Solar Resource and Infrastructure Assessment for the Town of Blandford

Dwayne Breger,[1] Zara Dowling,[1] River Strong,[1] and Alison Bates[2]

1 UMass Clean Energy Extension
2 Colby College

NREL Technical Monitor: Sara Farrar

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Contract No. DE-AC36-08GO28308

Subcontract Report
NREL/SR-7A40-90075
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Suggested Citation
Breger, Dwayne, Zara Dowling, River Strong, and Alison Bates. 2024. *Solar Resource and Infrastructure Assessment for the Town of Blandford*. Golden, CO: National Renewable Energy Laboratory. NREL/SR-7A40-90075. https://www.nrel.gov/docs/fy24osti/90075.pdf.

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National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401
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This work was authored in part by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Solar Energy Technologies Office. The views expressed herein do not necessarily represent the views of the DOE or the U.S. Government.

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REVIEW DRAFT

Solar Resource and Infrastructure Assessment

for

the Town of Blandford

June 30, 2020

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Completed as part of the

National Renewable Energy Laboratory
Solar Energy Information Network
Solar in Rural Communities Program

NREL Subcontract Agreement Number: SUB-2020-10269
NREL Technical Monitor: Joyce McLaren
Deliverable #3: Solar Resource Map & Grid Saturation Analysis

Table of Contents

Executive Summary

This report is a solar resource and infrastructure assessment for the town of Blandford, Massachusetts. The assessment was funded through the National Renewable Energy Laboratory, Solar Energy Innovation Network (NREL SEIN) Solar in Rural Communities Program, as part of a project to develop a Community-Informed Proactive Solar Siting and Financing Model. As a first step, the project lead organization, UMass Clean Energy Extension prepared an assessment of existing infrastructure, resources, and potential solar development opportunities in participating municipalities, including Blandford. This assessment was designed to describe relevant bylaws and infrastructure within the town, identify the types of solar facilities that could be developed, and quantify the total space available for each type of facility.

In this report, we reviewed existing electricity grid infrastructure, and the potential to interconnect additional solar facilities. At the present time, most distribution lines providing electricity to Blandford are over-saturated with authorized and proposed solar projects, and cannot accommodate additional solar projects to interconnect to the grid. We can expect significant upgrades to these circuits, if any of the in-process projects are to proceed, which might then free up additional capacity for new projects. There is one circuit which serves a section of North Blandford Road that is not over-saturated; for the immediate future, this is the most cost-effective location for new large-scale projects to be sited. Meanwhile, most three-phase lines could likely accommodate additional small-to-medium scale projects (under 200 kW), and most single-phase lines could likely accommodate additional projects under 50 kW in size. This description represents the local grid infrastructure as it is – planning for future scenarios of development could include recommendations for areas of grid infrastructure improvement to allow siting of distributed generation in preferred locations. Future scenarios may also include the addition energy storage and other "non-wires alternatives."

Potential sites to consider for solar arrays coupled with energy storage systems include the Blandford Town Hall, the Water Treatment Plant, and the Massachusetts Turnpike Service Plazas. The Residential and Business districts also have a higher concentration of development, energy use, and impervious surfaces, and could potentially be a good area for solar and energy storage systems. Other potential sites for solar identified in this report include the Massachusetts Turnpike Maintenance Facility, the municipal landfill, and the Blandford Ski Area.

There is also significant potential for additional solar arrays on residential rooftops and properties, businesses, small parking lots, and farms.

Depending on the restrictions imposed, there are still a number of large parcels in Blandford which could be appropriate for large-scale, commercial development of solar. Given the extent of forest land cover throughout the town, it may be difficult to identify sites where large arrays could be built without significant clearing of trees, or replacement of agricultural production.

A summary of solar technical potential for different site types is provided in Section 5.8 of this document.

This draft report will be made available to NREL SEIN and the full project team for feedback and revision, before a final public version of the document is issued.

Terminology

The following terms, abbreviations, and acronyms are used in this report.

Terms

Photovoltaic, or "PV," systems are solar arrays composed of panels that generate electricity from sunlight. These panels are a different type of technology than the types of panels used in "solar hot water" or "solar thermal" systems.

Voltage of an electric power line can be thought of as the equivalent of pressure in a water line. The voltage of transmission and distribution power lines is typically measured in kilo-volts (kV). One kilo-volt is equivalent to 1000 volts (V). In residential use in the United States, electrical wires within a household carry electricity at 120 V.

Capacity of a solar array is a description of the instantaneous power output of the panels at top production (i.e, in full sun). It is typically measured in kilowatts (kW) or megawatts (MW). A residential-size solar system is typically 5-10 kW in capacity. Commercial-scale solar arrays are typically 1 MW or greater in size. An average 1 MW array would cover approximately 4-5 acres of land.

Annual generation of a solar array is a measure of the yearly energy output produced by the panels. It is typically measured in kilowatt-hours (kWh) or megawatt-hours (MWh). In New England, annual generation is approximately equal to the array's capacity (in DC) *14% * 8760 hours per year.

DC is the abbreviation for direct current, the type of electricity produced by solar panels. The DC capacity of a solar array is a good indication of its size, and footprint on the landscape.

AC is the abbreviation for alternating current, the type of electricity flowing into the grid from a solar array, after it has gone through a transformer. In the absence of energy storage, a typical DC to AC ratio for solar array capacity is about 1.25:1. However, with energy storage, that ratio can be significantly higher (close to 2:1), since excess electricity can be stored in batteries during the day, and released into the grid during the night, when the panels are not generating electricity.

Solar facility size terms used in this report are in line with current state solar incentive program categories (not with municipal bylaws). That is:

- **Small** systems are 25 kW or less.
- **Medium** systems are 25-500 kW.
- **Large** systems are over 500 kW (0.5 MW) in size.

SMART is the abbreviation for the current state solar energy incentive program (the Solar Massachusetts Renewable Target program). This program replaced earlier solar incentive programs, commonly known as "SREC" programs, in November of 2018, and was further updated through an emergency regulation in April 2020. The SMART regulation includes incentives for projects up to 5 MW AC in size. Additional incentives are available for projects located on buildings, parking lot canopies, landfills, brownfields, and "dual-use" solar and agriculture projects, as well as certain types of projects that benefit public entities, like municipalities. The updated regulation places restrictions on what types of large, ground-mounted projects can receive incentives, if they are sited on undeveloped land designated as BioMap2 Critical Natural Landscapes or Core Habitat, by the state MassWildlife Natural Heritage and Endangered Species Program.

Abbreviations & Acronyms

CEE - UMass Clean Energy Extension
DOER - Massachusetts Department of Energy Resources
FRCOG - Franklin County Regional Council of Governments, the regional planning authority for Franklin County, MA
kV - kilo-volt
kW - kilowatt
kWh - kilowatt-hour
MDAR - Massachusetts Department of Agricultural Resources
MVP - Municipal Vulnerability Preparedness plan, a municipal planning document
MW - megawatt
MWh - megawatt-hour
NREL - National Renewable Energy Laboratory
OSRP - Open Space and Recreation Plan, a municipal planning document
PV – photovoltaic, the type of solar panels that generate electricity from sunlight
PVPC - Pioneer Valley Planning Commission, the regional planning authority for Hampden and Hampshire Counties, MA
SEIN - Solar Energy Innovation Network, a program of the National Renewable Energy Laboratory
sf - square feet

1. INTRODUCTION

This report is a solar photovoltaic resource and infrastructure assessment for the town of Blandford. Blandford is a small, rural community located in the foothills along the western edge of the Connecticut River Valley in Hampden County, Massachusetts. The town has a total land area of 53.5 square miles (34,267 acres). Estimates based on the 2010 census would suggest the town currently has a population of approximately 1,200 residents, living in a total of 623 households. Blandford became a designated Green Community in 2017, joining other municipalities across the state in setting ambitious goals for energy use reduction and encouraging renewable energy development[1].

This assessment was funded through the National Renewable Energy Laboratory Solar Energy Innovation Network (NREL SEIN) Solar in Rural Communities Program, as part of a project to develop a Community-Informed Proactive Solar Siting and Financing Model. The overall goals of the project include development of actionable, site-specific solar development plans for three rural municipalities, as well as development of a series of clear protocols, tools and templates to support implementation of this model in rural communities across the Northeast. The project team includes UMass Clean Energy Extension (CEE), the UMass Department of Environmental Conservation, the Massachusetts Department of Energy Resources (DOER), the Massachusetts Department of Agricultural Resources (MDAR), the Pioneer Valley Planning Commission (PVPC), the Franklin Regional Council of Governments (FRCOG), the Western Massachusetts Community Choice Energy Task Force, UMassFive College Credit Union, Northeast Solar, PV Squared, Co-op Power, and the Towns of Blandford, Wendell and Westhampton.

As a first step, the project lead organization, CEE, prepared an assessment of existing infrastructure, resources, and potential solar development opportunities in each participating municipality, in consultation with a subset of project partners (DOER, PVPC, FRCOG, municipal representatives). This assessment was designed to describe relevant bylaws and infrastructure within the town, identify the types of solar facilities that could be developed, and quantify the total space available for each type of facility.

In this report, we review and describe:

- Existing electricity grid infrastructure, and the potential to interconnect additional solar facilities
- Current municipal solar zoning bylaws and the solar overlay district
- Town conservation priorities and conservation land
- Existing renewable energy facilities
- Priority energy storage sites
- Sites with potentially moderate to heavy electricity use
- Areas available for development on:
    - Residential rooftops and properties
    - Medium to large-scale rooftops
    - Parking lots
    - Landfills and brownfields
    - Other previously developed sites
    - Farms
    - Undeveloped land suitable for commercial development

This draft report will be made available to NREL SEIN and the full project team for feedback and revision, before a final public version of the document is issued.

