.*" Concord must demonstrate no significant adverse impact in a written certification with the information listed in the policy. MassDEP may request additional information or deny the request within 30 days. Although the subject watershed lands are within Zone A and not a Zone 1 wellhead protection area, there should be a demonstration the energy project will have no significant adverse impact on water quality and that the energy generated will be used by the facility by direct consumption or other means to benefit the operation of the public water system.[2]

The change in use and sale or lease of watershed land for either limited residential development or solar PV or wind-based energy systems, presents a high degree of difficulty and requires a coordinated a technical, legal and political campaign to successfully navigate the permitting and approval processes and could take several years. The difficulty increases for a water-based solar array within Nagog Pond in the inlet near the current intake structure and upstream from the dam, not only because of the uniqueness of the concept,

[2] Lessons can be learned by consulting with the Wareham Fire District, which solicited private development proposals from solar energy developers to design, permit, build and operate a PV system within the Zone 1 to public water supply wells on Town-owned land under a 20-year lease.

but also because Nagog Pond is a listed Great Pond subject to Massachusetts Chapter 91 waterways licensing for what would likely be deemed a non-water dependent use. On the other hand, a small-scale, land-based PV system to serve an upgraded pumping and treatment facility will take less watershed land and require less clearing of trees.

Concord could argue that the larger PV system is not a true change in use, only in degree because the land will still be used for water supply purposes. There will still be passive protections and the energy is for water supply facilities. Meanwhile, any sale of parcels for single-family homes should include covenants and easements to protect watershed land and water quality (e.g., Low Impact Development for stormwater, Best Management Practices, enhanced septic systems, limits on recreation, etc.).

2.3 Zoning

The Concord-owned watershed parcels in Acton and Littleton are zoned residential and are subject to the specific zoning provisions for such use in each of these towns, including limitations on lot size, setbacks and frontage. The zoning regulations of both towns prohibit power generation in residential districts although, as discussed below, state law prohibits the outright prohibition of electric power generation by solar arrays. Constraints on the use of watershed lands for residential development and solar power generation are reviewed below.

2.3.1 Residential Zoning – Acton and Littleton

All of the Concord-owned watershed lands in the towns of Acton and Littleton are zoned "residential." More specifically, Littleton has only one residential zoning classification ("R"), with a base requirement that a lot be of a minimum 40,000 square-feet (0.9 acres). Meanwhile, the Town of Acton has a number of residential classifications and, as called out in Table 1, have base requirements of a minimum of 80,000 ("R8") and 100,000 ("R 8/10") square feet (1.8 aces and 2.3 acres, respectively).

Standard lot dimensional requirements include a minimum of 150 feet of roadway frontage in Littleton, and 200 or 250 feet in Acton, although Acton allows for a 50-foot reduction in frontage if the lot size is doubled. Additionally, Acton allows hammerhead lots with 50–foot frontages in Zones R8 and R8/10, provided that the lot has a minimum size of 200,000 square feet, while Littleton allows such lots provided the lot has a minimum of 35 feet of frontage and 40,000 square feet of area not including the connecting strip. Finally, Acton also allows for Planned Conservation Residential Community (PCRC) developments, whereby greater density is allowed in order to preserve open space. PCRC developments must have a minimum size of 8 acres, 60 percent of the lot must be set aside as open space, and the percentage of wetlands in the open space must not be greater than that of the parcel as a whole. The total number of units within the PCRC cannot exceed one per 80,000 for the lot as a whole, including the open space. Littleton has similar "Open Space Development" zoning for lots of greater than 10 acres. The number of units allowed in

such developments is determined by subtracting the area of regulated wetlands from the total lot acreage, reducing that number by 15 percent and dividing by 40,000 square feet.

2.3.2 State Law Zoning Exemption for Solar Energy Systems

State law provides solar installations an exemption from unreasonable or prohibitive local zoning regulations. "No zoning by-law shall prohibit or unreasonably regulate the installation of solar energy systems or the building of structures that facilitate the collection of solar energy, except where necessary to protect the public health, safety or welfare" (G.L. c. 40A, § 3; Adopted by St. 1985, c. 637, § 2).

Although both Acton and Littleton zoning by-laws prohibit power generation in the residential districts where the Town of Concord property is located, under General Laws chapter 40A, Section 3 an outright prohibition of electric power generation by solar arrays is contrary to the state Zoning Act and unenforceable. Nonetheless, the Towns may impose reasonable regulations[3] on a solar installation based upon public health, safety and welfare considerations, including a requirement to obtain a special permit from the local special permit granting authority.

2.3.3 Solar Energy System Zoning - Town of Littleton

A solar installation may be constructed and operated on the residentially zoned property in Littleton subject to the following.[4] Article XXVI of the Littleton Zoning Code, § 173-181 provides that "*construction and use of a commercial solar photovoltaic installation or any part thereof shall be permitted in any zoning district subject to the requirements set forth in this section*." Section 173-2 of the Littleton Code defines "*commercial solar photovoltaic installation*" as "*a solar photovoltaic system that is mounted on the ground, roof, or structure; and generates electric power onto the Littleton Electric Light Department's (LELD) distribution system for sale to LELD or others*." Note that the definition does not turn on the ownership of the solar array by a "commercial" entity and should be available to the Town of Concord. The condition for sale into the LELD system seems very questionable as a matter of zoning law, but may be practically applicable if the plan is to distribute the resulting electrical power into the local electrical distribution system.

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[3] There is no case law under G.L. c. 40A, § 3 discussing the limits of reasonable regulation of solar arrays. But there is case law under the analogous exemptions for agricultural, educational, and religious uses also found in G.L. c. 40A, § 3. Under the agricultural exemption, the Court has ruled that "regulation must bear a reasonably direct relation to significant considerations of public health, morals, safety and welfare based on findings justified by substantial evidence. *Cumberland Farms of Conn, Inc. v. Bd. Of Appeal of N. Attleborough,* 359 Mass. 68, 74-57 (1971). There is ample case law discussing limits on the degree to which towns can regulate protected uses that will support a conclusion that an outright prohibition is not enforceable.

[4] Clearly § 173-181 overrides the Use Regulations Schedule at § 173-26 that prohibits "commercial power generation" and "public utilities" in a residential zone.

Any commercial solar photovoltaic installation must obtain a special permit and site plan approval from the Littleton Planning Board. Of the special permit requirements and review criteria the most salient is that the lot must be at least three acres in size. Also relevant is the requirement that the installation must meet the requirement of the Littleton Electric Light Department "Qualifying Facility Power Purchase Rate" and "Standards for Interconnecting Distributed Generation."

2.3.4 Solar Energy System Zoning - Town of Acton

A review of the Town of Acton zoning code suggests that a solar energy system could be defined as a principal or accessory use, depending upon the specifics of the application. These differences are reviewed below. Note that the Town of Acton April 2013 Town Meeting adopted prospective zoning changes that would specifically allow certain solar power facilities in residential zones. These changes are under review by the Massachusetts Office of the Attorney general and are summarized as appropriate in the following discussion.

Principal Use of Property for a Solar Installation. A solar installation can be built and operated in the residential zone in Acton subject to certain conditions. Although the Acton Zoning By-Law does not allow "public or private utility facilities" in the residential zoning district, the Table of Principal Uses at Section 3.1 of the By-Law indicates that "other public uses" are allowable by use special permit and site plan special permit in accordance with Section 10.4 from the Board of Selectmen.[5] Section 3.4.5 of the Acton Zoning By-Law defines "other public uses" as "use of land, buildings and structures for a public purpose, other than educational use, by any town or local agency, except the Town of Acton and the Water Supply District of Acton." Section 3.4.7 of the By-Law defines "public or private utility facilities" as "facilities, equipment, and structures necessary for conducting a service by a public service corporation." Regardless of whether or not the owner of the solar installation would be considered a "public service corporation," the outright prohibition of a solar installation under the By-Law's public private utility exclusion is not enforceable under G.L. c. 40A, § 3. Thus, it would appear that the proper interpretation is that a solar installation by the Concord DPW in Acton would properly be considered an "other public use" allowable by special permit to the extent that it will be "for a public purpose . . . by any town or local agency." Finally, the recently passed By-Law amendment would allow the installation of ground-mounted solar systems, subject to a special permit from the Planning Board. There is no size limit to such systems, but certain visual, landscaping and

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5 Footnote 5 to the Table of Principal Uses cautions that if the proposed USE will be located in the Floodway Fringe, as defined in Section 4.1, or Zones 1, 2 or 3 of the Groundwater Protection District, as defined in Section 4.3, before granting a special permit under this Section the applicant shall submit the information required under Sections 4.1 or 4.3 and the Board of Selectmen shall find that the proposed USE complies with the requirements of Sections 4.1.8.1 and 4.1.9, and 4.3.8 through 4.3.10 respectively. Section 4.7.13 of the Zoning By-Law lists construction, maintenance and repair of municipal and private water supply structures as an allowed use in the Floodway Fringe.

design conditions do apply. The most notable of these as regards solar PV at Nagog Pond is a one acre limit on deforestation associated with the solar facility.

Accessory Use. In addition to the above, it appears that Section 3.8 of the Acton Zoning By-Laws may allow a solar system as an "accessory use" on the same lot with the water supply principal use in the residential zoning district. However there is some ambiguity as to whether the solar system needs to be "private" to be allowed. Specifically that Section allows: "private garages or carports; solar systems; greenhouses; tool sheds; barns; swimming pools or tennis courts provided that such recreational facilities are used only by the residents and their guests." Assuming that the accessory use is not limited to a "private solar system," since the Concord DPW's operation of its water treatment facility is an allowed or allowable principal "other public use" in the residential district, a solar system that is accessory to the water treatment facility should be allowed on the same lot. Further analysis would need to be performed to determine if adjoining lots can be treated as "the same lot" for these purposes.

2.3.5 Floating Solar Energy System Zoning - Acton

As discussed in Section 3.1.3, the potential exists for developing a solar energy system array on or immediately above the surface of Nagog Pond. For the purpose of this study it has been assumed that any such array would be developed in the shallower waters of the cove at the western edge of the reservoir, near the existing ozone facility and somewhat removed from watersheet vistas of Route 2A/119 and portions of Nashoba Road and Nagog Hill Road. As such, the array would be located within the Town of Acton.

As far as use regulation under the Acton Zoning By-Law is concerned, a floating solar array on Nagog Pond should be subject to the same residential zoning use permitting requirements described above as a land based system. The part of Nagog Pond within Acton proposed for use as a possible floating solar array should be considered to be zoned residential. (It is beyond this memorandum to ascertain ownership rights in Nagog Pond itself or the air space above the Pond, except to point out that the Pond is listed by MassDEP as a "Great Pond" and as such would be deemed to be owned by the Commonwealth, not the littoral owners.) Under § 2.3.1 of the Acton Zoning By-Law, "zoning district boundaries which follow water courses shall be deemed to follow the mean center line thereof." There is no other provision in the Acton Zoning By-Law that describes the boundary of a zoning district that bounds a pond. Although strictly speaking Nagog Pond is not a "water course," it is a body of water and does appear to have a center line (the Acton/Littleton Town line) which would likely be considered the boundary of the residential zoning district.

Finally, the proposed By-Law changes connote the intention to allow not only the "roof-, wall-, ground-, and pole-mounted installations, and canopy installations over parking lots," but also perhaps even floating accessory solar systems. Meanwhile, the proposed use By-

Law change connotes an intent to limit principal solar systems to those that are "structurally mounted to the ground in any manner."

2.4 Summary - Alternative Land Use Regulatory Considerations

In regards to federal, state and local wetland, water quality and waterway regulations, it can be presumed that no energy systems or residential development work would be allowed within vegetated wetland resource areas, and the buffer zones of such resource areas should be avoided. Wetland crossings to isolated upland areas may be allowed upon demonstration that no alternative access is available. Meanwhile, in water PV arrays and wind turbines may be allowed in water as piles are not deemed fill, although an alternatives analysis would likely be required under both state and federal statute. Subsequent in water would undoubtedly require both pre- and post-construction alter and/or sediment quality monitoring. Given both the state and local attitudes against tree clearing for energy systems, the results of an alternatives analysis may well favor in-water sites. Finally, silviculture within wetlands may be allowed, but only under strict conditions that require the work be conducted by cranes established beyond the resource limits. The lack of an existing forestry program or plan precludes the use of the forestry exemption in the MA Wetlands Protection Act and local Bylaws, although the crossing of wetlands to reach upland areas for forestry purposes would likely be allowed as a "limited project."

Local zoning regulations allow residential development in all Concord-owned watershed lands. Similarly, alternative energy systems, including those on the water, are allowed, but only through special permits, with conditions likely. As part of a recent Bylaw change the Town of Acton allows tree clearing of up to an acre for such systems. It is not known at this time what, if any, process the Town will offer for larger tree-clearing efforts associated with alternative energy systems. Current state law exempts solar energy systems from local zoning that prohibits or unreasonably regulates the installation of solar energy systems.

The change in use and sale or lease of watershed land for either limited residential development or alternative energy systems, presents a high degree of difficulty and requires a coordinated a technical, legal and political campaign to successfully navigate the permitting and approval processes. Given the EEA review process under Article 97, this could take several years. The difficulty increases for a water-based solar array within Nagog Pond, not only because of the uniqueness of the concept, but also because Nagog Pond is a listed Great Pond subject to Massachusetts Chapter 91 waterways licensing for what would likely be deemed a nonwater-dependent use. On the other hand, a small-scale, water-based PV system to serve an upgraded pumping and treatment facility has the desired benefit of requiring less watershed land and thereby less clearing of trees.

The Town of Concord could argue reasonably that the larger PV system is not a true change in use, in that the land will still be used for water supply and water quality purposes. There would still be passive protections while the energy generated would be for water supply facilities. Meanwhile, any sale of parcels for single-family homes would and should

undoubtedly include covenants and easements to protect watershed land and water quality (e.g., Low Impact Development for stormwater, Best Management Practices, enhanced septic systems, limits on recreation, etc.).

3.0 RENEWABLE ENERGY AND ALTERNATIVE LAND USE FEASIBILITY

The following sections present an analysis of the potential for alternate use of the Nagog Pond watershed lands for the purpose of generating revenue to advance the use of Nagog Pond as a public water source, with particular consideration given to renewal energy systems, but also with consideration of the conduct of systematic silviculture and of the potential sale of watershed lands for residential development.

3.1 Solar Energy Generation

Massachusetts government policy is currently strongly supportive of public and private entities developing projects comprised of, or including, photovoltaic (PV) panels to produce electricity from sunlight. This is reflected in such actions as the passage of state law exempting solar energy systems from local zoning as discussed in Section 2.3.2, above, to the creation of tax incentives in support of solar energy projects as discussed in Section 3.1.6, below. The following sections review the potential for the development of solar energy systems on the Town-owned lands of the Nagog Pond watershed, summarize the technical and financial assumptions around these potential opportunities, and conclude with a financial analysis of the various options deemed feasible (Section 3.1.9).

3.1.1 General Description and Logistics

Although there are various solar energy technologies, the typical arrangement for such projects in New England is an array of flat PV panels set at a fixed 20 to 30 degree angle above the horizontal, facing south to south-southwest and arranged in rows. Panels are electrically interconnected to one or more inverters and ancillary electrical monitoring and switching equipment, and ultimately connected to the commercial electrical grid at distribution voltage.

Whereas a PV system could be connected directly to the high voltage transmission system via a tap or substation, and thus by-pass any local distribution system constraints, there is no such transmission connection proximate to the site. Indeed, as shown in Figure 6, *Nagog Pond Watershed – Transmission Line Map*, the nearest high voltage transmission line is located almost four miles north of the watershed. Also, the cost for the high voltage transformer necessary for such a connection can be prohibitive for smaller projects. Therefore, this study assumes any solar installation would only connect to the local electrical distribution system.

The installation of PV arrays generally does not require significant excavation, other than grading. Either shallow footings or driven steel "hooks" are used to immobilize the framework of each panel row or segment against wind and snow load. The ground surface is then covered either by filter fabric and crushed stone or, in some cases, is seeded with slow-growing grasses. Thus, soil permeability for the recharge of stormwater runoff is maintained close to natural conditions. Runoff control in the form of stormwater retention

basins or swales may be required, but typically more so for construction runoff control than operational control.

PV arrays are passive and make no noise. Maintenance activities are typically limited to periodic inspection and occasional cleaning. The panels are unlikely to release any contaminants, and cleaning of the panels can be accomplished with water. Meanwhile, the electrical equipment, which is comprised of inverters and monitoring and metering equipment makes some minor noise (buzzing similar to a transformer), and contains oils. However, this equipment is contained within one or more small buildings that can be located so as to minimize or essentially eliminate any potential impact. Perimeter fencing and monitoring is typically provided for security purposes.

