REPORT

Town of Ayer, Massachusetts

Organics to Energy Study

July 2014

CDM Smith

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Executive Summary

1.0 Introduction and Existing Conditions

Background

The Massachusetts Department of Environmental Protection (MassDEP) has proposed a ban on the disposal of source separated organics (SSO) in landfills and incinerations for commercial wastes. Regulations resulting from this ban are expected to be implemented in mid-2014, at which time, approximately 1,000 wet tons per day (wtpd) of SSO would be diverted from landfills and incinerators state-wide to recycling facilities such as anaerobic digestion or composting facilities.

Concurrently, the Town of Ayer is struggling with biosolids disposal costs and operations. Current practice of hauling thickened sludge off-site for incineration is costly for the Town and, given increased scrutiny on air emissions from sludge incineration, provides limited long-term security for the management of Ayer's biosolids. As a result of the above factors, this study is intended to explore the technical feasibility of implementing an organics-to-energy program at the site of its Wastewater Treatment Facility (WWTF) located on Brook Street. The goal of this facility would be to provide a regional solution for organic waste disposal as well as a long-term, sustainable outlet for processing of biosolids from their existing wastewater treatment plant.

Existing Site Conditions

The town-owned parcel located on Brook Street includes substantial (126.5 acres) land area. The primary current use of the land includes the Town's Wastewater Treatment Plant (WWTP) along with other Department of Public Works (DPW) uses. Data pertaining to existing environmental features and potential hazards was collected and evaluated for the site and its immediate surrounding area as part of this study to determine whether any known hazards, sensitive receptors or other environmental resources may pose a concern for this potential project. The most notable concerns identified included the site being listed by MassDEP as an Area of Critical Environmental Concern (ACEC) as well as the previously identified presence of four protected or endangered species of plants and animal species at the site. As a result, the project would likely come under significant scrutiny during the environmental permitting process.

Wastewater Treatment Biosolids Production

As noted, the Brook Street Site supports the 1.79 million gallon per day advanced wastewater treatment facility. The Town currently hauls the sludge which is produced from the treatment process to the Upper Blackstone Water Pollution Abatement District (UBWPAD) facility located in Millbury, MA where it is dewatered and ultimately incinerated using a multiple hearth furnace. Based on recent operations data, the Ayer biosolids production which is currently hauled from the site and could potentially be processed through an organics to energy facility was determined to be approximately one dry ton per day at approximately 3.5% solids concentration (or 10,700 wtpy). It was also determined that treatment facility consumes an average of approximately 100 kW of electricity for the treatment process along with approximately 5,000 gallons of oil per year for heating which could also be offset by heat and power produced by an anaerobic digestion and cogeneration facility at the site.

2.0 Feedstock Alternatives

The potential organic waste sources associated with the pending ban will likely include food wastes from supermarkets, institutions, food producers, and other large generators. MassDEP published a 2002 survey (updated in 2011) which separated food waste generators into several categories and provided an estimate of the locations and quantities of the available waste. Based on this data, it is estimated that there may be approximately 338,000 wet tons per year (wt/yr) of organic waste within a 30-mile radius (regional) of the site.

3.0 Technology Review and Alternatives Development

Since it is unlikely that a facility built at the Brook Street site would be able to attract the full quantity of local or regional organic waste this current study conceptually analyzes three loading/sizing scenarios which are intended to represent a wide range of waste acceptance scenarios. Those scenarios were assumed to be: 1% of regional organic waste (3,400 wt/y); 5% of regional organic waste (17,000 wt/yr); and 10% of regional organic waste (34,000 wt/y).

In general, the infrastructure that would be expected to be required for any of the options would include: Pre-Processing Facility; Pre-Digestion Food Waste Storage Tanks and Pump Station; New Anaerobic Digester(s) and Ancillary Digestion Equipment; Biogas Collection, safety and boosting equipment; Digestate and Biogas Storage; New Cogeneration Engines; Dewatering Facility; and a Sidestream Treatment Facility. The design of this facility has been assumed to comply with redundancy standards and construction materials that are commonly applied to municipal infrastructure projects to properly protect from upset conditions and ensure adequate design life.

4.0 Alternatives Evaluation

Table ES-1 summarizes some of the key expected process performance values of these systems under average annual conditions for each option. Figure ES-1 provides an overview of the capital infrastructure required under each scenario.

	Alternative A	Alternative B	Alternative C
Ayer Biosolids Production (wet tons/year)	10,700	10,700	10,700
Potentially Available SSO (wet tons/year)	3,400	17,000	34,000
Biosolids Fed to Digester (gal/day)	7,000	7,000	7,000
SSO Fed to Digester (gal/day)	5,200	26,000	52,000
Digestion Volume (million gal)	240,000	950,000	1,800,000
Biogas Produced (cf/day)	67,000	279,000	544,000
CHP Electrical Production (kW)	180	800	1,800
CHP Net Electrical Remaining After Onsite Use (kW)	50	600	1,500
CHP Heat Recovered (MMBtu/hr)	0.9	2.9	6.5
CHP Net Heat Remaining after Onsite Use (MMBtu/hr)	(0.3)	1.1	3.7
Dewatered Cake (wet tons/day)	5	18	34
Dewatered Cake (cy/day)	8	27	51
Centrate Requiring Disposal (gal/day)	11,000	28,000	50,000

Table ES-1

Conceptual Digestion Facility Summary

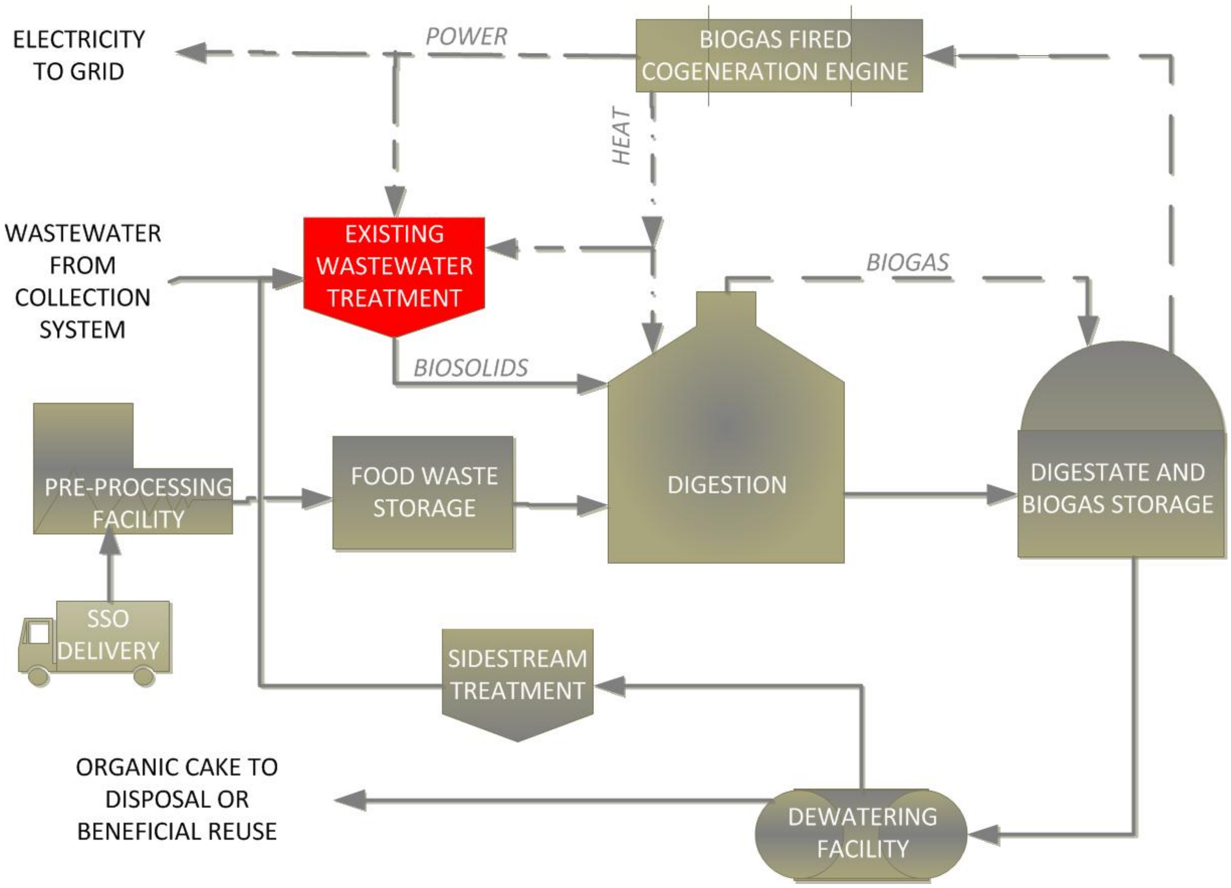


Figure ES-1
Simplified Facility Process Schematic

5.0 Implementation Considerations

Funding and Financing

Though financing projects of this nature can be complex and availability of assistance can vary depending on the ownership option selected, there are a number of possible programs available including state grants, low interest loans and tax incentives which could aid in the project development and financing. As detailed in Section 5, some of the potential grant programs that should be explored for this project include: MassCEC Organics to Energy Program grants, MassDEP Sustainable Materials Recovery grants; National Grid Custom Measures Program Grants; Mass Green Communities Competitive Grants; and Global Climate Change Incentive Mitigation Fund grants. Some of the low interest loans, bond funding and tax credit programs that may prove to be advantageous to this facility development could include: MassDEP Recycling Loan funding; MassDEP Clean Water State Revolving Fund; Qualified Energy Conservation Bonds; Business Energy Investment Tax Credit; MassDevelopment Tax Exempt Financing and other private tax exempt financing sources. In addition, tipping fees for accepting SSOs and cogeneration electrical production incentives (Net Metering credits and Renewable Energy Certificates) would serve to assist in financing of the required infrastructure.

Ownership Options

This report also provides an overview and comparison of various ownership options that may be considered by the Town for implementation of the organics-to-energy center at the Town-owned project site. The ownership options reviewed here incorporate different approaches to the allocation of project responsibility, risks and economic benefits. Ownership options evaluated include municipal ownership, public/private partnership, and site lease/private ownership.

Regulations and Permitting

As part of the current feasibility study, an initial assessment was completed of the regulatory trends, drivers and potential permits required for development of an organics to energy facility in Ayer. Though a specific permitting implementation plan would need to be developed as part of the design phase of this project, the significant potential permit applications that are likely required for the project would include: submittal of an Environmental Notification Form (ENF) to the Massachusetts Executive Office of Energy and Environmental Affairs (due to the site being located within and Area of Critical Environmental Concern) as well as the Natural Heritage and Endangered Species Program (due to the presence of endangered species); a non-major comprehensive air quality plan approval from the MassDEP; electrical interconnection application through National Grid; local planning board approval; letter of request to the Massachusetts Cultural Resource Information System; and a letter to MassDEP requesting approval for this project. In addition, the contractor would be required to apply for local building permits and stormwater management permits as part of the construction phase.

6.0 Summary of Findings

To compare relative costs and benefits of the alternatives, estimates of probable project cost were developed for each of the acceptance scenarios and the associated operations costs impacts were also conceptually quantified. A summary of the conceptual finances of each option is shown in Table ES-2.

	Alternative A (1% of Regional SSO)	Alternative B (5% of Regional SSO)	Alternative C (10% of Regional SSO)
Initial Capital Costs Including Pre-Processing	$33,000,000	$41,000,000	$52,000,000
Annual Capital Costs (Amortized 20 yrs @ 2.5%)	$2,100,000	$2,700,000	$3,400,000
Annual Operational Costs	$600,000	$1,200,000	$1,900,000
Annual Operational Credits	$465,000	$1,400,000	$3,000,000
Net Annual Cost	$2,200,000	$2,500,000	$2,300,000
Annual SSO Received (wt/yr)	3,400	17,000	34,000
Break Even Waste Tip Fee ($/wt)	$650	$145	$68
Break Even Waste Tip Fee without Installation of Pre-Processing ($/wt)	$350	$80	$35

Table ES-2
Conceptual Financial Summary

Based on discussions with national private haulers during the course of this study, experience in other parts of the country has indicated that market tipping fees for organic waste could be in the range of $30 to $40 per wet ton for pre-processed waste. Though the organics disposal market in the Commonwealth is currently in a state of flux due to the pending waste ban as well as the rapid development of various waste processing facilities, it is not currently known whether this experience in other parts of the country will be seen in Massachusetts. It is important to note, however, that the current average rate for municipal solid waste disposal in Massachusetts is in the range of $70 per ton, so tipping fees for non-preprocessed waste less than this may be able to be initially borne by the developing organics market in the Commonwealth. Despite this, it remains to be seen how low rates for these wastes, which have an inherent energy value as well as a potential digestate reuse value, will be ultimately driven down by competing processing facilities.

With consideration of the above factors and estimated costs, the apparent financial viability of the facility sizing options evaluated here can be summarized as follows:

- Alternatives A & B: The development of a facility to accept and process 17,000 wet tons per year or less of SSO combined with the Ayer biosolids stream is estimated to cost upwards of $40M. After accounting for the operations costs and energy benefits associated with the facility, an SSO tip fee well in excess of $100 per wet ton would need to be realized in order to break even. As this rate is greater than the current cost of municipal solid waste disposal in the Commonwealth and significantly greater than organics disposal rates in other parts of the country, the development of a facility of this size would not be financially viable without significant external funding incentives.

- Alternative C: Development of a larger facility which would be capable of processing approximately 34,000 wet tons per year of SSO along with the Ayer biosolids stream would likely cost on the order of $52M to develop and would translate to a break even tip fee between $35 and $68 per wet ton. These costs are still likely on the high end of the viable tip fees which may be able to be realized. In addition, this option does carry with it significant risk related to waste availability. The quantity assumed here translates to 10% of the estimated organic waste within a 30 mile radius and, based on the MassDEP waste availability study, could translate to approximately 250 different waste suppliers/accounts that would need to be managed. Therefore, pursuit of a facility approaching this size could be financially viable, but would carry with it significant risk and uncertainty related to waste availability and management.

Despite the unfavorable finances associated with the smaller of the options evaluated and the waste availability risks associated with the larger of the options, it may be possible to select a facility size somewhere within the range evaluated here which would balance these concerns. This selection would likely be drive by whether any substantial external funding may be able to be secured as well as proper determination of the risk tolerance of the Town. Based on experience in other similar municipalities, it is anticipated that the significant capital cost and risk associated with developing a project of this nature may not be bearable exclusively by a municipal ownership option. For this reason, if the Town believed that development of this facility was a priority and in the Town's best interest, private development or a public private partnership should be evaluated further through discussions with local private organics facility developers.

Section 1

Project Objectives and Existing Conditions

1.1. Project Objectives

The Massachusetts Department of Environmental Protection (MassDEP) has announced plans to impose a ban on source-separated organics (SSO), with the goal of diverting an additional 350,000 tons per year of SSO by 2020. MassDEP expects to have the proposed ban on disposal of SSO go into effect in the summer of 2014. As a result, feasibility studies are being completed to determine the ability of existing wastewater treatment facilities to incorporate co-digestion and co-generation into their treatment process as well as the feasibility of development of new facilities specifically designed for the digestion or composting of organic wastes.

Concurrently, the Town of Ayer is struggling with biosolids disposal costs and operations. Current practice of hauling thickened sludge off-site for incineration is costly for the Town and, given increased scrutiny on air emissions from sludge incineration, provides limited long-term security for the management of Ayer's biosolids.

As a result of the above factors, the Town is interested in exploring the technical feasibility of implementing an organics-to-energy program at the site of its Wastewater Treatment Facility (WWTF) located on Brook Street. The goal of this facility would be to provide a regional solution for organic waste disposal as well as a long-term, sustainable outlet for processing of biosolids from their existing wastewater treatment plant. An additional goal of the facility would be to provide energy savings to the town by offsetting current energy and heat demands from the exiting wastewater treatment plant and Department of Public Works (DPW) facilities which the site currently supports. The study of this site within the Town is intended to determine its viability for public or private development of this potential facility.

1.1.1 Goals

The overall goal of this study is intended to determine the ability of the proposed facility to:

- Reduce the costs of wastewater sludge disposal;
- Reduce energy costs (electricity, heating fuel and trucking fuel);
- Implement a renewable energy source;
- Provide a regional disposal option for food processing industries; and
- Continue to improve Ayer's status as a Green Community.

In order to determine the above, this study will:

- Identify the potential sources and quantities of organic waste which could be processed by a facility at this site;

- Determine the conceptual size of a processing facility which could be supported by the site and by the available waste sources;
- Evaluate the costs and benefits of the conceptual facility;
- Consider any impacts this development would have on the parcel and its abutters; and
- Describe the ownership options which are available to the Town.

1.1.2 Green Community Initiatives

The "Green Communities Act" of 2008 created a Green Communities Division within the Massachusetts Department of Energy Resources (DOER). The charge of this division is to guide all cities and towns within the Commonwealth "along a path of enhanced energy efficiency and renewable energy toward zero net energy." In general, the goal of this program is to maximize energy efficiency in public buildings, including schools, city halls, and public works and public safety buildings; generate clean energy from renewable sources; and manage rising energy costs. To achieve these goals, the Division currently provides the following resources:

- Education about the benefits of energy efficiency and renewable energy
- Guidance and technical assistance through the energy management process
- Facilitation of informed decisions and actions
- Collaboration through shared best practices among cities and towns
- Local support from regional Green Communities coordinators
- Opportunities to fund energy improvements

In order to be designated as a "Green Community", a City or Town must meet the following five criteria:

- Provide as-of-right siting in designated locations for renewable/alternative energy generation, research & development, or manufacturing facilities.
- Adopt an expedited application and permit process for as-of-right energy facilities.
- Establish an energy use baseline and develop a plan to reduce energy use by twenty percent (20%) within five (5) years.
- Purchase only fuel-efficient vehicles.
- Set requirements to minimize life-cycle energy costs for new construction; one way to meet these requirements is to adopt the new Board of Building Regulations and Standards (BBRS) Stretch Code.

The Town of Ayer was designated at a Green Community in July of 2011 and has established a Green Communities Committee to help guide the associated initiative within the Town. The current study is very much in line with the goals of the program as well as the Town's desire to reduce energy consumption and increase sustainability, not only within the Town, but also within the surrounding region.

1.1.3 Massachusetts Clean Energy Center (MassCEC) Grant

Funding opportunities currently available to assist in achieving the goals of the Commonwealth of Massachusetts 2010-2020 solid waste master plan include the following:

- MassDEP Recycling Loan Fund ($3 million in low-interest loans recently announced);
- MassDEP Sustainable Materials Recovery Grants ($1 million in grants recently announced);
- MassDEP Municipal Grants; and
- MassCEC Organics to Energy program.

The majority of this study has been funded under the Organics to Energy Program which is administered by the MassCEC. The goal of the MassCEC Organics-to-Energy Program is to "increase knowledge about and support the development of facilities that convert source-separated organic materials into heat and electricity, as well as create additional products of value in agriculture, horticulture or landscaping." The program is further designed to "advance the Commonwealth's goal of substantially increasing the diversion of source-separated organics away from landfilling or incineration."

Following an application process to MassCEC, the Town was selected for a grant related to this study and has entered into an agreement dated March 15, 2013 for its funding.

1.2 Existing Site Conditions

As shown in Figure 1-1, the town-owned parcel located on Brook Street includes 126.5 acres of land. The primary current use of the land includes the Town's Wastewater Treatment Plant (WWTP), the Department of Public Works (DPW) garage and operations building and the Town leaf, brush and yard waste composting operation. It should also be noted that the parcel also contains a closed sludge disposal landfill as well some remaining infrastructure from the former wastewater treatment facility which was used up until the construction of the current facility in the 1970's.

The WWTP is located on the western end of the parcel and the DPW office and garage is located on the eastern end of the parcel, at the end of Brook Street. There are two active access points to the site: The primary access is from Brook Street, off of Rt. 2A and the second access is from Bishop Road from the north. The project site is located approximately 4 miles from Route 2 and 6 miles from Route 495.

1.2.1 Land Use and Abutters

The zoning classification of the Town-owned parcel is Heavy Industrial (Ayer by-law XIX: Zoning bylaws; Article 3.3.3; version 2009). Upon review of the current Town of Ayer bylaws, the use of the site for waste processing does not appear to be specifically permitted and, therefore, it is assumed that a special permit would be required from the Town Zoning Board. Though, given the available land area at the site substantially larger setbacks would likely be possible, it was also noted within the regulations that any new facility structures would be required to comply with the following setbacks:

- Front Yard setback: 25-ft;
- Side Yard Setback: 25-ft (50-ft when abutting a residential property); and
- Rear Yard Setback: 30-ft.

Land use data was also assessed for the purpose of understanding existing site constraints and opportunities. As shown in Figure 1-2, land use within the site is shown as waste disposal, open land and forest.

Land use adjacent to the site is shown to be primarily forested land, wetlands and transportation. The majority of this land is associated with the Devens Regional Enterprise Zone (former Fort Devens Military Base) to the north and west along with St. Mary's Cemetery to the northeast. The Devens property is the largest abutter and is described in Devens Zoning By-Laws (Chapter V, section A.14) as "Open Space and Recreation." According to the by-laws, the goal of this zoning district is to "preserve and enhance the natural beauty and sensitive natural resources of Devens and serve as a buffer and transition zone for other uses."

There are some residential and commercial land uses along West Main Street and Park Street, though the directly abutting forest and wetlands appear to provide a reasonable buffer between site activities and these land uses. As also indicated in Figure 1-2, there is a power utility transmission line traversing the site which would presumably also limit future significant changes to existing zoning and land use. This utility infrastructure may also prove useful for the exporting of electricity from the site.

1.2.2 Potential Environmental Impact and Hazards

Data pertaining to existing environmental features and potential hazards was collected and evaluated for the site and its immediate surrounding area as part of this study to determine whether any known hazards, sensitive receptors or other environmental resources may pose a concern for this potential project. A variety of data sets were acquired from the Massachusetts Office of Geographic Information (MassGIS) and used as the primary basis for this analysis. The environmental datasets reviewed included the following:

- Bureau of Waste Prevention (BWP) Regulated Major Facilities;
- MassDEP Oil and/or Hazardous Material Sites with Activity and Use Limitations (AUL);
- MassDEP Waste Site Cleanup Program Activity and Use Limitation Sites;
- Municipal Solid Waste Combustion (Resource Recovery) Facilities;
- Handling Facilities (Transfer Stations, Compost and Other Wastes Handling);
- Department of Conservation and Recreation Areas of Critical Environmental Concern (ACEC);
- U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory; and
- Mass Division of Fisheries and Wildlife Natural Heritage and Endangered Species Program (NHESP) inventory, including:
  - Certified or Potential Vernal Pools;
  - Estimated Habitats of Rare Wildlife;
  - Priority Habitats of Rare Species; and
  - Natural Communities.

Figure 1-3 reflects the available data from the above sources, which showed that some of the above features or protected areas are present at the site. With respect to potential hazards or protected areas, the features identified in the immediate vicinity of the site included:

- Areas of Critical Environmental Concern (ACEC): The entire parcel and much of the surrounding open space is listed as an ACEC. According to the accompanying data, this parcel is located in the Squannassit ACEC and is listed due to its proximity to the Nashua River and its surrounding ecosystem. The report states that "the confluence of diversity of topography, soils, hydrology, and vegetation is unique and has, in turn, resulted in a corresponding diversity of habitat types and therefore of biodiversity. The area supports a remarkable richness of wildlife ranging from concentrations of rare and endangered species to deer, moose, fisher, bobcat, otter, and even occasional black bear."

- NHESP Estimated Habitats of Rare Wildlife and Priority Habitats of Rare Species: The available GIS data further indicated that the site is listed by the NHESP as a "Priority Habitat of Rare Species" (PH 1477) as well as an "Estimated Habitat or Rare Wildlife" (EH 959) as indicated in the Massachusetts Natural Heritage Atlas (13th Edition). As a result of this potentially significant concern, as part of this study, a letter of request was sent to NHESP to obtain additional details as the reason for these listings. As documented in a letter from NHESP dated September 20, 2013 (included in Appendix A), the reason for the listing is that the following rare species have been confirmed present in the vicinity of the site:

  - Blue-Spotted Salamander (*Ambystoma laterale*): Amphibian listed as a Special Concern;
  - Zebra Clubtail (*Stylurus scudderi*): Dragonfly, though not listed as of 2/27/13;
  - Blanding's Turtle (*Emydoidea blandingii*): Reptile listed as Threatened;
  - Wild Senna (*Senna hebecarpa*): Plant listed as Endangered.

  As indicated in the letter, the species listed above are protected under the Massachusetts Endangered Species Act (MESA) (M.G.L. c. 131A) and its implementing regulations (321 CMR 10.00). The state-listed wildlife indicated above are also protected under the state's Wetlands Protection Act (WPA) (M.G.L. c. 131, s. 40) and its implementing regulations (310 CMR 10.00). As a result, a Notice of Intent would be required to be submitted to both programs within the MassDEP and would come under significant scrutiny to ensure the proposed project development plans avoid or minimize impacts to the rare species and their habitats.

- Priority Natural Community: The entire parcel is also listed by NHESP as a "Priority Natural Community." It is classified under this program as an "excellent small river flood plain." The Priority Natural Community program further categorizes these types of communities from S5 ("secure") to S1 ("critically imperiled"). As of the most recent (2011) prioritization by the Natural Communities Program, the Brook Street site is currently classified as an S2 – "Imperiled Natural Community."

- Vernal Pools: One potential NHESP vernal pool within the parcel limits and multiple pools within the adjacent parcels.

Additional discussion permitting of the above concerns is included later in this report.

1.2.3 Potential Environmental Hazards

National Flood Insurance Rate Mapping (FIRM) developed by the Federal Emergency Management Agency in the area of the Town-owned parcel was also reviewed for this study. As shown in Figure 1-4, it is apparent from the existing mapping that the 100-year flood inundation area does include portions of the site, though this area is limited to the southern extremity of the parcel and planning of future infrastructure would likely be able to avoid this area.

1.2.4 Environmental Justice Population

One additional dataset which was reviewed as part of this study is the Environmental Justice (EJ) population locations. This data is the focus of the state's Executive Office of Energy and Environmental Affairs' (EEA) and reflects areas across the Commonwealth with high minority, non-English speaking, and/or low-income populations. Data in this layer were compiled at the block group level from the 2010 census redistricting tables.