[1] For more information, see the DOER Green Communities Division website (https://www.mass.gov/green-communities-designation-grant-program).

2. GRID INFRASTRUCTURE ASSESSMENT

2.1 Introduction

In this section, we provide a description of the existing electricity grid infrastructure serving the town, and the potential for new solar arrays to connect to existing circuits. Through this description, we hope to provide a general understanding of how the electricity grid functions, as well as to provide a snapshot of current conditions. Existing grid infrastructure plays a major role in where large solar arrays are built. The cost of connecting solar facilities to the grid varies widely in different locations, and hence is a primary decision-making factor in where solar developers propose to site projects.

It is important to note that while existing grid infrastructure may currently constrain the types of solar projects that can be developed cost-effectively in some locations, the electricity grid is in a constant state of change, and grid components are constantly being upgraded. This description of the current state of the grid may be most relevant to situations in which the town or community members have an interest in the development of a particular site for medium to large-scale solar in the near future. The current state of grid infrastructure within the town may be less relevant to long-term planning. In fact, we suggest that significant town-level planning around solar energy could potentially drive the location of electricity grid upgrades, to allow development in places where community members would prefer to see solar facilities sited.

2.2 Grid Infrastructure Basics

The New England electricity grid is overseen by ISO New England, the regional transmission organization that serves the states of Massachusetts, Maine, New Hampshire, Vermont, Connecticut, and Rhode Island. This non-profit organization is charged with ensuring grid reliability – that is, to continuously balance electricity supply and demand, in Massachusetts and throughout the region. The electricity grid consists of transmission lines, high-voltage lines which carry electricity over long distances, and distribution lines, lower voltage lines which distribute power to individual communities and households. Most transmission lines in Massachusetts are owned by the two major electricity utilities which operate in the state - Eversource (formerly NSTAR and WMECO) and National Grid. Distribution lines are typically owned by the local electricity provider, which could be Eversource, National Grid, Unitil, or a municipal utility. Transmission lines range in voltage from 69-345 kV. When these lines reach a substation, electricity is "stepped down" to a lower voltage, and distributed along 13-34 kV distribution lines.

The "interstate highways" of the electrical grid are 345 kV transmission lines. In western Massachusetts, one 345 kV line runs north-south, east of, but approximately paralleling, the Connecticut River (see **Figure 1**, next page). This line connects the pumped storage facility in Northfield with the Stonybrook Power Plant, an oil and natural gas facility, in Ludlow. A second 345 kV line runs west from the Northfield pumped storage facility, through Ashfield, Plainfield, and Pittsfield, and ultimately across the state line into New York.

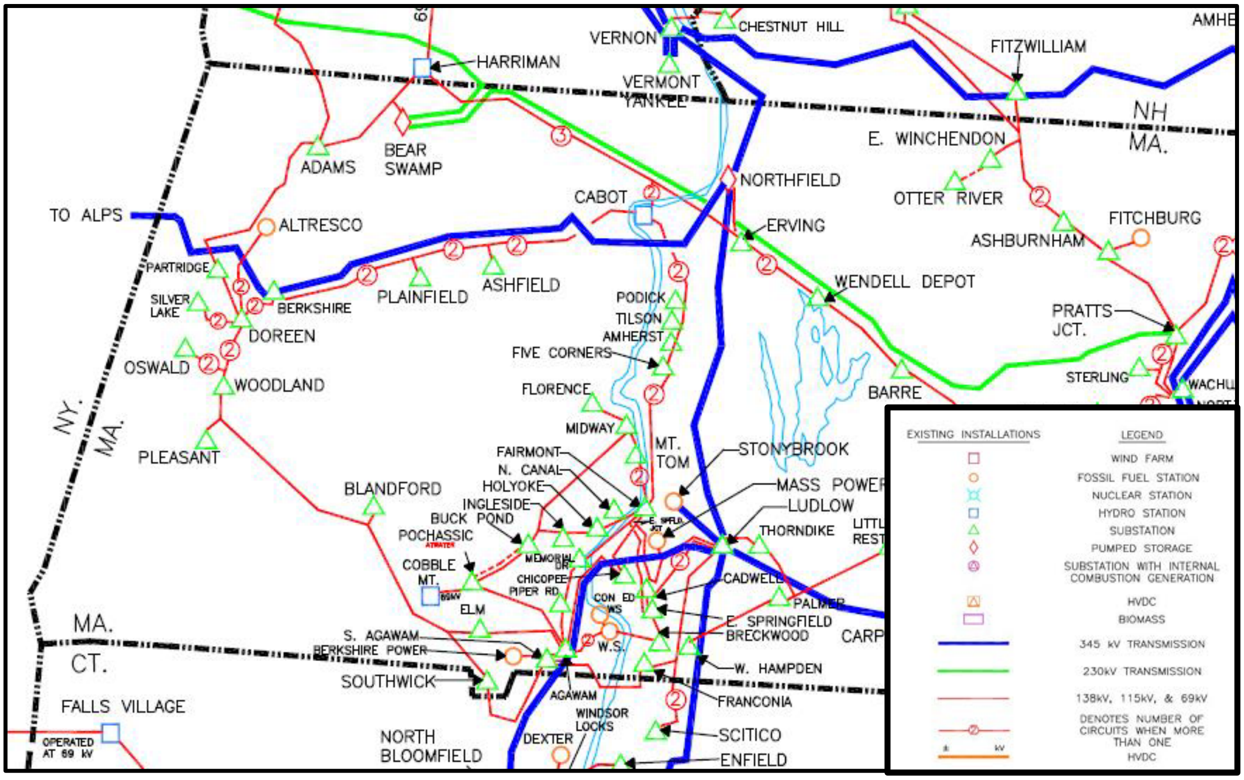


Figure 1 Major electricity transmission lines and substations in western Massachusetts.
Source: ISO New England 2019

2.3 Existing Grid Infrastructure

Blandford is served via a 115 kV transmission line, which connects to the east-west 345 kV line at in Pittsfield, and to an offshoot of the north-south 345 kV line in Agawam. The 115 kV line voltage is stepped down to 23 kV at the Blandford substation, which is located off of North Blandford Road, just west of its intersection with George Millard Road. There are four 23 kV "feeder" circuits that extend from the substation throughout much of the town - 19J1, 19J2, 19J3, and 19J4 (Figure 2). A separate feeder circuit, 29A5, connects to a substation in Southwick, and runs up through Granville into the southern edge of Blandford.

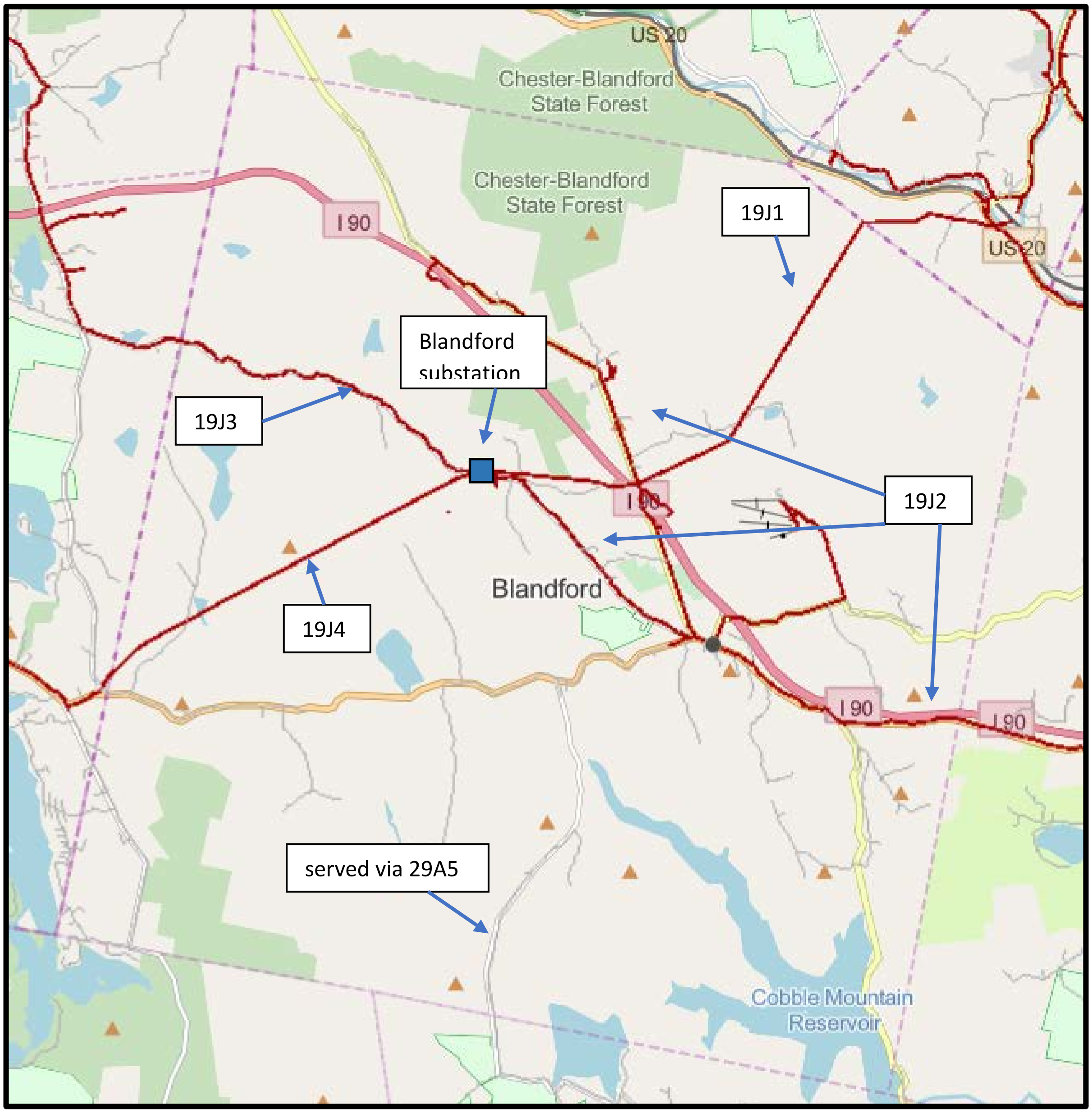


Figure 2 The Blandford substation (blue box) and major distribution lines (red lines) in town.
Source: Distributed Generation Hosting Capacity Map, Eversource 2020