3.1.2 Nagog Pond PV Site Screening Considerations

As noted above, the typical PV siting arrangement is an array of flat PV panels fixed at 20 to 30 degrees in rows facing south to southwest. Optimum construction cost efficiency is obtained by a square or rectangular array. However, collector rows can also be grouped in multiple smaller areas or arranged to fit the contours of an irregular area as needed without significant increases in cost. Arrays can be constructed on sloping land provided southern exposure is maintained. Panels can even be placed on the northern side of a hill if the slope is shallow so that the hill itself does not significantly shadow the array. Thus PV array siting can be easily adapted to the characteristics of the available property. Nominally, 4 to 6 acres of flat or nearly flat terrain can accommodate enough panels to comprise a 1,000 kW array.

In assessing the Town-owned watershed parcels for PV arrays a number of factors were taken into consideration. Of particular concern was the presence of wetland resource areas, particularly in consideration of the fact that all of the major wetland resource areas identified on Town-owned watershed lands have a direct hydrologic connected to Nagog Pond, or are associated with the Pond proper (i.e. Banks, Land Under Water). As discussed in Section 2.1.2, under the Wetlands Protection Act (and the Bylaws of the towns of Acton and Littleton), work within 100 feet of a wetland must be shown not to impact the functions of that wetland, including the regulatory presumption of the protection of water quality. In addition, the Town of Acton Bylaw has a minimum 75-foot wetland setback requirement for all structures. In consideration of all of these factors, as well as in recognition that some wetland crossings may be inevitable, the site screening conducted for this assessment assumed a 100-foot setback from currently identified wetlands, including the banks of Nagog Pond.

In addition to wetland setbacks, the site screening analysis assumed a 50-foot undisturbed vegetated buffer zone between the developed site and residential properties, and along public streets, to minimize visual impacts on the community. This limited setback was deemed adequate as PV arrays are not tall structures, panel tops are generally 10 to 14 feet

above grade, and ancillary electrical building(s) are very small. Therefore, large evergreen shrubs can provide an effective visual screen.

The above screening identified approximately 40.4 acres of watershed lands potentially suitable for PV array development, with individual sites ranging in size from a third of an acre to almost 15 acres. In addition, a potential 3-acre site was identified in the shallow waters of Nagog Pond near the ozone facility intake structure and the dam. This site was identified based on the assumption the generalized screening criteria that the water depths be no more than 10 feet, and that the site be isolated from public viewsheds. These sites are shown on Figure 7, *Nagog Pond Watershed – Possible PV Solar Sites (with Acreage)*.

Finally, shading can significantly reduce the amount of energy produced by a solar PV system, even when only affecting a portion of the array. An estimate of shaded area was made for each of the potential sites identified above and shown on Figure 7 based on estimated height of nearby vegetation, and shadow length based on sun position at 3:00 PM on the winter solstice (December 21). Assuming a tree height of 30 feet (many trees are white pine which grow higher than 30 feet), the analysis indicated that shadows would be cast for a distance of about 130 feet to the northeast. The resulting reduction in potential PV array acreage is shown on Figure 8*, Nagog Pond Watershed – Possible PV Solar Sites (with Acreage) after Estimated Shadows on December 21 at 3:00 PM*.

To make a viable solar project on any of the identified sites, the entirety of the associated area shown on Figure 7 would need to be cleared. That would allow panels to be placed in the areas shown in Figure 8 without being impacted by excessive shading.

In addition to the above, site grading can affect the available area for panels facing the sun, as well as site constructability, as standard PV panel footings require flat terrain. In the subsequent financial analysis, each potential site is reviewed and an adjustment is made to the usable area based on the slope towards or away from the south/southwest.

3.1.3 On-Water PV Array Case Study

The Town of Concord requested that the feasibility of placing a solar PV array on or immediately above the waters of Nagog Pond be included in the solar energy feasibility study presented herein. Toward this end, Epsilon contacted Bob Biehler, a Senior Project Manager at NJ American Water who was in charge of overseeing the construction of a floating panel effort at the Canoe Brook Water Treatment Plant in Millburn, New Jersey. The identification of the three acre site in the shallow waters of Nagog Pond discussed above was guided, in part, by this conversation. A review of the conversation with Mr. Biehler is presented herein for the purpose of insight to the relatively uncommon practice of placing solar arrays in or over water.

The Canoe Brook Water Treatment Plant is thus far the only location in the Northeast where a floating solar array has been installed in an environment exposed to freezing and thawing.

Mr. Biehler indicated that the system is relatively small and is located on, or over, approximately one-quarter of an acre of the adjacent reservoir. It has a low-profile, with the system only about 8 feet above the water. The panels are mounted on a soloflex anchoring system, which holds the array in place, but allows it to rise and fall with the water level. Mr. Biehler indicated that driving piles would have been much cheaper than the anchoring system that was ultimately used, but that anchors were utilized rather than piles in order to avoid puncturing the bottom of the reservoir and in consideration of the site's proximity to the reservoir dam and the potential for creating seepage.

The floating solar array at the Canoe Brook Water Treatment Plant provides 112 kW of power, which is approximately two percent of the power needed for the treatment plant. Mr. Biehler indicated that NJ American Water is considering expanding the system, but noted that the modular-system of the arrays is an expensive system, and that the anticipated payback period was on the order of about 7 years, even with the assistance of a variety of grants.

In regards to freeze-thaw, Mr. Biehler noted that the reservoir did not freeze during the winter of 2011/2012, but did freeze a few inches thick this year and the system performed as expected. He indicated the system is very rugged and is a pontoon system developed in Canada which contains foam encapsulated in HDPE. Similarly, there has not been an issue with cleaning the panels, as either rain washes the panels (into the reservoir) or maintenance cleans the panels with a squeegee. Mr. Biehler noted that in one area birds use the array as a perch for fishing, which he deemed to be a minor issue, but that raises the question as to attracting water fowl to the water body and the associated water quality issues.

He also indicated that the size of the system (one-quarter acre on a 200 acre reservoir) does not appear large enough to effect water quality in a positive way and no reduction in algal growth has been observed. It is his thought that with a larger system there might be a reduction in algal growth in the reservoir.

Mr. Biehler indicated that, as a floating system that did not require pile driving, permitting at the local level was relatively easy. A waiver from the New Jersey land use regulations was originally required because the reservoir was classified under New Jersey regulations as an open water of the state (even though this particular reservoir is not connected to any streams, and is man-made). It is Mr. Biehler's belief that these were important considerations in the system ultimately being granted a waiver from the above land-use permit.

3.1.4 PV Performance

Current commercial solar energy technology is comprised of PV panels that produce approximately 11 Watts per square foot of collector, although PV technology is improving and modest improvements in collector efficiency can reasonably be anticipated in the near

future. Thin film technology is cheaper per square foot, but less efficient and has only recently begun to see wide application in projects where land is plentiful and inexpensive. At this time, based on other utility scale projects in the region, a typical utility-scale PV development generates approximately 200 kW of rated DC capacity per acre, excluding site access and electrical interconnection rights-of-way. This 200 kW/acre average value assumes certain space for access between panel rows, circumferential access roads, stormwater runoff controls and ancillary electrical equipment.

Panel ratings are peak DC at a reference temperature. When inverter efficiency, seasonal temperature variation, layout and orientation of the panels, and meteorology (solar radiation) conditions are taken into consideration for the Nagog Pond sites, each one MW of rated capacity can be expected to yield approximately 1123 MWh/yr of delivered alternating current (AC) energy, which as a 12.8% capacity factor. This yield is calculated using PVWatts, a program developed by the National Renewable Energy Laboratory that simulates the power generation each hour of the year based on historical weather data. The PVWatts analysis for the Nagog Pond sites is presented in Attachment D.

As discussed above, it is assumed that a PV facility at Nagog Pond would feed into the grid at distribution voltage. The size of the PV facility would be limited by the capacity of the distribution system, which is commonly in the 5 MW range. PV facilities being constructed by the large investor-owned utilities and by municipalities through developers range between about 0.5 and 5 MW. The higher end of this range may not be achievable without expensive distribution system upgrades.

3.1.5 PV Costs

PV equipment costs have been declining in recent years as global production has increased and as manufacturing economies of scale are being achieved. Improvements in the technology of manufacturing have also helped to drive costs down. Whereas costs were being generally quoted in the $6,000 to 8,000 per kW range as little as four years ago, recent utility-scale PV projects in Massachusetts have been reported to cost in the close vicinity of $4,000 per kW. This corresponds reasonably well with an estimated U.S. average installed cost of $3,750 per kW in second quarter of 2011.[6]

For the purpose of analyzing the financial feasibility of generating solar PV energy at the Nagog Pond watershed sites identified in Section 3.1.2 (as well as for an on-water site, and treatment plant roofs and parking areas) a base installed capital cost of $4,000 per kW is deemed reasonable, modified by the following:

[6] Best Practices for Siting Solar Photovoltaics on Municipal Solid Waste Landfills, EPA/ NREL/TP-7A30-52615, February 2013.

- $250/kW interconnection cost, including application fees and upgrade costs. As discussed in Section 3.1.7, these costs can vary widely depending on the current system loads.
- 1.5X multiplier for roof-based PV panels, and for the on-pond potential site, to account for additional construction complexity.
- 3X multiplier for solar canopies (e.g. above parking spaces).
- $5000/acre additional land clearing cost for forested land.
- $25/square foot dock and/or pier cost for the on-pond potential site.[7]
- $100,000/project estimate of permitting costs associated with zoning and land use issues.
- $100,000/project estimate of permitting costs associated with wetland and Chapter 91 issues.

3.1.6 Solar Energy Incentives

Much of Massachusetts solar development has been spurred by tax incentives and grant programs (some of which are now defunct) designed to bootstrap the PV industry in the state. The most important current incentive programs are the Solar Renewable Energy Certificates (SRECs) program, the federal tax incentives, and the state tax incentives.

Solar Renewable Energy Certificates (SRECs). The Department of Energy Resources (DOER) has developed, and is implementing, a solar set-aside within its Renewable Portfolio Standards. A PV generator acquires SRECs, one for each MWh generated, and these SRECs are a marketable commodity. Specifically, there are approximately 25 regulated load-serving entities that are required to obtain 3% of peak load from PV generation (1% from private and 2% from municipal sources), which they do by buying SRECs. As discussed below, the program rules set a high market value on SREGs. Essentially, the program encourages the development of PV projects by providing an income stream that allows project financing to be obtained.

Solar power generation has been implemented quickly in Massachusetts, and the long-term availability of SRECs is uncertain. On May 1, 2013, the Patrick administration announced[8]

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[7] The dock cost and complexity multiplier correspond to a base installed capital cost for an on-water system of $11,450/kW, which corresponds reasonably well to the vendor-quoted average US installation cost of $10,000/kW from SPG Solar

[8] http://www.mass.gov/governor/pressoffice/pressreleases/2013/0501-solar-power-goal-reached.html, accessed 5/14/2013

that Massachusetts had reached its goal of 250 MW installed solar capacity four years early, and that:

> *"The Commonwealth's Renewable Portfolio Standard (RPS) Solar Carve-Out program has established a strong solar energy market in Massachusetts, with a current cap of 400 MW. As that target approaches, state energy officials are fast-tracking revisions to expand the program."*

As summarized by the U.S. Department of Energy's Database of State Incentives for Renewables & Efficiency[9], SRECs have an auction minimum price of $285/MWh, and a cap price that is currently $550/MWh but which is scheduled to shrink to $365/MWh by year 2021.

Utilities (including NSTAR[10]) have issued RFPs for contracts to purchase SRECs. The SRECs can also be sold on the spot market. Finally, a qualifying project is eligible to access the auction provisions (i.e., to obtain at least the auction minimum price of $285/MWh) for 10 years after operation commences.

Based on informal discussions with solar developers, SRECs are commonly purchased through long-term contracts below the minimum auction price. This is because, counting projects in development, the SREC market is fully subscribed. Current contracted prices are about $220/MWh. Per their website[11], "DOER is now actively engaged in developing policy to maintain the growth of the solar PV market in Massachusetts after the 400 MW cap of the current RPS Solar Carve-Out is reached." Epsilon has very recently received reports[12] that the 400 MW cap has been reached, and new projects will not be eligible for the current SREC program. DOER plans to announce its proposals for a new solar program on June 7, 2013.

The financial analysis presented in Section 3.1.9 assumes the projects identified qualify for SRECs, and that the SRECs generated by the project sell at the floor price of $285/MWh. The analysis allows for the input of a long-term contract price and term in the spreadsheet. Using a contract price of $220/MWh increases the payback time.

Tax Incentives. Broadly, the federal tax credit is 30 percent for solar PV and other renewable projects. Additional requirements (such as efficiency standards) apply. Federal incentives also include accelerated capital depreciation (5-year per Modified Accelerated Cost Recovery System (MACRS)).

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9 http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=MA98F, accessed 5/14/2013
10 http://www.nstar.com/business/energy_supplier/supply_renewable_contracts.asp, accessed 5/14/2013
11 http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/solar/rps-solar-carve-out/post-400-mw-solar-policy-development.html, accessed 5/21/2013
12 http://www.daypitney.com/news/newsDetail.aspx?pkid=4689, accessed 5/30/2013

There is a Massachusetts excise tax deduction on tangible property. Although municipalities cannot utilize most or all of the various incentives, it is possible for the municipality to contract with a third party to develop, own and operate the PV array and provide a long-term Power Purchase Agreement (PPA) to the municipality for electricity from the facility at favorable rates. The developer is able to utilize tax incentives and the SRECs and to provide electricity at, typically, below-market rates under a long-term (15 to 20 year) contract. In addition, the developer takes on all risks of the marketplace.

While having the Town of Concord DPW own the PV project would negate the value of tax incentives, per Section 3.1.8 below municipalities get a better net-metering deal for projects sized between 1,000 and 2,000 kW. As there may be advantages to that arrangement, financial performance is evaluated based on DPW ownership and based on third party ownership.

Based on informal discussions with solar developers, it can be challenging to arrange an ownership structure that takes full advantage of the tax credits and accelerated depreciation associated with PV projects.

3.1.7 Interconnections

The process for interconnecting a renewable energy system with NSTAR varies based on the size of the proposed system. Simplified application processes exist for small systems (25 kW or less) using a listed invertor (UL 1741).

For proposed projects greater than 15 kW but less than 2000 kW for single-phase invertors, and greater than 25 kW but less than 2000 kW for three-phase invertors, completing an Expedited/Standard Process Form is the first step in the application process. The application includes the general contact information, facility information, technical details of the generating units at the facility, and technical details about the interconnection equipment. In addition, the application must include a one-line diagram stamped by a Massachusetts professional engineer, site documentation the describes and details the operation of the protection and control schemes, and schematic drawings for all protection and control circuits, along with a site diagram that identifies the physical location of the facility.

Upon receipt, NSTAR will initiate review of the application on an expedited application schedule. This involves notifying the applicant of receipt within 3 business days, and reviewing the application for completeness within 10 business days. NSTAR will complete the screening review within 25 business days. If the application passes the screening review the applicant is sent an executable agreement within 10 business days. If NSTAR determines a supplemental review is needed it will follow the "standard" application time frame which would add an additional 90 business days to the review process. During this time period NSTAR will execute an Impact Study Agreement which provides a cost estimate for a more detailed study which would identify the system modification costs to accommodate the proposed renewable energy system.

Both the expedited and standard application schedules require the applicant to send a certificate of completion to NSTAR which is signed by the local building/electrical code inspector. The fee for interconnection for applicants qualifying for expedited review is $4.50/kW application fee (minimum of $300 and maximum of $7500) plus $150/hour up to 30 hours for Supplemental Review (if necessary). The fee for the standard application process is the same as the expedited process, plus the cost of any impact or feasibility studies that may be required.[13]

For projects larger than 500 kW the first step in the application process is to request and receive a pre-application report from NSTAR before submitting an application, there is no fee for this report.[14]

Littleton Electric and Light Department has an application process very similar to NSTAR for reviewing interconnection requests for renewable energy installations. In general the application review timelines and associated fees are similar to NSTAR.[15]

For either utility, the costs associated with interconnection will be very dependent on the available capacity in the circuits serving the area. If there is existing capacity, the interconnection can be inexpensive. If new circuits need to be brought into the area, the interconnection can by very costly.

3.1.8 Net Metering / Power Purchase Agreement

Both NSTAR and Littleton Electric and Light Department have net metering provisions based on the Commonwealth's model rule. Projects less than 500 kW are eligible for net metering, projects over 2,000 kW are not eligible for net metering, and projects in-between are eligible if they meet certain constraints. Both utilities exclude the delivery charges for non-municipal customers generating over 1,000 kW. The financial analysis in Section 3.1.9 assumes that a third-party owner would not get credit for delivery charges for projects over 1,000 kW.