The United States Environmental Protection Agency (USEPA) and MA EEA office define Environmental justice (EJ) as *"the fair treatment and meaningful involvement of all people regardless of race, color, sex, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations, and policies."* The EEA further defines its program goals as *"helping to address the disproportionate share of environmental burdens experienced by lower-income people and communities of color who, at the same time, often lack environmental assets in their neighborhoods"* and to *"promote community involvement in planning and environmental decision-making to maintain and/or enhance the environmental quality of their neighborhoods."*

Based on 2010 census data, as shown on Figure 1-5, a significant portion of the Town of Ayer qualifies as an "Environmental Justice Population." This qualification was made based on the percent of minority population as well areas of town which have median household income below 65% of the 2010 Massachusetts state median household income of $62,133. The analysis of this data is generally performed at the block group level rather than a street-by-street basis; however, it is notable for this project since the area in question encompasses the potential project site as well as its direct abutters. In addition, as discussed later in this report, waste hauling truck routes would be required to access the site through these populations. Though the issue may ultimately not be significant for the project, the Town should be cognizant of it as it may impact public acceptance of the project.

1.3 Wastewater Treatment Facility Operations

1.3.1 Wastewater Treatment Biosolids Production

The Town of Ayer Wastewater Treatment Facility is a 1.79 MGD advanced wastewater treatment facility that discharges to the Nashua River. It was originally constructed in the late 1970's and upgraded in 1996. The current wastewater treatment process includes the following major systems:

- Headworks (screening and grit removal);
- Clari-thickener primary sedimentation tanks;
- Anoxic basins;
- Extended aeration basins;
- Secondary sedimentation tanks;

- Tertiary filters; and
- Ultraviolet light (UV) disinfection.

For the treatment of residuals resulting from the wastewater treatment process, the solids from the secondary clarifiers are pumped back to the primary clari-thickeners and co-settled with the primary sludge. The original design of the facility included provisions for removal of the co-settled solids from the clari-thickeners and thickening utilizing dissolved air flotation thickeners (DAFs) after which the thickened sludge was dewatered utilizing vacuum filters. The DAFs were ultimately removed to allow for installation of the tertiary filters and the vacuum filters were replaced with a belt filter press which has also since been abandoned.

Current solids removal operation involves pumping of co-settled sludge directly from the clari-thickeners to a tanker truck. Sludge storage tanks (former aerated grit tanks converted to storage) are also used for temporary storage of the sludge prior to hauling on an as-needed basis. The Town currently hauls the sludge to the Upper Blackstone Water Pollution Abatement District (UBWPAD) facility located in Millbury, MA where it is dewatered and ultimately incinerated using a multiple hearth furnace.

Operations data from the calendar year 2012 were collected and reviewed for the purpose of this study. Review of this data yielded the following average solids production values:

- Volumetric sludge production: 8,640 gallons per day
- Dry weight solids production: 2,150 pounds per day
- Solids concentration: 3.0%

Due to recent operational adjustments to the clari-thickener system, data from April and May of 2013 was also obtained. This data yielded slightly lower solids production (1,850 dry lb/day) and slightly higher solids concentration (3.7%). Though this data shows that some improvement over 2012 solids concentration values is possible, due to the limited data set and the variable nature of biosolids production, it has been assumed for the purpose of this study that Ayer biosolids production would be as shown in Table 1-1.

Parameter	Value
Volumetric sludge production	7,000 gallons per day
Dry weight solids production	2,000 pounds per day
Solids concentration	3.5%

Table 1-1
Summary of Existing Biosolids Production

1.3.2 Wastewater Treatment Energy Usage

Recent energy use data for the existing site was collected from the Town for use in assessing the potential for onsite use and/or net exporting of power and/or heat from any future cogeneration system at the site. Electric use data was available for the period between August 2011 and March 2013 while fuel oil (used to heat the WWTP structures) was available for the 2008 through 2012 heating seasons. All values were averaged to provide an estimate of annual demand. Though this data will be further analyzed and compared in later sections of this report, a summary of recent electricity and heating oil use has been included in Table 1-2.

Electric (National Grid)	
Average Annual Use (kWh)	908,000
Average Equivalent kW	104
Average Monthly Peak Demand (kW)	161
Heating Oil	
Average Annual Use (gallons)	5,500
Average Annual (MMBtu/yr)	774
Demand if Assumed to be Consumed in 3 months (MMBtu/hr)	0.35

Table 1-2
Summary of Existing Site Energy Usage

CDM Smith

Figure 1-1
Existing Town of Ayer Site at 25 Brook Street

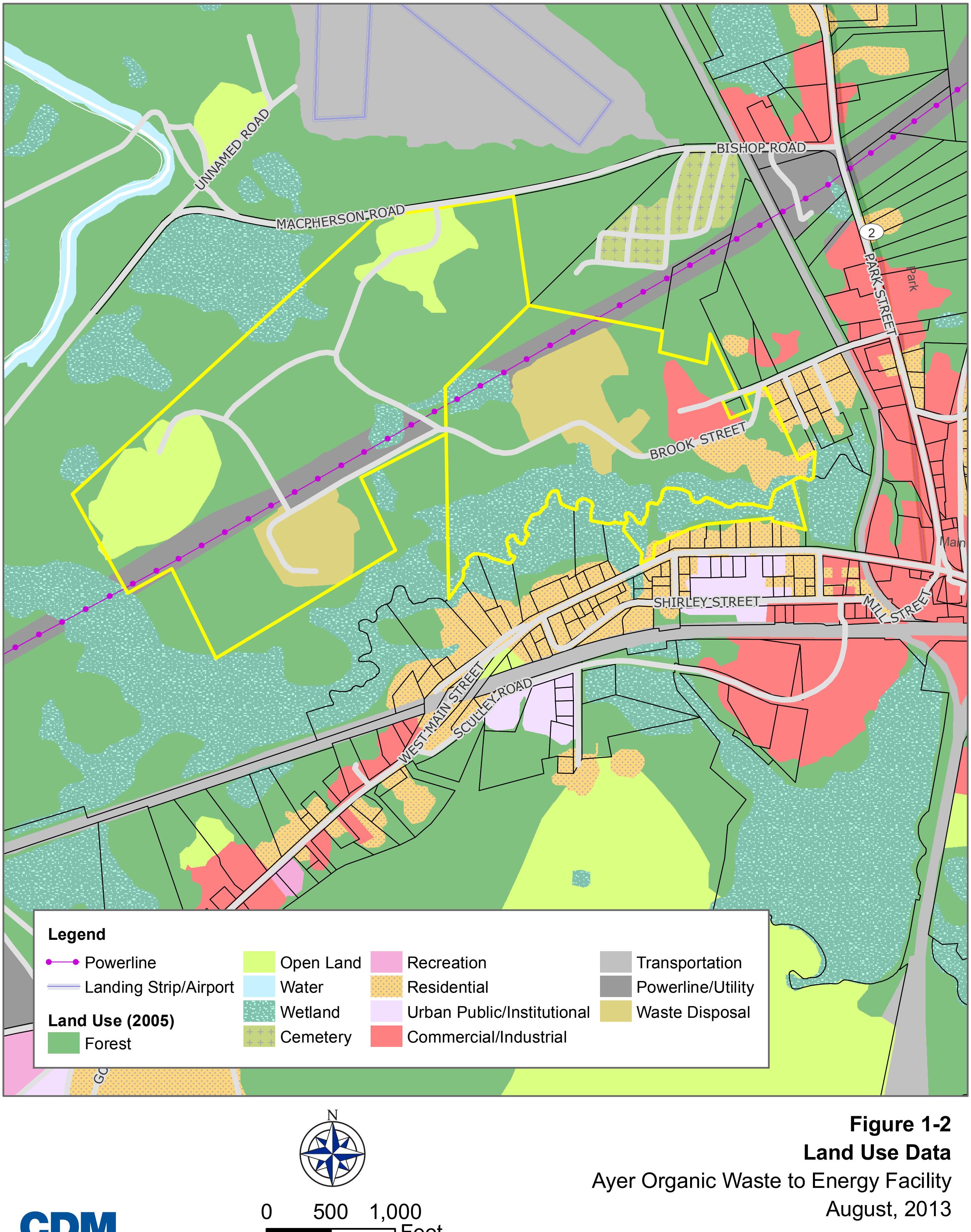
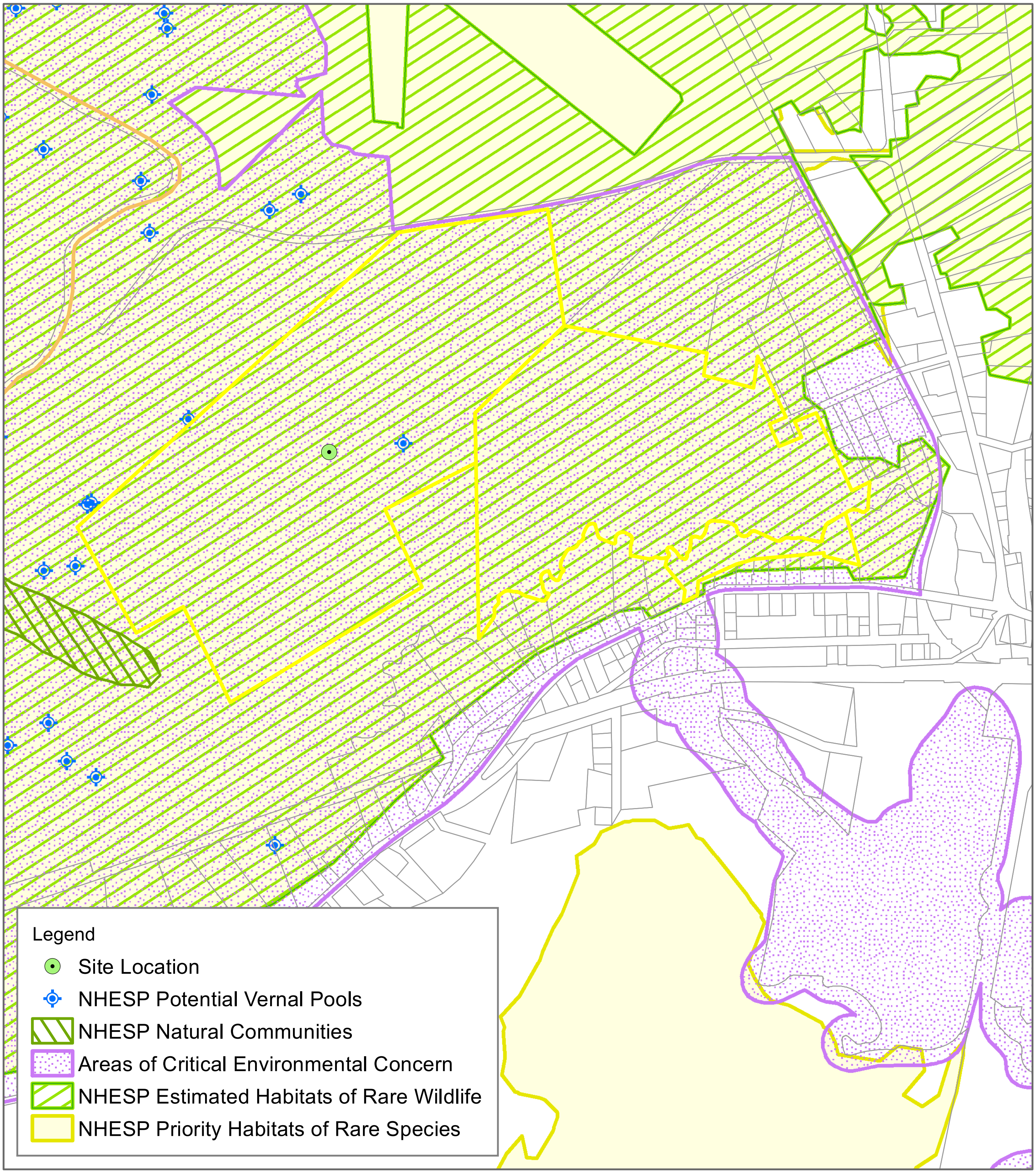


Figure 1-2
Land Use Data
Ayer Organic Waste to Energy Facility
August, 2013

CDM Smith



N

0 500 1,000
Feet
1 in = 1,000 ft

Figure 1-3
Potential Environmental Hazards
Ayer Organic Waste to Energy Facility
August, 2013

CDM Smith

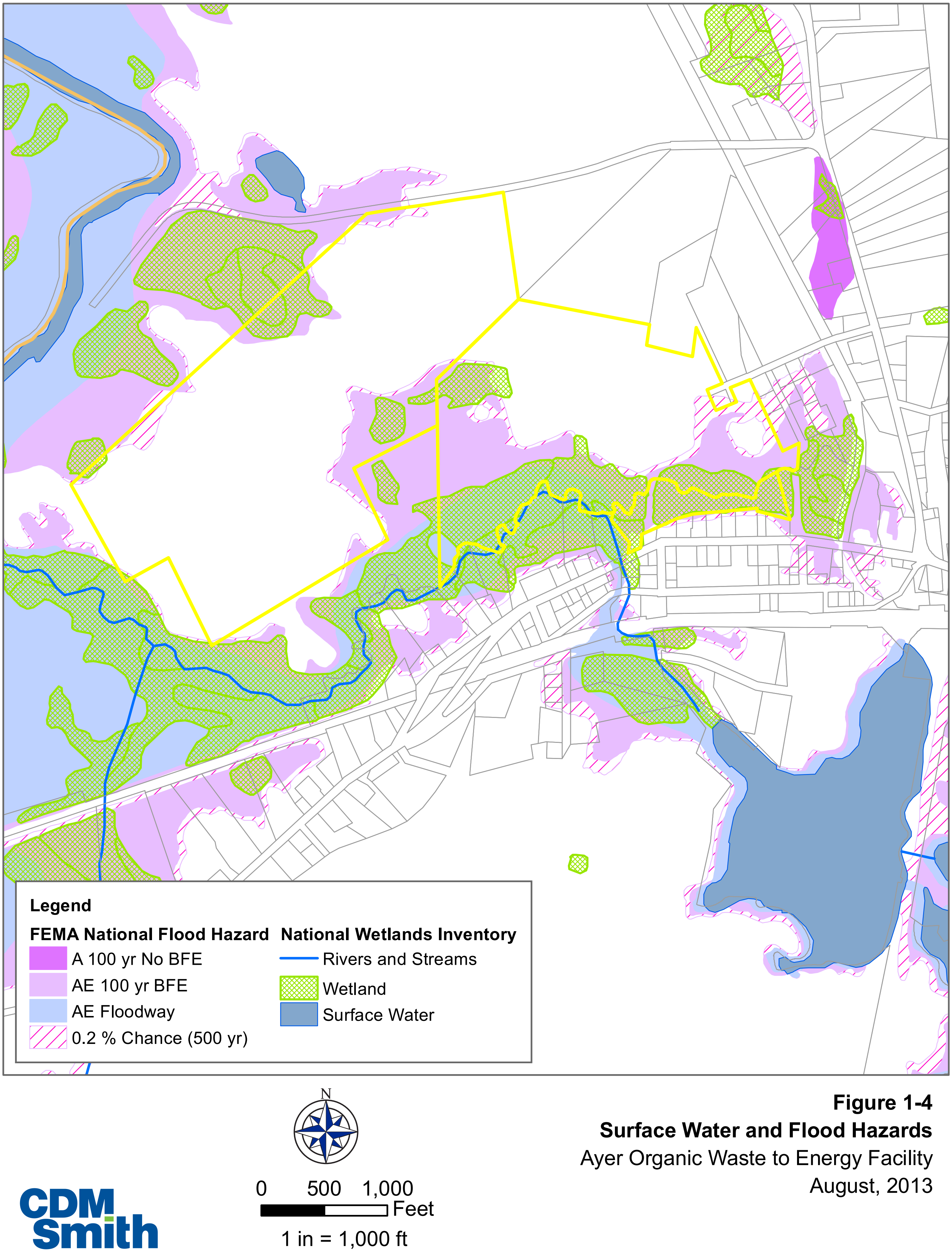
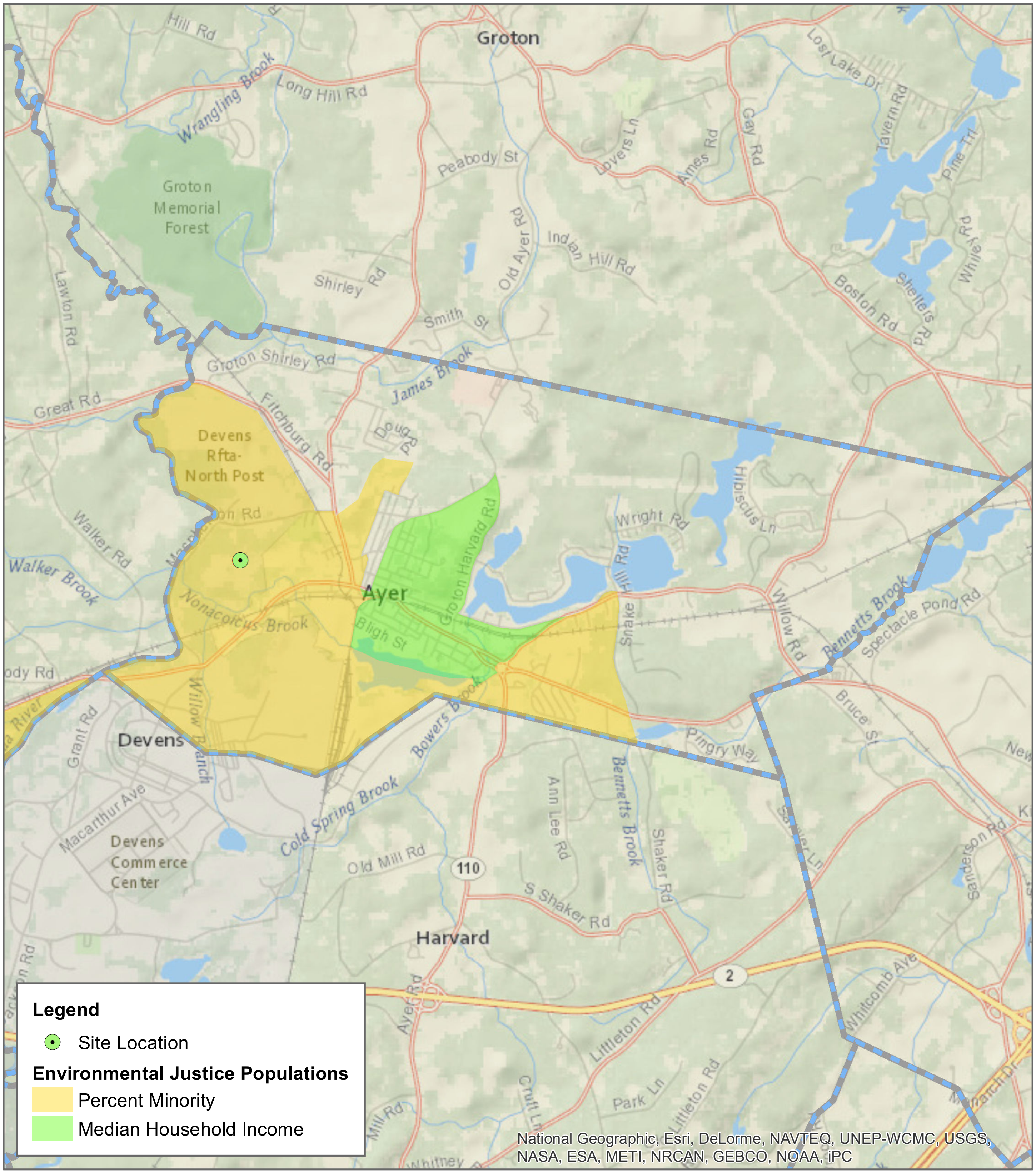


Figure 1-4
Surface Water and Flood Hazards
Ayer Organic Waste to Energy Facility
August, 2013

CDM Smith



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1 in = 6,000 ft

Figure 1-5
Environmental Justice Populations
Ayer Organic Waste to Energy Facility
August, 2013

CDM Smith

Section 2

Feedstock Alternatives

2.1 MassDEP Proposed Ban on Organics Disposal

As previously noted, the 2010-2020 Massachusetts Solid Waste Master Plan proposes a goal of reducing the quantity of waste disposed of in the Commonwealth by 30% by 2020. To accomplish this goal, the Draft Plan proposes adoption of a number of strategies for increasing the diversion of organic material from the solid waste stream. Among the alternatives for handling the diverted organics is utilization of anaerobic digestion facilities for treating organics. This initiative is creating a new demand for use of existing digesters for co-digestion and encouraging the development of new organics digestion facilities.

Currently private-sector solid waste transporters and disposal companies (referred to herein as "haulers") direct approximately 100,000 tons per year of food wastes to organics processing facilities in Massachusetts. There are approximately two dozen such facilities currently operating. The typical processing facility is a small-scale composting facility. MassDEP estimates that approximately 400 businesses and institutions are currently diverting organic wastes. The typical waste generator is a supermarket, large restaurant, college or university, or food producer.

MassDEP expects to have the proposed ban on disposal of SSO go into effect in the summer of 2014. Initially the ban will only impact generators of more than one wet ton per week of organic wastes. The current focus on diverting SSO is also driven by the interest of MassDEP and the Governor's Office in expanding renewable energy production, including through biogas.

2.2. Current Organics Diversion Efforts

MassDEP estimates that there are approximately 950,000 wet tons of such organics in the waste stream, and that currently only about 100,000 wet tons of pre-consumer food wastes are diverted, mostly by supermarkets, institutions, and other large generators. The SSO that is currently diverted is managed in any of the following ways:

- Edible food is provided to food banks – this is the highest priority use, if appropriate;
- Animal feed (e.g. at pig farms);
- Commodity processors, such as Baker Commodities (recycles high value grease and oil);
- Anaerobic digestion – a very limited amount is processed in anaerobic digesters at food production facilities or stand-alone commercial operations, such as the Jordan Dairy Farm digester (details below); and
- Composting – at municipal composting sites or the several commercial and/or on-farm composting operations in Massachusetts or in neighboring states.

Figure 2-1 depicts the general location and relative size of the existing permitted food waste processors throughout the Commonwealth. For comparison, the largest of these (located in Marlboro) is currently permitted to accept 100 TPD of waste while the majority of the smaller processors are generally local leaf and yard waste facilities permitted for up to 15 TPD of SSO co-composting.

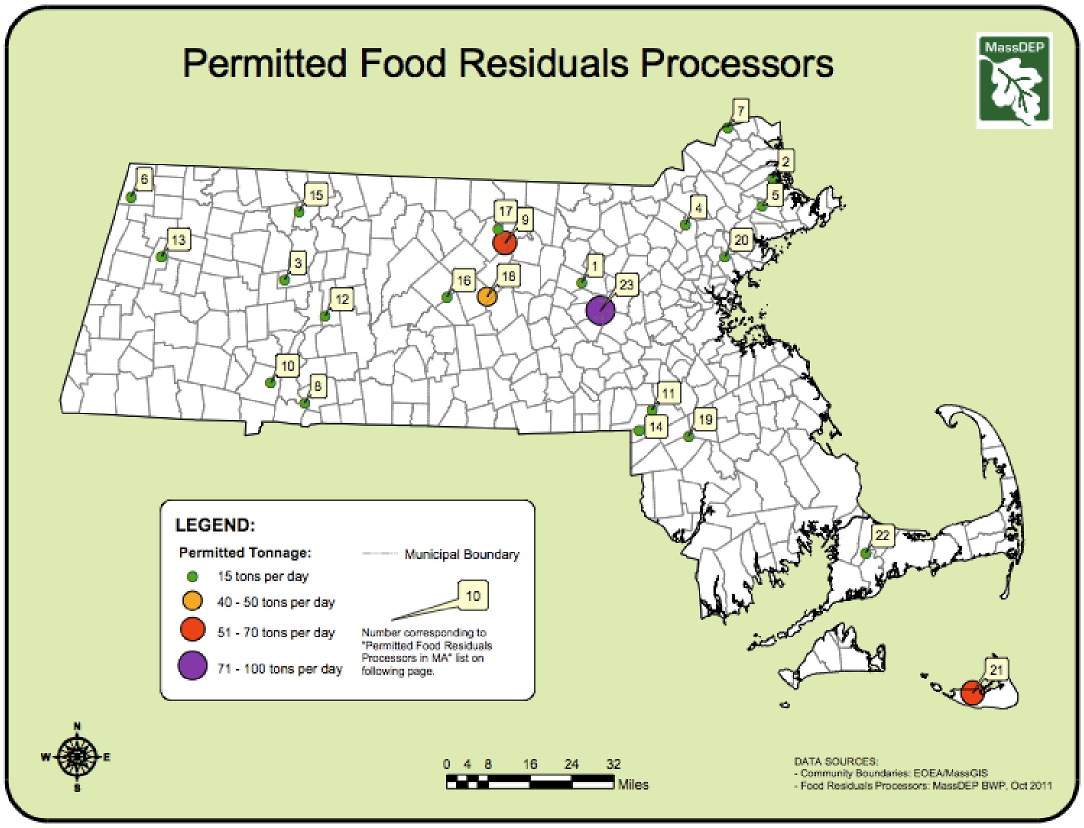


Figure 2-1
Permitted Food Residuals Processors throughout MA (courtesy of MassDEP)

2.3 Organics Digestion Experience and Initiatives

In conjunction with the organics ban, MassDEP is concurrently promulgating regulations intended to streamline the siting of facilities that can process the additional diverted SSO, including anaerobic digestion and composting facilities, and taking other steps to encourage such development. Another significant regulation change has also allowed for wastewater treatment plants to accept SSO for processing in existing anaerobic digesters with minimal permitting requirements.

MassDEP and the Governor's office are promoting the development of new or expanded anaerobic digestion capacity around the state. Recently, they have supported and applauded the creation of the "five farm" project proposed by AGreen Energy LLC that involves construction of new anaerobic digesters and CHP at five farms around the Commonwealth. In addition, there are a number of public and private initiatives currently focused on evaluating and/or developing separate organics digestion or co-digestion project.