The four 19J feeder circuits provide power to different sections of town, as follows:

- The **19J1** line runs east from the substation, crossing Interstate 90, and heading northeast into Huntington. It does not directly serve any load in Blandford; however, it does connect to the 19J2 line on North Road, west of the Blandford Service Plaza.
- The **19J2** line runs northwest from the intersection with 19J1 along North Road and Chester Road, as far as the Old Chester Road intersection, and provides electricity to the Massachusetts Turnpike Maintenance facility off of Old Chester Road. It also runs southeast from the intersection with 19J1, down North Street, through the center of Blandford, and continues southeast along Route 23, into the town of Russell. From the center of Blandford, the 19J2 line also continues northwest along North Blandford Road, back to the Blandford substation. There is a small subsection that extends a short way down Otis Stage Road. Within Blandford, the 19J2 line connects to single-phase, 23 kV lines serving sections of town north of Interstate 90, as well as much of the eastern portion of town.

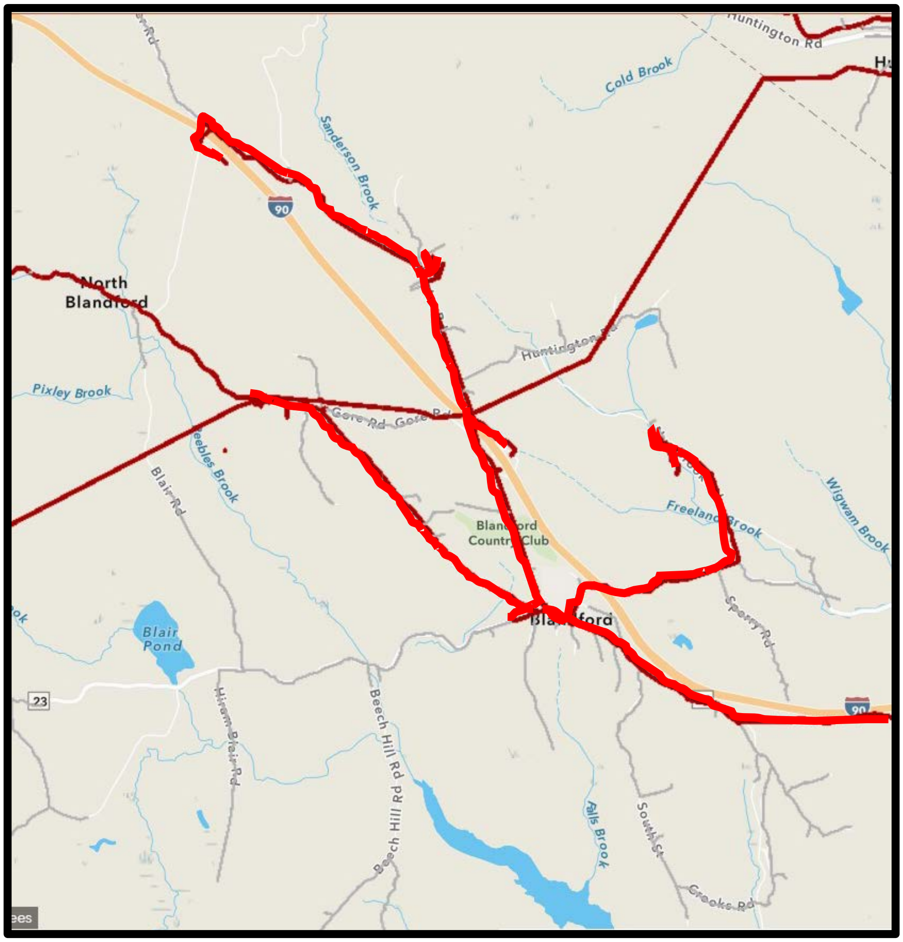
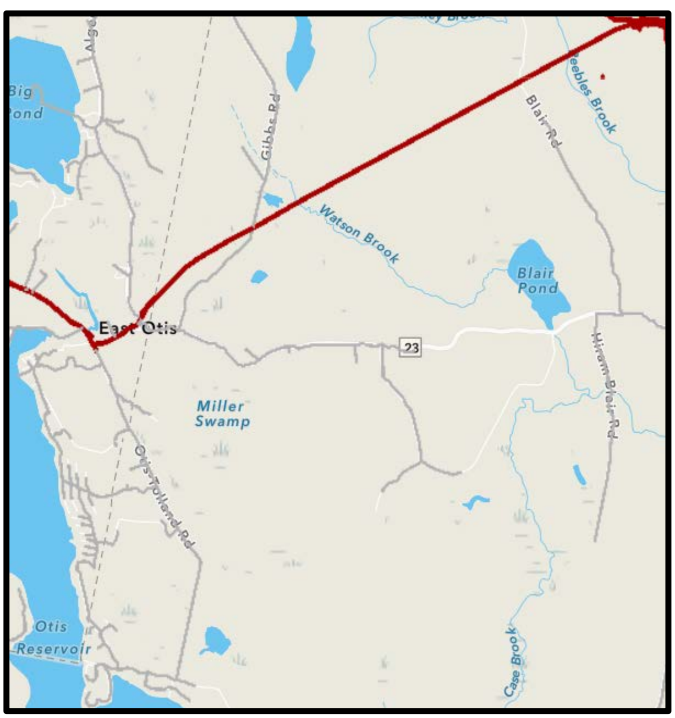


Figure 3 A close-up of the 19J2 feeder circuit, serving much of the northern and eastern sections of town with three-phase power (bright red line), and single-phase power (gray lines). Other feeder circuits are shown in dark red. Source: Distributed Generation Hosting Capacity Map, Eversource 2020

- The **19J3** line runs northwest from the Blandford substation along North Blandford Road, continuing into the town of Otis. The 19J3 line has single-phase 8.32 kV and 23 kV offshoots serving Blair Road and Lincoln Road respectively (**Figure 4**).

Figure 4 A close-up of the 19J3 feeder circuit, serving North Blandford Road with three-phase power (red line), and Blair and Lincoln Roads with single-phase power (gray lines).
Source: Distributed Generation Hosting Capacity Map, Eversource 2020



- The **19J4** line runs cross-country southwest from the Blandford substation, crossing Blair Road and Gibbs Road, and continuing into Otis. The 19J4 line connects to single-phase 8.32 kV lines serving roads along the southwestern corner of town (**Figure 5**).

The **29A5** feeder circuit provides power to Julian Hall Road and a section of Beech Hill Road via a 4.8 kV distribution line running north into Blandford from Granville (see **Figure 2**).

Figure 5 A close-up of the 19J4 feeder circuit (red line), serving Gibbs Road, Route 23, and other roads in the southwest corner of town with single-phase power.
Source: Distributed Generation Hosting Capacity Map, Eversource 2020

2.4 Existing Hosting Capacity

Historically, distribution lines in the electricity grid were designed as somewhat akin to one-way streets, supplying power to homes and businesses from large power plants connected to high-voltage transmission lines. With the addition of solar and wind resources, there are now many energy-generating facilities that seek to interconnect to the grid via distribution lines. These "distributed generation" electricity sources require that distribution lines act as two-way streets instead, allowing for energy to flow into the grid via distribution lines, while still allowing energy to continue to flow outward into individual homes and businesses. Balancing this two-way flow can represent a challenge for ensuring reliability and safety of the grid. This is especially true where distributed generation electricity sources are renewable sources, such as wind and solar energy, which supply electricity to the grid in an intermittent and variable manner. In order to ensure that generation facilities can be connected safely, developers are required to obtain written permission from the local utility company before interconnecting these systems to the electricity grid.

The "hosting capacity" of an electric power line identifies its ability to incorporate distributed generation electricity sources, such as wind and solar. In most places, including those served by single-phase distribution lines, small solar systems of up to 50 kW can be incorporated without adverse impacts on the grid's reliability. In areas served by three-phase power lines, solar systems of up to 200 kW can typically be interconnected without significant challenges. However, for larger systems, it is necessary to ensure there is sufficient capacity available on the distribution line before these facilities can be built and interconnected. Otherwise, power lines or substations may require upgrades before additional distributed generation sources can be interconnected without compromising reliability. While not true across the board, an industry 'rule-of-thumb' is that 6 MW can be connected safely for every 13.8 kV distribution line. In western Massachusetts, where many towns are served by one or a few low-voltage feeder circuits, the local grid can quickly become "saturated," such that there is not sufficient hosting capacity to incorporate additional medium to large solar arrays.