It is not clear whether either utility allows net metering if the PV project's capacity exceeds the host load at the site. EPG estimates an electrical usage of approximately 40,000 kWh per month. A solar PV system larger than about 400 kW would exceed that host load on a monthly average basis.

If net metering is not available, the project would need a Power Purchase Agreement (PPA) with the utility. The utility would then purchase power at wholesale rather than retail rates.

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13 Application materials for the expedited or standard application process is available at the following website: http://www.nstar.com/business/rates_tariffs/interconnections/expedited.asp

14 The request for a pre-application report is available here: http://www.nstar.com/business/rates_tariffs/interconnections/preapplication.asp

15 The Littleton Electric and Light interconnection and application requirements are available here: http://www.lelwd.com/file-upload/forms-and-reports/LELD_Interconnection_Standards4.PDF

Details for net metering and PPA provisions must be worked out through contact with NSTAR or Littleton Electric and Light Department. Since each of the identified potential sites in the Nagog Pond watershed has capacity less than 2MW rated DC, the sites are assumed to supply electricity through a net metering arrangement.

3.1.9 Solar: Financial Analysis and Results

The sizing and capital cost for each of the identified potential PV sites on Town-owned watershed lands (including over the water, on the treatment plant, or over the treatment plant parking area) have been calculated based on the assumptions discussed above and are presented in Attachment E, Solar PV Analysis Template. The financial analysis summary presented in Attachment E uses Mass DOER's "Solar Photovoltaic Project Simple Financial Model, RPS Solar Carve-Out Program v1.0."

With the assumptions discussed above, the best simple payback period for Solar PV within the Town-owned portions of the watershed is 6 to 7 years and is applicable to all of the land-based sites shown on Figures 7 and 8, with the exception of Location "F". All of these scenarios ("A" through "E", and "G") assume a project smaller than 1,000 kW owned by a third party who can take advantage of tax incentives. Note that these are not conservative estimates; the payback period could be longer if (1) net metering is not fully available, (2) the third party owner cannot take full advantage of tax incentives, (3) SRECs are purchased below the auction minimum price, (4) development costs are higher than estimated, or (5) interconnect costs are higher than estimated.

In contrast to the third party-owned projects, DPW-owned projects at these same land-based locations are indicated as having payback periods on the order of 9 to 10 years ("A", "B", "C", "E", and "G"), 13 years ("D"), and >25 years ("F").

The analysis in Attachment E indicates that the placement of a solar PV array on the roof of the treatment plant would have a simple payback period on the order of 8 years for a third party-owned array, and 17 years for a DPW-owned array. Meanwhile, the simple payback period for arrays on/over the waters of Nagog Pond, or mounted above the parking lot of the treatment facility, would be on the order of 19 to 21 years for a third party-owned array, and would exceed 25 years for a DPW-owned array. These costs reflect the high construction costs of these options relative to the power generated.

Ultimately, the analysis suggests that sites "A", "B", "C", "E", and "G" have similar payback periods, installed costs ($/kWh), and total kWh generation potential and would be the principal sites for any further feasibility investigations.

In addition to the hard copy summary presented in Attachment E, Epsilon is providing the financial analysis as a live Excel spreadsheet. Assumptions can be adjusted to refine this analysis or to test the sensitivity of the calculations to the assumptions. Also, the DOER financial model can be updated to reflect project financing options and to reflect new solar

incentives (to replace the SREC program) once those incentives are announced by DOER. Given that the status of Massachusetts solar incentives is in-transition, Epsilon recommends using the Excel spreadsheet to evaluate the financial performance after the new incentives are in-place.

3.2 Wind

The following sections review the potential for the development of wind energy systems on the Town-owned lands of the Nagog Pond watershed utilizing existing evaluation methods and in consideration of available funding sources. A financial analysis of potential wind energy development is presented utilizing base data from the solar analysis present above. As noted below, the

3.2.1 Wind: Regional Site Assessment and Available Funding

The Massachusetts Clean Energy Center (MassCEC) currently supports incentive programs for small wind, community wind and commercial wind projects, as described in the MassCEC Commonwealth Wind Incentive Program manual and the MassCEC Step-By-Step Guide to the Commonwealth Wind Incentive Program: Micro Scale Wind.[16,17] These project categories are defined as:

- **Small Wind:** A wind project that utilizes wind turbines less than 100 kilowatts (kW).
- **Community Wind:** A wind project that utilizes one or more wind turbines greater than 100 kW that meets one of the following criteria: Serves a load located on the project site, will have a net metering agreement with the utility company or serves the load requirements of a host municipal light department.
- **Commercial Wind:** A wind project with a generating capacity of 2 MW or greater, that serves the ISO-New England wholesale electricity market or municipal light plant system, or has an on-site load that does not qualify for net metering.

Community Wind and Commercial Wind grants are available for early stage funding opportunities aimed at investigating and evaluating the viability of a proposed project. However, the grant application process requires that the applicant demonstrate that wind speeds at the selected site are at least 6.0 meters per second (m/s) at a height of 70 meters, based on the MassGIS Wind Energy Site Screening Tool.[18] Based on the use of that

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[16] Commonwealth Wind Program Manual for Community and Commercial Wind Projects. Accessed on April 26, 2013 (http://www.masscec.com/index.cfm/page/Commonwealth-Wind-Site-Assessment-Offerings/cdid/14289/pid/11161)

[17] MassCEC Step-By-Step Guide to the Commonwealth Wind Incentive Program: Micro Scale Wind. Accessed on April 29th, 2013 (http://www.masscec.com/masscec/file/CW-1207-SmallWindStepByStepGuide.pdf)

[18] The screening tool is available at http://maps.massgis.state.ma.us/wind

screening tool, the Nagog Pond location has predicted wind speeds below the 6.0 m/s threshold at a height of 70 meters. The site would therefore not be eligible to apply for funding from MassCEC for this project.

Figure 9, *Average Wind Speeds Across Massachusetts*, shows average wind speeds across Massachusetts as determined by AWS Truepower in association with the National Renewable Energy Laboratory, and can be used to roughly identify locations where a Community Wind or Commercial Wind project is potentially viable.[19] As can been seen, the Acton/Littleton area averages 5.0 to 5.5 m/s at a height of 80 meters, making this area unlikely to meet the MassCEC viability criteria for a Community or Commercial Wind project.

Although early stage funding for large wind projects is not available through the MassCEC, the MassCEC tools can still be used to evaluate whether a small wind project might be attractive at this location. The MassCEC Commonwealth Wind Evaluation and Siting Tool (CWEST) provides "an approximation of wind resources in Massachusetts." The output from CWEST indicates that the Nagog Pond location would have a minimum average annual wind speed of 4.6 m/s at 30 meters, absent interference from any structures. The CWEST documentation says "*A minimum annual average wind speed of 4.5 to 5 meters/second at hub height is generally needed to support a well-performing system.*"[20] Available wind resources therefore appear to be at or near the minimum needed to support a small wind project.

3.2.2 Wind: Local Site Assessment

Wind energy development around Nagog Pond is constrained by both the limited regional wind resources and the physical location of the available Town-owned watershed properties.

Like any area within or adjacent to open unobstructed space, the conditions around the shoreline of Nagog Pond appear windy. However, as noted above, available wind resources are considerably below the minimum warranted to receive support from MassCEC for community or commercial wind energy projects (i.e. greater than 100 kWh), and are at or near the minimum needed to warrant support for a small wind project (less than 100 kWh). In addition the Pond is surrounded by hills with elevations up to 40 meters above the shoreline elevation of 70 meters (NAVD88). MassCEC guidelines suggest that wind turbines be mounted at least 10 meters above any obstruction within 175 meters (500 feet), thereby suggesting a minimum turbine height on the order of 50 meters.

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[19] Locations identified by MassCEC as viable locations are locations where average wind speeds are 6.0 m/s or greater at a height of 70 meters.

[20] CWEST User's Guide, May 16, 2011, Page 3.

There are no set standards for setbacks to wind turbines for safety, noise or aesthetic purposes. That said, typical guidelines include a protective radius of one and one-half times the combined hub and blade height to account for "blade throw." For a small wind turbine this may be on the order of 300 to 500 feet. As regards noise mitigation, while utility scale wind turbines may require 1,200-foot or more setbacks for noise abatement, small wind generators are generally quieter and setbacks on the order of 500 feet may be more than adequate. This can be highly dependent upon the local land use and, in particular, proximity to residences. Finally, aesthetic effects are similarly site specific and often ambiguous. By definition, the turbine should extend above the surrounding skyline so as to maximize wind capture.

An analysis of potential land-based wind turbine sites on Town-owned watershed lands was conducted based on the principals that any such site should lie 100 feet from any wetland resource areas, and 500 feet from any property line (the latter setback may be conservative for the Town-owned watershed properties abutting Town of Acton conservation lands and Acton Water District lands on the south side of the Pond, but these parcels are generally so narrow as to be eliminated by setbacks of as little as 300 feet). Utilizing these setbacks limits land-based wind turbine sites to three locations. These are identified as locations SW-1, SW-2, and SW-3 on Figure 10, *Nagog Pond Watershed – Potential "Small Wind" Turbine Sites* and correspond to Parcels "G", "E", "A" of the possible PV solar sites of Figure 7. Conceivably, an in-water site would be deemed feasible, but like the in-water site for solar panels would likely add considerable expense, both from construction and approval processes.

3.2.3 Financial Analysis

A comparison of an approximately 100 kW "small wind" turbine to the solar PV potential sites shows the following:

- Installed capacity cost is approximately the same. The industry nonprofit group Windustry estimates: "Wind turbines under 100 kilowatts cost roughly $3,000 to $8,000 per kilowatt of capacity.[21]"
- A wind turbine would have a much smaller footprint, with less change to the land use near the pond.
- A wind turbine would be visible from more neighboring sites than a solar array and potential noise impacts would need to be added into consideration.
- A wind turbine would likely have a higher capacity factor (~20% versus 12.8%) and therefore generate more electricity for the same installed capacity.

[21] http://www.windustry.org/resources/how-much-do-wind-turbines-cost, accessed 5/15/2013

- The interconnection logistics and net metering rules are the same.
- Wind energy has less generous price supports. Massachusetts Renewable Energy Credits (RECs) have varied widely in price, from $51/MWh in January 2008 down to $13/MWh in September 2010 back up to $59/MWh in May 2013[22]. MassCEC also provides rebates ($640/kW rebate for a qualifying 100kW project for a public host, $490/kW for a private host).

With an assumed $5,500/kW installed cost, assumed maintenance costs about the same as a PV system, and the other assumptions listed above, the payback period can be calculated using the same methodology as uses for solar PV in Section 3.1.9. The best simple payback period is 9 years. Again, the best payback is for a project owned by a third party who can take advantage of tax incentives.

3.3 Silviculture

In 2002, the Concord DPW commissioned a Forest Management Plan for the forestland surrounding Nagog Pond.[23] That plan described the forest as "typical of other forestland in the area, primarily oak and white pine forest types with associates of many other tree and shrub species." The report identified eleven separate forest types ranging in size from 2 to 25 acres and made recommendations for each. In regards to forestry practices, these recommendations ranged from leaving certain stands in their natural state to commercial thinning to promote healthier trees. The report also contained a number of forest area management recommendations regarding property maintenance, such as boundary demarcation, forestry road maintenance and public access maintenance.

Neither field inspections nor a review of current orthophotography revealed any significant changes in the forest character as described in the 2002 Forest Management Plan. That the report is eleven years old is notable in certain areas, such as the narrow stand along the northeastern end of Nashoba Road which was identified as "old field," but which is now dense enough to obstruct views along much of this section of the pond.

During the April 30, 2013 Project Workshop meeting, Concord DPW staff suggested the concept of selective thinning for forest health purposes, with a possible net gain from the sale of lumber. The 2002 Forest Management Plan contains the following specific recommendations consistent with the Concord DPW concept:

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[22] http://apps3.eere.energy.gov/greenpower/markets/certificates.shtml?page=5, accessed 5/15/2013

[23] Nagog Pond Area Forest Management Plan, 2002, prepared for the Town Of Concord Water Department, John Robbins, Consulting Forester, 59 Wilson Road Concord, MA, email correspondence 5/15/2013 Robbinsjohn5@aol.com

- 2-Acre Red Pine Stand: "In order to promote a healthier stand of trees, a commercial thinning of the trees should be considered. Red and white pines cut in this thinning could be sold for sawlogs so that there would be a net gain from this thinning project."

- 5-Acre White Pine - Red Pine/Birch Stand: "A light commercial thinning of portions of this stand that were not affected by the windstorm might be considered to promote the vigor of the healthiest trees."

- 7-Acre White Pine- Hardwood Stand: "Some light thinning of the planted trees might be considered, but only in areas of the stand at least 50' away from the pond edge."

The locations of these three stands are shown in Figure 11, *Nagog Pond Watershed – Wood Lot Stands Previously Recommended for Thinning*. Meanwhile, Figure 12, *Potential Silviculture Sites*, identifies those areas potentially available for active silviculture utilizing the setback criteria utilized for identifying potential PV sites as presented in Section 3.1.2; specifically, 100–foot setbacks from wetland resource areas and 50-foot setbacks from property lines. This would suggest a maximum area of slightly less than 40 acres available for more active forestry practices.

As regards commercial value, the 2002 Forest Management Plan suggested that "the sale of forest products from commercial thinning projects would at a minimum cover their costs." However, the report did not attempt to calculate the net value of the existing stand, nor did it explore implementing a more robust, sustainable commercial forestry operation on Town-owned watershed lands. As discussed at the Project Workshop, the value of partial clearing is currently on the order of $1,100 per acre, while that of clear-cutting may be on the order of approximately $2,200 an acre. Ultimately, there may be a one-time net revenue gain from the thinning program proposed, but it does not appear that such an approach would significantly enhance the future commercial value of the stand(s), nor represent an on-going, reliable stream of revenue. To this latter end, a professional assessment of the viability of a more aggressive, sustainable forestry plan, including the active cutting and re-planting of watershed lands should be pursued through a licensed forester and/or a commercial forestry company.

Finally, as discussed in Section 2.2, the Town-owned watershed lands are either known to have been, or can be can be assumed to have been, purchased for the protection of Nagog Pond and the water quality therein, and are therefore afforded protection under Article 97. As articulated in the 2002 Forestry Management Report, "The forest has been largely unmanaged for many decades. This naturally growing forest provides all the same water quality protection that an intensely managed forest does." That said, the introduction of a more active forest management program on watershed lands would not appear to be in conflict with the premise of the original purchase of these lands. However, any such activity would need to be proceeded by the adoption of a long-term management plan,

approved by DCR, and in full consideration of current regulations, particularly those regarding wetland protection and stormwater management.

3.4 Residential Development

As noted in Section 2.3, the Concord-owned watershed lands in both Littleton and Acton are zoned residential and could conceivably be converted to residential use, although prior approval under Article 97 would be required. This is particularly true in Littleton, where several of the larger parcels have extensive roadway frontage on Nashoba Road and Fort Pond Road. In contrast, only one two-acre parcel of Concord-owned watershed land has roadway frontage in Acton.

3.4.1 Article 97

As discussed in Section 2.2, the Town-owned watershed lands are either known to have been, or can be can be assumed to have been, purchased for the protection of Nagog Pond and the water quality therein, and are therefore subject to Article 97. Although argument could be made that the introduction of residential development would create additional security in remote areas of the watershed, the transfer, sale, grant or lease, or change in use associated with conversion to residential use of these lands will require adherence to the procedural protections afforded by Article 97. As outlined in Section 2.2, such a conversion would, at a minimum, require a two-thirds vote of town meeting to submit a "home rule" petition to the state legislature, a two-thirds vote of the state legislature; and, compliance with applicable funding sources and disposition policy. In addition, the conversion would need to meet the conditions of the EOEEA Article 97 Land Disposition Policy (see Attachment B).

3.4.2 Residential Development – Littleton

Assuming the constraints of Article 97 can be addressed, several of the Concord-owned watershed parcels in Littleton would be suitable for residential development. With the exception of the small, narrow parcels along Nashoba Road at the northeastern end of the Pond, all of the parcels can be readily combined so as to create a number of ANR lots (and the smaller lots could potentially be combined to account for frontage on the adjacent larger lots to the west). Potential residential development of the Littleton parcels (see Figure 1) includes:

Lots R01-16-1 and R01-16-0. These two lots located on the north shore of Nagog Pond have a combined acreage of approximately 14.71 acres, and a combined roadway frontage on Nashoba Road of approximately 1,200 feet (more if the frontage of the smaller lots to the immediate east can be utilized). While both of these lots are encumbered by some wetlands, the frontage and depth of the lots suggests the potential for a minimum of 8 ANR lots, with homes set well back from the water's edge. Alternative development arrangements, such as utilization of hammerhead lots or the creation of a subdivision, could

take advantage of the excess square footage associated with simple ANR development, resulting in the creation of additional lots.