2.3.1 Experience

The Jordan Dairy Farm in Rutland, MA – northwest of Worcester – is the first of several farm-based anaerobic digesters that will process a mixture of farm manures and SSO. The Jordan Farm's digester has been in operation since summer 2011 and treats a mixture of dairy manure and SSOs. The single digester has a capacity of approximately 25,000 gallons per day. The biogas produced is fed to an internal combustion engine, which is designed to produce 4,380 MW hours of electricity a year (500 kW average power production). Heat from the engine jacket is run through a heat exchanger to maintain digester temperature. Electricity generated by the facility provides 100 percent of the electricity needs of the farm; excess power is sold to the grid. The digestate residual is pumped to the farm's liquid manure pit, where it is stored until the farmer applies it to soils to support the growth of corn silage and hay crops. A second farm project involving the installation of digestion and cogeneration facilities at a farm in Hadley became operational in December 2013, with possible future facilities at farms in Granville and Shelburne.

Though unassociated with the five farms project, it should also be noted that co-digestion of organic waste with animal waste is also currently occurring at Pine Island Farm in Sheffield, Massachusetts. In November 2011, Pine Island Farm began using the manure as feedstock for its new anaerobic digester. Though the feedstock to the digester consists primarily of animal waste, approximately 10% of the capacity is currently used for digestion of excess whey from a local dairy processor. Biogas from the digestion system is currently used in a Combined Heat and Power (CHP) system to generate an average of 225 kilowatts of electricity for the farm and provide heat to the digester and for hot water heating needs. Excess power from the CHP system is fed back to the local electrical grid.

2.3.2 Initiatives

When the organics waste ban for pre-consumer food waste is instituted in 2014, MassDEP expects that approximately 3,000 businesses and institutions will be impacted – or nearly ten times the present number. Approximately 350,000 tons per year or approximately 1,000 tons per day of organic wastes will need to be recycled. To service these customers, many private companies and municipalities are evaluating the feasibility of developing organics digestion, organics co-digestion and co-composting facilities. In addition, private haulers are making plans to establish new or modified transfer stations throughout the Commonwealth to serve as collection and processing points for organics.

For reference, and for future partnership opportunity considerations, a few of the private firms actively pursuing this area include the following:

- Casella Organics (Partial Owner of Agreen Energy LLC) (Portland, ME);
- Waste Management Inc. (Houston, TX);
- Harvest Power (Waltham, MA);
- Anaergia (Burlington, ON);
- NEO Energy (Portsmouth, NH); and
- Applied Water Management (Division of Natural Systems Utilities (NSU) (Hillsborough, NJ).

It should also be noted that, beyond the farm digesters noted above, there are active organics digestion projects under development throughout Massachusetts. CDM Smith is currently aware of multiple initiatives in the eastern portions of the state including projects in Dartmouth (currently under construction), Bourne, Fall River and Millbury.

2.3.3 Ongoing Organics Characterization and Digestion Studies

CDM Smith has been conducting organics digestion research for several years. As part of these efforts, a laboratory treatability study was completed to evaluate the feasibility of an anaerobic digestion to process food wastes from Department of Defense (DOD) installations. This work was conducted on food wastes generated at the U.S. Air Force Academy in Colorado with the goal of quantifying food waste digestibility and energy yield, identifying potential nutrient limitations, and determining appropriate specific energy loading rates (SELR) for these wastes. These evaluations were completed in the absence of waste activated sludge (i.e., separate food waste digestion rather than co-digestion), similar to that being considered under this study. The results have provided estimates of expected volatile solids (VS) reduction and biogas production from SSO digestion which form the basis of this technical analysis.

It should also be noted that, as part of a project for the MWRA involving CDM Smith, Fay, Spofford & Thorndike (FST) and Dr. Chul Park at the University of Massachusetts/Amherst (MWRA project 7274A), an evaluation of the co-digestibility of food waste and wastewater solids was completed in October of 2013. The major findings of this study and laboratory analysis which are directly relevant to the Town of Ayer included the following:

- The addition of SSO to municipal biosolids at varying ratios of 0 to 50% showed no adverse effect on the stability of the digestion process;
- Increased percentages of SSO increased the volatile solids reduction and, in turn, additional biogas production; and
- The addition of SSO to biosolids of up to a 50% ratio is not expected to increase the concentration of total nitrogen or total phosphorus in the side-streams beyond the levels observed while digesting exclusively biosolids.

2.4 Types and Characteristics of Organic Wastes

The new regulations provide the following definitions pertaining to SSO and related materials:

- Food Material means source separated material produced from human or animal food production, preparation and consumption activities which consists of, but is not limited to, fruits, vegetables, grains, and fish and animal products and byproducts;
- Compostable Material means an organic material, excluding sanitary wastewater treatment residuals, that has the potential to be composted and which is source separated from waste;
- Organic Material means vegetative material, food material, agricultural material, biodegradable products, biodegradable paper, and yard waste; and
- Source Separated means separated from solid waste at the point of generation and kept separate from solid waste.

The MassDEP intends to ban SSO wastes from landfills and municipal solid waste (MSW) incinerators. These wastes typically include food wastes from supermarkets, institutions, food producers, and other large generators. However, there are other organic wastes such as fats, oils and greases (FOG), or airport deicing fluid that could also be considered.

The highest purity FOG wastes (e.g. fryolater grease) are typically collected from restaurants and other food establishments and recycled through rendering companies. These high quality wastes are a tradable commodity since they can be used directly in the manufacturing of biodiesel fuels. Other FOG wastes, with greater levels of contamination, have good properties for co-digestion with municipal biosolids since FOG has an extremely high energy content and nearly 100 percent conversion to biogas. If FOG wastes are a component of an organic food waste, they will improve the biodegradability of the mixture.

2.5 Potential Sources of Organic Feedstock

2.5.1 State-Wide Sources

MassDEP published a 2002 survey (updated in 2011) titled "Identification, Characterization, and Mapping of Food Waste and Food Waste Generators in Massachusetts" (completed by Draper/Lennon, Inc). The report separated Massachusetts food waste generators into the following categories:

- Manufactures/Processor
- Distributors/Wholesalers
- Hospitals
- Nursing Homes (and related facilities)
- Colleges and Universities
- Independent Preparatory School
- Correctional Facilities
- Resorts/conference facilities
- Supermarkets
- Restaurants

The study also provided a database which included the location and anticipated organic food waste generation in (tons/year) for each source. Though details as to the method of development of estimated quantities can be found in the study, it generally used the methodology shown in Table 2-1. The exception to this is that the producers within the Manufactures/Processor and Distributors/Wholesalers sectors were estimated on a state-wide basis due to the variability between each specific source location. It should also be noted that these sectors which were not specifically located are estimated to account for nearly 60 percent of the total waste as shown in Table 2-2. Further, Table 2-3 shows that most of the wastes are generated by a relatively small number of generators with approximately 80 percent of the annual tonnage being generated by only 30 percent of the total number of generators.

The results of this recently updated survey continue to serve as a basis for much of the organics diversion planning efforts throughout the Commonwealth and will be considered during the current Ayer feasibility study.

Generator Sector	Food Waste Generation Estimates by Generator Category
Hospitals	Food waste (lbs/yr) = N of beds * 5.7 meals/bed/day * 0.6 lbs food waste/meal * 365 days/yr
Nursing Homes and Similar Facilities	Food waste (lbs/yr) = N of beds *3.0 meals/bed/day * 0.6 lbs food waste/meal * 365 days/yr
Colleges, Universities, and Independent Preparatory Schools Residential Institutions	*Residential Institutions* Food waste (lbs/yr) = 0.35 lbs/meal * N of students * 405 meals/student/yr *Non-Residential Institutions (e.g., community colleges)* Food waste (lbs/yr) = 0.35 lbs/meal * N of students * 108 meals/student/yr
Correctional Facilities	Food waste (lbs/yr) = 1.0 lb/inmate/day * N of inmates * 365 days/yr
Resorts / Conference Properties	Food waste (lbs/yr) = 1.0 lbs/meal * N of meals/seat/day2 * N of seats * 365 days/yr
Supermarkets	Food waste (lbs/year) = N of employees * 3,000 lbs/employee/yr
Restaurants	Food waste (lbs/year) = N of employees * 3,000 lbs/employee/yr

Table 2-1
Quantity Estimate Methodology for Source Separated Organics Generators

Generator Sector	Estimates Tons/Year	Percent
Food and Beverage - Manufacturers and Processes	550,000	58
Restaurants	165,000	17
Supermarkets and Grocery Stores	105,000	11
All Other Sectors	130,000	14
Total	950,000	100

Table 2-2
Source Separated Organic Generators by Industry Sector

Tons Per Year Per Organics Generator	Number of Generators	Percent by weight
Greater than 400	860	59
200 - 400	295	8
100 - 200	930	14
Less than 100	4,775	19
Total	6,860	100

Table 2-3
Source Separated Organics Generator Size Distribution

2.5.2 Regional and Local Sources

Generally, the feasibility of collection and hauling of waste is evaluated on the basis of a 30 mile radius around the disposal destination. As a starting point for this evaluation, the quantity of anticipated waste in this 30 mile region was extracted from the organic waste survey data. The spatial distribution of the anticipated sources in this region is shown on Figure 2-1 while Table 2-4 provides a summary of the distribution of these expected sources between the various industry sectors.

	Quantity	Generation (Tons Per Year)
Resorts and Conference Facilities	58	1,000
Food and Beverage Manufacturers/Processors	*292*	*198,000*[1]
Supermarkets and Grocery Stores	247	37,000
Institutions -Colleges/Universities	43	11,000
Institutions -Healthcare Facilities	265	12,000
Institutions -Correctional Facilities	6	900
Institutions -Independent Schools	10	300
Restaurants	1381	59,000
Wholesale Distributors	*121*	*18,000*[1]
Total	**2423**	**338,000**

Notes: 1. Estimated based on statewide total to percent of generators within regional area.
2. “Regional” is considered to be within a 30-mile radius of the site

Table 2-4
Regional Organic Waste Source Distribution Based on MassDEP Database

More locally, there are a large number of food waste generators in Ayer and the surrounding areas that could contribute food waste to the Ayer facility. The spatial distribution of the anticipated sources in this region is shown on Figure 2-2 while Table 2-5 provides a summary of the distribution of these expected sources between the various industry sectors based on the MassDEP database. Included in Table 2-6 is a list of the larger potential local sources of organic waste in the vicinity of Ayer.

Local Organic Waste Sources	Quantity	Generation (Tons per Year)
Food and Beverage Manufacturers/Processors	*10*	*6,800*[1]
Supermarkets and Grocery Stores	5	800
Institutions -Healthcare Facilities	6	100
Institutions -Correctional Facilities	1	200
Institutions -Independent Schools	2	50
Restaurants	13	400
Wholesale Distributors	*2*	*300*[1]
Total	**40**	**8,700**

Notes: 1. Estimated based on statewide total to percent of generators within local area.
2. “Local” considered to include Ayer, Devens, Grafton, Groton, Harvard, Littleton and Shirley.

Table 2-5
Local Organic Waste Source Distribution Based on MassDEP Database

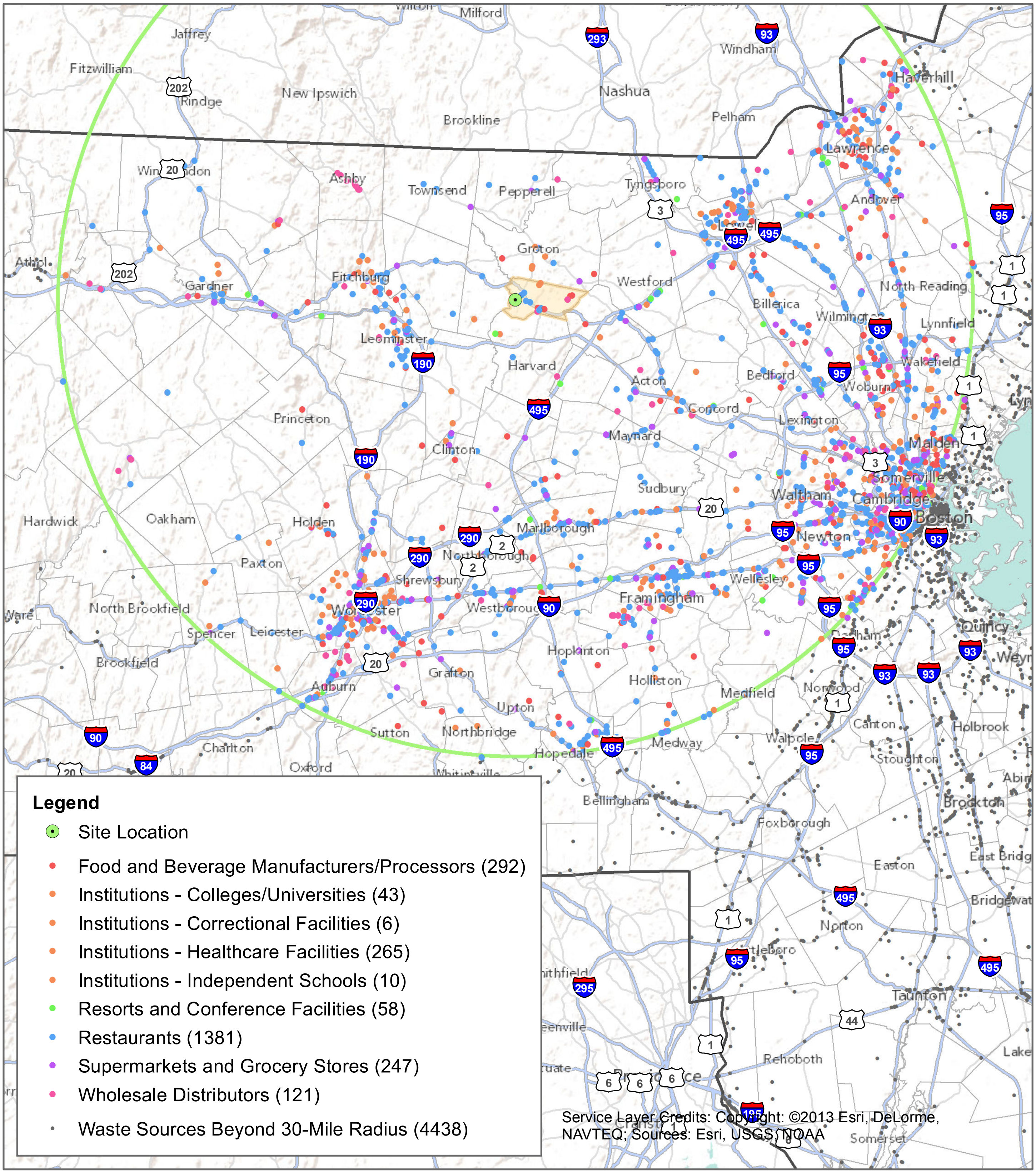
As previously noted, the 2002 survey and the data provided by the MassDEP do not include tonnage from specific Food and Beverage/Processors and Wholesale Distributors. For the conceptual totals presented in Tables 2-4, 2-5 and 2-6, quantities available from these sectors were determined using a ratio of the total estimated sector quantities compared to a percentage of the generators within the referenced area.

2.5.3 Fats, Oils and Grease (FOG)

Fats Oils and Greases (FOG) have long been the nemesis of wastewater collection and treatment operators. FOG in municipal collection systems can restrict and in some cases entirely block a sewer line and result in sanitary system overflows, which can be a public health and/or an environmental hazard. In addition, once the FOG arrives at the wastewater treatment facility (WWTF) it becomes a nuisance that can clog pipes, foul instruments and equipment, and be difficult to manage and dispose of. The cost to maintain and clean the system to avoid these situations is substantial. As a result, many communities require sewer services which are which are known contributors of FOG (e.g. restaurants, food processors) to install and maintain grease traps which separate the FOG from the sewerage before it is discharged into the collection system. This material is then generally collected by a private hauler and sent to a specialized FOG processing facility or landfill.

As previously noted, the addition of biodegradable fats, oil, and grease (FOG) to an anaerobic digestion system is beneficial due to the almost complete conversion of the material to biogas due to its high energy content. However, FOG digestion is more difficult to handle and supply to a digester than other materials (e.g. biosolids or food waste). For example, FOG tends to float, so the challenge is to break up the FOG by ensuring adequate digester mixing intensity. In addition, heating of the FOG to more than 160 ºF prior to injection into the digester will liquefy the FOG, promoting better FOG digestion from enhanced mixing, as well as even distribution of FOG throughout the digester volume. As a result, if substantial amounts of FOG are received at a facility, specialized processing equipment would be necessary to mitigate the inherent difficulties in product handling.

For the potential Ayer facility, due to the extensive capital cost that will be required for the base organics receiving and processing facility infrastructure, it has been assumed that specialized FOG receiving systems would not be included in the initial project. Though limited amounts of FOG would likely be able to be received with the traditional food waste and the facilities required to process substantial amounts of FOG could be added in the future, it has been assumed that this would be a substantial financial and operational undertaking and should be considered separately from the base organics digestion facility.



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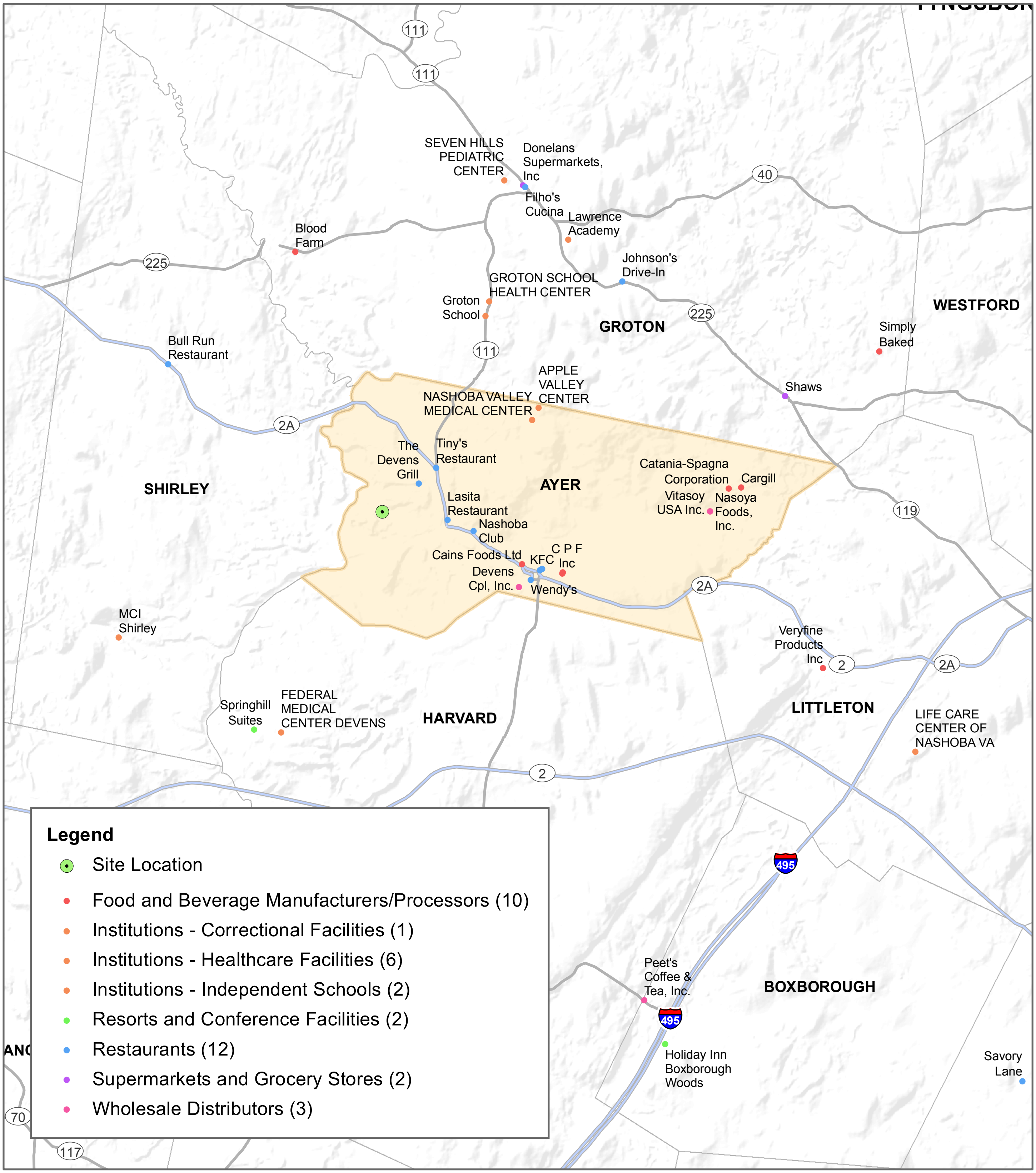
1 in = 9 mi

CDM Smith

Figure 2-2
Regional Organic Waste Sources within a 30 Mile Radius of Site
Ayer, MA Organic Waste to Energy Facility
August, 2013



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0 3,750 7,500 Feet

1 in = 7,500 ft

Figure 2-3
Regional Organic Waste Sources in the Vicinity of Ayer
Ayer Organic Waste to Energy Facility
August, 2013

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Generator Name	Street Address	Town/City	Estimated Generation (Tons Per Year)
Stop & Shop	100 Worcester St.	Grafton	317
MCI Shirley	Harvard Rd.	Shirley	214
Shaws	760 Boston Rd	Groton	167
Donelans Supermarkets, Inc	234 Great Rd	Littleton	143
Donelans Supermarkets Inc	236 Great Rd	Littleton	135
Donelans Supermarkets, Inc	250 Main St	Groton	54
Bull Run Restaurant	215 Great Rd	Shirley	53
KFC	4 Sandy Pond Rd	Ayer	45
Wendy's	2 Barnham Rd.	AYER	42
Johnson's Drive-In	164 Boston Rd	Groton	42
Apple Valley Center	400 Groton Rd.	AYER	40
Life Care Center	191 Foster St.	Littleton	39
McDonald's	2 Sandy Pond Rd	Ayer	38
Seasonal Specialties Catering	102 Prospect Hill Rd	Harvard	38
Yangtze River Restaurant	584 King St	Littleton	38
Nashobe Valley Medical Center	200 Groton St.	AYER	36
The Devens Grill	MacPherson Rd	AYER	30
Sesven Hills Pediatric Center	22 Hillside Ave.	Groton	27
Tiny's Restaurant	2 Groton School Rd	Ayer	27
Lawrence Academy	992 Powder House Rd	Groton	26
Groton School	Farmers Row	Groton	25
Filho's Cucina	235 Main St	Groton	23
Subway	287 Great Rd	Littleton	23
Nashoba Club	14 Central Ave	Ayer	18
Lasita Restaurant	13 Park St	Ayer	15
Groton School Health Center	282 Farmers Row	Groton	6

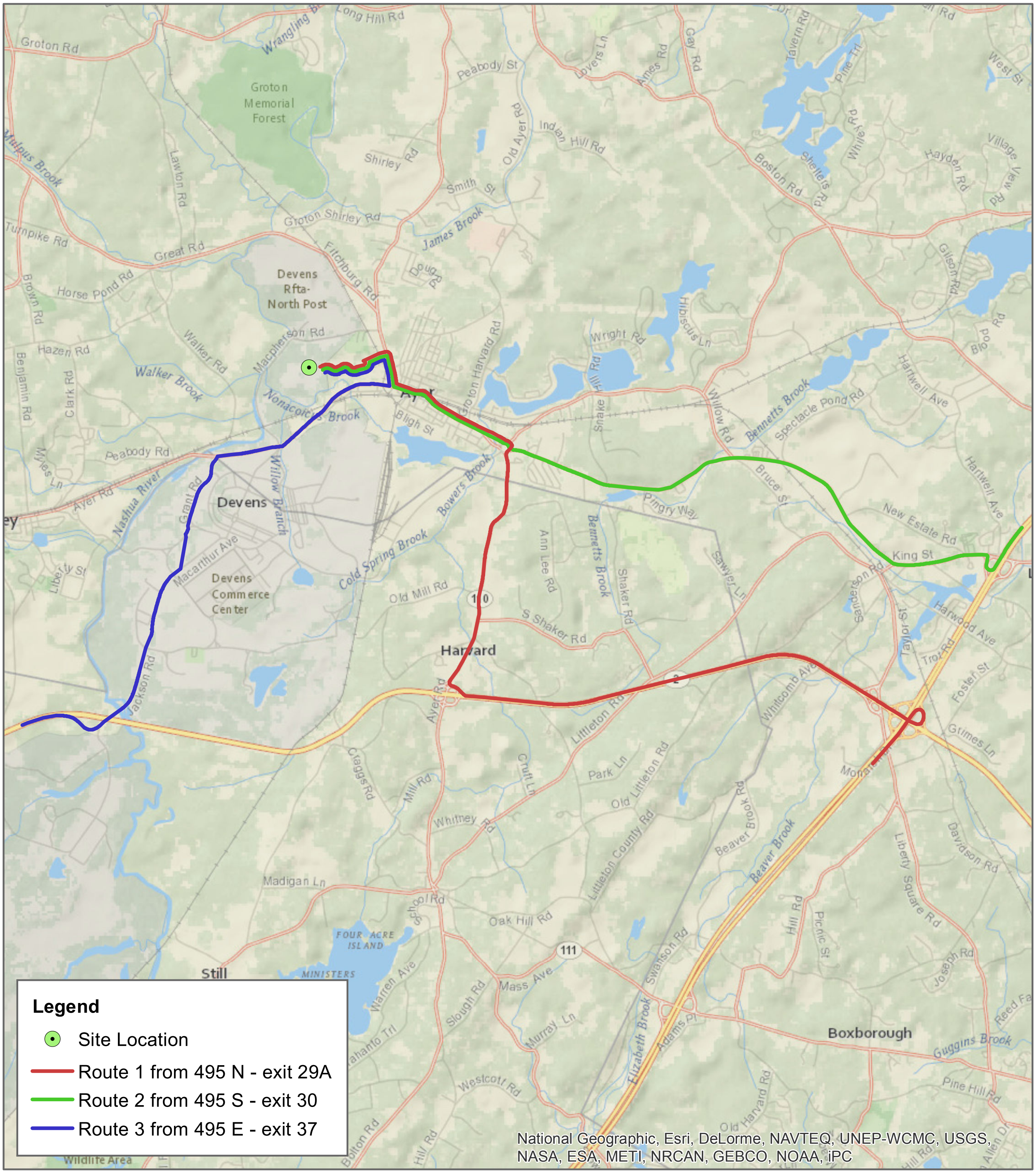
Table 2-6
Significant Local Potential Organic Waste Sources

2.6 Transportation Issues

Transportation of SSO to the site would likely occur via truck. As shown in Figure 2-4, there area few possible access routes from Interstate 495. Access from the north would likely involve using exit 30 to route 2A and route 111 for a total distance of approximately 6 miles from the interstate. Truck routing from other directions could utilize exits 37 or 38 from Route 2. From either exits, the distance from the highway is approximately 4 miles. Despite the relative proximity to major transportation corridors, routing from any direction would require hauling of waste through the heavily developed and often congested downtown area (Main Street and Park Street).