The state of Massachusetts now requires that utilities provide publicly-available maps and data regarding the available hosting capacity of distribution lines, and the level of saturation of individual feeder circuits. This public information lists all projects greater than 25 kW in capacity connected to three-phase lines, and all projects greater than 10 kW connected to single-phase lines. If circuits are currently saturated, it does not mean that no more distributed generation systems can be added to the circuit, but does suggest that upgrades are needed before additional projects can be interconnected. Upgrades may involve significant costs, which the energy facility developer is typically expected to pay for, as a condition of interconnection. Previously, interconnection applications were considered on a project-by-project basis, but recently, ISO New England has determined that multiple projects may be considered together as one group for the purposes of interconnection, in what are known as "Affected System Operator," or Group, studies. This change is anticipated to streamline the review of interconnection requests for projects "queued" up to connect to each circuit. Even if areas currently appear saturated on the map, they may not remain so. Companies developing large, more lucrative solar projects may be able and willing to support significant upgrades to these circuits (either individually or in groups with cost sharing). New upgrades may then open up new hosting capacity.

A listing of distributed generation projects authorized or in process on Blandford feeder circuits is provided in **Table 1.** It is not known how many of the projects currently "in process" will ultimately be built and connected to the grid. Individual descriptions of the hosting capacity of the three main circuits which feed town (19J2, 19J3, and 19J4) are provided below:

The **19J2** feeder circuit serving northern and eastern portions of town has a maximum hosting capacity with current infrastructure of 5,000 kW (5 MW). This feeder is entirely saturated, with 5,969 kW of projects already authorized, including two large projects in Blandford (1 MW and 4.9 MW). An impressive additional 51,000 kW (51 MW) of capacity have been proposed and are in process in this circuit, within the towns of Blandford and Russell. In Blandford, this includes four additional large solar arrays of 5.0 MW, 5.0 MW, 6.6 MW, and 19.2 MW, respectively. If all these projects were to move forward, the line would be over-saturated by 1020%, suggesting significant upgrades would be required to allow these projects to progress.

The **19J3** feeder circuit, serving part of the northwestern portion of town, has 1,560 kW of distributed generation authorized to interconnect, including a 1,500 kW wind facility in Otis, and several medium-scale solar projects in Becket. There are currently no projects in progress, and only 31% of existing hosting capacity is being utilized. This suggests that a large solar array could be built in this part of town without significant upgrades or major interconnection costs.

The **19J4** feeder circuit, serving part of the southwestern corner of town, also has a maximum hosting capacity of 5,000 kW (5 MW). Authorized projects on this circuit total 3,530 kW (3.5 MW), or 71% of hosting capacity, comprising two large solar arrays in Blandford (1.0 MW and 4.9 MW), as well as a small scale array in Russell. There are an impressive 31,497 kW (31.5 MW) of solar proposed and in progress on this circuit, including two large solar facilities proposed for Blandford (4.7 MW and 5.0 MW), three large arrays proposed for Tolland (5.0 MW each), two large arrays proposed for Otis (1.4 MW and 5.0 MW), and an 0.4 MW array proposed for Sandisfield. If all arrays were to proceed, they would over-saturate the circuit at 630%, again suggesting that upgrades will be required for all these projects to proceed.

In summary, the 19J2 and 19J4 feeder circuits are over-saturated with authorized or in-progress projects, with significant proposed capacity increases in progress. We can expect significant upgrades to these circuits, if any of the in-process projects are to proceed. The 19J1 circuit, which does not currently serve electricity load in Blandford, is also over-saturated with in-progress projects. The 19J3 circuit is the only one in town that could currently host large, newly-proposed projects without major upgrades. For the immediate future, the section of North Blandford Road served by this circuit is the most cost-effective location for new large-scale projects to be proposed. Meanwhile, most three-phase lines could likely accommodate additional small-to-medium scale projects (under 200 kW), and most single-phase lines could likely accommodate additional projects under 50 kW in size. This description represents the local grid infrastructure as it is – planning for future scenarios of development could include recommendations for areas of grid infrastructure improvement to allow siting of distributed generation in preferred locations. Future scenarios may also include the addition of what are known as "non-wires alternatives," which can reduce the needs for grid upgrades. These are technologies like energy storage, energy efficiency, demand-response, and grid software, which reduce the need for additional power lines to be added to the grid.

Circuit Name	Municipality	Capacity (kW)	Facility Type	Status of Project	Complete Application Date	Interconnection Agreement Sent Date	Authorization to Interconnect Date	Expedited/ Standard / Complex Project	Device Type
19J1	Huntington	990	Solar	In Process	6/20/2018			STD	Recloser
	Russell	495	Solar	In Process	6/13/2018			EXP	Recloser
	Huntington	4980	Solar	In Process	6/21/2018			STD	Recloser
19J2	Russell	49	Solar	Authorized	9/5/2014	12/16/2014	10/6/2015	EXP	Recloser
	Blandford	1000	Solar	Authorized	2/27/2017	11/17/2017	11/15/2019	STD	Recloser
	Blandford	4920	Solar	Authorized	7/20/2017	5/7/2018	12/27/2019	COMP	Recloser
	Russell	2988	Solar	In Process	10/17/2017	6/1/2018		COMP	Recloser
	Blandford	4980	Solar	In Process	9/12/2018			EXP	Recloser
	Blandford	4450	Solar	In Process	8/1/2018	8/5/2019		COMP	Recloser
	Russell	4998	Solar	In Process	10/29/2018			EXP	Recloser
	Russell	5000	Solar	In Process	12/19/2018			EXP	Recloser
	Blandford	19200	Solar	In Process	1/14/2019			EXP	Recloser
	Blandford	6607	Solar	In Process	10/7/2019			EXP	Recloser
	Russell	2750	Solar	In Process	1/15/2020			EXP	Recloser
19J3	Otis	1500	Wind	Authorized	12/17/2014	7/27/2015	3/9/2018	COMP	Recloser
	Becket	33	Solar	Authorized	1/22/2018	2/2/2018	7/18/2018	EXP	Recloser
19J4	Tolland	3500	Solar	Authorized	1/31/2013	9/6/2013	10/3/2014	COMP	Recloser
	Blandford	4700	Solar	In Process	8/18/2017	12/4/2017		COMP	Recloser
	Tolland	4980	Solar	In Process	10/17/2017	2/27/2018		COMP	Recloser
	Blandford	4998	Solar	In Process	2/22/2018			STD	Recloser
	Otis	1375	Solar	In Process	5/7/2018			STD	Recloser
	Tolland	4998	Solar	In Process	7/24/2018			STD	Recloser
	Otis	4998	Solar	In Process	12/11/2018			EXP	Recloser
	Sandisfield	400	Solar	In Process	9/21/2018			EXP	Recloser
	Tolland	5000	Solar	In Process	6/20/2019			EXP	Recloser

Table 1 Medium and large-scale (> 25 kW) distributed generation projects authorized or in process on all feeder circuits which run through Blandford. Source: DOER Circuit Analysis Pre-Screen Tool, April 2020.

3. MUNICIPAL PLANNING DOCUMENTS

3.1 Planning Documents & Bylaw Review

We conducted a brief review of relevant planning documents and municipal bylaws, and identified the following:

- The town does not have a Master Plan.
- The town has a Municipality Vulnerability Preparedness (MVP) plan, which is referenced in *Potential Energy Storage Sites*.
- The town's zoning bylaws include a section which specifically addresses solar development. These bylaws were updated in August 2019, and the solar zoning section was further updated on June 22, 2020. The content of these bylaws is addressed in Section 3.2 *Solar Zoning Bylaws*.
- The town does not have any municipal wetlands bylaws.
- The town has an Open Space and Recreation Plan (OSRP), which was completed in 2003. A summary of town conservation priorities from the plan is briefly outlined in Section 3.3 *Open Space and Recreation Planning.*

3.2 Solar Zoning

Blandford's zoning bylaw was updated in August 2019. Facing high solar development pressure, the town voted to implement a temporary moratorium on ground-mounted solar arrays. This moratorium was lifted on June 22, 2020, when solar zoning updates were voted in at town meeting.

The town has five types of zoning districts, including three primary districts (Agricultural, Business, and Residential), and two overlay districts (Long Pond Watershed Protection and Flood Plains). The Agricultural district covers the majority of the town.

Roof-mounted solar PV arrays are an allowed use in Agricultural, Residential, and Business districts.

Under the updated bylaw, ground-mounted arrays are categorized based on size and capacity:

- "Small" ground-mounted arrays are up to 10 kW DC, or occupy less than 1750 sf.
- "Medium" ground-mounted arrays are 10-250 kW DC, or occupy 1750 to 40,000 sf.
- "Large" ground-mounted arrays are more than 250 kW DC, or occupy more than 40,000 sf (about 1 acre).

Ground-mounted solar arrays are allowed in the Agricultural and Long Pond Watershed Protection districts, with approval requirements dependent on size:

- Small ground-mounted arrays of no more than 9 feet in height require a building permit. Small arrays 9-20 feet require site plan approval by the Planning Board. Small arrays over 20 feet in height require a site plan review and issuance of a special permit by the Planning Board.
- Medium ground-mounted arrays require site plan approval by the Planning Board.
- Large ground-mounted arrays require a site plan review and issuance of a special permit by the Planning Board.

Ground-mounted arrays do not appear to be allowed in Business or Residential districts.

Large ground-mounted arrays require property line setbacks of 100 feet on all sides, can be no more than 25 feet high, and require a minimum lot size of 12 acres.

The existing bylaw requires that ground-mounted solar arrays be designed to maximize the preservation of on-site and abutting natural and developed features, including retaining existing vegetation to the greatest extent possible, and minimizing tree removal. No more than 50% of the land parcel utilized for solar array may consist of land requiring clearing of forest. On agricultural and environmentally sensitive sites, no more than 50% of the total land area proposed for the solar array may be occupied by the solar panels, with the remainder of the land remaining as undeveloped open space left in its natural state. Arrays must be designed to be compatible with continued agricultural use of the land whenever possible.

In order to minimize erosion, no installations are allowed on slopes greater than 15% grade.