Lot R01-17-2. This 1.24 acre lot at the end of the private way "Dutton Road" meets the 40,000 square foot lot minimum and was presumably created as a single house lot in compliance with Littleton zoning when the "Dutton" parcel was subdivided in 1990. This parcel includes frontage on Nagog Pond and as a developed parcel would likely have only limited separation from the Pond. In consideration of water quality protection, this parcel may not be ideal for residential development.

Lot R02-6-1. This 2.26 acre hammerhead lot off of Sarah Doublet Road meets the 40,000 square foot lot minimum and was presumably created as a single house lot in compliance with Littleton zoning when the Sarah Doublet subdivision was created. This parcel includes frontage on Nagog Pond but could be developed so as to create a 100-foot or greater buffer between the developed lot and the water.

Lots R02-11-0 and R02-13-0. These two lots located on the southwestern shore of Nagog Pond have a combined acreage of approximately 18.15 acres, and a combined roadway frontage on Nagog Hill Road of approximately 1,400 feet. While the larger of the two lots is encumbered by some wetlands, the frontage and depth of the lots suggests the potential for a minimum of 9 ANR lots, with homes set well back from the water's edge. Alternative development arrangements, such as utilization of hammerhead lots or the creation of a subdivision, could take advantage of the excess square footage associated with simple ANR development, resulting in the creation of additional lots.

3.4.3 Residential Development – Acton

Assuming the constraints of Article 97 can be addressed, several of the Concord-owned watershed parcels in Acton would be suitable for residential development. However, with the exception of the 2.0 acre lot C3-3 on Nagog Hill Road, none of the parcels in Acton have roadway frontage. Hence, any development of these parcels would require the creation of subdivisions, with associated roadways and infrastructure. Development of these parcels is further complicated by the fact that any such subdivision road would likely need to run parallel with the shoreline to access the properties in any meaningful way. For obvious economic reasons, subdivision roadways are typically laid out so as to allow development on both sides of the roadway. However, doing so would result in subdivision lots on the water side of the roadway that would have only limited setback from the water. Other difficulties might include the length of the necessary roadway to access most of the parcels, regardless of roadway layout within the parcel proper.

3.4.4 Residential Development – Summary

The conversion of Town-owned watershed lands for the purpose of residential development will likely trigger the need for compliance with the procedural protections afforded by

Article 97. Given the current use of the lands, the proximity of the lands to a public water supply, and, for all or most part, the purpose of the original purchases, it can be reasonably assumed that any proposed conversion of watershed lands to residential use will undergo extensive scrutiny. Should such a conversion be successful, there are a number of parcels in the Town of Littleton that are well positioned for conversion to residential lots without the need for substantial infrastructure improvements. Conversely, the Concord-owned watershed lands in Acton are, with one two-acre exception, landlocked. Access to these parcels for residential development would require the development of subdivisions and the construction of significantly long access and subdivision roadways.

4.0 NAGOG POND WATERSHED AND SOLAR FEASIBILITY STUDY - FINDINGS AND RECOMMENDATIONS

The above information has been compiled for the purpose of updating of the Town of Concord *Watershed Resources Protection Plan* inventory and assessing the potential for utilization of watershed lands for the financial advancement of an advanced water treatment facility at Nagog Pond. This has included an assessment of the compatibility of said watershed lands for the development of solar photovoltaic and wind energy systems, and the potential for the generation of revenue through the practice of silviculture, and/or the sale of lands for residential purposes. The following summarizes the findings and recommendations of this investigation

4.1 Nagog Pond Watershed Resource Protection Plan Inventory Review

Findings

There has been no significant change in land use within the Nagog Pond watershed since the 2011 Water Resources Protection Plan inventory and, based on the review conducted, no specific changes are warranted to the text of the Land Use Assessment section of the 2011 Plan.

Several additional wetland resource areas have been identified on Concord-owned watershed lands. These wetlands do not change the existing character of the basin, but may create additional limitation to the alternative use of watershed lands.

There are two large-scale develops prosed within or proximate to the Nagog Pond watershed: the Residences at Quail Ridge in Acton and the Village Green at 15 Great Road in Littleton. In addition, the Town of Littleton is proposing the re-construction of Nashoba Road on the western side of the Pond.

Runoff from an approximately 60 acre portion of the Nagog Pond watershed is being collected in Little Nagog Pond and diverted from the watershed by way of storm drains associated with the Nagog Square shopping plaza.

Recommendations

The Town of Concord is an abutter to both the Residences at Quail Ridge and Nashoba Road re-construction projects. As such the Town should receive public notices for all permits associated with those projects. The Town should request abutter status for the Village Green at 15 Great Road Project.

As an abutter the Town should review and comment on all of the above projects. Doing so will increase the likelihood that the projects will be advanced in a manner that protects Nagog Pond, but will also insure the Town as standing should the projects be appealed or otherwise not perform as designed.

The diversion of watershed waters by way of Little Nagog Pond should be assessed as to quantity impacts, including reduction of both surface and groundwater contribution, versus potential water quality benefits.

4.2 Regulatory Considerations

Findings

The discovery of wetland resources not previously identified suggests other federal, state, or local regulated resources areas may be present on watershed parcels.

No energy systems or residential development work would likely be allowed within vegetated wetland resource areas, and the buffer zones of such resource areas should be avoided. Harvesting of lumber from wetland resources may be allowed within certain, narrowly defined guidelines, but the lack of an existing forestry program or plan precludes the use of the forestry exemption in the MA Wetlands Protection Act and local Bylaws for establishing new silviculture opportunities in such areas (i.e. forest planting plans).

Wetland crossings to isolated upland areas for energy systems, silviculture or residential development may be allowed upon demonstration that no alternative access is available.

In water PV arrays and wind turbines may be allowed as piles are not deemed fill, although an alternatives analysis would likely be required under both state and federal statute. In water work would likely require both pre- and post-construction water and/or sediment quality monitoring. State and local attitudes against tree clearing for energy systems may favor in-water sites.

Local zoning regulations allow residential development in all Concord-owned watershed lands.

Local zoning regulations allow alternative energy systems in all Concord-owned watershed lands, including those on the water, but only through special permits.

Current state law exempts solar energy systems from local zoning that prohibits or unreasonably regulates the installation of solar energy systems. Recent Bylaw changes in the Town of Acton allow tree clearing of up to an acre for such systems. It is not known at this time what, if any, process the Town will offer for larger tree-clearing efforts associated with alternative energy systems.

Concord's watershed holdings are public lands presumably acquired for protection of the Nagog Pond water resource. As such, the transfer, sale, grant or lease, or alteration of the use of these lands will require adherence to the procedural protections afforded by Article 97 of the Amendments to the Massachusetts Constitution. These procedures include demonstration that (1) no feasible and substantially equivalent option: (2) the disposition does not destroy or threaten a unique or significant resource; (3) minimum acreage

necessary for the proposed use and the resources are still protected to the maximum extent possible; (4) the disposition serves a public purpose; and, (5) the disposition is not contrary to the "express wishes" of the party who sold the land.

As regards solar and wind energy systems, the Town of Concord could argue reasonably that such systems do not represent a true change in use, in that the land will still be used for water supply and water quality purposes, and the power and/or revenue generated thereby will be utilized for the treatment of the water. A small-scale, water-based PV system to serve an upgraded pumping and treatment facility would have the added benefit of requiring less watershed land and thereby less clearing of trees.

Any sale of parcels for single-family homes would and should undoubtedly include covenants and easements to protect watershed land and water quality (e.g., Low Impact Development for stormwater, Best Management Practices, enhanced septic systems, limits on recreation, etc.).

Recommendations

Site specific investigations as to the presence of federal, state and/or local wetland resource areas should be undertaken prior to advancing any specific development or silviculture initiatives.

Implementation and/or the promulgation of regulations associated with the new Town of Acton solar development bylaw should be monitored closely, particularly as it relates to the clearing of forest lands.

An adherence assessment should be completed for the proposed alternative uses utilizing the EEA Article 97 Land Disposition Policy.

4.3 Alternative Land Use – Solar Energy

Findings

An assessment of the Concord-owned watershed lands applying setbacks of 50 feet from property lines and 100-feet from wetland resource areas results in the identification of approximately 40 acres of watershed lands potentially suitable for PV array development, with individual sites ranging in size from a third of an acre to almost 15 acres (sites "A" through "G").

A potential 3-acre site was identified in the shallow waters of Nagog Pond near the ozone facility intake structure and the dam. This site was identified based on the assumption the generalized screening criteria that the water depths be no more than 10 feet, and that the site be isolated from public viewsheds.

A base installed capital cost of $4,000 per kW is deemed reasonable for the purpose of analyzing the financial feasibility of generating solar PV energy at the Nagog Pond watershed sites (as well as for an on-water site, and treatment plant roofs and parking areas).

Preliminary analysis indicates that the best simple payback period for Solar PV within the Town-owned portions of the watershed is 6 to 7 years and is applicable to all of the land-based sites, with the exception of Location "F". All of these scenarios ("A" through "E", and "G") assume a project smaller than 1,000 kW owned by a third party who can take advantage of tax incentives.

The payback period could be longer if (1) net metering is not fully available, (2) the third party owner cannot take full advantage of tax incentives, (3) the future value of Massachusetts incentives is lower than the recently- completed SRECs program, (4) development costs are higher than estimated, or (5) interconnect costs are higher than estimated.

In contrast to the third party-owned projects, DPW-owned projects at these same land-based locations are indicated as having payback periods on the order of 9 to 10 years ("A", "B", "C", "E", and "G"), 13 years ("D"), and >25 years ("F").

The analysis indicates that the placement of a solar PV array on the roof of the treatment plant would have a simple payback period on the order of 8 years for a third party-owned array, and 17 years for a DPW-owned array.

The simple payback period for arrays on/over the waters of Nagog Pond, or mounted above the parking lot of the treatment facility, would be on the order of 19 to 21 years for a third party-owned array, and would exceed 25 years for a DPW-owned array. These costs reflect the high construction costs of these options relative to the power generated.

Recommendations

The analysis suggests that sites "A", "B", "C", "E", and "G" have similar payback periods, installed costs ($/kWh), and total kWh generation potential and would be the principal sites for any further feasibility investigations.

Of the above sites, Site "B" has the best simple payback periods and is located proximate to the Town of Concord Ozone Facility and accessway. As such, this site represents the "preferred alternative" at this time.

Constructability investigations at this site should focus on access, wetland resources, and interconnection feasibility. At approximately 5.5 forested acres this site may be in conflict with recent Town of Acton zoning bylaw changes regarding solar power.

Specific next steps would include: 1) initiation of interconnection study with NSTAR, in order to refine the interconnection cost estimate; 2) clarification with NSTAR regarding the

project's ability to use net metering; 3) informal consultation with third-party developers to gauge the interest in development of available parcels; 4) tracking the status of the proposed replacement to the Massachusetts SREC program; and 5) revising the financial model with the new information gained in steps 1 through 4.

In the event that the Town wishes to further review the on-water option, direct contact with NJ American Water regarding the Canoe Brook Water Treatment project is recommended.

4.4 Alternative Land Use – Wind

Findings

The Massachusetts Clean Energy Center Commonwealth (MassCEC) Wind Evaluation and Siting Tool (CWEST) indicates that available wind resources at Nagog Pond are at or near the minimum needed to support a "Small Wind" project of 100 kW or less.

By definition, Nagog Pond is located in the topographic low point of the surrounding landscape. Given the surrounding topography, MassCEC guidelines would suggest a minimum turbine height on the order of 50 meters.

An assessment of the Concord-owned watershed lands applying setbacks of 225 for safety, 500 feet from property lines and roadways for noise and aesthetic purposes, and 100-feet from wetland resource areas results in the identification of three viable locations for a small wind turbine on Concord-owned watershed lands.

Preliminary analysis indicates an installed cost of approximately $5,500/kW and a simple payback period of 9 years for a third party that can take advantage of tax incentives. The simple payback period for a Concord-owned system would be on the order of 18 years.

Recommendations

The feasibility of a small wind project relies on many of the same considerations as for a solar PV project as discussed in Section 4.3 above. The next steps recommended for solar PV can be extended to include small wind. Specifically, these include contact with NSTAR regarding interconnections and net metering, contact with third-party developers regarding ownership, tracking the value of financial incentives, and updating the financial model.

4.5 Alternative Land Use - Silviculture

Findings

Neither field inspections nor a review of current orthophotography revealed any significant changes in the forest character as described in the 2002 Forest Management Plan.

The limited thinning program suggested in the 2002 Forest Management Plan was recommended primarily for forest health and would likely not significantly enhance the commercial value of the stands.

A more robust, sustainable commercial forestry operation would not necessarily conflict with Article 97, but would require the adoption of a long-term Management Plan approved by the Department of Conservation Resources, and developed in full consideration of current wetland and stormwater runoff regulations.

An assessment of the Concord-owned watershed lands applying 100–foot setbacks from wetland resource areas and 50-foot setbacks from property lines suggests a maximum area of slightly less than 40 acres available for more active forestry practices.

Recommendations

The 2002 Forest Management Plan should be updated to include consideration of a commercial forestry operation on watershed lands.

4.6 Alternative Land Use – Residential Development

Findings

Article 97 essentially precludes the conversion of lands purchased for the purpose of watershed protection from being sold for, or otherwise converted to, residential uses.

Existing lot front on Concord-owned watershed lands in Littleton would allow the creation of approximately 19 "Approval Not Required" (ANR) lots in Littleton.

Existing lot front on Concord-owned watershed lands in Acton would allow the creation of only one ANR lot in Acton.

Alternative development options (sub-divisions and or hammerhead lots) may increase the number of zoning-complaint lots on the large parcels on Nashoba Road and Nagog Hill Road in Littleton.

Alternative development options may allow for the development of portions of the watershed lands in Acton, but access and sub-division layout constraints may be prohibitive.

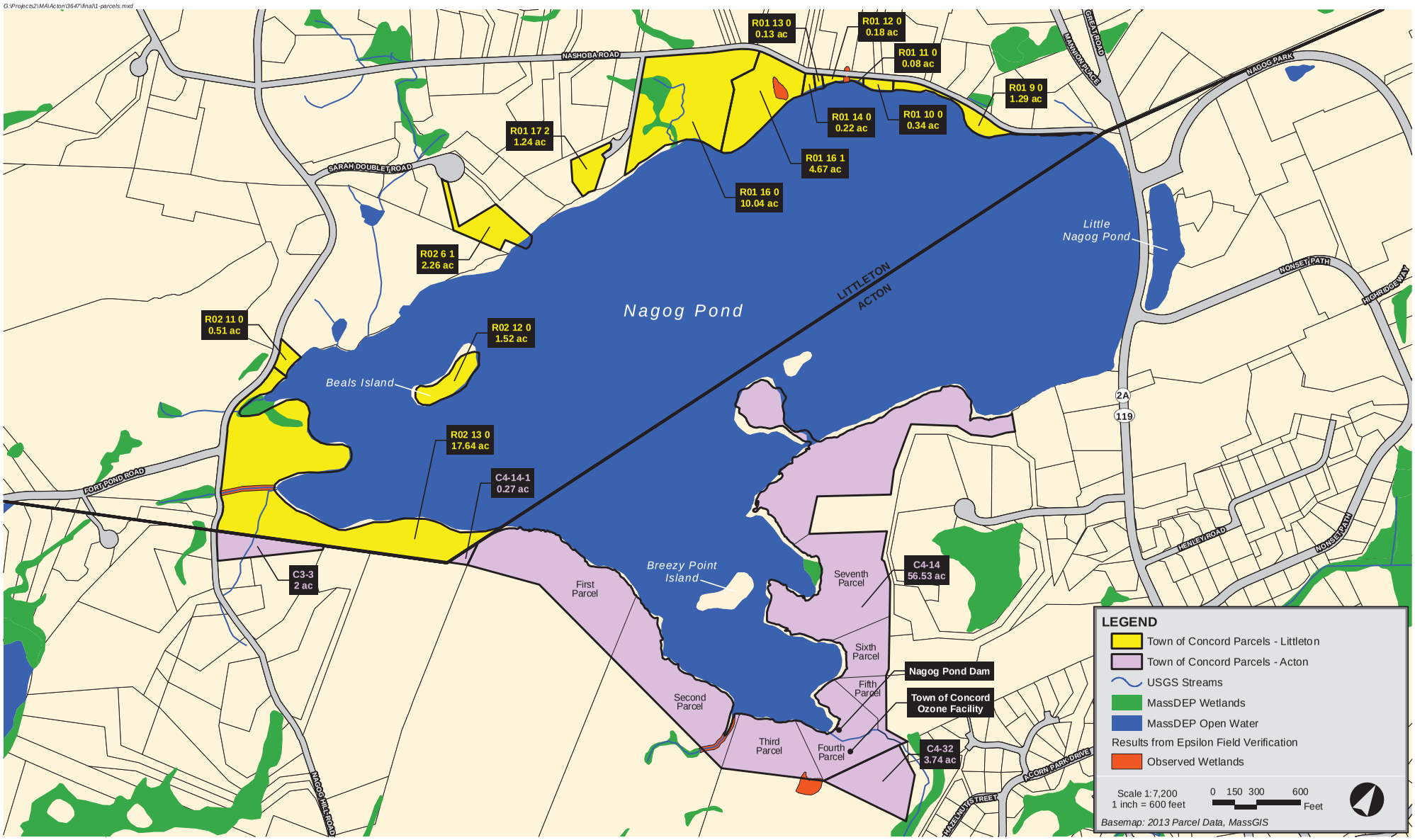
Recommendations

An adherence assessment should be completed for the proposed residential uses utilizing the EEA Article 97 Land Disposition Policy.