As previously noted, the organics diversion and hauling market within Massachusetts is in its infancy and the types of trucks that will be used to haul the material is not currently known. Much of the current diversion practice involves hauling of liquid organic waste using a sealed tanker truck while solid organic waste is hauled using traditional solids waste trucks. Odors from either of these transportation methods will depend on the design and age of the truck with the liquid tankers yielding less odor and leakage than a solid waste truck. It should also be noted that there are other types of vehicles in used in other US and foreign organic waste markets with rotating cylindrical bodies which mix collected material, distribute the load across the trailer and with reduced leakage and odors as compared to traditional waste hauling. As the organics diversion market gains momentum in Massachusetts, additional details and experience with hauling operations will become available from the haulers involved in this market.

Additional discussion related to truck traffic generation will be discussed later in this report along with the evaluation of the various sizing alternatives.



0 4,000 8,000 Feet

1 in = 8,000 ft

Figure 2-4

Potential Truck Routes to Site

Ayer Organic Waste to Energy Facility

August, 2013

2.7 Potential Revenue and Costs Related to Feedstock

Operating revenue associated with the project would include a tipping fee charged for disposal of organic wastes at the facility. As noted, there are a very limited number of operating organics diversion facilities in the Commonwealth at the moment and most of the tip fee pricing is not publicly available. Further, the pending organics ban along with the ongoing development of processing facilities will significantly alter the current organic waste disposal market in the coming months/years. For these reasons, projections of potential tipping fees are difficult to predict at this stage.

However, it can be noted that, based on discussions with national private haulers during the course of this study, experience in other parts of the country has indicated that market tipping fees for organic waste could be in the range of $30 to $40 per wet ton for pre-processed waste. Non pre-processed waste (raw food waste) would likely yield higher tip fees due to the significant cost associated with pre-processing as described later in this report. It can also be noted that liquid organic feedstock (ice cream, yogurt whey, etc) with a high percentage of volatile solids and which does not require preprocessing would likely yield a lower tip fee but would result in lower processing costs and likely higher energy production return when compared to other feedstocks.

The economic analysis included later in this report will evaluate "break-even" tip fees which will then be compared to the above known national market pricing to provide a sense as to the feasibility of each alternative.

Section 3

Technology Review and Alternatives Development

3.1. Digestion Process Overview

Anaerobic digestion (AD) is a biological process in which micro-organisms break down or "digest" organic materials in the absence of oxygen. The products of this digestion process include biogas (containing methane, carbon dioxide and other trace contaminants) and digestate (liquid and/or solid fraction remaining after digestion). Depending on the technology used, anaerobic digestion commonly reduces biosolids volume by approximately 40% and food waste by approximately 70%. As discussed further below, the biogas from this process can be converted to energy (electricity and/or heat) while the digestate can, provided an outlet exists, be used as a fertilizer or soil amendment product.

There are two main types of anaerobic digestion processes which are generally referred to as "wet" (typically up to ~15% solids) and "dry" (~30%+ solids) and both technologies have been employed for a wide range of project scales. A wet digestion process is limited by the need to pump and mix the material within a tank where it is held for an extended period to allow for the biological processes to occur. Raw material not meeting the pumping and mixing requirement is typically conditioned to the appropriate solids content by adding process water as required. Wet anaerobic digestion is the most commonly employed technology within the United States and there are currently six municipal wastewater treatment facilities within Massachusetts with operating wet digestion systems.

Though there are only limited small-scale dry systems currently in use within the United States, "dry" or "High Solids Anaerobic Digestion (HSAD)" has been utilized in Europe (multiple commercial scale facilities operating) and Canada (one commercial scale facility operating) for over twenty years to recycle source separated organics (SSO) while producing biogas. The dry digestion process involves stacking the product into a sealed tunnel and recirculating fluid through the beds for a holding period similar to that required for wet digestion. Due to the need to pre-process (screen, pulp and dilute) SSO prior to digestion in a wet system, dry digestion is advantageous and most commonly employed for a waste stream consisting of exclusively solid organic food and limited yard waste. Dry digestion is not commonly used for applications involving biosolids for a variety of reasons, including, but not limited to:

- The need to dewater dilute biosolids prior to dry digestion;
- Pile porosity issues for percolation liquid when high ratios of biosolids are used;
- Increased sensitivity to variations in feedstock using dry digestion; and
- Classification of digestate as a biosolids product requiring disposal or additional treatment.

For these reasons along with the need to process both biosolids and SSO feedstock at the potential Ayer facility, the following technology review and alternatives review will focus on wet digestion technologies. Though the additional details regarding the process are provided later in this section, Figure 3-1 shows the major components of a wet digestion system and the ancillary facilities that could be utilized at a conceptual Ayer organics to energy facility.

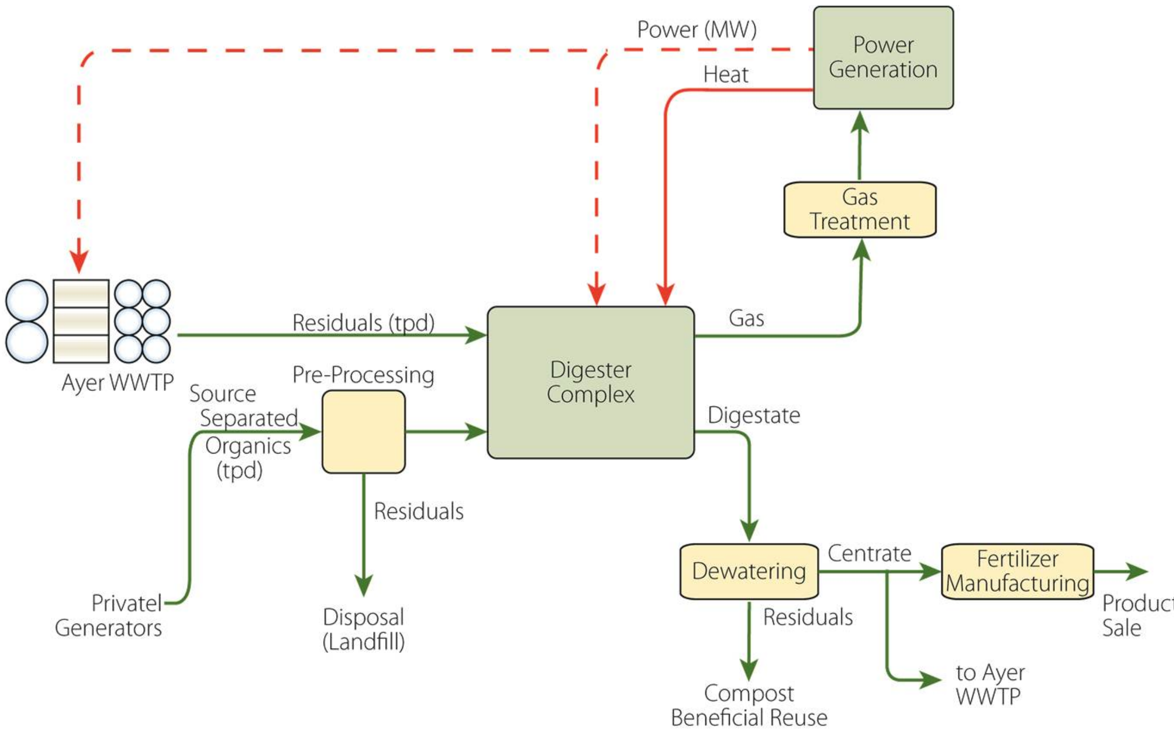


Figure 3-1
Conceptual Digestion Facility Process Schematic

3.2 Conceptual Facility Sizing

As outlined in Section 2, based on a review of available data, it is estimated that there may be approximately 338,000 wet tons per year (wt/yr) of organic waste within a 30-mile radius (regional) of the Ayer Brook Street site. However, it is unlikely that a facility built at the site would be able to attract this full quantity of waste as a result of a few factors, including:

- The waste generation estimates provided in the MassDEP study are conceptual in nature and include an estimate of total theoretical organic waste production. It is unlikely that all generators considered will be able to completely separate organics and some percentage will continue to be included in their solid waste stream;
- Concurrent with this study, there are a number of private and public entities studying the feasibility of developing source organics processing facilities as a result of the pending organics disposal ban in the Commonwealth of Massachusetts. As shown on Figure 2-1, the assumed 30-miles radius encompasses the majority of the metro-west region of Massachusetts and extends to points within the I-95 corridor and includes portions of the City of Boston. Based on recent discussions and planning within the industry, it appears likely that other facilities will be developed in the commonwealth that will compete with the potential Ayer facility for the sources within this area. Specifically, the MassDEP is currently studying development of a similar facility at the nearby MCI Shirley complex and a private developer is reportedly in the final stages of planning or a merchant facility in Ayer, MA.

- Also as a result of the pending organics disposal ban, the Massachusetts Water Resources Authority (MWRA) is currently pursuing a pilot program to further evaluate the use of significant excess digestion capacity at its Deer Island Treatment Plant for the co-digestion of organic waste. Prior planning of this pilot program projected that it would involve up to approximately 55,000 wt/year of pre-processed, source-separated organics being processed, with significant expansion of this acceptance rate possible upon full-scale implementation. The waste sources for this large-scale outlet will likely be from a large portion of eastern Massachusetts, including some of the area considered to be within the regional radius evaluated in this study. However, it should be noted that implementation of this pilot program is currently on hold due to community trucking concerns and alternative transportation methods are being evaluated.

As a result of the above factors, the current study will conceptually analyze three loading/sizing scenarios which are intended to represent the potential bounds of waste acceptance. For the purpose of this study, those scenarios are assumed to include:

- Alternative A: 1% of regional organic waste = 3,400 wt/yr;
- Alternative B: 5% of regional organic waste = 17,000 wt/yr
- Alternative C: 10% of regional organic waste = 34,000 wt/yr

Based on the feedstock quantity above, incoming truck traffic would likely range between 1 and 9 trucks per day assuming a 15 ton capacity. However, it should be noted that these quantities may vary significantly depending on the consistency and transportation method of the waste.

All scenarios will also include the biosolids quantities currently produced by the Ayer Wastewater Treatment Plant of 7,000 gallons per day which equates to 2,000 dry pounds per day at 3.5% solids concentration.

The following sections will review the estimated infrastructure and associated cost associated with each of these acceptance scenarios.

3.3 Organics Receiving and Pre-Processing

Though few facilities presently exist nationwide for the pre-processing of source separated organic food waste, there are some operational facilities in Canada and Europe. A facility of this nature would include equipment to process in-coming wastes in order to produce a product that can be easily digested. Processing is expected to include machinery to screen and pulp the wastes, remove contaminants (e.g., glass, plastics, metals, and cardboard), and produce a uniform pumpable material that is readily digestible.

3.3.1 Pre-Processing System Sizing

It has been assumed, based on industry research, that the food waste would be delivered to the facility at a solids percentage of 31% (69% water). At this high percentage of solids, even following pre-processing, the resultant product is not conducive to pumping to or mixing within anaerobic digestion tanks. As a result, it has been assumed that the waste would be diluted to approximately 13% solids content prior to being introduced to the digestion facility. This resultant product is sometimes referred to as Engineered Food Waste (EFW).

As shown in Table 3-1, this would translate to between 5,200 and 52,000 gal/day of EFW being fed to digestion with between 3,000 and 30,000 gal/day of dilution water being required. It should also be noted that, though public water supply is a potential source for this dilution water, rain water and/or other liquid organic wastes can also be used for this purpose and would be more cost effective. Installation of a water supply well for this water could also be considered. It should also be noted that use of dewatering filtrate for dilution water is not considered feasible at this time due to the recirculation of ammonia that would occur which could create the potential for ammonia toxicity within the digestion process. For conceptual costs purposes, it is assumed that municipal drinking water will be used for this purpose and costs will be carried accordingly.

	Alternative A	Alternative B	Alternative C
Annual Rates			
Potentially Available SSO Waste (wet tons/year)	3,400	17,000	34,000
Potentially Available SSO Waste (wet tons/day)	9	47	93
Daily Volume Diluted to 13% (gal/day)	5,200	26,000	52,000
Water Required for Dilution (gal/day)	3,000	14,800	29,600
Daily Rates (Based on 8 hrs/day & 5 days/week Receiving)			
Pre-Processing Rate (wet tons/hr)	1.6	8.2	16.3
Daily Volume Received (gal/day)	3,100	15,700	31,400
Daily Volume Diluted to 13% (gal/day)	7,300	36,500	73,000
Storage Volume (2 days) (gal)	14,600	73,000	146,000
Water Required for Dilution (gal/day)	4,200	20,800	41,600

Table 3-1
SSO Receiving and Pre-Processing

3.3.2 Pre-Processing Equipment

One of the limited examples of preprocessing systems that has been utilized to-date is the "CORe" (Centralized Organics Recycling equipment) system developed by Waste Management. This system is a source separated food waste processing and blending system designed to remove the non-degradable contaminants from source separated food waste streams. The major components of this system include an organic material feed hopper, hopper auger feed, bio-separator (cylindrical screen) and bio-slurry tanks. It is intended to utilize a small footprint and provide a totally enclosed solution for SSO preprocessing at a WM transfer station(s), landfill, or on a partner's property. Using this system, the received material is blended into a consistent feedstock. Pilot testing of the CORe system was completed at Victor Valley Water Reclamation Authority in CA with reportedly positive results. However, it is noted that this system is currently proprietary and costs for installation in Ayer are not currently available.

Another existing preprocessing system in use in North America is employed at a privately owned and operated facility in Zaneville, OH. The facility is owned and operated by Quasar Energy Group utilizes a Dupps Food Waste Depackaging System. The depackaging process includes a receiving hopper, an auger to move the material up to a hammer mill where the packaging is coarsely ground and augered to the organics extruding screw press. The screw press then allows liquid to be extruded out and pumped into receiving pits ahead of digestion.

A third known example of a pre-processing system is that currently offered by Komptech USA of Westminster, Colorado (though headquartered in Germany). The pre-processing system that they offer includes shredding, pulping, screening/pressing, sand separation and hygienisation stages. Though they do not currently have any US installations, the equipment they offer has been used extensively in Europe.

Example Receiving and Pre-Processing Equipment (Courtesy of Komptech)

Costs evaluated later in this section include costs for this type of pre-processing system as well as the required dilution water at the Ayer site. For the purpose of equipment sizing, it has been assumed that waste would be received 8 hrs/day, 5 days/wk.

3.3.3 Pre-Digestion Storage and Feed

The efficiency of an anaerobic digestion system is contingent upon the ability to feed it at a relatively constant rate. Highly variable loading or 'slugs' of feed material being introduced into the process creates a potential for upsets (significant decrease in biogas production), foaming and/or an overall reduction in volatile solids destruction efficiency.

As a result of the continuous feeding needs in comparison with the receiving schedule noted previously, it is expected that pre-digestion engineered food waste storage tank(s) would be required. In addition, this storage would serve to address variations in SSO supply and potential system operational issues. For the purpose of this study, it is assumed that a total of 2 days of diluted SSO storage would be required. As shown in Table 3-1, this equates to between 15,000 and 150,000 gallons for the options being evaluated.

3.3.4 Pre-Processing Odor Control

Due to the nature of the waste which would be received and handled within the pre-processing system, and despite the relatively remote nature of the Ayer site, it is expected that odor control treatment of the exhaust air from this area of the process would be required. There are several types of odor control technologies that would be suitable for use at this facility, which could include:

- Biofiltration (conveyance of air upward through an organic or inorganic media that supports a population of microorganisms that consume odor forming compounds);
- Wet Scrubbing (treatment of air through a scrubbing chemical solution which oxidizes and neutralized the odor forming compounds); or
- Carbon Adsorption (use of a carbon impregnated with caustic or a catalytic carbon with an enhanced affinity for hydrogen sulfide is generally used to absorb the odor forming compounds).

Though the exact technology used at this location would need to be refined during the design stage, an allowance will be carried in the cost evaluation to address this need.

3.4 Anaerobic Digestion

Wet anaerobic digestion has been practiced for decades and is one of the most common technologies used for the stabilization (pathogen and odor reduction) of wastewater treatment residuals (biosolids) utilized in the United States. As previously noted, some of the major benefits of this process include the following:

- Biosolids quantity reduction can commonly exceed 40 percent;
- Digester gas produced (biogas) can be converted to electricity;
- Digested solids produced exhibit less odor then undigested solids; and
- The carbon footprint of facilities with anaerobic digestion is significantly less than competing biosolids management technologies.

Previous and continued research in the area of anaerobic digestion has generally focused on improved solids pre-treatment, improved digestion efficiency and maximization of digester gas production. In addition, there are many technologies that are being developed to improve sludge quality, making it more amenable to digestion. These technologies disrupt the cell membranes with chemical, heat or pressure to accelerate the digestion process and improve biogas production. There are also several variations of the anaerobic digestion process itself which have been employed by some municipalities. These include staged systems (acid-phase digesters followed by gas-phase digesters), high temperature thermophilic digesters (140°F) and other combinations which are also intended to improve the efficiency of the digestion process.

More recently, as discussed in Section 2, there has been a significant increase in the emerging area of organics digestion and co-digestion of organics with biosolids. There are a number of ongoing studies in this area including work with the Department of Defense and the Massachusetts Water Resources Authority to help refine data pertaining to the expected volatile solids (VS) reduction and biogas production from organics digestion.

3.4.1 Digester Tank Sizing

Anaerobic digesters are sized based upon solids retention time (SRT) and hydraulic retention time (HRT). For the conceptual Ayer digestion facility, is has been assumed that the process would utilize a conventional mesophylic process (95°F process temperature) and would be sized for an average SRT of 20 days. This retention time is industry standard and is based on allowing adequate time for the biological process within the digester to optimize the volatile solids destruction and associated biogas production. It is further assumed that this high rate digester system will not include supernatant decant and therefor, the HRT is equivalent to the SRT and the terms may be used interchangeably.

Though the SRT generally dictates digester volumetric sizing for most biosolids applications, the amount of volatile solids (VS) fed per unit digester volume becomes an increased concern when highly concentrated wastes such as SSO are fed to a digester at high percentages. The limitation of this loading is important to ensure stable operations and biogas production and to reduce the potential for process upset. Based on recent studies, laboratory testing and full-scale co-digestion applications, the recommended upper bound of this loading is currently believed to be approximately 0.20 pounds of volatile solids per cubic foot of digestion capacity per day (lb VS/CF/day). As is the case for

Alternatives B and C evaluated here, when VS loading is above this criteria, the digester volume it commonly increased above that determined by SRT sizing criteria to reduce the VS loading.

Table 3-2 summarizes the recommended basis of design used to size the digester system under each acceptance alternative. As shown below, it is anticipated that required digestion volume would range from 0.24 Mgal to 1.8 Mgal.

It should also be noted that the materials of construction for digestion tanks under municipal ownership and operations is commonly cast-in-place or pre-stressed concrete. This selection of material is typically made due to considerations including service life and reduced maintenance costs when compared to other options. It also provides the most flexibility with respect to biogas pressures and cover options. However, in industrial settings, steel digestion tanks tend to be selected more commonly due to the associated capital cost savings. Steel tanks can be provided with welded or bolted steel and coated with epoxy coatings or fused glass materials. For the purpose of this conceptual analysis, it has been assumed that the tanks(s) will be constructed of cast-in-place concrete.

	Alternative A	Alternative B	Alternative C
Service Area (Municipal) Loading[1]			
Flow (gal/day)	7,000	7,000	7,000
Solids (lbs/day)	2,000	2,000	2,000
VS Reduced (lbs/day)	900	900	900
Solids Remaining (lbs/day)	1,100	1,100	1,100
Biogas Produced (cf/day)	14,000	14,000	14,000
Outside Waste (SSO) Loading[2]			
Flow (gal/day)	5,200	26,000	52,000
Solids (lbs/day)	5,600	28,000	56,000
VS Reduced (lbs/day)	3,900	19,500	39,000
Solids Remaining (lbs/day)	1,700	8,500	17,000
Biogas Produced (cf/day)	53,000	265,000	530,000
Total Loading			
Flow (gal/day)	12,200	33,000	59,000
VS Reduced (lb/day)	4,800	20,400	39,900
Digestate Solids (lbs/day)	2,800	9,600	18,100
Digestate Solids Concentration (%)	2.8%	3.5%	3.7%
Biogas Produced (cf/day)	67,000	279,000	544,000
Digester Sizing			
Digester Volume for 20 day SRT (gal)	244,000	-	-
Digester Volume for 0.20 lb/cf/day VSLR (gal)	-	951,000	1,841,000

[1] Assumes TS of 4.3%, VS/TS of 81.2%, VS reduction of 54.6% and biogas production of 15 cf/lb VSR.

[2] Assumes TS of 13%, VS/TS of 85%, VS reduction of 82% and biogas production of 13.6 cf/lb VSR.

Table 3-2
Anaerobic Digestion Conceptual Sizing

3.4.2 Biogas Production Estimate

Based on recent studies[1], it has been shown that the ratio of volatile solids to total solids and the biogas production per pound of volatile solids reduced for source separated organic (SSO) waste is relatively similar to that of municipal biosolids. However, it was also shown that the reduction of the volatile solids in the SSO stream within an anaerobic digester is significantly greater than is typically seen with municipal sludge (82% VS reduction for SSO vs. 55% VS reduction of municipal sludge). This, combined with the fact that SSO is generally fed to digesters at higher solids concentrations, enables the biogas yield from a gallon of SSO to significantly exceed that of from a gallon of municipal sludge. When this difference in gas production is considered on a unit basis, the yield from SSOs is approximately four times that of municipal sludge (10 cf biogas/gal SSO vs. 2.5 cf biogas/gal sludge).

As previously noted, this evaluation included three scenarios to represent the potential bounds for SSO acceptance volumes. It was determined that the average available SSO acceptance capacities under each of these scenarios would be between 5,200 gal/day and 52,000 gal/day. Using these values, along with theoretical digestion performance parameters for digestion of biosolids and SSO, the total anticipated biogas yield under each of these scenarios was calculated. As shown in Table 3-2, the total theoretical biogas production under these loading conditions would be between approximately 67,000 and 544,000 cf/day.

3.5 Ancillary Equipment

Anaerobic digestion systems require a significant amount of ancillary equipment to ensure proper process operations and safety. The following includes a brief discussion on each of the four major ancillary systems, which include:

- Heating system;
- Mixing system;
- Digester covers;
- Digester biogas handling equipment;
- Biogas storage system; and
- Biogas treatment and boosting systems.

3.5.1 Digester Heating

Anaerobic digesters are heated to maintain an environment conducive to methane forming microorganisms and to ensure greases and fats within the digester remain in an emulsified state so they can be broken down biologically.

There are two main types of heating systems: internal and external.

- Internal: With an internal arrangement, heat is applied to the sludge while it remains in the digester tank. Older digester heating arrangements included mounting pipes to the interior of

[1] Anaerobic Digestion and Energy Recovery from Food Waste, J. Amador, D. Nelsen, C. McPherson, P. Evans and D. Parry (CDM Smith), H. Stensel (University of Washington), and T. Hykes, (U.S. Air Force Academy), WERF, 2012.

the digester wall in which hot water circulates and draft tube mixers equipped with hot water jackets. In recent years, these arrangements have become less popular due to operational issues, including the buildup of sludge on the heating surface and access restrictions. Because all internal heating systems rely on the digester mixing system to circulate heat within the digester, the mixing system must be operated on a continuous basis. Without continuous mixing, heat gradient will develop in the tank and create biologically inactive zones.

- External: Newer digesters typically use external heating systems that recirculate sludge through external heat exchanger(s) using a recirculation pump. Most external heating systems incorporate means to heat the sludge before it enters the digester (i.e. influent heat exchanger). The feed sludge is typically interlocked with the sludge recirculation pumps, allowing the blending and preheating of the feed and active digester sludge before it enters the digester.

Hot water for the digester heating systems is typically supplied by either waste heat from a cogeneration system and/or a boiler that utilizes biogas from the anaerobic digester. Natural gas or propane can be used as a supplemental fuel when not enough biogas is produced to heat the digester or if all of the digester gas in used in cogeneration and the waste heat is not sufficient to meet heating demands.

For the Ayer conceptual analysis, is has been assumed that external heat exchangers will be utilized and cogeneration waste heat will serve to supply the process heating needs. The energy balance and cogeneration sizing will be discussed later in this section.

3.5.2 Digester Mixing

Mixing in high rate digestion systems is important to maintain uniformity within the digester and to prevent scum accumulation in the digester tank. Digester mixing is a crucial component and poor mixing typically results in lower volatile solids destruction and decreased biogas production. Presently, the most common mixing systems are: recirculation pumps, compressed biogas and mechanical mixing.

- Recirculation Pumps: Pump systems use external pumps to recirculate the sludge for mixing. Sludge is pumped from the digester tank and is typically reintroduced through several ports located around the circumference of the digester or discharged through nozzles. Depending on tank diameter, pumping rates typically turn over the contents of the digester every 3 to 12 hours.

- Compressed Biogas: The four major gas mixing systems are gas discharged lances, floor-mounted diffusers, confined draft tubes, and "bubble-gun" gas mixers. On each of these systems, the gas compressor and control valves are the major mechanical pieces of equipment. In each system, biogas is taken from the headspace of the digester tank, compressed, and distributed to multiple mixing devices.

- Mechanical Mixing: These systems consist of a propeller, drive shaft and drive. Most mechanical mixing systems are mounted in a draft tube to direct sludge flow within the digester, while others are simply installed through tank wall penetrations with the motor and gear end external from the tank and with the propeller shaft penetrating though and generally perpendicular to the tank wall. When installed in a draft tube, drives are typically reversible, allowing the sludge to discharge at the top or bottom of the draft tube. Mixer/draft tube assemblies may be located at the center of the digester tank, at the mid-radius point or outside the digester tank.