3.3 Open Space and Recreation Planning

Blandford's *Open Space and Recreation Plan* was completed in 2003, with significant public comment and input. The plan highlighted the value community residents place on the town's rural character, and raised concern about the impacts of increasing residential development. Priorities identified in the plan included farmland preservation, preserving the historic town center, protecting scenic views along roads and ridgelines, and protecting public drinking water resources for Blandford and neighboring towns. The plan identified BioMap habitat as the land to focus on for protection of wildlife.

4. COMMUNITY INFRASTRUCTURE

4.1 Introduction

In this section, we briefly review community infrastructure of relevance to solar energy development and energy storage. Information included in this section was drawn from a variety of sources, including:

- A brief survey of municipal representatives involved in this project
- Municipal planning documents
- Department of Energy Resources (DOER) databases of renewable energy generation facilities
- Reference USA database of businesses by zip code
- Community Involved in Sustaining Agriculture Farm Finder
- MassGIS geospatial data layers

Associated maps are provided in Appendix A of this document.

4.2 Existing Renewable Energy Infrastructure

The town currently has no municipally-owned solar facilities. According to DOER, there are 39 residential solar arrays in town, totaling 335 kW of capacity. There are two commercial, large ground-mounted solar arrays identified by the town, and also listed by DOER – a 1 MW DC array on North Blandford Road, and a 7.2 MW DC (4.9 MW AC) array on Chester Road. A third commercial ground-mounted array with a capacity of 4.7 MW appears to have received municipal and DOER approval to be built on Otis Stage Road, and a fourth array (5.23 MW) proposed for Chester Road is going through the municipal permitting process. Eversource, the electrical utility, has received interconnection applications for an additional four commercial projects totaling 35.2 MW (4.5, 5.0, 6.6 and 19.2 MW respectively). It is not clear how many of the proposed projects will ultimately move forward to construction.

4.3 Potential Energy Storage Sites

Energy storage systems help to balance differences between electricity demand and generation, and are especially valuable components for intermittent energy sources like wind and solar, which do not produce energy 24 hours a day, and may not be producing during times of peak demand.

Energy storage systems have the potential to allow larger solar facilities to be built in areas where interconnecting a medium or large solar array could otherwise exceed the ability of the local distribution lines to accommodate additional renewable energy capacity. Prices of battery storage are dropping quickly, but energy storage is still a relatively expensive technology. At present, these types of systems typically require loads larger than residential-scale to be cost-effective where cost is the sole consideration, but these systems can provide energy reliability during outages, which means that they also provide additional value in terms of public health and safety.

Blandford officials and volunteers are well-aware of the importance of energy storage in town. As part of the Municipal Vulnerability Planning process, workshop participants identified the need to increase storage capacity for electricity generated by renewable resources, and to ensure back-up power for a more resilient grid.

In this section, we briefly review sites where considering energy storage may be of value.

4.3.1 Town Hall

The Blandford Town Hall (1 Russell Stage Road) is one of the town's more heavily-used municipal buildings. The town does not have an official emergency shelter, but the internal, 'informal' plan is to use the Town Hall in case of emergency. One challenge is that the Town Hall does not currently have a back-up energy system. The only system in the Town Hall which is connected to back-up power is the sprinkler system, meaning that when power goes out, all other systems go offline. Town staff are eager to invest in back-up power for the building, and would like to understand the feasibility of relying on solar battery storage as opposed to a gas-powered generator. The Town Hall has both a flat roof section (estimated by the town to be a half-acre in size), and a paved parking lot (estimated by the town to be a half-acre in size), which could be suitable for solar. The Town Hall is one of the two largest municipal electricity users – annual electricity usage data for the program can be derived through the Mass Energy Insight portal.

One challenge noted by town staff as part of the MVP process was flooding in the basement and back entrance of the Town Hall. During rainstorms, water flows from a slope in the back (north) of the property toward the rear entrance of the building, and enters the Town Hall through the door. Town Hall staff use temporary measures, such as hay bales and leaf piles, on an ad hoc basis to redirect the sheet flow to other areas of the parking lot. Water also accumulates in the basement, where it threatens the building's electrical switch gear. Located on a cement slab elevated five inches above ground level, the electrical panel has been breached by flood water before. The basement has two sump pumps which work to keep the water at a manageable level, but these pumps are not connected to back-up power. When the building loses power during a rain event, the sump pumps stop running and the basement begins to fill up with water. Sheet flow from the adjacent parking lot, runoff from the flat roof, and a seasonal high water table may also be contributing to basement flooding.

4.3.2 Water Treatment Plant

The Blandford Water Department provides water to approximately 67% of the town's population. There are a total of 238 connections, including two Interstate 90 (Massachusetts Turnpike) service areas, serving an estimated 875 people. Blandford Water Department is supplied solely from Long Pond Reservoir. The treatment plant, located off of Gibbs Road, adjacent to Long Pond, went online in July 2007, with an average day design flow of 130,000 gallons per day.

There is no corresponding municipal sewer system in Blandford – buildings are served by private septic systems.

4.3.3 Businesses and Institutions

The town of Blandford does not have a large amount of commercial or industrial development, and therefore has few areas which might have high electricity load, and which could therefore benefit from energy storage. There are no schools located within town – Blandford students are served by the Gateway School District, and typically attend Chester Elementary in the neighboring town of Chester, or Gateway Middle School and High School, in neighboring Huntington.

The town does have adjacent Business and Residential districts within the town, where development is more tightly concentrated, and where there is potential for a higher collective electricity load.

In addition, we identified the following commercial and non-profit entities active in town, which could have higher electricity use than local residences:

- Blandford Service Plaza Eastbound and Westbound (I-90 Milepost 29) – These establishments include several businesses and a Gulf Oil gas station.
- Blandford Animal Hospital (46 Woronoco Road)
- Blandford Country Club (17 North Street) – This establishment may only experience heavy use seasonally.
- Blandford Country Store/Blue Rhino (98 Main Street)
- Blandford Ski Area (41 Nye Brook Road) – This establishment is currently shut down.

- Chester Granite Company (2200 Algerie Road)
- Cooper Excavating & Truck Inc (2 Beulah Land Road)
- First Congregational Church (91 Main Street) – This is a historic property, and would require Historic Commission approval prior to installation of a solar array.
- K's Kloset (239 Otis Stage Road)

4.3.4 Residential Sites

During the MVP process, workshop participants noted that the town has a high population of seniors, many of whom are living alone. Participants also identified a fiercely independent mentality among town residents, and noted many might prefer to "shelter in place," in case of an emergency. Given these characteristics, residential-scale energy storage systems may be of interest from a public safety perspective, if installation of such systems is economically feasible.

4.4 Other Relevant Infrastructure

4.4.1 Parking Lots

As discussed above, the Town Hall has an approximately half-acre, paved parking lot, which could be evaluated for solar development. The town center has other, small parking lots – for example, outside the Post Office. The Massachusetts Turnpike runs through Blandford, and there are large parking areas at the Westbound and Eastbound Service Plazas, as well as at the Massachusetts Turnpike Maintenance Facility. In addition, there is a large parking lot at the Blandford Ski Area, which is currently shut down.

4.4.2 Landfills and Brownfields

The Massachusetts Department of Environmental Protection does not list any identified brownfields within the town of Blandford.

There is one municipally-owned landfill site, located off of Huntington Road, which could be evaluated for solar potential.

4.4.3 Farms

There are a number of farms in town, which could be approached regarding their interest in agriculturally-related energy projects. These include:

- Blueberry Hill Farm – 56 Chester Road
- Falls Brook Farm – 39 Herrick Road
- Ramona Farms – 12 George Millard Road
- Walnut Hill Farm – 35 Gibbs Road
- Windy Ridge Farm – 30 Huntington Road

5. SOLAR RESOURCE ASSESSMENT

5.1 Introduction

In this section, we identify, summarize, and attempt to quantify the available solar resources in the town of Blandford. We identify a number of different types of potential resources in this assessment, including:

- Residential-scale solar resources (roof-mounted and small ground-mounted systems)
- Medium to large-scale roofs (greater than 5,000 sf)
- Parking lots
- Landfills and brownfields
- Other previously developed land
- Undeveloped land suitable for commercial-scale solar development

This analysis was a desktop analysis, incorporating publicly-available geospatial data layers downloaded from MassGIS, the state's Bureau of Geographic Information. It is important to recognize that information contained within these data layers may be out-of-date, inaccurate, or include irregularities that reduce the accuracy of this analysis. For example, tax parcel data included in this analysis was last updated in June 2019. Boundaries of conserved land outlined in the MassGIS Protected and Recreational Open Space data layer do not appear to line up perfectly with tax parcel boundaries. This should be considered as a preliminary analysis, providing direction regarding where more in-depth site assessments can be conducted.

5.2 Residential-Scale Resources

We are currently working with National Renewable Energy Laboratory (NREL) experts on a detailed analysis of rooftop solar potential on small buildings in Blandford. This nuanced analysis will be based on lidar (light detection and ranging) data, a remote-sensing technique that uses laser light to densely sample surfaces, providing detailed information about roof pitch, aspect, and shading by trees. This analysis will be included in the final report to the town. In the current analysis, we provide several rough estimates of solar potential, based on MassGIS structures data, and NREL solar potential estimates for small buildings. For this analysis, we follow NREL's definition of a "small building" as one with a roof area of 5,000 sf or less.