Attachment A

Figures

Figure 1	Concord-Owned Watershed Parcels Map
Figure 2	Nagog Pond Watershed – Aerial Locus Map
Figure 3	Nagog Pond Watershed - Land Use Map
Figure 4	Nagog Pond Watershed – Bathymetry, Terrain and Wetlands Map
Figure 5	Little Nagog Pond Surface Water Runoff Collection System
Figure 6	Nagog Pond Watershed – Transmission Line Map
Figure 7	Nagog Pond Watershed – Possible PV Solar Sites (with Acreage)
Figure 8	Nagog Pond Watershed – Possible PV Solar Sites (with Acreage) after Estimated Shadows on December 21 at 3:00 PM
Figure 9	Average Wind Speeds Across Massachusetts
Figure 10	Nagog Pond Watershed – Potential "Small Wind" Turbine Sites
Figure 11	Nagog Pond Watershed – Wood Lot Stands Previously Recommended for Thinning
Figure 12	Nagog Pond Watershed – Potential Silviculture Sites



Nagog Pond Watershed and Solar Feasibility Study

Epsilon ASSOCIATES INC.

Figure 1

Concord-Owned Watershed Parcels Map (with Parcel ID and Acreage)

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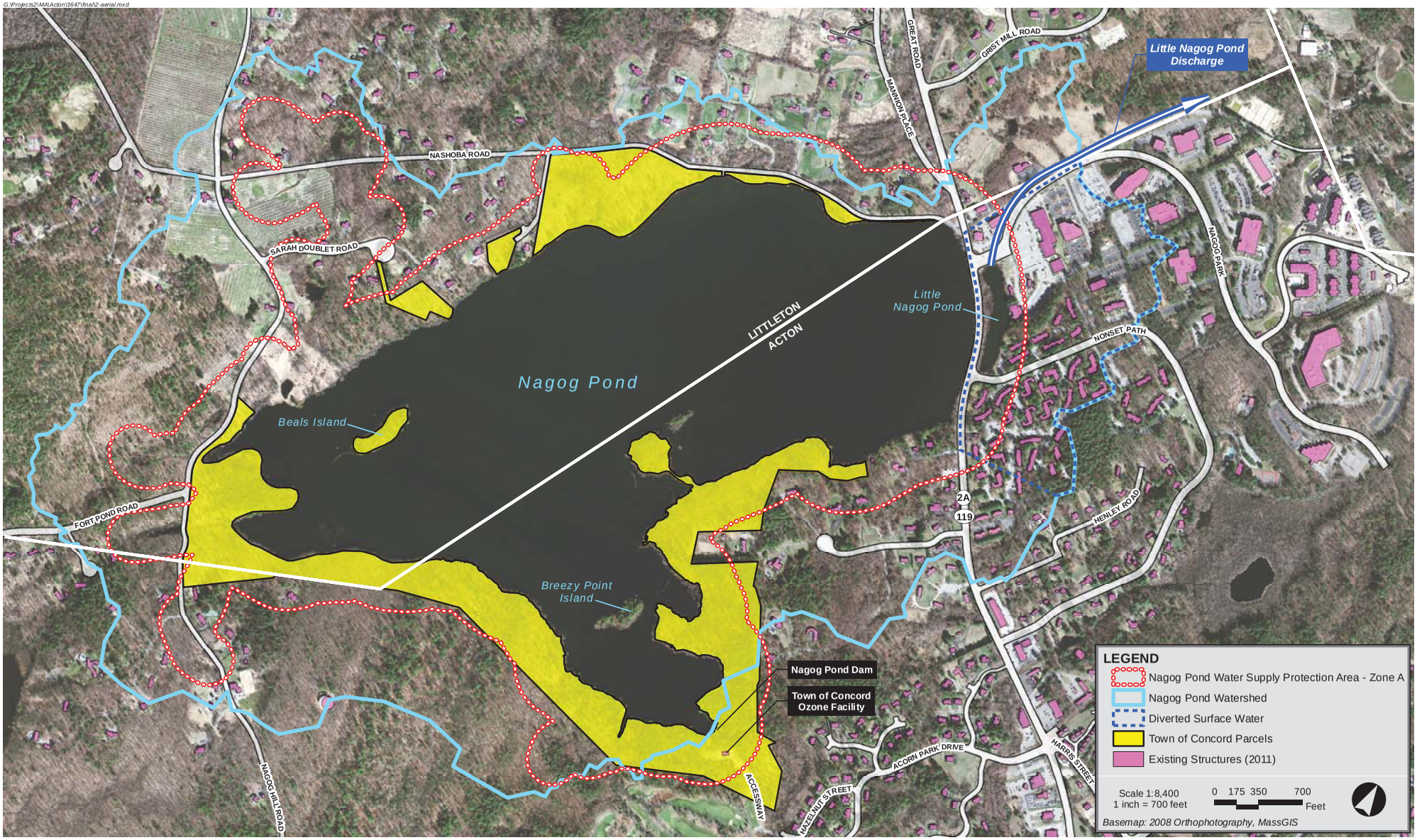

Nagog Pond Watershed and Solar Feasibility Study

Epsilon Associates Inc.

Figure 2

Nagog Pond Watershed - Aerial Locus Map

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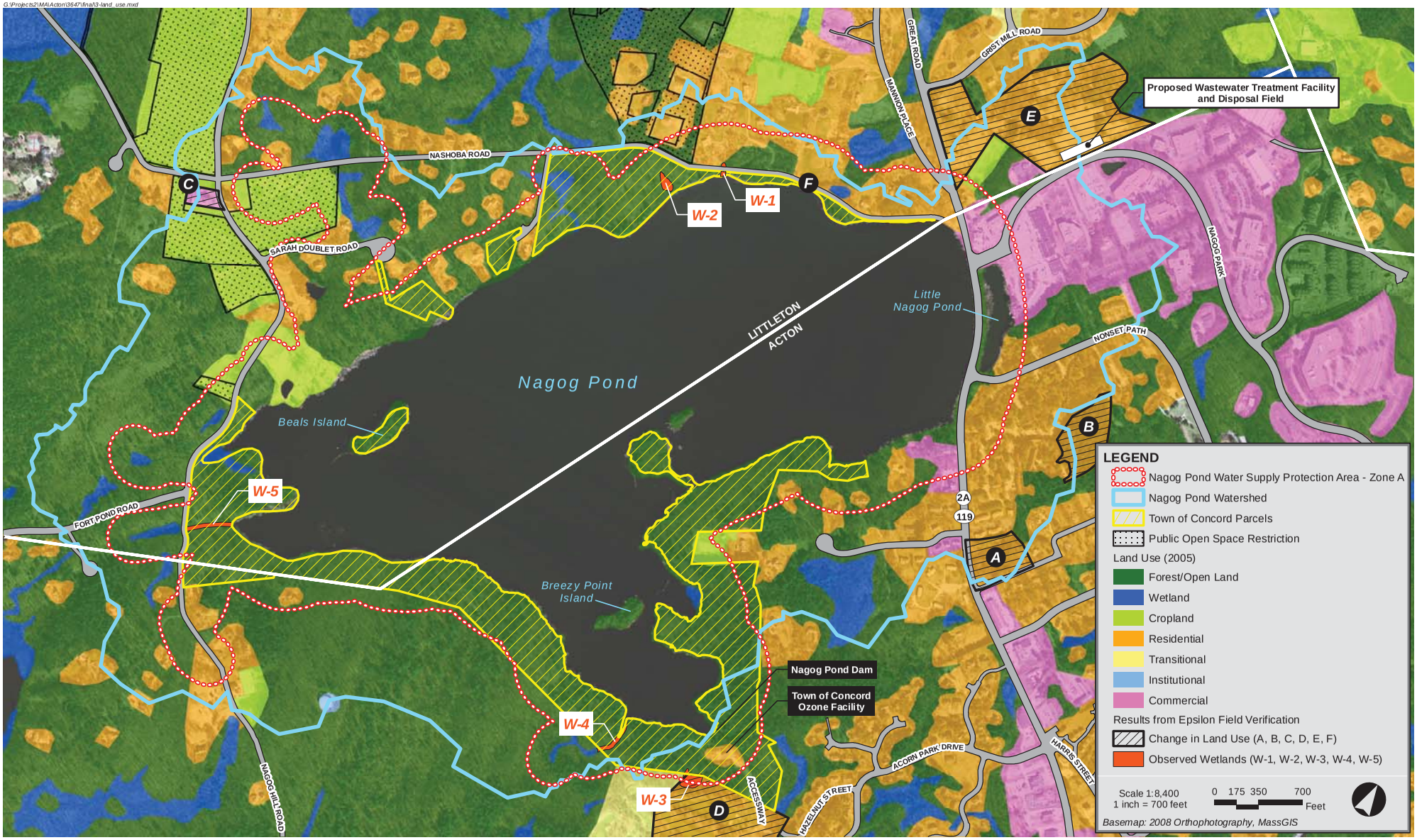
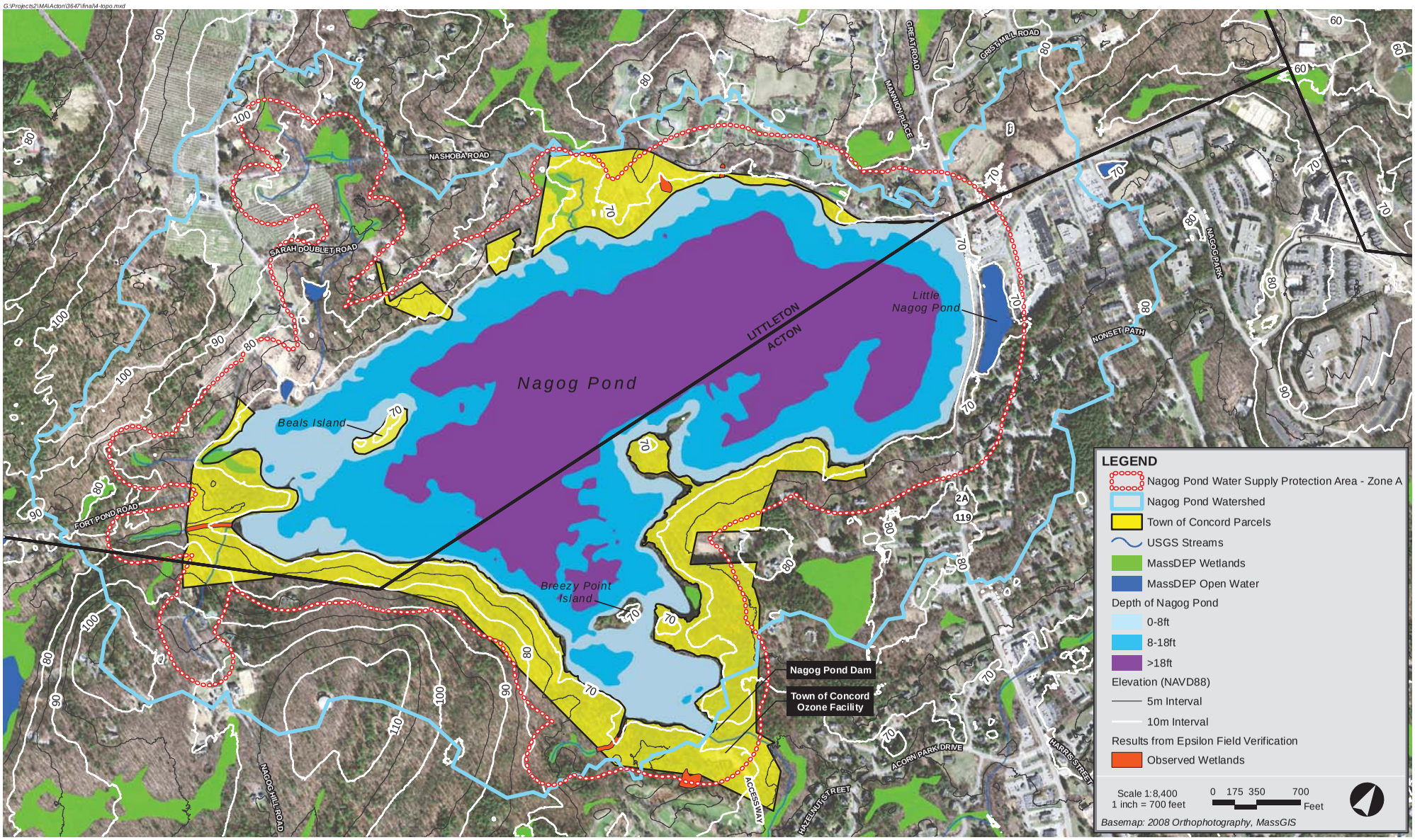


Nagog Pond Watershed and Solar Feasibility Study

Epsilon ASSOCIATES INC.

Figure 3

Nagog Pond Watershed - Land Use Map



Nagog Pond Watershed and Solar Feasibility Study

Epsilon ASSOCIATES INC.

Figure 4

Nagog Pond Watershed - Bathymetry, Terrain, and Wetlands Map

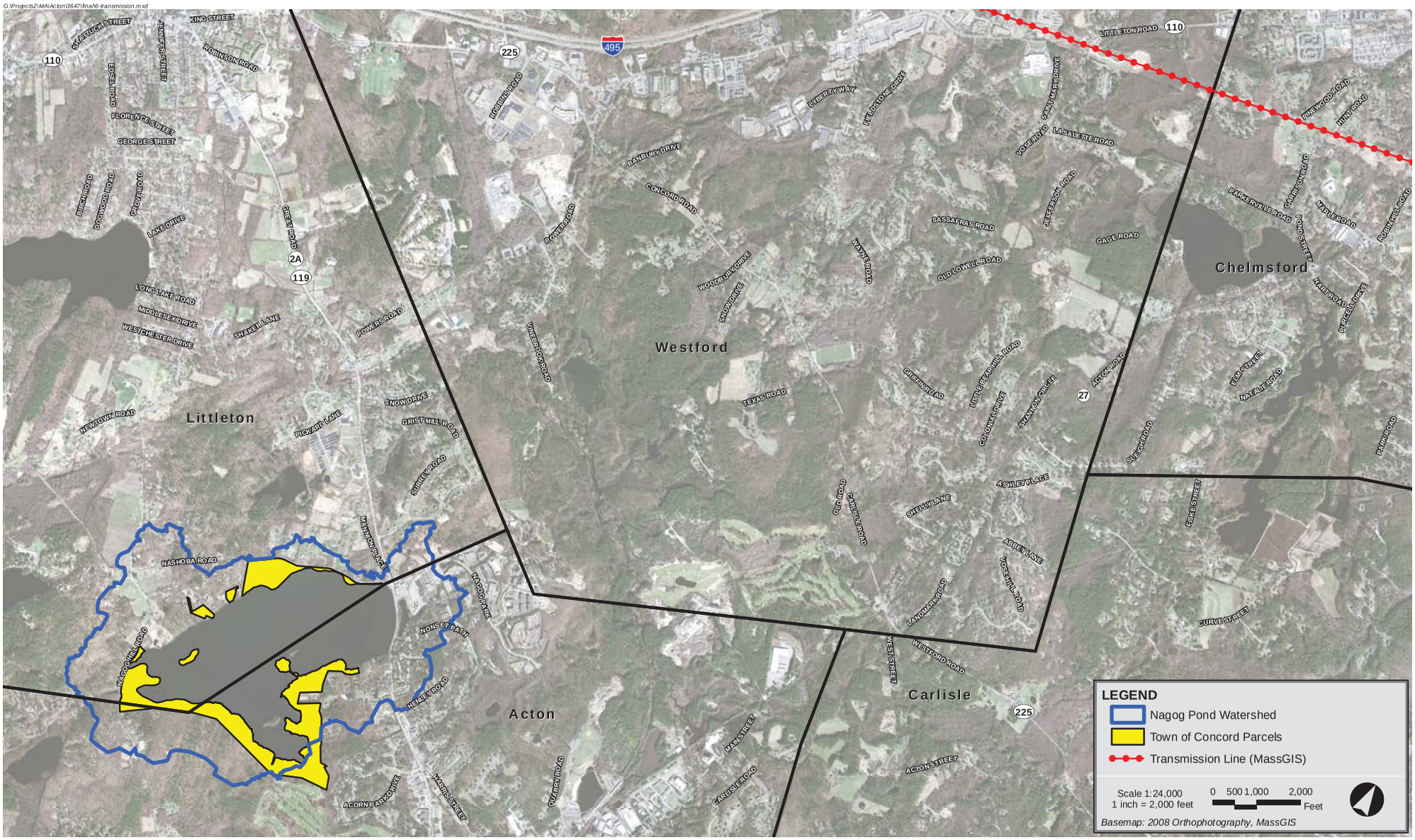
Source: Town of Acton Massachusetts Sewerage Study Committee, Sheet B-4, 1965

Nagog Pond Watershed and Solar Feasibility Study

Epsilon ASSOCIATES INC.