A pump recirculation mixing system is recommended for Ayer based primarily on operation and maintenance considerations. With these systems, pumps are located inside a building along with other equipment and are easily accessed. In comparison, mechanical draft tube motors are located on top of the digester tanks creating a difficult maintenance environment especially during winter conditions. In addition, due to the inability to grind the recirculation flow with a draft tube mixer, rags and other fibrous materials could tend to accumulate within the digesters and create a maintenance concern. Further, due to the configuration of draft tube mixers, a crane would be required for any significant maintenance procedures. Gas mixing systems were removed from consideration due to cost and the historical maintenance concerns associated with the biogas compressor systems and general safety concerns associated with biogas handing. It should also be noted that a mixing system will also be required for the sludge storage tank discussed later in this section.

3.5.3 Digester Covers

Digester tanks require covers to maintain anaerobic conditions in the tank, contain and assist in collecting biogas produced during the digestion process, reduce odors, retain heat to maintain internal temperatures, and support some types of mixing equipment (e.g., internal draft tube mixers supported from fixed covers). There are four basic types of digester covers: floating, fixed, submerged fixed, and gas membrane.

- Floating Covers: Floating covers have been widely used throughout the wastewater industry for years. They have typically been used to provide for some liquid storage (conventional floating covers), as well as some gas storage (gas holding covers). Conventional floating covers float directly on the sludge surface, which provides for fluctuations of the liquid sludge level with minimal change in biogas pressure.

- Fixed Covers: Fixed concrete and steel covers are also widely used throughout the wastewater industry. They have historically been the option with the lowest cost and least potential for operation and maintenance problems in comparison to floating covers. However, fixed covers offer minimal biogas storage and limited flexibility with regard to sludge liquid level. One variation on the fixed concrete cover design is the submerged fixed cover (SFC). Compared to flat fixed cover designs, the submerged fixed cover is effective at utilizing the upper portion of the tank volume by inhibiting the buildup of floating foam and scum and directs mixing energy for better efficiency.

- Submerged Fixed Covers (SFC): These are similar in costs to flat roof digesters and less costly to construct than domed roofs. The key to the submerged fixed cover digester is a sloped roof that leads to a centrally located gas dome. In a SFC design, the liquid level is allowed to rise into the gas dome above the side wall, submerging the underside of the cover. Submerging the cover provides a gradual transition at the cover side wall connection, directing mixing patterns more effectively. Operating the liquid level in the gas dome minimizes the gas to liquid interface. By minimizing this interface, foam and scum can be removed more effectively. With minimal gas storage volume, a fixed cover system must either rely on storage spheres, piping, flares, vacuum and pressure relief valves, or some other means of gas storage to keep the pressures consistent inside the tank.

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- Gas Membrane Covers: Gas membrane covers are a relatively new product that was first used in the U.S. in the early 1990s. They provide a large volume of digester gas storage using a double-membrane design and may be installed on digester tanks or sludge storage tanks. The outer membrane maintains a consistent dome shape, while the inner membrane moves up or down depending upon gas storage requirements. Ambient air fans and valves add or release air from the space between the inner and outer membranes to maintain the consistent outer membrane shape and constant biogas pressure. This also allows for substantial changes in the depth of sludge in the digester.

It has been assumed that SFCs will be used at the Ayer facility as fixed covers tend to be less costly than floating covers or gas holder membranes and SFCs minimize foaming, which is often expensive and difficult to control and contain. It is further recommended that the digested sludge storage tank, as discussed further below, be installed with a gas membrane cover to store excess biogas before it is used in cogeneration.

3.5.4 Gas Handling Equipment

Gas handling equipment consists of gas storage, conveyance and safety equipment. The conveyance system brings biogas at the rate it is produced in the digesters to equipment for consumption, storage, or wasting (combustion prior to release to atmosphere). Most biogas conveyance systems are low pressure and operate at approximately 12 inches of water column (< 0.50 psig). Biogas may be stored based on production and utilization demands of the boiler or cogeneration equipment. Storage devices include digester tank gas holder covers which are part of the digester itself and membrane gasholders that are external to the digester and are typically located in close proximity to the digester on a concrete pad.

Similar to natural gas, biogas is explosive at low concentrations of approximately 1 volume of gas to 15 volumes of ambient air. As such, it is of the utmost importance that the biogas handling system be fitted with appropriate gas-safety equipment, to protect against the risk of ignition and a potentially catastrophic explosion.

Any source of ignition, such as waste gas burners, engines, or boilers must be protected against flashback through the piping with a flame arrestor or flame traps. A flame arrestor works to quench the flame by dissipating any heat from a potential explosion in the piping. A flame trap is a combination of a flame arrestor and a thermal shutoff valve. If a propagating flame is stopped by the arrestor but continues to burn in the piping, a thermal element in the thermal shutoff valve will melt and seal off the remainder of the upstream piping from the fuel source.

Anaerobic digesters are provided with pressure/vacuum relief valves, typically mounted directly on top of the digester tank. These valves release any biogas to the atmosphere when the pressure rises above a set-point to protect from over-pressurization of the tank. Additionally, a vacuum relief valve will allow entry of ambient air into the tank during any vacuum conditions, to protect the tank from imploding. Costs for these systems have been incorporated into the project lifecycle evaluation included later in this section.

3.5.5 Biogas Storage Systems

As previously noted, because digesters do not produce biogas at a constant rate, nor is gas usage always constant, biogas storage is often recommended to maximize the biogas capture rate and increase the efficiency of the overall system. The most likely and viable alternative for providing storage capacity in this application would be the use of a double membrane gas holder.

Gas membrane covers were first used in the U.S. in the early 1990s. They provide a large volume of digester gas storage using a double membrane design. The outer membrane maintains a consistent dome shape while the inner membrane moves up or down depending upon gas storage requirements. Ambient air fans and valves add or release air from the space between the inner and outer membranes to maintain the consistent outer membrane shape and constant biogas pressure. The exterior membrane is typically made out of polyester fiber fabric that is coated with PVC that is microbial and abrasion resistant. The internal membrane is also typically manufactured from PVC coated polyester fiber fabric, which is microbial, abrasion and biogas resistant. Some of the key drivers for this technology have been the need for large gas storage volumes and/or large fill and draw capacity in the tank.

There are several suppliers of membrane covers in the U.S. including WesTech, Ovivo, Siemens and JDV. WesTech, Siemens and JDV have several installations in the U.S. and most of the JDV and WesTech membrane systems are standalone on a concrete pad as opposed to on top of a tank.

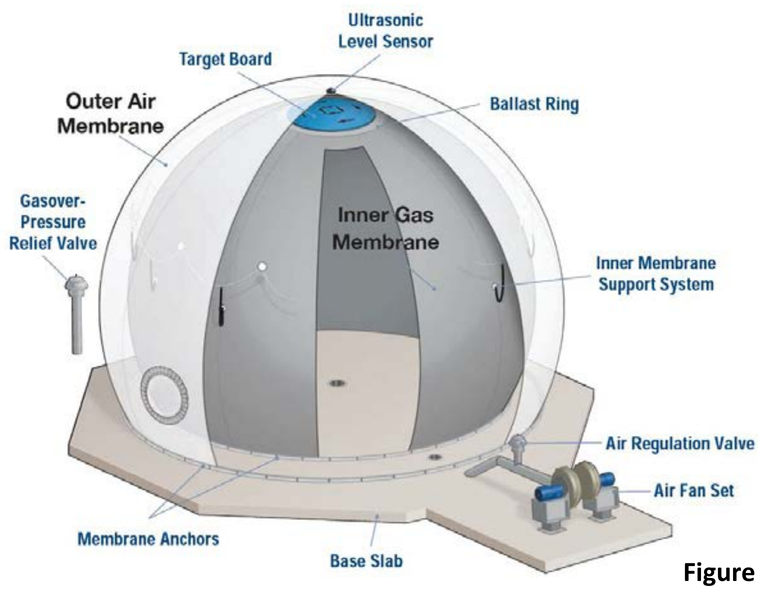

Figure 3-3
Typical Gas Membrane Storage System
Figure Courtesy of WesTech

Membrane covers have proven to be reliable systems with the older installations having a life expectancy of 10 years. However, suppliers indicate that the technology has improved in recent years and newer membranes should have a service life of approximately 15 years.

It is conceptually estimated that a total biogas storage volume equating to 8 hrs of average production would provide adequate storage capacity to enable a high biogas capture percentage. As such, the additional storage required to be supplied by this new storage system would equate to 24,000, 96,000 and 184,000 cf for Alternatives A through C, respectively.

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3.5.6 Biogas Treatment and Boosting Systems

Biogas Treatment

Prior to being utilized in a cogeneration system, some level of biogas treatment is typically required to remove contaminants. The level of treatment depends on the concentrations of contaminants in the biogas and end use of the gas. Contaminants often found in digester gas produces from wastewater treatment residuals include hydrogen sulfide (H_2S) and siloxanes.

Hydrogen sulfide (H_2S) in biogas is formed by the reduction of sulfates by anaerobic bacteria within the digester. Sulfates occur naturally in wastewater from the decomposition of urine and protein in the influent sludge. Siloxanes are often used in the manufacture of personal hygiene, health care and industrial products and eventually end up in wastewater. Siloxanes volatilize into the biogas during the digestion process and when this biogas is combusted, siloxanes are converted to silicon dioxide (SiO_2), which is then deposited in the combustion or exhaust stages of the equipment. In reciprocating engines, the presence of hydrogen sulfide and/or siloxanes can lead to premature deterioration and excessive maintenance of the equipment components. For this analysis, it is assumed that moisture, sediment and hydrogen sulfide removal along with biogas pressure boosting will be required. A siloxane treatment system is not currently assumed to be required as the presence of siloxanes in digester biogas is difficult to predict without facility-specific biogas sampling. Further, the cost of siloxane removal systems can be substantial and it is believed that inclusion of these costs at the feasibility stage of the project would be overly conservative.

Biogas Pressure Boosting

Biogas pressure boosting is generally required in CHP applications due to the relatively low gas pressures which anaerobic digesters are typically operated at. The pressure of the biogas from anaerobic digesters is generally 12 inches of water column (< 0.50 psig) or less. This head space pressure is not sufficient for internal combustion engines which generally require an inlet pressure of between 2–5 psi of inlet gas pressure. As a result, the biogas utilization system at this facility would require a biogas booster system. In this system, the digester gas would first enter through a blower inlet moisture/particulate filter to remove any free moisture and particulates prior to being compressed with a blower. The blower would compress the gas to about 5 psig prior to entering a heat exchanger which would reduce the dew point of the gas to 40°F and reheat the gas to 80°F. All condensed moisture would be removed inside the heat exchanger and drained through a no-gas-loss drain. The heat exchanger would be supplied with cold glycol from a remote mounted glycol chiller.

Figure 3-4
Representative Biogas Booster System

3.6 Energy Recovery

Digester biogas is commonly used to heat the digester and facility buildings by using the biogas in hot water boilers. However, in recent years, the prevalence of biogas fueled cogeneration systems have increased in popularity due to their ability to produce electricity and heat simultaneously. These systems which produce both electricity and recovered heat energy are commonly referred to as Combined Heat and Power (CHP) systems.

Though the electrical efficiency of an engine generator is significantly less than the overall efficiency of a boiler system, when coupled with a waste heat recovery system, the combined efficiency of the cogeneration system can be competitive with that of a boiler. As is the case in Ayer, a CHP system is often preferable to a boiler system due to the lack of sufficient heat demand to fully utilize the thermal output from a boiler system.

The following includes a brief description of available CHP technologies, and a conceptual evaluation as to the anticipated heat and electrical balance between production and on site use.

3.6.1 CHP Technology Alternatives

Currently, the most common technologies used for cogen are microturbines and reciprocating engines. In addition, other innovative technologies may become competitive in the future by reducing the need for biogas cleaning prior to use, therefore reducing overall complexity and equipment cost. For general background and potential future consideration, both established and innovative CHP technologies are briefly described below.

Internal Combustion Engines

Internal combustion (IC) engines are the most widely used CHP technology. They are often the most economical CHP technology and have combined electrical and heat recovery efficiencies higher than any other currently available CHP technology. Heat can be recovered from the engine jacket water and from the exhaust gas. The technology is reliable and available from a number of reputable manufacturers. IC engines are less sensitive to biogas contaminants than most other CHP technologies, reducing the gas cleaning performance requirements; however, cleaning is often recommended to remove moisture, hydrogen sulfide, and siloxanes as discussed above.

One disadvantage of IC engines is their relatively high emissions, as compared to other CHP technologies, such as microturbines and fuel cells. IC engine emissions can cause permitting difficulties in areas with strict air quality limits and may require additional emissions control, such as selective catalytic reduction to meet emission requirements. However, most IC engines installed since 2005 are lean-burn engines, with higher fuel efficiency and lower emissions than rich-burn engines which were more commonly used before the 1970s.

Combustion Gas Turbines

Combustion gas turbines are often a good fit for very large biogas production rates. Like IC engines, combustion gas turbines are a reliable, well-proven technology available from several manufacturers. Large Waste Water Treatment Plants (WWTPs) in the US use biogas-fueled combustion gas turbines or CHP. Heat can be recovered from the exhaust gas. Combustion gas turbines are relatively simple, containing few moving parts and consequently requiring little maintenance. While infrequent, the maintenance of combustion gas turbines requires specialized service.

Microturbines

As the name suggests, a microturbine is a much smaller version of a combustion gas turbine. Microturbine capacities range from 30 kW to 250 kW and are often a good fit for smaller WWTPs with anaerobic digestion. Microturbines are relatively new, introduced about 15 years ago. Despite their somewhat recent development, microturbines have become the second most widely used technology at WWTPs for harvesting electricity and heat from biogas energy due to their small capacity and clean emissions. However, microturbine electrical efficiency is considerably lower than that of IC engines. Microturbines require relatively clean fuel, increasing the performance requirements and cost of biogas treatment, but their exhaust emissions are among the lowest of all CHP technologies. Microturbines are currently available from two manufacturers.

Fuel Cells

Fuel cells are unique in that they do not combust biogas to produce power and heat. Instead, fuel cells convert chemical energy to electricity using electrochemical reactions. Their benefits include high electric efficiency and extremely clean exhaust emissions. However, fuel cells are one of the most expensive CHP technologies in terms of both capital and operation and maintenance (O&M) costs. In addition, they are extremely sensitive to impurities in the biogas, requiring the highest level of biogas cleaning of all CHP technologies. For these reasons, fuel cell installations are typically limited to locations with strict air quality regulations and fuel cell-specific grants or incentives.

Stirling Engines

While Stirling engine technology is well established, their application to biogas is innovative. There has been increased interest in this CHP technology in recent years due to its reduced biogas cleaning requirements. A Stirling engine is an external combustion process. Biogas is combusted outside of the prime mover. The heat generated by the combustion process expands a working gas (generally helium), which moves a piston inside a cylinder. Because combustion occurs externally to the cylinder and moving parts, very little biogas cleaning is required.

Pipeline Injection

Pipeline quality biogas has extremely low concentrations of contaminants and must be compressed to match the natural gas transmission line pressure. Biogas contaminants that must be removed include foam, sediment, water, siloxanes, hydrogen sulfide, and carbon dioxide. Following cleaning, biogas must be compressed for pipeline injection. Biogas cleaning to pipeline quality has high capital and O&M costs. In most situations, generation of pipeline quality biogas is not cost-competitive with CHP. This biogas use is a better fit for large biogas producers (to take advantage of economies of scale) that near a natural gas pipeline. If financial incentives are available, pipeline injection can become attractive. There are currently only a few facilities cleaning biogas to pipeline quality in the US.

CNG or LNG Vehicle Fuel

Biogas can be upgraded to displace CNG or liquid natural gas (LNG) in vehicles capable of using these fuels. In Europe, upgrading biogas to fuel vehicular fleets is a well-established practice. In the US, there are only a few installations. Purity requirements for vehicular fuel are lower than those for pipeline injection. The biggest barriers to CNG or LNG conversion are the lack of a widespread infrastructure for gas filling stations and the cost of vehicle conversion for CNG or LNG use. Small scale packaged CNG conversion systems and filling station equipment are available from a single manufacturer and includes sulfur removal in a vessel with proprietary media, siloxanes removal in an activated carbon vessel and membrane carbon dioxide removal. There are currently three biogas CNG installations in the US, two at landfills and one at the Janesville, WI WWTP.

Cogeneration Technology Selection

As previously noted, reciprocating internal combustion engines are the most widespread, economical and efficient of all CHP technologies currently used for biogas cogeneration. Though the selection of CHP technology should be revisited during later stages of development for this project, internal combustion engines were selected for use in the following system sizing as well as the economic evaluation included later in this section.

Figure 3-5
GE Jenbacher 850 kW IC Engine

For the purpose of engine sizing, it was assumed that engine selection would be based on ensuring that the average biogas production rate under each alternative would be capable of being utilized by the selected engine(s). Biogas feed rate to the engine less than the total rated capacity would be utilized by either running the engines at a reduced rate or running less than the total number of installed units. It was further assumed that a parasitic load of 5% of the total electrical output is needed to provide energy for compression, gas boosting and gas treatment. For example, a 400 kW unit will produce 380 kW assuming 5% of the power produced is consumed by the parasitic load of the equipment used to operate the cogeneration system.

3.6.2 Projected Energy Balance

As noted previously, the digestion of organics yields biogas production and associated energy recovery opportunities. However, the processing of solids yields energy consumption in the following areas:

- Heat required for preheating of incoming waste;
- Heat to replace energy lost to the environment through tank walls, cover, etc;
- Electrical energy for the digestion system components (pumps, mixers, etc); and
- Electrical energy for the downstream processing of digestate (effluent from the digester).

The above demands need to be considered along with the anticipated CHP energy production in order to yield a realistic estimate of net energy which would be available for other purposes.

CHP Energy Production

As noted above, in order to realize an environmental and financial benefit from this biogas, it would need to be utilized in a CHP cogeneration system. The internal combustion engine assumed for this analysis would have an average electrical generation efficiency generally between 30- and 40-percent. However, when the waste heat produced by this equipment is recovered and reused for process or facility heating requirements, an overall system efficiency of over 80% can generally be realized.

Table 3-3 summarizes the amount of power and heat produced if the biogas is utilized in a reciprocating engine. As shown, the total estimated electrical output using average biogas production rates and assuming a 95% capture rate is estimated to range from 180 kW to approximately 1,800 kW. In addition, based on engine manufacturer data, the total recoverable heat from these engines would equate to between approximately 0.9 and 6.5 MMBtu/hr, respectively.

Heat Balance

In this application, the waste heat from the CHP equipment would be recovered and applied to influent preheating and to maintain mesophylic digestion tank temperatures. The theoretical energy use for these heating needs was calculated and included in Table 3-3. As shown, the influent preheating requirements are currently estimated to range from 0.2 to 0.9 MMBtu/hr while the conductive process heat loss was estimated to be between 0.2 and 0.6 MMBtu/hr. It should be noted that these heat demand values are based on the noted temperatures and could be significantly less during the warmer seasons and/or with warmer incoming waste temperatures.

In addition to process heat, the new buildings required to house the equipment are assumed to utilize CHP waste heat for facility heating demands. Based on a conceptual estimate of 25 Btu/sf, this would equate to between 0.5 and 1.0 MMBtu/hr under peak (winter) conditions. It was additionally assumed that the existing WWTP building would be heated with CHP waste heat and values for these facilities were derived from recent utility bills provided by the Town. The energy balance included in Table 3-3 takes into account these heating demands and the calculated 'Net Remaining Heat Energy' was then carried forward into the alternatives cost analysis discussed in Section 4 of this report. It should also be noted that conceptual cost allowances have been included in the financial analysis to cover the heat recovery loop (likely glycol circulation system) which would be required to distribute heat to these existing buildings.

As shown in the table, during the peak heat demand season (winter), after accounting for the anticipated heat demands, the lower bound estimate yields a conceptually equal heat balance while the larger acceptance scenario (10% of regional SSOs) yields an excess of 3.7 MMBtu/hr. During the summer months, there appears to be an excess heat recovery capacity of between 1 and 6 MMBtu/hr.

It should also be noted that heating value of digester biogas typically ranges from 500 to 650 BTU/cubic foot, with 600 BTU/cf being used in this estimate. For comparison, natural gas typically contains an average heating value of approximately 1,000 BTU/cf.

Electricity Balance

The expected electrical production from the CHP system is currently estimated to range from 180 to 1,800 kW, depending on the waste acceptance quantity. Conceptual estimates of electrical demand from the new systems were also completed. This demand would originate from the equipment required for the pre-processing equipment, digestion process, biogas treatment, dewatering systems and side stream treatment (discussed later in this section). In addition, it was assumed that the electrical demands of the existing WWTP at the site (from recent Town utility information) would be satisfied by the CHP electrical production. As noted in Table 3-3, after satisfying these estimated and actual demands, the net available electrical energy from the system is estimated to range between 50 and 1,500 kW.

Biogas Production and CHP Sizing	Alternative A Summer	Alternative A Winter	Alternative B Summer	Alternative B Winter	Alternative C Summer	Alternative C Winter
Biogas Production (cf/day)	67,000	67,000	279,000	279,000	544,000	544,000
Biogas Production (scfm)	47	47	194	194	378	378
Average Biogas Captured (95%)(scfm)	44	44	184	184	359	359
Equivalent reciprocating engine size (kW at full load)	230	230	800	800	2,000	2,000
Total Recoverable Heat (MMBtu/hr at full load)	1.2	1.2	2.9	2.9	7.2	7.2
CHP Capacity Utilization with Average Biogas (%)	80%	80%	100%	100%	91%	91%
Heat Balance						
Recoverable Heat from Average Biogas (MMBtu/hr)	0.94	0.94	2.9	2.9	6.5	6.5
Design Temperatures						
Minimum Ambient Design Temperature (deg F)	60	0	60	0	60	0
Incoming EFW Temperature (assumed) (deg F)	60	50	60	50	60	50
Internal Digester Temperature (deg F)	95	95	95	95	95	95
SSO Feed Heat Requirement						
Flow Rate (gpm)	8	8	23	23	41	41
Total Feeding Heat Required (MMBtu/hr)	0.15	0.19	0.40	0.52	0.72	0.92
Maximum Conductive Heat Loss (MMbtu/hr)						
Cover (Insulated, U=0.28)	0.01	0.04	0.04	0.10	0.06	0.15
Wall (Insulated Above Grade, U=0.14)	0.01	0.04	0.04	0.10	0.06	0.15
Bottom (Uninsulated, U=0.50)	0.03	0.07	0.06	0.18	0.10	0.27
Total Maximum Conductive Heat Loss	0.06	0.15	0.14	0.37	0.21	0.58
Building Heat Requirements (MMBtu/hr)						
Existing WWTP	0.00	0.35	0.00	0.35	0.00	0.35
New Process Buildings (~25 Btu/sf)	0.0	0.5	0.0	0.5	0.0	1.0
Total Potential Heat Demand (MMbtu/hr)	0.2	1.2	0.5	1.7	0.9	2.9
Net Remaining Heat Energy (MMbtu/hr)	0.7	-0.3	2.3	1.1	5.6	3.7
Electricity Balance						
CHP Electrical Output at Average Biogas (kW)	180	180	800	800	1,800	1,800
Electric Demand (kW)						
Existing WWTP	100	100	100	100	100	100
New Process Equipment	24	24	71	71	120	120
Biogas Boosting (5% of Production)	9	9	40	40	90	90
Total Demand	133	133	211	211	310	310
Net Remaining Electrical Energy (kW)	50	50	590	590	1,500	1,500

Table 3-3
CHP Sizing and Energy Balance

3.7 Solid and Liquid Products and Byproducts

Though the potential benefits of accepting and processing organics can be significant due to the biogas production potential, the digestate flow from the process is roughly equivalent to the hydraulic input and contains significant inert and undigested solids that must be dealt with. In certain applications, this digestate can be beneficially reused so as to improve facility economics and environmental impact. Some potential methods of digestate solids reuse include the following:

- Land apply liquid digestate as a Class B fertilizer: This is generally relegated to applications where hauling of liquid digestate is not required, there is sufficient on-site storage for digestate during any non-growing season and there is sufficient established demand for the product (i.e. on-farm digestion facilities);

- Dewater digestate for use as Class B fertilizer: In other applications where there is limited space to store significant quantities of liquid digestate or hauling of liquid would be cost prohibitive, the product is first dewatered, stored temporarily and then land applied as a fertilize/soil amendment;

- Dewater and compost for use as a Class A fertilizer: The addition of a properly designed composting facility to process dewatered solids would create a higher quality product with additional reuse opportunities. However, the composting process is space intensive and would add significant capital and operational costs to the project; or

- Dewater and thermal dry for use as a Class A fertilizer: It should be noted that excess heat from the cogeneration engines could also be used to dry the dewatered digestate and, in turn, produce a potentially marketable dried fertilizer product. Due to the temperatures of the heat that is recovered, this would likely be relegated to transfer of heat via hot oil or water to a belt dryer system. However the dryer and cogeneration system heat recovery would be required to operated simultaneously and continuously (compared to the assumed 5 days per week, 8 hours per day staffing of this facility). It should also be noted that the quality of product from a belt dryer system is significantly lower than the granular products produced by a rotary dryer (as produced at the MWRA and GLSD facilities) and would likely yield a lower market value. It is currently estimated that inclusion of this type of system in the current project could add somewhere on the order of $10M to the overall Alternative C facility capital cost.

Reuse of digestate through any of the above means would also be contingent upon securing a viable and consistent outlet for the product. As the organics reuse market within the region is not well developed at this time, it is not currently known whether, and to what extent, this opportunity exists. In addition, the seasonal nature of the agricultural fertilize demands in this region would likely necessitate the shipping of the product to other parts of the country during certain parts of the year and the demand and market rates for purchasing of this potential product are not currently known.

As a result of the above considerations, it was assumed that expansion of the current project for the purpose of digestate reuse would not be pursued as part of the initial facility development. Instead, it was assumed that, as discussed further below, the digestate would be dewatered and transported to an offsite location for disposal.