Based on MassGIS Structures data, the town of Blandford has a total of 1,282 small buildings, totaling 1,598,704 sf in roof area. The majority of these buildings are residential structures, including houses, garages, and sheds, although some small businesses and farm outbuildings are included in this total. The National Renewable Energy Laboratory (NREL) estimates that nation-wide, an average of 26% of the roof area of small buildings is suitable for solar[2]. Therefore, we could project a total technical solar resource of 415,663 sf available, equivalent to 6,651 kW (6.7 MW) of solar. Of course, this is the *technical* resource available. It is not feasible to connect solar panels to electric lines at all locations, some roofs may not have the structural integrity necessary to support solar panels, and it is not cost-effective to install panels in locations where the available space is small.

NREL provides additional data and estimates regarding small building roof space in western Massachusetts[2]. In Blandford, approximately 75% of small buildings have some roof space suitable for solar. Of small buildings in western Massachusetts with some potential for solar, approximately half have at least 10 m^2 (roughly 100 sf) of roof available for solar. If we assume 75% of small buildings in Blandford have some space available for solar, and 50% of those have at least 10 m^2 available, we can estimate that about 481 buildings could support at least 10 m^2

[2] Gagnon, P., Margolis, R., Melius, J., Phillips, C. and Elmore, R., 2016. *Rooftop solar photovoltaic technical potential in the United States. A detailed assessment* (No. NREL/TP-6A20-65298). National Renewable Energy Lab.(NREL), Golden, CO (United States).

of solar (at least 1.75 kW). Let us consider this the maximum number of buildings which could economically support solar in town. The average roof area of a small building in Blandford is 1,317 sf. If we assume half of that roof space has the proper aspect for solar, and multiply the average roof space by the number of buildings, we arrive at a slightly more conservative estimate of residential solar potential – 5,065 kW (5.1 MW).

A third, and perhaps more practical, estimate of residential-scale solar potential can be derived by considering the potential for roof-mounted OR small-scale ground-mounted arrays to support residential use. Blandford has a total of about 623 households. If 75% of them were to install solar at their residences, either on a rooftop, or as a ground-mounted system, the town would ultimately have 468 residential systems. The average size of a residential solar system in Blandford currently is 8.59 kW. By this method, we can estimate a potential residential solar capacity of 4,014 kW (4.0 MW).

5.3 Medium to Large-Scale Rooftops

Table 2 (next page) provides a list of the 20 largest roofs in Blandford. This list includes two municipal buildings (the Town Hall and Water Treatment Facility), five Massachusetts Turnpike buildings (maintenance facilities and service plazas), six barns, the Blandford Ski Area lodge, and a number of private residences with large garages.

As described above, we are currently working with NREL on a more detailed analysis of rooftop solar potential using lidar data. The numbers provided in the table reflect a rough estimate of technical potential, based on nationwide data from NREL. NREL's analysis suggests that virtually all medium and large-scale buildings have a roof plane suitable for solar, and that on average, approximately 49% of area on medium-scale roofs is available[2]. Our technical estimates are based on this statistic. As described above, this technical potential is not reflective of roof structural integrity or economic viability, and on-the-ground assessments would need to be conducted.

Blandford has 25 buildings with roofs over 5,000 sf, totaling 186,985 sf of roof space. An estimated 91,623 sf are suitable for solar. Our estimate of total technical potential on medium to large-scale roofs is 1,466 kW (1.5 MW).

Structure	**Street Address**	**Total Roof Area** (sq ft)	**Estimated Technical Solar Potential** (kW)
Town Hall	1 RUSSELL STAGE ROAD	18,387	144
Barn & Stables	54 GIBBS ROAD	16,047	126
Barn attached to house	12 GEORGE MILLARD ROAD	13,721	108
Mass Turnpike Service Plaza - Westbound	40 WEST NORTH STREET	11,848	93
Private Residence, with Garage	1 HUNTINGTON ROAD	7,650	60
Private Residence, with Garage	8 NYE BROOK ROAD	7,529	59
Blandford Water Treatment Facility	GIBBS ROAD	7,337	58
Mass Turnpike Maintenance Facility	3 OLD CHESTER ROAD	7,266	57
Mass Turnpike Maintenance Facility	3 OLD CHESTER ROAD	6,861	54
Mass Turnpike Service Plaza - Eastbound	32 EAST NORTH STREET	6,561	51
Barn	55 WORONOCO ROAD	6,455	51
Barn	56 CHESTER ROAD	6,230	49
Private Residence	15 CROOKS ROAD	5,903	46
Private Residence	10 NORTH STREET	5,621	44
Private Residence	56 CHESTER ROAD	5,599	44
Ski Lodge	41 NYE BROOK ROAD	5,599	44
Private Residence, with Barn	167 CHESTER ROAD	5,523	43
Barn	24 SHEPARD ROAD	5,448	43
Mass Turnpike Maintenance Facility	3 OLD CHESTER ROAD	5,371	42
(*building type unclear*)	NORTH BLANDFORD RD	5,317	42

Table 2 A list of the 20 largest roofs identified in Blandford.

5.4 Parking Lots

We identified a number of sites with at least 0.5 acres of parking lot or paved area in town. The Blandford Town Hall has a 0.5 acre parking lot, which could accommodate a solar parking canopy. The Blandford Ski Area is not currently active, but the dirt parking lot at this site is about 4 acres in size. There are also a number of small parking areas, particularly in the Business district, which are not quantified here.

The Massachusetts Turnpike Service Plaza Westbound has a 3-acre parking lot, while the Eastbound Plaza has a 2-acre lot. In addition, there is a nearby gravel lot which appears to be 0.75 acres in size. The Massachusetts Turnpike Maintenance Facility has a large paved area, approximately 2 acres in size.

Potential sites for parking canopies are summarized in **Table 3** (next page). Technical estimates are based on a packing density of 263 kW per acre[3]. Our estimate of total technical potential on the listed parking lots is 3,220 kW (3.2 MW).

[3] Krishnan, Ram. 2016. *Technical solar photovoltaic potential of large scale parking lot canopies*. Dissertation, Michigan Technological University.

Location	**Approximate Area** (acres)	**Estimated Solar Technical Potential** (kW)
Town Hall	0.5	130
Mass Turnpike Service Plaza - Westbound	3	790
Mass Turnpike Service Plaza - Eastbound	2	525
Mass Turnpike Service Plaza - adjacent gravel lot	0.75	200
Mass Turnpike Maintenance Facility	2	525
Ski Lodge	4	1050

Table 3 Parking lots and paved surfaces identified in Blandford.

5.5 Landfills and Brownfields

The town's transfer station sits on an 8.5 acre parcel, which we assumed to be the site of the former landfill. Much of the site has now grown in with trees. About 0.5 acres are paved, or occupied by the town's transfer station building. If the remaining 8 acres were to be developed for solar, the expected maximum capacity would be about 1.6 MW. As previously noted, there are no identified brownfields in Blandford.

5.6 Agricultural Resources

Blandford has a number of farms, and significant acreage in agricultural production. Based on MassGIS Land Cover data, some 635 acres are in pasture, hay production, or cultivation. Eleven properties totaling 192 acres currently are included in the Chapter 61a program for the purposes of agricultural production (this figure does not include productive woodlots).

Opportunities are available to site solar projects on barn roofs. Other types of solar development – such as systems designed to support on-farm electricity use, solar parking canopies to protect farm equipment, or dual-use systems developed to allow continued use of the land underneath the panels for agriculture – may be appropriate for some sites. On-farm solar potential can be further explored in conjunction with the Massachusetts Department of Agricultural Resources.

5.7 Commercial-Scale Development Sites

As a final step in this analysis, we explored the potential for large-scale commercial solar development. Significant portions of the town are currently undeveloped. Mass Audubon's analysis[4] indicates 32,394 acres (95%) are in a "natural" condition, 1,221 acres (4%) are "open" land, and 439 acres (1%) are developed. Thirty-six acres were developed over the 5-year period between 2012 and 2017 – relative to its land area, Blandford ranked 319 out of 351 municipalities in terms of its pace of development over that time period. Between 2005 and 2013, 12 acres were developed (rank, 331 out of 351). Between 1999 and 2005, 174 acres of natural land were converted to development, and the town ranked 83 out of 351, again, relative to its size.

A total of 16,494 acres (48%) of land in town are permanently conserved, placing Blandford 18th in the state in terms of conserved land, relative to its size. A total of 2,225 acres were conserved in Blandford between 2012 and 2019, including 216 acres of BioMap2 Core Habitat, 1,744 acres of BioMap2 Critical Natural Landscape, and 104 acres of land ranked by The Nature Conservancy as "resilient."

[4] Ricci, E.H., J. Collins, J. Clarke, P. Dolci, and L. de la Parra. 2020. Losing Ground: Nature's Value in a Changing Climate. Massachusetts Audubon Society, Inc., Lincoln, Massachusetts, 33 pp.

For our analysis, we considered properties with a minimum lot size of 5 acres – equivalent to approximately 1 MW of solar development. In Blandford, there are 497 "large" parcels with an area of 5 acres or more, totaling some 32,182 acres. After removing permanently protected land, and land unlikely to be developed (e.g. cemeteries), 424 large parcels, totaling 15,740 acres, remain. Further removing wetland areas, and a minimum 25 ft buffer zone around them, yields a total of 397 parcels with at least 5 developable acres, a total of 13,051 acres available for development (Scenario 1).

The current state solar incentive program does not provide incentives for solar development on land identified in state databases as important habitat conservation land – designated either as BioMap2 Core Habitat or Critical Natural Landscapes – or for development on parcels on which more than half of property receives this designation. Further excluding these parcels, and BioMap2 habitat on developable parcels, yields a total of 257 parcels with 5 or more acres available for development, totaling 5,281 acres (Scenario 2).

Blandford's current bylaw prohibits development on slopes of greater than 15% grade. Eliminating locations with a steeper grade, while still maintaining at least 5 acres available for development, yields a total of 202 parcels, totaling 3,435 acres (Scenario 3).