Figure 5

Little Nagog Pond Surface Water Runoff Collection System

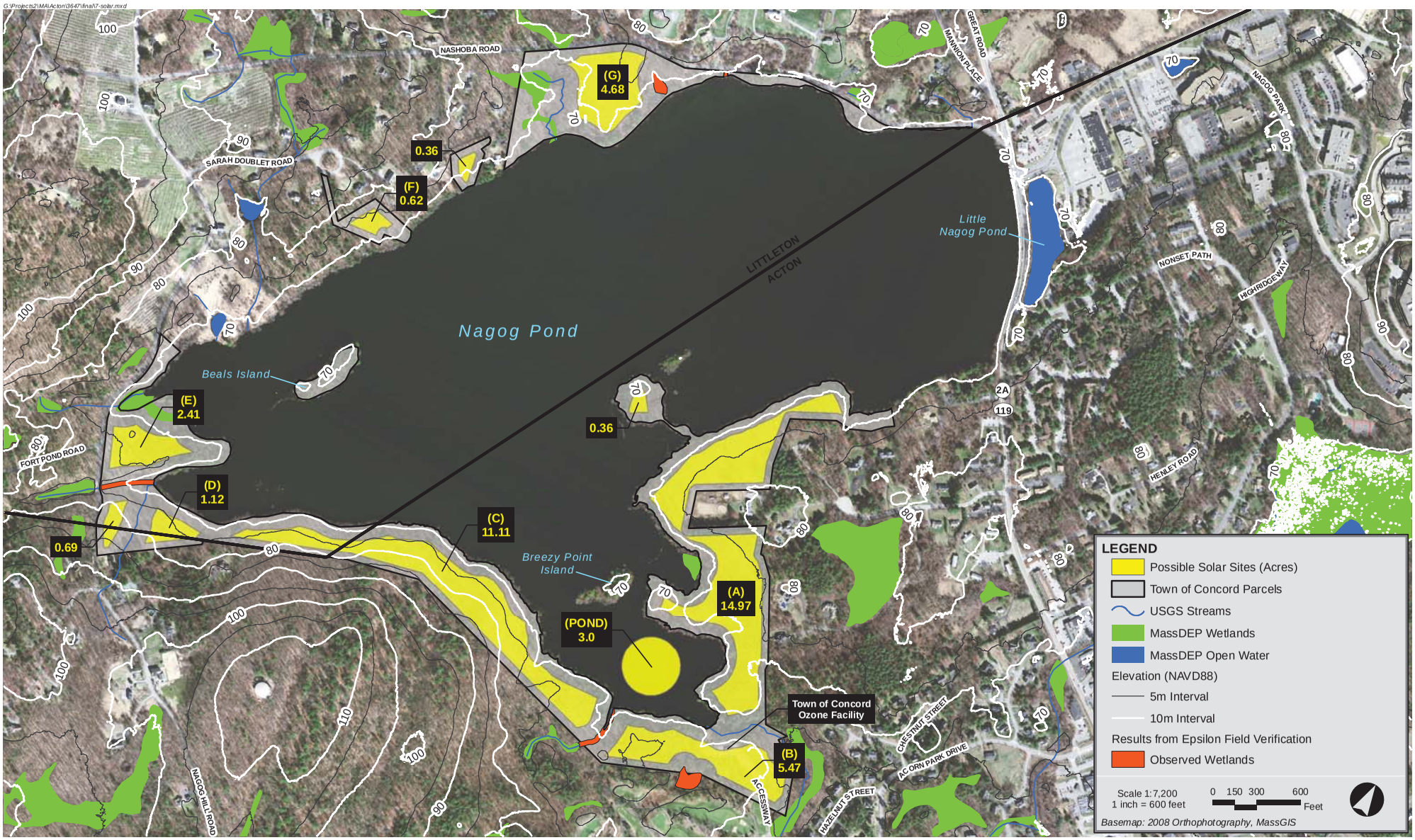


Nagog Pond Watershed and Solar Feasibility Study

Epsilon Associates Inc.

Figure 6

Nagog Pond Watershed - Transmission Line Map

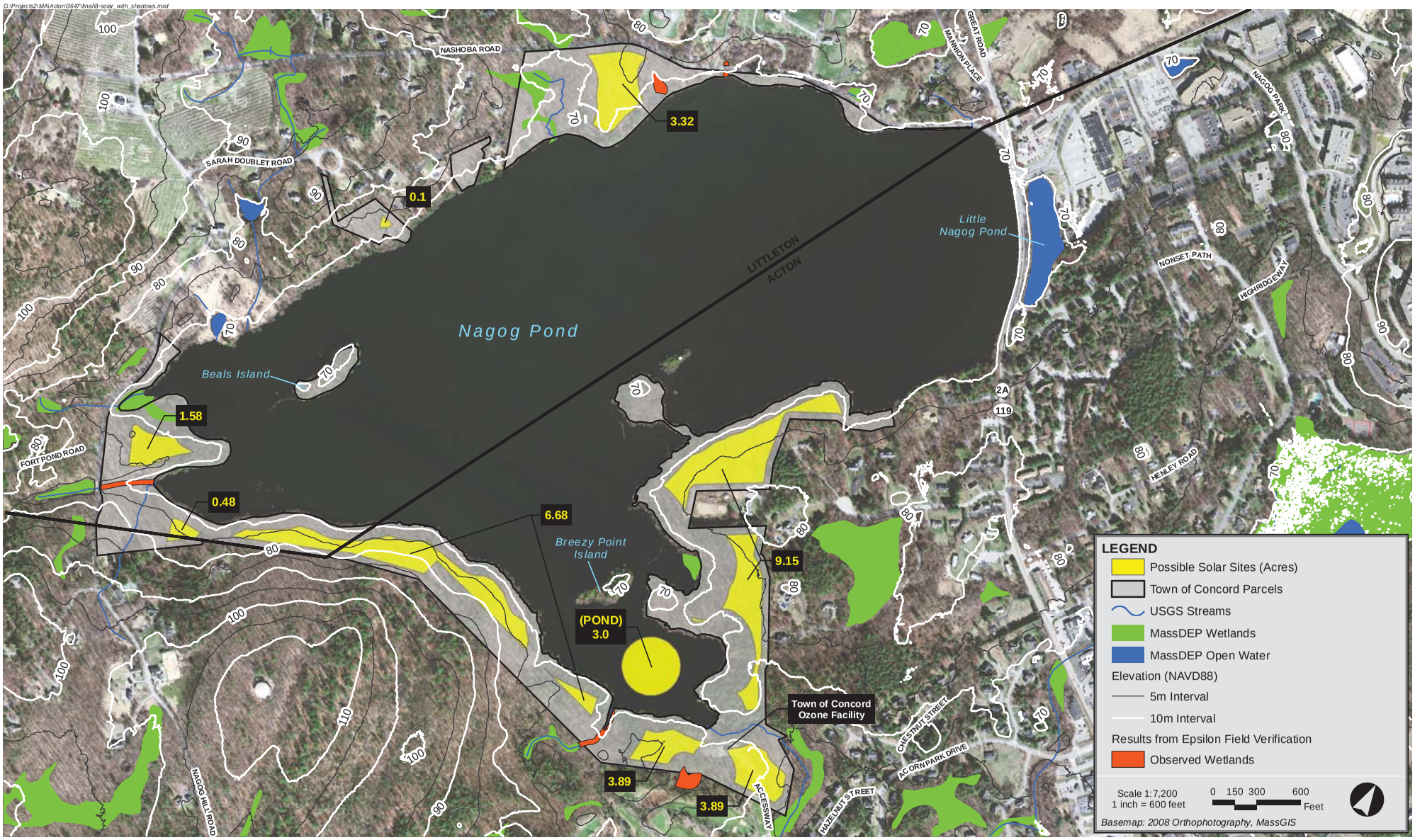


Nagog Pond Watershed and Solar Feasibility Study

Epsilon ASSOCIATES INC.

Figure 7

Nagog Pond Watershed - Possible PV Solar Sites (with Acreage)



Nagog Pond Watershed and Solar Feasibility Study

Epsilon ASSOCIATES INC.

Figure 8

Nagog Pond Watershed - Possible PV Solar Sites (with Acreage) after Estimated Shadows on Dec. 21 at 3pm