3.7.1 Digestate Storage

The dewatering system for the conceptual facility (discussed below) would likely be operated on a similar daily schedule as the receiving and pre-processing system. As the digester(s) would be fed and would discharge continuously, digestate storage volume would be required during the hours when the dewatering system is not in operation. At average day conditions, the digester would provide a continuous output of between approximately 8 and 40 gpm for the options evaluated in this study. If 2 days of storage were provided, this would equate to between approximately 24,000 gallons and 118,000 gallons of digestate tank volume.

With the use of submerged fixed covers over the digestion tank(s) and the need for biogas storage volume (discussed previously), the digestate storage tanks provides a good opportunity to cover this tank(s) with a biogas membrane and use the headspace of the tank as the storage mechanism. This also enables any additional biogas production resulting from methanogenesis within the storage tank to be captured and utilized. Costs included in Section 4 incorporate this concept of dual purpose storage.

3.7.2 Dewatering Technology Selection and Sizing

There are a variety of technologies available for the dewatering of digestate. A brief description of the leading and most proven technologies is as follow:

- Belt Filter Press: A conventional belt filter press (BFP) is a dewatering device that applies mechanical pressure to a chemically conditioned digestate, which is sandwiched between two (2) tensioned porous belts. By passing those belts through a serpentine of decreasing diameter rolls, the digestate is gradually compressed by increasing pressure which presses water out while leaving a moist "cake" behind. This material typically has the consistency of damp soil. Belt filter presses offer numerous advantages over comparable dewatering technologies including: Rapid start-up and shut-down of equipment; less noise and low electrical power consumption compared to centrifuges; low polymer consumption; relatively low maintenance to operate; and low staffing requirements. Conversely, major disadvantages of a belt filter press unit include; odor release during dewatering requires high rate ventilation and odor control; require extensive manual cleaning at the end of an operating cycle for wash down, moderate to high water demands for belt wash system.

- Rotary Press: Rotary presses offer moderate to high degree of dewatering with minimal equipment foot print, minimize odor control and room ventilation requirement by fully enclosing the dewatering process, and provide a fully automated cleanup cycle minimizing staffing needs for cleanup. The basic operating principal of a rotary press is to feed digestate between twin perforated plates that simultaneously compress and dewater it. Major advantages of rotary presses over belt filter presses and centrifuges include automated wash down cycle, low housekeeping maintenance requirements and minimal odor generation;, major disadvantages include poor dewatering performance on thin, low-fiber digestates and considerably variable operating performance amongst existing installations.

- Centrifuge: Centrifugal solids dewatering is a high speed process that utilizes the centrifugal forces generated during high speed rotation of a cylindrical bowl assembly to physically separate and dewater solids from liquid in wastewater sludge. Liquid digestate is pumped into a stainless steel bowl that is spun at very high speeds producing gravity accelerations between 2,500 -3,500 G. The heavier digestate solids accumulate at the bowl wall and are then discharged by means of a helicoidally shaped screw known as a scroll, which pushes the solids from the cylindrical section of the bowl, up through the conical section and towards the discharge ports. The liquid phase of the digestate, known as the centrate, finds its way back down the centrifuge bowl where it flows out to the discharge pipe. Centrifuges offer numerous advantages including high loading capacity, smaller equipment footprint, minimal operator attention and minimal odor emissions disadvantages include high energy costs, lengthy shut-down period and generally require special structural considerations due to weight and dynamic loading concerns.

For the purpose of this analysis, it has been assumed that BFP technology will be used as a result of its low energy cost and proven reliability in dewatering non-fibrous digestate as is likely to be discharged from an exclusively organics digester. It has been further assumed that the belt filter press would be installed in the location of the existing BFP within the WWTP operations building.

Table 3-4 summarizes the assumed operating parameters and anticipated performance of this system under the three loading scenarios.

It should also be noted that, in addition to the incoming waste truck traffic of between 1 and 9 trucks per day, an additional 1 to 4 trucks per day hauling dewatered cake offsite would be required assuming use of a 20 cubic yard truck. These quantities may vary significantly depending on the consistency and transportation of the waste.

	Alternative A	Alternative B	Alternative C
Flow to Dewatering (gal/day)	12,200	33,000	59,000
Flow to Dewatering (8 hrs/day, 5 days/wk) (gpm)	36	96	172
Solids to Dewatering (lb/day)	2,800	9,600	18,100
Solids to Dewatering (8 hrs/day, 5 days/wk) (lb/hr)	500	1,700	3,200
Digestate Storage Volume (assuming 2 days) (gal)	24,000	66,000	118,000
Dewatering Feed Concentration (%)	2.8%	3.5%	3.7%
Assumed Dewatered Cake Solids (%)	25%	25%	25%
Assumed Dewatering Solids Capture (%)	95%	95%	95%
Dewatered Cake Water Content (gal/day)	1,300	4,600	8,700
Dewatered Cake Requiring Disposal (wet tons/day)	5	18	34
Centrate Requiring Disposal (gal/day)	11,000	28,000	50,000

Table 3-4
Digestate Dewatering

3.7.3 Side Stream Treatment Considerations

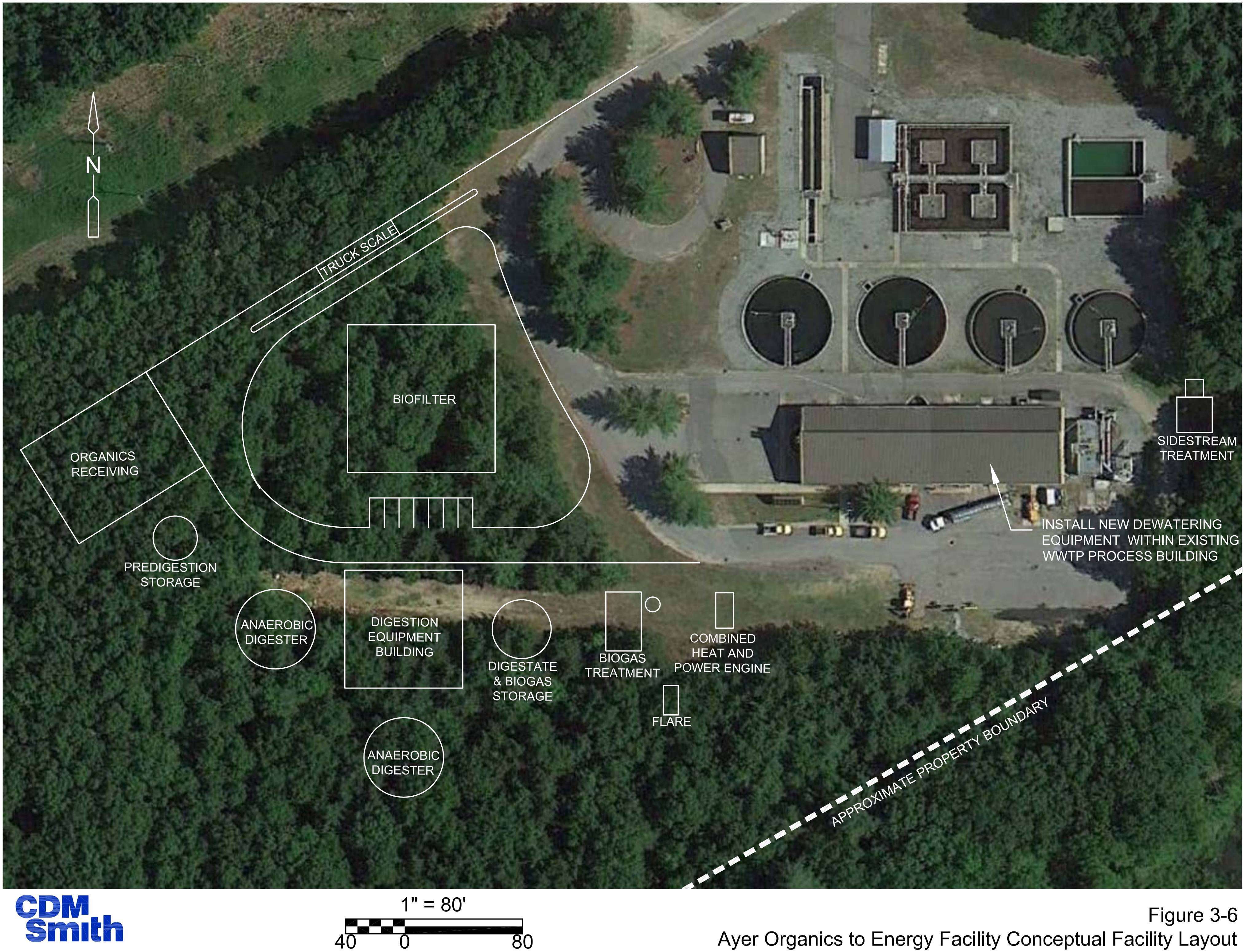
As noted above, the dewatering process would concentrate the digested solids while producing a side stream flow that would require further management. The amount of side stream to be managed is estimated to range between 11,000 and 50,000 gal/day. Though limited data is available pertaining to the quality of this flow from co-digestion of biosolids with SSO, it is known that typical dewatering side stream downstream of anaerobic digestion can have significant ammonia concentrations.

The presence of ammonia in wastewater can significantly increase secondary wastewater treatment process oxygen requirements along with the associated aeration costs. This results from the biological nitrification process where approximately four times the oxygen is required to treat one pound of ammonia as compared to one pound of typical BOD. For this reason, many municipal treatment facilities enforce ammonia pretreatment limits which must be achieved prior to discharge to the municipal collection system.

Due to the significant energy costs and operational concerns associated with treating this high ammonia side stream through the existing Ayer WWTP, this conceptual analysis assumes that an onsite pretreatment system would be required to reduce the side stream ammonia concentrations. The costs for this system have been included in the financial analysis later in this section.

3.8 Conceptual Site Plan

In an attempt to confirm the viability of the site to support the organics to energy facility sizes evaluated in this report, a conceptual site plan of the larger of the two options (10% of regional SSO) was developed. As shown in Figure 3-6, this conceptual site plan shows that the largest of the three options evaluated herein would be capable of being supported by the current site.



CDM Smith

Figure 3-6
Ayer Organics to Energy Facility Conceptual Facility Layout

Section 4

Alternatives Evaluation

Determining the economic feasibility of a digestion facility requires an understanding of the cost of the improvements that would be required to accept and process the SSO materials, the infrastructure necessary to process the material and harness energy value of the additional biogas produced along with the impact to ongoing operations costs. To compare relative costs and benefits of the alternatives, estimates of probable project cost were developed for each of the acceptance scenarios and the associated operations costs impacts were also conceptually quantified.

4.1 Summary of Process and Infrastructure Needs

Three SSO acceptance conditions were evaluated during this study to evaluate a wide range of potential cost and benefits. Figure 4-1 provides an overview of the capital infrastructure required and operational impacts under each scenario. Table 4-1 summarizes some of the key expected process performance values under average annual conditions associated with each of these options.

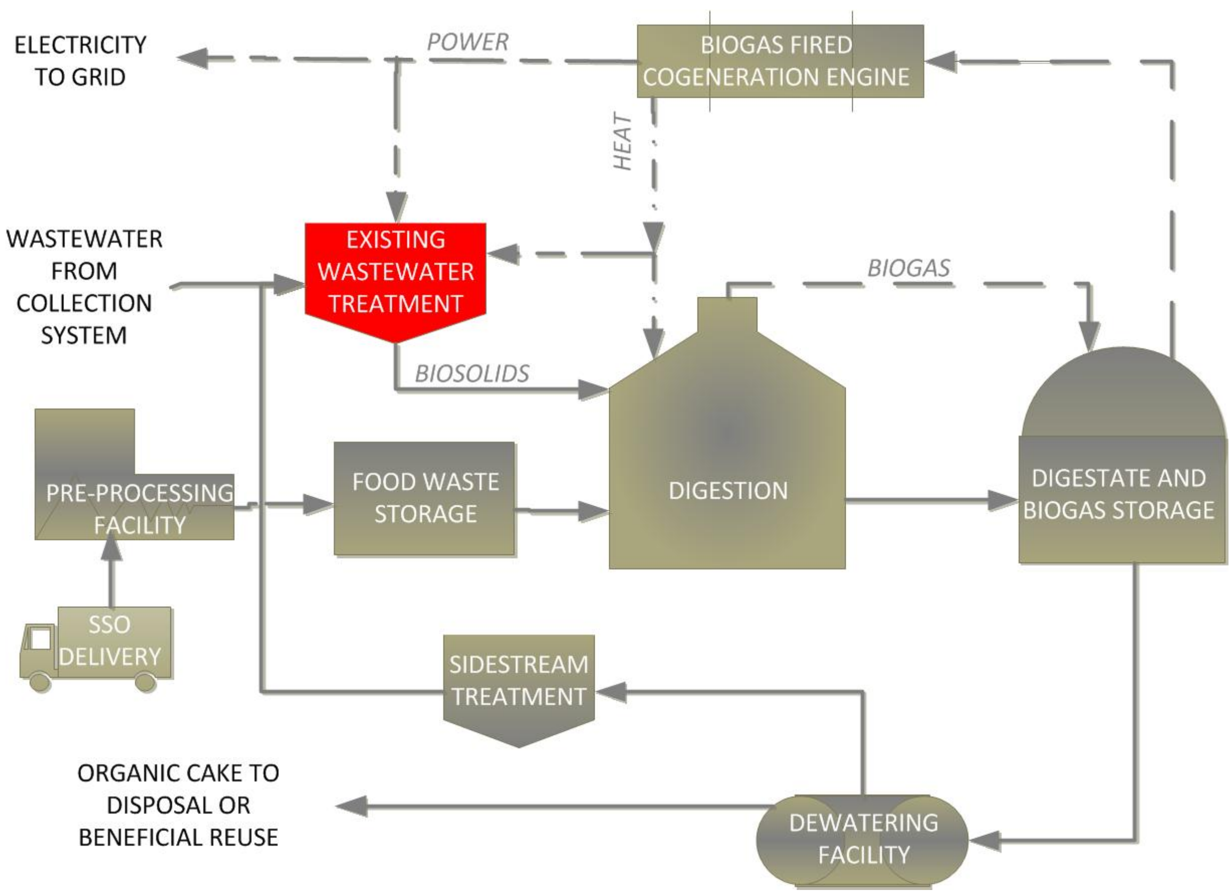


Figure 4-1
Simplified Facility Process Schematic

	Alternative A	Alternative B	Alternative C
Ayer Biosolids Production (wet tons/year)	10,700	10,700	10,700
Potentially Available SSO (wet tons/year)	3,400	17,000	34,000
Biosolids Fed to Digester (gal/day)	7,000	7,000	7,000
SSO Fed to Digester (gal/day)	5,200	26,000	52,000
Digestion Volume (million gal)	240,000	950,000	1,800,000
Biogas Produced (cf/day)	67,000	279,000	544,000
CHP Electrical Production (kW)	180	800	1,800
CHP Net Electrical Remaining After Onsite Use (kW)	50	600	1,500
CHP Heat Recovered (MMBtu/hr)	0.9	2.9	6.5
CHP Net Heat Remaining after Onsite Use (MMBtu/hr)	(0.3)	1.1	3.7
Dewatered Cake (wet tons/day)	5	18	34
Dewatered Cake (cy/day)	8	27	51
Centrate Requiring Disposal (gal/day)	11,000	28,000	50,000

Table 4-1
Conceptual Digestion Facility Summary

4.2 Capital Cost Estimates

As generally reflected in Figure 4-1, the major new facility components that would be required for this facility and which serve as the basis for the conceptual capital costs summarized in Tables 4-2 through 4-4 include the following:

- Pre-Processing Facility: The components and design of this system would be intended to process the incoming waste into a pumpable and digestible material free from foreign objects. The equipment associated with this system is assumed to be housed inside a building with all required ancillary systems including adequate ventilation and odor control. The processing capacity of the system considered here could range between 2 wt/hr to 16 wt/hr.

- Pre-Digestion Food Waste Storage Tanks and Pump Station: As a result of the continuous feeding needs in comparison with the receiving schedule noted previously, it is expected that pre-digestion engineered food waste storage tank(s) would be required. The estimated size of this storage would equate to between 15,000 and 150,000 gallons for the two options being evaluated.

- New Anaerobic Digester(s) and Ancillary Digestion Equipment: The two options evaluated yield a need for between 0.3and 1.8 million gallons of digestion capacity. It has been assumed that this would be provided inside of cast-in-place concrete tanks with submerged fixed covers. In addition, a digester equipment building would be provided to house the mixing, heating and other ancillary digestion equipment. Biogas Collection, Safety and Boosting Equipment would also be provided in the form of collection headers, foam separator, sediment trap, flame arrestors, condensate traps, emergency relief valves, as well as a waste gas burner system to combust any biogas not utilized in the CHP system. In addition, a pressure boosting system would be required to increase the gas pressure being fed to the CHP system.

- Digestate and Biogas Storage: Due to the assumed dewatering schedule relative to the constant effluent rate from the digester, additional digestate storage volume would be required. In addition, biogas storage would be required to help maximize the CHP utilization by adsorbing fluctuations in biogas production and CHP operation. It is recommended that these two components be combined into a new concrete tank covered by a gas holder membrane and associated costs have been included.

- New Cogeneration Engines: As previously noted, reciprocating internal combustion engines are the most widespread, economical and efficient of all CHP technologies currently used for biogas cogeneration. Though the selection of CHP technology should be revisited during later stages of this project, internal combustion engines were selected for use in the system sizing as well as the economic evaluation included in the following tables. As shown, the size of this cogeneration capacity is estimated to range from between 180 and 1,800 kw for the options evaluated here.

- Dewatering Facility: Due to the low solids concentration of the digestate, a solids dewatering system would be required. The system is assumed to include feed pump system (housed within the digester equipment building), belt filter press dewatering equipment (housed within the existing WWTP process building in place of the existing BFP), cake truck storage bay and other ancillary systems.

- Sidestream Treatment Facility: The dewatering process would concentrate the digested solids while producing a high ammonia concentration side stream flow that would require further treatment. The amount of side stream to be disposed of is estimated to range between 11,000 and 50,000 gal/day. Conceptual costs for a separate deammonification treatment system have been included in the analysis.

- Rolling Stock: Various pieces of equipment would be required for receiving of materials and maintenance of the facility. As such, an associated allowance has been included.

All capital costs include a 25% allowance for project contingencies and an additional 25% for engineering of the associated improvements. The costs for the above improvements were estimated and then amortized assuming a 20-year bond at an interest rate of 2.5 percent to achieve an equivalent annual cost.

4.3 Operation and Maintenance Costs

Operation of an organics processing facility at the site would carry with it significant costs which need to be considered in the conceptual financial analysis. Tables 4-2 through 4-4 also include the following financial considerations for annual operation and maintenance (O&M) costs:

- Labor: It is assumed that additional staffing resources would be required to operate a facility of this nature. Though delivery is assumed to be handled and funded by outside haulers, facility maintenance and operation is assumed to require between 2 and 4 employees during core operating hours (5 days/wk, 10 hrs/day). As such, the associated total labor costs were developed based on a rate of $50/man hour (including fringe benefits).

- Dilution Water: As previously noted, the dilution of incoming waste may be required and it has been assumed that this would be accomplished using domestic water at the current Town rate of between $2.41 and $3.53 per 100 cubic feet, depending on total usage. As discussed in

Section 3, other liquid organic wastes can also be used for this purpose, though it would be aggressive to assume that these wastes are available in sufficient quantities at the stage of planning.

- Wastewater Disposal: As noted above, the dewatering of digestate and treatment of the resulting sidestream will also require disposal of the wastewater. Though the opportunity exists for common municipal ownership of both facilities, the costs for final secondary treatment of the flow would still be borne by the Town. For this reason, costs for disposal of this wastewater have been incorporated into this evaluation at the current Town rate of between $6.49 and $8.46 per 100 cubic feet.

- Dewatering Chemicals: Dewatering of digestate will require polymer for proper operation and solids capture. It was assumed that this chemical would be consumed at a rate of 50 lbs polymer per dry ton of organic solids and would cost approximately $1.50/lb Polymer.

- Offsite Cake Disposal: Though there may be an opportunity for use of this material for animal bedding or agricultural fertilizer, as there have not been any specific outlets identified at this time, it has been assumed that disposal will be required at a rate of $50/wet ton including transportation.

- General System Maintenance: Systems and equipment of this magnitude will inherently carry with it ongoing costs for operations and maintenance. For general maintenance activities, it has been assumed that this annual cost would equate to ~2% of the equipment capital cost.

4.4 Operation and Maintenance Credits

As noted earlier in this report, the Town of Ayer currently transports is thickened sludge from resulting from its wastewater treatment plant operations to the Upper Blackstone Water Pollution Abatement District (UBWPAD) facility in Millbury, MA for incineration. This is completed using a Town-leased truck and a Town employee with an average of two trips per day, five days per week. The costs of this transportation, combined with the disposal fees at UBWPAD, are estimated to cost the Town approximately $200,000 per year under current operations. Upon instituting an anaerobic digestion program as discussed in this study, these costs would be offset by the operations and maintenance costs described above. Accordingly, a credit for this has been included within Tables 4-2 through 4-4.

In addition, the benefits of the combined heat and power (CHP) system would be realized by the Town upon implementation of this project. Credits corresponding to the respective heat (facility currently heated using ~5,000 gallons of heating oil per year) and electrical output (using current Town rate of ~$0.18/kWh) have also been incorporated into the break-even costs analysis for each facility size option.

4.5 Summary of Financial Analysis

As shown within Tables 4-2 through 4-4, the total cost of developing a digestion facility at the Ayer site is estimated to range from $17M to $52M depending on the assumed waste acceptance quantities and whether a preprocessing system is included in the project. After considering the significant financial benefits of the associated combined heat and power system in addition to the operational costs of the facility, the net annual cost is estimated to range from $1.2M to $2.3M before accounting for tipping fee revenues. At these costs and assumed SSO quantities, the break-even tipping fee would equate to between $650 (for the 1% of regional waste option) to $68 (for the 10% of regional waste option) per wet ton received. In the event the preprocessing system was to be excluded from the project, the break-even tipping fees would equate to between approximately $350 and $35 per wet ton, respectively.

Based on discussions with national private haulers during the course of this study, experience in other parts of the country has indicated that market tipping fees for organic waste could be in the range of $30 to $40 per wet ton for pre-processed waste. Though the break-even tip fees for the larger of the conceptual Ayer facility options are within this range, it should be noted that this conceptual analysis has included some conservative assumptions where further analysis may prove it to be more cost effective.

The most significant conservatism to be noted is the assumptions related to facility design, materials of construction and the resultant capital cost estimates. The design of this facility has been assumed to comply with redundancy standards and construction materials that are commonly applied to municipal infrastructure projects to properly protect from upset conditions and ensure adequate design life. It has been shown historically that less robust and often less costly solutions (i.e. steel tanks in lieu of concrete tanks, steel or wood in lieu of masonry buildings, less installed redundant equipment) are often employed when development is completed by a private for profit-entity. In the event this project was to be developed by a private entity, some of these savings may be able to be realized.

Beyond capital cost estimate assumptions, a few of the additional conservatisms included herein which, upon refinement, may yield additional financial benefit include:

- Significant excess CHP heat is present for the larger scale organics receiving option. Though there does not appear to be any current ability to reuse this heat onsite, in the event an adjacent facility or other onsite use for this heat were to become available, use/sale of this heat may benefit the economics of this project;
- Organic waste volatile solids reduction (VSR) and biogas production have been shown in some studies to exceed the assumed values of 82% VSR and 13.6 cf biogas/lb VSR;
- Financial benefits available from the sale of Renewable Energy Certificates (RECs) have been assumed to be valued at approximately $20 per MWh/year (approximately half of the current market values). This conservative value was selected due to the variability and uncertainly of this market over the assumed 20-year planning period used for this study, though additional revenue could be realized from this source in the event the market for these certificates remains strong; and
- The digestate is assumed to require disposal (with an associated cost) rather than have potential as a product that may earn revenue.

Further, though overall costs would be expected to increase in the future proportional to the rate of inflation, based on recent history, energy price escalation will likely exceed that of standard inflation indices. Therefor the net benefit of additional biogas production and net revenues from digestion are likely to be greater in future years.

All costs noted with this memorandum are in present day (August 2013) dollars.