Eliminating properties on which a structure worth more than $25,000 currently sits leaves a total of 91 parcels available for development, totaling 1,498 acres (Scenario 4).

In sum, approximately 5% of all land contained in large (>5 acre parcels) is available for commercial-scale development, once existing legal protections, habitat protection standards, slope considerations, and siting off of properties that may already contain houses, are considered.

These values do not include additional considerations regarding existing land cover. Blandford's current bylaws call for avoiding forest clearing on more than 50% of a parcel identified for solar development. Only 38 of the 497 large parcels identified in this assessment had less than 50% forest cover. Among the 91 parcels and 1,498 acres that met other criteria used in this analysis, the average forest cover was 80%. A total of 41 of these parcels had at least 2.5 acres of unforested land, suggesting at least 5 acres could be developed without clearing more than half of the site of forest. However, for a number of these sites, a significant proportion of the remaining land is in agricultural production. Our desktop analysis suggests that 11 large parcels, totaling 160 acres, could be developed, without more than half of the parcel being cleared of forest or stripped of agricultural production. However, some of these sites are currently performing other functions – for example, serving as golf courses.

5.8 Summary

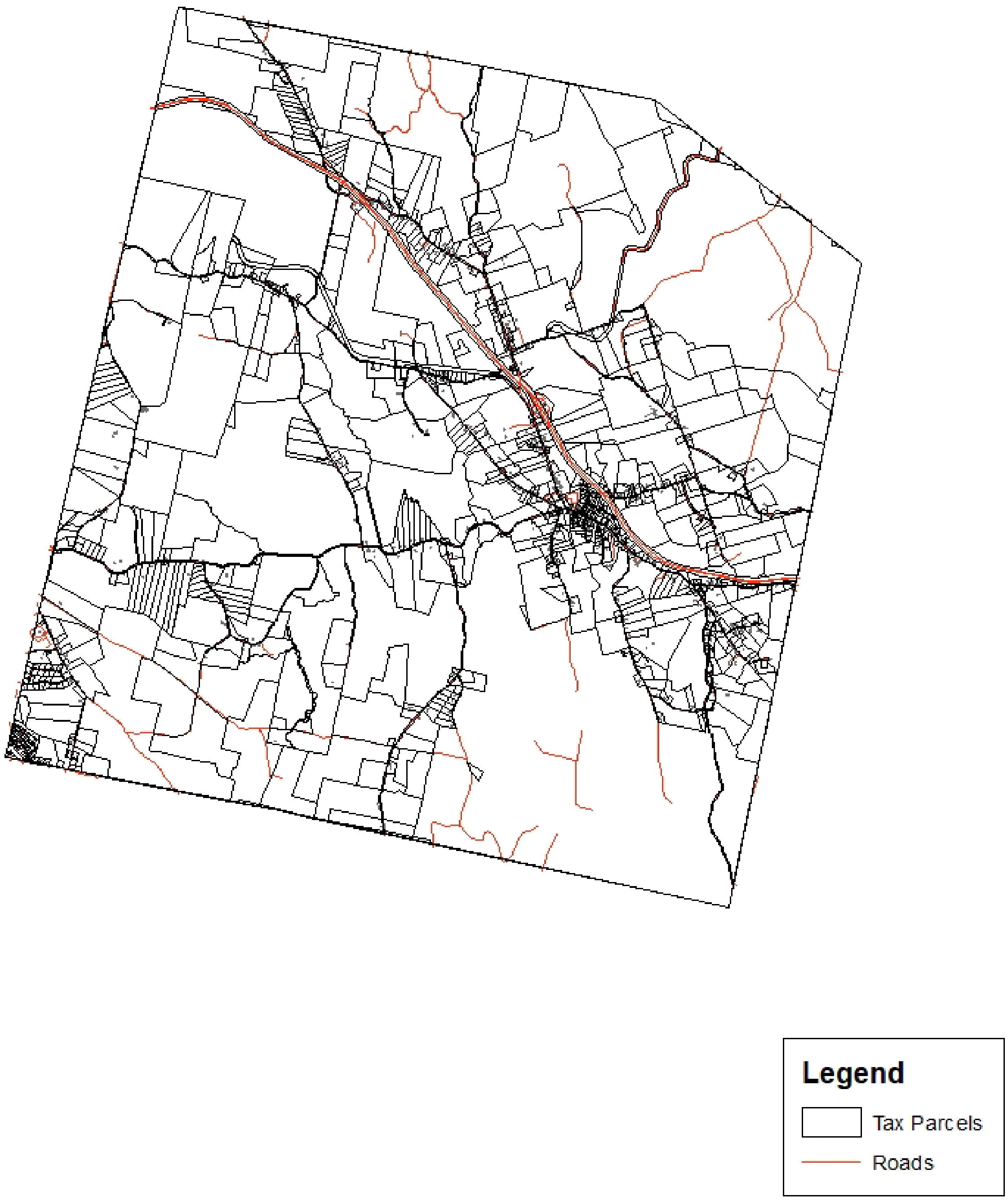
Table 5 below provides a summary of solar resources identified in this assessment.

Resource Type	Resources Available	Estimated Technical Potential
Residential-Scale Solar	- Estimated 415,700 sf of small building roof space suitable for solar - Estimated 962 buildings (75%) could support some solar - Estimated 481 buildings (38%) could support at least 1.75 kW of solar	At least 4.0 MW, if 75% of households can install a roof or ground-mounted system* **More detailed assessment forthcoming*
Medium to Large Scale Roofs	-Estimated 91,600 sf of large building roof space suitable for solar	Estimated at 1.5 MW
Parking Lots	- 0.5 acre lot at Town Hall - 4 acre dirt parking lot at Ski Area -5.75 acres at MA Turnpike Service Plaza areas -2 acres at MA Turnpike Maintenance Facility	3.2 MW, if all sites listed were to be developed
Landfills and Brownfields	- 8.5 acre former landfill property includes 0.5 acres of pavement, plus municipal transfer station	Maximum of 1.6 MW, if entire 8 acres were to be developed
Agricultural Resources	- Active farms and private residences with large barn roofs - Estimated 635 acres in agricultural production - Approximately 192 acres in Chapter 61a program for agriculture	Dependent on project type
Undeveloped Land	- 91 large land parcels have at least 5 acres that are not protected, meet current state solar incentive criteria, municipal slope requirements, and do not have a structure worth more than $25,000 on the property = 1,498 acres - 11 large land parcels could be developed without clearing more than half the site of forest or displacing agriculture from more than half of the property = 160 acres	Approximately 1 MW per 5 acres: 1,498 acres = 300 MW 160 acres = 32 MW *It is not expected that all undeveloped land available would be built out for solar development.*

Appendix A – Maps of Solar Resources and Infrastructure

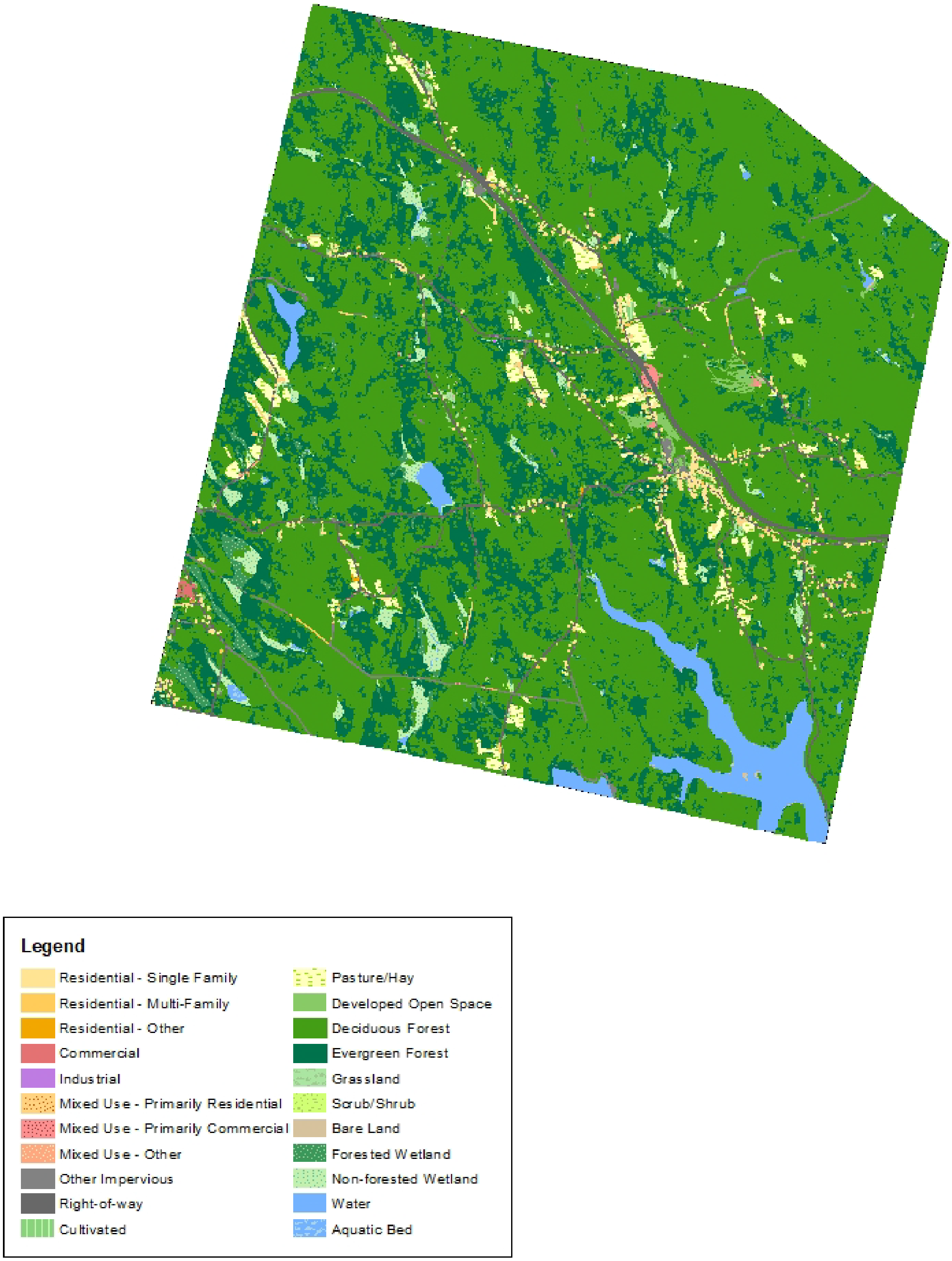
A.1 Roads and Property Lines

Data from MassGIS Tax Parcel data (https://docs.digital.mass.gov/dataset/massgis-data-standardized-assessors-parcels) and MassDOT roads (https://docs.digital.mass.gov/dataset/massgis-data-massachusetts-department-transportation-massdot-roads).