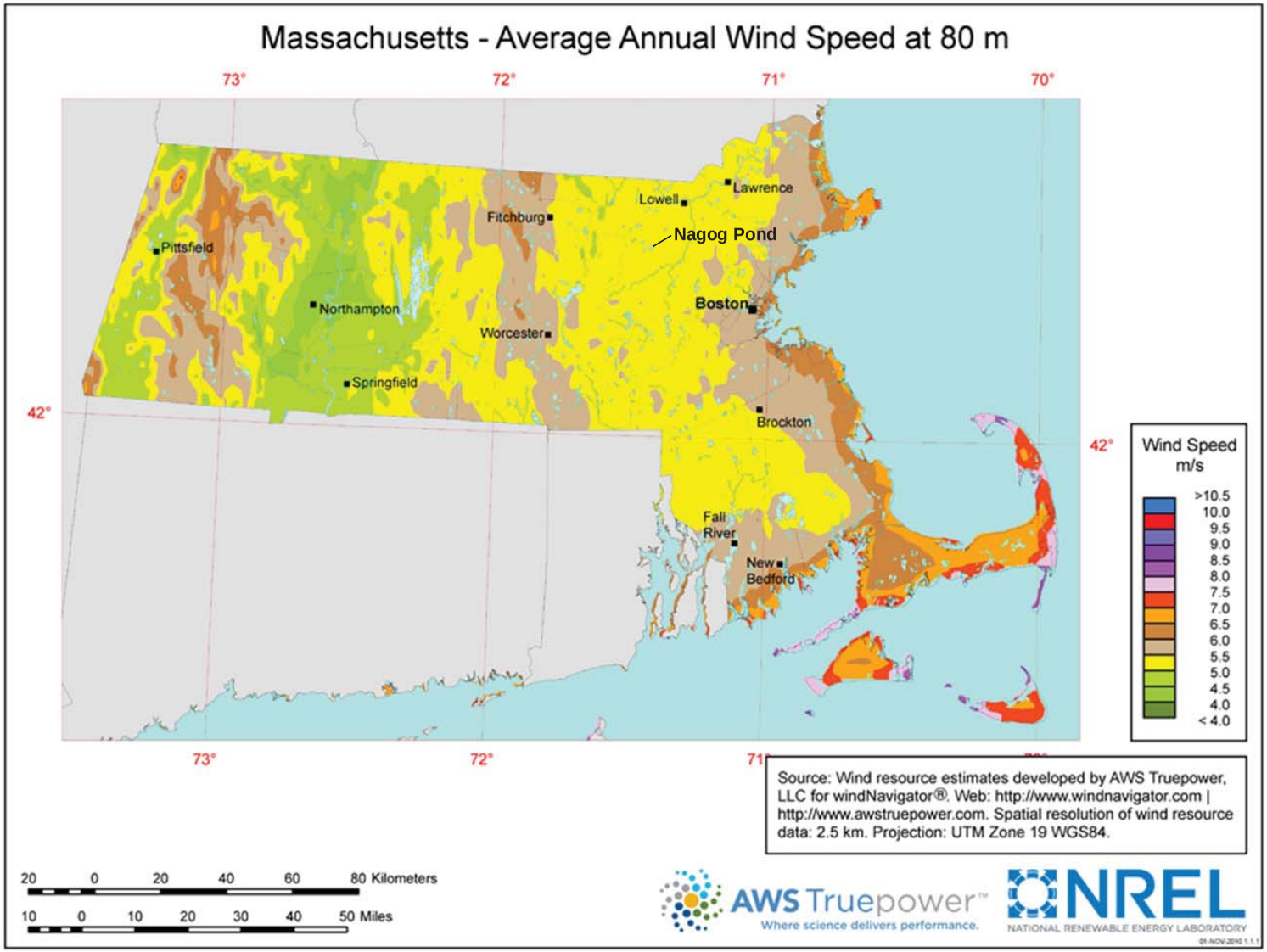


Figure 9

Average Wind Speeds Across Massachusetts

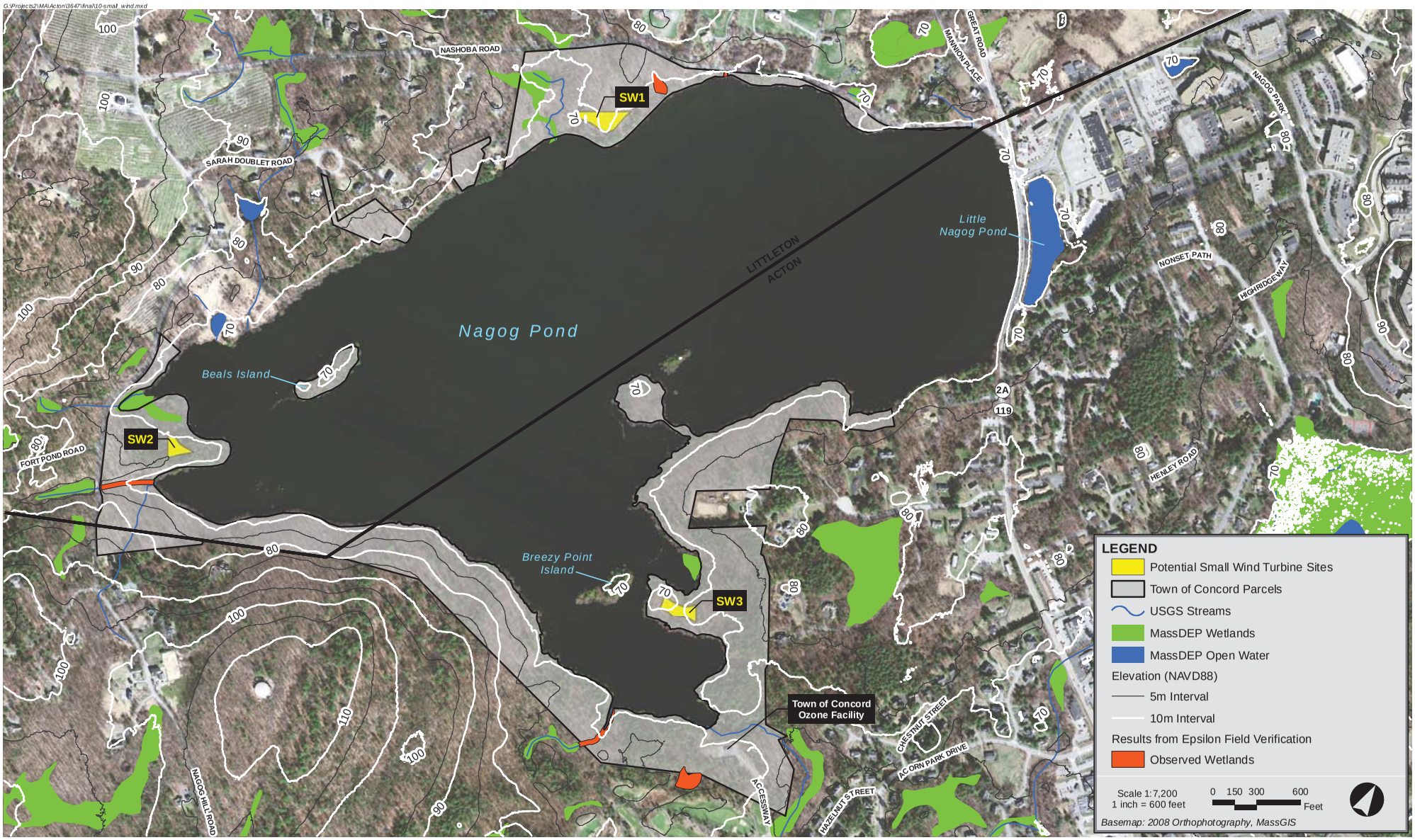
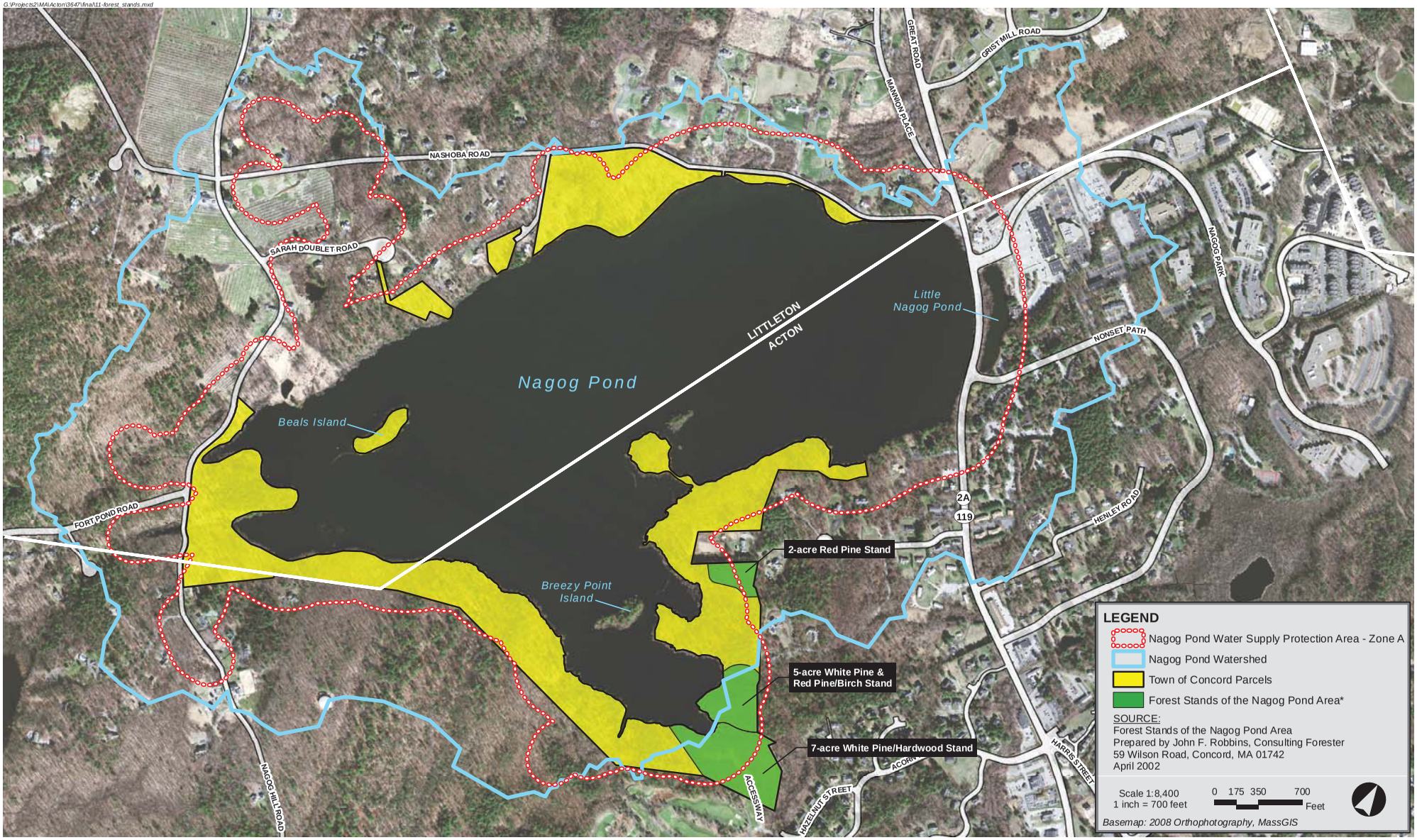


Figure 10

Nagog Pond Watershed - Potential Small Wind Turbine Sites

G:\Projects2\MA\Acton\3647\final\11-forest_stands.mxd

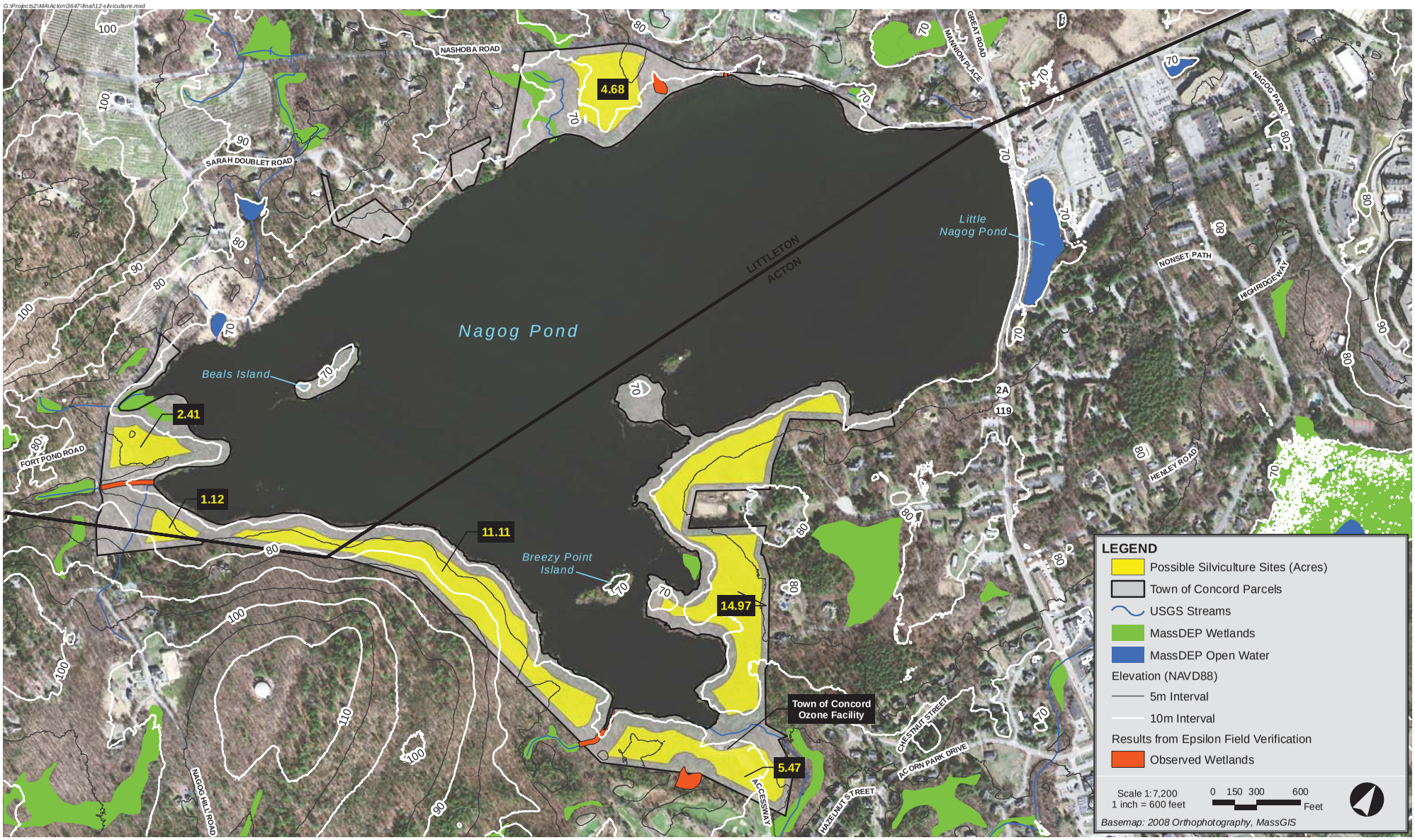


Nagog Pond Watershed and Solar Feasibility Study

Epsilon ASSOCIATES INC.

Figure 11

Nagog Pond Watershed - Wood Lot Stands Previously Recommended for Thinning



Nagog Pond Watershed and Solar Feasibility Study

Epsilon ASSOCIATES INC.

Figure 12

Nagog Pond Watershed - Potential Silviculture Sites (with Acreage)

Attachment B

February 19, 1998 Article 97 Land Disposition Policy

The Official Website of the Executive Office of Energy and Environmental Affairs

Energy and Environmental Affairs

EEA Article 97 Land Disposition Policy

FEBRUARY 19, 1998

I. Statement of Policy
It is the policy of EEA and its agencies to protect, preserve and enhance all open space areas covered by Article 97 of the Articles of Amendment to the Constitution of the Commonwealth of Massachusetts. Accordingly, as a general rule, EEA and its agencies shall not sell, transfer, lease, relinquish, release, alienate, or change the control or use of any right or interest of the Commonwealth in and to Article 97 land. The goal of this policy is to ensure no net loss of Article 97 lands under the ownership and control of the Commonwealth and its political subdivisions. Exceptions shall be governed by the conditions included in this policy. This policy supersedes all previous EEA Article 97 land disposition policies. An Article 97 land disposition is defined as: a) any transfer or conveyance of ownership or other interests; b) any change in physical or legal control; and c) any change in use, in and to Article 97 land or interests in Article 97 land owned or held by the Commonwealth or its political subdivisions, whether by deed, easement, lease or any other instrument effectuating such transfer, conveyance or change. A revocable permit or license is not considered a disposition as long as no interest in real property is transferred to the permittee or licensee, and no change in control or use that is in conflict with the controlling agency's mission, as determined by the controlling agency, occurs thereby.

II. Conditions for Disposition Exceptions
EEA and its agencies shall not support an Article 97 land disposition unless EEA and its agencies determine that exceptional circumstances exist. A determination of "exceptional circumstances" is subject to all of the following conditions being met: all other options to avoid the Article 97 disposition have been explored and no feasible and substantially equivalent alternatives exist (monetary considerations notwithstanding); Note: The purpose of evaluating alternatives is to avoid using/affecting Article 97 land to the extent feasible. To that end, the scope of alternatives under consideration shall be commensurate with the type and size of the proposed disposition of Article 97 land, and must be performed by the proponent of the disposition to the satisfaction of EEA and its agencies. The scope of alternatives extends to any sites that were available at the time the proponent of the Article 97 disposition first notified the controlling agency of the Article 97 land, and which can be reasonably obtained: (a) within the appropriate market area for private proponents, state, and/or regional entities ; or (b) within the appropriate city/town for municipal proponents. the disposition of the subject parcel and its proposed use do not destroy or threaten a unique or significant resource (e.g., significant habitat, rare or unusual terrain, or areas of significant public recreation), as determined by EEA and its agencies; as part of the disposition, real estate of equal or greater fair market value or value in use of proposed use, whichever is greater, and significantly greater resource value as determined by EEA and its agencies, are granted to the disposing agency or its designee, so that the mission and legal mandate of EEA and its agencies and the constitutional rights of the citizens of Massachusetts are protected and enhanced; the minimum acreage necessary for the proposed use is proposed for disposition and, to the maximum extent possible, the resources of the parcel proposed for disposition continue to be protected; the disposition serves an Article 97 purpose or another public purpose without detracting from the mission, plans, policies and mandates of EEA and its appropriate department or division; and 6. the disposition of a parcel is not contrary to the express wishes of the person(s) who donated or sold the parcel or interests therein to the Commonwealth.

III. Procedures for Disposition
Although legislation can be enacted to dispose of Article 97 land without the consent of an EEA agency, it is the policy of EEA to minimize such occurrences. To that end, and to ensure coordination, EEA agencies shall: develop an internal review process for any potential Article 97 land disposition to ensure that, at a minimum, the conditions in Section II above are met; develop, through the Interagency Lands Committee, a joint listing of all requests, regardless of their status, for the disposition of Article 97 land; notify the Interagency Lands Committee of any changes to the Article 97 land disposition list; monitor all legislation that disposes of Article 97 land, and communicate with legislative sponsors regarding their intent; recommend to the Secretary that the Governor veto any legislation that disposes of Article 97 land, the purchase, improvement, or maintenance of which involved state funds, on and for which the EEA agency has not been consulted and received documentation (including information on title, survey, appraisal, and a MEPA review, all at the proponent's expense); 6. obtain the concurrence of the Secretary of EEA for any proposed Article 97 land disposition decision prior to finalizing said decision; if recommending an Article 97 disposition, attach to all Article 97 legislative recommendations and TR-1 forms a justification of the disposition and an explanation of how it complies with this policy, signed by the EEA agency head; ensure that any conditions approved by EEA and its agencies to any Article 97 land disposition are incorporated within the surplus declaration statement submitted to and published by DCPO as required by G.L. c. 7, ss. 40F and 40F½ and throughout the disposition process, and if such conditions are not incorporated in said statement throughout the disposition process, the EEA agency head shall recommend to the Secretary that the Governor veto any resulting legislation; recommend to the Secretary that the Governor veto legislation that disposes of Article 97 land of which the agency disapproves; and ensure that any Article 97 land disposition is authorized by enacted legislation and approved by all municipal, state and federal agencies, authorities, or other governmental bodies so required and empowered by law prior to conveyance.

IV. Applicability of This Policy To Municipalities To comply with this policy, municipalities that seek to dispose of any Article 97 land must: obtain a unanimous vote of the municipal Conservation Commission that the Article 97 land is surplus to municipal, conservation, and open space needs; obtain a unanimous vote of the municipal Park Commission if the land proposed for disposition is park land; obtain a two-thirds Town Meeting or City Council vote in support of the disposition; obtain two-thirds vote of the legislature in support of the disposition, as required under the state constitution; comply with all requirements of the Self-Help, Urban Self-Help, Land and Water Conservation Fund, and any other applicable funding sources; and comply with the EEA Article 97 Land Disposition Policy. After the effective date of this policy, any municipality that proposes, advocates, supports or completes a disposition of Article 97 land without also following the terms of this policy, regardless of whether or not state funds were used in the acquisition of the Article 97 land, shall not be eligible for grants offered by EEA or its agencies until the municipality has complied with this policy. Compliance with this policy by municipalities shall be determined by the EEA Secretary, based on recommendations by the EEA Interagency Lands Committee.

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Attachment C

March 26, 2012 Guideline from the MassDEP Bureau of Resource Protection Drinking Water Program for Proposed Wind and Solar Energy Projects on Lands Owned or Controlled By Public Water Systems for Drinking Water Purposes

Guideline
Bureau of Resource Protection
Drinking Water Program

Information to be Submitted to MassDEP for Proposed Wind and Solar Energy Projects on Lands Owned or Controlled By Public Water Systems for Drinking Water Purposes

Effective Date: September 1, 2011
Updated: March 26, 2012
Guideline # BRP 2011-1
Applicability: Public Water Systems

Approved by /signed/
Bethany Card, Assistant Commissioner, Bureau of Resource Protection

Supersedes Guideline: None

Purpose: To provide guidance to public water suppliers on information to be submitted to MassDEP for wind and solar energy projects proposed on lands owned or controlled by public water systems for drinking water purposes.

Applicability: This Guideline applies to public water suppliers and their representatives requesting written approval from MassDEP to install wind and solar energy projects on lands held by public water systems for drinking water purposes.

Note: The public water supplier may need to seek additional approvals from other entities and/or MassDEP, including, but not limited to, municipal approval, legislative approval pursuant to Article 97, and MEPA approval pursuant to 301 CMR 11.00.

Authority/Background:

M.G.L. Chapter 111, Section 160 titled "Examinations of water supply; Rules; Penalty for violation," states that the department may “make rules and regulations and issue such orders as its opinion may be necessary to prevent the pollution ... and to ensure the delivery of a fit and pure water supply to all consumers.”

310 CMR 22.21(1) and 22.21(3)(b) require activities in the Zone I to be limited to those directly related to the provision of public drinking water or that will have no significant adverse impact on water quality.

310 CMR 22.24: Sale, Transfer of Property Interest, or Change in Use of Water Supply Land
(1) No supplier of water may sell, lease, assign, or otherwise dispose of, or change the use of, any lands used for water supply purposes without the prior written approval of the Department. The Department will not approve any such disposition or change in use unless the supplier of water demonstrates to the Department's satisfaction that such action will have no significant adverse impact upon the supplier of water's present and future ability to provide continuous adequate service to consumers under routine and emergency operating conditions, including emergencies concerning the contamination of sources of supply, failure of the distribution system and shortage of supply.