Capital Costs	Unit Size		Total
SSO Receiving Tank, Feed Pumps & Mixers	14,600 gal & 14'tall		$300,000
Pre-Preprocessing System	2 wt/hr		$16,000,000
Anaerobic Digester	240,000 gal & 34.5' tall		$5,000,000
Digestate & Biogas Holding Tank	24,000 gal digestate 24,000 cf gas		$500,000
Dewatering System Size	40 gpm (0.5M)		$700,000
Biogas Treatment	65 scfm		$1,600,000
CHP Engine	230 kW		$900,000
Sidestreatm Treatment	11,000 gpd		$900,000
Truck Scale	-		$600,000
Rolling Stock	-		$500,000
Electrical & I&C	-		$4,600,000
Sitework and Yard Piping	-		$1,000,000
	Total w/out Preprocessing System		$16,600,000
	***Amortized Annual Cost w/out Preprocessing*[1]**		***$1,100,000***
	Total w/Preprocessing System		$32,600,000
	***Amortized Annual Cost w/Preprocessing*[1]**		***$2,100,000***
O&M Costs	**Unit Cost**	**Quantity**	**Annual Cost**
Labor	$50/hr	120 mh/wk	$300,000
Dewatering Process Chemicals	40 lbs/DT, $1.50/lb Polymer		$30,000
Offsite Cake Disposal	$50/wt	5 wt/day	$100,000
General O&M	2% of equiptment cost		$130,000
Pre-Processing Dilution Water	4,000 gpd		$7,000
Wastewater Disposal	11,000 gpd		$44,000
	Annual O&M Cost		***$600,000***
O&M Credits	**Quantity**	**Unit Cost**	
Electrical Offset of Existing Use Plus Net Export	150 kW	$0.18/kWh	($200,000)
Avoided Biosolids Disposal Costs			($200,000)
Sale of Renewable Energy Certificates (RECs)	1,300 MWh	$20/MWh	($65,000)
	Annual O&M Credit		***($465,000)***
Total			
	Annual SSO Received (wt/yr)		3,400
	Net Annual Cost w/out Preprocessing		$1,200,000
	Break Even Tip Fee w/out Preprocessing ($/wt)		$350
	Net Annual Cost w/Preprocessing		$2,200,000
	Break Even Tip Fee w/Preprocessing ($/wt)		$650

[1] Based on 2.5% interest rate on 20-year bond

[2] Negative values in above table indicate financial credit

[3] Capital costs include 50% allowance for Engineering and Contingencies

Table 4-2
Ayer, MA Organics to Energy Facility
Financial Feasibility at 3,400 WT/YR SSO Acceptance Rate

Capital Costs	Unit Size		Total
SSO Receiving Tank, Feed Pumps & Mixers	73,000 gal & 22' tall		$700,000
Pre-Preprocessing System	8 wt/hr		$16,000,000
Anaerobic Digester	950,000 gal x 58' tall		$8,000,000
Digestate & Biogas Holding Tank	66,000 gal digestate 96,000 cf biogas		$1,200,000
Dewatering System Size	100 gpm (1M)		$1,000,000
Biogas Treatment	260 scfm		$2,200,000
CHP Engine	800 kW		$2,600,000
Sidestream Treatment	28,000 gpd		$1,200,000
Truck Scale	-		$600,000
Rolling Stock	-		$700,000
Electrical & I&C	-		$5,500,000
Site work and Yard Piping	-		$1,100,000
	Total w/out Preprocessing System		$24,800,000
	Amortized Annual Cost w/out Preprocessing [1]		***$1,600,000***
	Total w/Preprocessing System		$40,800,000
	Amortized Annual Cost w/Preprocessing [1]		***$2,700,000***
O&M Costs	**Unit Cost**	**Quantity**	**Annual Cost**
Labor	$50/hr	180 mh/wk	$500,000
Dewatering Process Chemicals	40 lbs/DT, $1.50/lb Polymer		$100,000
Offsite Cake Disposal	$50/wt	18 wt/day	$300,000
General O&M	2% of equiptment cost		$160,000
Pre-Processing Dilution Water	20,000 gpd		$34,000
Wastewater Disposal	28,000 gpd		$110,000
		Annual O&M Cost	***$1,200,000***
O&M Credits	**Quantity**	**Unit Cost**	
Electrical Offset of Existing Use Plus Net Export	700 kW	$0.18/kWh	($1,100,000)
Facility Heat Offset by CHP	5,000 gal	$4/gal	($20,000)
Avoided Biosolids Disposal Costs			($200,000)
Sale of Renewable Energy Certificates (RECs)	6,100 MWh	$20/MWh	($122,000)
		Annual O&M Credit	***($1,400,000)***
Total			
		Annual SSO Received (wt/yr)	17,000
		Net Annual Cost w/out Preprocessing	$1,400,000
		Break Even Tip Fee w/out Preprocessing ($/wt)	$80
		Net Annual Cost w/Preprocessing	$2,500,000
		Break Even Tip Fee w/Preprocessing ($/wt)	$145

[1] Based on 2.5% interest rate on 20-year bond

[2] Negative values in above table indicate financial credit

[3] Capital costs include 50% allowance for Engineering and Contingencies

Table 4-3
Ayer, MA Organics to Energy Facility
Financial Feasibility at 17,000 WT/YR SSO Acceptance Rate

Capital Costs	Unit Size		Total
SSO Receiving Tank, Feed Pumps & Mixers	146,000 gal		$1,100,000
Pre-Preprocessing System	16 wt/hr		$16,000,000
Anaerobic Digester	2 X 900,000 gal		$12,200,000
Digestate & Biogas Holding Tank	118,000 gal digestate 184,000 cf biogas		$1,600,000
Dewatering System Size	170 gpm (2M)		$1,300,000
Biogas Treatment	490 scfm		$2,800,000
CHP Engine	2,000 kW		$5,000,000
Sidestream Treatment	50,000 gpd		$2,000,000
Truck Scale	-		$600,000
Rolling Stock	-		$1,000,000
Electrical & I&C	-		$6,800,000
Site work and Yard Piping	-		$1,200,000
	Total w/out Preprocessing System		$35,600,000
	Amortized Annual Cost w/out Preprocessing[1]		***$2,300,000***
	Total w/Preprocessing System		$51,600,000
	Amortized Annual Cost w/Preprocessing[1]		***$3,400,000***
O&M Costs	**Unit Cost**	**Quantity**	**Annual Cost**
Labor	$50/hr	240 mh/wk	$600,000
Dewatering Process Chemicals	40 lbs/DT, $1.50/lb Polymer		$200,000
Offsite Cake Disposal	$50/wt	34 wt/day	$600,000
General O&M	2% of equipment cost		$200,000
Pre-Processing Dilution Water	42,000 gpd		$70,000
Wastewater Disposal	50,000 gpd		$200,000
		Annual O&M Cost	***$1,900,000***
O&M Credits	**Quantity**	**Unit Cost**	
Electrical Offset of Existing Use Plus Net Export	1,600 kW	$0.18/kWh	($2,500,000)
Facility Heat Offset by CHP	5,000 gal	$4/gal	($20,000)
Avoided Biosolids Disposal Costs			($200,000)
Sale of Renewable Energy Certificates (RECs)	14,000 MWh	$20/MWh	($280,000)
		Annual O&M Credit	***($3,000,000)***
Total			
		Annual SSO Received (wt/yr)	34,000
		Net Annual Cost w/out Preprocessing	$1,200,000
		Break Even Tip Fee w/out Preprocessing ($/wt)	$35
		Net Annual Cost w/Preprocessing	$2,300,000
		Break Even Tip Fee w/Preprocessing ($/wt)	$68

[1] Based on 2.5% interest rate on 20-year bond

[2] Negative values in above table indicate financial credit

[3] Capital costs include 50% allowance for Engineering and Contingencies

Table 4-4
Ayer, MA Organics to Energy Facility
Financial Feasibility at 34,000 WT/YR SSO Acceptance Rate

Section 5

Implementation Considerations

5.1 Funding

There are a number of project development and ownership options available for this project. In addition to the allocation of project responsibility and risks, a major driver in the decision as to the most advantageous option surrounds maximizing the affordability and economic benefits. Though financing projects of this nature can be complex and availability of assistance can vary depending on the ownership option selected, there are a number of possible programs available including state grants, low interest loans and tax incentives which could aid in the project development and financing. In addition, tipping fees for accepting SSOs and cogeneration electrical production incentives would serve to assist in financing of the required infrastructure. A brief description of each available program is described further below.

5.1.1 Potential Grants and Loans

MassCEC Organics to Energy Program

The Massachusetts Clean Energy Center (MassCEC) administers the Commonwealth's Organics-to-Energy Program. In addition to providing technical assistance related to the development of projects that convert source-separated organic materials into heat and electricity, it also provides grants for the development of related facilities. Projects must be located in the service territories of the investor-owned or municipal electric distribution companies that pay into the Massachusetts Renewable Energy Trust Fund -- administered by the Massachusetts Clean Energy Center ("MassCEC") -- and must produce 1) electricity that is eligible for the Massachusetts Renewable Portfolio Standard or 2) thermal energy that can be used outside the organics processing system itself. The principal technology supported is anaerobic digestion, although a limited number of awards may be made for projects employing other commercially available technologies.

The MassCEC provides grant funding for feasibility studies, technical studies, pilot projects and construction projects. As noted earlier, the majority of the funding for the current feasibility study was provided through the MassCEC Organics to Energy Program. The dollar cap for pilot studies is currently $200,000 while construction project grants are capped at $400,000.

MassDEP Recycling Loan Fund

As announced in July of 2013, in an effort to support the pending organic waste diversion regulations, the Commonwealth of Massachusetts has made $3 million in low-interest loans available to private companies for construction of anaerobic digestion facilities. The low-interest loans will be administered by BCD Capital through MassDEP's Recycling Loan Fund, with monies provided by the Department of Energy Resources (DOER). The loans range from $50,000 to $500,000 with terms up to ten years and are intended to be used for permanent working capital, refinancing, and real estate, machinery & equipment, and acquisition financing.

MassDEP Sustainable Materials Recovery Grants

MassDEP Sustainable Materials Recovery Program (SMRP) Municipal Grants offer funding to cities, towns and regional entities for "recycling, composting, reuse and source reduction activities that will increase diversion of municipal solid waste and household hazardous waste from disposal." Historically, grants were general geared toward recycling and composting equipment, Pay-As-You-Throw programs, waste reduction enforcement, school recycling and local/regional waste reduction projects. During 2012, a total of approximately $2 million was awarded across 118 projects. MassDEP typically accepts applications for this program between early April and mid-June annually

It was also recently announced that DOER is making $1 million available in grants for anaerobic digestion to public entities for projects on municipal or state land through the SMRG program. The grants will be awarded in amounts up to $500,000 per project (multi-year grant). MassDEP and DOER have awarded the first AD grant of $100,000 to the Massachusetts Water Resources Agency (MWRA) for co-digestion pilot testing at its wastewater treatment plant at Deer Island.

National Grid Energy Efficiency Incentives

This project may also qualify for National Grid Custom Measure Incentives Program for New Construction. Though this program has historically been geared toward providing financial assistance to energy efficiency measures, such as the use of specific high efficiency lighting fixtures or water heating systems, custom incentives also apply to more complex projects that provide energy efficient solutions – including cogeneration projects. For electrical efficiency studies, in the event the project meets a series of screening criteria and prerequisites, this program can provide up to 70% of incremental cost of higher efficiency equipment, or an amount that buys down the incremental investment to a 1.5 year simple payback. However, as the name suggests, this program is highly customized and additional technical discussions with National Grid would be required to determine project eligibility and potential funding.

National Grid CHP Incentive

Also potentially available from National Grid are funds from the CHP incentive program. Generally, equipment qualifying for CHP incentives include reciprocating engines, gas turbines (also called combustion turbines), and back pressure steam turbines. A CHP system can use any type of fuel – including biogas. Inorder to quality for this program, the CHP equipment would need to have a combined electric and thermal efficiency equal to or greater than 60%. Though funding is based on a tiered structure, it is believed that incentives could approach $950/kW.

Green Communities Competitive Grant

The "Green Communities Act" of 2008 created a Green Communities Division within the Massachusetts Department of Energy Resources (DOER). The charge of this division is to guide all cities and towns within the Commonwealth "along a path of enhanced energy efficiency and renewable energy toward zero net energy." In general, the goal of this program is to maximize energy efficiency in public buildings, including schools, city halls, and public works and public safety buildings; generate clean energy from renewable sources; and manage rising energy costs. To achieve these goals, the Division currently provides technical assistance as well as opportunities to fund energy improvements.

The Town of Ayer is currently designated as one of the 110 Green Communities in the Commonwealth of Massachusetts and is eligible for grant funding for energy efficiency measures and renewable energy projects through the Green Communities Grant Program. DOER Green Communities Competitive Grants are awarded to existing Green Communities that have successfully invested their initial designation grants. In 2013, a total of $3.7million in competitive grants were awarded which were capped at $250,000 per municipality. The competitive grants are funded through proceeds from Regional Greenhouse Gas Initiative auctions (RGGI).

Clean Water State Revolving Fund (CWSRF) Loans

Every year the Commonwealth of Massachusetts funds millions of dollars' worth of water and wastewater projects through the Department of Environmental Protection (MassDEP) State Revolving Fund (SRF). The Clean Water State Revolving Fund (CWSRF) Loans could provide an avenue for low interest loans and principal forgiveness to fund this potential project. Though the CWSRF program has historically concentrated on water-related projects, the based on recent project examples and discussions with MassDEP, it has been noted that organic diversion projects are also being looked upon favorably within their current project prioritization system. As such, if selected for CWSRF funding, this project would be eligible for low interest loans (2% interested rate) as well as any potential principal forgiveness which the program may have to offer at that time. During the 2012 funding process, the CWSRF program offered approximately $300 million in financing for clean water projects across the Commonwealth.

Based on the 2013 Intended Use Plan (IUP) developed by the MassDEP, the Commonwealth was expected to receive an estimated $47.9 million federal grant to subsidize the CWSRF program. In 2012, Congress required at least 10% of the federal grant be used to fund "green infrastructure" and it is expected that a similar requirement for 2013 will be enforced. Based on the IUP, the MassDEP intended to finance (including both grants and loans) approximately $68 million for Green Infrastructure project components.

Clean Renewable Energy Bonds (IRS)

Clean Renewable Energy Bonds (CREBs) are 0% interest bonds typically issued for up to approximately $3.0 million administered by the Internal Revenue Service (IRS). The IRS initiated the program in 2005 and accepted applications intermittently through 2010. The most recent round of funding included approximately $2.4 billion in funding. However, the IRS is not currently accepting application for this program and it is unknown when/if additional funding will be made available. For more information, please refer to http://www.irs.gov/Tax-Exempt-Bonds/.

Qualified Energy Conservation Bonds

Qualified Energy Conservation Bonds (QECBs) are tax credit bonds, bonds which the borrower pays back the principal on the bond, and the bondholder receives federal tax credits in lieu of traditional bond interest payments. QECBs can be issued to qualified energy conservation projects, including anaerobic digestion projects. A total of $3.2 billion of QECBs were initially authorized under the federal Energy Improvement and Extension Act of 2008 and American Reinvestment and Recovery Act of 2009 (ARRA). QECBs were allocated based on population and Massachusetts received $67million of the total. DOER administered a series of Program Opportunity Notice (PON) to allocate this funding, the most recent of which was dated April 18, 2013 and labeled as PON-ENE-2013-070. Based on this recent solicitation, only $4 million of the original total Massachusetts allocation remains available for distribution.

Global Climate Change Mitigation Incentive Fund

The Economic Development Agency (USEDA)(part of the U.S. Department of Commerce) administers the GCCMIF to public works projects that reduce greenhouse gas emissions and creates new jobs. In FY 2012, $16.5 million was allocated to the grant-based fund, and additional funding is expected to be allocated in FY 2013. Applications are due on a rolling basis. Private sector and or for-profit companies are not eligible for this fund.

Business Energy Investment Tax Credit (ITC)

A Business Energy Investment Tax Credit (ITC) is available from the U.S. Internal Revenue Service (IRS) for combined heat and power systems. The tax credit is only available for commercial, industrial or utility entities. Tax-exempt municipal entities, including the Town of Ayer, would not be eligible for this tax credit. As discussed below, the Town would be able to indirectly benefit from the tax credit by entering a long term agreement with an Energy Service Company (ESCO) for development of the facility. The credit is equal to 10% of CHP expenditures, with no maximum.

MassDevelopement Tax Exempt Financing

The Massachusetts Development Finance Agency (MassDevelopment) was created in 1998 under legislation which merged the Massachusetts Government Land Bank with the Massachusetts Industrial Finance Agency. MassDevelopment works with private- and public-sector clients to stimulate economic growth by creating jobs and increasing the state's housing supply. Among other financing options, they offer tax exempt financing to municipal and non-profit entities for funding of large-scale projects. Because they are exempt from federal taxes and in certain cases state taxes, tax-exempt bonds are usually the lowest interest rate option for real estate projects and new equipment purchases. In the fourth quarter of FY 2013 (April, May & June of 2013), MassDevelopment financed 84 projects totaling approximately $800 million in investment in the Commonwealth.

Private Tax-Exempt Financing

Similar to traditional municipal bond financing, there are many private financial service companies that offer a myriad of options for tax-exempt financing of municipal projects. The providers of these services suggest that this capital can be offered at competitive rates in an expedited timeframe and with fewer complications when compared to traditional municipal financing methods. Though these factors would need to be compared on a case-by-case basis, the one distinct advantage to private financing on the current project would likely be the flexibility to structure payments to meet budget needs with consideration given to the terms and conditions of existing loan and/or bond agreements. For example, this mechanism could be used to limit the initial debt payments when the current bond debt is the greatest and the operations savings of the project has yet to be fully realized. It should also be noted that, in many cases, the construction and long term financing can be rolled into a single private financing agreement. Also, in some instances, equipment manufacturers have the ability to offer competitive financing terms (e.g. Siemens Financial Services Corporation), though financing from these sources is generally contingent upon a substantial portion of the project cost (~20% to 30%) being for their respective equipment.

Table 5-1 provides a summary of the general characteristics of each grant and loan program described in this study. The grant and loan landscape is subject to change and should be monitored for the latest opportunities.

5.1.2 Potential Operating Revenue

Organic Waste Tipping Fees

As discussed previously, fees for disposal of SSOs at the facility would likely serve as a source of revenue to fund the project. Though this rate would be driven by the waste disposal market in the Commonwealth and would be influenced by a number of factors, based on discussions with national private haulers during the course of this study, experience in other parts of the country has indicated that market tipping fees for organic waste could be in the range of $30 to $40 per wet ton for pre-processed waste.

Digestate Beneficial Reuse

In the event a market for the final digestate product was identified, theoretically, the sale of the product for its remaining nutrient content could yield additional operating revenue. However, as discussed previously, this market is not well developed within the Commonwealth and the demand for such a product is not currently known. Due to the ongoing activity and discussions pertaining to the organics processing and reuse markets, additional opportunities and potential financial implications may become more clear in the coming months.

Net Metering

In 2012, legislation was passed in Massachusetts, which is currently being developed into regulation, allowing anaerobic digestion and cogeneration facilities to avail themselves of the "net-metering" provisions of the Green Communities Act. The premise of the program is to provide incentives to supplying renewable energy into the local power grid.

Massachusetts Net Metering Regulations, 220 CMR 18.00 et seq., defines that an Anaerobic Digestion Net Metering Facility must:

- Generates electricity from a biogas produced by the accelerated biodegradation of organic materials under controlled anaerobic conditions;
- Has been determined by the Department of Energy Resources, in coordination with the Department of Environmental Protection, to qualify under the Department of Energy Resources' regulations as a Class I renewable energy generating source under 225 CMR 14:00: Renewable Energy Portfolio Standard – Class I and M.G.L. c. 25A, § 11F; and
- Is interconnected to a Distribution Company.

The regulations further define three classes of energy facilities eligible for net metering categorized by their rated capacity. The capacity ranges for the three classes are:

- Class I Net Metering Facility means a plant or equipment that is used to produce, manufacture, or otherwise generate electricity and that is not a transmission facility and that has a design capacity of <u>60 kilowatts or less</u>.
- Class II Net Metering Facility means an Agricultural Net Metering Facility, Anaerobic Digestion Net Metering Facility, Solar Net Metering Facility, or Wind Net Metering Facility with a generating capacity of <u>more than 60 kilowatts but less than or equal to one megawatt</u>; provided, however, that a Class II Net Metering Facility of a Municipality or Other Governmental Entity may have a generating capacity of more than 60 kilowatts but less than or equal to one megawatt per unit.
- Class III Net Metering Facility means an Agricultural Net Metering Facility, Anaerobic Digestion Net Metering Facility, Solar Net Metering Facility, or Wind Net Metering Facility with a generating capacity of <u>more than one megawatt but less than or equal to two megawatts</u>; provided, however, that a Class III Net Metering Facility of a Municipality or Other Governmental Entity may have a generating capacity of more than one megawatt but less than or equal to two megawatts per unit.

Both options evaluated in this study would quality the facility as a Class III net metering facility.

A facility's maximum capacity will also help determine whether it is a "public" or a "private" project. If a net metering facility is designed for the private net metering cap, then the maximum total capacity is 2 MW. If a net metering facility is designed for the public net metering cap, then the maximum capacity is 10 MW. Only Class II and Class III facilities may be included in the public net metering cap.

Under the net metering program, in installations where power produced does not exceed on-site power use, the host customer is able to apply net metering credits to offset its bill from the electric distribution company. If more power is generated than can be used onsite, and as long as two basic conditions are met, a Host Customer may apply net metering credits to other accounts, even if the other accounts are not held by the Host Customer. The Host Customer can allocate net metering credits to other accounts as long as all of the accounts are with the same electric distribution company and located within the same ISO-NE load zone. Because the facility options evaluated here would likely exceed the current total Town of Ayer town account electric usage, a partner electric customer would need to be secured in order to fully utilize the net metering credits that would be produced by this project. In addition, if the facility were to fall under the public net metering cap described above, any partner customer that were to receive the net metering credits from the facility would be required to be a public entity.

If a net metering facility has a capacity of 1 MW to 2 MW (making it a Class III facility), the electric distribution company may decide to pay the Host Customer for the value of any credits from excess generation, instead of applying any credits to accounts. Under state law, this decision is left entirely up to the electric distribution company, but the utility must decide before the facility becomes operational what it will do in this regard.

For the purpose of the financial analysis included in Section 4 of this study, it has been assumed that the Ayer facility would be a Class III public net metering facility and would either utilize a public net metering electric customer partner to utilize the extra credits produced or would be paid directly for the credits by National Grid.

Renewable Energy Certificates (RECs)

As part of the Massachusetts Renewable Portfolio Standards (RPS), electric suppliers are required to have an annually-increasing percentage of their retail sales generated by renewable energy. Electric suppliers fulfill this obligation by purchasing renewable energy certificates (RECs) from the owners of qualified renewable energy generating systems and recording these purchases with the New England Power Pool (NEPOOL) Generation Information System (GIS). One REC is created for every 1,000 kWh (1 MWh) of renewable electricity generated. The RPS, and creation of RECs, is intended to provide additional revenue flow and financial support for renewable energy projects in Massachusetts. As of April 2013, Class I RECs, which include electricity generation from wind, wave, tidal, geothermal and sustainable biomass were trading at around $64/MWh.

An Alternative Compliance Payment (ACP) is a payment of a certain dollar amount per MWh, which a retail electricity supplier may submit to DOER in lieu of purchasing RECs. These payments are provided to the MasCEC and the revenue generated from ACPs is used to fund new renewable generation projects. In Massachusetts, this ACP is currently set at $65.27 per MWh, which effectively sets the ceiling price for the REC purchasing market. The ACP may vary year to year but by no more than 10 percent per year.

Under current regulations, the power from an Ayer organics-to-energy system could be sold to the market as RPS Class I Renewable Energy Certificates (RECs). Though the pricing is quite strong for RECs in Massachusetts at the present time, the increase of renewable energy production systems (solar, other organics to energy facilities, etc) will impact and likely force a decrease in the pricing within this market. However, as a point of comparison, based on the alternatives evaluated in this study and at the current REC market pricing, the power could translate into between $350,000 per year and $2 million per year assuming 90% system availability and facility operations at full capacity.

Table 5-2 includes a summary of the potential operating revenue associated with this facility along with the associated assumption included within the Section 4 financial analysis.

	Type of Funding	Applicant Type	Recent Statewide Allocation	Dollar Cap Per Project
MassCEC Organics to Energy Program	Grants	Public & Private	Unknown	$200,000 (Piloting) $400,000 (Construction)
MassDEP Recycling Loan Fund	Low Interest Loans	Private	$3M for AD	$50,000 to $500,000
MassDEP Sustainable Materials Recovery Grants	Grants	Public	$1M for AD	$500,000
National Grid Custom Measures Program	Grants	Public & Private	Unknown	70% of Incremental Cost or Buy-Down to 1.5 yr Payback
Green Communities Competitive Grant	Grants	Public	$3.7M (2013)	$250,000
MassDEP Clean Water State Revolving Fund (CWSRF)	Low Interest Loans & Principal Forgiveness	Public	$68M for Green Infrastructure (2013)	None
Clean Renewable Energy Bonds (CREBs)	Not current accepting applications			
Qualified Energy Conservation Bonds	Tax Credit Bonds	Public & Private	$4M	None
Global Climate Change Incentive Mitigation Fund	Grants	Public	$16.5M Nationwide (2012)	Unknown
Business Energy Investment Tax Credit	Tax Credit	Private	N/A	10% of Combined Heat and Power Costs
MassDevelopment Tax Exempt Financing	Tax Exempt Bonds	Public & Private	$800M (Q2 2013)	None
Private Tax Exempt Financing	Tax Exempt Bonds	Public & Private	None	None

Table 5-1
Summary of Grant and Loan Opportunities

	Potential Range	Current Study Assumption
Organic Waste Tipping Fees	$30 to $40 per Wet Ton for SSO	Solved for Break-Even Tipping Fee
Digestate Beneficial Reuse	Unknown	Offsite Disposal Cost of $50/wet ton
Electrical Net Metering	Current rate of $0.18/kWh	Included Full Credit for All Power Production
Renewable Energy Certificates (RECs)	Current rate of $64/MWh	Not Included in Operating Revenues

Table 5-2
Potential Operating Revenues

5.2 Ownership Options

This Section provides an overview and comparison of various ownership options that may be considered by the Town for implementation of the project. Depending on the ownership option ultimately chosen, certain legal issues (such as Town contracting authority and applicable procurement procedures) will need to be addressed by Town legal counsel at a later date.

The ownership options reviewed here incorporate different approaches to the allocation of project responsibility, risks and economic benefits in the following key aspects of implementation:

- Design, construction and operation of project facilities;
- Collection of source-separated organics (SSO); and
- Energy savings.

With regard to certain so-called "uncontrollable risks" (such as change in law or regulations, force majeure, unknown site conditions, permitting, etc.), it generally can be expected that such risks would be allocated to the Town under each of the ownership options.

5.2.1 Public Implementation

Under the municipal ownership option, the Town would own the organic-to-energy center facilities and would provide financing for design and construction. Operation and maintenance could be performed by Town employees or by an outside firm under a short-term (5 years) or long-term (10 to 20 years) contract with the Town. Design and construction could be performed through one of the following methods:

- A traditional design-bid-build approach (where a design engineer is retained to prepare detailed plans and specifications for public bidding and a construction contract is awarded to the lowest responsible bidder);
- A design-build contractor (where design and construction is performed under a single contract); or
- A construction management at-risk approach (where a design engineer is retained to prepare detailed plans and specifications and a construction management firm is hired at an early point in the design development process to provide pre-construction services and work with the design engineer and to provide the Town with an "open book" guaranteed maxim price to perform construction).

The design-build approach may require special legislative authority for the Town.

The municipal ownership option would have the Town undertake primary responsibility for all aspects of project implementation. The Town would thereby assume the overall profile of project risks (costs and long-term performance) and economic benefits (net revenue from SSO collection and energy savings). Certain income tax benefits that may be available in the case of private ownership would not be available to the Town.

5.2.2 Private Implementation

Under the Site Lease/Private Ownership option, the Town would turn the project site (portion of the existing parcel, excluding existing buildings and facilities) over to a private company via a long-term lease agreement. The company would design, construct, finance, own and operate the organic-to-energy center facilities, pay a fixed annual rent and provide certain performance guarantees to the Town, and the Town would enter into a power purchase agreement with the company and/or an agreement to buy net metering credits. In this arrangement, the risks related to the project's costs, performance and revenue associated with the implementation, ownership and long-term operation of the organic-to-energy center facilities would be allocated to the private company.