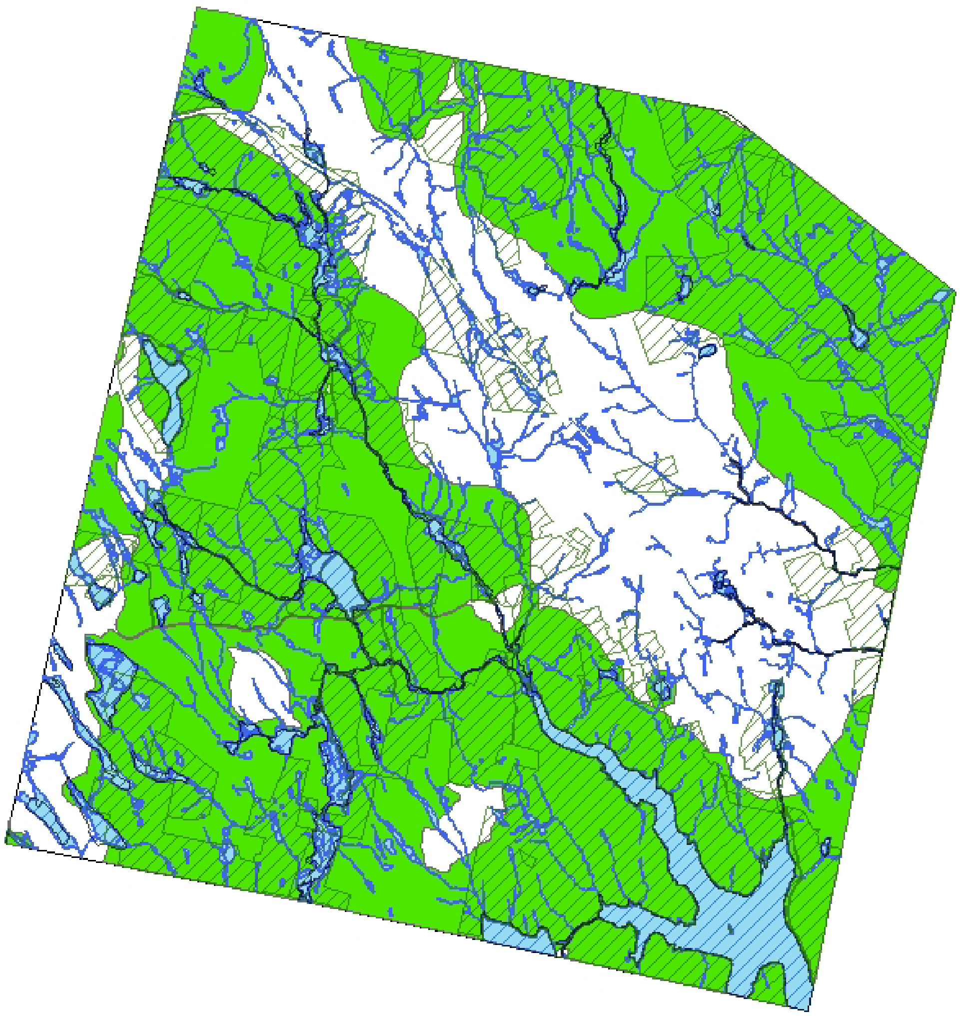
A.2 Land Cover

Land cover data from the MassGIS Land Cover/Land Use data layer, updated in 2016 (https://docs.digital.mass.gov/dataset/massgis-data-2016-land-coverland-use).



A.3 Conservation Land

Data from MassGIS BioMap2 repository (https://docs.digital.mass.gov/dataset/massgis-data-biomap2), MassGIS Protected Land and Recreational Open Space (https://docs.digital.mass.gov/dataset/massgis-data-protected-and-recreational-openspace), and MassGIS OLIVER DEP wetlands data layer (http://maps.massgis.state.ma.us/map_ol/oliver.php).

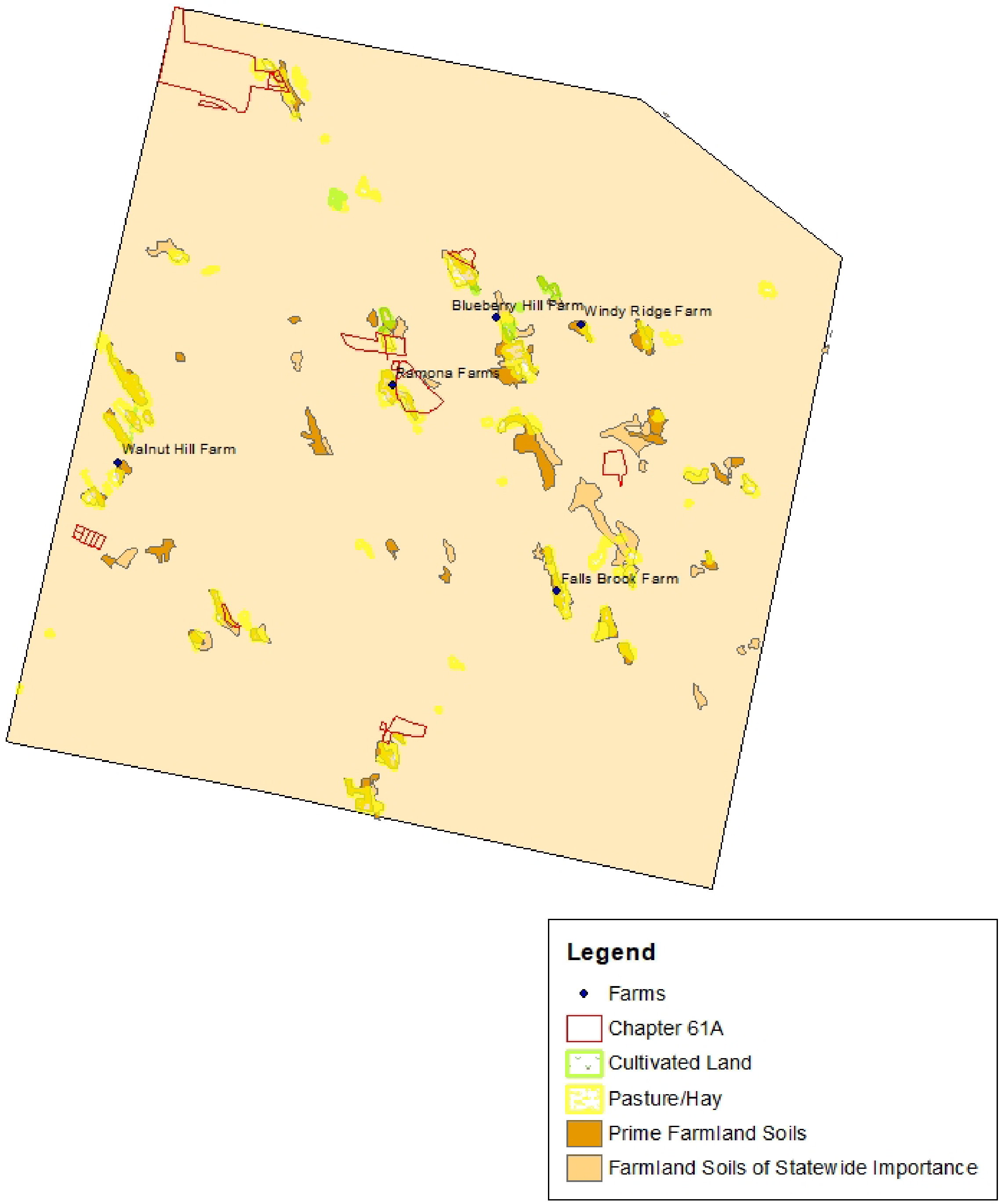


Legend

- Protected in Perpetuity
- Limited Protection
- Floodplain
- Wetlands, with 25 ft buffer
- BioMap2 Core Habitat & CNL

A.4 Agricultural Resources

Data from MassGIS Tax Parcel data (https://docs.digital.mass.gov/dataset/massgis-data-standardized-assessors-parcels), MassGIS Land Cover/Land Use data layer (https://docs.digital.mass.gov/dataset/massgis-data-2016-land-coverland-use), and NRCS SSURGO-Certified Soils (https://docs.digital.mass.gov/dataset/massgis-data-nrcs-ssurgo-certified-soils).



A.5 Parcels available for Commercial-Scale Development

Map represents a compilation of data drawn from the sources listed for maps A1-A4. Please see Section 5.7 for an explanation of the Scenarios depicted.