In addition, M.G.L. Chapter 40, Section 15B, states "[a] town, city or district authorized to furnish water for domestic purposes, may, with the advice and approval of the state department of environmental protection ... in its discretion, by lease, license or other agreement, permit the construction and maintenance on any land under its control of towers, poles, wires, and other structures for the purpose of transmitting electric power over lands and water held for water supply purposes; provided, that such lease, license or agreement will not, in the opinion of the said department, affect or interfere with the water supply; and provided, further, that said city, town or district may, with the approval of said department, revoke said lease, license or agreement for cause to be determined by it."

Review and Approval

MassDEP supports wind and solar energy projects but also recognizes that lands that are under the control of public water systems have been identified as the most critical to protect public drinking water reservoirs and wells. In addition, these lands may be the future sites for new or replacement public water system sources. Pursuant to 310 CMR 22.24(1), public water suppliers must obtain written approval from MassDEP for projects described in the Applicability section above.

Public water suppliers shall submit a written certification to MassDEP that proposals to construct and maintain wind and solar energy projects will have no significant adverse impact on the public water supplier's present and future ability to provide continuous adequate service to consumers under routine and emergency operating conditions, including emergencies concerning the contamination of sources of supply, failure of the distribution system and shortage of supply. The certification should include maps, plans or other documentation to support that statement and should address, at a minimum, the information listed in Part A below. Public water suppliers and their contractors, operators, and/or lessees will be required to adhere to the applicable conditions in Part B below as a condition of their approval. For Zone I projects, the public water supplier should also certify that the wind and/or solar energy project will have no significant adverse impact on water quality and that the energy generated by the facility will be used to benefit, either by direct consumption or by other means, the operation of the public water system.

If a public water supplier submits a written certification in accordance with this Guideline, MassDEP approval will be presumed unless the agency informs the public water supplier otherwise within 30 days of the Department’s receipt of the submission. MassDEP may request additional information or deny the request within 30 days.

A. General Site Information and Site Design

- The location of the public water system source; water supply protection areas; and depth to ground water.
- Project footprint; new easements or roads; existing water system structures.
- A description of the wind or solar infrastructure proposed for the site.
- The estimated schedule and duration for the construction of the project.
- The type of soils, vegetation, and slopes in the project area; the location and amount to be disturbed; and the method of soil/slope stabilization during and after the project.
- The location and amount of pervious surface that will be changed to impervious surface and a description of how stormwater will be managed on the site.

- A list of expected coolants, lubricants, cleaning products and other potential contaminants associated with the construction and maintenance of the infrastructure.
- Descriptions of any wash water disposal practices and/or equipment used at the site.
- For projects located within the Zone I, an explanation of how the energy generated will benefit the operation of the public water system.
- Description of emergency response procedures (e.g. fire safety measures) in place.
- Any other information requested by MassDEP to protect the public water supply.

B. Construction and Post-Construction Conditions

- All exposed soils and slopes shall be stabilized with erosion controls during and after construction until vegetation is established.
- Vegetation related to the facility shall be managed through mowing or other mechanical means or with native plantings if possible. If pesticide use is necessary for employee safety, such as to control poison ivy, the application shall comply with local, state, and federal requirements. There shall be no application of pesticides or fertilizers in the Zone I.
- There shall be no oil, hazardous materials, cleansers or other potential contaminants stored on-site in the Zone I. If these materials are stored on-site in Zones II and III and in Zones A, B, and C, they shall properly labeled, covered and contained.
- Disposal of wash water at the facility shall be avoided or minimized to prevent contamination of ground or surface waters and will comply with any applicable regulatory requirement (including underground injection control registration).
- Emergency response procedures shall be developed by the public water system in conjunction with any contractors, operators, and/or lessees.
- The public water supplier shall notify MassDEP within 30 days of project completion.
- Any other conditions required by MassDEP to protect the public water supply.

MassDEP staff may conduct an initial site visit and/or a final inspection of the installation. The installation and operations are subject to review during sanitary surveys or other MassDEP inspections.

The public water supplier is responsible for ensuring that project construction and operation are consistent with the proposal and approval including all conditions. The public water system and this project remain subject to Massachusetts General Laws, the Massachusetts Drinking Water Regulations, all other relevant Massachusetts regulations, and MassDEP's authority herein.

Model CERTIFICATION

The PWS _____ provides this certification to MassDEP that its proposal to construct and maintain wind and solar energy projects will have no significant adverse impact on its present and future ability to provide continuous adequate service to consumers under routine and emergency operating conditions, including emergencies concerning the contamination of sources of supply, failure of the distribution system and shortage of supply. If this proposal is for Zone I, PWS _____ also certifies that the wind and/or solar energy project will have no significant adverse impact on water quality and that the energy generated by the facility will be used to benefit, either by direct consumption or by other means, the operation of the public water system.

Note: The public water supplier may need to seek additional approvals from other entities and/or MassDEP, including, but not limited to, municipal approval, legislative approval pursuant to Article 97, and MEPA approval pursuant to 301 CMR 11.00.

In support of this proposal the PWS is attaching the following:

- The location of the public water system source; water supply protection areas; and depth to ground water.
- Project footprint; new easements or roads; existing water system structures.
- A description of the wind or solar infrastructure proposed for the site.
- The estimated schedule and duration for the construction of the project.
- The type of soils, vegetation, and slopes in the project area; the location and amount to be disturbed; and the method of soil/slope stabilization during and after the project.
- The location and amount of pervious surface that will be changed to impervious surface and a description of how stormwater will be managed on the site.
- A list of expected coolants, lubricants, cleaning products and other potential contaminants associated with the construction and maintenance of the infrastructure.
- Descriptions of any wash water disposal practices and/or equipment used at the site.
- Description of emergency response procedures (e.g. fire safety measures) in place.
- For projects located within the Zone I, an explanation of how the energy generated will benefit the operation of the public water system.

PWS _____ also certifies that the proposal will meet the following conditions:

- All exposed soils and slopes shall be stabilized with erosion controls during and after construction until vegetation is established.
- Vegetation related to the facility shall be managed through mowing or other mechanical means or with native plantings if possible. If pesticide use is necessary for employee safety, such as to control poison ivy, the application shall comply with local, state, and federal requirements. There shall be no application of pesticides or fertilizers in the Zone I.
- There shall be no oil, hazardous materials, cleansers or other potential contaminants stored on-site in the Zone I. If these materials are stored on-site in Zones II and III and in Zones A, B, and C, they shall properly labeled, covered and contained.

- Disposal of wash water at the facility shall be avoided or minimized to prevent contamination of ground or surface waters and will comply with any applicable regulatory requirement (including underground injection control registration).
- Emergency response procedures shall be developed by the public water system in conjunction with any contractors, operators, and/or lessees.
- The public water supplier shall notify MassDEP within 30 days of project completion.

_____ [signature] Date: _____

Title: _____ for the _____ Public Water System

Attachment D

PVWatts Model Output

PVWatts * * * * *

AC Energy & Cost Savings

* * * * *

Cautions for Interpreting the Results

Nagog Pond Basic 1000 kW Project

Station Identification

Cell ID:	0273365
State:	Massachusetts
Latitude:	42.5 ° N
Longitude:	71.4 ° W

PV System Specifications

DC Rating:	1000.0 kW
DC to AC Derate Factor:	0.770
AC Rating:	770.0 kW
Array Type:	Fixed Tilt
Array Tilt:	20.0 °
Array Azimuth:	180.0 °

Energy Specifications

Cost of Electricity:	15.4 ¢/kWh

Results

Month	Solar Radiation (kWh/m²/day)	AC Energy (kWh)	Energy Value ($)
1	2.45	60098	9255.09
2	3.36	74900	11534.60
3	4.41	105057	16178.78
4	4.85	108850	16762.90
5	5.53	123106	18958.32
6	5.70	119117	18344.02
7	5.71	122915	18928.91
8	5.38	116582	17953.63
9	4.70	101173	15580.64
10	3.69	84415	12999.91
11	2.48	56235	8660.19
12	2.12	50665	7802.41
Year	4.20	1123112	172959.24

Output Hourly Performance Data

(Gridded data is monthly, hourly output not available.)

Output Results as Text

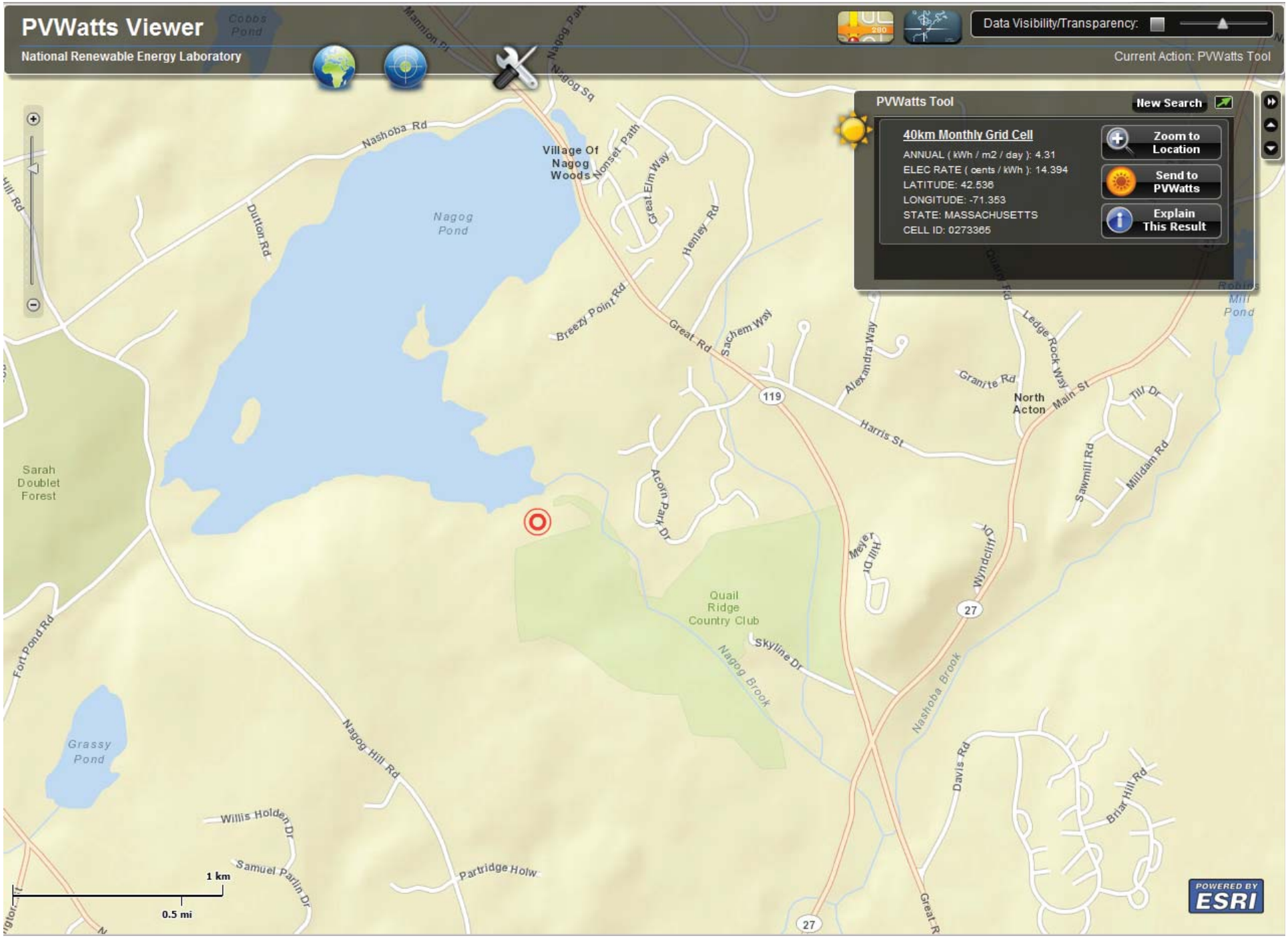
Saving Text from a Browser

Run PVWATTS v.2 for another location

Run PVWATTS v.1

Please send questions and comments to Webmaster
Disclaimer and copyright notice.

RReDC home page (*http://rredc.nrel.gov*)


PVWatts Viewer
National Renewable Energy Laboratory
Data Visibility/Transparency:
Current Action: PVWatts Tool
PVWatts Tool
New Search
40km Monthly Grid Cell
ANNUAL (kWh / m2 / day): 4.31
ELEC RATE (cents / kWh): 14.394
LATITUDE: 42.536
LONGITUDE: -71.353
STATE: MASSACHUSETTS
CELL ID: 0273365
Zoom to Location
Send to PVWatts
Explain This Result
Nagog Pond
Village Of Nagog Woods
Nashoba Rd
Dutton Rd
Nonset Path
Great Elm Way
Henley Rd
Breezy Point Rd
Great Rd
Sachem Way
Alexandra Way
Granite Rd
Ledge Rock Way
North Acton
Main St
Harris St
Sawmill Rd
Millidam Rd
Sarah Doublet Forest
Acoin Park Dr
Quail Ridge Country Club
Skyline Dr
Nagog Brook
Nashoba Brook
Wyndcliff Dr
Fort Pond Rd
Grassy Pond
Nagog Hill Rd
Willis Holden Dr
Samuel Parlin Dr
Partridge Holw
Davis Rd
Briar Hill Rd
Robbins Mill Pond
1 km
0.5 mi
POWERED BY ESRI

Attachment E

Solar PV Financial Analysis Template
(Summary Sheet and CD)

Solar PV Financial Analysis Template
COSTS AND MWh/yr OUTPUT

Key Inputs & Assumptions: PV	
200	kW/acre average DC rating
$4,000	/kW installed base cost for PV system
1.5	cost multiplier for roof-based or on-water PV systems
3	cost multiplier for solar canopies
$250	/kW interconnection cost
$5,000	/acre land clearing cost
$25	/square foot dock and/or pier cost
$100,000	/project estimate of permitting costs: zoning & land use
$100,000	/project permitting costs: wetlands & Chapter 91
1123.1	kWh/yr/kW DC Rating (from PVWatts)
12.8%	kW (DC STC) to kWh AC Annual Net Capacity Factor
$0.285	/kW SREC Value

Key Inputs & Assumptions: Wind	
$5,500	/kW installed base cost for small (<100kW) wind system
$250	/kW interconnection cost
$5,000	/project land clearing cost
$100,000	/project estimate of permitting costs: zoning & land use
20.0%	kW (DC STC) to kWh AC Annual Net Capacity Factor
$0.059	/kW REC Value

POTENTIAL SITE Name:	A	B	C	D	E	F	G	Pond	Roofs	Parking Lot	Wind
Available acreage:	14.97	5.47	11.11	1.12	2.41	0.62	4.68	3	0.036	0.1	
Unshadowed acreage:	9.15	3.89	6.68	0.48	1.58	0.1	3.32	3	0.036	0.1	
percent useful acreage gain/loss based on grade	0%	-5%	-15%	-8%	-5%	0%	5%	0%	0%	0%	
Acreage of panels	9.15	3.6955	5.678	0.4416	1.501	0.1	3.486	3	0.036	0.1	
PV array DC rating, kW	1830	739	1136	88	300	20	697	600	7	20	100
Installation type (ground/roof/canopy/water)	ground	ground	ground	ground	ground	ground	ground	water	Roof	Canopy	
PV basic installation cost	$7,320,000	$2,956,400	$4,542,400	$353,280	$1,200,800	$80,000	$2,788,800	$3,600,000	$43,200	$240,000	$550,000
Interconnection cost	$457,500	$184,775	$283,900	$22,080	$75,050	$5,000	$174,300	$150,000	$1,800	$5,000	$25,000
Site clearing & prep cost	$74,850	$27,350	$55,550	$5,600	$12,050	$3,100	$23,400	$0	$0	$0	$5,000
Dock/pier cost	$0	$0	$0	$0	$0	$0	$0	$3,267,000	$0	$0	
Permitting cost	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$200,000	$0	$0	$100,000
Total estimated project capital cost:	$7,952,350	$3,268,525	$4,981,850	$480,960	$1,387,900	$188,100	$3,086,500	$7,217,000	$45,000	$245,000	$680,000
kWh/yr generated	2,055,295	830,092	1,275,406	99,193	337,158	22,462	783,034	673,867	8,086	22,462	175,200
Installed cost, $/kW rated DC	$4,346	$4,422	$4,387	$5,446	$4,623	$9,405	$4,427	$12,028	$6,250	$12,250	$6,800
Simple payback (years), 3rd party owned	7	6	7	7	6	14	6	22	8	22	9
Simple payback (years),DPW owned	8	10	10	15	11	>25	10	>25	18	>25	18