The private ownership option would have the private company undertake primary responsibility for all aspects of project implementation. The company would thereby assume the overall profile of project risks (costs and long-term performance) and economic benefits (net revenue from SSO collection). Certain income tax benefits may be available in the case of private ownership to help off-set the higher cost of capital typically associated with private financing.

5.2.3 Public Private Partnership/Co-Development

The Public/Private Partnership option would involve ownership and financing arrangements whereby certain project's risks and rewards are shared between the Town and a private company. Such options might include:

- Town design, construction, financing and ownership of the facilities coupled with a long-term operations/concession agreement whereby the net revenues or economic benefits are shared between the Town and private operator;
- Town financing and ownership of the facilities coupled with a long-term design, build and operations/concession agreement whereby the net revenues or economic benefits are shared between the Town and private operator; or
- Private design, construction, financing, ownership and operation of the facilities coupled with a long-term site lease agreement whereby the net revenues or economic benefits are shared between the Town and private operator. Each of these approaches may require special legislative authority for the Town.

The public-private partnership option would have the Town enter into an arrangement with a private company whereby the responsibilities for project implementation are shared, the specifics of which would depend on the options described above. Under this arrangement, the Town and private company would also share the project's risks (costs and long-term performance) and economic benefits (net revenue from SSO collection and "behind the meter" energy savings). Certain income tax benefits may or may not be available to the private company in the case of the public-private partnership option.

5.2.4 Preliminary Comparison of Options

Table 5-3 compares the ownership options described previously in terms of the following key factors:

- Design and construction risks
- Financing risks and costs
- Operation and maintenance risks
- Economic benefits and risks
- Life-cycle project costs
- Implementation time
- Private sector capabilities/interest

	Town Ownership	Public-Private Partnership	Private Ownership
Design/construction risks	Assumed primarily by the Town if design-build-build. Town can transfer these risks with design-build or design-build-operate contracting.	Allocated to the party responsible for design and construction.	Assumed primarily by the private company.
Financing risks/costs	Assumed by the Town.	Depends on source of financing.	Transaction costs and return on equity assumed by private company. Debt interest rate assumed by the Town until financial close. Cost of capital for private financing typically higher than Town financing.
Operations risks	Assumed by the Town.	Allocated to the party responsible for operation.	Assumed by the private company.
Economic benefits/risks	Allocated to the Town.	Depends on the specific arrangement.	Allocated to the private company, though lease payment is benefit to Town and PPA could provide price certainty to Town.
Life-cycle project costs	Assumed by the Town.	Depends on the specific arrangement.	Assumed by the private company and partially recovered in the service fee/charges to the Town.
Implementation time	Depends on the procurement method.	Depends on the procurement method.	Depends on the procurement method.
Private sector capabilities/interest	Should be a competitive market of capable firms.	Needs to be determined.	Needs to be determined.

Table 5-3
Comparison of Ownership Options

5.3 Regulations and Permitting

As part of the current feasibility study, an initial assessment was completed related to the regulatory trends and drivers related to development of an organics to energy facility in Ayer along with the potential permitting associated with development of the facility.

5.3.1 Regulatory Trends

State Regulatory Trends

As has been previously noted, MassDEP is now focusing a great deal of attention on organic residuals: especially SSO. The agency has announced its intention to ban certain large scale (e.g. commercial and institutional) SSO from landfills in 2014. In preparation for this ban on landfill disposal, two significant regulatory changes were developed in 2011, one to the solid waste regulations (310 CMR 16.00 and 19.00) and one to the wastewater regulations (314 CMR 12.00). These changes were finally adopted in late November, 2012, and now the solid waste rules allow for streamlined siting of facilities that process SSO (e.g. compost or anaerobic digestion facilities). The wastewater rules have been changed to allow for wastewater treatment facilities with anaerobic digesters to accept and process SSO. The change to the wastewater treatment facility regulations is a simple rule change that was widely supported while the solids waste changes (siting of new facilities) received opposition from those representing local boards of health.

A few specific changes in the recent promulgation include the following:

- 310 CMR 16.02 defines "source separated" as "separated from solid waste at the point of generation and kept separate from solid waste."
- 310 CMR 16.02 (and 310 CMR 19.000) revised the definition of solid waste to exempt "organic material when handled at a Publicly Owned Treatment Works as defined in 314 CMR 12.00 and as approved by the Department pursuant to 314 CMR 12.00."
- 314 CMR 12.00 will require written approval from MassDEP to accept SSO materials at AD units.
- A site assignment under the solid waste regulations and laws (310 CMR 16.00 and MGL ch.111 § 150A, respectively) is only required for an area of land where solid waste uses can occur. Therefore, since the SSO materials handled at WWTP's or exclusively organics processing facilities is not considered a solid waste by definition, it would not require a solid waste site assignment.
- 314 CMR 12.00 notes that "Fish and animal material from slaughterhouses, butchering and processing facilities, pet food production facilities and supermarkets may not be accepted into anaerobic digesters operated at a wastewater treatment facility without specific written approval of such materials by the Department."

MassDEP's focus on organics seems to be a lasting trend, driven, in large part, by the fact that organics are the last and greatest untapped potential resource in landfilled solid waste – and it can be a source of renewable energy. As long as the political will remains, it seems likely that a landfill ban will be enacted in Massachusetts in the next few years, if not by the current 2014 deadline.

In addition, whereas comprehensive energy and GHG emissions policy has stalled at the national level, Massachusetts has adopted leading programs for both. With new alternative energy production from biogas, Ayer would be able to take advantage of markets for renewable portfolio standards (RPS) (as discussed previously). Planning for this potential facility should presume that these kinds of state policies will continue, making renewable energy and documented reductions in GHG emissions likely more valuable with time. National and private market incentives may also come to play a significant role in the future.

Local Regulatory Trends

Massachusetts local Boards of Health are also raising concerns about the proposed MassDEP regulations streamlining the siting of organics processing facilities. Their objections appear to be mostly about having their local power taken away in the siting process for smaller facilities. In general, as noted above, local control is a strong force in Massachusetts, and Boards of Health express concern about local nuisance and environmental impacts from managing organics – which can be odorous if not handled properly.

5.3.2 State and Local Permits Required

Development of an organics to energy facility at the Ayer Brook Street site would involve installation of substantial new infrastructure for any of the alternatives being evaluated. State and local permits are required whenever proposed work may affect certain environmentally sensitive resources, disturbs a specific amount of land and/or constructs new infrastructure subject to local building and zoning board reviews. Though a detailed permitting review would need to be conducted during later stages of project implementation, the following provides a brief description of the likely permits required for anaerobic digestion related improvements to the Ayer site.

MassDEP and Board of Health Approvals

Also at noted within revisions to 314 CMR 12.00, acceptance of SSO at Ayer will require a written approval to accept SSO materials at AD units from the MassDEP. However, based on the known goals for the SSO initiative, this approval is unlikely to meet resistance at the state level.

As noted above, the changes to the CMR solid waste and wastewater treatment regulations allowed for streamlining of new facility siting and eliminated the need to acquire a solids waste site assignment for SSO processing. Since SSO is not considered a solid waste, a new "site assignment" through the local board of health would not be required.

Air Quality Permitting

The installation of new biogas-fired boilers and cogeneration engines is expected to require a new air permit. Per 310 CMR 4.10(2), it would be necessary to apply for a Non-Major Comprehensive Plan Approval from the MassDEP, and to have this permit in hand before installing the equipment. A Non-Major Comprehensive Plan Approval application can take four to six weeks to prepare, and is required to include a Best Available Control Technology analysis, and possibly also a dispersion modeling demonstration. MassDEP approval of this permit is expected to take about six months.

In addition, all digester-gas fired engines must comply with U.S. EPA emission limits in 40 CFR 60 Subpart JJJJ, Standards of Performance for Stationary Spark Ignition Internal Combustion Engines, shown in Table 5-4, for nitrogen oxides (NOx), carbon monoxide (CO), and volatile organic compounds (VOC). The reciprocating biogas fired cogeneration engines investigated under this evaluation for potential use at Ayer do appear to meet the USEPA limits identified in Table 5-4.

Engine Type	Manufacture Date	Maximum Rated Engine Power	Oxides of Nitrogen	Carbon Monoxide	VOC
Digester Gas, Except Lean Burn 500≤HP<1,350	On and after 1/1/2011	HP<500	2.0 g/HP-hr or 150 ppmvd @ 15% O_2	5.0 g/HP-hr or 610 ppmvd @ 15% O_2	1.0 g/HP-hr or 80 ppmvd @ 15% O_2
	On and after 7/1/2010	HP≥500	2.0 g/HP-hr or 150 ppmvd @ 15% O_2	5.0 g/HP-hr or 610 ppmvd @ 15% O_2	1.0 g/HP-hr or 80 ppmvd @ 15% O_2
Digester Gas, Lean Burn	On and after 7/1/2010	500≤HP<1,350	2.0 g/HP-hr or 150 ppmvd @ 15% O_2	5.0 g/HP-hr or 610 ppmvd @ 15% O_2	1.0 g/HP-hr or 80 ppmvd @ 15% O_2

Table 5-4
U.S. EPA Emissions Standards for Stationary Digester Gas Engines

Review pursuant to the Massachusetts Environmental Policy Act (MEPA) by the Executive Office of Energy and Environmental Affairs

The project exceeds the MEPA threshold for an Environmental Notification Form (ENF). The MEPA threshold exceeded is 301 CMR 11.03(11)(b) *Any Project within a designated ACEC unless the Project consists solely of one single family dwelling*. The parcel is located in the Squannassit Area of Critical Environmental Concern (ACEC), therefore this project will require an ENF.

Natural Heritage and Endangered Species

As previously noted, GIS data identified that the Brook Street site is currently mapped by Natural Heritage and Endangered Species Program (NHESP) as a “Priority Habitat of Rare Species” as well as an “Estimated Habitat of Rare Wildlife” as indicated in the Massachusetts Natural Heritage Atlas (13th Edition). This classification was further confirmed through written correspondence with the NHESP where it was determined that the reason for the listing is due to the known presence of Blue-Spotted Salamander (*Ambystoma laterale*), Zebra Clubtail (Dragonfly) (*Stylurus scudderi*), Blanding's Turtle (*Emydoidea blandingii*) and Wild Senna (plant) (*Senna hebecarpa*) in the vicinity of the site. As indicated in the letter, the species listed above are protected under the Massachusetts Endangered Species Act (MESA) (M.G.L. c. 131A) and its implementing regulations (321 CMR 10.00).

Coordination with NHESP will occur prior to filling and during the review period of the ENF per the MEPA. Potential mitigation measures implemented to avoid a “take” under the MA Endangered Species Act include but are not limited to conducting a wildlife habitat assessment and plant survey and habitat assessment prior to filing of the ENF and time of year restrictions for construction.

Wetland Resources

Though the exact facility layout would need to be refined during design, due to the size of the site and its relationship to surface water resources, it is likely that the new facilities would be able to be installed outside of the 200-ft Riverfront Area, 100-year floodplain and the 100-foot Buffer Zone from any Bordering Vegetated Wetlands. Under these conditions, a Notice of Intent (NOI) to the Ayer Conservation Commission would not be required as a result of work within Wetland Resource Areas and the 100-foot Buffer Zone.

Cultural Resources

During the early stages of the project, review of the Massachusetts Cultural Resource Information System (MACRIS) would be required to identify any potential historical or archaeological resources at the site.

Flood Protection

Commonly accepted design guidelines for similar waste processing facilities, suggests that infrastructure should provide for protection against structural and equipment damage from the 100-year flood level. It is assumed design of this project would likely follow similar guidance. According to the most recent FEMA flood insurance mapping, only a minor portion of the site falls within the 100-yr flood plain of Nonocoicus Brook and the new infrastructure would likely be able to be located outside of this area. As such, it is not expected that special design considerations or construction methods would be required to protect from the 100-yr flood event.

Stormwater

EPA currently regulates stormwater discharges from construction sites that disturb 1 acre or more and construction dewatering activities. It is likely that facility construction would disturb greater than 1 acre of land and will therefore require a Construction Activities Permit. As part of the construction contract, the Contractor typically obtains the required NPDES Permit.

A Stormwater Pollution Prevention Plan (SWPPP) would also be prepared during final design according to the MassDEP General Permit requirements for stormwater discharges. The Plan would identify a pollution prevention team, potential pollutant sources, stormwater monitoring requirements, record keeping, reporting responsibilities, and stormwater management controls. The Plan would also include a site map showing discharge locations, stating receiving water bodies, and showing locations of materials exposed to precipitation.

Planning Board

As noted previously, there does not appear to be any specific prohibition against siting of an organics processing facility within the current zoning regulations for this site. However, the final determination as to whether review of this project by the local Planning Board should be determined by local officials. Based on the scale of this project, it is likely that a project of this nature would be required to be reviewed and approved.

Local Building Permits

Local building permits are typically the responsibility of the general contractor performing the construction and are obtained during the construction phase.

5.3.3 Electrical Interconnection Requirements

The electrical interconnection of a cogeneration facility can be a significant component of the project. Cogeneration facilities capable of generating thousands of megawatt hours per year will require an electrical utility service and associated infrastructure capable of transmitting a significant electrical load to the grid. As previously noted, the existing wastewater treatment facility at the Brook Street site has an average annual energy consumption of approximately 100 kW while, depending on the size of the facility pursued, the new systems associated with the anaerobic digestion facility could double this load. Based on the alternatives evaluated here, the peak output of the cogeneration facility could be in the range of 200 kw to 2 MW. Since the output of the cogeneration facility scenarios exceeds the electrical demand, the facility will need to be directly connected to National Grid and net metered so as to recover the benefits of this electrical production.

Typical cogeneration facilities of this size produce power at either 480 volts or 4160 volts, three phase 60 hertz. The facility will therefore require a separate transformer that converts the produced voltage to 13.2 kV which is assumed to be the electric utility service voltage currently serving the Brook Street Site. These values would need to be confirmed during the design phase. Regardless of exact voltages, a three phase step-up transformer with utility metering on the primary (13.2 kV side) would be required. The transformer should comply with the Department of Energy (2010 compliant) for energy efficiency.

In addition, a bi-directional net meter provided by the utility (National Grid) will need to be installed to measure and record the site consumption and production when the facility is producing more power than demand. If the facility were to be municipally owned, based on the net metering concept, when the facility produces more power than consumed, the utility will record and credit other town-owned electrical accounts. It should also be noted that National Grid may also require a reclosing device to disconnect the cogeneration system from the grid, but this will not be definitely known until further discussions are conducted with the utility during design. Final design and integration of the cogeneration facility system must comply with the National Grid Standards for Integrating Distributed Generation, IEEE 1547.

Due to the direct utility tie-in, it is expected that a National Grid impact study will be needed prior to commencing construction; this has a maximum time frame of 90 day to complete. The maximum time frame for interconnection approval is 150 days through the Standard Process Interconnection Application, including the impact study. The application fee for this work should not exceed $2,500 per National Grid standards and the Impact Study may cost approximately $10,000 based on prior experience, but actual cost of the study will be provided by National Grid once the requirement is determined.

Section 6

Recommendations

6.1 Summary of Findings

As previously noted, three SSO acceptance conditions were evaluated during this study so as to analyze a wide range of potential cost and benefits. Using these waste acceptance scenarios, conceptual systems were sized to adequately process this waste. Systems included preprocessing, anaerobic digestion, digestate dewatering, sidestream treatment, biogas treatment and biogas fired cogeneration equipment.

To compare relative costs and benefits of the alternatives, estimates of probable project cost were developed for each of the acceptance scenarios and the associated operations costs impacts were also conceptually quantified. As summarized in Table 6-1, the total cost of developing a digestion facility at the Ayer site is estimated to range from $17M to $52M, depending on the assumed waste acceptance quantities and whether a preprocessing system is included in the project. After considering the significant financial benefits of the associated combined heat and power system in addition to the operational costs of the facility, the net annual cost is estimated to range from $1.2M to $2.3M before accounting for tipping fee revenues.

At these costs and assumed SSO quantities, the break-even tipping fee would equate to between $650 (for the 1% of regional waste option) to $68 (for the 10% of regional waste option) per wet ton received. In the event the preprocessing system was to be excluded from the project, the break-even tipping fees would equate to between approximately $350 and $35 per wet ton, respectively.

	Alternative A (1% of Regional SSO)	Alternative B (5% of Regional SSO)	Alternative C (10% of Regional SSO)
Initial Capital Costs Including Pre-Processing	$33,000,000	$41,000,000	$52,000,000
Annual Capital Costs (Amortized 20 yrs @ 2.5%)	$2,100,000	$2,700,000	$3,400,000
Annual Operational Costs	$600,000	$1,200,000	$1,900,000
Annual Operational Credits	$465,000	$1,400,000	$3,000,000
Net Annual Cost	$2,200,000	$2,500,000	$2,300,000
Annual SSO Received (wt/yr)	3,400	17,000	34,000
Break Even Waste Tip Fee ($/wt)	$650	$145	$68
Break Even Waste Tip Fee without Installation of Pre-Processing ($/wt)	$350	$80	$35

Table 6-1
Conceptual Financial Summary

Based on discussions with national private haulers during the course of this study, experience in other parts of the country has indicated that market tipping fees for organic waste could be in the range of $30 to $40 per wet ton for pre-processed waste. Though the organics disposal market in the Commonwealth is currently in a state of flux due to the pending waste ban as well as the rapid development of various waste processing facilities, it is not currently known whether this experience in other parts of the country will be seen in Massachusetts. It is important to note, however, that the current average rate for municipal solid waste disposal in Massachusetts is in the range of $70 per ton, so tipping fees for non-preprocessed waste less than this may be able to be initially borne by the developing organics market in the Commonwealth. Despite this, it remains to be seen how low rates for these wastes, which have an inherent energy value as well as a potential digestate reuse value, will be ultimately driven down by competing processing facilities.

With consideration of the above factors and estimated costs, the apparent financial viability of the facility sizing options evaluated here can be summarized as follows:

- Alternatives A & B: The development of a facility to accept and process 17,000 wet tons per year or less of SSO combined with the Ayer biosolids stream is estimated to cost upwards of $40M. After accounting for the operations costs and energy benefits associated with the facility, an SSO tip fee well in excess of $100 per wet ton would need to be realized in order to break even. As this rate is greater than the current cost of municipal solid waste disposal in the Commonwealth and significantly greater than organics disposal rates in other parts of the country, the development of a facility of this size would not be financially viable without significant external funding incentives.

- Alternative C: Development of a larger facility which would be capable of processing approximately 34,000 wet tons per year of SSO along with the Ayer biosolids stream would likely cost on the order of $52M to develop and would translate to a break even tip fee between $35 and $68 per wet ton. Though these fees appear to be more in line with the potential market rates for this material, these costs are still likely on the high end of the viable tip fees which may be able to be realized. In addition, this option does carry with it significant risk related to waste availability. The quantity assumed here translates to 10% of the estimated organic waste within a 30 mile radius and, based on the MassDEP waste availability study, could translate to approximately 250 different waste suppliers/accounts that would need to be managed. Therefore, pursuit of a facility approaching this size could be financially viable, but would carry with it significant risk and uncertainty related to waste availability and management.

6.2 Public Participation

As noted in correspondence to the MassCEC on July 16, 2013, an extensive community outreach program is being implemented for this project so as to further determine the risk tolerance and any potential local stakeholder opposition to this project. The outreach program is intended to insure that the Town's residents, Town leaders, business community and regulatory community are informed and can provide needed input.

To-date, this program has included the following specific activities:

- Presentation at Annual Spring Town Meeting, May 13, 2013: The Green Community Committee gave a brief presentation on several energy related projects in the Town. A brief overview of the project was presented by the DPW Superintendent. There were approximately 200 people in attendance.

- Green Community Committee and Energy Committee Meetings: These committees meet approximately monthly. The committees include Town officials, Department heads and residents. The DPW Superintendent is a member of the Energy Committee and attends most of the Green Community Committee meetings. This will be a vehicle to get input from citizens, develop communication plans and have Ayer citizens assisting in public presentations.

- Public Forum August 8, 2013: The project team held an initial public form on August 8, 2013 to present the background and status of the feasibility study. The forum was attended by a small but actively engaged group of local residents and Town committee members. A hand-out and formal presentation summarizing the project objectives, scope, benefits and issues was developed in advance of the forum and placed through-out town and posted on the Town web site and Facebook page. The public forum was videotaped and broadcast over the Town Public access and the video posted on the Town web site. In addition, a follow-up article was published in the Ayer Public Spirit and Lowell Sun (newspapers).

Feedback received from the above efforts regarding this project has been generally positive with no known substantial opposition to the project identified. It should also be noted that the public participation effort is ongoing and it is expected that additional presentations to the local Board of Selectmen and potentially additional public forums will be pursued in an effort to make the most appropriate decision as to whether, and in what form, this project should be pursued.

6.3 Implementation Recommendations

Despite the unfavorable finances associated with the smaller of the options evaluated and the waste availability risks associated with the larger of the options, it may be possible to select a facility size somewhere within the range evaluated here which would balance these concerns. This selection would likely be drive by whether any substantial external funding may be able to be secured as well as proper determination of the risk tolerance of the Town. Based on experience in other similar municipalities, it is anticipated that the significant capital cost and risk associated with developing a project of this nature may not be bearable exclusively by a municipal ownership option. For this reason, if the Town believed that development of this facility was a priority and in the Town's best interest, private development or a public private partnership (see Section 5) should be evaluated further through discussions with local private organics facility developers.

For reference, and for future partnership opportunity considerations, a few of the private firms actively pursuing this area include the following:

- Anaergia (Burlington, ON);
- Applied Water Management (Division of Natural Systems Utilities (NSU) (Hillsborough, NJ);
- Casella Organics (Partial Owner of Agreen Energy LLC) (Portland, ME);
- Harvest Power (Waltham, MA);
- NEO Energy (Portsmouth, NH);
- Synagro (Baltimore, MD); and
- Waste Management Inc. (Houston, TX).

Appendix A

NHESP Letter Dated September 20, 2013

Commonwealth of Massachusetts

Division of Fisheries & Wildlife

MassWildlife

Wayne F. MacCallum, *Director*

September 20, 2013

Andrew Poyant
Camp Dresser & McKee, Inc.
50 Hampshire Street
Cambridge MA 02139

RE: Project Location: 25 Brook Street
Town: AYER
NHESP Tracking No.: 11-29604

To Whom It May Concern:

Thank you for contacting the Natural Heritage and Endangered Species Program of the MA Division of Fisheries & Wildlife (the "Division") for information regarding state-listed rare species in the vicinity of the above referenced site. Based on the information provided, this project site, or a portion thereof, is located **within** *Priority Habitat 1477* (PH 1477) and *Estimated Habitat 959* (EH 959) as indicated in the *Massachusetts Natural Heritage Atlas* (13th Edition). Our database indicates that the following state-listed rare species have been found in the vicinity of the site:

Scientific name	Common Name	Taxonomic Group	State Status
Ambystoma laterale	Blue-Spotted Salamander	Amphibian	Special Concern
Stylurus scudderi	Zebra Clubtail	Dragonfly	Not Listed As of 2/27/2012
Emydoidea blandingii	Blanding's Turtle	Reptile	Threatened
Senna hebecarpa	Wild Senna	Plant	Endangered

The species listed above are protected under the Massachusetts Endangered Species Act (MESA) (M.G.L. c. 131A) and its implementing regulations (321 CMR 10.00). State-listed wildlife are also protected under the state's Wetlands Protection Act (WPA) (M.G.L. c. 131, s. 40) and its implementing regulations (310 CMR 10.00). Fact sheets for most state-listed rare species can be found on our website (www.mass.gov/nhesp).

Please note that projects and activities located within Priority and/or Estimated Habitat **must** be reviewed by the Division for compliance with the state-listed rare species protection provisions of MESA (321 CMR 10.00) and/or the WPA (310 CMR 10.00).

Wetlands Protection Act (WPA)

If the project site is within Estimated Habitat and a Notice of Intent (NOI) is required, then a copy of the NOI must be submitted to the Division so that it is received at the same time as the local conservation commission. If the Division determines that the proposed project will adversely affect the actual Resource Area habitat of state-protected wildlife, then the proposed project may not be permitted (310 CMR 10.37, 10.58(4)(b) & 10.59). In such a case, the project proponent may request a consultation with the

Division of Fisheries and Wildlife
Temporary Correspondence: 100 Hartwell Street, Suite 230, West Boylston, MA 01583
Permanent: Field Headquarters, North Drive, Westborough, MA 01581 (508) 389-6300 Fax (508) 389-7890
An Agency of the Department of Fish and Game

Division to discuss potential project design modifications that would avoid adverse effects to rare wildlife habitat.

A streamlined joint MESA/WPA review process is available. When filing a Notice of Intent (NOI), the applicant may file concurrently under the MESA on the same NOI form and qualify for a 30-day streamlined joint review. For a copy of the NOI form, please visit the MA Department of Environmental Protection's website: http://www.mass.gov/dep/water/approvals/wpaform3.doc.

MA Endangered Species Act (MESA)

If the proposed project is located within Priority Habitat and is not exempt from review (see 321 CMR 10.14), then project plans, a fee, and other required materials must be sent to Natural Heritage Regulatory Review to determine whether a probable "take" under the MA Endangered Species Act would occur (321 CMR 10.18). Please note that all proposed and anticipated development must be disclosed, as MESA does not allow project segmentation (321 CMR 10.16). For a MESA filing checklist and additional information please see our website: www.mass.gov/nhesp ("Regulatory Review" tab).

We recommend that rare species habitat concerns be addressed during the project design phase prior to submission of a formal MESA filing, as avoidance and minimization of impacts to rare species and their habitats is likely to expedite endangered species regulatory review.

This evaluation is based on the most recent information available in the Natural Heritage database, which is constantly being expanded and updated through ongoing research and inventory. If you have any questions regarding this letter please contact Amanda Veinotte, Endangered Species Review Assistant, at (508) 389-6380.

Sincerely,

Thomas W. French

Thomas W. French, Ph.D.
Assistant Director

cdmsmith.com